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Exam number/name: _____

**ST ANNE'S DIOCESAN COLLEGE****TRIAL EXAMINATION****PHYSICAL SCIENCES****PAPER 1 PHYSICS****30 August 2018**

Time: 3 hours

200 Marks

Examiner: S Schwartz

Moderator: T van Niekerk

The use of other IEB teachers' questions, in whole or in part, is gratefully acknowledged.

- Weighting of knowledge areas (**Target $\pm 5\%$**):
Kinematics 21%(**25%**) / Newton's Laws 15%(**15%**) / p,W,E,P 18.5%(**15%**) / Gravitational & Electric Fields 10%(**10%**) /
Electric Circuits 16%(**15%**) / Electrodynamics 11%(**12%**) / Photons & Electrons 8.5%(**8%**)
- Cognitive Levels (**Target**): 1 – 15%(**15%**); 2 – 30.5%(**35%**); 3 – 42.5%(**40%**); 4 – 12%(**10%**)

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:

- p2-14: Questions 1 to 9;
- p15 and 16: Table 1: Physical Constants and Table 2: Physics Formulae
- p17: APPENDIX answer sheet
- P18: GRAPH PAPER for Q 4

Please make sure that your question paper is complete.

2. You may detach the data sheet if necessary.

3. Read the questions carefully and answer in any order, with clear numbering.

4. Show your working in all calculations, including the equations used.

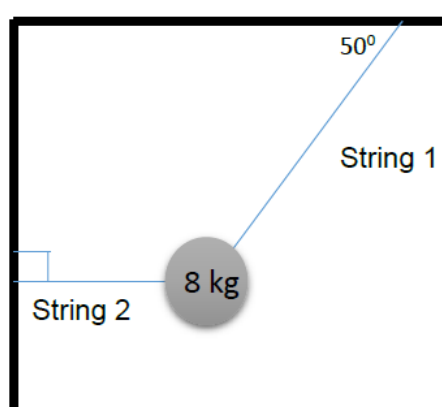
5. Units need not be included in the working of calculations, but appropriate **units must be shown in the answer.**

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	TOTAL	
/ 20	/ 43	/ 21	/ 19	/ 20	/ 18	/ 12	/ 30	/ 17	/200	%

QUESTION 1 MULTIPLE CHOICE QUESTIONS

- Four options are provided as possible answers to the following questions.
- Each question has only ONE correct answer.
- Use the Multiple Choice Answer Grid provided IN THE APPENDIX on p17.

1.1 An 8kg mass is suspended from two massless strings at angles as shown.



The tension, in Newtons, in String 1 is...

- A $\frac{78,4}{\cos(50)}$
- B $\frac{\sin(50)}{78,4}$
- C $78,4 \tan(40)$
- D $\frac{78,4}{\cos(40)}$

1.2 A model car completes one lap around a circular track of 400 m at an average speed of 5 m.s^{-1} and then a second lap at an average speed v . The average speed for the completion of both laps was 8 m.s^{-1} .

What was the average speed v , in m.s^{-1} , of the second lap?

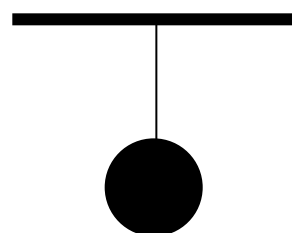
- A 11,0 B 12,5 C 15,0 D 20,0

1.3 Displacement is...

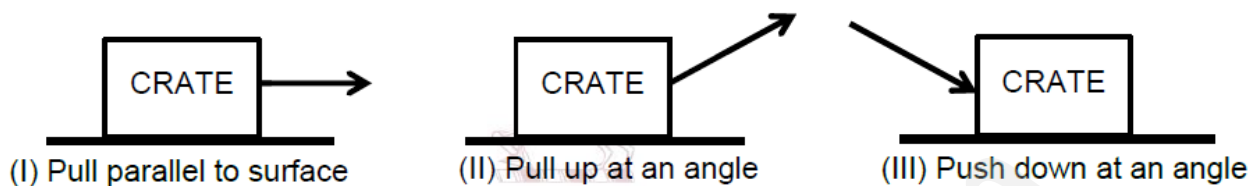
- A the rate of change of position B a change in position
- C distance with direction D the length of path travelled

1.4 A sphere is attached to a string, suspended from a ceiling, as shown. The reaction force to the weight of the sphere is...

- A the force of the sphere on the earth
- B the force of the ceiling on the string
- C the force of the string on the sphere
- D the force of the ceiling on the sphere

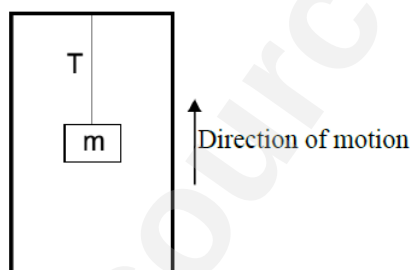


- 1.5 A heavy crate is at rest on a rough horizontal surface. The diagrams indicate three different attempts at trying to move the crate. In each situation the crate is just on the point of sliding.



The maximum force of static friction is ...

- A the greatest in situation (I) B the greatest in situation (II)
 C the greatest in situation (III) D the same in all three situations
- 1.6 An object, of mass m , hangs at the end of a string from the ceiling of a lift cage. The lift is moving upward while speeding up uniformly. The acceleration due to gravity is g .

