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TOTAL MARKS

NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2024

PHYSICAL SCIENCES: PAPER I

EXAMINATION NUMBER

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 30 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. Two blank pages (pages 28 and 30) 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. Spare graph paper is included on page 29.

FOR OFFICE USE ONLY: MARKER TO ENTER MARKS

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Total
Mark												
Marker Initial												
Moderated Mark												
Moderator Initial												
Question Total	**20**	**17**	**16**	**15**	**17**	**16**	**16**	**20**	**27**	**18**	**18**	**200**
Re-mark												
Initial												
Code												

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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**	**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**

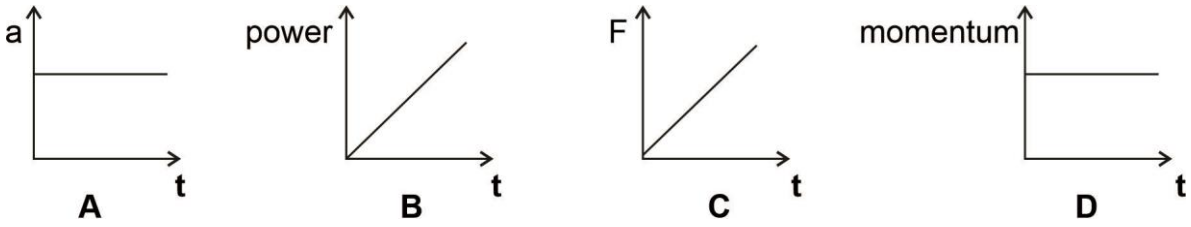
YOU ARE ENCOURAGED TO USE THE SPACE BETWEEN THE MULTIPLE CHOICE QUESTIONS TO SOLVE THESE QUESTIONS, BUT MUST INDICATE YOUR CHOSEN ANSWER FOR EACH QUESTION IN THE GRID ABOVE.

1.1 The formula $s = ut + \frac{1}{2} at^2$ contains:

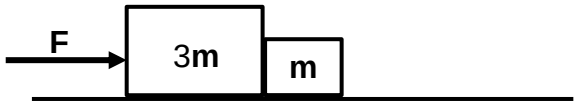
A four vector quantities
B three vector quantities and a scalar quantity
C two vector quantities and two scalar quantities
D one vector quantity and three scalar quantities

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1.2 An object is accelerated uniformly from rest. The velocity reached by the object in a time **t** is given by the area under which of the following graphs?



1.3 Two blocks with masses of 3**m** and **m** are in contact with one another on a frictionless surface. A force **F** is applied, as shown in the diagram below.



The force that the 3**m** block exerts on the block of mass **m** is:

A **F** B $\frac{\mathbf{F}}{4}$ C $\frac{\mathbf{F}}{3}$ D 0 N

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1.4 Two identical trolleys are moving along a smooth, frictionless surface. The trolleys are loaded with different masses and have different velocities, given in the table below:

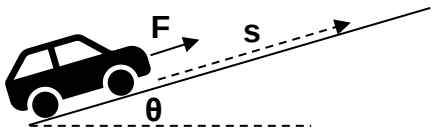
	Mass (kg)	Velocity ($m \cdot s^{-1}$)
Trolley A	2	0,3
Trolley B	3	0,2

Which statement about the inertia and momentum of each trolley is true?

A Trolley A and Trolley B have the same inertia and the same momentum.
B Trolley A has more inertia, but less momentum than trolley B.
C Trolley A has more inertia than trolley B, but they have the same momentum.
D Trolley A has less inertia than trolley B, but they have the same momentum.

1.5 A car of mass **m** drives at constant velocity **v** up a slope that makes an angle of **θ** with the ground. There is a driving force, **F**, acting on the car up the slope, as shown in the diagram below. The work done by kinetic friction can be ignored.

When the car moves a distance **s** up the slope, the work done by the driving force is:



A **m**g.**v**
B **m**g**(**sin **θ)**
C **m**g**(**sin **θ).v**
D **m**g**(**sin **θ).s**

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1.6 Which of these units is equivalent to a joule?

