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**TOTAL MARKS**

INTERNATIONAL SECONDARY CERTIFICATE EXAMINATION
MAY 2024

## PHYSICAL SCIENCES: PAPER I

**EXAMINATION NUMBER**

Time: 3 hours 200 marks

**PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY**

1. This question paper consists of 32 pages and a Data Sheet of 2 pages (i–ii). Please check that your question paper is complete.
2. **Answer ALL the questions on the question paper and hand it in at the end of the examination. Remember to write your examination number in the space provided above.**
3. Read the questions carefully.
4. Use the data and formulae whenever necessary.
5. Show your working in all calculations.
6. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
7. Answers must be expressed in decimal format, not left as proper fractions.
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.
10. TWO blank pages (pages 30 and 31) and graph paper (page 32) are included at the end of the paper. If you run out of space for a question, use these pages. Clearly indicate the question number of your answer should you use this extra space.

**FOR MARKER'S USE ONLY**

| **Question** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Marks** | 20 | 26 | 29 | 24 | 26 | 17 | 23 | 19 | 16 | **200** |
| **Marked** | | | | | | | | | | |
| **Moderated** | | | | | | | | | | |

## QUESTION 1

**Answer these questions on the multiple-choice answer grid below. Make a clear cross (X) in the box corresponding to the letter that you consider to be correct. Every question has only one correct answer.**

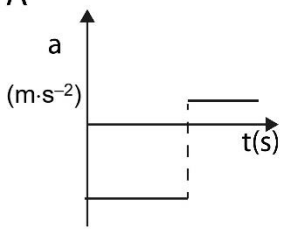
| A | B | C | D |
|---|---|---|---|

Here the option C has been marked as an example.

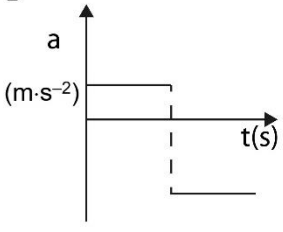
| | | | | |
|---|---|---|---|---|
| 1.1 | **A** | **B** | **C** | **D** |
| 1.2 | **A** | **B** | **C** | **D** |
| 1.3 | **A** | **B** | **C** | **D** |
| 1.4 | **A** | **B** | **C** | **D** |
| 1.5 | **A** | **B** | **C** | **D** |
| 1.6 | **A** | **B** | **C** | **D** |
| 1.7 | **A** | **B** | **C** | **D** |
| 1.8 | **A** | **B** | **C** | **D** |
| 1.9 | **A** | **B** | **C** | **D** |
| 1.10 | **A** | **B** | **C** | **D** |

1.1 Two friends are playing a game by dropping different objects straight down into a swimming pool from a three-metre-high diving board. Which graph correctly shows the acceleration of the objects from the time it leaves their hands to the time it reaches the deepest point under the water?

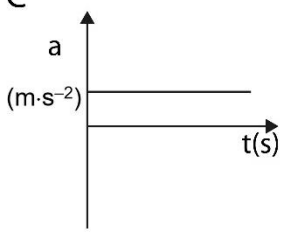
A



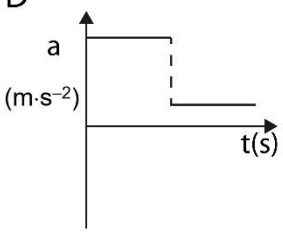

B




C




D




(2)

1.2 A man, mass ***m***, decides to climb Mt. Everest. The attractional force of the earth, mass ***M***, on the man before he starts the climb is ***F***. The distance between the midpoints of the earth and the man before he starts to climb is ***R***. When he reaches a distance ***r*** up the mountain, he had lost 3% of his mass. The force of the earth on him will now be:

A $\frac{\left(6{,}67\times10^{-11}\right)(3m)(M)}{(r+R)100}$

B $\frac{\left(6{,}67\times10^{-11}\right)(3m)(M)}{100(r+R)^2}$

C $\frac{\left(6{,}67\times10^{-11}\right)(97m)(M)}{(100r+R)^2}$

D $\frac{\left(6{,}67\times10^{-11}\right)(97m)(M)}{100(r+R)^2}$

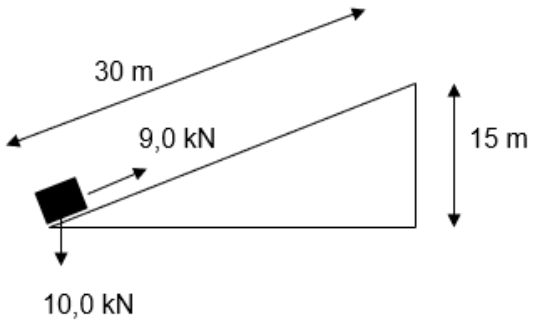
(2)

1.3 Two objects of equal mass travel towards each other on a frictionless air track at speeds of 6 m·s$^{-1}$ and 4 m·s$^{-1}$ respectively. They stick together on impact and continue to move together.


What is the velocity of the masses directly after the impact?

