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TOTAL MARKS

NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 2025

PHYSICAL SCIENCES: PAPER I

EXAMINATION NUMBER

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Time: 3 hours

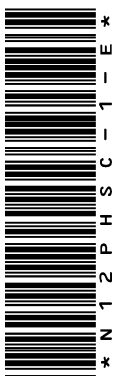
200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 28 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 when 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 26 & 28) and extra graph paper (page 27) are included at the end of the paper. If you run out of space for a question, use these pages. Clearly indicate the number of your answer should you use this extra space.

FOR OFFICIAL USE ONLY: MARKER TO ENTER MARKS

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Total
Mark										
Marker Initial										
Moderated Mark										
Moderator Initial										
Question Total	20	24	23	25	29	16	29	16	18	200
Re-mark										
Initial										
Code										



QUESTION 1 MULTIPLE CHOICE

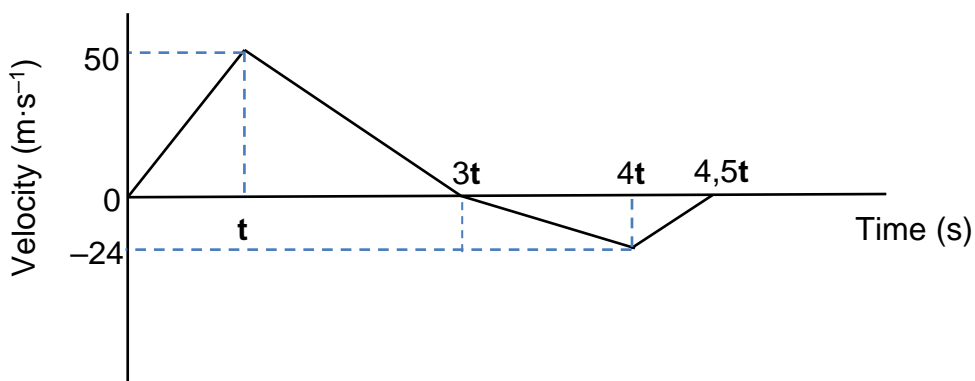
Answer these questions on the answer grid below. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

A	B	C	D
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Here, 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 A car travelled in a straight line throughout its motion. The velocity-time graph given below illustrates how the car's velocity changed over time. The graph is not drawn to scale.



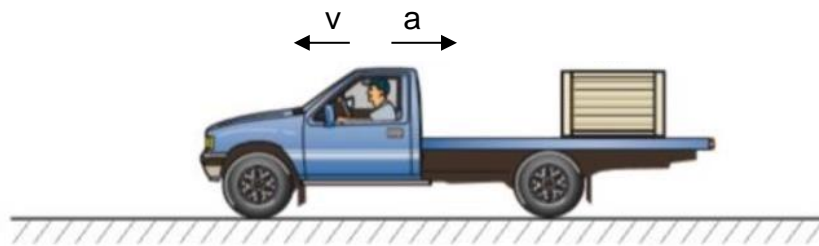
During which interval did the greatest net force act on the car?

- A $0 \rightarrow t$
- B $t \rightarrow 3t$
- C $3t \rightarrow 4t$
- D $4t \rightarrow 4,5t$

1.2 A ball is in contact with the floor for a brief period during a bounce. Which one of the following combinations is correct for the ball while it is in contact with the floor?

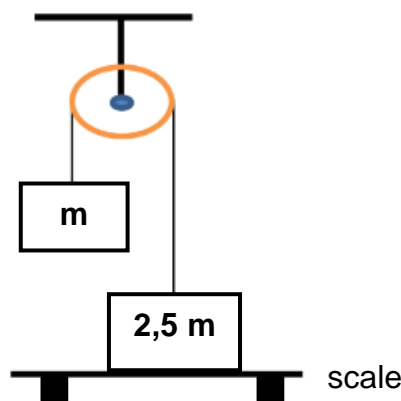
	Direction of Δv	Relationship between F_N and F_g on the ball
A	Upward	$F_N < F_g$
B	Downward	$F_N = F_g$
C	Upward	$F_N > F_g$
D	Downward	$F_N > F_g$

1.3 A crate is at rest on the back of a truck that is moving on a flat, horizontal road. The truck has a velocity to the left, but its acceleration is to the right.



The force of friction on the CRATE is ...

- A to the left and is equal to $\mu_s F_N$.
 - B to the left but is not necessarily equal to $\mu_s F_N$.
 - C to the right and is equal to $\mu_s F_N$.
 - D to the right but is not necessarily equal to $\mu_s F_N$.
- 1.4 Two objects with masses m and $2,5 m$ respectively are connected by a string that runs over a frictionless pulley, as shown in the diagram below. The $2,5 m$ mass rests on a scale measuring in Newtons. Ignore the mass of the pulley, the mass of the string and all the effects of friction.



