SACRED HEART COLLEGE

PHYSICAL SCIENCE

PAPER 1

JULY 2016

TIME: 3 hours + 10 minutes reading time

MARKS: 200

EXAMINER: Mr F Hollingworth

MODERATOR: Mr D Armour

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
   a question paper of 20 pages, an Answer Sheet; a Data and Formulae sheet
   and a graph sheet for Question 3.6
   Please make sure that your question paper is complete.
2. 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. The letter that corresponds with your choice of the correct answer must be marked with a cross as shown in the example below:

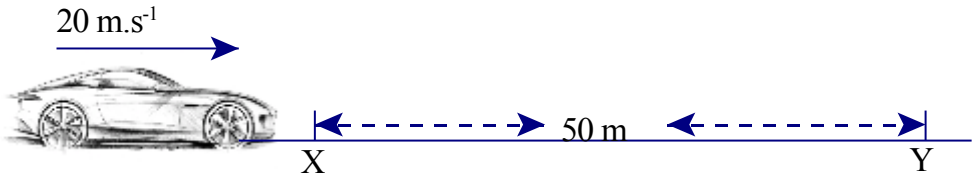
A	B	C	D

Here the answer C has been marked.

3. **START EACH QUESTION ON A NEW PAGE.**
4. It is in your own interest to write legibly and to set your work out neatly.
5. Show your working in all calculations.
9. Where appropriate take your answers to 2 decimal places unless instructed otherwise.
10. Units need not be included in the working of calculations, but appropriate units must be shown in the answer.

QUESTION 1 MULTIPLE CHOICE

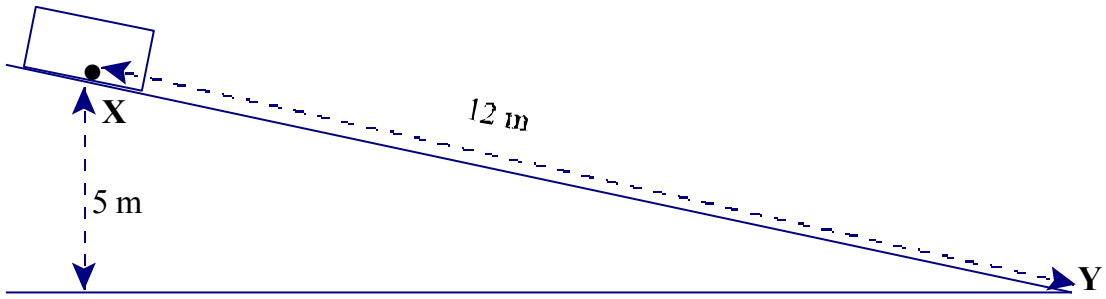
1.1 A car of mass 1200 kg is travelling along a straight level road at a constant speed of 20 m.s^{-1}. The driving force on the car is 2500 N. The frictional force on the car is 2500 N.



The work done moving the car between point X and point Y is

A. 0 J
B. 11 800 J
C. 125 000 J
D. 250 000 J.

1.2 A box of mass 0,40 kg slides down a 12 m long frictionless slope.

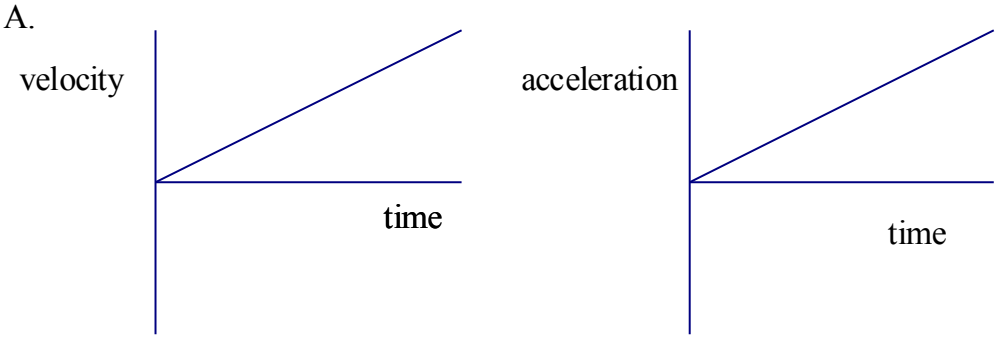


The box starts from rest at point X on the slope which is at a height of 5,0 m. The kinetic energy of the box at point Y is

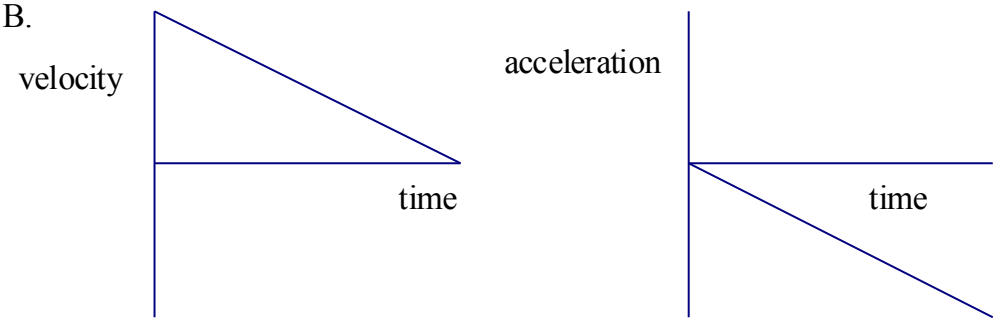
A. 3,92 J
B. 19,6 J
C. 47,04 J
D. 60 J

1.3 A vehicle is travelling in a straight line. Graphs of velocity and acceleration against time are shown. Which pair of graphs could represent the motion of the vehicle?