A 1 m·s$^{-1}$, right
B 1 m·s$^{-1}$, left
C 2 m·s$^{-1}$, left
D 5 m·s$^{-1}$, right (2)

1.4 A box needs to be moved 30 m up an incline. If it reaches the top, it would have gained a vertical height of 15 m. To be able to do this, a force of 9,0 kN is needed as the box has a weight of 10,0 kN. If the box is moved at a constant speed, how much work needs to be done to overcome friction?

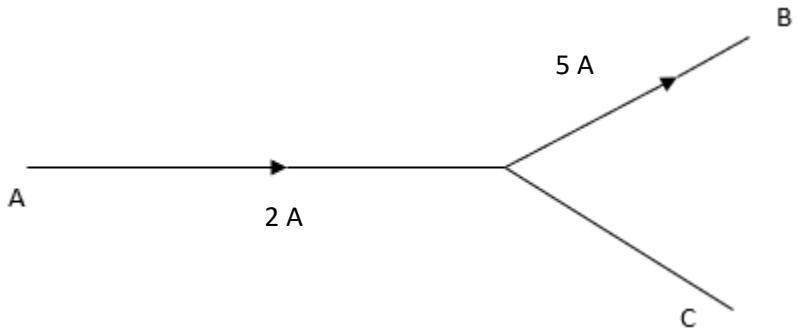



A 120 kJ B 240 kJ

C 360 kJ D 600 kJ (2)

1.5 The diagram shows a point in a circuit where three wires A, B and C meet. The currents in A and B are 2 A and 5 A respectively and flow in the directions as shown.




How much charge pass a given point in wire C in 5 seconds?

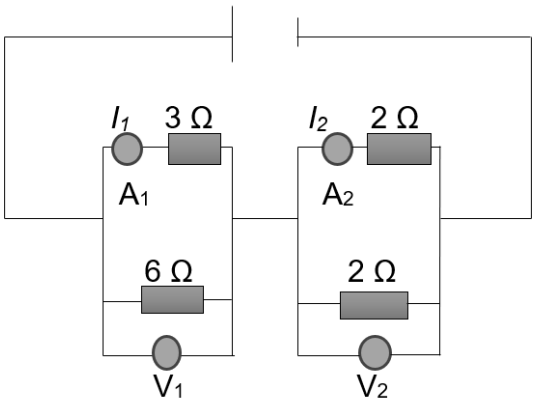
A 0,6 C

B 10 C

C 15 C

D 25 C (2)

1.6 In the circuit shown below, the ammeters $A_1$ and $A_2$ have negligible resistance and the voltmeters have infinite resistance.




If $A_1$, $A_2$, $V_1$ and $V_2$ show readings when connected as shown on the diagram, which one of the following will be correct?

A $I_1 > I_2$ and $V_1 < V_2$

B $I_1 < I_2$ and $V_1 > V_2$

C $I_1 > I_2$ and $V_1 > V_2$

D $I_1 < I_2$ and $V_1 < V_2$ (2)

1.7 The potential difference between point A and point B is 12 V. The time taken for charge carriers to move from A to B is 15 s. In this time, the energy of the charge carriers changes by 120 J. What is the current flowing between A and B?

A 0,67 A

B 1,5 A

C 96 A

D 150 A (2)

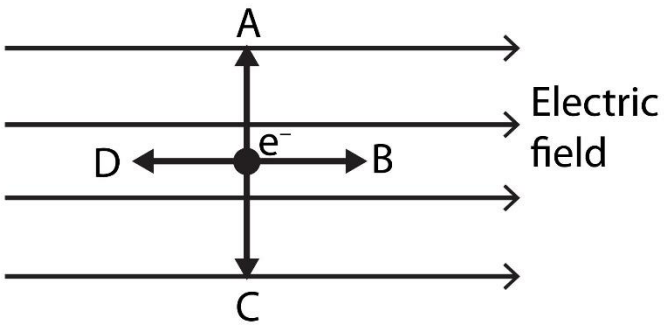
1.8 The North pole of a magnet is slowly lowered towards a metal ring lying on a wooden table. The direction of the induced magnetic field, the direction of the induced current in the ring, and the reason for this direction is given in the table below.

Which one of the options in the table is the correct combination?

| | **Induced magnetic field direction** | **Direction of induced current** | **Reason** |
|---|---|---|---|
| A | Upwards through ring | Clockwise | Wants to decrease magnetic field of magnet |
| B | Downwards through ring | Clockwise | Wants to increase magnetic field of magnet |
| C | Upwards through ring | Anticlockwise | Wants to decrease magnetic field of magnet |
| D | Downwards through ring | Anticlockwise | Wants to increase magnetic field of magnet |

(2)

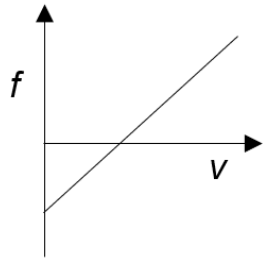
1.9 The diagram below shows an **electron** in an electric field. The direction of the electric field is indicated in the diagram. In which direction will the electron accelerate?