Which one of the following expressions best describes the force reading on the scale if this experiment is done on Earth?

- A $24,5 m$
- B $1,5 m$
- C $14,7 m$
- D $2,5 m$

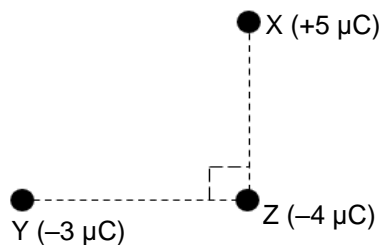
- 1.5 Two trolleys, each with a mass m , are held stationary with a compressed spring between them on a frictionless surface. When the spring is released, the trolleys move in opposite directions, each with a speed v . Which one of the following best describes the total momentum of the system and the nature of the interaction (collision) which takes place?

	Total momentum	Nature of interaction (collision)
A	Conserved	Elastic
B	Conserved	Inelastic
C	Not conserved	Elastic
D	Not conserved	Inelastic

- 1.6 Assume the mass of the earth is M , and it has a radius of r . An object has a weight of W on Earth. What will the weight of the object be on a planet which has a mass of $4M$ and a radius of $\frac{1}{4}r$?

- A $8W$
- B $16W$
- C $32W$
- D $64W$

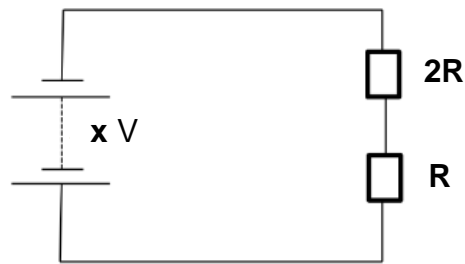
- 1.7 Three-point charges are placed at fixed positions X, Y and Z as shown in the diagram below.



In which direction does the point charge placed at position Z ($-4 \mu\text{C}$) experience a net force?

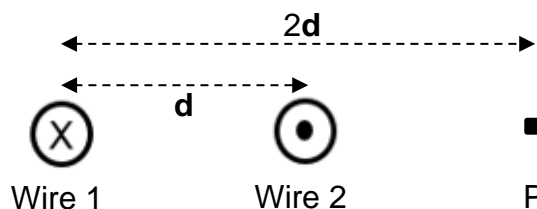
- A
- B
- C
- D

- 1.8 The battery in the circuit shown below, has an emf of x V and negligible internal resistance. The resistors are connected in series and have resistances of R and $2R$, as shown in the diagram.



What is the potential difference in volts across resistor R ?

- A $\frac{1}{2}x$
 - B $\frac{1}{3}x$
 - C $\frac{2}{3}x$
 - D x
- 1.9 Wire 1 and Wire 2 are both current-carrying conductors which are positioned as shown in the diagram below. Both wires carry equal current. Point P is a distance $2d$ and d away from Wire 1 and Wire 2 respectively.



Which of the following best represents the direction of the resultant magnetic field at point P?

- A Downwards (clockwise)
 - B Out of the page
 - C Upwards (anticlockwise)
 - D Into the page
- 1.10 The component of a DC motor that ensures that the coil rotates continuously in ONE DIRECTION is the ...
- A split-ring commutator.
 - B slip rings.
 - C carbon brushes.
 - D battery.

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QUESTION 2 KINEMATICS

A car was travelling along a straight, level road at a constant velocity. The car's velocity was $144 \text{ km}\cdot\text{h}^{-1}$ North as it passed a stationary police officer's car.

2.1 Define *velocity*. (2)

2.2 Convert the car's velocity to $\text{m}\cdot\text{s}^{-1}$. (2)

As the car passed the police officer, the car slowed down at a constant rate for 14 s to travel at the speed limit of $120 \text{ km}\cdot\text{h}^{-1}$.

2.3 Define *displacement*. (2)

2.4 Calculate the distance covered by the car while slowing down for 14 s. (5)

The stationary police officer started chasing the car as the car went past. The police officer accelerated uniformly at $3,5 \text{ m}\cdot\text{s}^{-2}$ for 14 s, after which the police officer maintained a constant speed until they caught up with the car.

