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Brescia House School

Physical Science Paper I Grade 12 12 July 2024

Time: 3 hours

Total: 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of 30 pages and a **data sheet** of two pages. Ensure that your paper is complete.
2. Read the questions carefully.
3. Answer ALL the questions on the question paper and hand it in at the end of the examination.
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. One blank page is included at the end of the paper. If you run out of space for an answer, use these pages. Clearly indicate the number of your answer should you use this extra space. PLEASE ASK FOR PAPER IF YOU NEED MORE.
11. You will be provided with 1 sheet of paper for rough work only.

Examiners: Mrs. K Trenor

Moderator: Mrs. A Bruns

External Moderator: Mrs. S Crossman

NAME: _____

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	TOTAL
Question	20	20	15	17	13	30	22	24	24	15	200
Moderated											

QUESTION 1:

Answer these questions on the multiple-choice grid.

Make a cross (X) in the box corresponding to the letter that you consider to be correct.

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

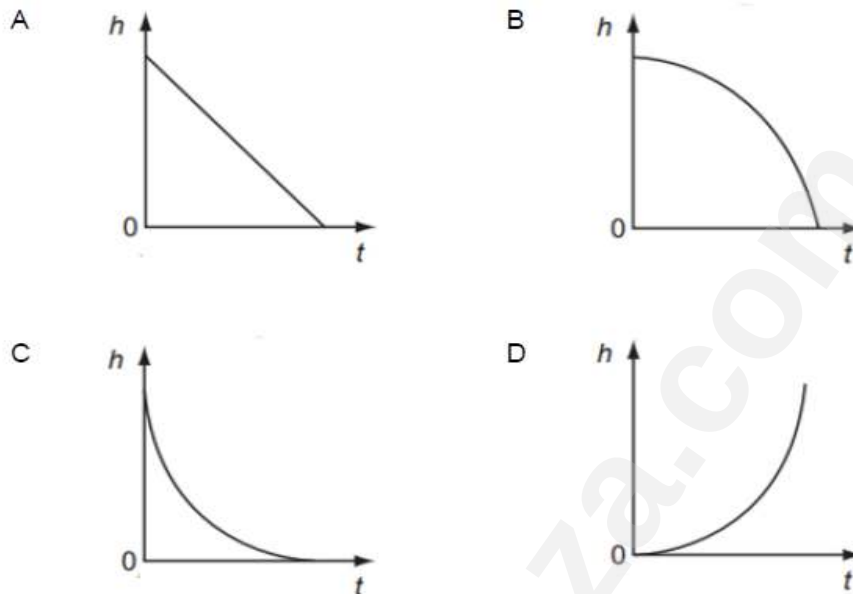
1.1. Two forces of 6 N and 10 N respectively, act simultaneously on an object.

Which of these magnitudes is **not** a possible resultant force of this combination of forces? (2)

- A. 4 N
- B. 9 N
- C. 16 N
- D. 18 N

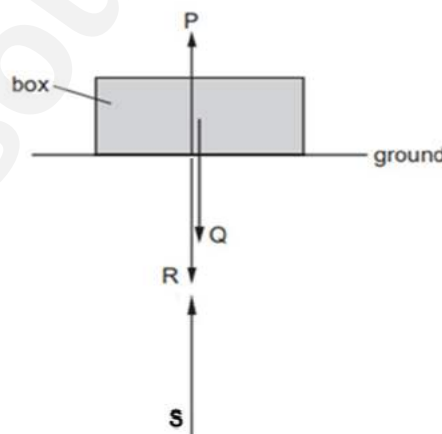
1.2. A small steel ball falls freely under gravity after being released from rest.

Which graph best represents the variation of the height h of the ball with time t when using the ground as reference? (2)



1.3. A box is shown resting on the ground. Newton's Third Law implies that four forces of equal magnitude are involved. These forces are labelled **P**, **Q**, **R** and **S**. Forces **P** and **Q** act on the box. Forces **R** and **S** act on the Earth.

For clarity, the forces are shown as slightly separated.

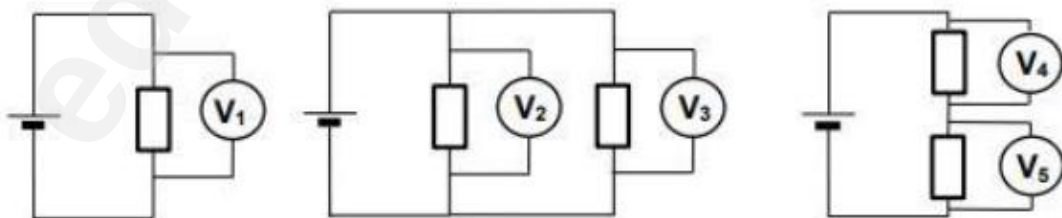


Which statement about the forces is correct? (2)

A	Force P is equal and opposite to force Q and both are forces of contact.
B	Force Q is equal and opposite to force P and both are gravitational forces.
C	Force S is equal and opposite to force Q and both are gravitational forces.
D	Force R is equal and opposite to force S and both are forces of contact.