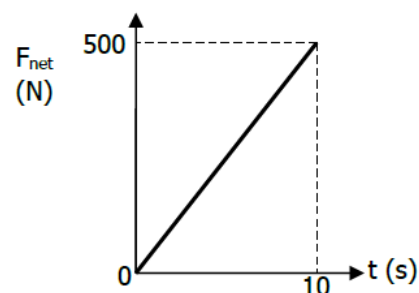


Which one of the following statements regarding the tension (T) in the string is CORRECT? The tension T ...

- A will be equal to mg . B will be less than mg .
 C will be greater than mg . D is zero
- 1.7 The graph shows how the net force on a motorcycle changes with time.

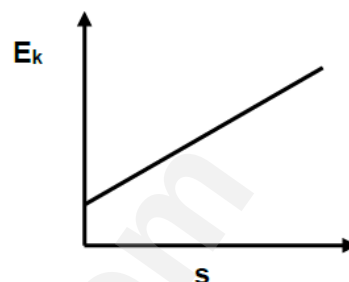
The total impulse experienced by the motorcycle over this time period is...

- A 50 N.s B 500 N.s
 C 2500 kg.m.s⁻¹ D 5000 kg.m.s⁻¹



- 1.8 The adjacent graph shows the kinetic energy (E_k) of an object vs. distance (s). The gradient of the graph represents:

- A the net force acting on the object
- B the acceleration of the object
- C the momentum of the object
- D the power of the object



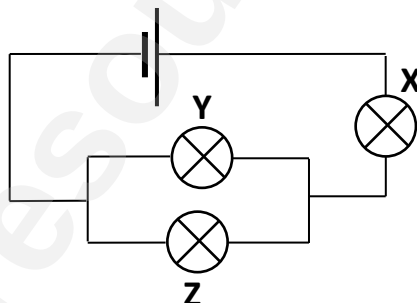
- 1.9 Consider two hypothetical planets, X and Y.

- Planet X has twice the mass of planet Y.
- The diameter of planet Y is one third 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 $18g$ B $4,5g$ C $3g/2$ D $2g/9$

- 1.10 In the circuit depicted below bulbs Y and Z are equal in resistance. Bulb X has **half** the resistance of either bulb Y or Z. Internal resistance can be ignored.



Which bulb(s) will shine the brightest?

- A Bulb X
- B Bulbs Y and Z
- C They will all be equally bright
- D Not enough information is provided

[10 X 2 = 20]

QUESTION 2 KINEMATICS

2.1 An object of mass 500 g is moving horizontally along the ground under the influence of two forces, both acting parallel to the ground.

- Force A is 0,50 N acting on a bearing of 220° and
- Force B is 1,00 N acting on a bearing of 310°

2.1.1 Draw a vector sketch and then determine **by calculation** (2dp) the magnitude and bearing of the combined effect of Forces A and B on the object. (6)

Assume that the forces are constant and that the object experiences a constant friction force of 0,70 N while moving.

2.1.2 Show that the magnitude of the acceleration of the object is $0,84 \text{ m.s}^{-2}$. (3)

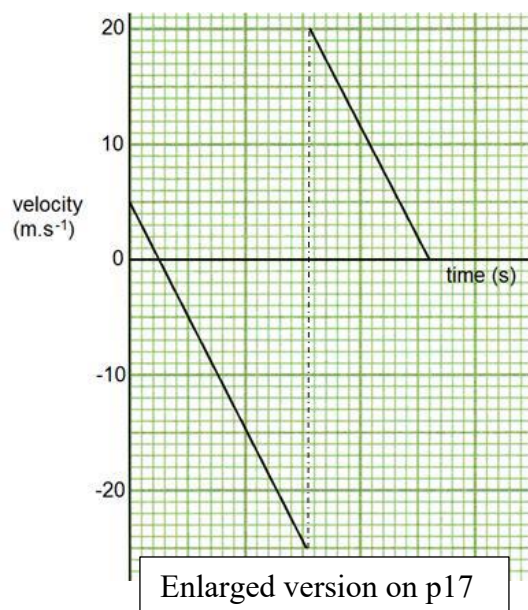
2.1.3 Hence, calculate the time that it will take the object, moving initially at 1 m.s^{-1} , to travel a distance of 20 cm. (4)

2.2 Gugu stands on the balcony overlooking the street. Leaning over the balcony wall, she throws a ball vertically upwards. Sometime later the ball hits the street below the balcony and then bounces vertically upwards. The velocity-time graph shows the motion of the ball. Ignore air resistance.

