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KINGSWOOD COLLEGE

GRADE 12

PHYSICAL SCIENCE PAPER 1 (PHYSICS) SEPTEMBER 2021

Examiner: D. Price

Moderator: G. Makoni

Time: 3 hours

Total: 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
 - A question paper with 16 pages, excluding the cover page
 - An answer sheet for Question 1 and Question 9.1.7 on page 13 and 14, respectively
 - A data and formulae sheet on page 15 and 16
2. There are 12 questions. Answer all of them.
3. Use the data and formulae sheet whenever necessary.
4. Where appropriate express answers to **TWO** decimal places.
5. Show your working in all calculations.
6. Appropriate units should be shown in the answer.
7. At the end of the exam place the answer sheet and graph paper inside the front cover of the answer book.

DO NOT TURN THIS PAGE OVER UNTIL THE INVIGILATOR TELLS YOU TO

QUESTION 1:

The following questions are multiple choice and each consists of 4 possible answers **A – D**, choose the letter that represents the best answer and mark it on the grid given on page 13

1.1

You can replace two non collinear forces, P and Q, with a single force of 7 N. If the magnitude of force P is 3 N, which one of the following can be the magnitude of force Q?

- A. 2 N
 - B. 3 N
 - C. 8 N
 - D. 13 N
- (2)

1.2

An object of weight 50 N falls in air at a constant velocity. The force exerted by the air on this object is :

- A. less than 50 N
 - B. more than 50 N
 - C. equal to 50 N
 - D. zero
- (2)

1.3

A ball of mass 400 g is travelling at a speed of 2m.s^{-1} It's momentum is:

- A. 800 kg.m.s^{-1}
 - B. 0.8 kg m.s^{-1}
 - C. 0.8 kg.m.s^{-2}
 - D. 200 kg.m.s^{-1}
- (2)

1.4

An electric motor lifts a load of mass **m** through a vertical height **h** at a constant speed **v** in time **Δt** . Which one of the following expressions can be used to calculate the rate at which work is done on the load while it is being lifted at a constant speed?

- A. mgv
 - B. mgh
 - C. $(mgh + \frac{1}{2}mv^2)/\Delta t$
 - D. $\frac{1}{2}mv^2/\Delta t$
- (2)

1.5

Two identically charged objects are separated by a distance r . They exert a force F on each other. If you **halve** the distance between the two charged objects, what will be the new force that the charged objects exert on each other?

- A. $2 F$
 - B. $\frac{1}{2} F$
 - C. $4 F$
 - D. $\frac{1}{4} F$
- (2)

1.6

Two resistors of equal resistance are connected in SERIES to a battery with negligible internal resistance. The current through the battery is I . When the two resistors are connected in PARALLEL to the same battery, the current through the battery will be ...

- A. $4 I$
 - B. $2 I$
 - C. I
 - D. $\frac{1}{2} I$
- (2)

1.7

The operation of a motor and a generator are each underpinned by an energy transformation together with Fleming's hand rule. Which one of the following combinations will be TRUE?

	MOTOR	GENERATOR
A.	Electrical to mechanical; Fleming's left-hand rule	Mechanical to electrical; Fleming's right-hand rule
B.	Mechanical to electrical; Fleming's right-hand rule	Electrical to mechanical; Fleming's left-hand rule
C.	Electrical to mechanical; Fleming's right-hand rule	Mechanical to electrical; Fleming's left-hand rule
D.	Mechanical to electrical; Fleming's left-hand rule	Electrical to mechanical; Fleming's right-hand rule

1.8

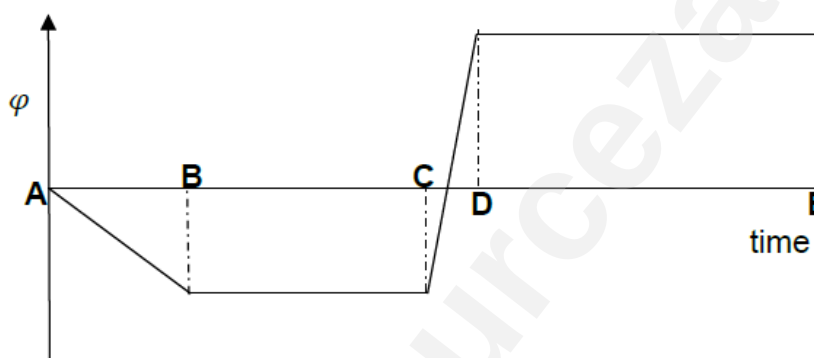
A step-down transformer changes 240 V AC to 6 V AC. There are 75 turns on the secondary coil. How many turns are there on the primary coil?