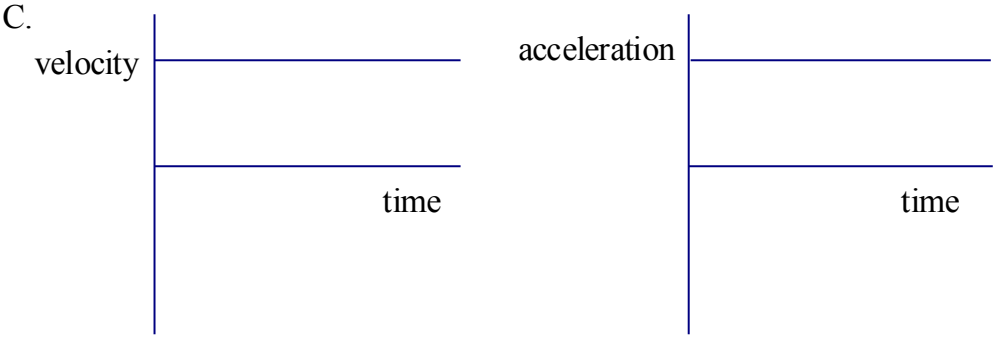
A.



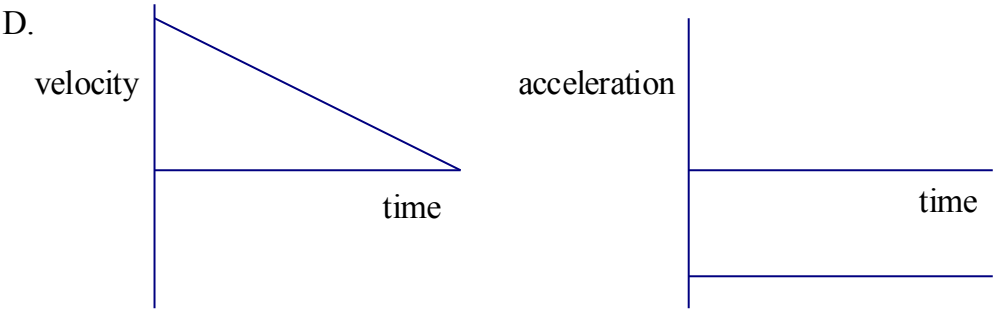
B.



C.



D.



1.4 A spacecraft of mass *m* is at the mid-point between the centres of a planet of mass M_1 and its moon of mass M_2. If the distance between the spacecraft and the centre of the planet is *d*, what is the magnitude of the resultant gravitational force on the spacecraft?

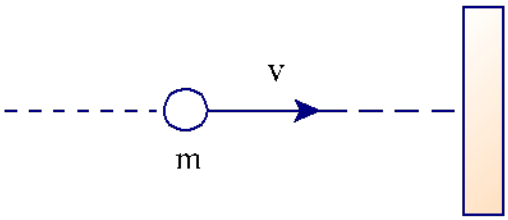
A. $\frac{G\,m\,(M_1 - M_2)}{d}$

B. $\frac{G\,m\,(M_1 + M_2)}{d^2}$

C. $\frac{G\,m\,(M_1 - M_2)}{d^2}$

D. $\frac{G\,m\,(M_1 + M_2)}{d^2}$

1.5 A ball of mass m travelling at velocity v collides normally with a smooth wall, as shown in the diagram, and rebounds elastically.



Which line, A to D, in the table, gives the correct expressions for the magnitude of the change of momentum, and the change of kinetic energy, of the ball?

	Magnitude of change of momentum	**Change of Kinetic energy**
A.	2mv	0
B.	2mv	mv^2
C.	0	0
D.	0	mv^2

