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GLENWOOD
HOUSE
SCHOOL

PHYSICAL SCIENCES
Preliminary Examinations
Physics

Grade: 12
Date: 31 August 2020
Examiner: Mr Baehnisch

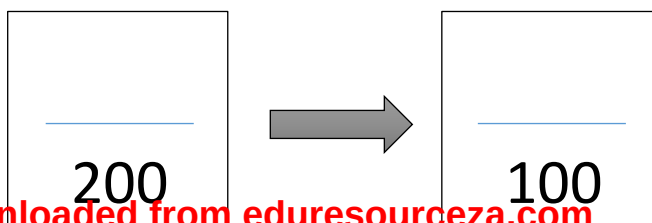
Time: 180 minutes
Marks: 200
Moderator: Mrs Baehnisch

Name: _____

INSTRUCTIONS

1. Answer ALL the questions
2. **START EACH QUESTION ON A NEW PAGE.**
3. It is in your own interest to write legibly and to present your work neatly. Please leave a line open after every sub question.
4. Ensure that the numbering of your answers is correct.
5. Show all your working, where necessary.
6. A data sheet is provided which may be used to assist you in answering the questions.
7. Round off your final answers to two decimal places. Use scientific notation where appropriate.
8. Answers must be expressed in decimal format, not left as proper fractions.
9. Staple your answer script to the back of this question paper.

QUESTION	1	2	3	4	5	6	7	8	9	10	TOTAL
MARK											
MAXIMUM MARK	20	17	31	24	12	20	17	20	24	15	200



In each of the following questions, four possible answers are provided. Write down the letter of the correct answer next to the question number. Leave a line open between answers.

1.1 Which one of the following consists of two scalar quantities?

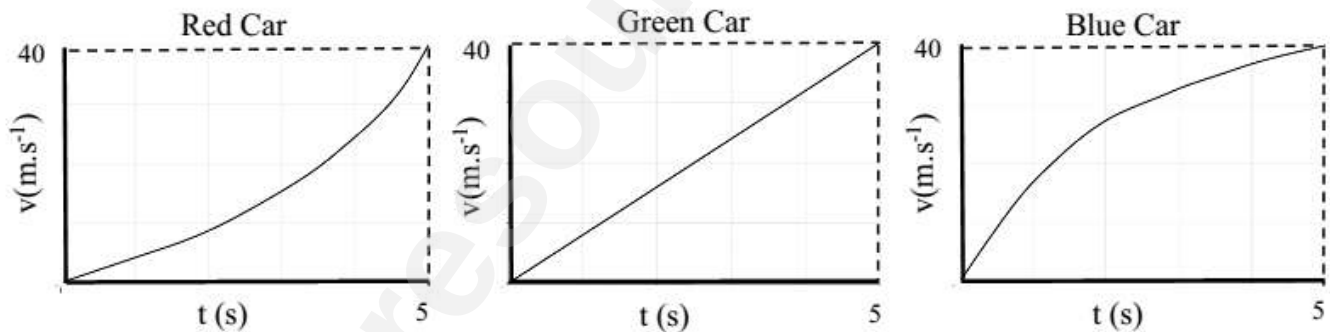
- A power and electric field
- B acceleration and velocity
- C frequency and energy
- D force and magnetic flux

1.2 Which one of the following is a unit of impulse?

- A N.s
- B N.m
- C kg.m.s^{-2}
- D N.s^{-1}

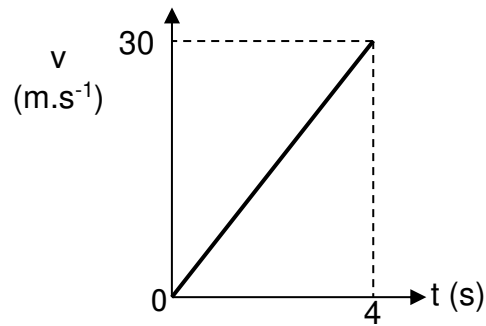
1.3 Velocity vs. time graphs are shown for three racing cars, a red car, a green car and a blue car.

At $t = 5 \text{ s}$ which car has the greatest displacement?



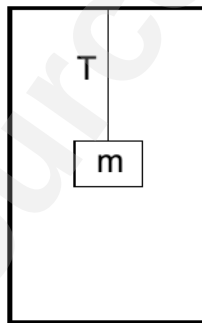
- A The red car
- B The green car
- C The blue car
- D All cars have the same displacement.

- 1.4 The graph shows how the velocity of a 500 kg motorcycle changes with time.



What is the net work done on the motorcycle?

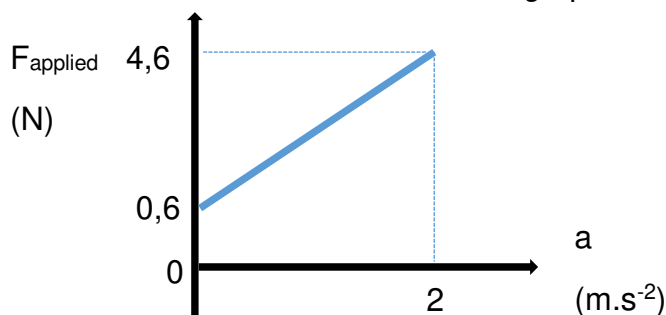
- A 120 J
 - B 225 kJ
 - C 3250 J
 - D 7500 J
- 1.5 An object, of mass m , hangs at the end of a string from the ceiling of a lift cage. The lift is moving downwards at uniform velocity. The acceleration due to gravity is g .



Which ONE of the following statements regarding the tension (T) in the string is CORRECT? The tension T ...

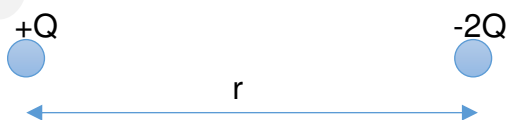
- A will be equal to mg .
- B will be less than mg .
- C will be greater than mg .
- D is zero

- 1.6 A 2 kg dynamics trolley was pulled across a rough surface using different horizontal applied forces and the acceleration was measured. The graph below summarises the results.



