ieb assessment matters

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TOTAL MARKS

Sequence number

NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2025

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. Read the questions carefully.
3. **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.**
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. Where appropriate, express answers to TWO decimal places.
8. It is in your own interest to write legibly and to present your work neatly.
9. Three blank pages (pages 30–32) are included at the end of the question paper. Use these pages if you run out of space for a question. Clearly indicate the number of the question you are answering, should you use this additional space.

FOR OFFICE USE ONLY: MARKER TO ENTER MARKS

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
Mark											
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Question Total	**20**	**16**	**29**	**19**	**13**	**16**	**20**	**27**	**24**	**16**	**200**
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QUESTION 1 MULTIPLE CHOICE

Answer these questions on the multiple-choice answer sheet below. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

A	~~B~~ (X)	C	D

Here the option B 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

YOU ARE ENCOURAGED TO USE THE SPACE BETWEEN THE MULTIPLE CHOICE QUESTIONS TO SOLVE THESE QUESTIONS, BUT MUST INDICATE YOUR CHOSEN ANSWER FOR EACH QUESTION IN THE GRID ABOVE.

1.1 Which of the following units is the same as the unit of the universal gravitational constant $\left(N \cdot m^2 \cdot kg^{-2}\right)$?

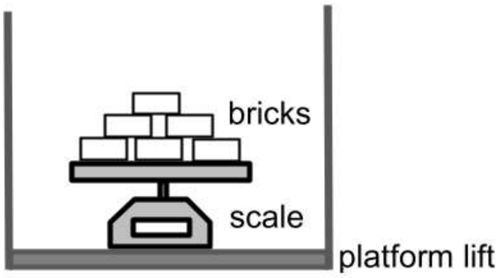
A $kg \cdot m^2 \cdot s^{-2}$

B $kg \cdot m^3 \cdot s^{-2}$

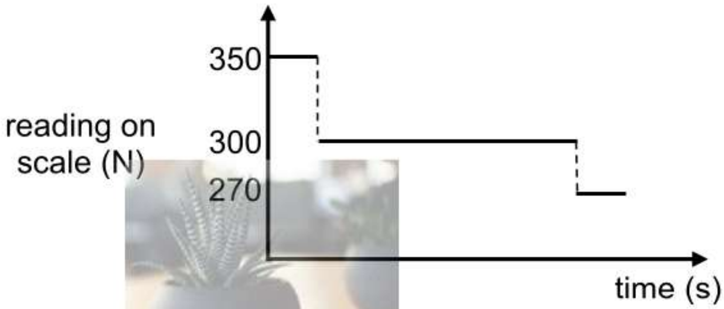
C $kg^{-1} \cdot m^2 \cdot s^{-2}$

D $kg^{-1} \cdot m^3 \cdot s^{-2}$

1.2 A platform lift is used to move bricks up and down a building. The bricks are on a scale which gives a reading in Newtons.



The graph below shows the reading on the scale for a period of time when the platform lift is moving bricks. The platform lift accelerates as it starts moving (a_{START}) and then later comes to rest again (a_{STOP}).



Which of the following are possible descriptions of the direction of movement and the magnitude of acceleration of the platform lift?

	Direction of movement of platform lift	Magnitude of acceleration
A	downwards	$a_{START} > a_{STOP}$
B	downwards	$a_{START} < a_{STOP}$
C	upwards	$a_{START} > a_{STOP}$
D	upwards	$a_{START} < a_{STOP}$

1.3 A tennis ball, with a mass of 0,06 kg, collides with a wall. The velocity of the ball is 6 m·s^{-1} to the left before the collision. The ball leaves the wall after the collision with a velocity of 2 m·s^{-1} to the right.

The change in momentum of the ball is:

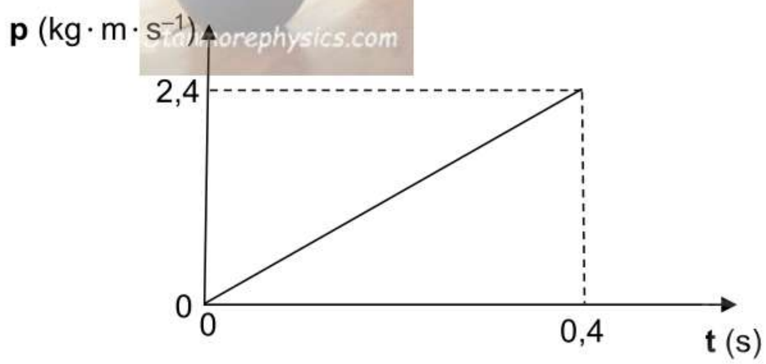
A 0,24 kg·m·s^{-1} to the right

B 0,48 kg·m·s^{-1} to the right

C 0,24 kg·m·s^{-1} to the left

D 0,48 kg·m·s^{-1} to the left

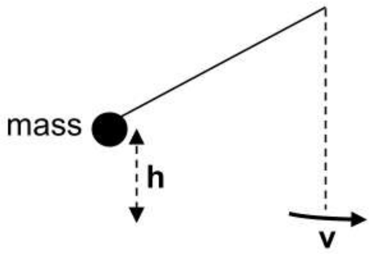
1.4 The graph below represents the relationship between momentum (**p**) and time (**t**) for an object that is moved from rest by a constant net force.



The net force acting on the object is:

A 0,48 N B 0,96 N C 3 N D 6 N

1.5 A mass **m** is tied to a piece of string and raised to a height **h** above its starting point, as shown. It is released and reaches a velocity **v** at the lowest point of its swing.