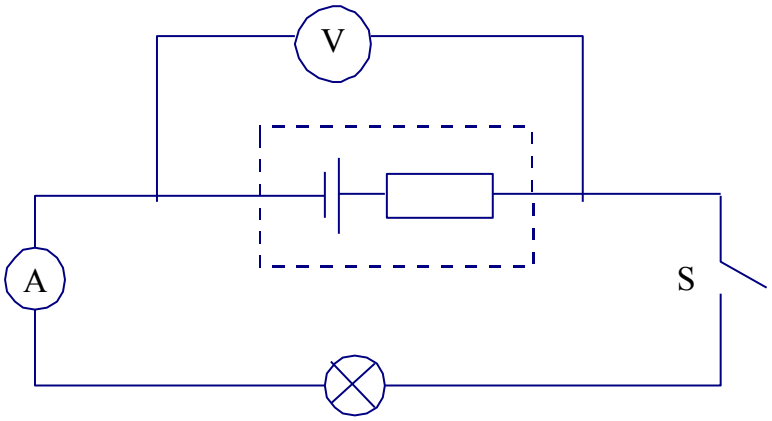
1.6 The total mass of a motorcycle and rider is 250 kg. During braking, they are brought to rest from a speed of 15 $m.s^{-1}$ in a time of 10 s. The maximum energy which could be converted to heat by the brakes is

A. 3 750 J
B. 28 125 J
C. 37 500 J
D. 56 250 J

1.7 A kilowatt hour (kWh) is a measure of

A. Power
B. Energy
C. Potential difference
D. Charge

1.8 The circuit below can be used to determine the emf and the internal resistance of a cell.



Ammeter and voltmeter readings are taken when switch S is open and when it is closed. The results are as follows:

Switch S open:	Current = zero:	Voltage = V_1
Switch S closed:	Current = I :	Voltage = V_2

The emf of the cell is equal to

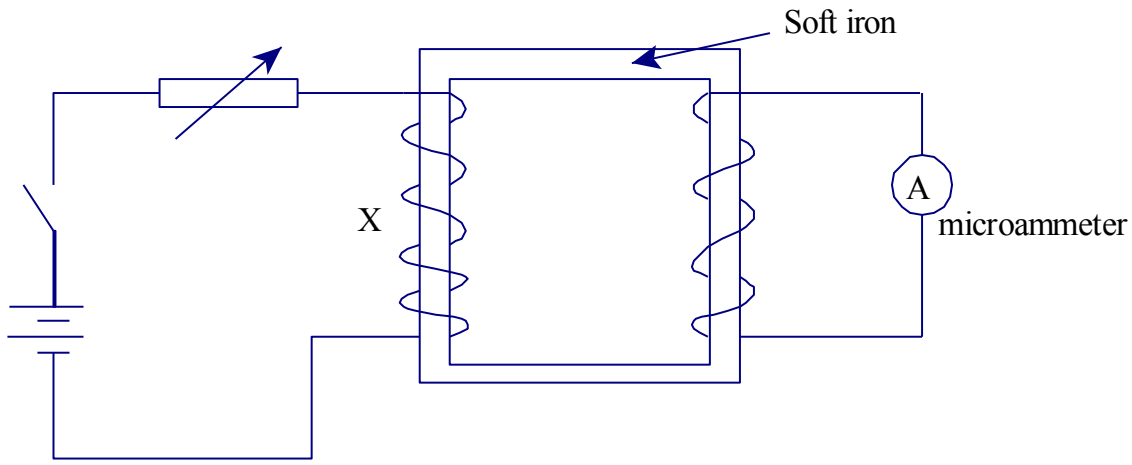
A. V_1

B. V_2

C. $V_1 - V_2$

D. $\frac{V_2 - V_1}{I}$

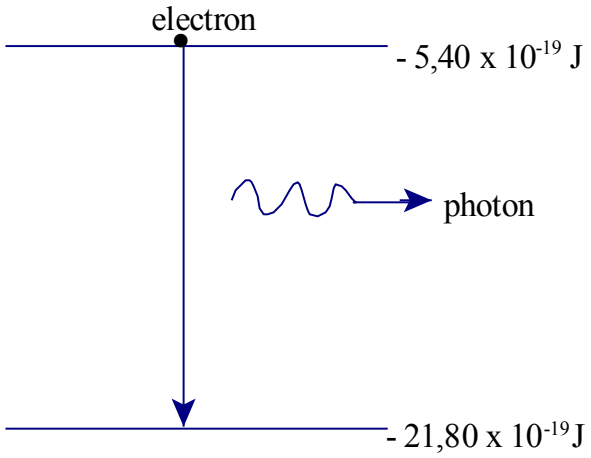
1.9 Using the circuit shown, and with the switch closed, a small current was passed through the coil X. The current was slowly increased using the variable resistor. The current reached a maximum value and was then switched off.



The maximum reading on the microammeter occurred when

A. the small current flowed at the start.
B. the current was being increased.
C. the current was being switched off.
D. the current in X was zero.

1.10 In an atom, a photon of radiation is emitted when an electron makes a transition from a higher energy level to a lower energy level as shown.