The magnitude of the coefficient of kinetic friction is

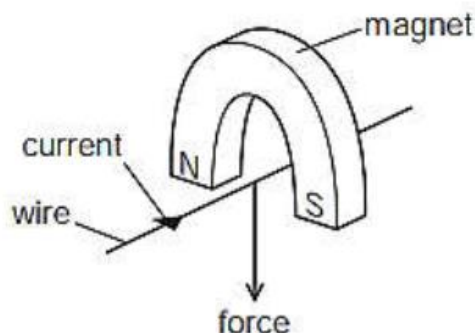
- A 0,031
 B 0,204
 C 0,235
 D 0,5
- 1.7 Two hypothetical planets, X and Y, with X having 3 times the mass of Y. The diameter of planet Y is double that of planet X. If the acceleration due to gravity on the surface of planet X is g , then the acceleration due to gravity on the surface of planet Y will be ...
- A $0,0833g$
 B $0,75g$
 C $6g$
 D $12g$
- 1.8 The diagram shows two particles at distance r apart. One particle has charge $+Q$ and the other $-2Q$. The two particles exert an electrostatic force of attraction, F , on each other. Each particle is then given an additional charge $+3Q$ and their separation is increased to distance $2r$.



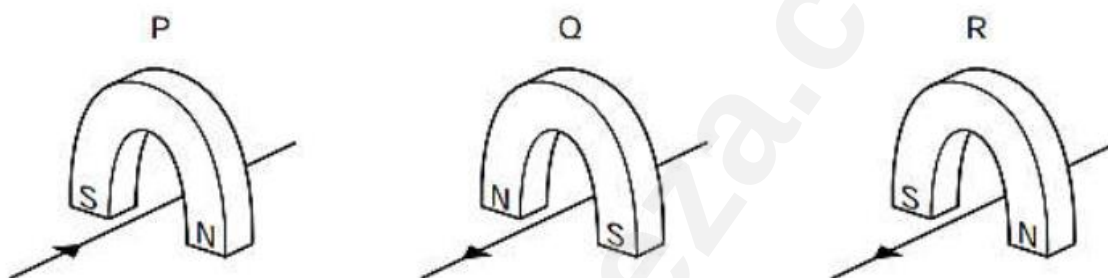
Which one of the following gives the force that now acts between the two particles?

- A an attractive force of $\frac{9}{4}F$
 B a repulsive force of $0,5F$
 C an attractive force of F
 D a repulsive force of $2F$

- 1.9 A wire is placed between the poles of a horseshoe magnet. There is a current in the wire in the direction shown, and this causes a force to act on the wire.



Three other arrangements, P, Q and R, of the wire and magnet are set up as shown.



Which arrangement or arrangements will cause a force in the same direction as the original arrangement?

- A P, Q and R
 B P and Q only
 C P only
 D R only
- 1.10 The photoelectric effect is being observed when the intensity of the monochromatic light source is increased. Which one of the following is correct?

	Energy of emitted photon	Number of photons emitted per second
A	Increases	Increases
B	Increases	Unchanged
C	Unchanged	Increases
D	Unchanged	unchanged

(10 x 2) = [20]

QUESTION 2 KINEMATICS EXPERIMENT

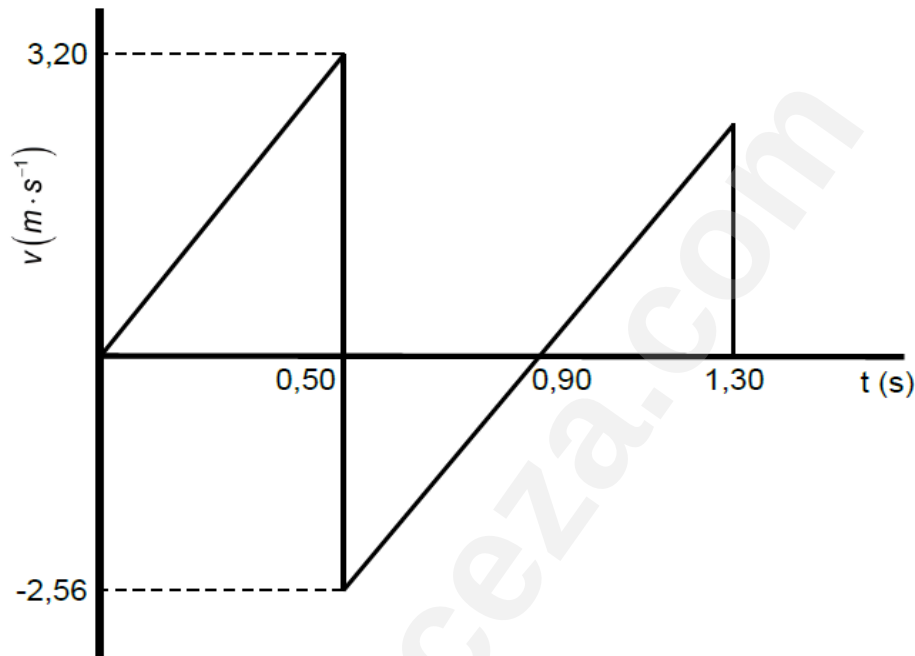
In an investigation Dylan and Angus investigate the velocity of a lead object, dropped from different heights. They released a lead weight from set heights and used video analysis to measure the velocity of the lead weight as it reached the ground.

Their results are recorded in the table:

Data for investigation of impact velocity vs height		
Height of drop (cm)	Impact velocity (m.s ⁻¹)	v _i ² (m ² .s ⁻²)
20	2.0	
40	2.7	Complete on
60	3.4	Appendix
80	4.0	Answer
100	4.3	sheet
120	4.7	

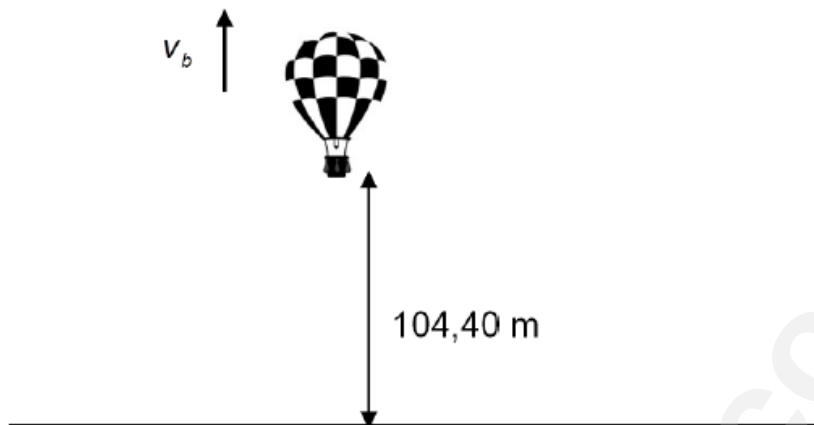
- 2.1 State a suitable hypothesis for the investigation. (2)
 - 2.2 Name the dependent variable. (1)
 - 2.3 Calculate impact velocity squared (v_i²) and record **ON THE ANSWER SHEET** in the column provided. Express the answers to one decimal place. (2)
 - 2.4 **On the graph paper provided**, plot a graph of v_i² against height. (5)
 - 2.5 Determine the gradient of your graph, with units. (3)
 - 2.6 A straight-line graph is described by the equation $y = mx + c$. We also know that $v_f^2 = v_i^2 + 2a\Delta x$ is an equation of motion that relates velocity squared to displacement. Use this knowledge and your answer in 2.5 to determine the acceleration due to gravity. (3)
 - 2.7 Suggest why the value obtained from the graph is different from the actual value. (1)
- [17]**

- 3.1 A ball is dropped from a certain height on a distant planet X. The velocity-time graph represents the motion of the ball as it bounces vertically on a solid floor. The time of the bounce is negligible. Planet X has no atmosphere so there is zero air resistance.