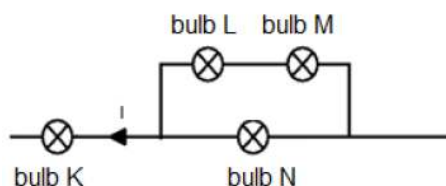
- 1.4. A heavy ball of mass $6m$ is travelling along a straight horizontal surface at a speed v . It collides with a stationary light ball of mass m . The surface on which they collide is frictionless. The heavy ball continues at half its original speed after the collision. The speed of the light ball after the collision will be equal to: (2)
- A. $2v$
 B. $4v$
 C. $3v$
 D. $6v$
- 1.5. Linear momentum is defined as the product of the mass and velocity of the object ($p = mv$). This consists of: (2)
- A. one vector quantity and two scalar quantities.
 B. two vector quantities and one scalar quantity.
 C. three vector quantities.
 D. three scalar quantities.
- 1.6. Two charged particles, **X** and **Y** exert repulsive forces on each other. The charge on **X** is $+4q$ while the charge on **Y** is $+q$. The magnitude of the force on particle **Y** is (2)
- A. four times as big as the force on **X**.
 B. twice as big as the force on **X**.
 C. the same size as the force on **X**.
 D. one quarter as big as the force on **X**.
- 1.7. Three circuits with identical resistors are shown below. The cells connected to the circuits are identical and the internal resistance of these cells can be ignored.

Rank the readings on the five voltmeters from largest to smallest. (2)



- 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. $V_1 > V_2 = V_3 > V_4 = V_5$

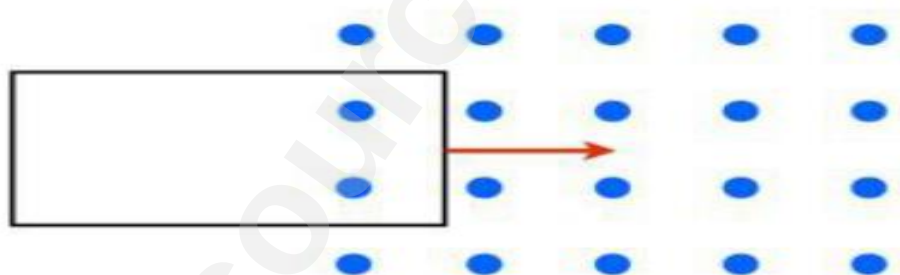
- 1.8. Four identical bulbs, K, L, M and N, with the same resistance, R , are connected in a circuit as shown below. A current, I , flows through bulb, K.



If the power in bulb K is equal to P , which combination of expressions regarding the power in the bulbs L and N is correct? (2)

	Power in bulb L	Power in bulb N
A	$\frac{4}{9} P$	$\frac{1}{9} P$
B	$2 P$	$\frac{1}{2} P$
C	$\frac{1}{2} P$	P
D	$\frac{1}{9} P$	$\frac{4}{9} P$

- 1.9. A rectangular loop of wire moves at constant velocity into a uniform magnetic field, which is directed out of the page, as shown by the dots in the diagram.

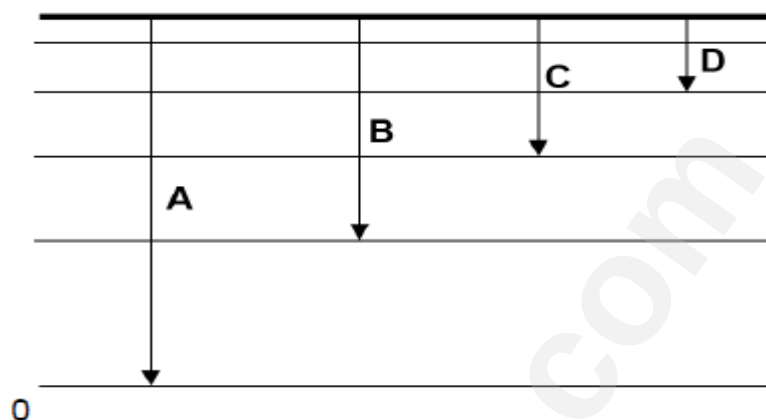


As the loop continues to move into the magnetic field to its mid-point, which one of the following gives the direction and magnitude of the current induced in the loop? (2)

	Direction	Magnitude
A	clockwise	increasing
B	anticlockwise	increasing
C	clockwise	decreasing
D	anticlockwise	decreasing

1.10. Four electron transitions in an atom of an unknown gas are shown on the energy level diagram below. *The diagram is not drawn to scale.*

The diagram below shows these four transitions on the emission spectrum for this gas.



Which of the four electron transitions shown above (A, B, C or D) corresponds to the emission line at 410 nm? (2)