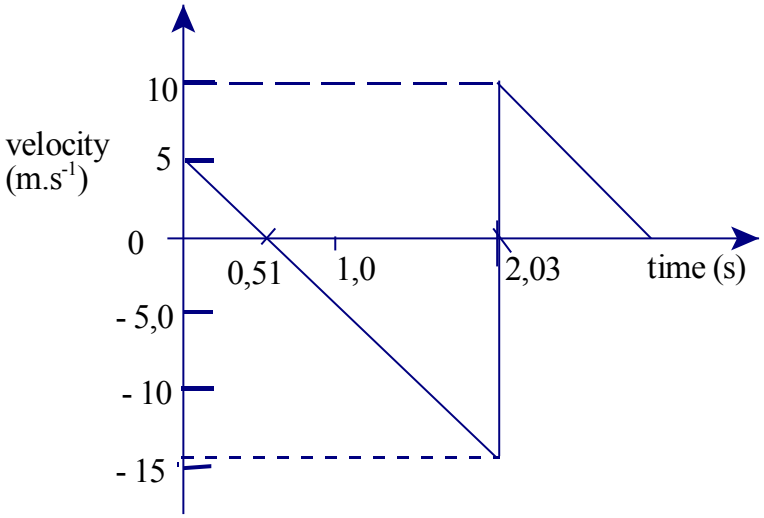
The wavelength of the radiation emitted due to an electron transition between the two energy levels shown is

A. $1,2 \times 10^{-7}$ m
B. $7,3 \times 10^{-8}$ m
C. $8,2 \times 10^{6}$ m
D. $1,4 \times 10^{7}$ m

[2 marks each = 20]

QUESTION 2

A ball bounces vertically on a hard surface after being thrown vertically up into the air by a boy standing on the edge of a building. Just before the ball hits the ground for the first time, it has a velocity of magnitude **14,89 m.s^{-1}**. Immediately after bouncing, it has a velocity of magnitude 10 m.s^{-1}.



The graph shows the velocity of the ball as a function of time, from the moment it is thrown upwards into the air until it reaches its maximum height after bouncing once.

2.1 Define *velocity*. (2)

2.2 At what velocity does the boy throw the ball into the air? (2)

2.3 What can be determined by calculating the gradient of the graph during the first 2,03 seconds? (2)

2.4 Determine the gradient of the graph during the first 2,03 seconds. State its units. (3)

2.5 How far below the boy's hand does the ball hit the ground? (5)

2.6 Use an equation of motion to calculate how long it takes from the time the ball was thrown, for it to reach its maximum height after bouncing. (5)

2.7 What is the position of the ball, measured from the boy's hand, when it reaches its maximum height after bouncing? (5)

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QUESTION 3

A car is travelling at 30 $m.s^{-1.}$ The driver, at a position P, suddenly sees a truck 60 m ahead which is moving at 10 $m.s^{-1}$ in the same direction. The driver of the car steps on the brakes immediately and the car decelerates at a uniform rate of 5 $m.s^{-2}$, then continues behind the truck at a constant velocity.

3.1 Define acceleration. (2)

3.2 How far does the car travel before reaching the same speed as the truck? (3)

3.3 How long does it take the car to cover this distance calculated in 3.1? (3)

3.4 How much further has the truck moved forward whilst the car is braking? (2)

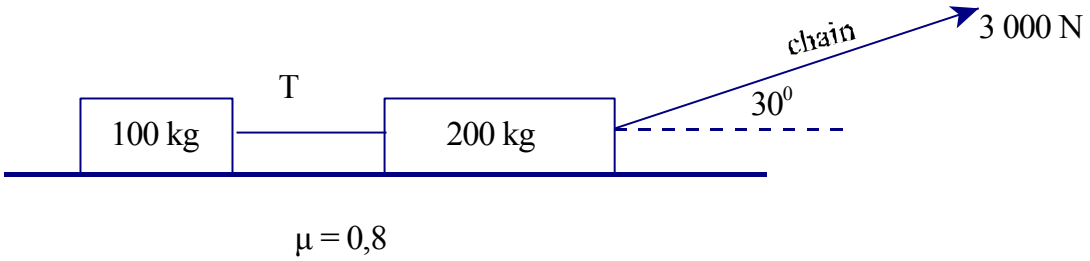
3.5 How far behind the truck will the car be when the driver slows the car to 10 $m.s^{-1}$? (4)

3.6 Using the grid provided, making use of the values you have calculated and any others you may need, on the same set of axes, draw a displacement/time graph for the motion of the car and the truck for the first 6 seconds after the car's brakes were applied at position P. (8)

[22]

QUESTION 4

A tractor pulls two tree trunks, of mass 100 kg and 200 kg respectively, along a horizontal road. The force in the chain is 3000 N and the chain forms an angle of 30^0 with the ground. The coefficient of friction between the logs and the road is 0,8



4.1 Write down Newton's second law of motion in words. (2)

4.2 Draw a labelled free-body diagram for

4.2.1 the 200 kg log. (4)

4.2.2 the 100 kg log. (4)

4.3 Calculate the frictional force between the road and the

4.3.1 100 kg log. (2)

4.3.2 200 kg log. (4)

4.4 Calculate

4.4.1 the acceleration of the logs; (5)

4.4 .2 the tension T in the chain between the logs. (3)

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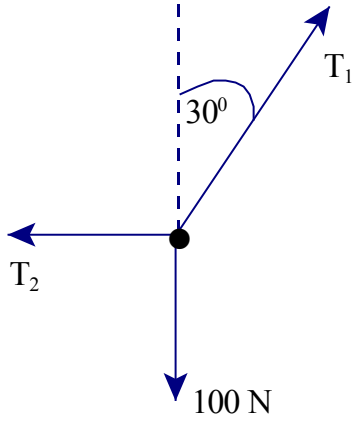
QUESTION 5

A weight of 100 N is maintained in equilibrium by means of two strings, as indicated in the sketch.