- 3.1.1 Define *acceleration*. (2)
- 3.1.2 Calculate the magnitude of the acceleration of the ball on this planet. (3)
- 3.1.3 The planet has half the mass of the Earth. Calculate the ratio $\frac{r_x}{r_{Earth}}$, where r_x and r_{Earth} is the radius of planet X and Earth respectively. (4)
- 3.1.4 Calculate the height from which the ball was dropped. (3)
- 3.1.5 Draw a labelled free-body diagram showing the forces acting on the ball at 0,7 s. (2)
- 3.1.6 State the magnitude of the velocity with which the ball hits the ground at 1,30 s. (2)
- 3.1.7 Sketch the corresponding position-time graph for the motion of the ball from 0 s to 1,3 s. Use the ground as position zero. Use the ANSWER SHEET. (3)

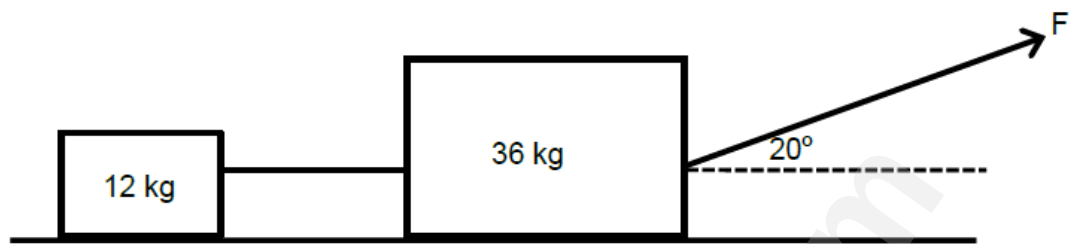
- 3.2 A hot air balloon is rising vertically upwards at a constant velocity. A smartphone is accidentally dropped from the balloon when the balloon is at a height of 104,40 m as shown in the diagram. The phone strikes the ground 6 s after it is dropped. Ignore air resistance.



- 3.2.1 Calculate the speed with which the balloon is rising when the phone is dropped. (4)
- 3.2.2 State the velocity of the phone at the instant it is dropped. (1)
- 3.2.3 Calculate the maximum height that the phone reaches above the ground. (4)
- 3.2.4 Calculate the height of the balloon when the phone strikes the ground. (3)
- [31]**

QUESTION 4

Two blocks have masses of 12 kg and 36 kg and are joined together by a light inextensible rope. A force, F , is applied to the 36 kg block at an angle of 20° to the horizontal as shown. The coefficient of static friction between the surface and the 12 kg block is 0,7.



Initially the blocks do not slide.

- 4.1 State *Newton's First Law of Motion*. (2)
 - 4.2 Calculate the maximum frictional force that could act on the 12 kg block. (3)
 - 4.3 State the magnitude of the tension in the rope joining the blocks when the blocks are about to start sliding. (1)
- The force, F , is gradually increased until it reaches a value of 400 N. At this force, the blocks accelerate to the right. Whilst accelerating the 12 kg and 36 kg blocks experience kinetic friction of 50 N and 91,83 N respectively.
- 4.4 Sketch a labelled free-body diagram showing all the forces acting on the 36 kg block. (4)
 - 4.5 Calculate the acceleration of the system and the tension in the rope joining the blocks whilst the blocks are accelerating. (6)
 - 4.6 Define *normal force*. (2)
 - 4.7 Calculate the normal force acting on the 36 kg block whilst accelerating. (3)
 - 4.8 Calculate the co-efficient of kinetic friction for the 36 kg block. (3)

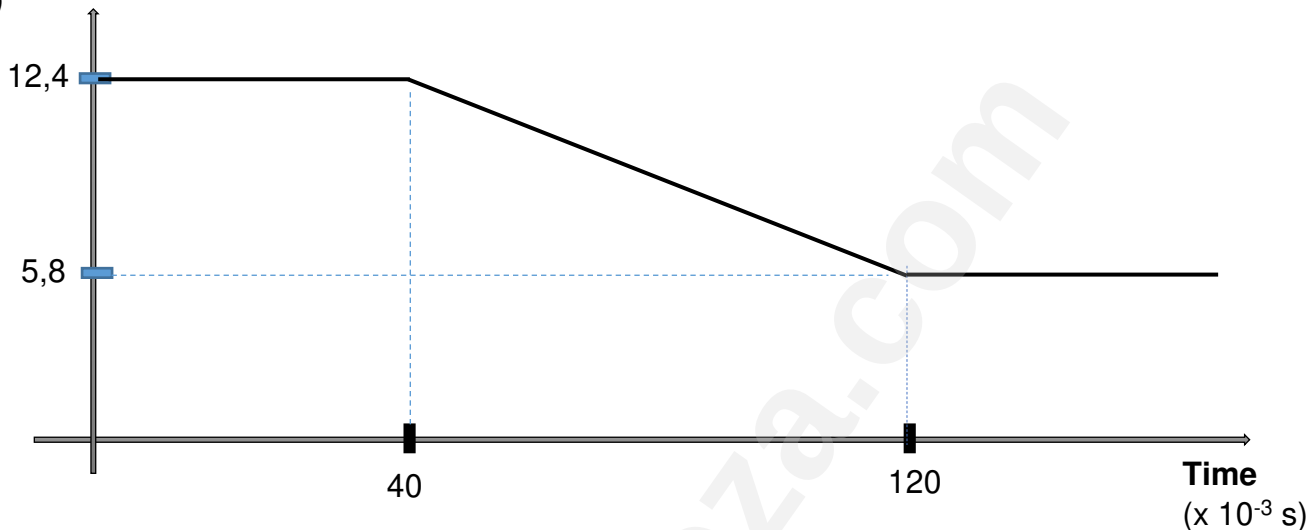
[24]

QUESTION 5

A student is experimenting with two carts on a horizontal frictionless surface. Cart X has a mass of 0,5 kg and is initially at rest. Cart Y has a mass of 1,2 kg and collides with cart X. Cart Y is initially travelling at $12,4 \text{ m}\cdot\text{s}^{-1}$ east and travels at $5,8 \text{ m}\cdot\text{s}^{-1}$ east after colliding with cart X. The velocity of cart Y is represented on the velocity time graph below.