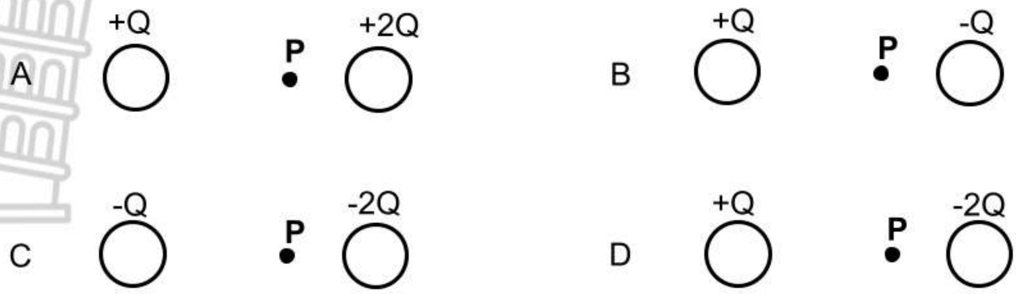
The mass is now lifted to half the original height and is released. The velocity at the lowest point of the swing will now be:

A $\frac{1}{2}\mathbf{v}$ B $\frac{1}{\sqrt{2}}\mathbf{v}$ C $\sqrt{2}\mathbf{v}$ D $\frac{1}{4}\mathbf{v}$

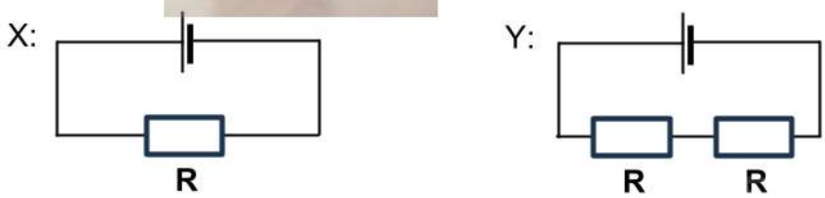
1.6 The gravitational acceleration on the surface of a planet with radius R is $\boldsymbol{g_p}$. The gravitational acceleration at a height of 2R above the surface of this planet is:

A $\frac{\boldsymbol{g_p}}{2}$ B $\frac{\boldsymbol{g_p}}{3}$ C $\frac{\boldsymbol{g_p}}{4}$ D $\frac{\boldsymbol{g_p}}{9}$

1.7 Point **P** is between two charged objects. In which of these situations could the electric field at point **P** be directed to the left?



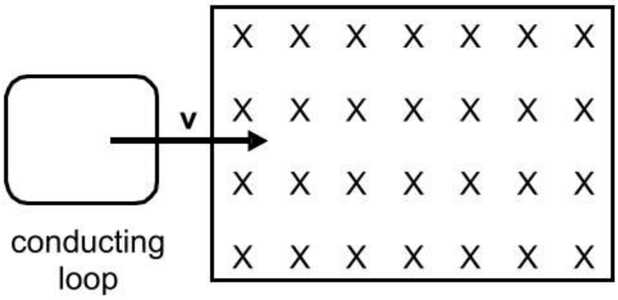
1.8 Two circuits, X and Y, are shown below. The cells have the same emf and negligible internal resistance and all resistors, **R**, are identical.



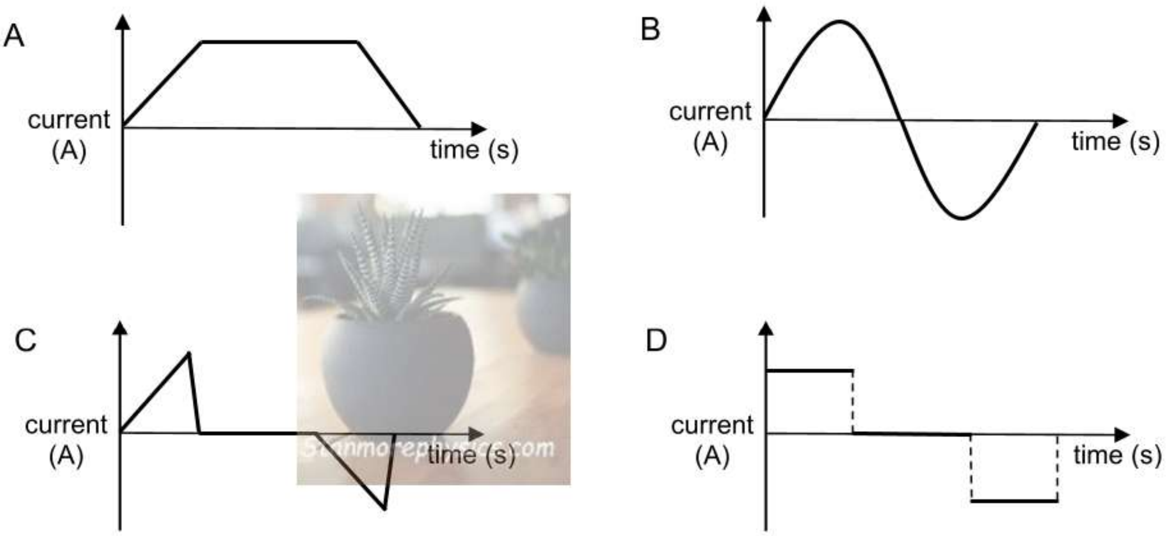
The power dissipated by the resistor, **R**, in circuit X is **P**. The total power dissipated by each resistor in circuit Y is:

A $\frac{P}{4}$ B $\frac{P}{2}$ C **P** D 2**P**

1.9 A uniform magnetic field is directed into the page, as shown. A conducting loop is moved at a constant velocity through the magnetic field, from left to right.



The current produced in the loop over the time period that it is moved into, through and out of the magnetic field is best represented by which of the following graphs?



1.10 High energy light is shone onto a metal plate and electrons are emitted from the surface of the metal. Which statement correctly predicts the change when the brightness of the light is increased?

A More electrons will be emitted.

B Fewer electrons will be emitted.

C The emitted electrons will move faster.

D The emitted electrons will move slower.