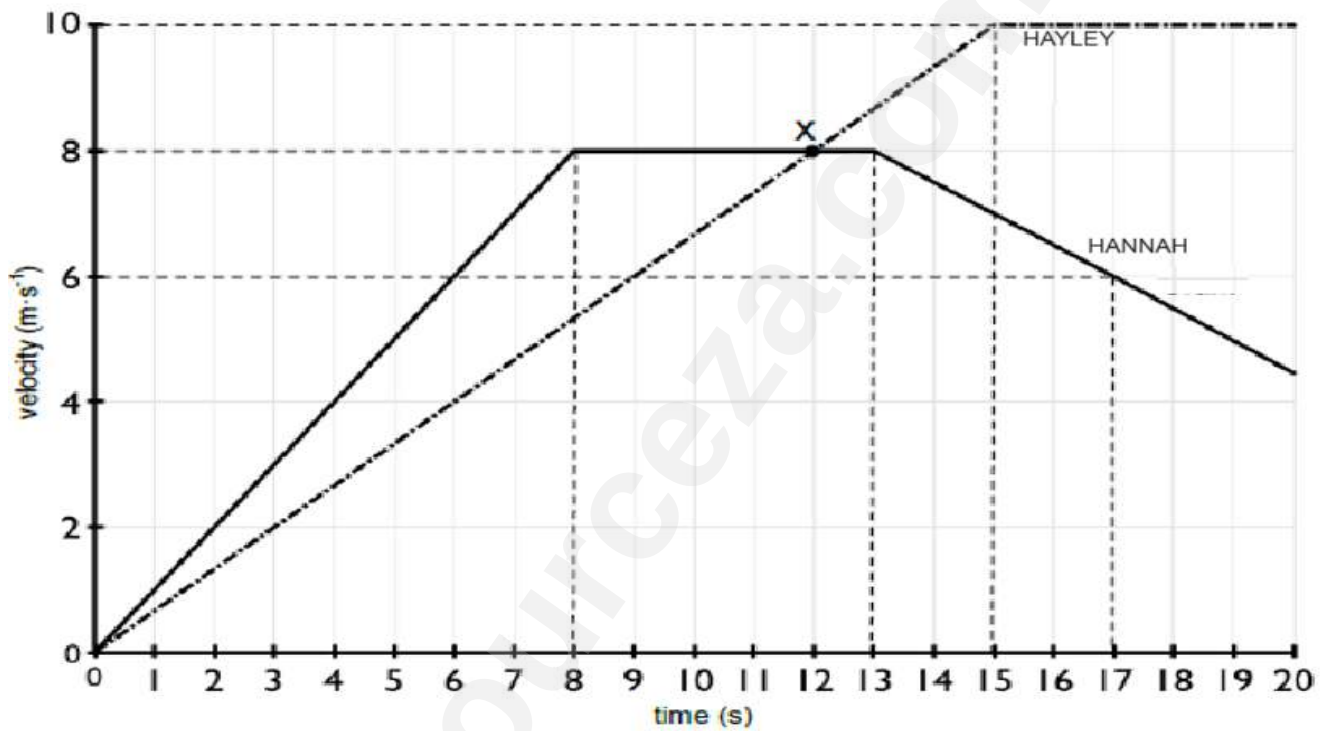


[20 marks]

QUESTION 2:

2.1. Two athletes, Hayley and Hannah, challenge each other to a race over 100 m.

The velocity-time graph for the race is shown.



2.1.1. Define *acceleration*.

(2)

2.1.2. Determine the magnitude of Hannah's acceleration during the first 8 s of the race.

(2)

2.1.3. Describe Hannah's motion between 8 s and 13 s. (2)

2.1.4. Determine how far Hannah ran in 17 s. (4)

2.1.5. The two graphs intersect at point X. What can you conclude about the athlete's motion at that point? (2)

2.1.6. Determine who won the race. (4)

2.2. A small boy is confidently crossing the road on his bike at a speed of 2 m.s^{-1} .

- The road is 6 m wide.
- A car is travelling towards him at 108 km.h^{-1} (30 m.s^{-1}).
- The car is 100 m away when the driver sees the boy.
- The driver takes 1,5 s before reacting and slamming on the brakes.
- The car slows down at a rate of $8,8 \text{ m.s}^{-2}$.

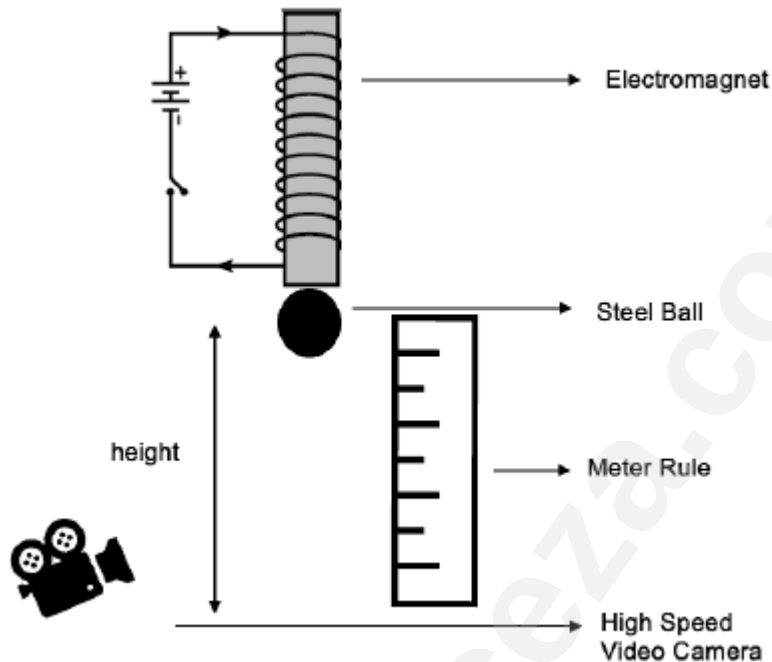


Will the small boy cross the road safely? Justify your answer by showing the calculations. (4)

[20 marks]

QUESTION 3:

A student investigates a steel ball in free fall. The steel ball is released from rest, from an electromagnet and its displacement and time are measured using a high frame rate video camera as indicated in the diagram below.