Velocity

(m/s)

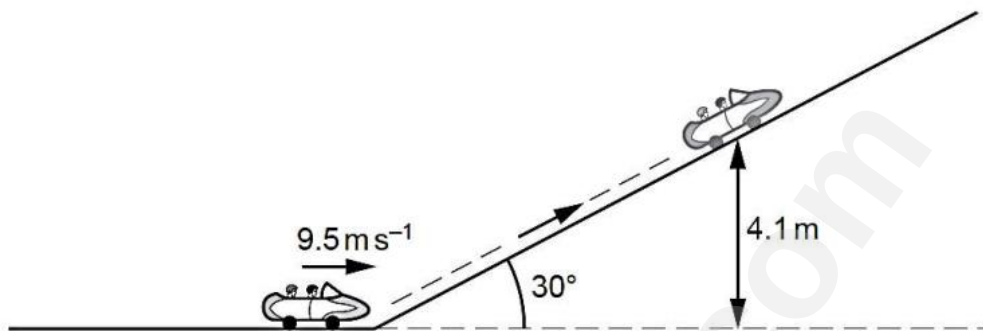


- 5.1 Calculate the final velocity of cart X. (4)
- 5.2 Calculate the change in momentum of cart Y. (3)
- 5.3 State *Newton's second law in terms of momentum*. (2)
- 5.4 Calculate the force that cart X exerts on cart Y during the collision. (3)

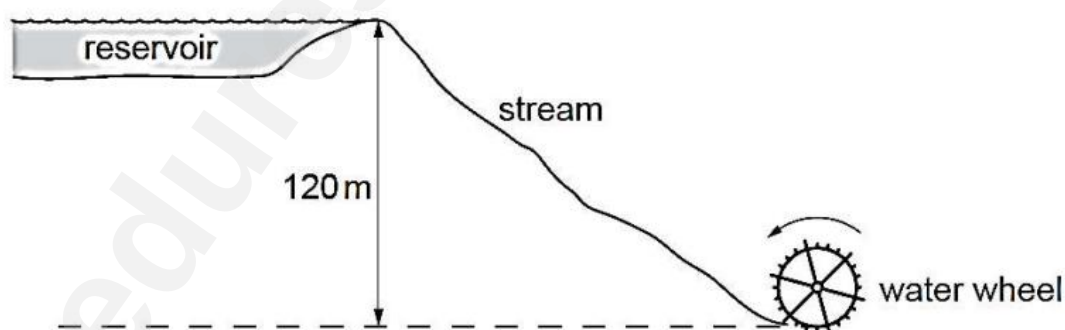
[12]

QUESTION 6

- 6.1 The diagram below shows a fairground ride with a carriage on rails. The carriage has no engine. The carriage and passengers have a total mass of 500 kg. The carriage is travelling at a speed of $9,5 \text{ m.s}^{-1}$ when it reaches a slope inclined at 30° to the horizontal. The carriage comes to rest after travelling up the slope to a vertical height of 4,1 m.



- 6.1.1 State the *work-energy theorem*. (2)
- 6.1.2 Calculate the kinetic energy of the carriage and passengers as they travel towards the slope. (3)
- 6.1.3 Calculate the work done by the frictional force as the carriage moves up the slope. (4)
- 6.1.4 Calculate the magnitude of the frictional force acting against the carriage as it moves up the slope. (4)
- 6.2 Water flows down a stream from a reservoir and then causes a water wheel to rotate, as shown in the diagram below:



1 kg of water falls through a vertical height of 120 m. At the water wheel, the kinetic energy of the water is only 40 % of its gravitational potential energy at the reservoir.

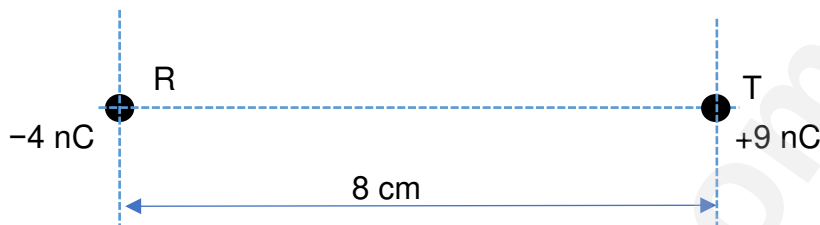
- 6.2.1 Show that the speed of the water as it reaches the wheel is $30,67 \text{ m.s}^{-1}$. (3)
- 6.2.2 The rotating water wheel produces 110 kW of output electrical power. The production of electrical energy from the kinetic energy of the water is 80 % efficient. Calculate the mass of water flowing through the wheel per second. (4)

[20]

QUESTION 7

- 7.1 Two identical isolated metal spheres, R and T, carry charges of -4 nC and $+9 \text{ nC}$ as shown in the diagram.

7.1.1 What is an electric field? (2)

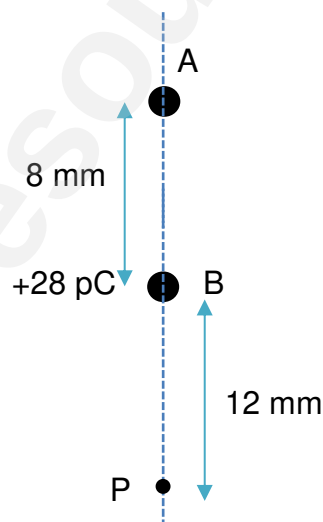


7.1.2 Sketch the electric field pattern around the two charged spheres. Use the space provided on the ANSWER SHEET. (3)

7.1.3 State *Coulomb's Law*. (3)

7.1.4 Calculate the force that T exerts on R. (4)

- 7.2 Two identical isolated charged metal spheres, A and B are arranged as shown in the diagram. Sphere B has a net charge of $+28 \text{ pC}$. A point P is located 12 mm below the charged sphere B.