[20]

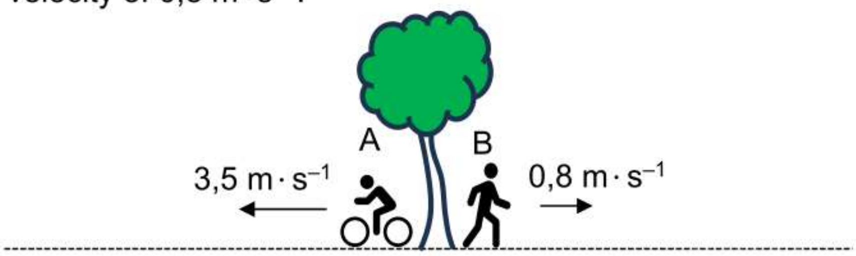
QUESTION 2 KINEMATICS

2.1 An athlete accelerates for 6 seconds from an initial speed of 1,4 $m \cdot s^{-1}$, running a distance of 15,6 m.

2.1.1 Calculate the magnitude of the athlete's acceleration over this 6 second period. (3)

2.1.2 How fast was the athlete running after the period of acceleration? (3)

2.2 Two people were standing together under a tree. Person A cycled away from the tree at a constant speed of 3,5 $m \cdot s^{-1}$, while person B walked in the opposite direction at a constant velocity of 0,8 $m \cdot s^{-1}$.



After cycling for 10 seconds, person A turned around to cycle back towards person B at a constant velocity of 4,5 $m \cdot s^{-1}$. Person B continues to walk at a constant velocity of 0,8 $m \cdot s^{-1}$.

2.2.1 Define *displacement*. (2)

2.2.2 Ignoring the time that it takes to turn the bicycle around, how long would it take person A to catch up to person B? (5)

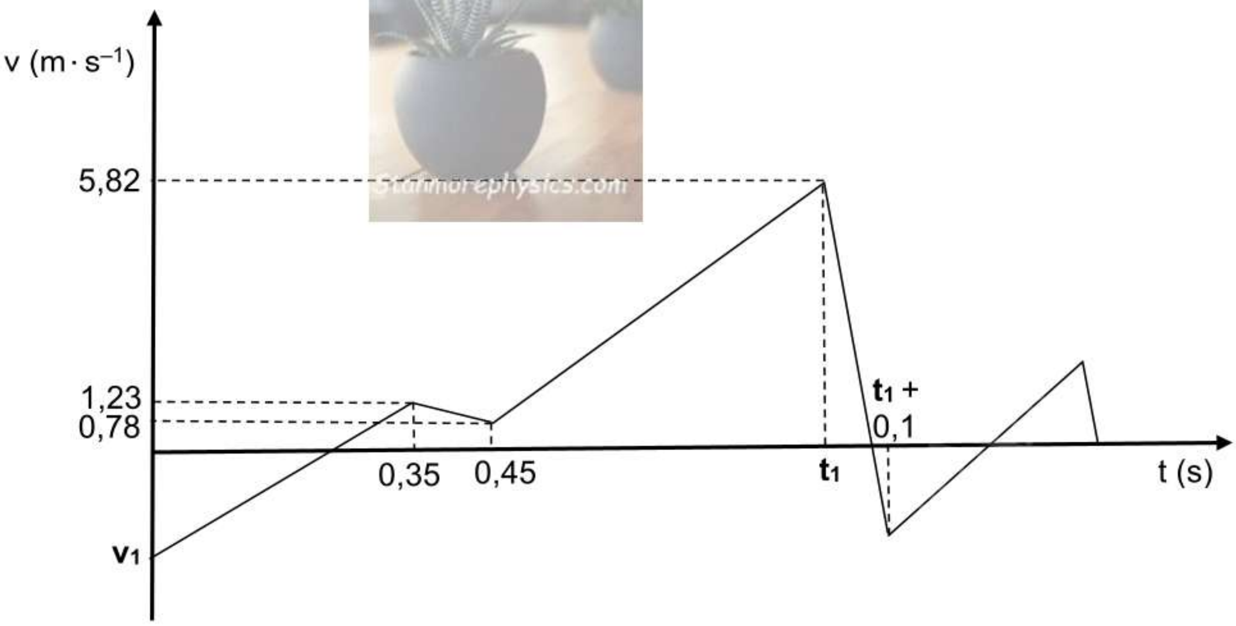
2.2.3 How far would person B have walked from the tree when person A caught up to them? (3)

[16]

QUESTION 3 KINEMATICS – IMPULSE

A ball (mass 0,16 kg) is thrown upwards with an initial velocity of $\mathbf{v_1}$. On its path to the ground, the ball falls through some leaves (shown in the picture below) 0,35 s after it was thrown. *The picture is not to scale*.

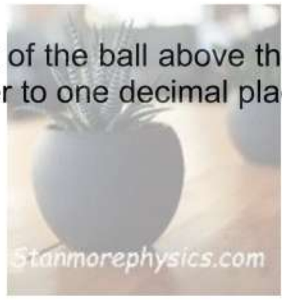
The ball strikes the leaves with a speed of 1,23 m·s^{-1}. Just 0,1 s later, the ball falls out of the leaves with a speed of 0,78 m·s^{-1}. The velocity-time graph below represents the motion of the ball from the moment it was thrown to the time when it came to rest on the ground. Air friction can be ignored throughout the question. *The graph is not drawn to scale.*