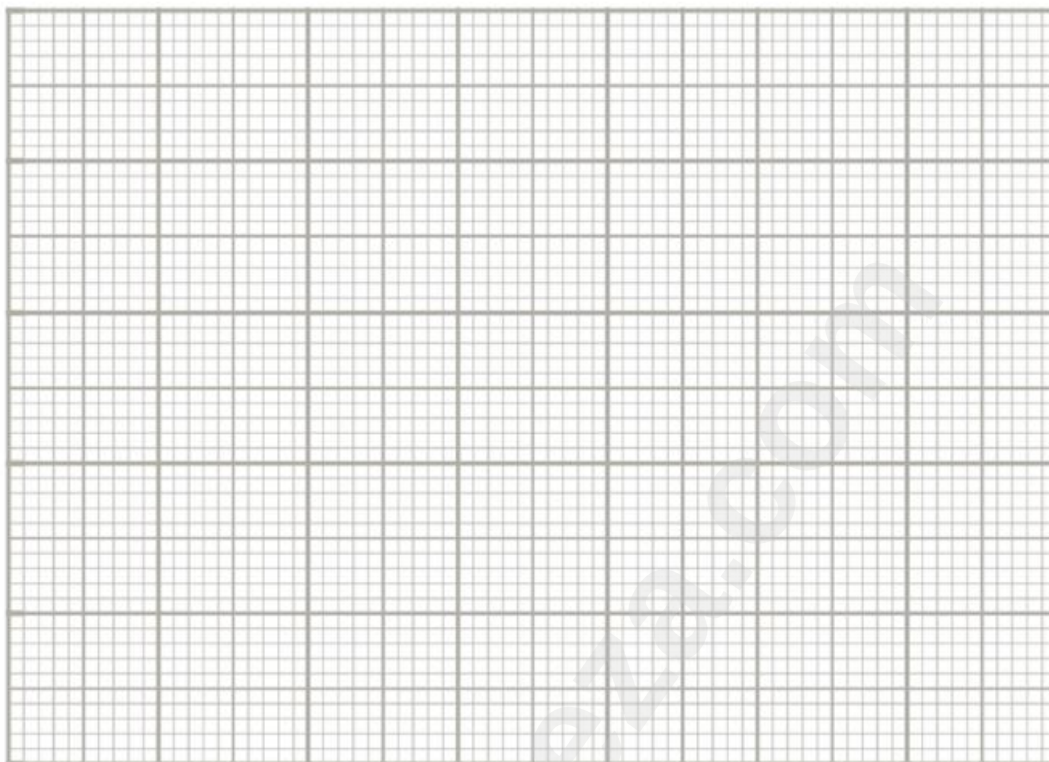


The student collects the data from the footage of the camera as the ball falls. The results are shown in this table.

Displacement (m)	Time ² (s ²)
12	2,0
49	10,0
110	22,0
196	42,0
420	90,0

3.1. Explain what is meant by a projectile in free fall. (2)

3.2. From the data given in the table, plot a displacement vs time² graph. Remember to use a pencil for the graph. (6)



3.3. Calculate the gradient of the graph. Include a suitable unit. (4)

3.4. Use a suitable equation of motion and your knowledge of straight-line graphs to calculate the acceleration of the ball in free fall. (3)

[15 marks]

QUESTION 4:

A firefighting helicopter is used to put out a fire. This helicopter collects water directly from the sea and drops the water on the fire to try and kill the fire.



As shown above, the helicopter lifts a bucket of water out of the sea. The helicopter must collect and drop as much water on the fire, as often as possible.

- 4.1. State *Newton's second law of motion*. (2)

The upward acceleration of the helicopter and the full water bucket is $1,5 \text{ m.s}^{-2}$.

- 4.2. Draw a labelled free-body diagram of the vertical forces acting **on the bucket** as the helicopter and full water bucket accelerate upwards. (3)

- 4.3. The tension in the rope attached to the bucket is 70000 N. Calculate the mass of the full water bucket. (4)

The helicopter reaches an upward velocity of 5 m.s^{-1} and continues rising at this constant velocity.

- 4.4. Calculate the magnitude of the tension in the rope attached to the bucket while the helicopter and full water bucket rise at constant velocity. (2)

The helicopter is flown to the fire. It hovers at a constant height of 100 m above the flames maintaining a stationary position.

- 4.5. State the direction of the acceleration of the helicopter as it begins to reduce its upward velocity to maintain a constant height above the fire. (1)

A second helicopter carries a full bucket of water with a mass of 1000 kg. In 4 s, the bucket is emptied of all the water.

- 4.6. If the pilot makes no adjustments to the helicopter's controls, **describe and explain** the helicopter's motion as water is emptied onto the fire. (5)

- _____

- _____

- _____

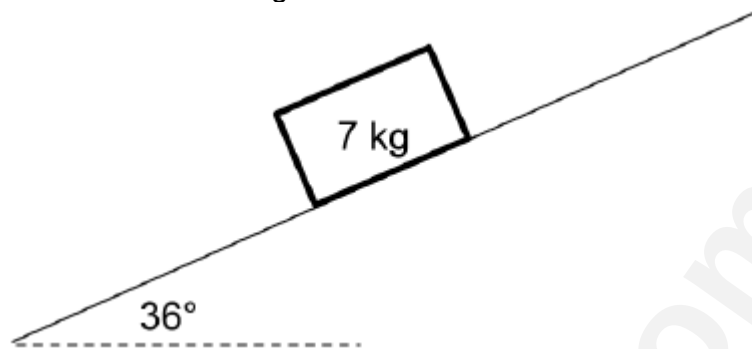
- _____

- _____

[17 marks]

QUESTION 5:

A box (mass 7 kg) is at rest on a rough slope that makes an angle of 36° to the horizontal, as shown in the diagram below.



