SENIOR CERTIFICATE EXAMINATIONS

PHYSICAL SCIENCES: PHYSICS   (P1)

2017

MARKS: 150

TIME: 3 hours

This question paper consists of 15 pages, 3 data sheets and 1 graph sheet.

INSTRUCTIONS AND INFORMATION

1.   Write your examination number and centre number in the appropriate spaces on the ANSWER BOOK and on the attached GRAPH SHEET. Place the GRAPH SHEET in your ANSWER BOOK and hand it in with your ANSWER BOOK.

2.   This question paper consists of 11 questions. Answer ALL the questions in the ANSWER BOOK.

3.   Start EACH question on a NEW page in the ANSWER BOOK.

4.   Number the answers correctly according to the numbering system used in this question paper.

5.   Leave ONE line between two subquestions, for example between QUESTION 2.1 and QUESTION 2.2.

6.   You may use a non-programmable calculator.

7.   You may use appropriate mathematical instruments.

8.   You are advised to use the attached DATA SHEETS.

9.   Show ALL formulae and substitutions in ALL calculations.

10.   Round off your FINAL numerical answers to a minimum of TWO decimal places.

11.   Give brief motivations, discussions, et cetera where required.

12.   Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Write down the question number (1.1–1.10), choose the answer and make a cross (X) over the letter (A–D) of your choice in the ANSWER BOOK.

EXAMPLE:			
1.11	A	B	C	~~D~~

1.1   A constant net force acts on a trolley.

According to Newton's Second Law, the acceleration of the trolley is … the mass of the trolley.

A   equal to

B   independent of

C   directly proportional to

D   inversely proportional to   (2)

1.2   The weight of a man on the surface of the Earth is **w**. Planet **X** has the *same* radius as the Earth, but *half* the mass of the Earth.

If the same man goes to Planet **X**, his weight on the surface will be …

A   ¼ **w**

B   ½ **w**

C   **w**

D   2 **w**   (2)

1.3   An object falls freely in a vacuum near the surface of the Earth.

Which ONE of the following statements regarding the motion of the object is CORRECT?

A   The velocity of the object will remain constant.

B   The velocity of the object will decrease uniformly.

C   The rate of change of velocity of the object will increase uniformly.

D   The rate of change of velocity of the object will remain constant.   (2)

1.4   A ball, moving horizontally, hits a wall with a speed 2*v*. The ball then bounces back horizontally with a speed *v*, as shown in the diagram below.

BEFORE COLLISION   **AFTER COLLISION**
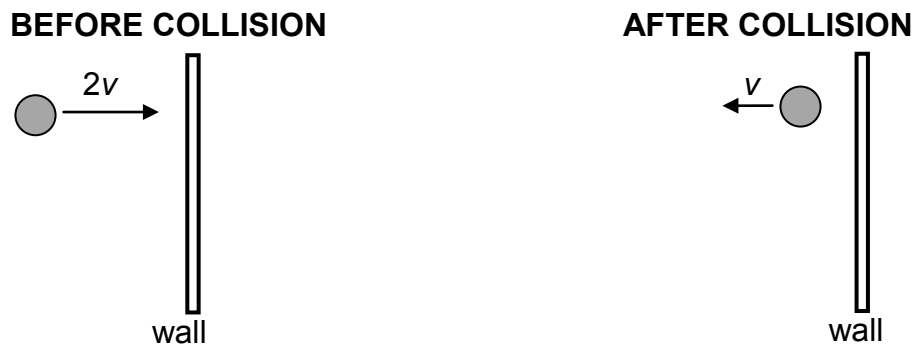
wall   wall

Which ONE of the following combinations regarding the linear momentum and the total kinetic energy of the ball for the collision above is CORRECT? Assume that the ball-wall system is isolated.