3.1 Calculate the magnitude of the initial velocity, $\mathbf{v_1}$, with which the ball was thrown. (3)

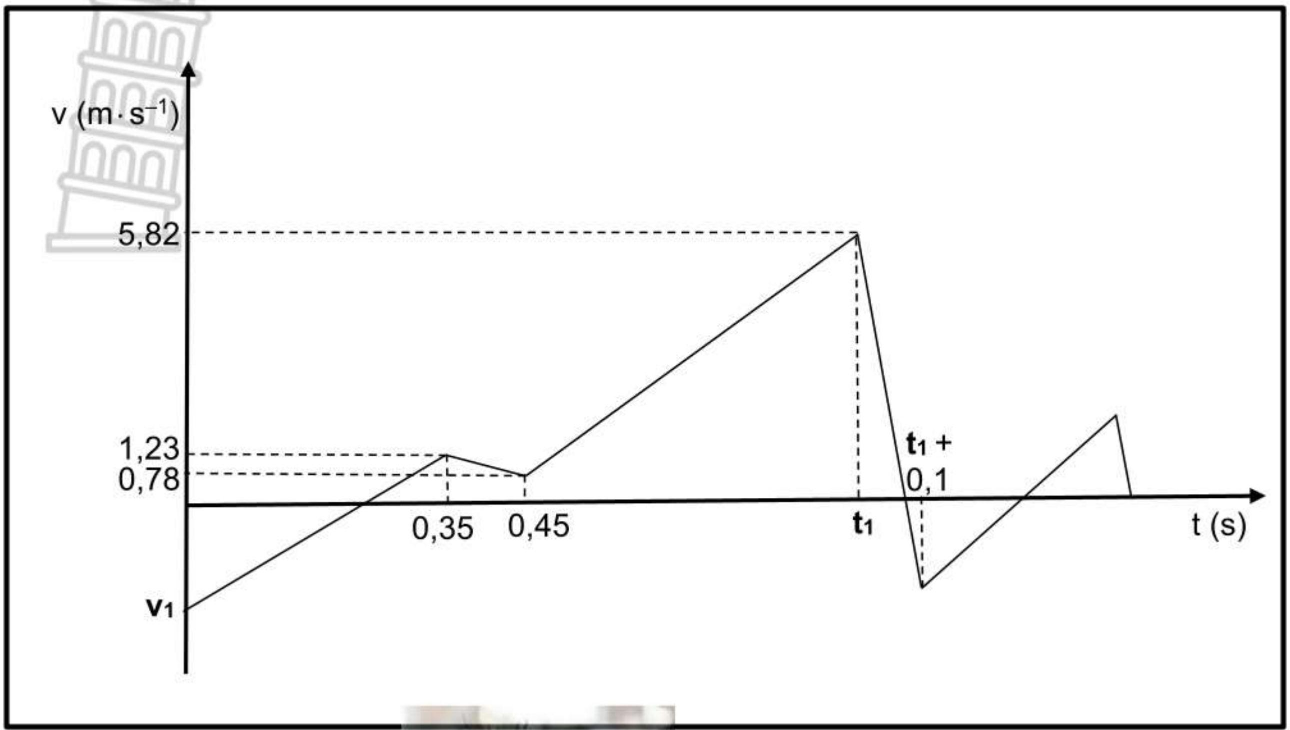
3.2 Determine time, $\mathbf{t_1}$, when the ball hits the ground. (4)

3.3 Calculate the height of the ball above the ground when it emerges from the leaves. Express your answer to one decimal place. (3)



3.4 Calculate the change in momentum of the ball caused by the leaves. (4)

The graph that was shown on page 10 is repeated here so that you do not have to turn back (it is the identical graph).



3.5 Define *impulse*. (2)

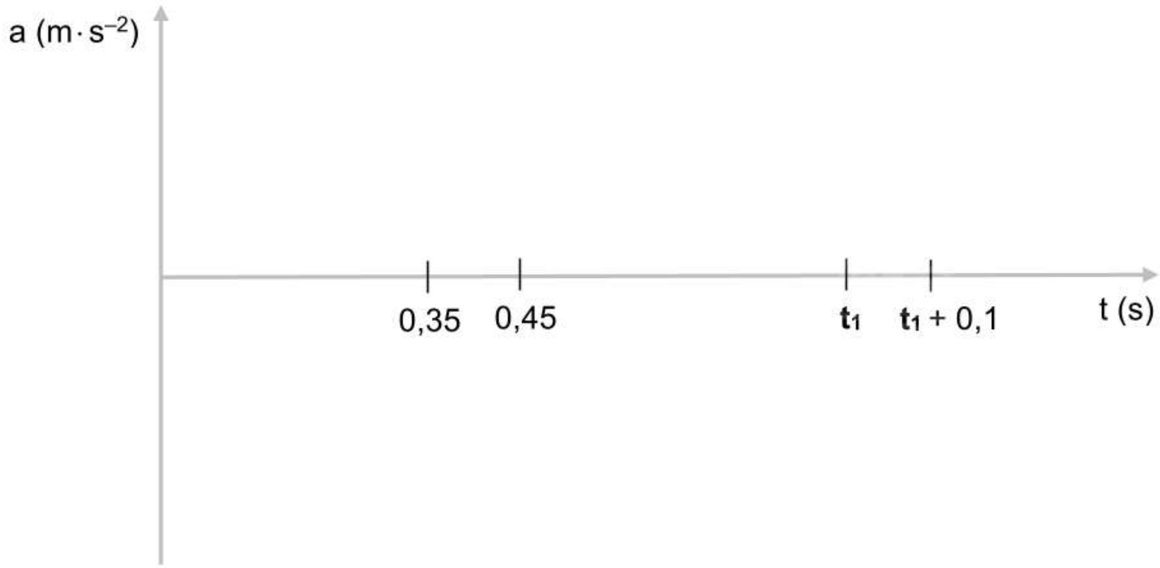
3.6 Determine the average force that the leaves exerted on the ball. (4)

The ball is in contact with the leaves for the same amount of time as it is in contact with the ground, as shown on the velocity-time graph.