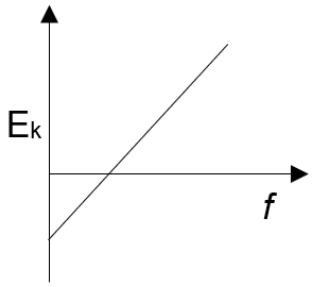

(2)

1.10 Light with different frequencies, ***f***, is shone onto a metal. Electrons moved away from the metal with a velocity ***v*** for some of the frequencies light. Graphs were drawn, using this information, for these different frequencies of light used. Which graph shows the correct relationship?

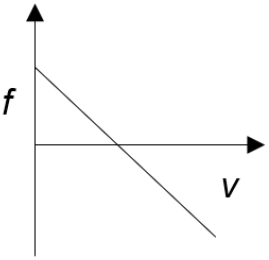
A



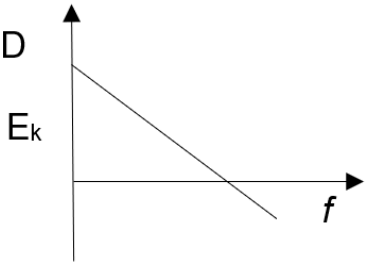

B




C



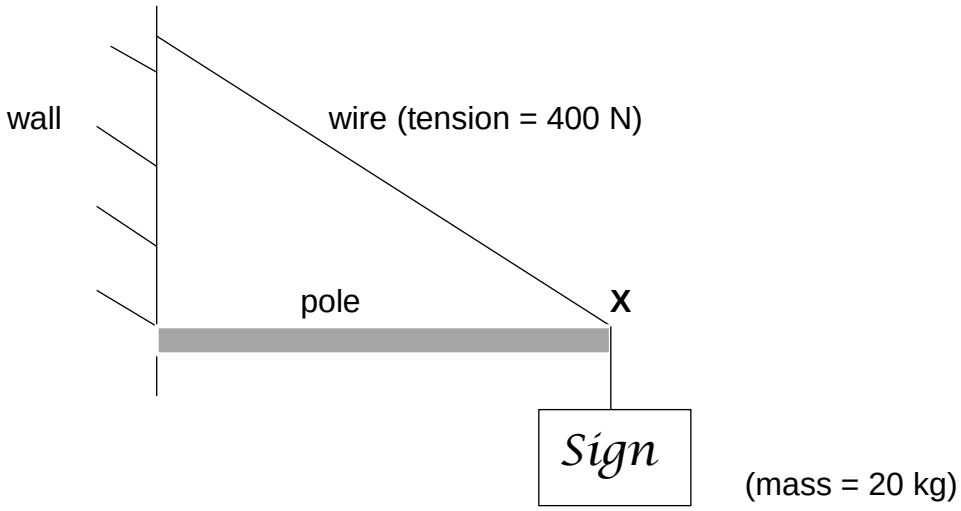

D




(2)
**[20]**

## QUESTION 2

2.1 The diagram shows a sign with a mass of 20 kg suspended from a pole, attached horizontally to a wall. The pole is kept in equilibrium by a wire attached at point **X** of the pole. The tension in the wire is 400 N.




2.1.1 Calculate the weight of the sign.

(2)

2.1.2 Draw a labelled free-body diagram of all the forces acting on point **X**.

(3)

2.1.3 Calculate the magnitude of the force exerted on point **X** by the **pole**, by making use of a vector diagram.

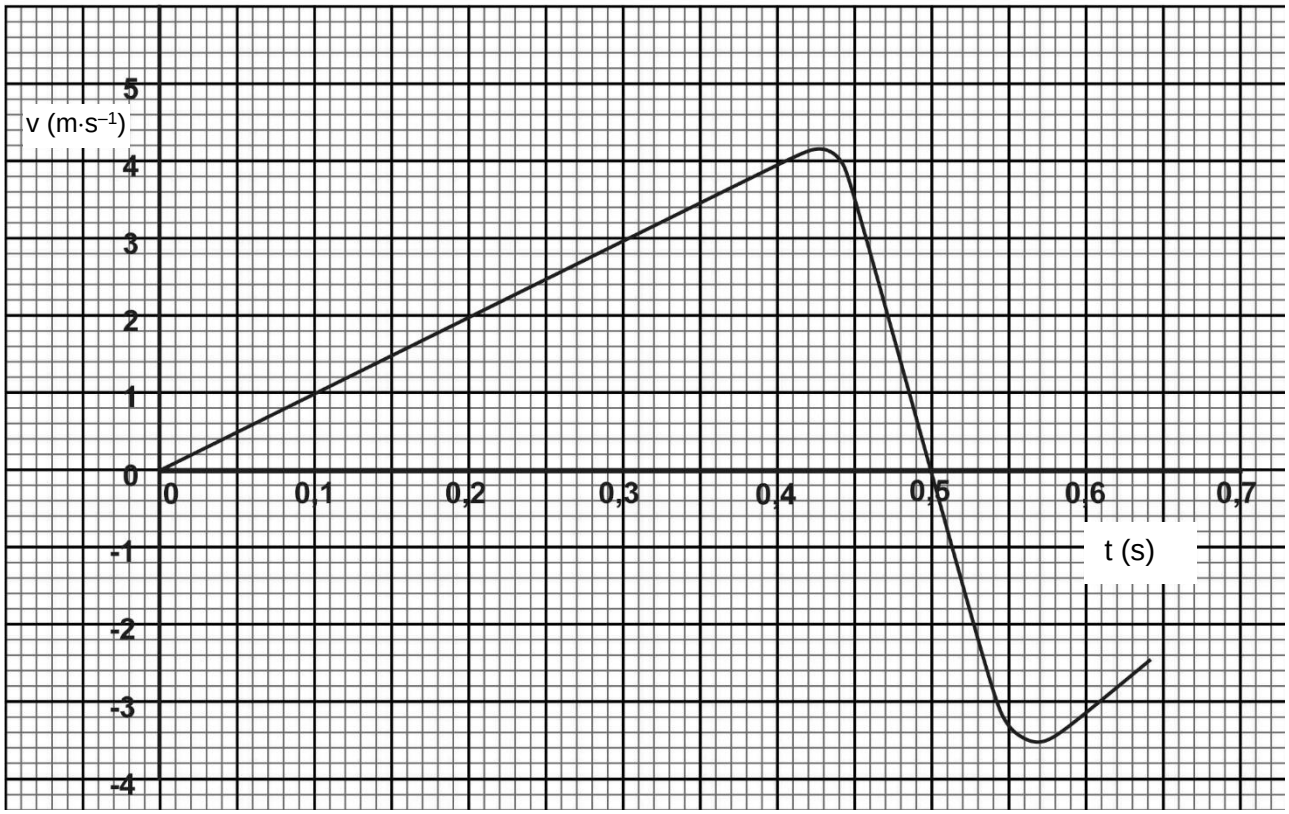
(3)