	LINEAR MOMENTUM	TOTAL KINETIC ENERGY
A	Conserved	Not conserved
B	Conserved	Conserved
C	Not conserved	Not conserved
D	Not conserved	Conserved

(2)

1.5   A constant horizontal force **F** displaces a box by Δx over a rough horizontal surface. Study the diagram below.

surface
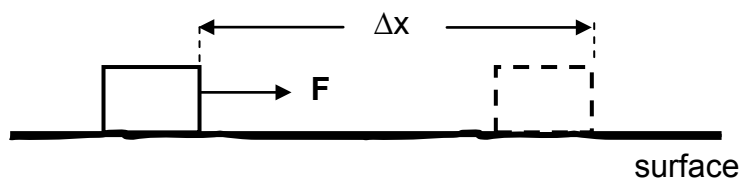
The normal force acting on the box does NO work on the box during the motion, because it is …

A   equal to the applied force.

B   perpendicular to the applied force.

C   equal and opposite to the weight of the box.

D   perpendicular to the displacement of the box.   (2)

1.6   A car travels at a constant velocity towards a stationary listener. The car's hooter emits a sound of constant frequency as it approaches the listener.

Which ONE of the following statements regarding the frequency and wavelength of the sound of the hooter is CORRECT as observed by the listener?

A   Both the frequency and wavelength have decreased.

B   The frequency has increased while the wavelength has decreased.

C   The frequency has decreased while the wavelength has increased.

D   Both the frequency and wavelength have increased.   (2)

1.7   Three identical positive point charges, Q_1, Q_2 and Q_3, are initially situated on a smooth flat table at the corners of a right-angled triangle. The diagram below shows the charges as viewed from above.
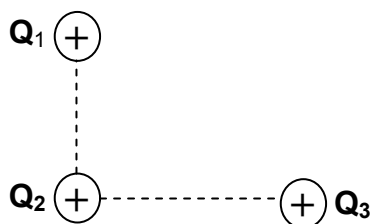
Which ONE of the following diagrams shows the direction in which Q_2 will move as a result of the electrostatic forces exerted by Q_1 and Q_3 on it?

(2)

1.8   A certain conductor obeys Ohm's law.

Which ONE of the statements below regarding the resistance of the conductor is CORRECT?

The resistance of this conductor …

A   changes as the potential difference across it changes at constant temperature.

B   changes as the current passing through it changes at constant temperature.

C   remains unchanged, even if the potential difference across it or current in it changes at constant temperature.

D   remains unchanged, even if its temperature changes.   (2)

1.9   Which ONE of the following energy conversions takes place when an AC generator is in operation?

        A   Electrical to mechanical

        B   Mechanical to electrical

        C   Heat to mechanical

        D   Electrical to potential   (2)

1.10   The diagram below shows four energy levels of an atom. The transition of the atom from higher energy levels to lower energy levels results in the emission of a photon.
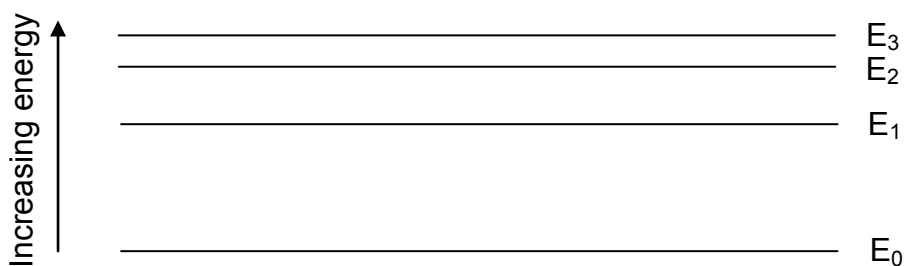
        Which ONE of the following transitions will lead to the emission of a photon with the shortest wavelength?

   A   From energy level E_2 to energy level E_1

        B   From energy level E_3 to energy level E_0

        C   From energy level E_3 to energy level E_2

        D   From energy level E_1 to energy level E_0 (2)
                                                                                                         [20]

QUESTION 2   (Start on a new page.)

2.1   A crate of mass 2 kg is being pulled to the right across a *rough* horizontal surface by a constant force F.

The force F is applied at an angle of 20° to the horizontal, as shown in the diagram below.
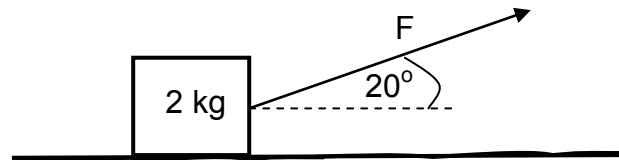
2.1.1   Draw a labelled free-body diagram showing ALL the forces acting on the crate.   (4)

A constant frictional force of 3 N acts between the surface and the crate. The coefficient of kinetic friction between the crate and the surface is 0,2.