2.2.1 What sign convention has been used in drawing this graph: *upwards is positive* OR *downwards is positive*? Give a reason for your answer. (3)

2.2.2 Write down...

- the magnitude of the gradient of this velocity-time graph. (2)
- the speed with which Gugu releases the ball. (1)
- the speed with which the ball bounces off the ground. (1)



2.2.3 **Use an equation of motion** to determine the time intercept on the graph when the ball reaches its maximum height after being thrown into the air. (4)

2.2.4 **Use the graph** to calculate the height above the point of release reached by the ball before it falls to the street below. (4)

2.2.5 If the total time taken for the ball to strike the street below is 3,06 s, calculate the height from which the ball was thrown. (4)

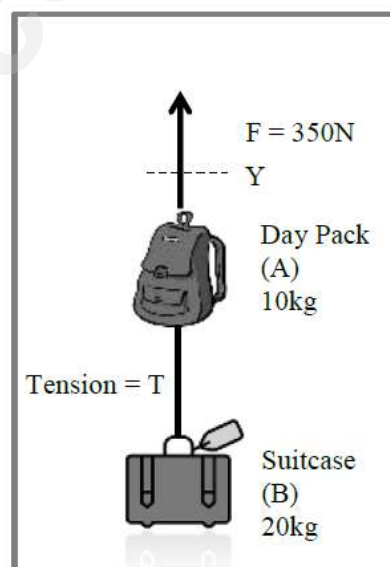
Q2 continues overleaf...

- 2.2.6 By inspection of the graph, state with a reason whether or not the ball bounces back up to its original height. (3)
- 2.2.7 By inspection of the graph, state with a reason whether the collision of the ball with the ground is elastic or inelastic. (3)
- 2.2.8 If the ball has a mass of 200 g and is in contact with the ground for 0,1 s, calculate the net force acting on the ball during impact. (5)

[43]

QUESTION 3 NEWTON'S LAWS and MOMENTUM

- 3.1 In the diagram shown, an applied force, F , of 350 N is used to hoist two pieces of luggage onto the roof-rack of a bus. A day pack (A) of mass 10 kg is joined to a suitcase (B) of mass 20 kg by a short rope. The rope used has negligible mass. Ignore friction and the effects of air resistance.



- 3.1.1 State *Newton's Third Law*. (2)
- 3.1.2 Calculate the acceleration of the system. (4)
- 3.1.3 Calculate the magnitude of the tension (T) in the rope connecting A to B. (3)
- 3.1.4 While hoisting the load, the rope through which the applied force acts breaks at point Y. Draw a labelled force diagram showing the force(s) acting on the day pack (A) as it falls. (2)
- 3.2 In the diagram below, a small block of mass 1,2 kg is sliding at a constant velocity of $6,2 \text{ m}\cdot\text{s}^{-1}$ to the right when it collides with a larger 2,4 kg block sliding to the right at $3,2 \text{ m}\cdot\text{s}^{-1}$ along a frictionless horizontal surface. After the collision the 2,4 kg block slides at $5,0 \text{ m}\cdot\text{s}^{-1}$ to the right.



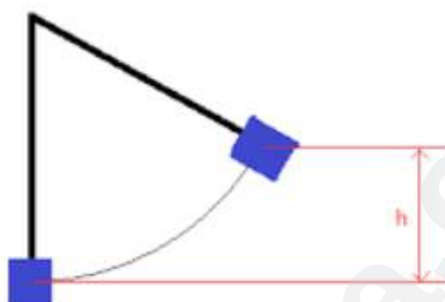
- 3.2.1 State, in words, *the law of conservation of momentum*. (2)
- 3.2.2 Calculate the velocity of the small block after the collision. (4)
- 3.2.3 How far apart will the blocks be 5 seconds after the collision? (4)

[21]

QUESTION 4

WORK, ENERGY AND POWER (GRAPHING)

Roxy and Bronwyn are time-transported to a strange planet. In order to identify the planet they are on, they set up an experiment to find the gravitational acceleration, g . Using the pendulum set-up shown below, they release the block from different heights and measure the speed with which the block passes the lowest point of the swing. Air resistance is negligible in the thin atmosphere of this planet.



Their experimental data is tabulated below:

Table 1: Data from pendulum experiment to determine g		
Height of release (m)	Velocity at lowest point ($\text{m}\cdot\text{s}^{-1}$)	Square of velocity, v^2 () (1)
0,2	2,4	
0,4	3,5	
0,6	4,2	
0,8	4,9	
1,0	5,5	

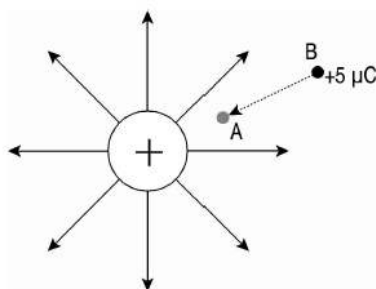
1 dp (2)

- 4.1 Complete the Table (units and values of v^2) **ON THE APPENDIX SHEET (p17)**. (3)
- 4.2 Make use of the principle of conservation of mechanical energy to derive an equation relating the velocity at the bottom of the swing to the height of release. (4)
- 4.3 Plot a graph (**graph paper on p18**) of the square of the velocity vs the height. (6)
- 4.4 Calculate the gradient of your graph. Include the units. (3)
- 4.5 Make use of your answers in 4.2 and 4.4 to determine the value of g on this planet. (3)

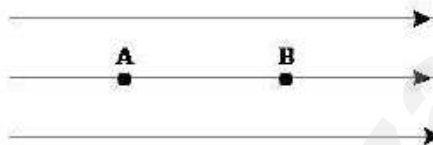
[19]

QUESTION 5 ELECTRIC FIELDS

- 5.1 When moving a charge of $+5 \mu\text{C}$ from point **B** to point **A** in an electric field (as shown below) $0,05 \text{ J}$ of work is done. Calculate the potential difference between points **A** and **B**. (3)

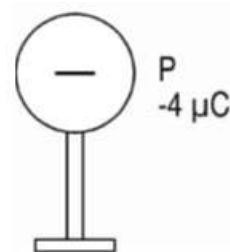


- 5.2 The diagram below shows two points, **A** and **B**, in a uniform electric field.