One string has a tension T_1 and it acts at an angle of 30^0 to the vertical.

The other string has a tension T_2 and it acts in a horizontal direction.

5.1 Calculate

5.1.1 the tension T_1 (3)

5.1.2 the tension T_2 (3)

5.2 The coefficient of friction between hard rubber and normal street pavement is 0,8.

What is the steepest incline (maximum angle) on which a car can be safely parked?

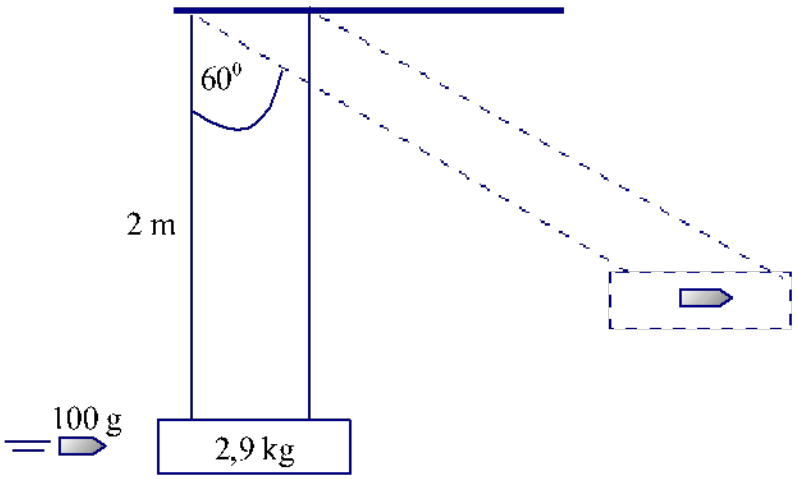
(6)

[12]

QUESTION 6

In order to find the velocity of a bullet, a ballistic pendulum can be used, whereby a bullet is fired into a block of wood on the end of light strings. The height through which the block rises is calculated, and hence the velocity of the bullet can be found.

A bullet of mass 100g is fired into a block of wood of mass 2,9 kg. The bullet-and-block rise so that at its highest point, the strings make an angle of 60^0 with the vertical. The strings are each 2 m long.



6.1 State the principle of conservation of mechanical energy. (2)

6.2 Using energy principles, calculate the velocity of the bullet-and-block immediately after the bullet enters the block. (5)

6.3 State the principle of conservation of momentum. (2)

6.4 Calculate the velocity of the bullet just before impact with the block. (4)

6.5 In the collision between the bullet and block, show that kinetic energy is not conserved. (4)

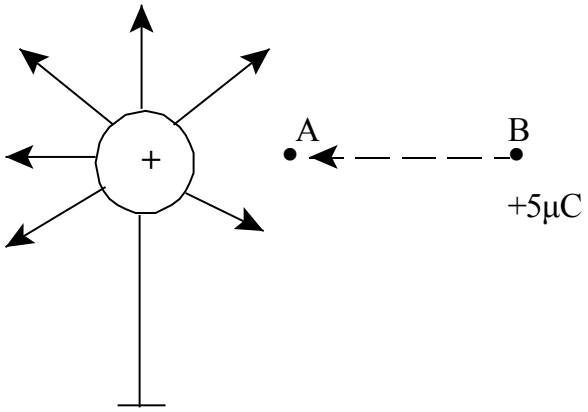
6.6 What type of collision is this? (1)

6.7 Account for the difference in kinetic energy. (2)

[20]

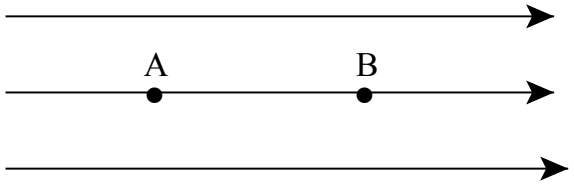
QUESTION 7

7.1 When moving a charge of +5μC from point B to point A in an electric field, as shown below, 0,05 J of work is done.



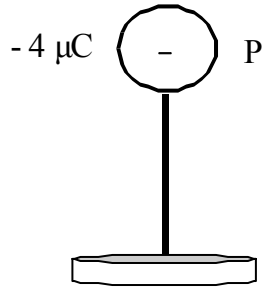
Calculate the potential difference between the points A and B . (3)

7.2 The diagram below shows two points A and B in a uniform electric field.



If the magnitude of the electric field strength at A is 1,8 x 10^5 $N.C^{-1}$, calculate the acceleration in magnitude and direction which an electron will undergo when released at A. (4)

7.3 The diagram below shows a small metal sphere **P** on an insulated stand. The sphere carries a charge of - 4 μC, as shown in the diagram.