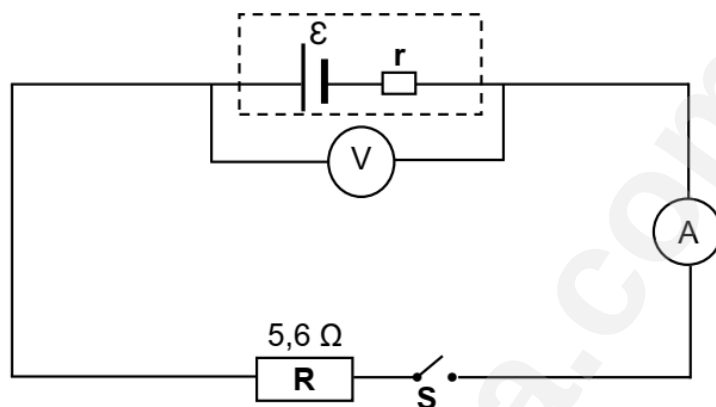
The net electric field at point P is 805 N.C^{-1} downwards. Calculate the net charge on sphere A. (5)

[17]

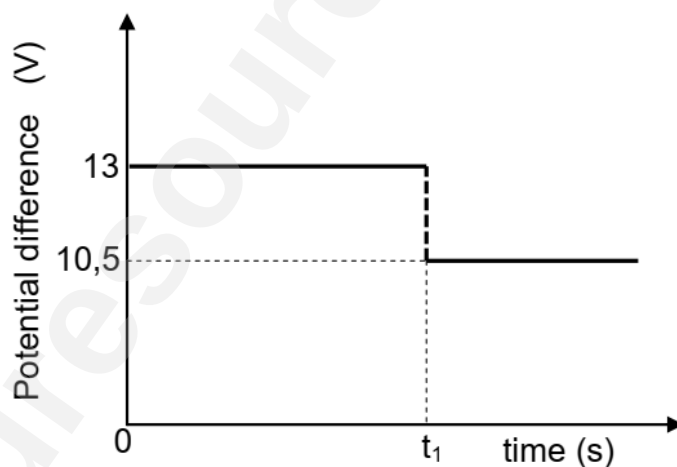
QUESTION 8

In the circuit diagram below, resistor R , with a resistance of $5,6\ \Omega$, is connected, together with a switch, an ammeter and a high-resistance voltmeter, to a battery with an unknown internal resistance, r .

The resistance of the connecting wires and the ammeter may be ignored.

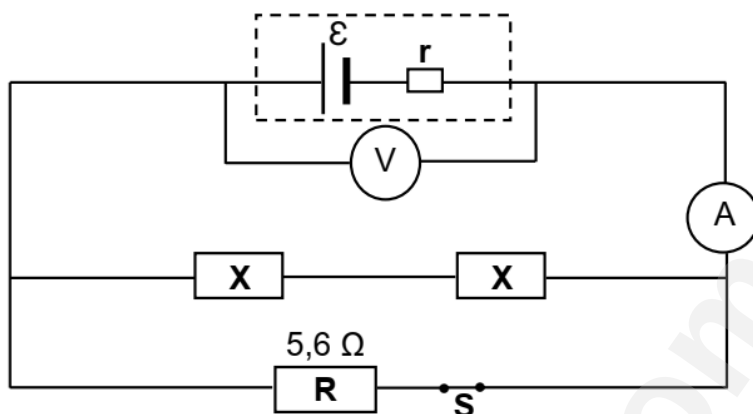


The graph below shows the voltmeter reading as a function of time. At time t_1 , switch S is closed.



- 8.1 Define the term *emf*. (2)
- 8.2 Write down the value of the emf of the battery. (1)
- 8.3 When switch S is CLOSED, calculate the:
 - 8.3.1 Current through resistor R (3)
 - 8.3.2 Internal resistance, r , of the battery (3)
 - 8.3.3 amount of thermal energy generated inside the battery in two minutes. (3)

- 8.4 Two IDENTICAL resistors, each with resistance X , are now connected in the same circuit with switch S closed, as shown below.



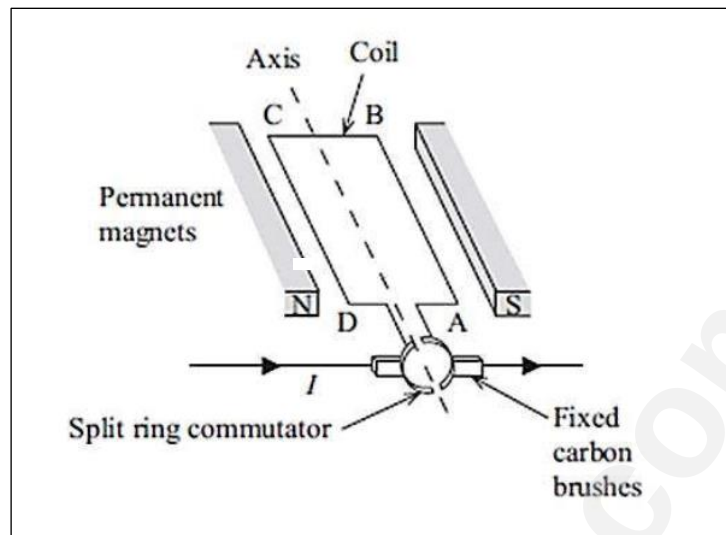
8.4.1 Explain how the voltmeter reading will change. (4)

8.4.2 The current through the $5,6 \Omega$ resistor is now $1,75 \text{ A}$. Calculate resistance X . (4)

[20]

QUESTION 9

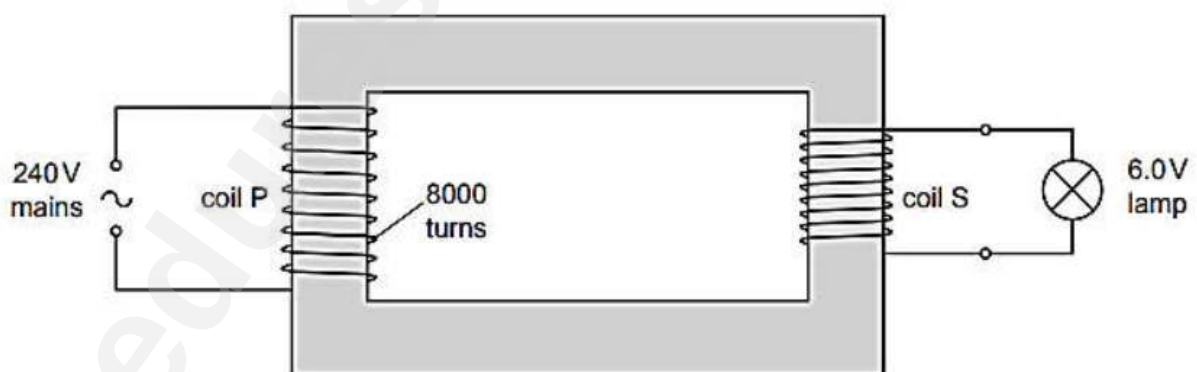
9.1 The simplified diagram below illustrates a DC electric motor.