Calculate the magnitude of the:

2.1.2   Normal force acting on the crate   (3)

2.1.3   Force F   (4)

2.1.4   Acceleration of the crate   (3)

2.2   A massive rock from outer space is moving towards the Earth.

2.2.1   State Newton's Law of Universal Gravitation in words.   (2)

2.2.2   How does the magnitude of the gravitational force exerted by the Earth on the rock change as the distance between the rock and the Earth becomes smaller?

Choose from INCREASES, DECREASES or REMAINS THE SAME.

Give a reason for the answer.   (2)
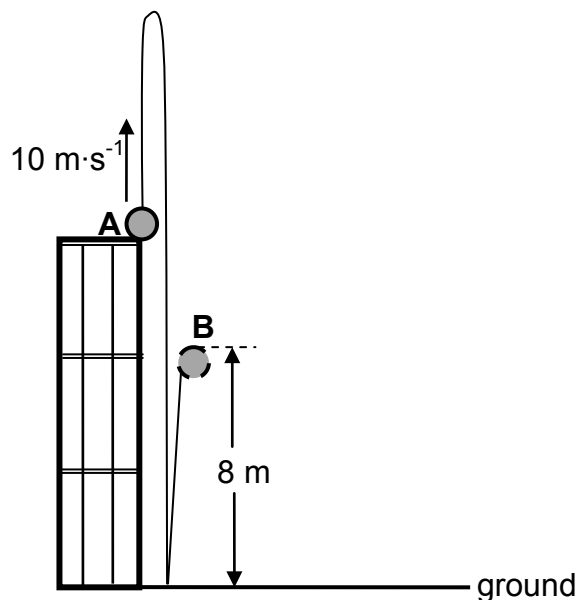   **[18]**

QUESTION 3   (Start on a new page.)

A ball is projected vertically upwards with a speed of 10 m·s^{-1} from point **A**, which is at the top edge of a building.

The ball hits the ground after 3 s. It is in contact with the ground for 0,2 s and then bounces vertically upwards, reaching a maximum height of 8 m at point **B**. See the diagram below.

Ignore the effects of friction.

3.1   Why is the ball considered to be in free fall during its motion?   (2)

3.2   Calculate the:

    3.2.1   Height of the building   (3)

    3.2.2   Speed with which the ball hits the ground   (3)

    3.2.3   Speed with which the ball leaves the ground   (3)

3.3   Draw a velocity versus time graph for the complete motion of the ball from **A** to **B**. Show the following on the graph:

- The magnitude of the velocity with which it hits the ground
- The magnitude of the velocity with which it leaves the ground
- The time taken to reach the ground, as well as the time at which it leaves the ground   (4)

[15]

QUESTION 4   (Start on a new page.)

A teacher demonstrates the principle of conservation of linear momentum using two trolleys. The teacher first places the trolleys, **A** and **B**, some distance apart on a flat frictionless horizontal surface, as shown in the diagram below. The mass of trolley **A** is 3,5 kg and that of trolley **B** is 6,0 kg.

Trolley **A** moves towards trolley **B** at constant velocity. The table below shows the position of trolley **A** for time intervals of 0,4 s before it collides with trolley **B**.

RELATIONSHIP BETWEEN POSITION AND TIME FOR TROLLEY A				
Position of trolley **A** (m)	0	0,2	0,4	0,6
Time (s)	0	0,4	0,8	1,2

4.1	Use the table above to prove that trolley **A** is moving at constant velocity before it collides with trolley **B**.	(3)

4.2	State the principle of conservation of linear momentum in words.	(2)

At time t = 1,2 s, trolley **A** collides with stationary trolley **B**. The collision time is 0,5 s after which the two trolleys move off together.

4.3	Calculate the magnitude of the average net force exerted on trolley **B** by trolley **A**.	(6)

[11]

QUESTION 5 (Start on a new page.)