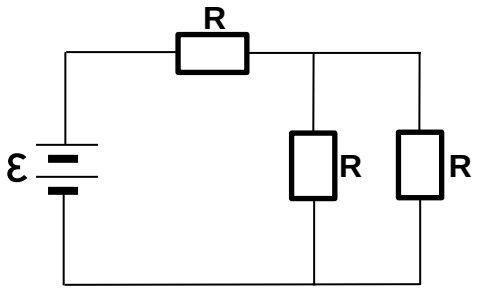
A $kg \cdot m \cdot s^{-1}$ B $kg \cdot m \cdot s^{-2}$ C $kg \cdot m^2 \cdot s^{-2}$ D $kg \cdot m^2 \cdot s^{-1}$

1.7 Object A and Object B of equal mass **m** exert a force **F** on each other when placed a distance **r** apart. The mass of A is then doubled (2**m**) and the mass of B is made one quarter of its original mass $\left(\frac{1}{4}\mathbf{m}\right)$. The distance between object A and B is halved. The force between them is now:

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

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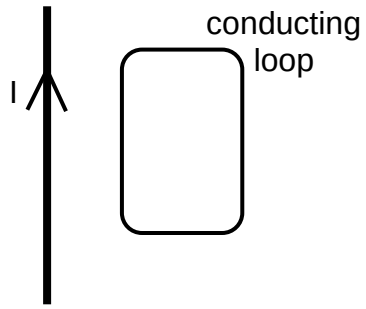
1.8 The resistors in the circuit shown below are identical. The battery has emf $\mathcal{E}$ and the internal resistance of the battery can be ignored.



The current through the battery is:

A $\frac{\varepsilon}{3R}$ B $\frac{3\varepsilon}{2R}$ C $\frac{2\varepsilon}{3R}$ D $\frac{\varepsilon}{R}$

1.9 The diagram below shows a current carrying wire with current flowing towards the top of the page, as shown. Alongside the wire is a closed conducting loop.

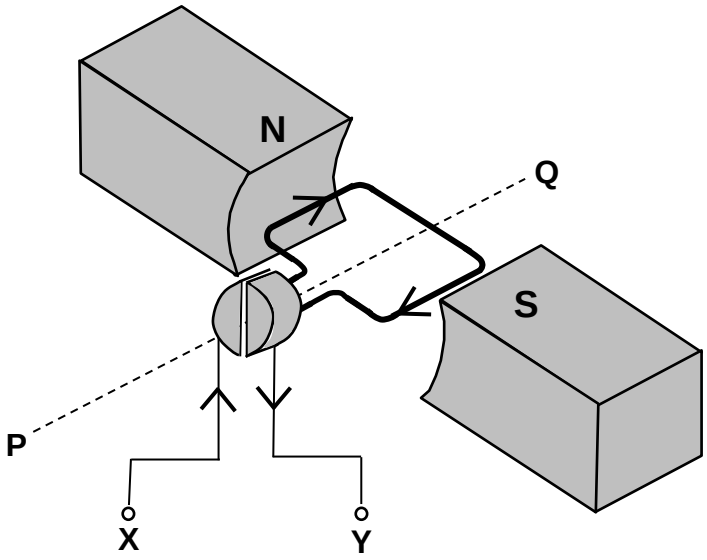


The current in the wire is increased. Choose the correct combination from the table below to describe the effect of increasing the current in the wire on the flux through the conducting loop and the direction of the current in the conducting loop.

	Flux through conducting loop	**Direction of current in loop**
A	Increases	Clockwise
B	Decreases	Clockwise
C	Increases	Anticlockwise
D	Decreases	Anticlockwise

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1.10 The simplified diagram below shows a set-up with a coil of wire in a magnetic field. The direction of current supplied through points X and Y is shown.



Identify the function of the set-up shown and the direction of rotation of the coil in the magnetic field, when viewed along the line P to Q.

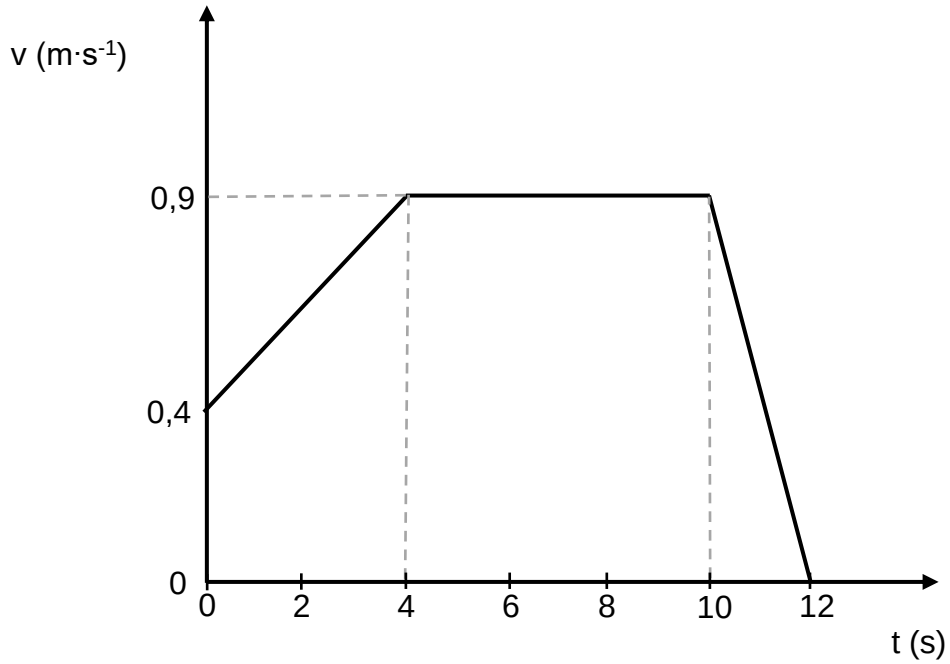
	Function of set-up	**Direction of rotation of coil**
A	Motor	Clockwise
B	Motor	Anticlockwise
C	Generator	Clockwise
D	Generator	Anticlockwise