2.5 Calculate the magnitude of the police officer's displacement while accelerating. (3)

2.6 Calculate the time it takes the police officer to catch up with the car from the start of the chase. (6)

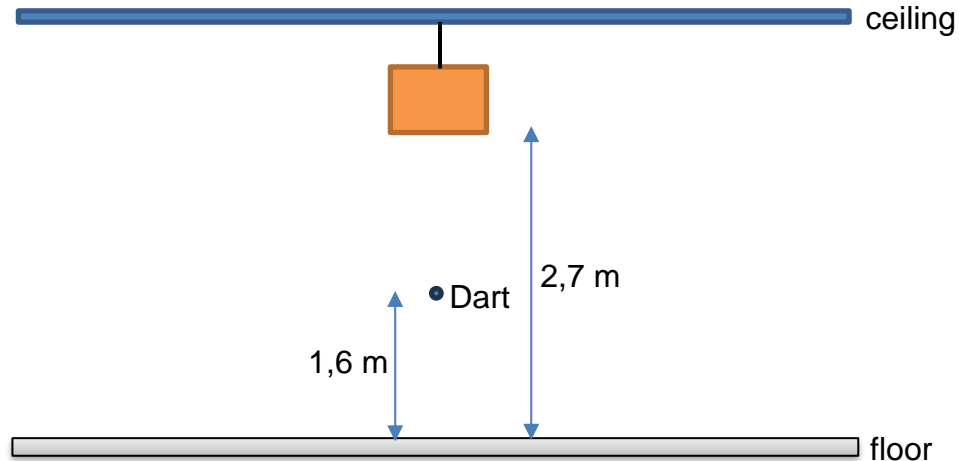
2.7 On the axes below, draw velocity-time graphs for each vehicle from the moment the chase started until the police officer caught up with the car. Clearly label your graphs POLICE CAR and CAR. (4)



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QUESTION 3 KINEMATICS

A block hangs vertically downwards from the ceiling. The distance between the floor and the bottom of the block is 2,7 m, as shown in the diagram below. A student throws a dart vertically upwards towards the block from a height of 1,6 m above the floor. The dart imbeds in the block. The diagram is not drawn to scale.



- 3.1 State the position of the dart relative to the bottom of the block, before it is thrown upwards. (2)

The dart strikes the block with a velocity of $5 \text{ m}\cdot\text{s}^{-1}$ upwards and comes to rest in the block. The effects of air resistance and any other external forces are negligible.

- 3.2 Calculate the magnitude of the velocity with which the dart was thrown. (4)

The dart has a mass of 45 g while the block has a mass of 255 g.

- 3.3 State the *Law of Conservation of Linear Momentum*. (2)

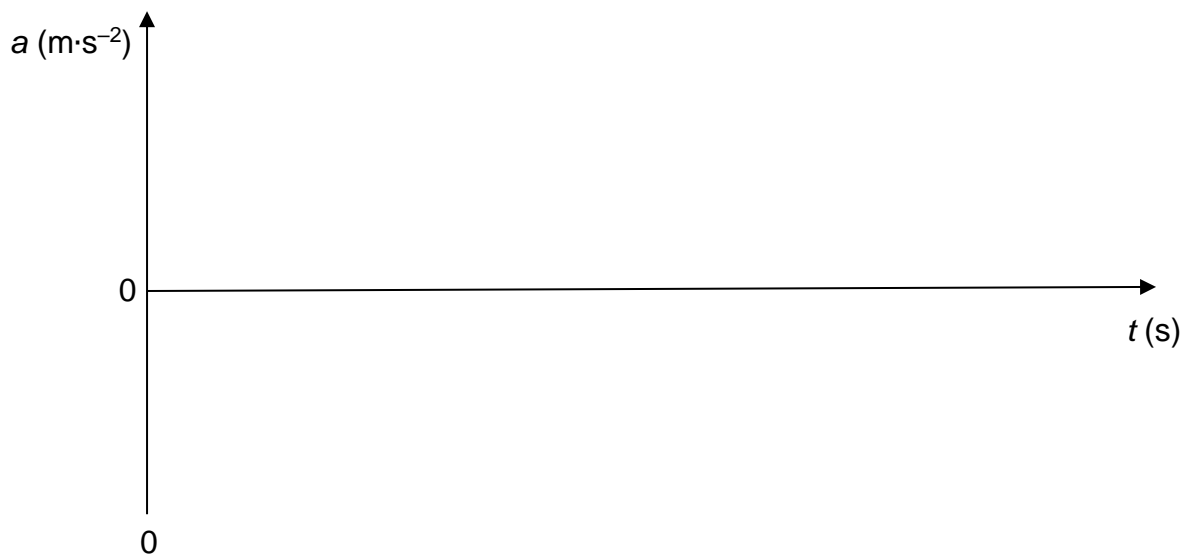
Ignore the effects of air resistance and any other external forces during the collision.