The diagram below shows a boy skateboarding on a ramp which is inclined at 20° to the horizontal. A constant frictional force of 50 N acts on the skateboard as it moves from **P** to **Q**. Consider the boy and the skateboard as a single unit of mass 60 kg.

Ignore the effects of air friction.
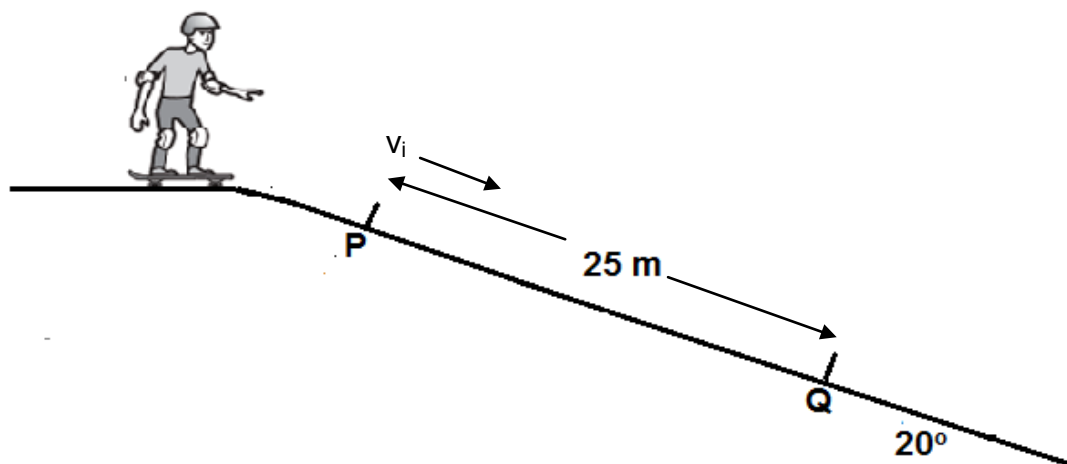
5.1　　Draw a labelled free-body diagram, showing ALL the forces acting on the boy-skateboard unit while moving down the ramp from **P** to **Q**.　　(3)

Points **P** and **Q** on the ramp are 25 m apart. The skateboarder passes point **P** at a speed v_i and passes point **Q** at a speed of 15 m·s^{-1}.

Ignore rotational effects due to the wheels of the skateboard.

5.2　　State the work-energy theorem in words.　　(2)

5.3　　Use energy principles to calculate the speed v_i of the skateboarder at point **P**.　　(5)

5.4　　Calculate the average power dissipated by the skateboarder to overcome friction between **P** and **Q**.　　(4)

[14]

QUESTION 6 (Start on a new page.)

6.1　　A police car is moving at constant velocity on a freeway. The siren of the car emits sound waves with a frequency of 330 Hz. A stationary sound detector measures the frequency of the sound waves of the approaching siren as 365 Hz. Take the speed of sound in air as 340 m·s^{-1}.

　　　　6.1.1　　State the Doppler Effect in words.　　(2)

　　　　6.1.2　　Calculate the speed of the car.　　(5)

6.2　　The spectrum of a distant star when viewed from an observatory on Earth appears to have undergone a red shift.

　　　　Use your knowledge of the Doppler effect to explain the term *red shift*.　　(3)

[10]

QUESTION 7   (Start on a new page.)

In the diagram below, **Q$_1$**, **Q$_2$** and **Q$_3$** are three stationary point charges placed along a straight line. The distance between **Q$_1$** and **Q$_2$** is 1,5 m and that between **Q$_2$** and **Q$_3$** is 1 m, as shown in the diagram below.

●	●	●
Q$_1$	**Q$_2$**	**Q$_3$**
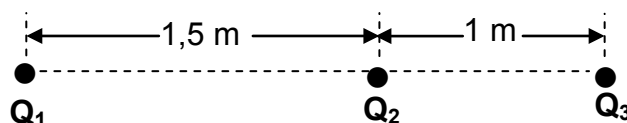
7.1   State Coulomb's law in words.   (2)

7.2   The magnitude of charges **Q$_1$** and **Q$_2$** are unknown. The charge on **Q$_1$** is positive. The charge on **Q$_3$** is $+2 \times 10^{-6}$ C and it experiences a net electrostatic force of 0,3 N <u>to the left</u>.