3.7 How does the force that the LEAVES exert on the ball compare to the force that the GROUND exerts on the ball? Justify your answer. (3)

3.8 Define *acceleration*. (2)

3.9 Draw an acceleration-time graph for the motion of the ball from the moment it was thrown until it leaves the ground after bouncing. No further calculations are required (only known values need to be shown), but relative sizes should be shown. (4)

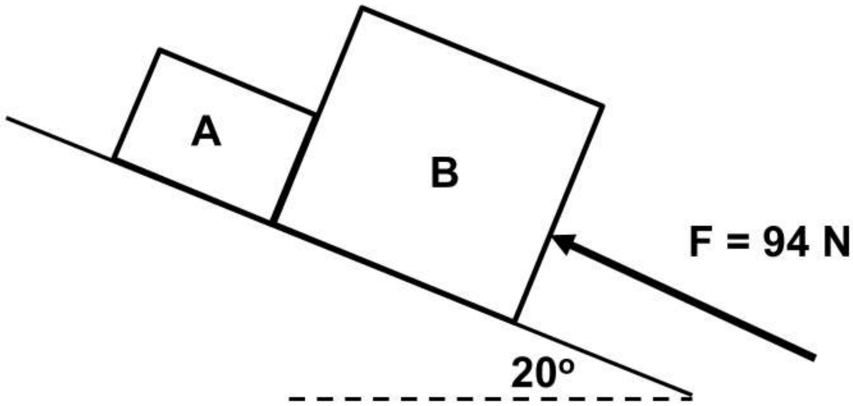


[29]

QUESTION 4 APPLICATION OF NEWTON'S LAWS

Two wooden blocks are pushed up a 20° incline with a force of 94 N applied parallel to the incline to block B.

Block A (mass 5 kg) experiences a frictional force of 18,4 N and block B (mass 8 kg) experiences a frictional force of 29,5 N.



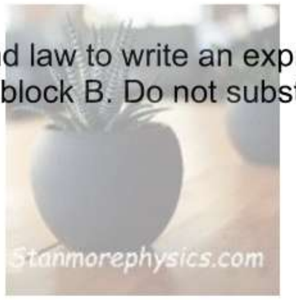
4.1 State *Newton's third law*. (2)

4.2 Draw a labelled free-body diagram of all the forces acting on block B. (5)

4.3 Determine the coefficient of kinetic friction between the blocks and the surface of the incline. (4)

4.4 State *Newton's second law*. (2)

4.5 Use Newton's second law to write an expression of $\mathbf{F}_{\mathbf{net}}$ in terms of acceleration and the forces acting on block B. Do not substitute any values. (2)



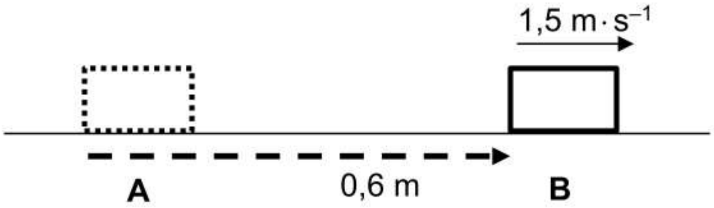
4.6 Determine the magnitude of the force that block A exerts on block B. (4)

[19]

QUESTION 5 MOMENTUM, WORK, ENERGY AND POWER

A block with an unknown mass, **m**, slides along a rough horizontal surface from position A to position B, shown in the diagram below. The coefficient of kinetic friction between the rough surface and the block is 0,28.

The block is travelling at 1,5 $m \cdot s^{-1}$ at position B.



5.1 Write an expression for the kinetic energy of the block at position B, in terms of **m**. (2)

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

5.3 Write an expression for the frictional force acting on the block as it slides along the rough horizontal surface, in terms of **m**. (2)

5.4 Determine the initial velocity of the block at position A. (4)

5.5 Calculate the time taken by the block to slide from A to B. (3)

[13]

QUESTION 6 GRAPH SKILL

A trolley of unknown mass is pushed up a frictionless inclined track with different initial velocities and the kinetic energy of the trolley is determined for each velocity (by seeing how high up the slope the trolley travels).

The kinetic energy of the trolley for each initial velocity is provided in the table below.

v (m·s^{-1})	v^2 (m^2·s^{-2})	E_K (J)
0,45	0,20	0,05
0,63	0,40	0,11
0,89	0,79	0,20
1,10	1,21	0,30
1,26	**missing value**	0,41
1,34	1,80	0,46

6.1 Write the value that is missing from the table (to two decimal places). (2)

The data from the table has been plotted for you on the graph on page 19 (alongside this one). Use the graph to answer the questions below.