The arrows show the direction of current as it enters and exits the coil through the carbon brushes and the split ring commutator.

- 9.1.1 State whether the coil turns clockwise or anti-clockwise when viewed from the split-ring commutator. (2)
- 9.1.2 State the function of the split-ring commutator. (2)
- 9.1.3 Refer to an appropriate formulae to explain three ways in which the turning force that the coil experiences can be increased. (3)

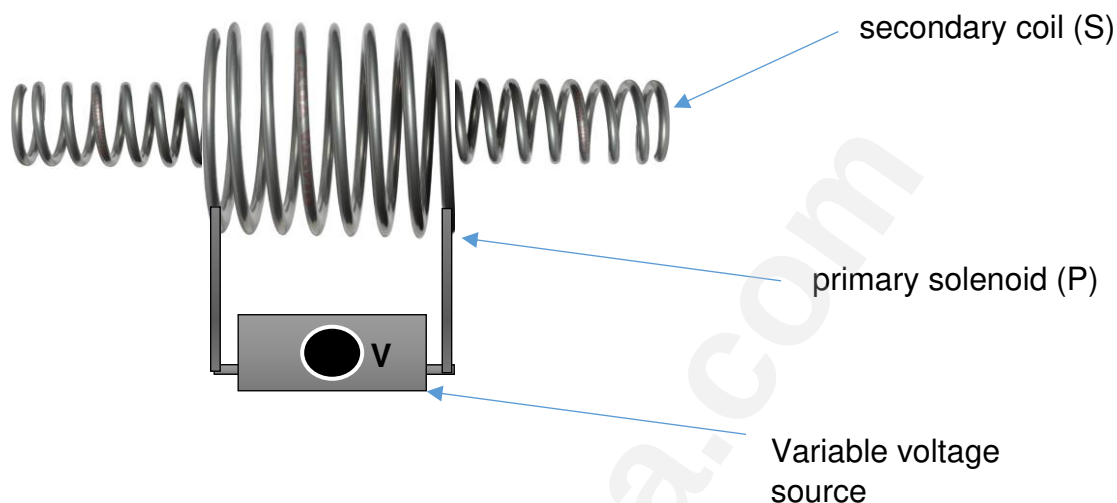
9.2 The diagram below shows a transformer.



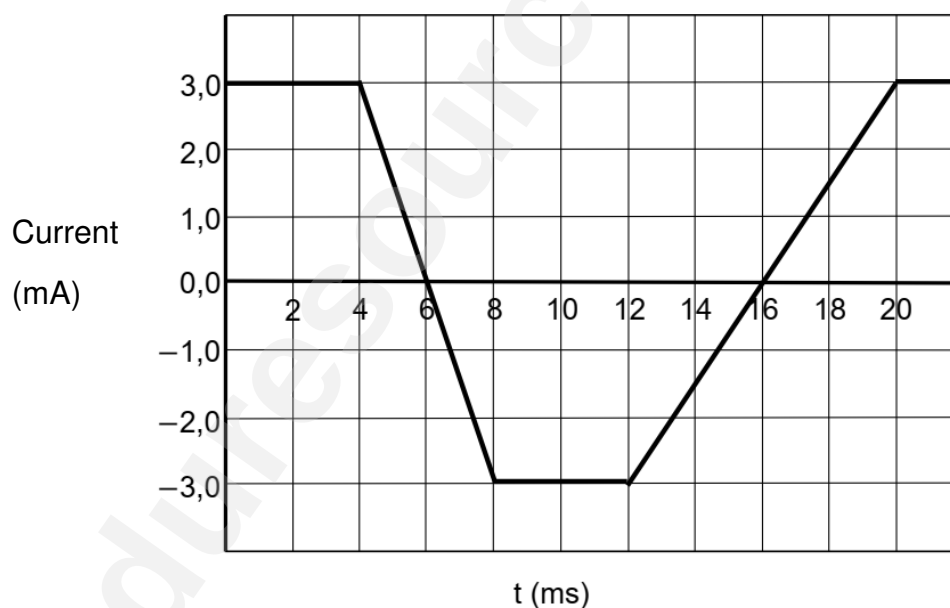
The primary coil P, connected to the 240 V mains supply, has 8000 turns. The secondary coil S supplies 6 V to a lamp.

- 9.2.1 Calculate the number of turns in the secondary coil. (3)
- 9.2.2 The current in the primary coil is 0,05 A. Calculate the power input to the transformer. (3)
- 9.2.3 85 % of the power input to the transformer is transferred to the lamp. Calculate the current in the lamp. (2)

- 9.3 A secondary coil (S) has a primary solenoid (P) wound around the middle as shown in the diagram.



The current in the **primary solenoid** is changed with time as shown on the graph below.



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

- 9.3.2 Explain why an emf is induced in the secondary coil. (3)

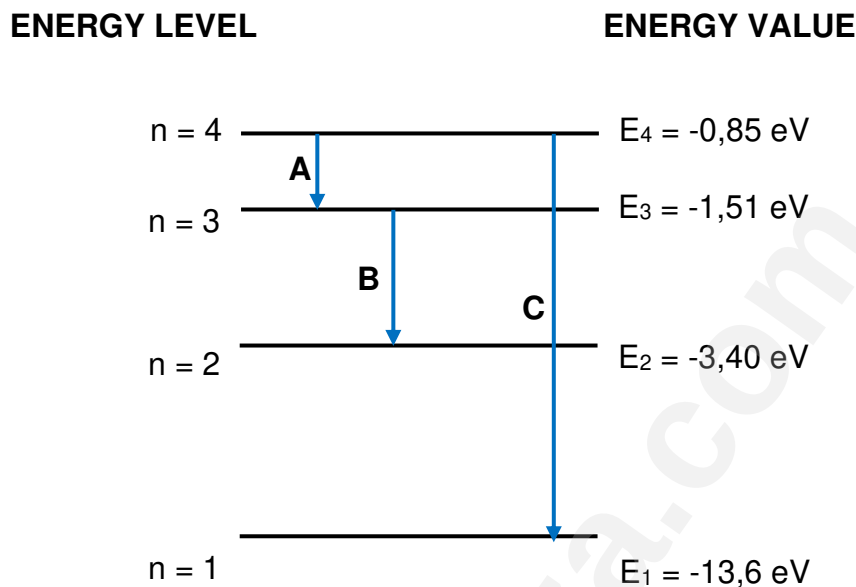
The **maximum emf** induced in the secondary solenoid is **200 mV**.