3.4 Calculate the velocity of the dart-block system immediately after the collision. (4)

3.5 Define *acceleration*. (2)

3.6 Upon inspection, it was found that the dart penetrated the block to a depth of 5 cm. Calculate the average acceleration of the dart as it penetrates the block. (4)

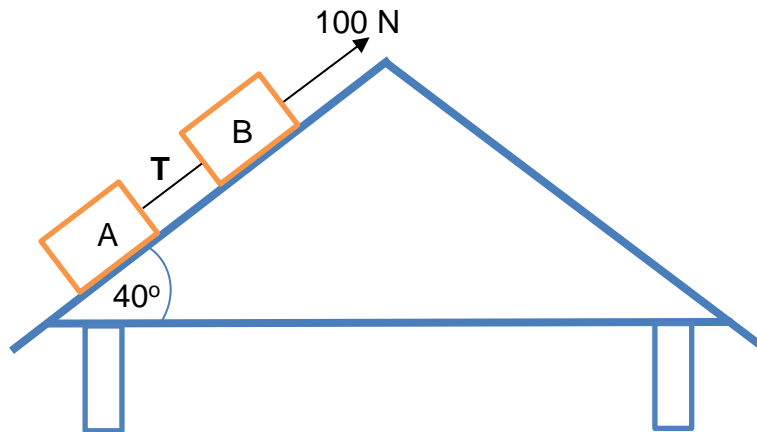
3.7 On the axes below, draw an acceleration-time graph for the entire motion of the dart after it was thrown. Acceleration values must be shown, but time values are not needed. (5)



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QUESTION 4 TWO-BODY SYSTEM

Block A (mass 20 kg) is attached to Block B (mass 10 kg) via a light inextensible string as shown in the diagram below. The blocks are lowered down a rough symmetrical roof by a contractor who applies an upward force of 100 N, parallel to the roof. The tension in the string connecting the two blocks is labelled **T**. The coefficient of kinetic friction between each block and the roof is 0,2.



4.1 Define *weight*. (2)

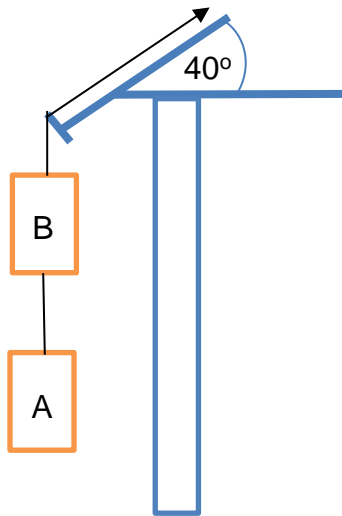
4.2 Draw a labelled free-body diagram of all the forces acting on Block B as it slides down the roof. (5)

4.3 Calculate the magnitude of the frictional force acting on Block A as it slides down the roof. (4)

4.4 Hence, state the magnitude of the frictional force acting on Block B. (2)

4.5 Calculate the magnitudes of the tension labelled **T** AND the acceleration of the blocks. (6)

The blocks slide over the side of the roof while the contractor continues to lower them down to the ground with the same force as before, as shown in the diagram below. All effects of friction can now be ignored.

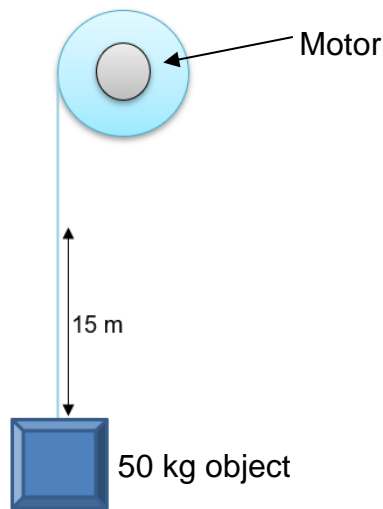


4.6 How does the acceleration of the blocks now compare to the value calculated in Question 4.5? State only GREATER THAN, LESS THAN or EQUAL TO. (2)

4.7 How does the magnitude of the tension in the string connecting the two blocks compare to the weight of Block A? State GREATER THAN, LESS THAN or EQUAL TO and explain your answer by referring to a relevant formula and using Block A as reference. (4)

QUESTION 5 SYSTEMS

- 5.1 An electrical motor is used to lift a 50 kg object through a height of 15 m as shown in the diagram below. The object is lifted at a constant speed of $1,5 \text{ m}\cdot\text{s}^{-1}$.



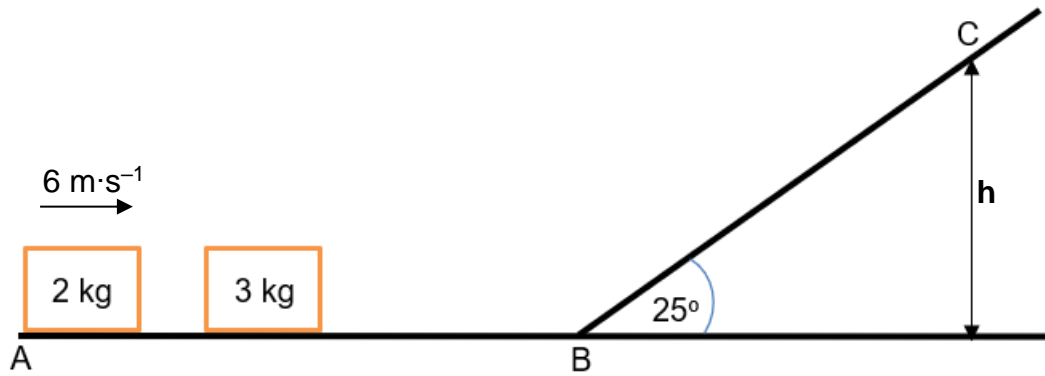
5.1.1 Define *power*. (2)