- A 40
- B 75
- C 240
- D 3 000

(2)

1.9

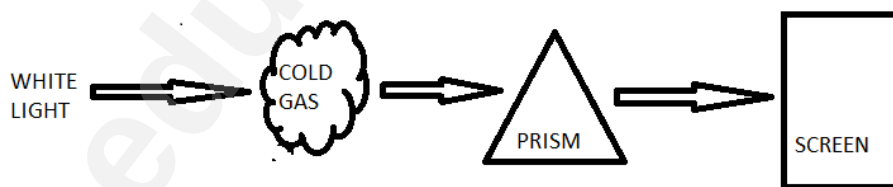
The magnetic flux (ϕ) through a loop of wire changes as shown in the sketch graph below. During which time interval will the induced emf be **positive and non-zero**?



- A. A - B
- B. B - C
- C. C - D
- D. D - E

1.10

Light spectra help to identify elements. White light is passed through a cold gas and then through a prism as shown in the sketch below.



What type of spectrum is observed on the screen?

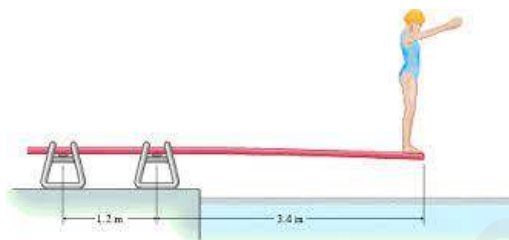
- A. Line absorption spectrum
- B. Line emission spectrum
- C. Continuous absorption spectrum
- D. Continuous emission spectrum

(2)

TOTAL QUESTION 1: [20]

QUESTION 2:

The 2020 Olympics recently took place in Tokyo, Japan. In the diagram below, a **65 kg** Olympic springboard diver jumps up into the air at the end of a diving board. The diver lands on the springboard, travelling downward at **8 m.s⁻¹** and leaves the springboard moving upward at **12 m.s⁻¹**.



- 2.1 Draw a labelled free-body diagram of the forces acting on the diver while she is in contact with the springboard. The lengths of the vectors must be proportional (3)
- 2.2 Define *momentum*. (2)
- 2.3 Calculate the diver's change in momentum while she is in contact with the springboard? (3)
- 2.4 The diver's feet are in contact with the springboard for **0.8 s**. Calculate the force that the springboard exerts on her. (5)

TOTAL FOR QUESTION 2: [13]

QUESTION 3:

Skateboarding proved to be a very popular Olympic sport this year. Jenna is a keen skater and hopes to compete at the next Olympic games. Jenna, mass **60 kg**, is running at **3 m.s⁻¹** east when she jumps onto a **2 kg** stationary skateboard.



- 3.1 Define the *Law of Conservation of Linear Momentum* (2)
- 3.2 Calculate the velocity of Jenna and the board after she has landed on it. (4)
- 3.3 Show that this collision is inelastic (3)
- 3.4 Explain the concept of a follow-through in any of your favourite sports at Kingswood by referring to physics principles. (3)

TOTAL FOR QUESTION 3: [12]

QUESTION 4:

To celebrate the end of school a group of Grade 12 Kingswood College students decide to go on a hike. After a couple of hours of walking they come to a krans (a sheer cliff). The first hiker, Cole, uses a chain ladder to climb from the soft dry river bed below to the top of the **20 m** krans.



The hikers below ask him to send some oranges down to them before they climb the ladder. The oranges strike the soft river bed below. Assume that air resistance is negligible.

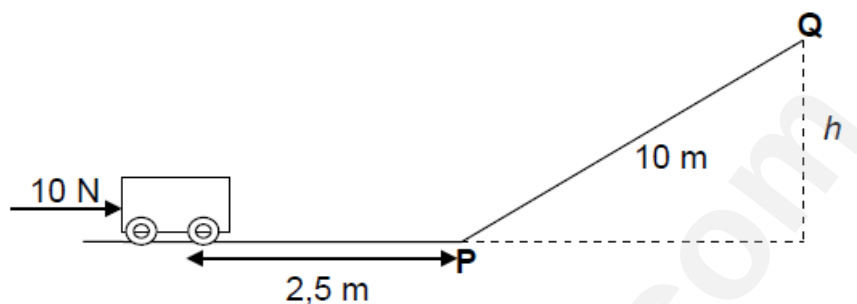
- He drops the first orange (A) from a height of **20 m**.
- He sends the second orange (B) down to them, throwing it with a velocity of **10 m.s⁻¹** downward.
- He throws a third orange (C) upward into the air with a speed of **10 m.s⁻¹**.