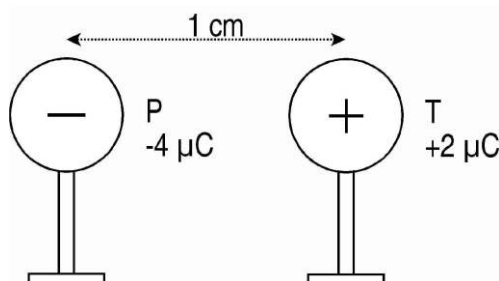
If the magnitude of the electric field strength at **A** is $1,8 \times 10^5 \text{ N}\cdot\text{C}^{-1}$, calculate the magnitude and direction of the acceleration that an electron will undergo when released at **A**. (5)

- 5.3 The diagram shows a small metal sphere **P** on an insulated stand. The sphere carries a charge of $-4 \mu\text{C}$, as shown in the diagram.



- 5.3.1 State Coulomb's law in words. (2)
- 5.3.2 Draw the electric field pattern around sphere **P**. Assume that no other charges affect this pattern. (2)
- 5.3.3 Calculate the number of electrons in excess on sphere **P**. (2)

A second metal sphere, **T**, carrying a charge of $+2 \mu\text{C}$ is placed such that the centres are 1 cm apart, as shown in the diagram below.

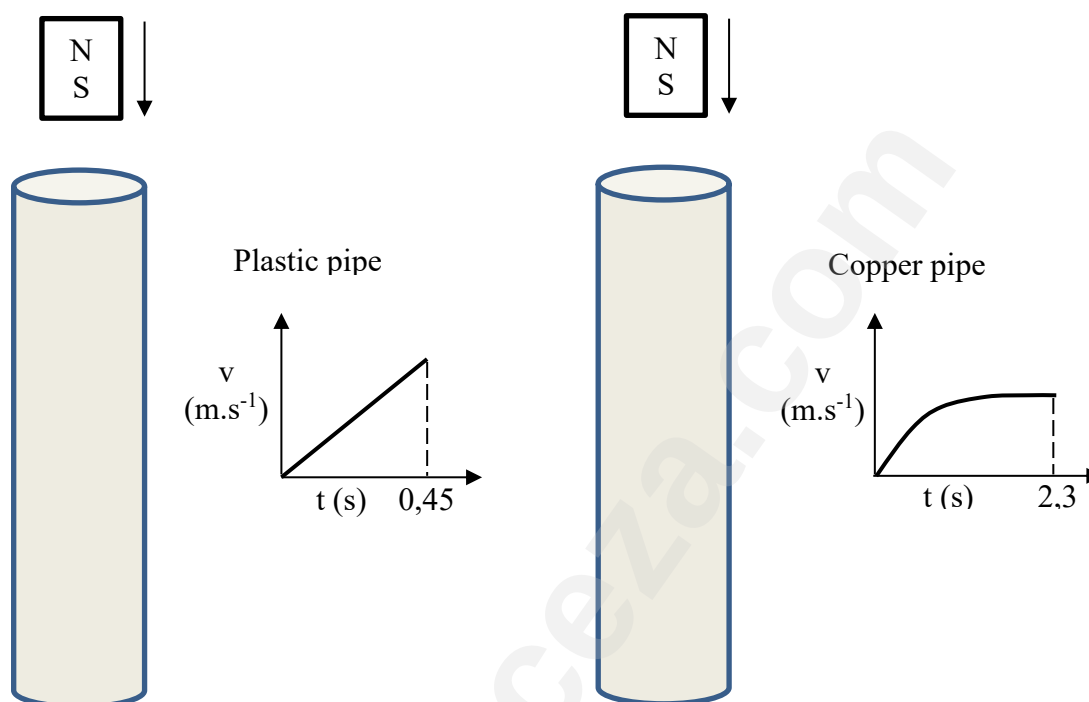


- 5.3.4 The spheres are now brought into contact with each other and then returned to their original positions. Calculate the electrostatic force that sphere **P** now exerts on sphere **T**. (6)

[20]

QUESTION 6 ELECTROMAGNETISM

A magnet is dropped through a 1 m plastic pipe and then through a 1 m copper pipe. (Assume negligible air resistance.) The velocity-time graph for the magnet's fall through the 1 m pipe is shown in each case.