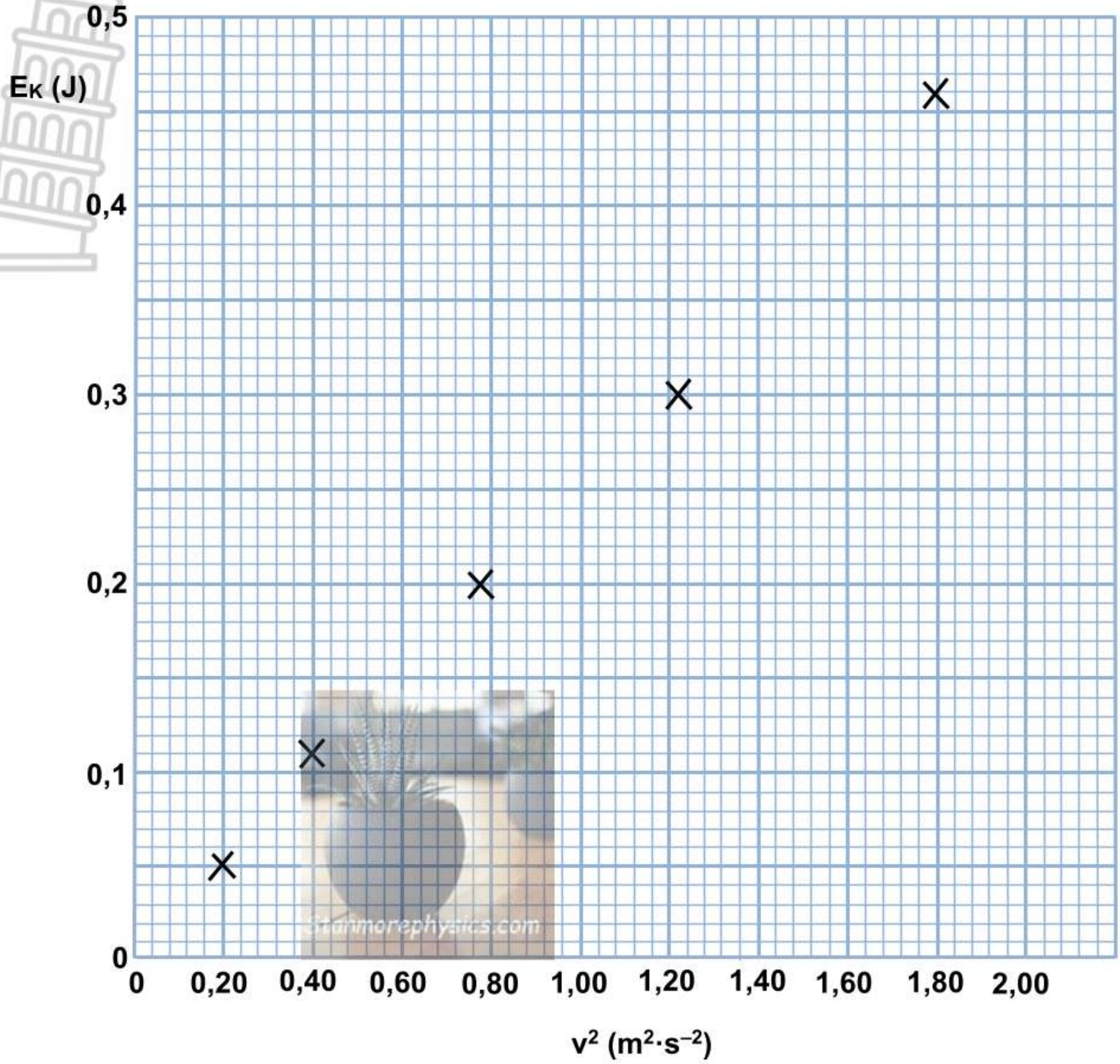
6.2 Plot the point that is not plotted (with the value that was missing from the table). (1)

6.3 Draw the appropriate line to represent the relationship between the kinetic energy of the trolley and the squared velocity of the trolley. (1)

6.4 Calculate the gradient of the graph. Show your working and the points that you used on the graph. No unit is required for your answer. (4)

6.5 Hence, determine the mass of the trolley. (3)

Kinetic energy vs velocity squared



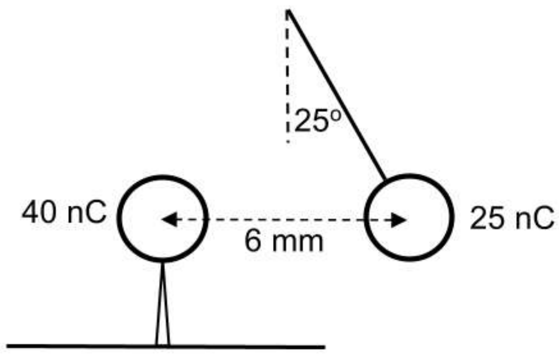
6.6 Use the graph to determine how fast the trolley was moving when it had a kinetic energy of 0,28 J. Show how you determined this value. (3)

6.7 Briefly explain why the kinetic energy was plotted against the **squared** velocity of the trolley and not against the velocity of the trolley. (2)

[16]

QUESTION 7 FIELDS

A small charged sphere carrying a negative charge of 40 nC is fixed on an insulating stand. Another small charged sphere carrying a charge of 25 nC is suspended by a piece of light insulating string. It remains at rest at a position that is at the same height as the fixed charge. The distance between the two charges is 6 mm.



7.1 Is the 25 nC sphere **POSITIVELY** or **NEGATIVELY** charged?

(*You may just circle your choice of the options in bold.*) (1)

7.2 Draw a labelled free-body diagram showing all the forces acting on the 25 nC charge when it is at rest, as shown. (3)

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

7.4 Calculate the magnitude of the electrostatic force due to the fixed 40 nC charge that the 25 nC charge experiences as it is suspended as shown in the diagram. (4)

7.5 Define *weight*. (2)

7.6 Determine the mass of the suspended 25 nC charge. (3)

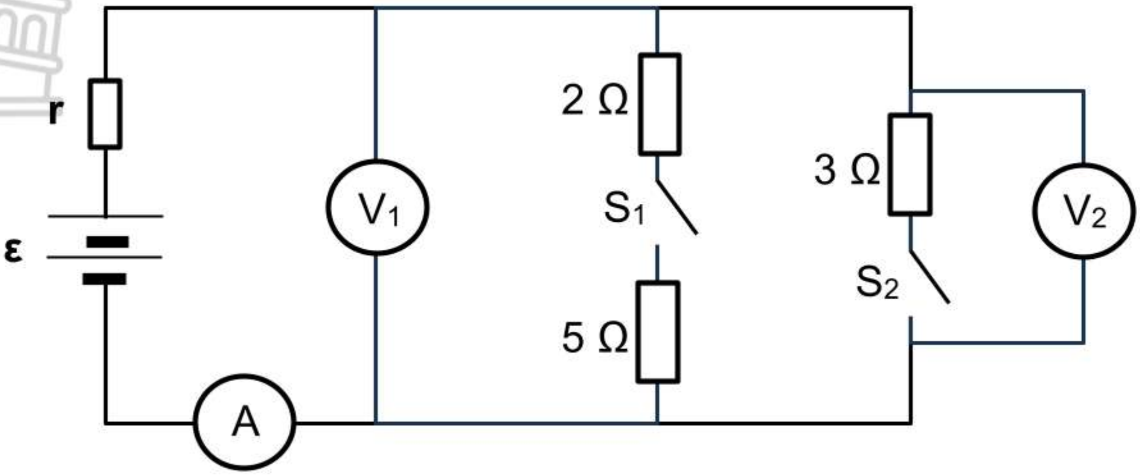
7.7 Explain the effect (if any) on the magnitude of the tension in the string of moving the 40 nC charge further away from the 25 nC charge. (3)

7.8 Why is the effect of the gravitational force between the masses of the spheres not considered in this problem? (2)

[20]

QUESTION 8 ELECTRIC CIRCUITS

8.1 In the circuit shown below, the battery of emf, **ε**, has a significant but unknown internal resistance (**r**). The resistance of the ammeters can be ignored and the resistance of the voltmeters is infinitely high.