- 4.1 State the difference between speed and velocity?. (2)
- 4.2 Calculate the time taken for orange A to reach the river bed below. (3)
- 4.3 Calculate the magnitude of the impact velocity of each of the oranges when it reaches the river bed 20 m below him. Do this for:
 - 4.3.1 Orange A (3)
 - 4.3.2 Orange B (3)
 - 4.3.3 Orange C (2)
- 4.4 Sketch a velocity vs time sketch graphs (on the same set of axes) for the flight of each of the three oranges from when it leaves Cole's hand. Label the graphs A, B and C to correspond with each of the oranges A, B and C. Numerical values are not needed on the sketch graph but the axes must be clearly labelled. (6)
- 4.5 One of the hikers, Wanda, is curious about how the depth of the crater formed by a falling orange varies with the impact velocity of the orange. Suggest a hypothesis for her question. (2)

TOTAL FOR QUESTION 4: [21]

QUESTION 5:

A 3 kg trolley is initially at rest on a horizontal frictionless surface. A constant horizontal force of 10 N is then applied to the trolley over a distance of 2,5 m.



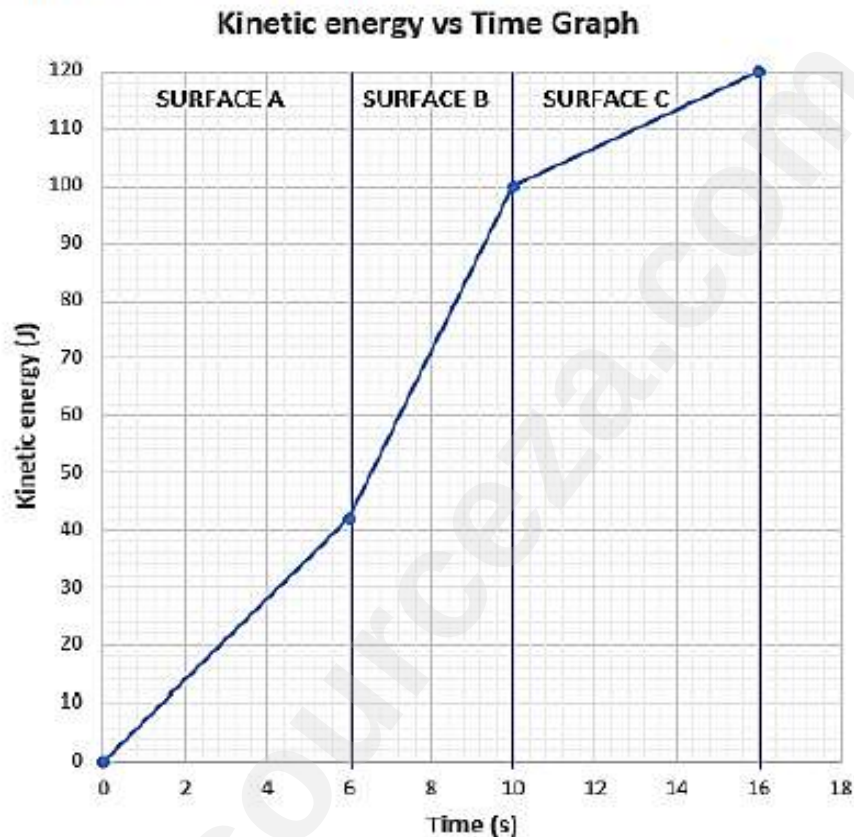
When the force is removed at point P, the trolley moves a distance of 10 m up the incline until it reaches the maximum height at point Q. While the trolley moves up the incline, there is a constant frictional force of 2 N acting on it.