5.1.2 Calculate the power output of the electrical motor. (3)

5.1.3 The electrical motor is rated as 1,2 kW; 220 V. Explain the meaning of this statement. (2)

5.1.4 Calculate the percentage efficiency of the electrical motor. (3)

- 5.2 A crate of mass 2 kg slides along a frictionless horizontal surface AB at $6 \text{ m}\cdot\text{s}^{-1}$. It collides with a stationary 3 kg crate and comes to rest after the collision.



- 5.2.1 Show, by doing an appropriate calculation, that the speed of the 3 kg crate at point B is $4 \text{ m}\cdot\text{s}^{-1}$. (3)

- 5.2.2 Use appropriate calculations to determine if the collision of the two crates was elastic or inelastic. (4)

After the collision, the 3 kg crate slides up the incline BC and experiences a frictional force of 8 N until it reaches its maximum height (**h**).

5.2.3 Define *frictional force*. (2)

5.2.4 Draw a labelled free-body diagram of all the forces acting on the 3 kg crate as it slides up incline BC. (3)

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

5.2.6 Calculate the maximum height (**h**) reached by the 3 kg crate. (5)

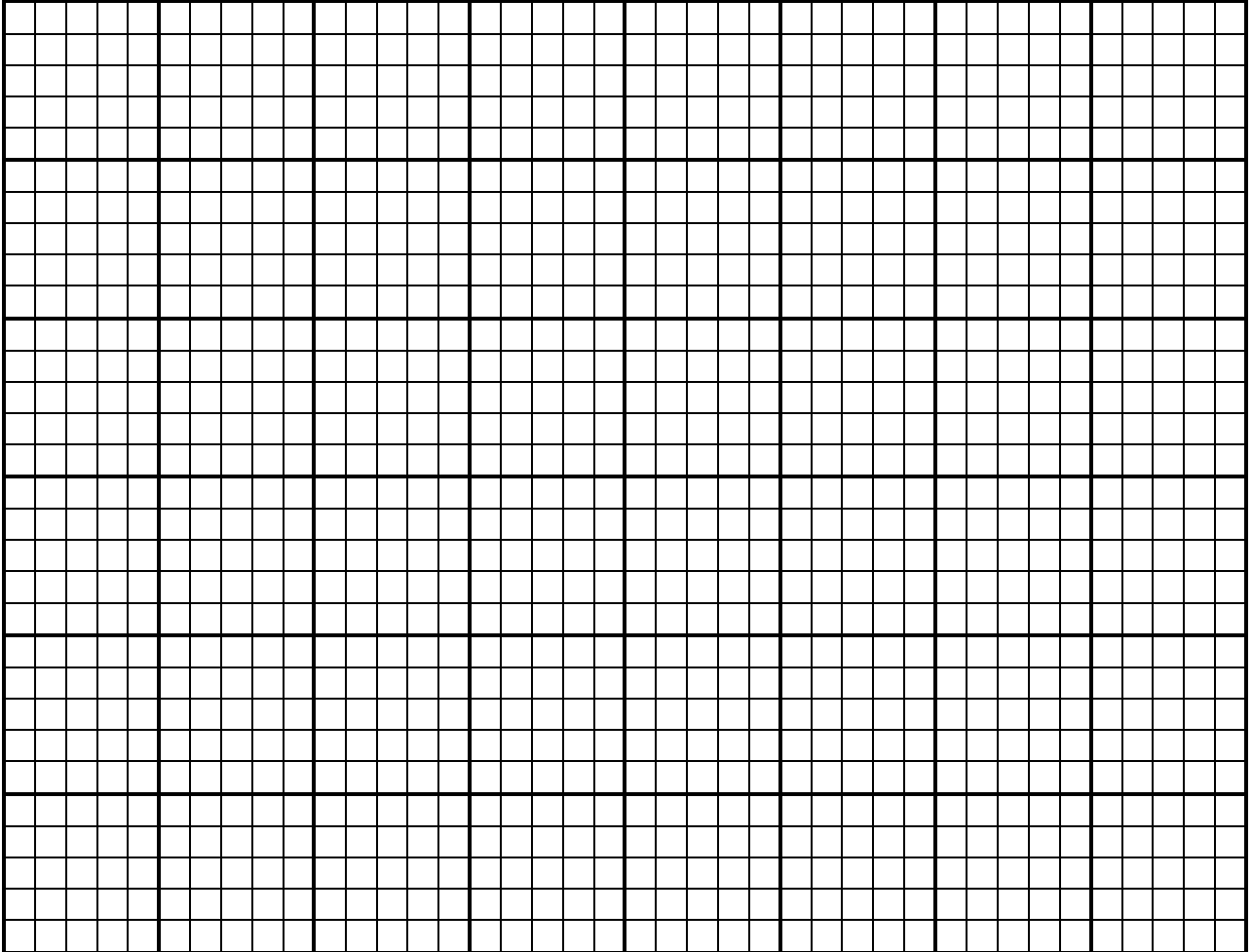
QUESTION 6 FIELDS

The electric field was measured at a constant distance from various point charges. The results obtained are shown in the table below:

The magnitude of the electric field ($\times 10^5 \text{ N}\cdot\text{C}^{-1}$)	The magnitude of the charge ($\times 10^{-6} \text{ C}$)
0,4	1,4
0,8	2,3
1,4	3,8
1,9	5,0
2,2	6,1
2,4	6,6

- 6.1 Define *electric field at a point*. (2)
- 6.2 Plot a graph of the magnitude of the electric field (on *y*-axis) versus the magnitude of the charge (on *x*-axis) on the graph paper provided on the next page. (6)
- 6.3 Calculate the gradient of your graph. Show the values that you used on your graph. Include a relevant unit in your answer. (4)
- 6.4 Use a relevant formula and the value that you calculated in Question 6.3 to determine the distance at which the electric field strength was measured. (4)

Graph paper for Question 6.2.

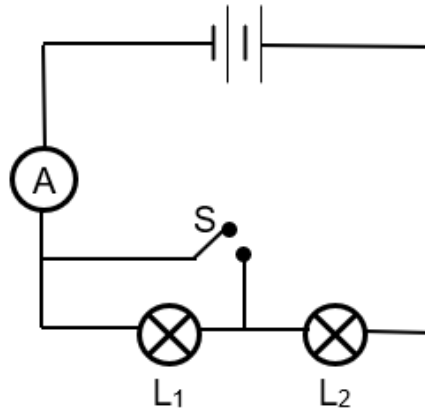


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QUESTION 7 ELECTRIC CIRCUITS

- 7.1 In the circuit represented below, the battery has an emf of 12 V and negligible internal resistance. The resistance of the connecting wires and the ammeter can be ignored.

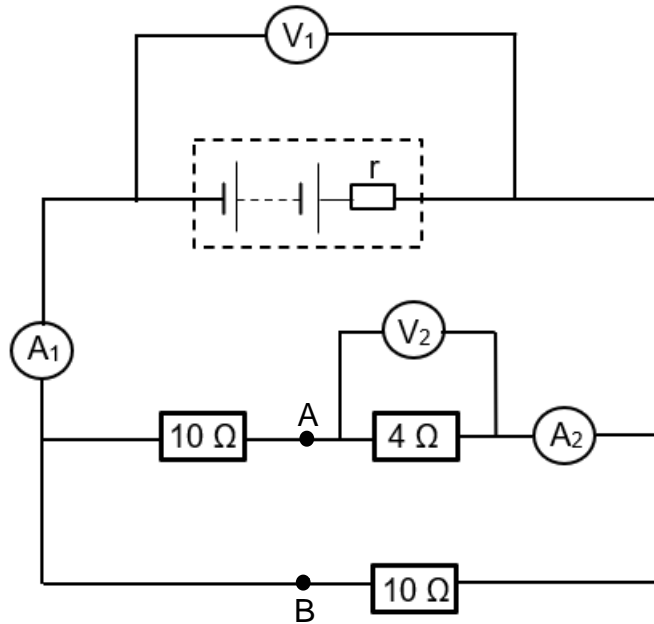


- 7.1.1 Define *current*.

(2)

- 7.1.2 How would the brightness of L₂ be affected if switch **S** is closed? Explain your answer by referring to a relevant formula. (4)

7.2 In the circuit represented below, the battery has an unknown emf and an internal resistance of 1Ω . Ammeter A_1 reads $1,32 \text{ A}$. The ammeters have zero resistance, and the voltmeters have infinite resistance.



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

7.2.2 Determine the total resistance of the external circuit. (3)

7.2.3 Calculate the emf of the battery. (3)

7.2.4 Calculate the reading on voltmeter V_2 . (4)

7.2.5 Calculate the heat dissipated in the $4\ \Omega$ resistor if current flows for 2 minutes. (4)

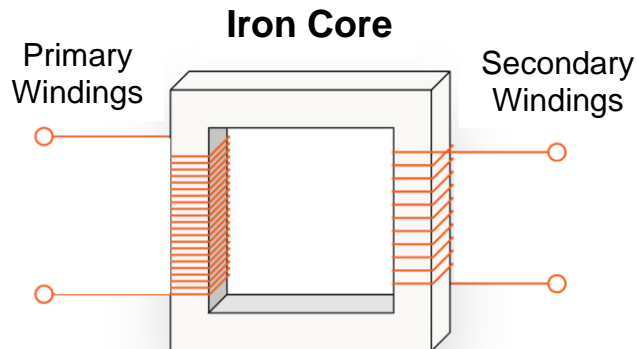
A voltmeter V_3 is now connected between points A and B indicated in the circuit diagram.