[20]

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QUESTION 2 KINEMATICS

The velocity-time graph below represents the motion of a trolley on a surface during a 12 second time period:



2.1 Define *acceleration*. (2)

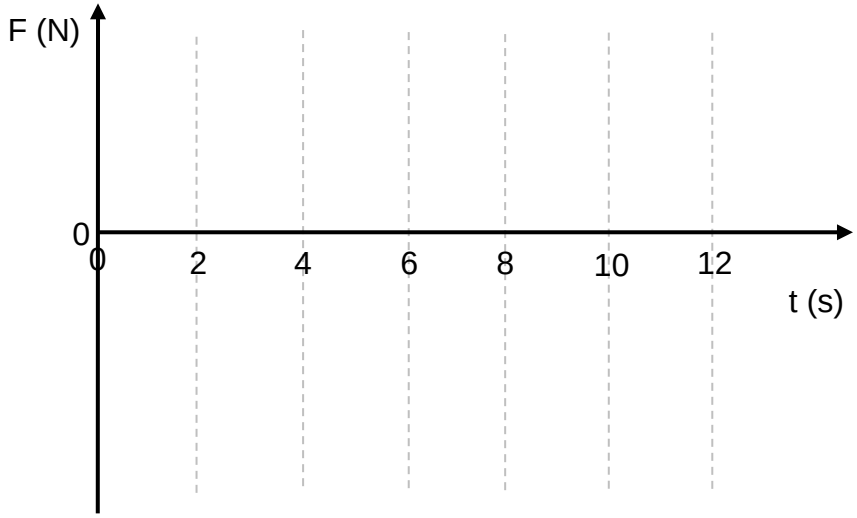
2.2 Determine the magnitude of the acceleration of the trolley during the first 4 seconds shown. (3)

2.3 Calculate the magnitude of the displacement of the trolley from 0 s to 4 s. (3)

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

2.5 On the axes given below, sketch a graph of the net force acting on the trolley over the 12 second period. No values need to be shown. (4)



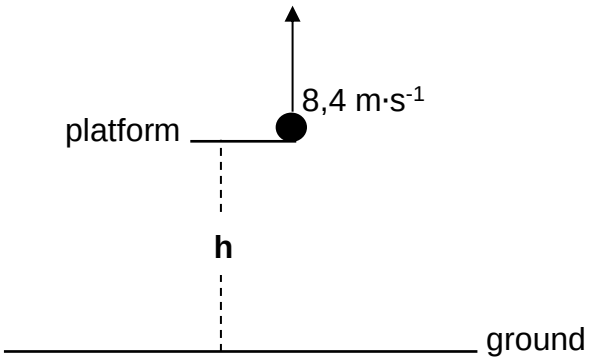
2.6 The magnitude of the net force on the trolley between 10 s and 12 s is 0,18 N. Determine the mass of the trolley. (3)

[17]

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QUESTION 3 KINEMATICS

A ball is hit vertically upwards at 8,4 m·s^{-1} from a platform of unknown height (**h**) above the ground. The ball lands on the ground 2,25 seconds after it is hit.