2.1.4 Calculate the angle between the wall and the wire.

(2)

2.2 A ball, mass 165 g, falls from rest onto a flat horizontal surface. The graph shows the variation of the velocity *v* with time *t* of the ball as it approaches and rebounds from the surface.




[Source: <https://dynamicpapers.com/wp-content/uploads/2015/09/9702_w02_qp_2.pdf>]

2.2.1 Give Newton's second law of motion in terms of momentum.

(2)

2.2.2 Explain whether the collision is elastic or inelastic.

(2)

Calculate:

2.2.3 The distance travelled by the ball during the first 0,40 s.

(3)

2.2.4 The change in momentum of the ball, during contact with the surface.

(4)

2.2.5 The average force acting on the ball during contact with the surface.

(3)

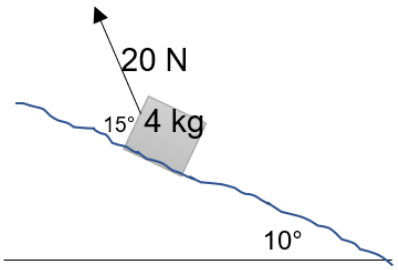
 

2.2.6 Draw a sketch graph of acceleration against time for the 0,6 s on the given set of axes.


(2)
**[26]**

## QUESTION 3

3.1 A force of 20 N is applied to an object with mass 4 kg, pulling it up a rough incline. The **incline** makes an angle of 10° with the horizontal. The **force** makes an angle of 15° with the plane of the incline surface.




3.1.1 Show all forces acting perpendicular to the surface of the object, making use of a labelled free-body diagram.

(3)

3.1.2 Calculate the magnitude of the normal force acting on the object.

(6)

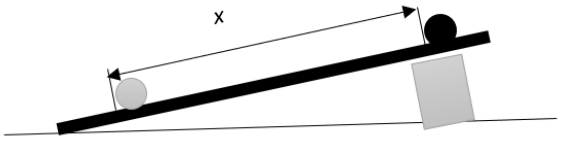
3.1.3 If the object moves at constant velocity, calculate the magnitude of the frictional force acting on the object.

(4)

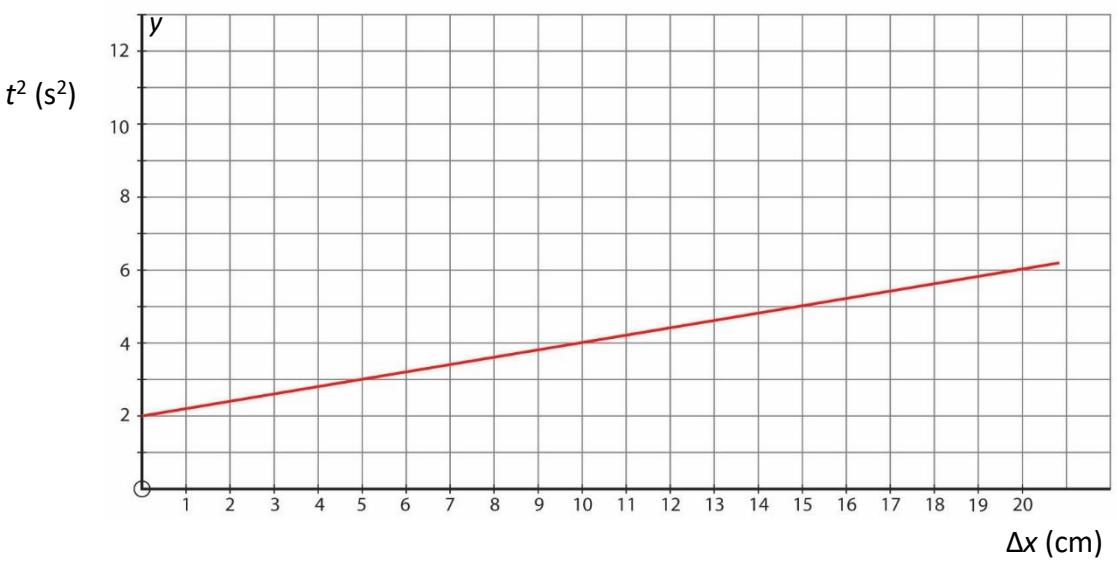
3.1.4 Calculate the coefficient of kinetic friction.