5.1. Define *frictional force*. (2)

5.2. Draw a labelled free-body diagram showing all the forces acting on the box. (3)

5.3. Determine the magnitude of the component of the weight of the box that is perpendicular to the slope. (2)

5.4. If the box is just about to slide down the slope, determine the coefficient of maximum static friction between the box and the slope. (4)

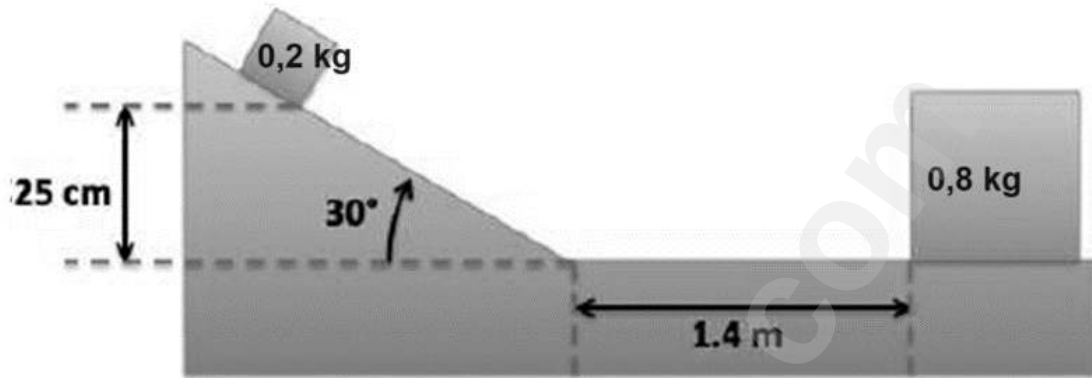
The 7 kg box is replaced with a box of the same material but with a much smaller mass.

- 5.5. Explain whether the second box with a smaller mass is MORE LIKELY, EQUALLY LIKELY, or LESS LIKELY to slide down the slope than the 7 kg box. (2)

[13 marks]

QUESTION 6:

A 0,2 kg box is released from rest at a height of 25 cm. The slope and the horizontal surface are frictionless. The slope is inclined at 30° to the horizontal, as shown.



The box slides down the slope and then along the frictionless horizontal surface until it collides perfectly elastically with block **B**. Block **B** is placed at a distance of 1,4 m from the bottom of the incline, its mass is 0,8 kg, and it is initially at rest.

6.1. Define *mechanical energy*. (2)

6.2. Calculate the gravitational potential energy stored in the 0,2 kg box when it is at a height of 25 cm above the horizontal. (3)

6.3. **Show that** the speed of the 0,2 kg box as it reaches the horizontal surface is about $2,2 \text{ m.s}^{-1}$. (4)

- 6.4. Why does the velocity of the 0,2 kg box remain constant as it moves along the 1,4 m of the horizontal surface?

You must refer to one of Newton's laws in your answer. (3)

- 6.5. State the *law of conservation of momentum*. (2)

- 6.6. Draw a labelled free-body diagram of the forces acting on the 0,2 kg box as it slides down the incline. (2)

- 6.7. Calculate the force that causes the box to slide. (3)

- 6.8. Calculate the acceleration of the box as it slides. (3)

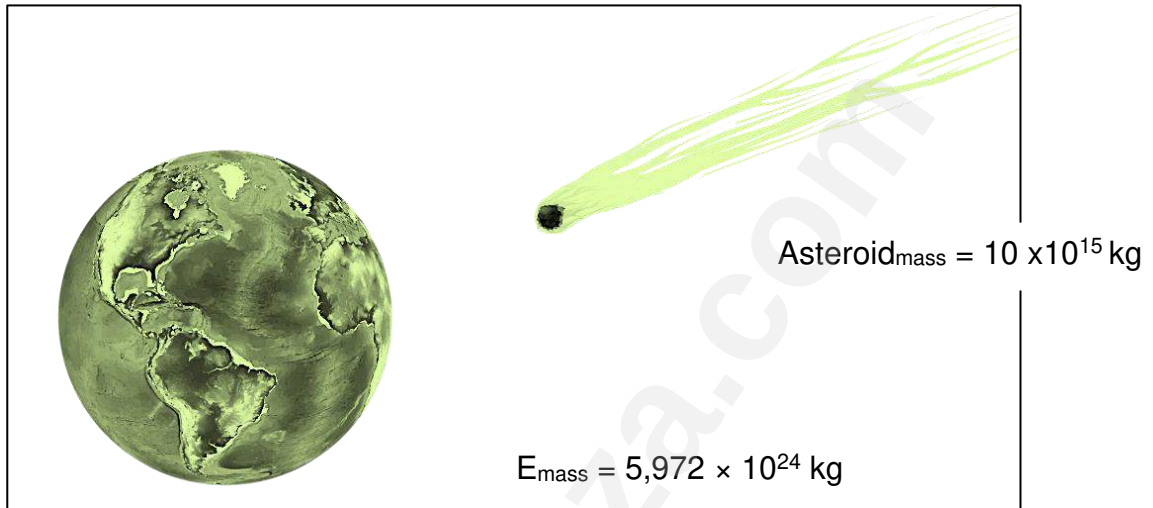
- 6.9. Define an *elastic collision*. (2)

- 6.10. Calculate the magnitude of the velocity of the 0,8 kg block immediately after the 0,2 kg box collides **elastically** with it. Assume that the initial speed of the box is $2,2 \text{ m.s}^{-1}$. (6)

[30 marks]

QUESTION 7:

- 7.1. The asteroid, designated as Asteroid 2023 JB3 by NASA's Centre for Near Earth Object Studies (CNEOS), made its closest approach to Earth on 9th June 2023, at a distance of 5.4 million kilometres. It dashed towards Earth at a fearsome speed.