3.1 Determine the maximum height above the platform that the ball reaches. (3)

3.2 Calculate the time that the ball takes to reach maximum height. (3)

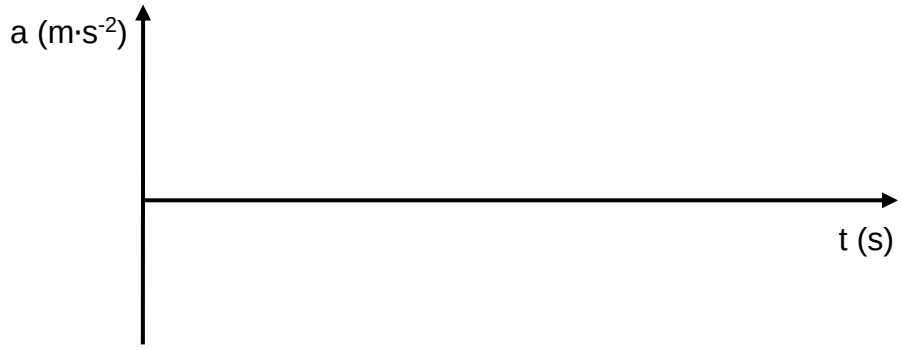
3.3 Calculate the height (**h**) of the platform above the ground. Give your answer to one decimal place. (4)

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3.4 Sketch a position-time graph for the motion of the ball from when it was hit from the platform to when it landed on the ground. No further calculations are required, but known values of position and time should be shown.
Use the ground as the reference frame (x = 0). (4)



3.5 Sketch an acceleration-time graph for the motion of the ball from when it was hit to when it landed on the ground. Indicate acceleration and time values on the graph.
(2)



[16]

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QUESTION 4 KINEMATICS – GRAPH SKILL

An object is moving along a frictionless surface at a constant velocity, $\mathbf{v_i}$. A constant force is applied to the object for varying distances and the final velocity of the object $\mathbf{v_f}$ is recorded in the table below:

Distance (m)	v_f (m·s^{-1})	v_f^2 (m^2·s^{-2})
1,6	1,7	2,9
3,4	2,0	4,0
4,6	2,2	4,8
7,0	2,5	6,3
8,0	2,6	6,8

4.1 Plot a graph of the final velocity squared ($\mathbf{v_f^2}$) of the object (on *y*-axis) vs the distance over which the force is applied to the object (on *x*-axis) on the graph paper on the next page. (6)
(Spare graph paper is printed on page 29, should you need it.)

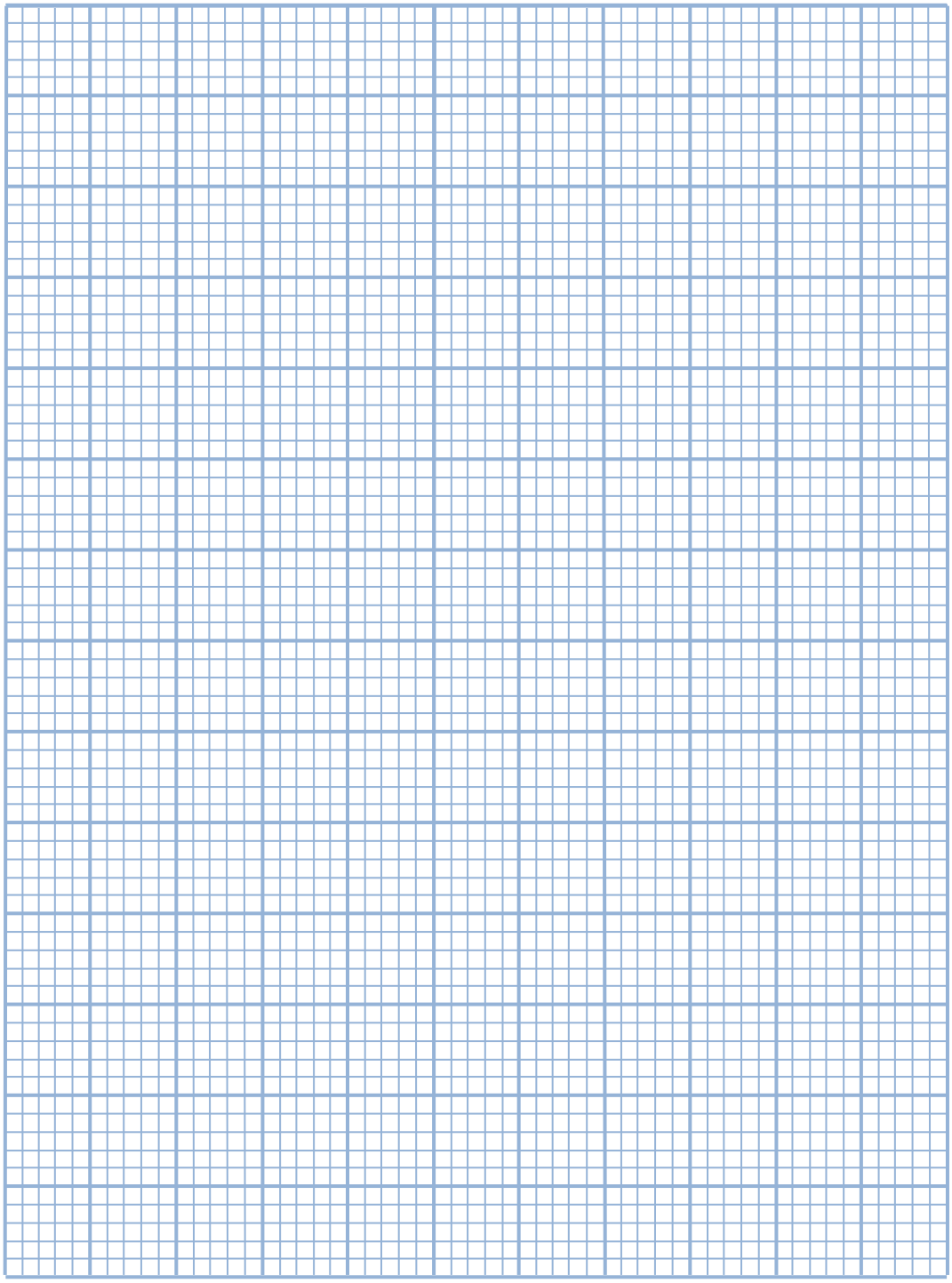
4.2 Calculate the gradient of your graph. Show your working below and indicate on your graph which points you have used. (4)