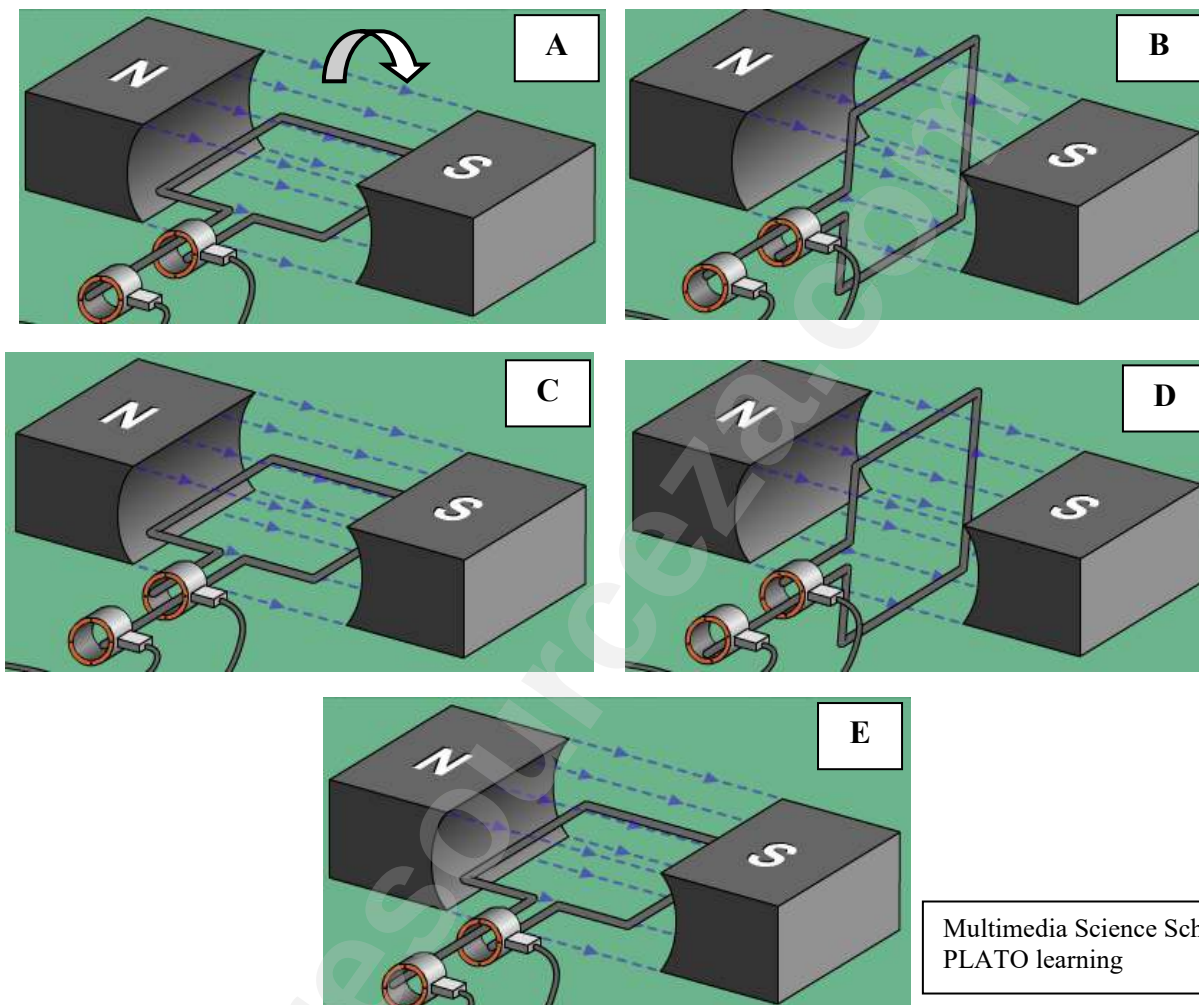
- 6.1 Sketch the pattern of field lines around the magnet, indicating the direction of the field. (2)
- 6.2 What property of copper vs plastic causes the difference in the falling times of the magnet? (1)
- 6.3 Draw a free-body diagram showing the force(s) acting on the magnet while it is falling through the plastic pipe. (2)
- 6.4 As seen from the v-t graph, when the magnet falls through the copper pipe, its velocity eventually becomes constant.
 - 6.4.1 What is this constant velocity called? (1)
 - 6.4.2 Refer to Lenz's Law to explain why an upward force acts on the falling magnet. (2)
 - 6.4.3 Refer to Faraday's Law to explain why this upward force increases as the magnet falls. (3)
 - 6.4.4 Refer to a force diagram to explain how the magnet eventually reaches a constant velocity. (5)
- 6.5 As viewed from the top of the copper pipe, in what direction would the induced current be flowing as the magnet enters the pipe? State either **clockwise** or **anti-clockwise**. (2)

[18]

QUESTION 7 ELECTRODYNAMICS

Consider diagram I below which shows five positions of the coil for one complete rotation of a simple a.c. generator.

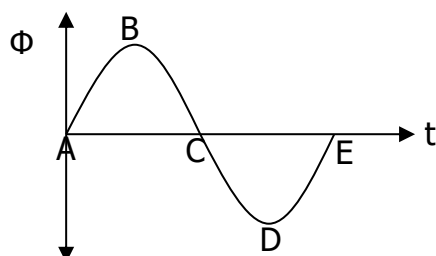
Diagram I



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PLATO learning

The sketch graph (Diagram II) below shows how the flux (Φ) varies with time for the positions A to E of the generator as shown in diagram I.

Diagram II

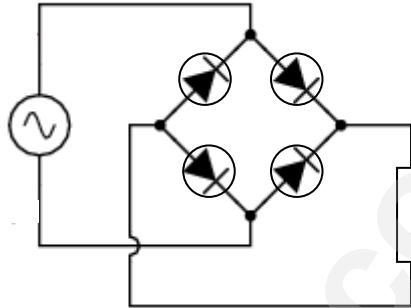


- 7.1 State the energy conversion in a generator. (2)
- 7.2 With reference to the formula for magnetic flux explain why the flux (Φ) passing through the coil is zero when the coil is in positions A, C and E. (3)

Q7 continues overleaf...