Consider the motion of the Asteroid 2023 JB3 when it was at a distance of $2,50 \times 10^{11} \text{ m}$ from Earth.

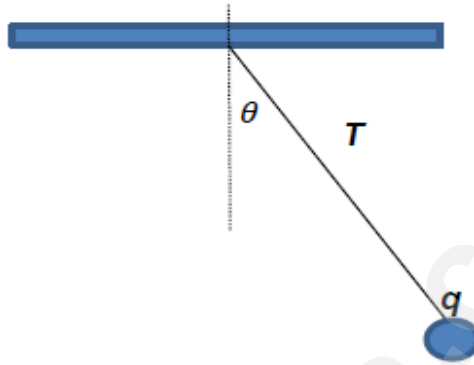
- 7.1.1. Calculate the force of gravity between Earth and the Asteroid 2023 JB3 at this point. (4)

- 7.1.2. What was the asteroid's resultant acceleration. (3)

- 7.2. A small charged conducting sphere of mass 4 g, carrying a charge q , is suspended by a string in a uniform electric field of $3 \times 10^5 \text{ N}\cdot\text{C}^{-1}$ to the right.

The electrostatic force experienced by the sphere is 0,07 N to the right.

The string experiences a tension T when the electrostatic force acts on the sphere.



- 7.2.1. Define the magnitude of an electric field. (2)

- 7.2.2. Calculate the magnitude of the charge q on the charged sphere, and state whether it is negative or positive. (4)

- 7.2.3. Draw the electric field pattern due to charge q . (2)

- 7.2.4. State the magnitude of the resultant (net) force on the charged sphere. (2)

7.2.5. Making use of a vector diagram, calculate:

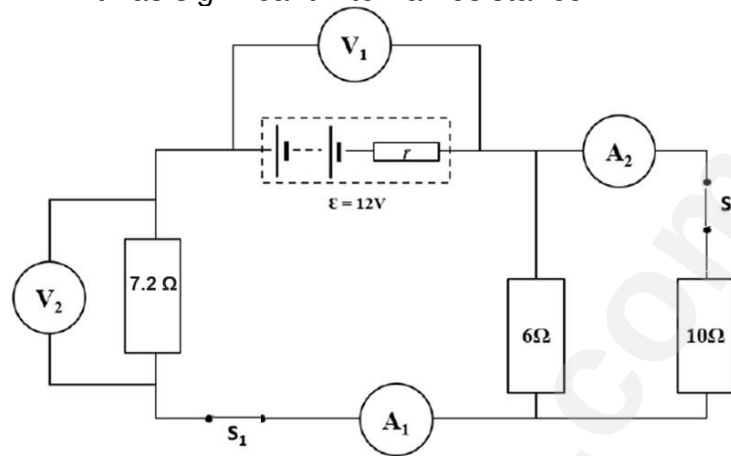
a) the magnitude of the tension T in the string. (3)

b) the angle θ that the string makes with the vertical. (2)

[22 marks]

QUESTION 8:

An electric circuit is set up as shown in the diagram below. The resistances of the switch, ammeters, and connecting wires are negligible. The battery has an emf (ϵ) of 12 V and it has significant internal resistance.



- Switches S_1 and S_2 are closed.
- The reading on ammeter A_1 is 0,95 A.

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

8.2. Calculate the reading on voltmeter V_2 . (2)

8.3. Define *resistance*. (2)

8.4. Calculate the equivalent resistance of the resistors in parallel. (2)

8.5. Define *current*. (2)

8.6. Calculate the reading on ammeter A_2 . (2)

8.7. Calculate the internal resistance of the battery. (5)

8.8. Calculate the reading on voltmeter V_1 . (2)

8.9. Predict the effect that the following actions would have on the reading on voltmeter V_1 . Write only *increase*, *decrease* or *no effect*.

8.9.1. Opening switch S_1 . (1)

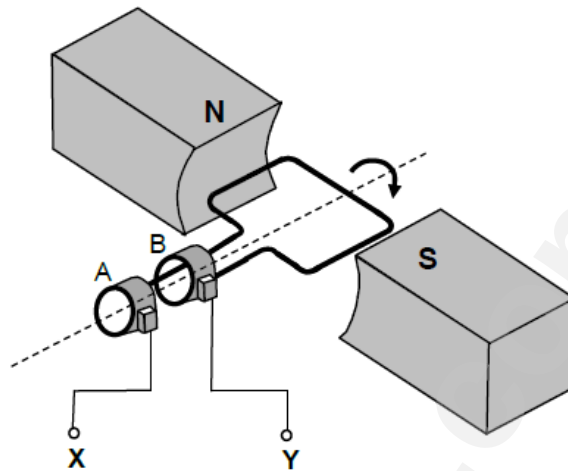
8.9.2. Opening switch S_2 . (S_1 is closed) (1)

8.9.3. Provide an explanation for your answer to question 8.9.2. (3)

[24 marks]

QUESTION 9:

The diagram below shows a simple generator with a coil that is rotated clockwise in the magnetic field.