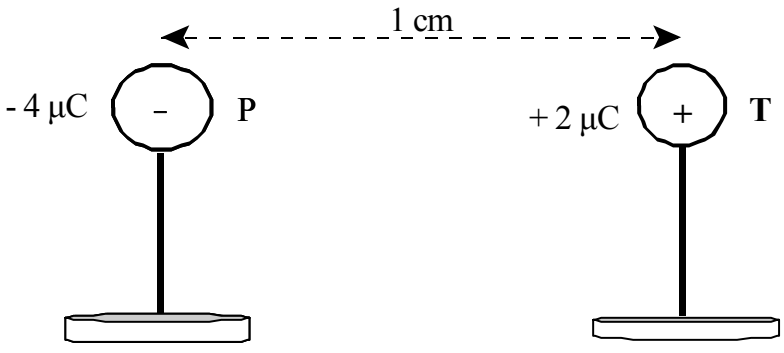


7.3.1 State Coulomb's law in words. (3)

7.3.2 Draw the electric field pattern around sphere **P**. Assume that no other charges affect this pattern. (2)

7.3.3 Calculate the number of electrons in excess on sphere **P**. (3)

A second metal sphere **T** carrying a charge of +2 μC is placed such that the centres are 1 cm apart, as shown in the diagram below.



7.3.4 The spheres are now brought into contact with each other and returned to their original positions.

Calculate the electrostatic force that sphere **P** exerts on sphere **T**. (4)

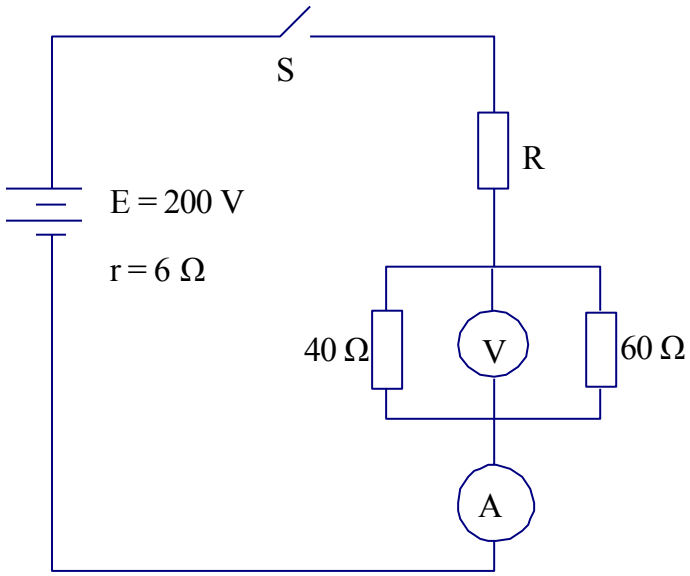
[19]

QUESTION 8

8.1 In the circuit below the voltmeter V has a very high resistance and the ammeter A has a very low resistance.

The emf of the power supply is 200 V and its internal resistance is 6 Ω.

The 40 Ω resistor gives off **18 000 J** of energy in **50s** when the switch S is closed.



8.1.1 State Ohm's law (2)

8.1.2 Calculate the reading on voltmeter V (4)

8.1.3 Calculate the current in the 60 Ω resistor. (3)

8.1.4 Calculate the reading on ammeter A (3)

8.1.5 Calculate the resistance of R. (5)

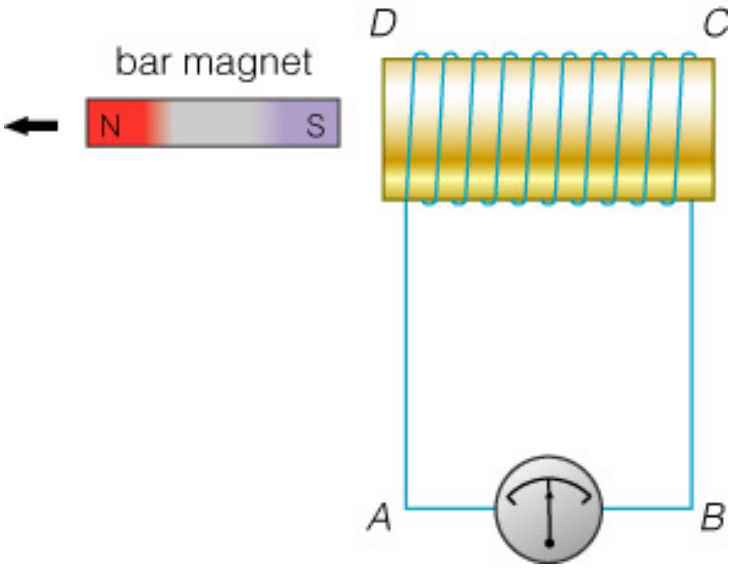
8.2 The 40 Ω resistor above is in fact a small electric heater. If electricity costs R1,60 per kWh, what does it cost to leave this heater switched on for 2 hours? (4)