4.3 Use the equation of motion $v_f^2 = v_i^2 + 2as$ and the gradient of your graph calculated above to determine the magnitude of the acceleration of the object. (3)

4.4 Use your graph to determine the magnitude of the initial velocity $\mathbf{v_i}$ of the object. (2)

[15]

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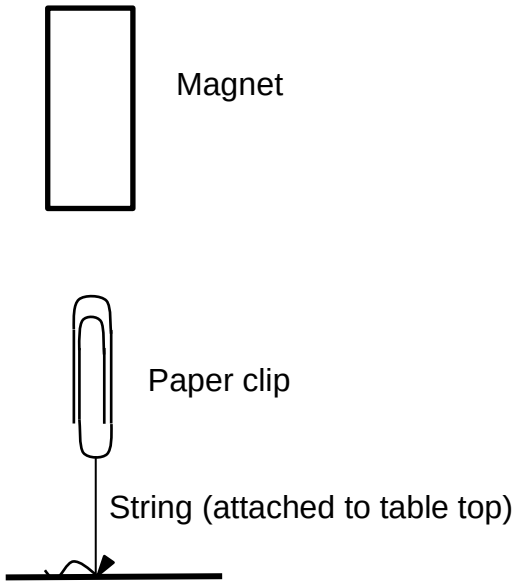


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QUESTION 5 PHYSICS GAMES

5.1 Magnets attract certain metal objects, such as steel paper clips.

A paper clip (with a mass of 2 g) is tied to a very thin piece of string (with negligible mass) and the other end of the string is attached to a table top. A strong magnet is held near the paper clip so that the paper clip is stationary in the position shown in the diagram below:



5.1.1 Draw a free-body diagram of all the forces acting on the paper clip. (3)

5.1.2 Calculate the tension in the string, if the magnet exerts a force of 0,24 N on the paper clip at this distance. (3)

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The string comes loose from the table and the paper clip moves upwards.

5.1.3 Is it correct to state that the net force on the paper clip just after the string comes loose is equal to the tension in the string calculated in Question 5.1.2? Explain your reasoning. (3)

5.1.4 Explain why we cannot use an equation of motion to calculate the time that the paper clip is in the air after the string comes loose. (2)

5.2 A cricket ball (mass 0,16 kg) and a tennis ball (mass 0,06 g) roll towards one another on a horizontal, frictionless surface and collide. Friction and rotational effects of the ball must be ignored.

The cricket ball is moving at 0,4 $m \cdot s^{-1}$ to the right before the collision and comes to rest immediately after the collision. The tennis ball is moving at 0,85 $m \cdot s^{-1}$ to the left before the collision.

5.2.1 State the *law of conservation of linear momentum*. (2)

5.2.2 Determine the velocity of the tennis ball immediately after the collision. (4)

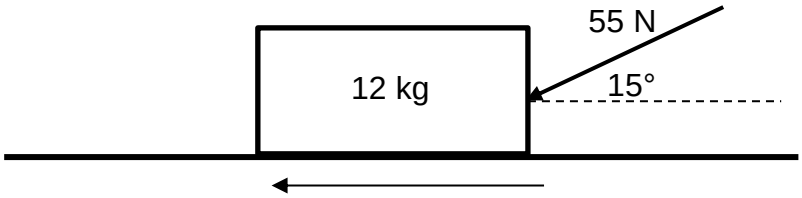
[17]

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QUESTION 6 FORCES, WORK & ENERGY

A student pushes a 12 kg box from rest with a force of 55 N that is applied at an angle of 15° to the horizontal, as shown in the diagram below.