- 7.3 Draw a sketch graph of induced emf vs. time for positions A to E of the coil. Clearly label positions A, B, C, D and E. (3)
- 7.4 The output current from this a.c. generator is passed through a bridge rectifier consisting of 4 diodes connected as shown in diagram III below.

Diagram III

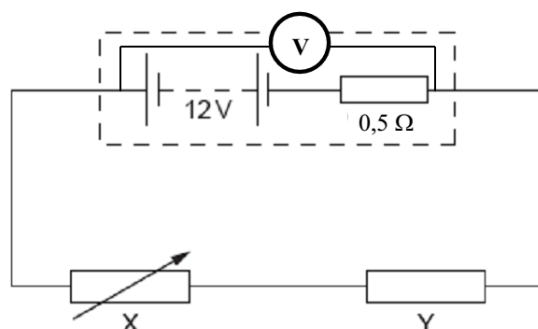


- 7.4.1 Define a diode. (2)
- 7.4.2 Draw a sketch graph of the output voltage across the resistor vs. time for one complete rotation of the generator coil. Assume the coil starts in the horizontal position, i.e. position **A** in diagram I of the generator. (2)

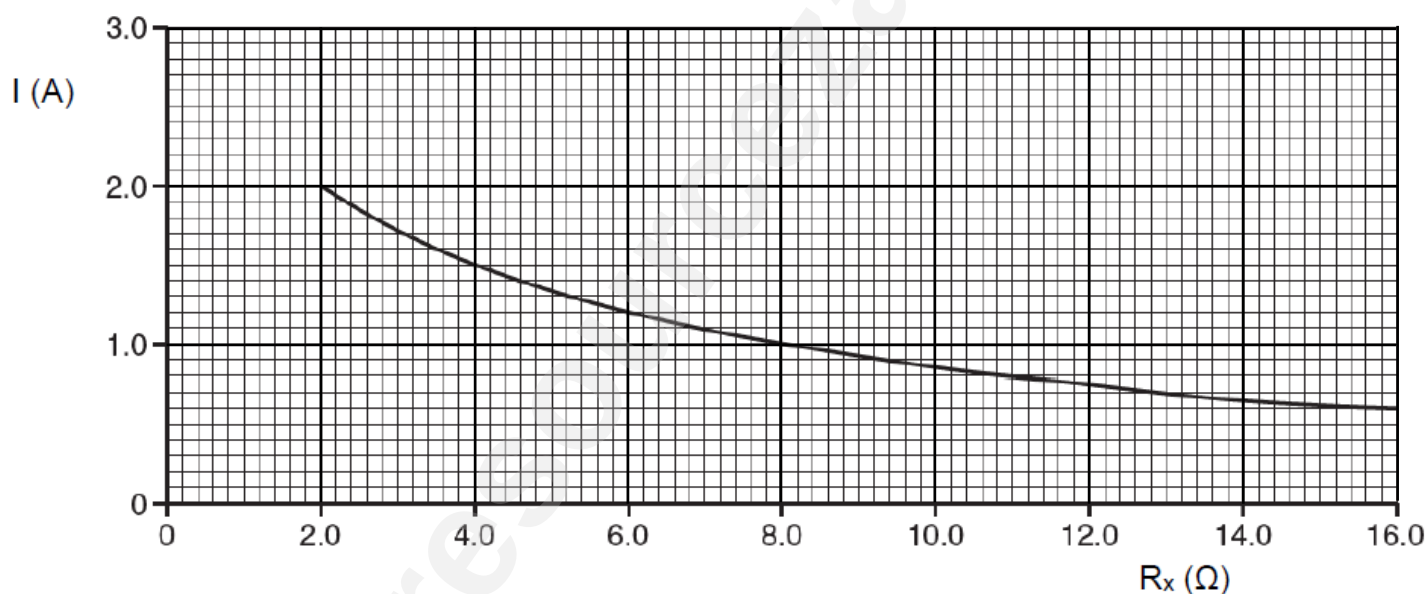
[12]

QUESTION 8 ELECTRIC CIRCUITS

- 8.1 A battery of emf 12 V and internal resistance $0,50\ \Omega$ is connected to a variable resistor (rheostat) **X** and a resistor **Y** of constant resistance, as shown in the diagram below.