8.3 If the 60 Ω resistor were to break, what would happen to the reading on ammeter A? Explain briefly. (3)

[24]

QUESTION 9 (Adapted from St Stithian's paper 1 2014)

The sketch below shows a permanent magnet being **pulled out** of a solenoid in the direction shown. The solenoid is connected to a sensitive galvanometer



9.1.1 State Lenz's Law. (2)

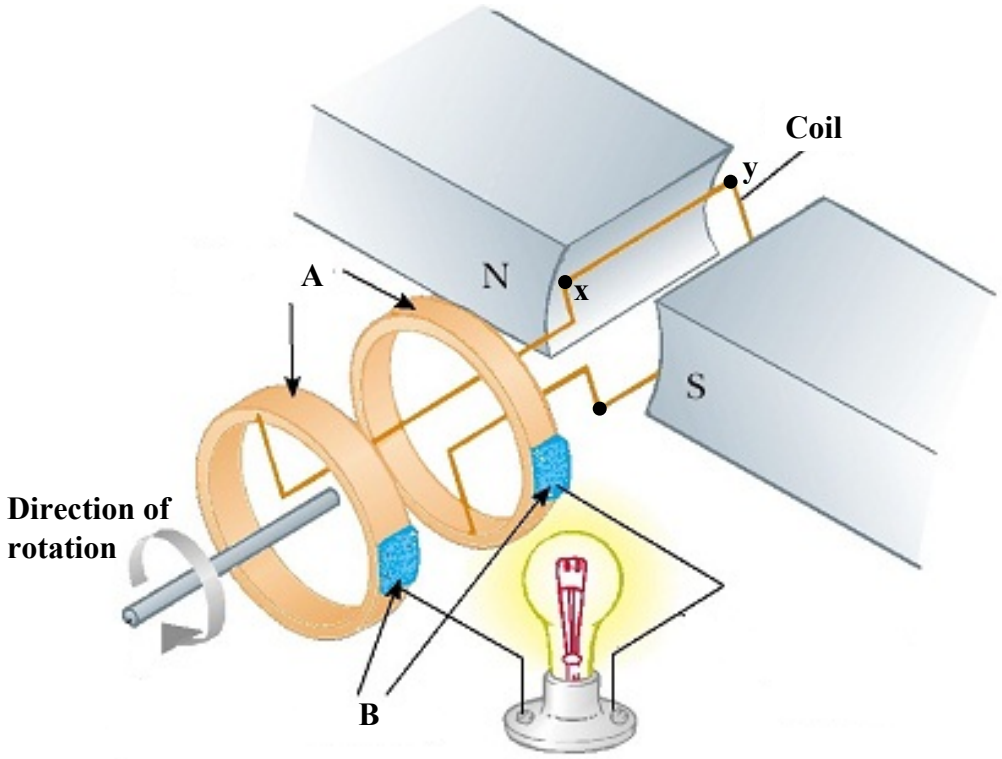
9.1.2 State the direction of the induced current through the galvanometer (A to B **or** B to A)? (1)

9.1.3 If the magnet is now pushed into the coil and then held stationary inside the coil, what would you observe on the galvanometer? (1)

9.1.4 If the magnet is pushed quickly into the coil, what would you observe on the galvanometer? . (1)

9.1.5 Briefly describe how you would produce an alternating current in the solenoid. (2)

9.2 Consider the diagram shown below of a simple AC generator.



9.2.1 Name the parts labelled **A.** (1)

9.2.2 Consider the position of the rotating coil in the above diagram. State the direction of the current in segment **xy** of the coil as it is rotated clockwise. (1)

9.2.3 State the <u>position</u> of the rotating coil when:

9.2.3.1 the current in the bulb is a maximum. (1)

9.2.3.2 the current in the bulb is zero. (1)

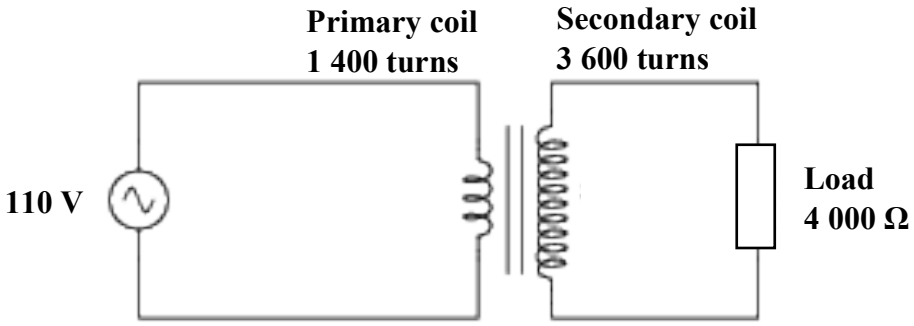
9.2.3.3 the current in the coil changes direction. (1)

9.2.4 If the coil spins at 4 500 rpm (revolutions per minute), what will be the frequency of the output voltage? (2)

9.2.5 What changes must be made to this AC generator to make it function as a DC motor? (1)

9.3

Consider the diagram below of a step-up transformer.