- 5.1 Define *distance* (2)
- 5.2 Write down the name of a non-conservative force acting on the trolley as it moves up the incline. (2)
- 5.3 Draw a labelled free-body diagram showing all the forces acting on the trolley as it moves along the **horizontal** surface. (3)
- 5.4 Calculate the speed of the trolley when it reaches point P. (4)
- 5.5 Calculate the height, h , that the trolley reaches at point Q. (5)

TOTAL FOR QUESTION 5: [16]

QUESTION 6:

A graph of kinetic energy against time for the motion of a toy truck (mass **2 kg**) across three different **horizontal** surfaces, A, B and C is shown below. A constant force F is applied to the truck as it moves in a straight line across the three different surfaces.



- 6.1 State the *work energy theorem*. (2)
- 6.2 Calculate the net work done on the truck during the first 6 seconds of the motion. (2)
- 6.3 Calculate the displacement of the truck in the first 6 seconds of the motion. (4)
- 6.4 Determine the net force acting on the truck during the first 6 seconds of the motion. (2)
- 6.5 Which surface, A, B or C, has the greatest coefficient of kinetic friction? Justify your answer by referring to the graph, as well as an equation. (4)
- 6.6 Determine the acceleration of the truck as it rides over surface B. (4)
- 6.7 Determine the magnitude of the force, F , if the coefficient of friction of surface B is 0.25 (5)

TOTAL FOR QUESTION 6: [23]

QUESTION 7:

The table below shows the radius and mass of Mars

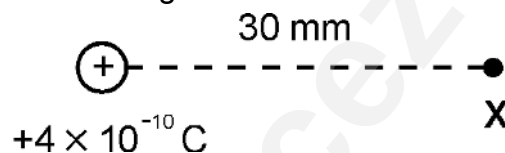
Planet	Radius (km)	Mass (kg)
Mars	3 400	$6,4 \times 10^{23}$

- 7.1 Define *gravitational field*. (2)
- 7.2 Calculate the magnitude of the gravitational field on the surface of Mars. (4)
- 7.3 Define *weight*. (2)
- 7.4 Calculate the weight of a robot on Mars if its weight on Earth is 500 N (3)

TOTAL FOR QUESTION 7: [11]

QUESTION 8

A small point charge carries a charge of $+4 \times 10^{-10}$ C.



- 8.1 Define *electric field strength* at a point. (2)
- 8.2 Calculate the magnitude of the electric field strength at a distance of 30 mm from the point charge. (4)
- 8.3 A second point charge of -8×10^{-10} C is placed at position X. Calculate the magnitude of the force between the charges. (4)
- 8.4 State whether this is a force of attraction or repulsion. (1)