- 9.3.3 On the graph provided **on the answer sheet**, draw the corresponding induced emf vs time graph for the **secondary coil**. The relative sizes of the emf must be included on the graph. (4)

[24]

QUESTION 10

Consider the simplified energy diagram showing the first four energy levels in a hydrogen atom.



Energy level $n=1$ is the ground state.

An excited hydrogen atom can emit photons of certain discrete frequencies. Three possible transitions are shown in the diagram.

The transitions shown in the diagram result in photons being emitted in the **ultraviolet, visible and infrared** regions of the electromagnetic spectrum.

10.1 To which region of the spectrum do the emitted photons of A belong? (1)

10.2 Calculate the wavelength of the photon emitted when the electron transition is from the $n=3$ level to the ground state. (4)

The surface of a sample of caesium is exposed to photons emitted in each of the three transitions shown above. The threshold frequency for caesium is $5,1 \times 10^{14} \text{ Hz}$.

10.3 Define *work function of caesium*. (2)

10.4 Calculate the work function of caesium. (3)

10.5 Express your answer to 10.4 in electron-volts. (1)

10.6 Photons each with energy $12,1 \text{ eV}$ are incident on the surface of the caesium sample. Calculate the maximum speed of electrons emitted from caesium. (4)

[15]

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EXAMINATION DATA SHEET FOR THE PHYSICAL SCIENCES
(PHYSICS)

TABLE 1 PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Acceleration due to gravity	g	$9,8 \text{ m}\cdot\text{s}^{-2}$
Speed of light in a vacuum	c	$3,0 \times 10^8 \text{ m}\cdot\text{s}^{-1}$
Universal gravitational constant	G	$6,7 \times 10^{-11} \text{ N}\cdot\text{m}^2\cdot\text{kg}^{-2}$
Coulomb's constant	k	$9,0 \times 10^9 \text{ N}\cdot\text{m}^2\cdot\text{C}^{-2}$
Magnitude of charge on electron	e	$1,6 \times 10^{-19} \text{ C}$
Mass of an electron	m_e	$9,1 \times 10^{-31} \text{ kg}$
Planck's constant	h	$6,6 \times 10^{-34} \text{ J}\cdot\text{s}$
1 electron volt	eV	$1,6 \times 10^{-19} \text{ J}$

TABLE 2 PHYSICS FORMULAE

MOTION

$v = u + at$ or $v_f = v_i + a\Delta t$	$s = \left(\frac{v+u}{2}\right)t$ or $\Delta x = \left(\frac{v_f+v_i}{2}\right)\Delta t$
$v^2 = u^2 + 2as$ or $v_f^2 = v_i^2 + 2a\Delta x$	$s = ut + \frac{1}{2}at^2$ or $\Delta x = v_i\Delta t + \frac{1}{2}a(\Delta t)^2$

FORCE AND MOMENTUM

$F_{net} = ma$	$F_{net} = \frac{\Delta p}{\Delta t}$ or $F_{net}\Delta t = m\Delta v$	$J = \Delta p = mv - mu$ or $J = \Delta p = mv_f - mv_i$
$p = mv$	$F_g = mg$	$F_{fs}^{max} = \mu_s F_N$ $F_{fk} = \mu_k F_N$

WORK, ENERGY AND POWER

$W = Fs$ or $W = F\Delta x$ or $W = F\Delta x \cos \theta$	$P = \frac{W}{t}$	$P = Fv$
$E_p = mgh$	$E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta E_K$
efficiency = $\frac{\text{power}_{out}}{\text{power}_{in}} \times 100$		

GRAVITATIONAL AND ELECTRIC FIELDS

$F = G \frac{m_1 m_2}{r^2}$	$g = \frac{F}{m}$	$g = G \frac{M}{r^2}$
$F = k \frac{q_1 q_2}{r^2}$	$E = \frac{F}{q}$	$E = \frac{kQ}{r^2}$

ELECTRIC CIRCUITS

$I = \frac{q}{t}$	$V = \frac{W}{q}$
$R = \frac{V}{I}$	$emf = I(R_{ext} + r)$ or $emf = V_{load} + V_{internal\ resistance}$
$R_s = R_1 + R_2 + \dots$	$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
$P = \frac{W}{t} \quad \text{or} \quad W = Pt$	
$W = VIt \quad \text{or} \quad W = I^2 R t \quad \text{or} \quad W = \frac{V^2}{R} t$	
$P = VI \quad \text{or} \quad P = I^2 R \quad \text{or} \quad P = \frac{V^2}{R}$	

ELECTRODYNAMICS

$\Phi = BA \cos \theta$	$emf = - \frac{N \Delta \Phi}{\Delta t}$	$F = IB \ell \sin \theta$
$V_p I_p = V_s I_s$	$\frac{N_s}{N_p} = \frac{V_s}{V_p}$	