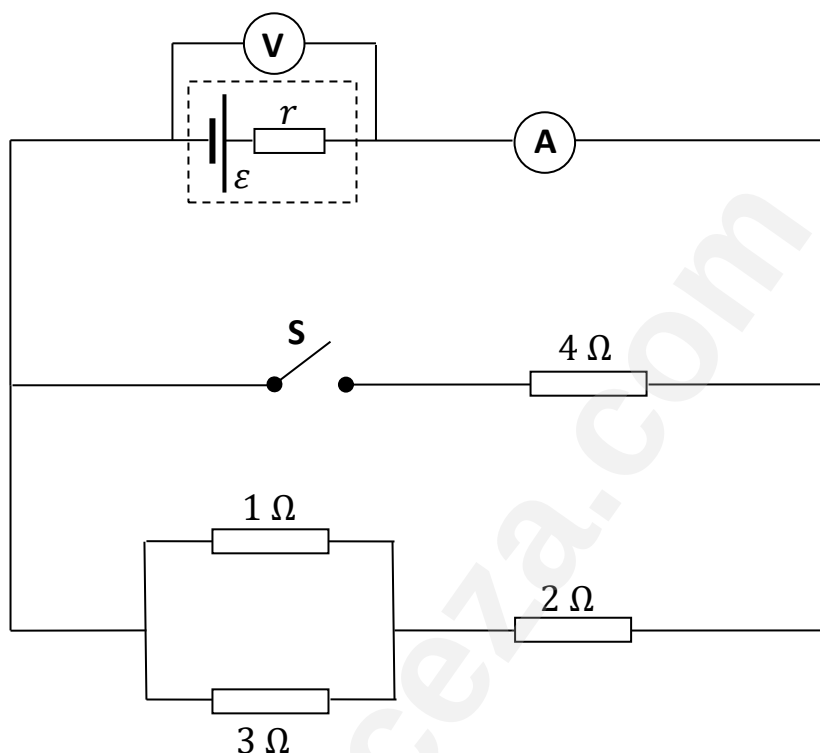
The resistance of **X** (R_X) is increased from $2\ \Omega$ to $16\ \Omega$.
The variation of the current (I) with R_X is shown in the graph below.



- 8.1.1 Define *emf*. (2)
- 8.1.2 When the current is **1,6 A**,
- Use the graph to read off the resistance of **X** (R_X). (1)
 - Calculate the potential difference across **X**. (3)
 - Calculate the resistance of **Y**. (5)
- 8.1.3 The resistance of **X** is adjusted to $11\ \Omega$. Calculate the amount of charge passing through the battery per minute when $R_X = 11\ \Omega$. (4)
- 8.1.4 Use the graph to EXPLAIN how and why the terminal potential difference, as given by the reading on the voltmeter, will change as the resistance of **X** is increased. (3)

Q8 continues overleaf...

- 8.2 The circuit in the diagram below consists of four resistors connected as shown, a voltmeter, an ammeter, a switch and a battery of internal resistance r and emf ε .



- When switch S is OPEN the reading on the voltmeter is 9,6 V and the reading on the ammeter is 3,49 A.
- When switch S is CLOSED the reading on the voltmeter is 8,4 V and the reading on the ammeter is 5,15 A.

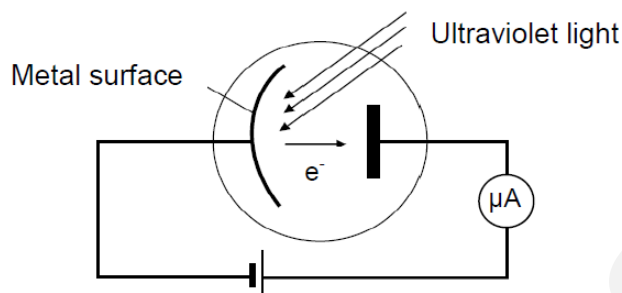
- 8.2.1 Set up a pair of simultaneous equations and then calculate r , the internal resistance of the battery. (5)
- 8.2.2 Hence, calculate ε , the emf of the battery. (2)
- 8.2.3 Calculate the current flowing through the $2\ \Omega$ resistor with switch S CLOSED. (5)

[30]

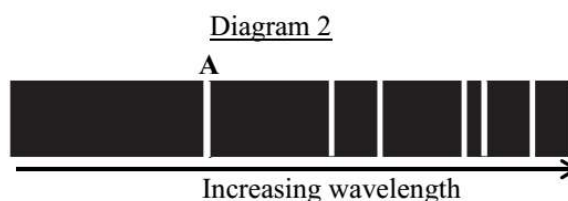
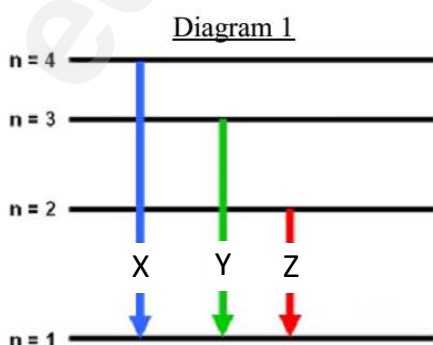
QUESTION 9

PHOTONS AND ELECTRONS

- 9.1 The diagram shows ultraviolet light falling on the surface of a caesium cathode in a photocell. The work function of caesium is $3,36 \times 10^{-19} \text{ J}$. The wavelength of a photon of ultraviolet light is 350 nm.



- 9.1.1 Describe the photoelectric effect. (2)
- 9.1.2 Calculate the energy of a photon of ultraviolet light. Report your answer in electronvolts. (4)
- 9.1.3 Calculate the maximum speed of the photoelectrons emitted. (4)
- 9.1.4 The intensity of the ultraviolet light is such that it transfers $1,24 \times 10^{-8} \text{ J}$ of energy in one second to the caesium cathode. If one photon releases one electron then calculate the number of electrons released from the cathode in one second. (2)
- 9.1.5 How will the number of electrons emitted be affected if:
- The **intensity** of the incident radiation is increased. (1)
 - The **frequency** of the incident radiation is increased. (1)
- 9.2 Diagram 1 below shows some of the possible energy emissions as excited electrons in a hot gas fall to lower energy levels. (Level $n = 4$ has the highest energy.) Diagram 2 below shows the line emission spectrum produced. The white lines indicate the wavelengths at which light was observed.
- Which of the emissions, **X**, **Y** or **Z** (diagram 1) is most likely to correspond to spectral line **A** in diagram 2? Explain your answer. (3)



[17]

THE END - Be sure to submit all working, including the Appendix sheet.