Switches S_1 and S_2 are initially both open. When they are closed, the reading on V_1 drops by 0,47 V and the ammeter reads 2,63 A.

8.1.1 Define *emf*. (2)

8.1.2 Determine the value of the internal resistance of the battery, **r**. (3)

Both switches are now closed:

8.1.3 Calculate the effective resistance of the parallel resistors. (3)

8.1.4 Calculate the emf ($\boldsymbol{\varepsilon}$) of the battery. (4)

8.1.5 Calculate the amount of heat energy dissipated in the battery in 2 minutes. (4)

Switch S_1 remains closed, but S_2 is opened.

8.1.6 Determine the reading on voltmeter V_1. (5)

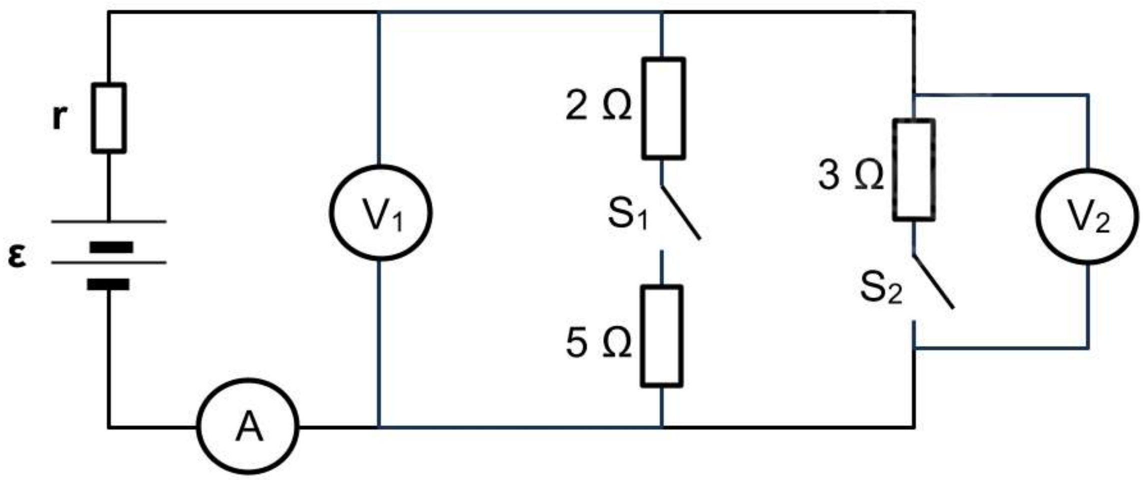
8.1.7 What will be the reading on voltmeter V_2 now? (1)

8.1.8 When switches S_1 and S_2 are both open, what will the reading on voltmeter V_2 be? Briefly explain your answer. (2)

8.1.9 A learner connecting the circuit shown connects an ammeter in the place of voltmeter V_2. Will the reading on voltmeter V_1 INCREASE, DECREASE or STAY THE SAME? Briefly explain your answer. (3)

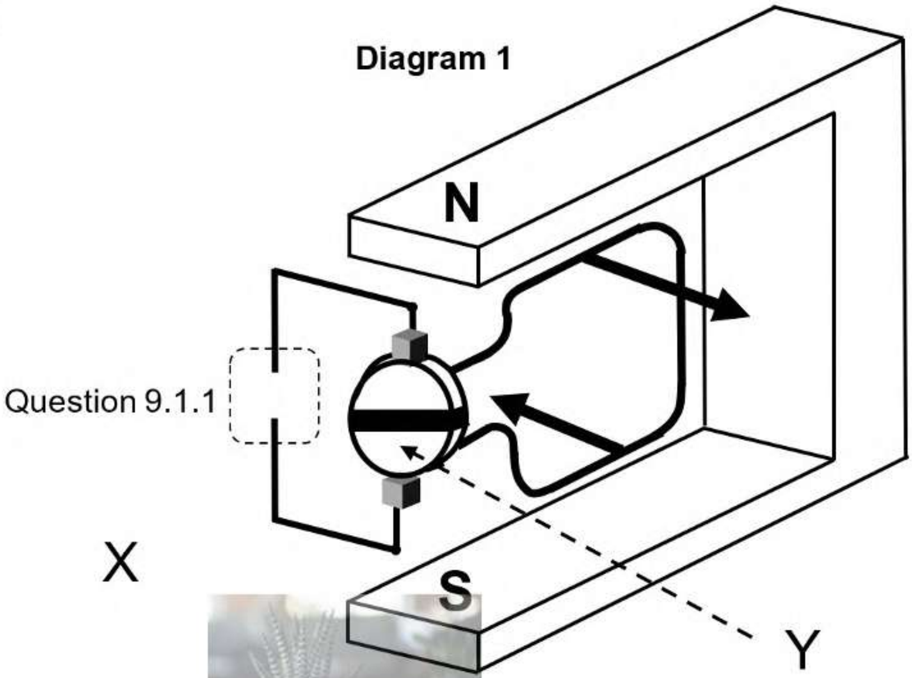
[27]

The circuit from page 22 is repeated here for your convenience:



QUESTION 9 ELECTRODYNAMICS

9.1 A loop of wire rotates clockwise in a uniform magnetic field when current is supplied to it from an external source, as shown in Diagram 1 below (clockwise rotation viewed from point X shown).