PHOTONS AND ELECTRONS

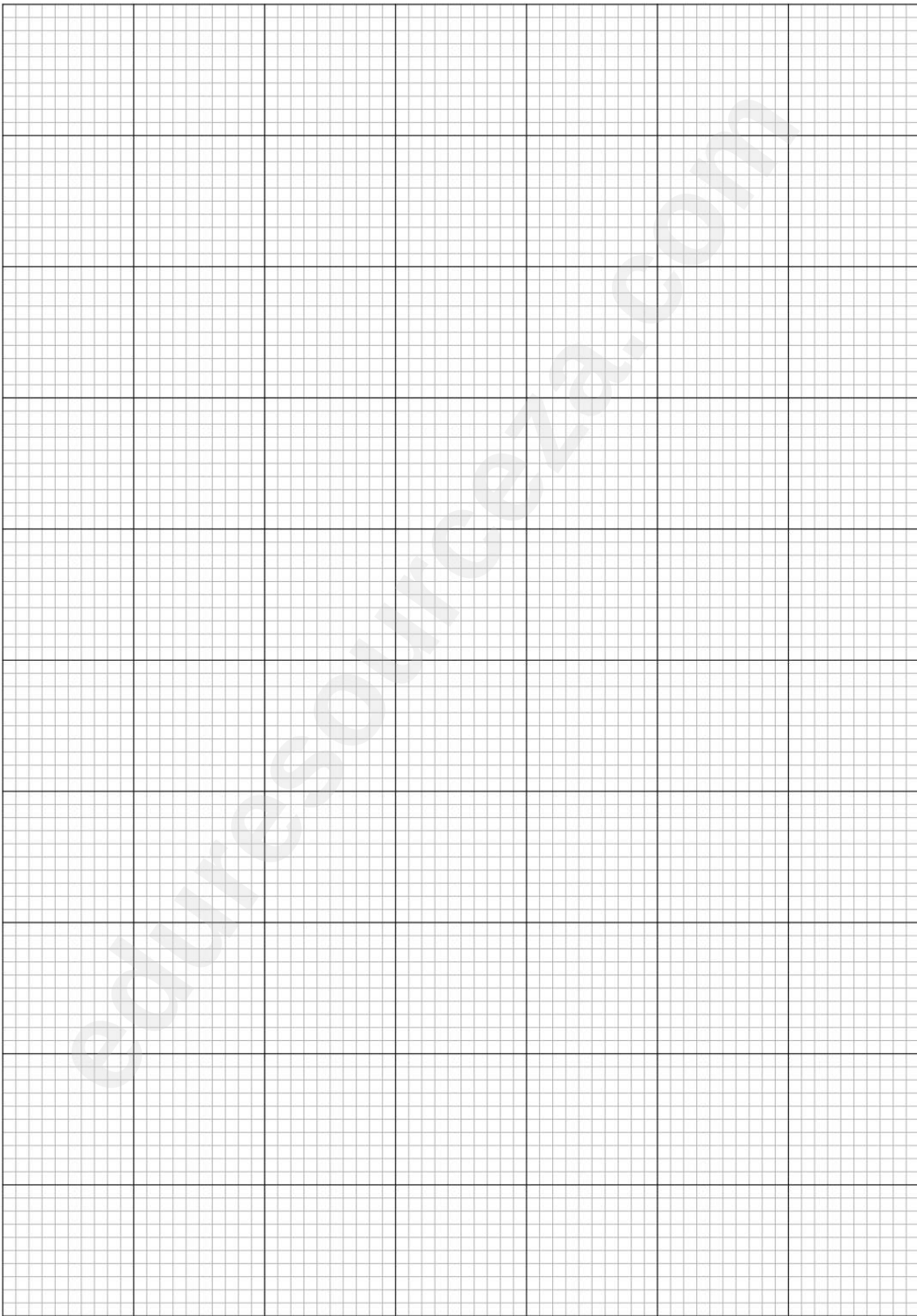
$c = f \lambda$	$E = hf$ or $E = \frac{hc}{\lambda}$	
$E = W_0 + E_{K(max)}$	$W_0 = hf_0$	$E_{K(max)} = \frac{1}{2} m v_{max}^2$

ANSWER SHEET

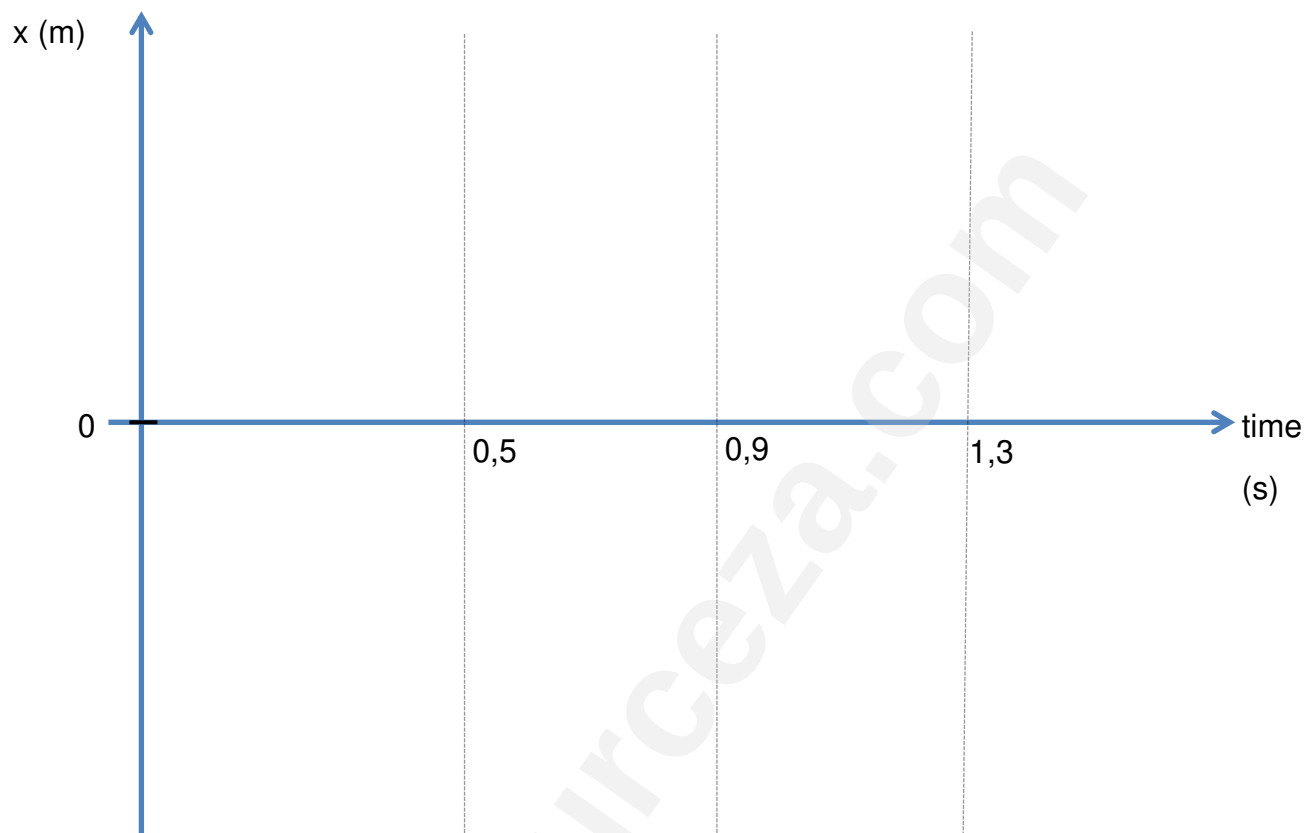
NAME: _____

QUESTION 2.3

Data for investigation of impact velocity vs height		
Height of drop (cm)	Impact velocity (m.s ⁻¹)	v _i ² (m ² .s ⁻²)
20	2.0	
40	2.7	
60	3.4	
80	4.0	
100	4.3	
120	4.7	



Position vs. time



NAME: _____

QUESTION 9.3.3Induced emf vs. time