EXAMINATION DATA SHEET FOR THE PHYSICAL SCIENCES
(PHYSICS)

TABLE 1 PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Acceleration due to gravity	g	9,8 m.s ⁻²
Speed of light in a vacuum	c	3,0 × 10 ⁸ m.s ⁻¹
Universal gravitational constant	G	6,7 × 10 ⁻¹¹ N.m ² .kg ⁻²
Coulomb's constant	k	9,0 × 10 ⁹ N.m ² .C ⁻²
Magnitude of charge on electron	e	1,6 × 10 ⁻¹⁹ C
Mass of an electron	m _e	9,1 × 10 ⁻³¹ kg
Planck's constant	h	6,6 × 10 ⁻³⁴ J.s
1 electron volt	eV	1,6 × 10 ⁻¹⁹ J

TABLE 2 PHYSICS FORMULAE

MOTION

$v = u + at$ or $v_f = v_i + a\Delta t$	$s = \frac{v+u}{2} t$ 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 $F_{net}\Delta t = m\Delta v$	$\Delta p = mv - mu$ or $\Delta p = mv_f - mv_i$
$p = mv$	$w = F_g = mg$	$F_f^{max} = \mu F_N$

WORK, ENERGY AND POWER

WORK, ENERGY AND POWER			
$W = F_S$ or $W = F\Delta x$ or $W = F\Delta x \cos \theta$		$P = \frac{W}{t}$	$P = Fv$
$E_p = mgh$	$E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta E_K$	$efficiency = \frac{power_{out}}{power_{in}}$

GRAVITATIONAL AND ELECTRIC FIELDS

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

ELECTRIC CIRCUITS

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

ELECTRODYNAMICS

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

PHOTONS AND ELECTRONS

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

APPENDIX ANSWER SHEET

Exam number/name:

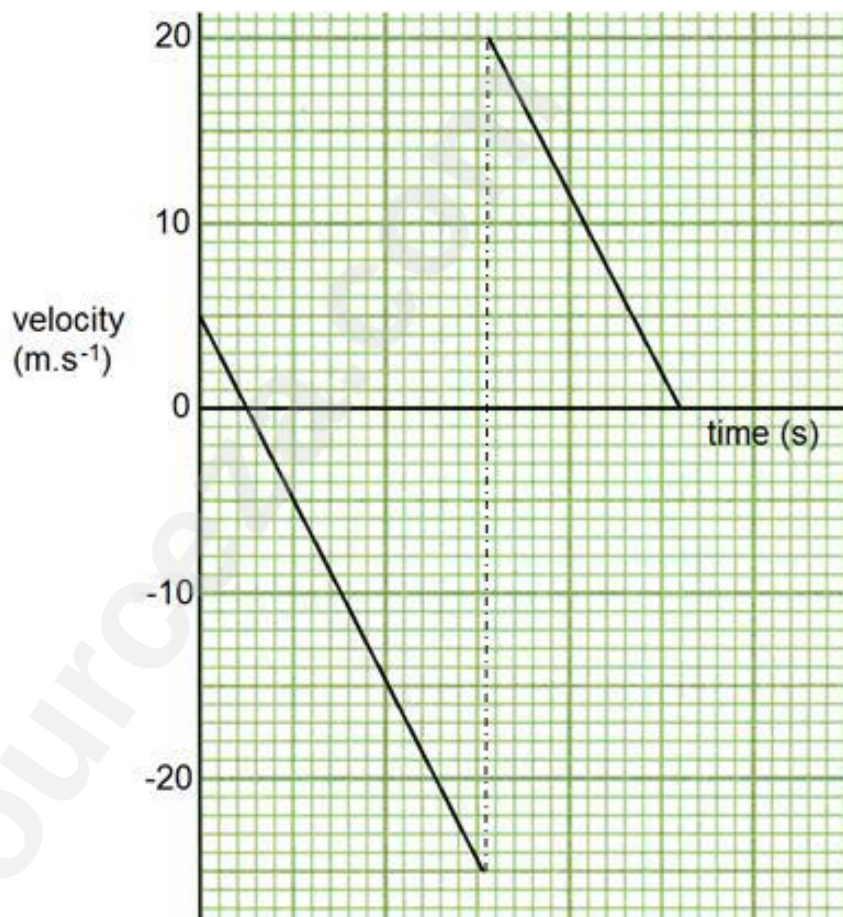
QUESTION 1

MARK THE CORRECT ANSWER WITH A CROSS.

Eg	A	☒ B	C	D
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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

QUESTION 2.2



QUESTION 4.1

Table 1: Data from pendulum experiment to determine g		
Height of release (m)	Velocity at lowest point (m.s ⁻¹)	Square of velocity, v ² () (1)
0,2	2,4	
0,4	3,5	
0,6	4,2	
0,8	4,9	
1,0	5,5	

1 dp (2)

QUESTION 4.3