9.1. Name the components that are labelled **A** and **B** on the diagram. (1)

9.2. Explain why current flows in the coil when it is rotated through the magnetic field. (3)

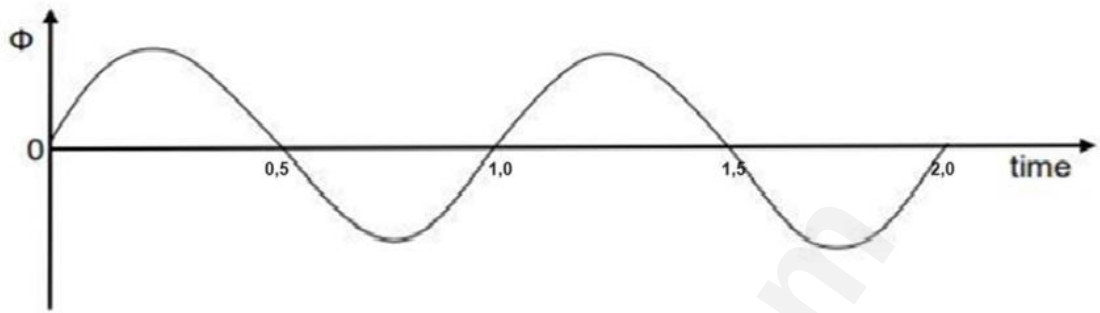
9.3. In which direction will the current flow in an **EXTERNAL** circuit connected to **X** and **Y**?

Circle the correct answer: **X to Y** OR **Y to X**. (1)

9.4. Two positions of the coil as seen from the axis of rotation are shown below:

Coil in horizontal position	Coil in vertical position
P	Q

The graph below shows the magnetic flux (Φ) experienced by the coil as it is rotated against time.

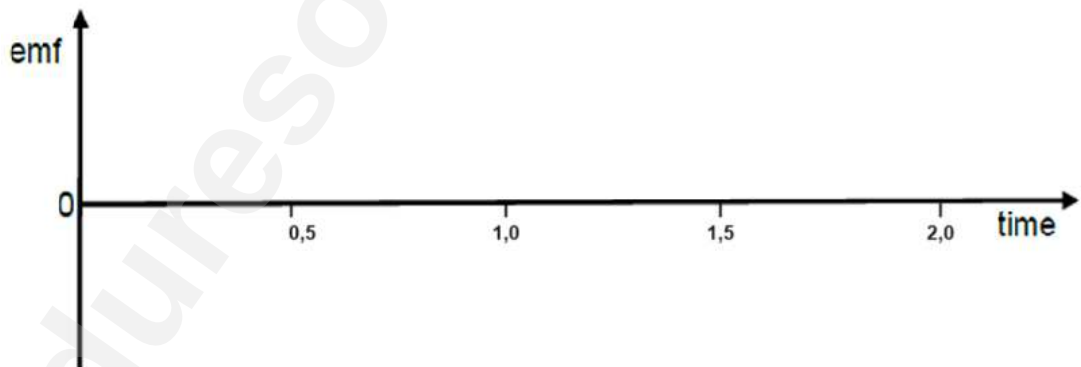


9.4.1. Will the coil be in position **P** or **Q** at time $t = 0$ s? (2)

Circle the correct answer: **P** or **Q**

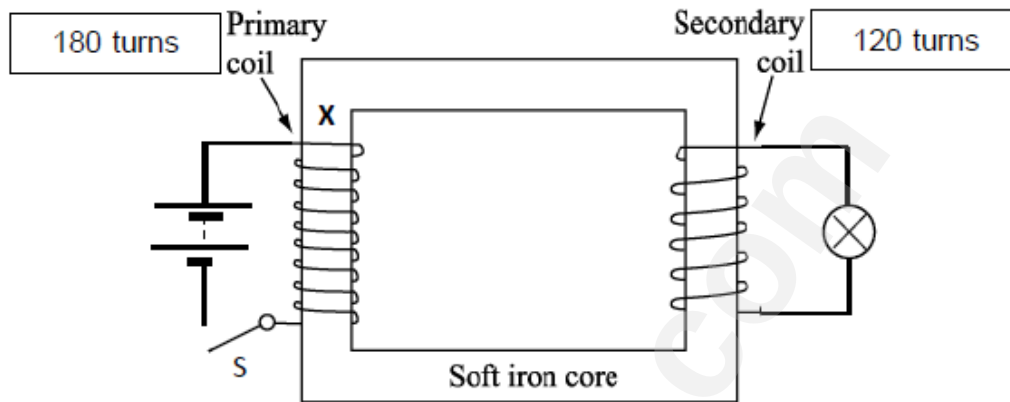
9.4.2. Give a reason for your answer to 9.4.1. (2)

9.4.3. Draw a sketch graph on the axes given below showing the emf against time for the coil, corresponding to the magnetic flux against time graph shown above. (2)



- 9.5. A transformer is shown in the diagram below. Two coils are wound onto a soft iron core. The primary coil is INCORRECTLY connected to a DC battery.

When the switch, S, in the primary circuit, is closed the light bulb connected to the secondary coil flashes once and then goes out.



- 9.5.1. State the polarity of the magnetic pole X when the switch in the primary circuit is closed. (1)

Circle the correct answer: **NORTH** or **SOUTH**.