(2)

3.2 A student has been asked to determine the linear acceleration of a ball as it moves down a slope. The apparatus is set up as shown.




The time $t$ to move from rest through a distance $x$ is found for different values of $x$. A graph of $t^2$ is plotted against $\Delta x$ as shown.




3.2.1 Give an equation of motion linking displacement $\Delta x$ and $t^2$.

(1)

3.2.2 Determine the gradient of the line on the graph.

(4)

3.2.3 Hence by using $y = mx + c$ and the gradient, calculate the acceleration of the ball in $m \cdot s^{-2}$. Explain your working.

(4)

3.2.4 (a) Give two variables that should be kept constant during the experiment.

_____

(2)

(b) Give the independent variable.

_____

(1)

3.2.5 Systematic errors (something you keep doing wrong each time without realising it) caused the graph to pass through the y-axis and not the (0;0) point. Give two possible actions you might have done wrong, which could have contributed to the systematic error.

_____

_____

_____

_____

(2)
**[29]**

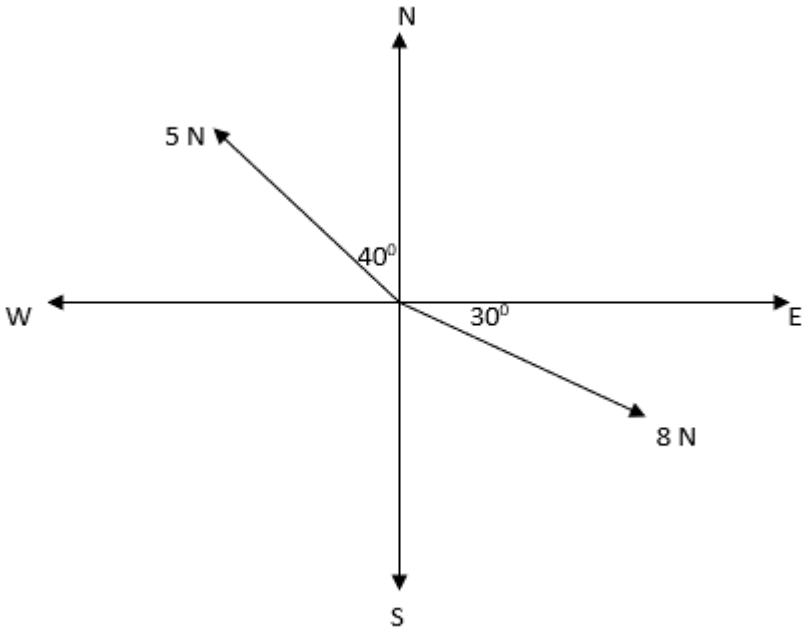
 

## QUESTION 4

4.1 Define a *resultant vector*.

(2)

4.2 Two vectors, 8 N and 5 N, act on the same point in the directions as shown in the sketch.




4.2.1 Write the direction of the 8 N vector as a navigational direction from the North.

(1)

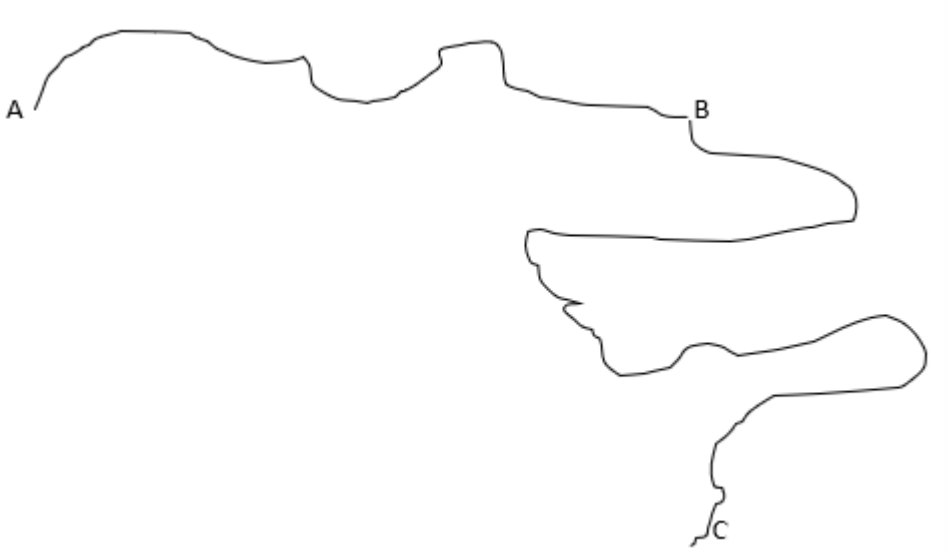
4.2.2 Calculate the resultant vector of these two vectors.