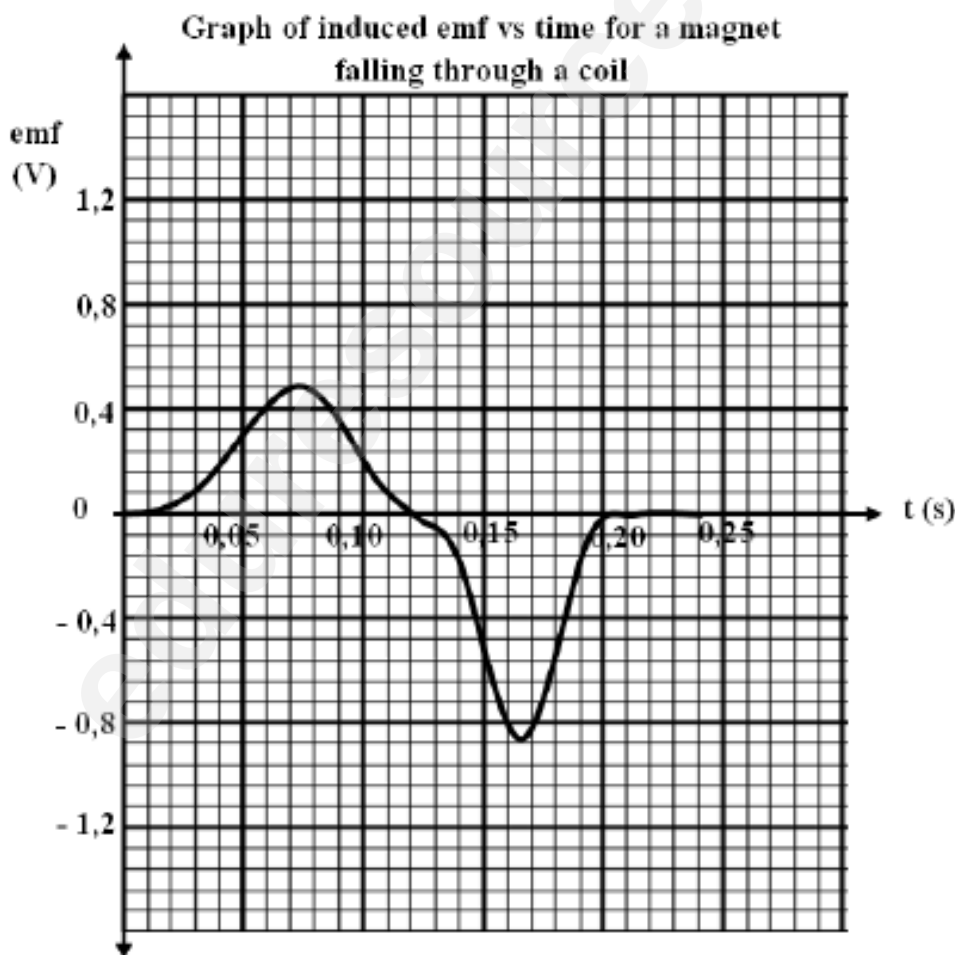
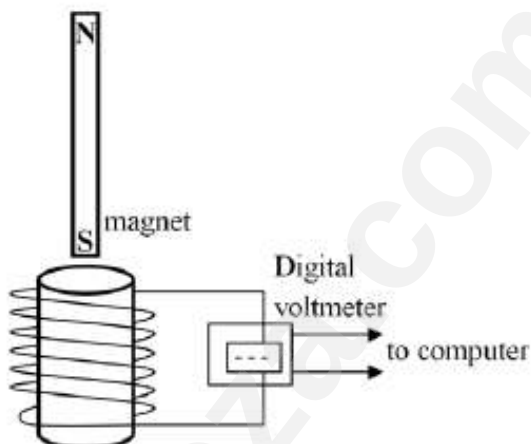
TOTAL FOR QUESTION 8: [11]

QUESTION 9:

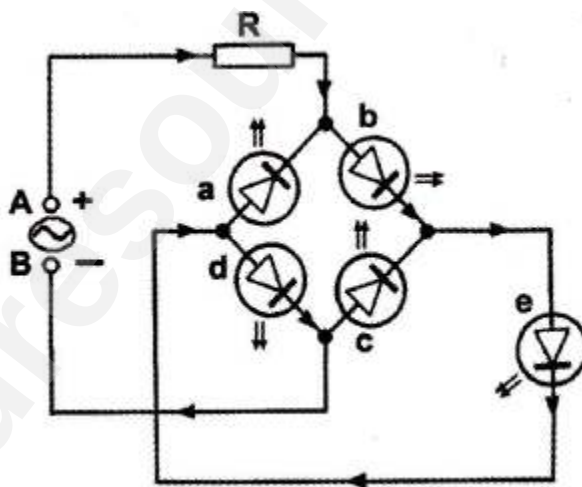
9.1 A bar magnet is dropped through a coil attached to a digital voltmeter as shown in the diagram. As the magnet falls through the coil it induces an emf in the coil. The voltmeter is connected to a computer which plots a graph of the induced emf against time.

NOTE:

There are many more windings on the coil than are shown in this simplified diagram.



- 9.1.1 State *Lenz's Law* (2)
- 9.1.2 State the polarity (north or south) of the bottom of the coil as the magnet exits the coil, (2)
- 9.1.3 Draw a labelled free body diagram to represent the forces acting on the magnet as it exits the coil. Air resistance can be ignored. (3)
- 9.1.4 Define *magnetic flux linkage* (2)
- 9.1.5 Explain how an emf is induced in the coil by referring to an appropriate equation. (3)
- 9.1.6 Why is the magnitude of the maximum induced emf greater as the magnet exits the coil than when it enters the coil? (2)
- 9.1.7 The graph of emf versus time for the magnet falling through the coil has been reproduced on page 14. On this set of axes draw a graph to represent the induced emf against time when the following change is made to the initial experiment: The same magnet is dropped through a coil from the same original height but the number of turns on the coil has halved and the North pole of the magnet enters first. (4)
- 9.2 Five LED's have been connected to the circuit shown in the diagram below. A resistor R has been connected in series, as shown. The circuit is connected to an AC supply between A and B.