7.2.6 Determine the reading on voltmeter V_3 . (3)

7.2.7 When points A and B are connected by a conducting wire, what happens to the reading on V_1 ? Write only INCREASES, DECREASES or REMAINS THE SAME and explain your answer. (4)

QUESTION 8 ELECTRODYNAMICS

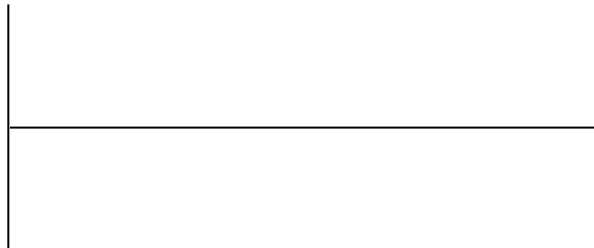
The diagram below shows a simple transformer with primary windings, secondary windings, and an iron core.



[Diagram source: <<https://www.maddoxtransformer.com/electrical-transformers>>]

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

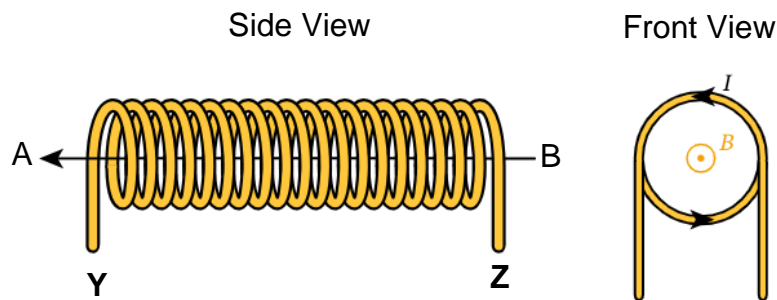
8.2 Draw a sketch graph of current versus time for the input to this transformer. (2)



8.3 Explain the operation of a transformer. (3)

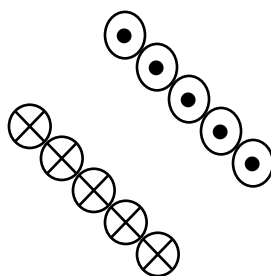
- 8.4 Hence, explain why the emf across the secondary windings is less than the emf across the primary windings. Use a suitable formula to aid your explanation. (2)

A diagram of a simple solenoid is shown below. A DC power supply must be connected across the ends of the solenoid to create a magnetic field.



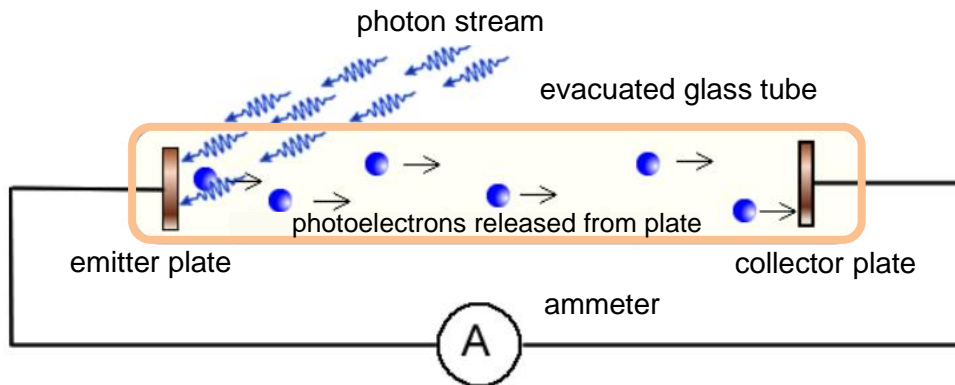
[Diagram source: <<https://www.nagwa.com/en/explainers/186157825721/>>]

- 8.5 Where must the positive terminal of the DC power supply be connected to set up a magnetic field line (AB) as shown in the diagram? Write only **Y** or **Z**. (2)
- 8.6 Does the front view represent the solenoid as seen from position A or position B? (2)
- 8.7 The diagram below represents the current flow in a different solenoid to the one shown above. Draw in the magnetic field lines AND also indicate where the north and south poles of the solenoid are situated. Draw at least three field lines. (3)



QUESTION 9 PHOTONS AND ELECTRONS

The apparatus shown below is known as a photosensitive vacuum tube. This is often used to illustrate the photoelectric effect. The incident radiation (labelled as the photon stream) is shone onto an emitter plate. Under specific conditions this metal plate can emit electrons, which will then move to the collector plate, causing the ammeter to register a current reading.