(8)

4.3 Define the *distance covered*.

(2)

4.4 Peter walked through a forest from point A to point B, which is directly east from A. He covered 1,2 km in 20 minutes and then he rested for a while at point B. He then decided to run and ended up at point C, which is 3 km away from B. Point C is directly south of B. The total time for his movement from A to C was 1 hour 30 minutes.




4.4.1 Calculate his speed from A to B.

(3)

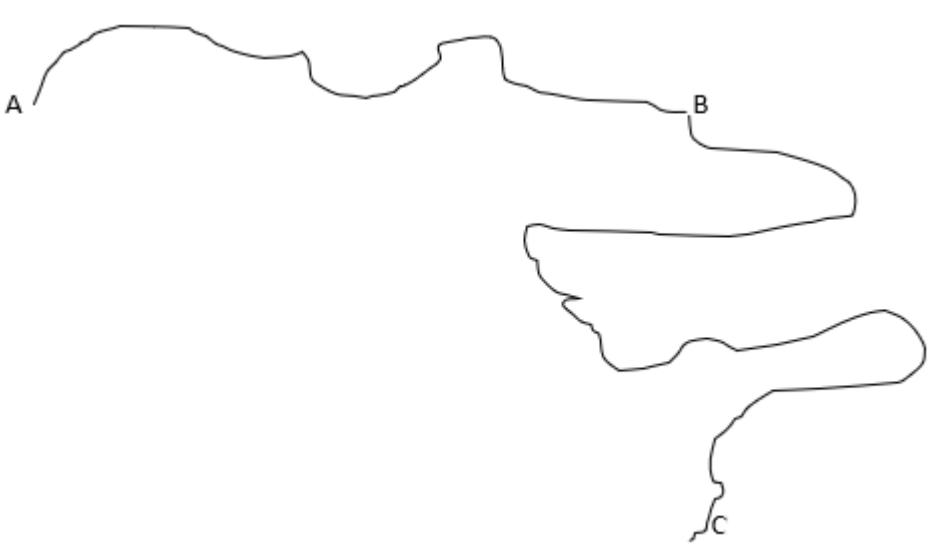
4.4.2 Calculate his speed from B to C.

(2)

4.4.3 Calculate his average speed from A to C.

(2)

4.4.4 Draw his displacement in on the sketch below.



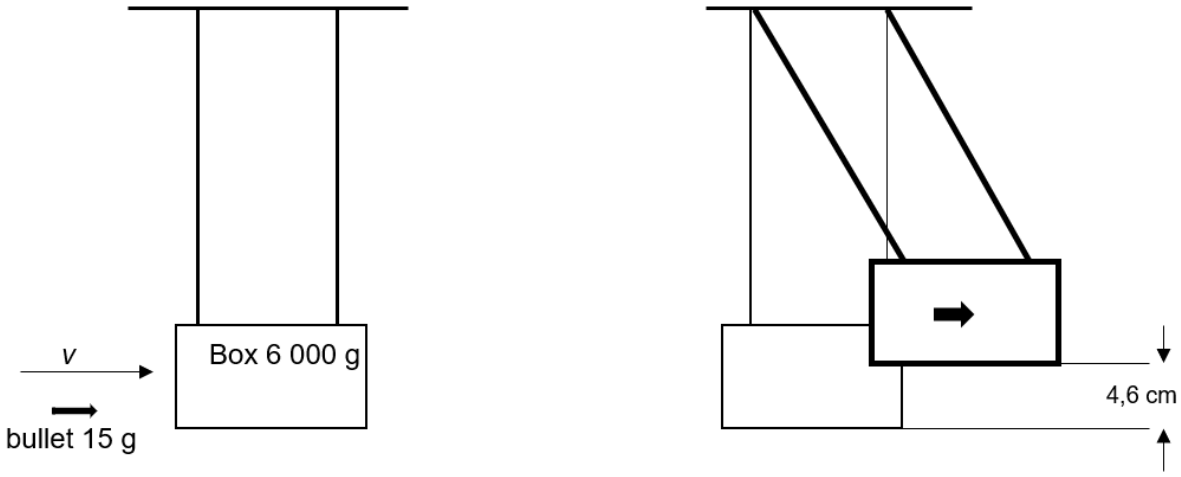

(1)

4.4.5 If his velocity from A to C is 2,2 $km.h^{-1}$, calculate the magnitude of his displacement in meters.

(3)
**[24]**

## QUESTION 5

5.1 An experiment is carried out to determine the speed of a bullet. The bullet, of mass 15 g and speed ***v***, is fired horizontally at a box of sand of mass 6 000 g, suspended by strings as shown.