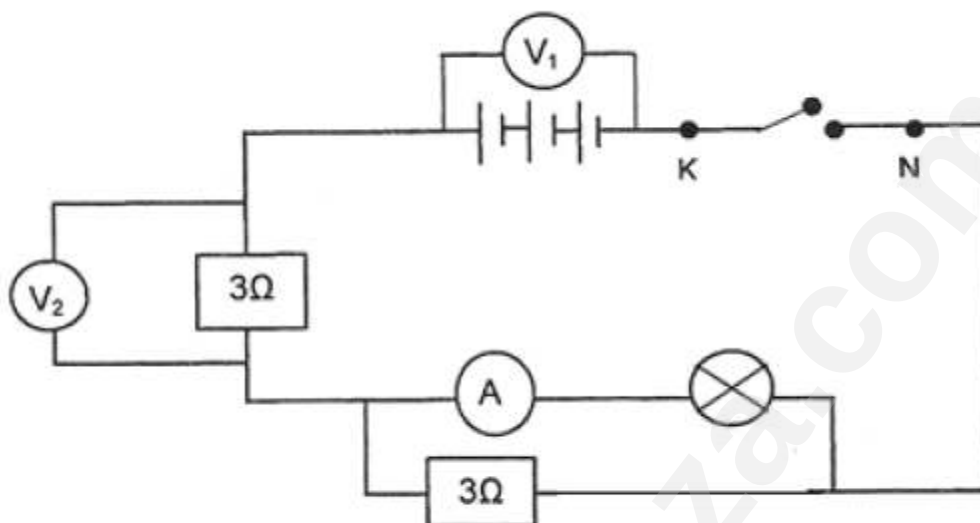
Draw separate sketch graphs to show how current varies with time in:

- a) resistor R (3)
- b) LED e (3)

TOTAL FOR QUESTION 9: [24]

QUESTION 10:

10.1 The internal resistance of the circuit below is 1 ohm



The reading on the voltmeter V_1 decreases from 12 V to 10 V when the switch is closed.

10.1.1 Define the term *emf* (2)

10.1.2 Explain why the reading on the voltmeter V_1 decreases when the switch is closed (2)

10.1.3 Calculate the current that flows through the light bulb (6)

10.1.4 The voltmeter V_2 is now removed from its present position and is connected across points KN. The switch is opened. Explain how the brightness of the bulb will be affected. (4)

10.2 Two filament type light bulbs are marked “60 W, 120 V” and “40 W, 120 V”

This information tells us that if the potential difference across each of the light bulbs is 120 V they will generate 60 W and 40 W of power respectively. Since the power rating of a light bulb is a measure of its brightness the 60 W light bulb will burn brighter than the 40 W light bulb.

These two light bulbs are now connected in series across a potential difference of 120 V.

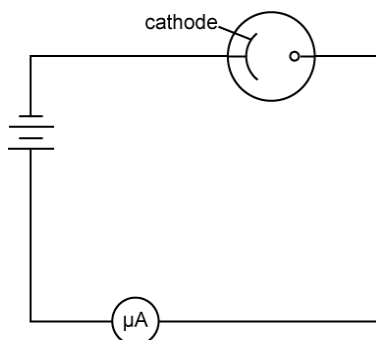
10.2.1 Calculate the resistance of each light bulb. (3)

10.2.2 Hence determine the power generated by each light bulb when they are connected in series. (assume that the resistance of the filaments does not vary with current) (5)

TOTAL FOR QUESTION 10: [22]

QUESTION 11:

A metal-coated cathode of a photocell is illuminated first with green light and then with yellow light. Electrons are emitted from the metal surface when green light is used, but not when yellow light is used.



Daniel suggests that red light, like green light, will also result in electrons being emitted from the cathode.

- 11.1 Do you agree with Daniel's suggestion? Give reasons for your answer. (3)
 11.2 What would the effect on the cathode of the photocell be if it were irradiated with blue light? Give a reason for your answer. (3)

It requires $3,118 \times 10^{-19}$ J of energy to remove a single electron from the surface of the cathode when the metal is illuminated with light having a wavelength of $0,6 \mu\text{m}$ in air.