[Diagram reference: <www.cyberphysics.co.uk>]

9.1 State the significance of the photoelectric effect. (2)

9.2 State the specific condition under which the metal plate would emit electrons. (2)

The metal used on the emitter plate is tungsten. The work function of tungsten is 4,5 eV.

9.3 Convert the given work function of tungsten to joules. (2)

A UV light stream, with a wavelength of 200 nm, is shone onto the tungsten metal plate. The UV light source has an output power rating of 0,3 mW.

9.4 Calculate the energy of a single photon from the UV source. (3)

9.5 Calculate the maximum speed of the ejected electrons. (4)

9.6 Calculate the number of photons passing through a given cross-section of the UV light stream each second. (5)

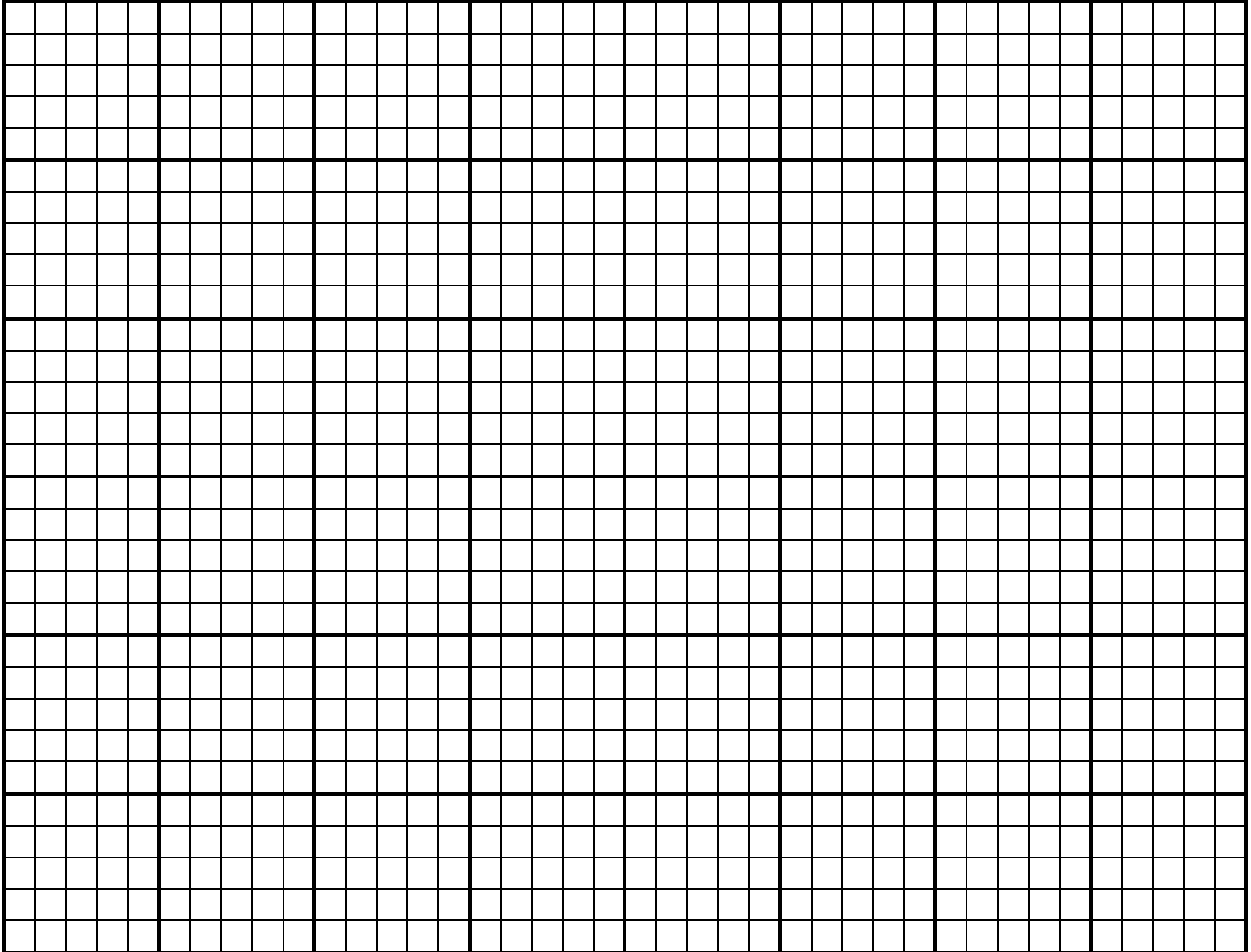
[18]

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.

QUESTION 6.2 EXTRA GRAPH PAPER



ADDITIONAL SPACE (ALL QUESTIONS)

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