The box moves 2 m and then the student stops pushing the box.



Direction of motion of box

The coefficient of kinetic friction between the box and the floor is 0,3.

6.1 Calculate the work done by the student while pushing the box. (3)

6.2 Define *frictional force*. (2)

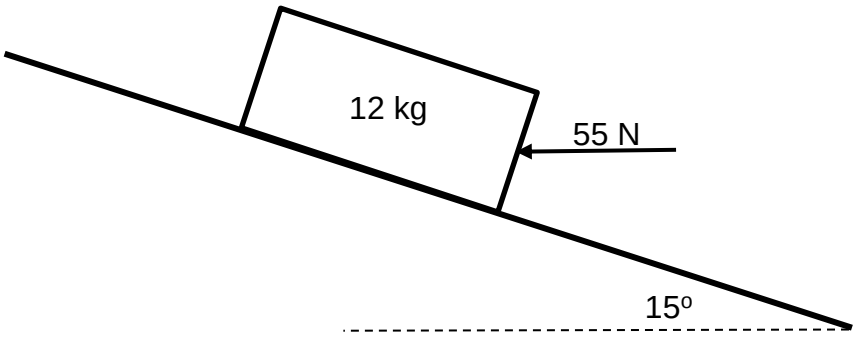
6.3 Calculate the magnitude of the frictional force that the box experiences as it is being pushed. (4)

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6.4 Sketch a velocity-time graph for the motion of the box from the moment the student starts pushing it to when it comes to rest. No velocity or time values need to be shown on your graph. (4)



The student applies the same force of 55 N horizontally on the box as it moves up a **frictionless** incline, as shown in the diagram below. The incline is at an angle of 15° to the horizontal.



6.5 Would the work done by the student in pushing the box a distance of 2 m up this frictionless incline be LESS THAN, THE SAME AS or GREATER THAN the work done by the student pushing the box as calculated in Question 6.1. Explain your reasoning. (3)

[16]

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QUESTION 7 SPORT

A hockey ball with a mass of 200 g is at rest when it is hit by a stick that applies a horizontal force of 30 N to the ball. The ball leaves the stick travelling at 25 $m \cdot s^{-1}$ along the ground.

7.1 Will the force that the ball exerts on the stick be GREATER THAN 30 N, EQUAL TO 30 N or LESS THAN 30 N? Briefly justify your answer. (2)

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

7.3 If the hockey ball comes to rest after travelling a distance of 44,6 m, calculate the magnitude of the frictional force that the ball experiences. (3)

7.4 Define *impulse*. (2)

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7.5 Explain how the velocity of the hockey ball could be increased while the same force is applied by the stick. Use an appropriate equation in your answer. (3)

7.6 Another hockey ball is hit towards the goal from a point that is 15 m from the goal. The ball travels along the ground at a constant speed of 14 $m \cdot s^{-1}$ (friction can be ignored). A player, who is 6 m from the goal, accelerates from rest towards the goal to try and stop the ball before it reaches the goal. This player starts running 0,25 s after the ball was hit.

Calculate the minimum acceleration of the player to reach the ball before it reaches the goal. (4)

[16]

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QUESTION 8 FIELDS

8.1 Mercury is the closest planet to the Sun, with a distance of 46×10^6 km between the centre of the Sun and the centre of Mercury, when Mercury is at its closest to the Sun.

Mercury has a mass of $3{,}3 \times 10^{23}$ kg and the Sun has a mass of $1{,}99 \times 10^{30}$ kg.

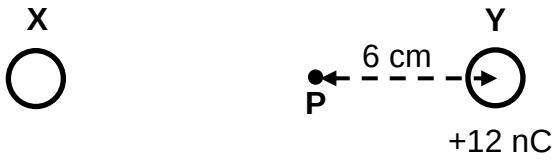
8.1.1 State *Newton's law of universal gravitation*. (2)

8.1.2 Calculate the magnitude of the gravitational force exerted by the Sun on Mercury when Mercury is at its closest distance to the Sun. (4)

8.1.3 Mercury's radius is 2 441 km. Calculate the magnitude of the gravitational field on the surface of Mercury. (4)

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8.2 Two identical spheres, **X** and **Y**, which are positively charged, are placed 15 cm apart in empty space. Sphere **X** has a positive charge of unknown magnitude. Sphere **Y** has a charge of +12 nC, which is greater than the magnitude of the charge on **X**. Point **P**, shown in the diagram below, is 6 cm from sphere **Y**.