- 11.3 Define the following:
 (a) *Work function* (2)
 (b) *Threshold frequency* (2)
 11.4. Determine the energy of the photon. (5)
 11.5 What will the kinetic energy of the electron be? (3)
 11.6 Determine the speed with which the electron is ejected. (3)

TOTAL FOR QUESTION 11 [21]

QUESTION 12:

The line spectrum for a particular type of atom is found to include radiation of the following wavelengths:

- i) 83 nm ii) 50 nm iii) 25 nm

- 12.1 Calculate the frequency that corresponds to 50 nm (3)
 12.2 Which wavelength will be emitted when an electron moves between orbitals which have a large energy difference? (3)

TOTAL FOR QUESTION 12 [6]

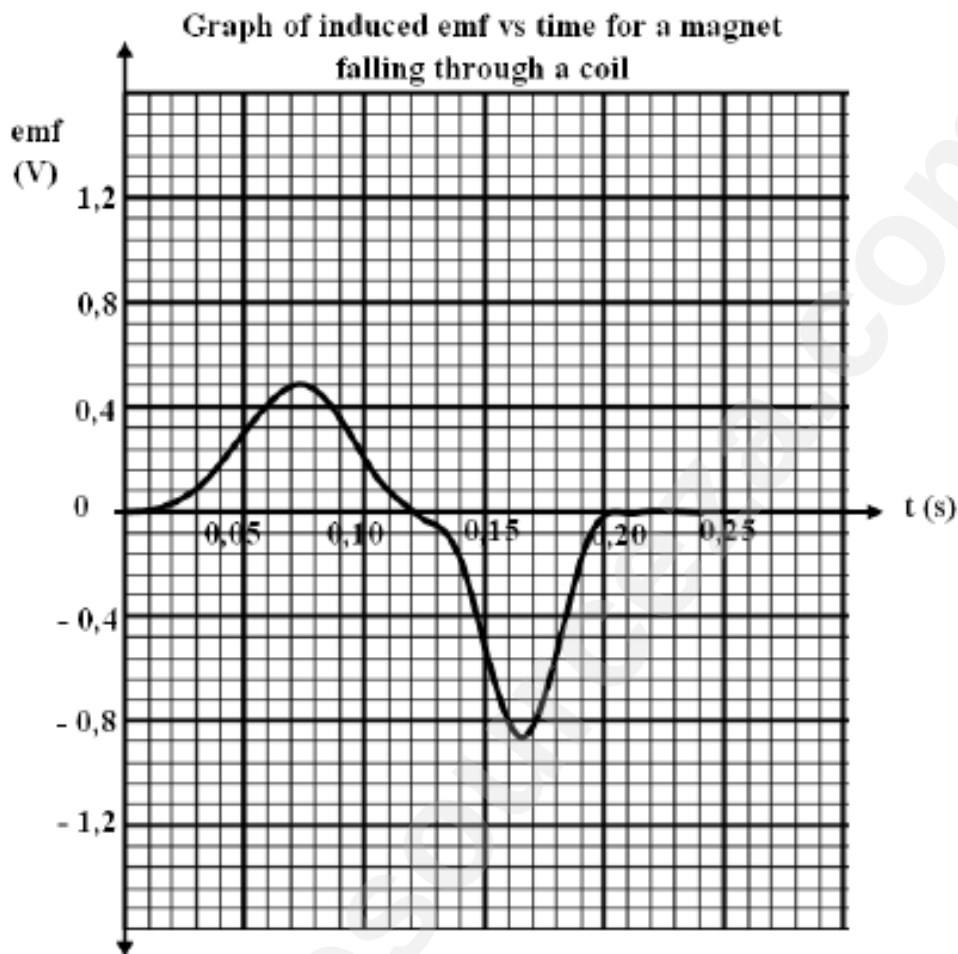
Name: _____

Answer sheet for question 1

- Put an X in the box which contains the letter which corresponds to the correct answer.
- There is only one correct answer for each question.
- Remember to detach this answer sheet and put it in your answer booklet.

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 9.1.7



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

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

WORK, ENERGY AND POWER

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

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 $emf = V_{load} + V_{internal\ resistance}$
$R_s = R_1 + R_2 + \dots$	$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
$P = \frac{W}{t}$ or $W = Pt$	
$W = VIt$ or $W = I^2 R t$ or $W = \frac{V^2}{R} t$	
$P = VI$ or $P = I^2 R$ or $P = \frac{V^2}{R}$	

ELECTRODYNAMICS

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

PHOTONS AND ELECTRONS

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