The diagram shows an AC input voltage of 110 V across the primary coil.
There are 1 400 turns in the primary coil and 3 600 turns in the secondary coil.

9.3.1 Can a transformer function properly using a DC battery as an input voltage? Give a brief reason for your answer. (2)

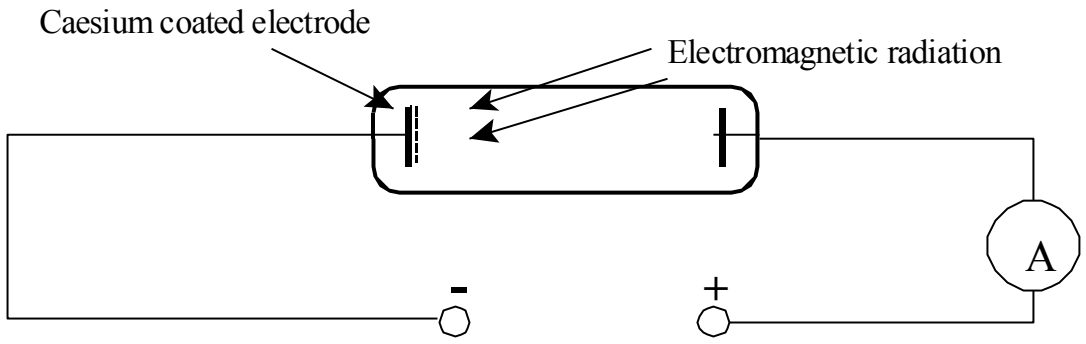
9.3.2 Calculate the current in the 4 000 Ω load resistor connected to the secondary coil. (3)

[20]

QUESTION 10

The apparatus below is used to investigate photoelectric emission from a caesium coated electrode when electromagnetic radiation shines on the surface.

The frequency of the electromagnetic radiation can be varied.



10.1.1 A text book states that "the work function of Caesium is 3,04 x 10^{-19} J".

Explain what is meant by this statement. (3)

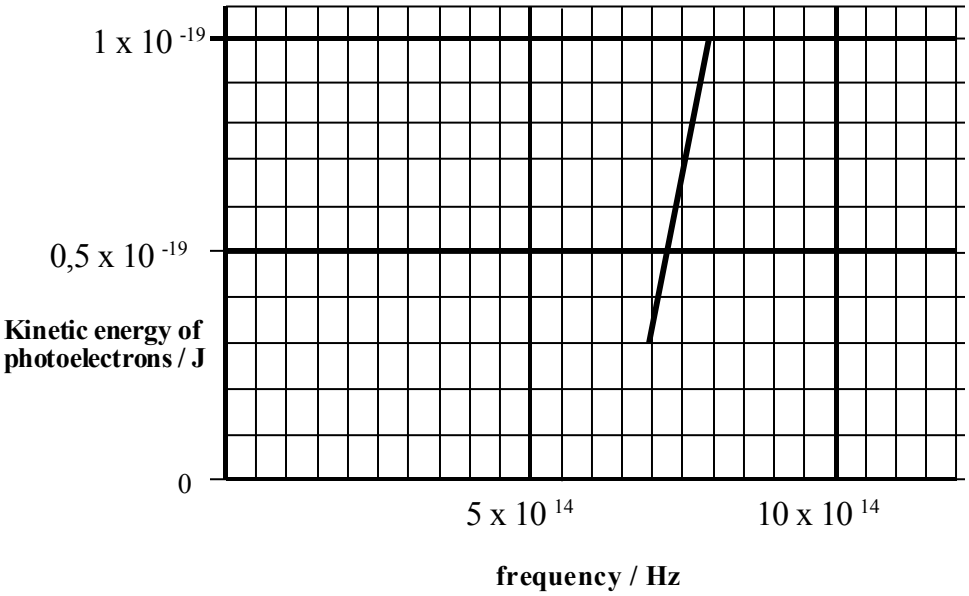
10.1.2 Why is there no reading on the ammeter when the frequency of the radiation is decreased below a particular value? (3)

10.1.3 Light of frequency 6,1 x 10^{14} Hz shines on the caesium coated electrode.

Calculate the maximum kinetic energy of a photoelectron leaving the caesium coated electrode. (4)

10.2 In another experiment with a different metal, X, the maximum kinetic energy of the photoelectrons emitted from the X electrode is measured for a number of different frequencies of the radiation.

The graph on the next page shows how this kinetic energy varies with frequency:



10.2.1 Use the graph to find the threshold frequency for metal X (3)

10.2.2 The table below gives the work function of different metals.

Metal	Work function (J)
Potassium	$3,2 \times 10^{-19}$
Calcium	$4,3 \times 10^{-19}$
Zinc	$6,9 \times 10^{-19}$
Gold	$7,8 \times 10^{-19}$

Which one of these metals was used in the investigation?
You must justify your answer using the information given in the table. (4)

[19]