8.2.1 Define *the electric field at a point*. (2)

8.2.2 Determine the magnitude and direction of the electric field due to charge **Y** at point **P**. (5)

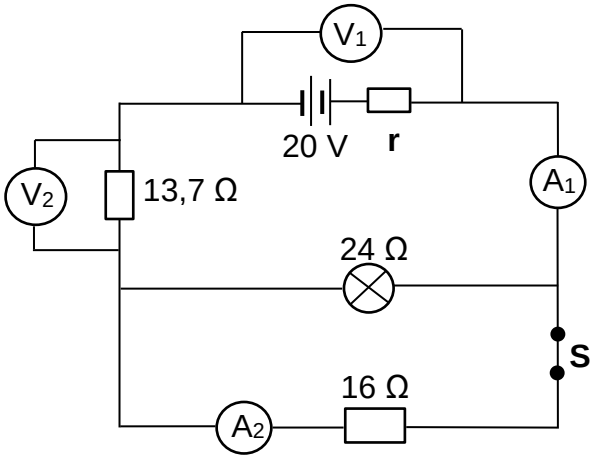
8.2.3 Would the resultant electric field at point **P** due to both charges be TOWARDS **X** or TOWARDS **Y**? Explain your answer. (3)

[20]

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QUESTION 9 ELECTRIC CIRCUITS

The circuit below is connected to a battery with an emf of 20 V and a significant, but unknown internal resistance, **r**. Switch **S** is initially closed, as shown. Ammeter A_1 reads 0,8 A.



9.1 State *Ohm's Law*. (2)

9.2 Calculate the reading on V_2. (3)

9.3 Determine the effective resistance of the bulb and resistor in parallel, when switch **S** is closed. (2)

9.4 Determine the reading on ammeter A_2 when switch **S** is closed. (4)

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9.5 Calculate the power dissipated by the bulb. (4)

9.6 Calculate the internal resistance, **r**, of the battery. (4)

9.7 *For each of the questions below, circle the appropriate answer and explain your answer when instructed to:*

Switch S is now opened. How will this affect the:

9.7.1 reading on V_2? (2)

INCREASE or STAY THE SAME or DECREASE

9.7.2 reading on V_1? (3)

INCREASE or STAY THE SAME or DECREASE

Briefly explain your answer.

9.7.3 brightness of the bulb? (3)

INCREASE or STAY THE SAME or DECREASE

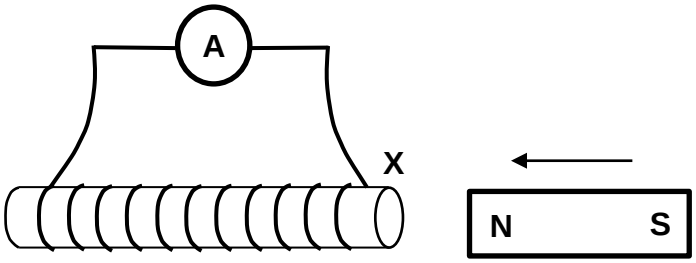
Briefly explain your answer.

[27]

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QUESTION 10 ELECTRODYNAMICS

10.1 A coil wrapped around a soft iron core is suspended by a light conducting wire, so that it is able to move. The North pole of a magnet is moved towards the coil as shown in the diagram below.



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

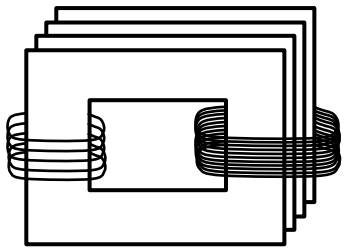
10.1.2 Would the side of the coil marked X be a North or a South pole? (2)

10.1.3 As the magnet moves towards the coil, what would you expect to observe? (2)

10.1.4 What would you observe when the magnet stops moving towards the coil? Explain your answer. (4)

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10.2 The transformer shown below has 92 turns on the primary coil and 414 turns on the secondary coil. The input voltage is 48 V.



10.2.1 Is this a step-up or a step-down transformer? Briefly explain your answer. (2)

10.2.2 Calculate the output voltage of this transformer. (4)

10.2.3 Explain why transformers only operate using alternating current and not direct current. (2)

[18]

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QUESTION 11 PHOTONS AND ELECTRONS

Electrons are emitted from an aluminium surface when radiation with a frequency of 18×10^{14} Hz is shone on the surface. The work function of aluminium is 4,3 eV.