- 9.5.2. Explain why the light bulb in the secondary circuit does not remain lit. (3)

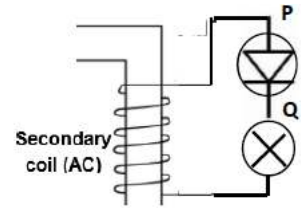
- 9.6. The DC battery is now replaced with an AC source so that the transformer operates correctly. The bulb requires a voltage of 6 V to glow with maximum brightness.

- 9.6.1. What type of transformer is shown in the diagram? (1)

Circle the correct answer: **STEP-DOWN** or **STEP-UP**.

- 9.6.2. Calculate the input voltage in the primary coil when the bulb glows at maximum brightness. (3)

9.7. A diode is now connected in series with the bulb as shown.



9.7.1. Define *diode*.

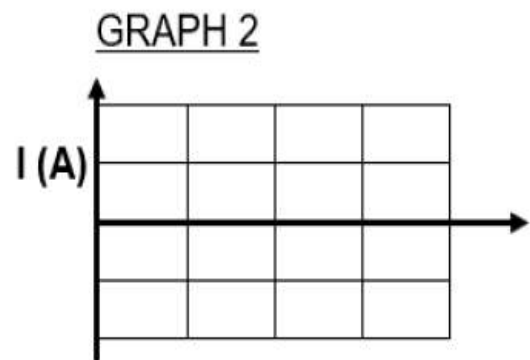
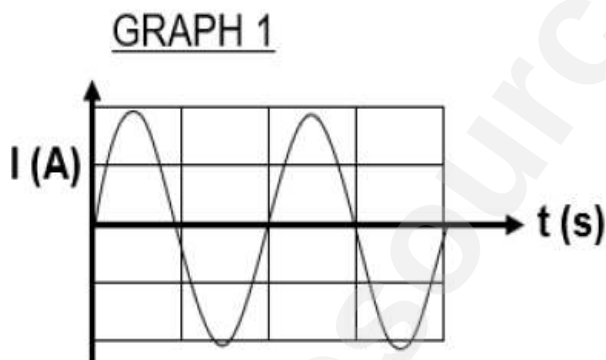
(2)

9.7.2. In which direction can current flow through the diode?

Circle the correct answer: from **P** to **Q** or from **Q** to **P** (1)

9.7.3. Graph 1 below shows the current through the bulb BEFORE the diode was connected.

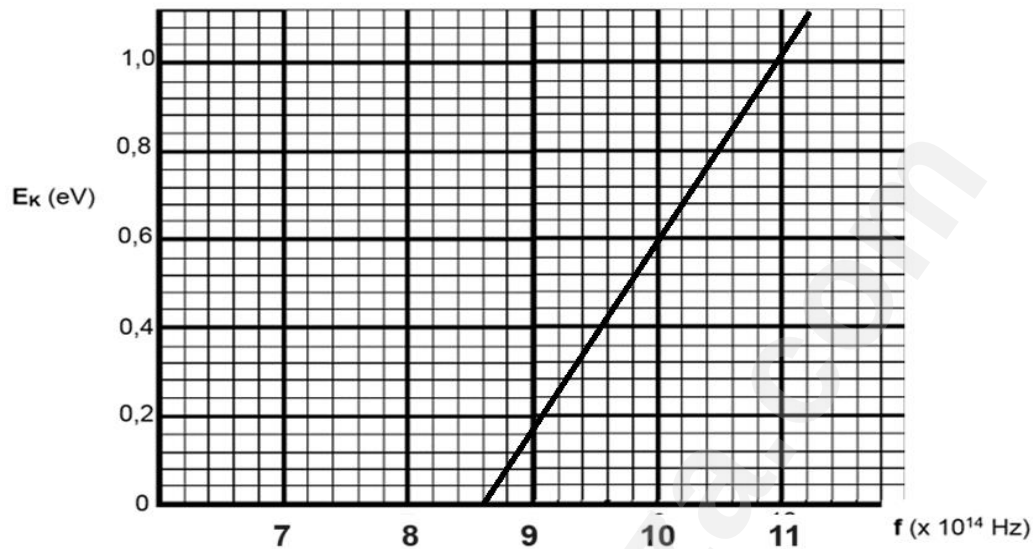
Draw graph 2 to show the current through the bulb AFTER the diode was connected. (2)



[24 marks]

QUESTION 10:

The graph below represents the maximum kinetic energy of an electron (E_k) ejected from the surface of a metal as the frequency (f) of light shone on it is increased.



10.1. Define *threshold frequency*. (2)

10.2. Determine the threshold frequency of the metal. (2)

10.3. A table of the work functions of four metals is shown below.

Metal	Potassium	Uranium	Copper	Gold
Work function (eV)	2,30	3,55	4,65	5,10

Determine which metal was used to produce the graph. (5)

10.4. On the graph given at the start of the question, draw a line to represent the relationship between the maximum kinetic energy of the ejected electrons (E_k) and the frequency of the incident light (f) for a metal with a lower work function. (2)

10.5. The intensity of the incident light is increased without changing the frequency.

10.5.1. State and explain any change in the maximum kinetic energy of emitted electrons. (2)

10.5.2. State and explain any change in the rate of emission of electrons. (2)

[15 marks]

[TOTAL: 200]

ADDITIONAL SPACE (ALL QUESTIONS)

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

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