The bullet becomes embedded in the sand in the box and causes the box to rise to a maximum height of 4,6 cm, as shown.

5.1.1 Give the definition for the *conservation of mechanical energy* in words.

_____

_____

(2)

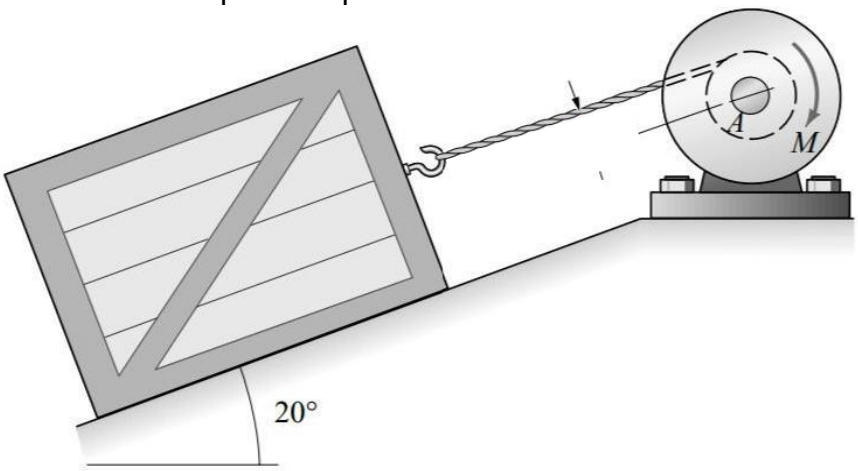
5.1.2 Use the principle of conservation of mechanical energy to show that the initial speed of the box, immediately after the bullet has become embedded, is 0,95 $m \cdot s^{-1}$.

(3)

5.1.3 Calculate the initial speed of the bullet.

(3)

5.2 A winch pulls a crate of mass 40 kg from rest up a slope, inclined at 20° to the horizontal, by applying a constant force of 400 N. A frictional force of 20 N acts on the crate as it moves up the slope for 6 m.




[Source: <db62a7fe0d044811be38bee45e304f7d.jpeg>]

5.2.1 Give the work-energy theorem in words.

(2)

5.2.2 Draw a labelled free-body diagram of all the forces acting on the crate during its motion.

(4)

5.2.3 Use the work-energy principle and calculate the speed of the crate after it has moved 6 m up the slope.

(4)

5.2.4 Calculate the power needed for the winch to pull the crate 6 m up the incline.

(4)

5.2.5 If the winch is a 2 000 W mechanical winch, calculate the efficiency of the winch.

(2)

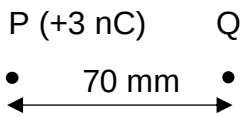
5.2.6 The cable connecting the crate to the winch snaps and the crate slides down the incline at a constant speed. Write down the net work done on the crate. Give a reason for your answer.

(2)
**[26]**

## QUESTION 6

Two point charges P and Q, with a distance of 70 mm between them, carry charges of +3 nC and –2 nC respectively.




6.1 When you look at a representation of an electric field pattern, how can you tell where the electric field strength is the strongest?

(2)

6.2 Calculate the magnitude of the electrostatic force between the two spheres.

(4)

6.3 Point R lies 50 mm to the right of sphere Q. Calculate the net electric field strength experienced at point R.

(8)

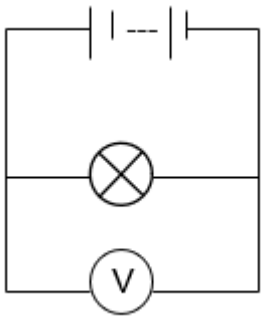
6.4 A point charge of –4 nC is now placed at point R. Calculate the magnitude of the electrostatic force that the charge will experience due to the electric field generated by spheres P and Q.

(3)
**[17]**

## QUESTION 7

A 12,0 V car battery is to be used to power some lamps. A voltmeter reads 12 V when connected across the battery. A lamp is connected with the battery. The voltmeter now reads 11,7 V.




7.1 Explain the change which occurs in the voltmeter reading when the lamp is connected.

(3)

7.2 The current flowing through the lamp is measured and found to be 1,5 A.

7.2.1 Show that the resistance of the lamp is 7,8 Ω.

(2)

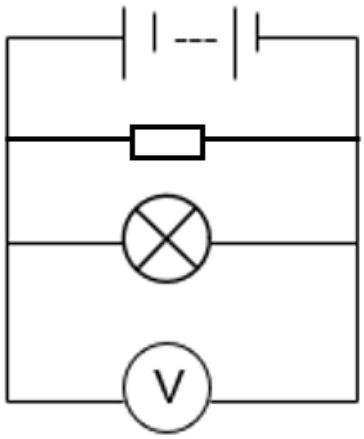
7.2.2 Calculate the internal resistance of the battery.