9.1.1 Draw the battery into the dashed box (labelled Question 9.1.1 on Diagram 1) that supplies current to the loop of wire resulting in the clockwise rotation. (2)

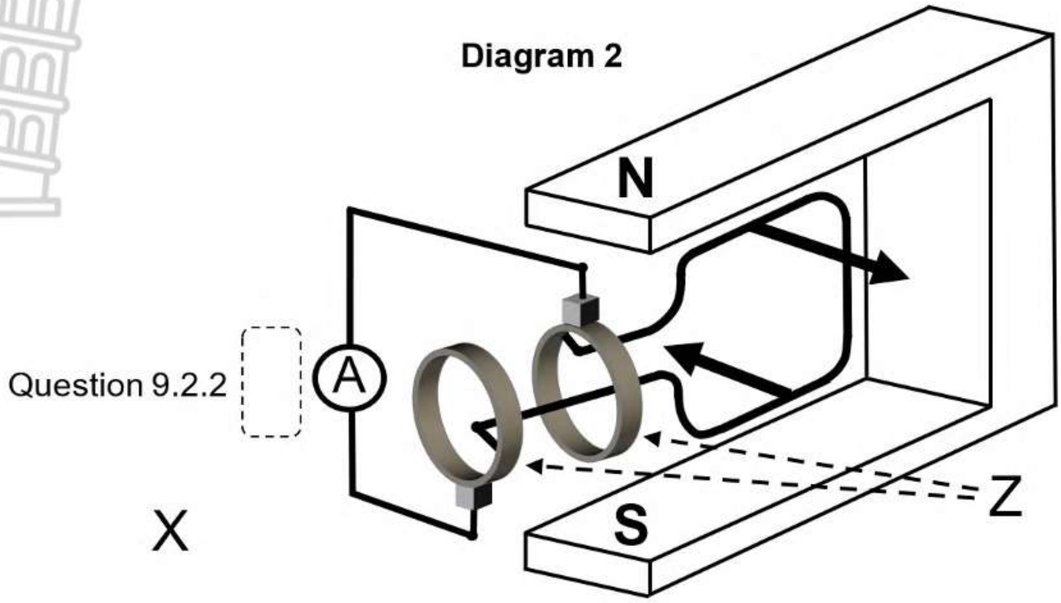
9.1.2 Briefly explain why the loop of wire experiences a turning force when current is supplied to it. (3)

9.1.3 Name the component labelled Y and briefly state its function. (3)

9.1.4 State one way in which the turning force on the loop of wire could be increased. (1)

9.2 The set-up is now changed as shown below in Diagram 2. The battery is removed, component Y is replaced with the components labelled Z and the loop of wire is rotated in the uniform field in a clockwise direction as shown (observed from point X).

Diagram 2



9.2.1 Name the components labelled Z. (1)

9.2.2 In the dashed box (labelled Question 9.2.2), indicate the direction of the current through the ammeter with an arrow. (2)

9.2.3 Would the loop of wire experience maximum magnetic flux or zero magnetic flux in its position shown in Diagram 2? You may write only MAXIMUM or ZERO. (2)

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

9.2.5 On the axes supplied below, sketch a graph of emf vs angle of rotation for one full cycle of rotation. Your graph should begin with the loop in the position shown in Diagram 2. (3)

9.2.6 On the axes above, sketch the graph of the emf when the loop of wire is rotated at half the original speed (which was sketched in Question 9.2.5). Clearly label this graph as SLOW. (3)

9.2.7 Explain why the loop at 0° rotation (shown in the diagram) corresponds to the emf that you have indicated as the starting value on your graph. (2)

[24]

QUESTION 10 PHOTONS AND ELECTRONS

10.1 Potassium has a threshold frequency of $5,56 \times 10^{14}$ Hz. Green light with a wavelength of 520 nm is shone on a potassium surface.

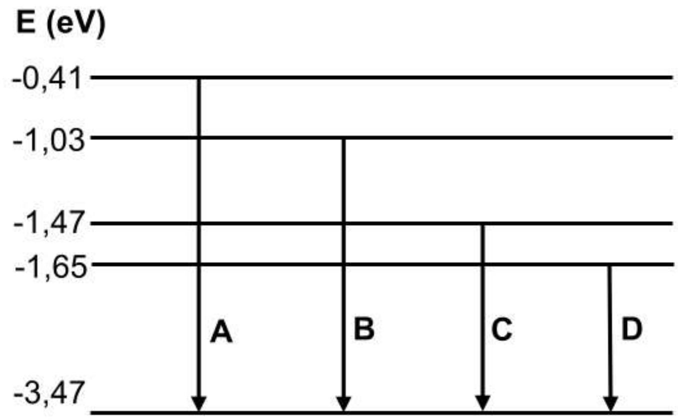
10.1.1 Define *work function*. (2)

10.1.2 Calculate the work function of potassium. (3)

10.1.3 By means of a calculation, determine whether this green light (520 nm) would be able to emit electrons from the potassium surface or not. (5)

10.2 The energy level diagram of hypothetical (made up) element M is shown below in Figure 1. Four electron transitions (**A**, **B**, **C** and **D**) are shown.

Figure 1



10.2.1 Calculate the wavelength of the photon emitted by transition **B** shown above. (4)

Four emission lines corresponding to the electron transitions shown above, are shown in Figure 2 below.

Figure 2

10.2.2 On Figure 2, label the line that corresponds to transition A shown in Figure 1 above. (2)

[16]

Total: 200 marks

ADDITIONAL SPACE (ALL QUESTIONS)

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