11.1 Define *threshold frequency*. (2)

11.2 Calculate the threshold frequency of aluminium. (4)

11.3 Determine the maximum kinetic energy of the emitted electrons. (4)

11.4 The intensity of the 18×10^{14} Hz radiation is increased. Circle the phrase that best describes how this will affect:

11.4.1 the velocity of the emitted electrons. (2)

INCREASES or STAYS THE SAME or DECREASES

11.4.2 the number of emitted electrons per unit time. (2)

INCREASES or STAYS THE SAME or DECREASES

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Light with a wavelength of 200 nm is shone on the aluminium surface.

11.5 Would this light of 200 nm emit electrons from the aluminium surface? Justify your answer with a calculation. (4)

[18]

Total: 200 marks

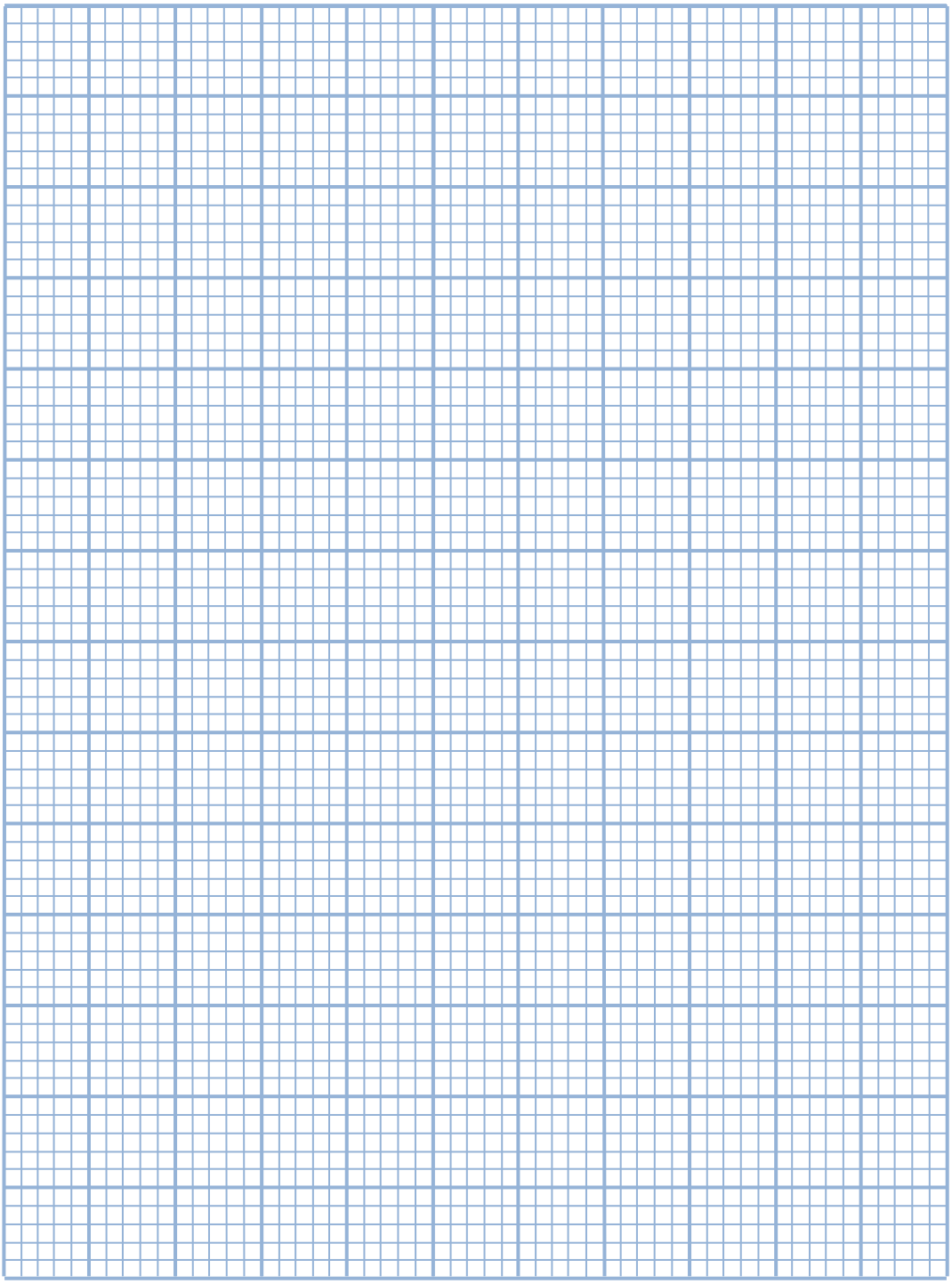
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ADDITIONAL SPACE (ALL QUESTIONS)

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

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QUESTION 4.1 EXTRA GRAPH PAPER



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ADDITIONAL SPACE (ALL QUESTIONS)

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

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