(3)

7.2.3 Calculate the cost of keeping the lamp on for 3 hours if the cost is R1,50 per kWh.

(4)

7.3 A second resistor, with a resistance of 15,6 Ω, is connected in parallel to the first lamp.




Calculate:

7.3.1 The total current in the battery.

(5)

7.3.2 The amount of charge that moved through the 15,6 Ω resistor in 30 min.

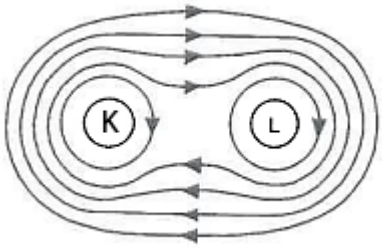
(4)

7.3.3 The potential difference over the external resistors.

(2)
**[23]**

## QUESTION 8

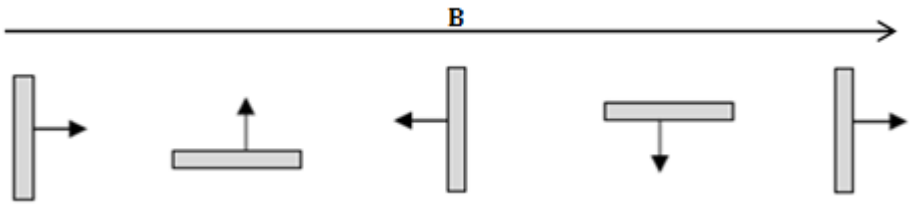
8.1 Two parallel conductors, K and L, carrying currents are shown below:




Explain, by referring to the sketch, whether the conductors will attract each other or repel each other.

(3)

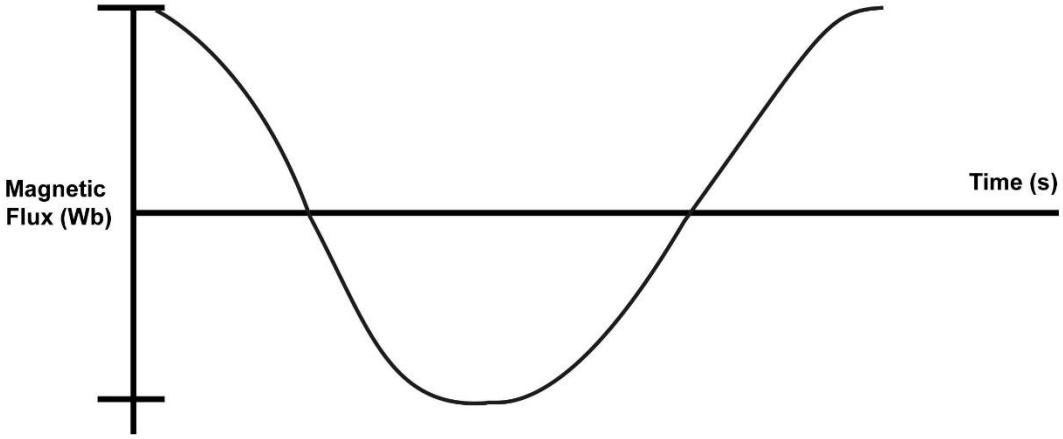
8.2 The following diagram represents a coil that is rotating anticlockwise in a magnetic field B, as shown. (The arrows represent the normal to the coil.)




8.2.1 Define *magnetic flux linkage*.

(2)

8.2.2 The following graph represents the magnetic flux vs time for the diagram above:




(a) Does the shape of the graph correctly correspond with the positions of the coil as it is turning?

(1)

(b) Explain your answer by referring to the graph above and the meaning of the formula $\Phi = BA\cos\theta$. Also mention the positions of the maximum and minimum points.

(6)

8.2.3 On the same axis as the graph given in 8.2.2, draw a graph to show the corresponding emf vs time for the **given graph**.

(5)

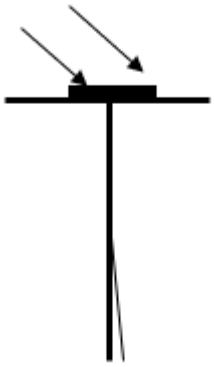
8.3 State Faraday's law of electromagnetic induction.

(2)
**[19]**

## QUESTION 9

9.1 A piece of metal is placed on top of a neutral electroscope. A red light is used to shine onto the metal but there is no change in the electroscope. Then the red light is intensified.



9.1.1 Why is the electroscope used and the metal not just placed on the table?

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(1)

9.1.2 Explain what will happen if the red light is intensified.

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(2)

A blue light is now used to shine onto the piece of metal on the electroscope. The gold foil lifts.

9.1.3 Explain why, and how it is possible, for the gold foil to lift.

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(4)

9.1.4 If the wavelength of the blue light is 460 nm, calculate the energy transferred to the electrons.

(3)

9.1.5 If the work function of the metal is $4{,}26 \times 10^{-19}$ J, calculate the threshold frequency of the metal.

(2)

9.1.6 Calculate the speed with which the electrons are emitted.

(4)
**[16]**

**Total: 200 marks**

 

**ADDITIONAL SPACE (ALL QUESTIONS)**

**REMEMBER TO CLEARLY INDICATE AT THE QUESTION THAT YOU USED THE ADDITIONAL SPACE TO ENSURE THAT ALL ANSWERS ARE MARKED.**