      7.2.1   Write down the sign (POSITIVE or NEGATIVE) of charge **Q$_2$**.   (2)

      Charge **Q$_2$** is now removed. The magnitude of the electrostatic force experienced by charge **Q$_3$** due to **Q$_1$** now becomes 0,012 N.

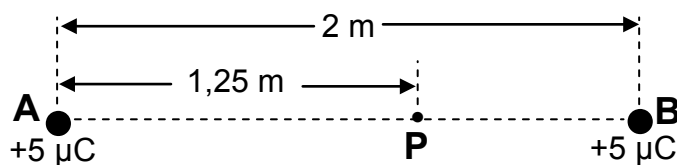   7.2.2   Calculate the magnitudes of the unknown charges **Q$_1$** and **Q$_2$**.   (7)
                                                                         [11]

QUESTION 8   (Start on a new page.)

Two small identical spheres, **A** and **B**, each carrying a charge of +5 µC, are placed 2 m apart.

Point **P** is in the electric field due to the charged spheres and is located 1,25 m from sphere **A**.

Study the diagram below.

A ●   **P** ●   **B** ●
+5 µC   +5 µC

8.1   Describe the term *electric field*.   (2)
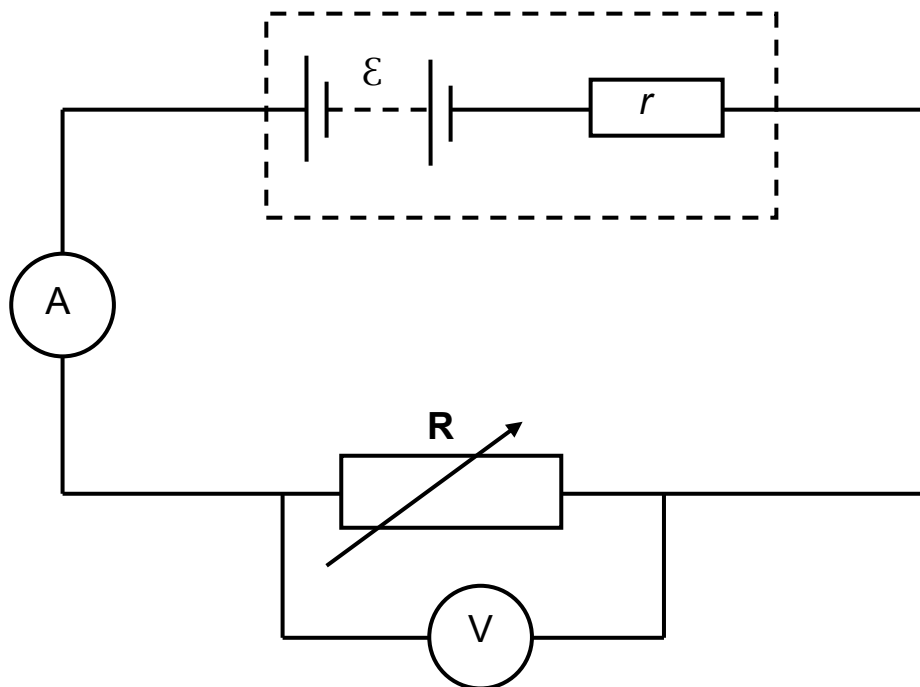
8.2   Draw the resultant electric field pattern due to the two charged spheres.   (3)

8.3   Calculate the magnitude of the net electric field at point **P**.   (5)
                                                                         [10]

QUESTION 9   (Start on a new page.)

9.1   The emf and internal resistance of a certain battery were determined experimentally.

The circuit used for the experiment is shown in the diagram below.

9.1.1   State Ohm's law in words.   (2)

The data obtained from the experiment is plotted on the attached graph sheet.

9.1.2   Draw the line of best fit through the plotted points. Ensure that the line cuts both axes.   (2)

Use information in the graph to answer QUESTIONS 9.1.3 and 9.1.4.

9.1.3   Write down the value of the emf (ε) of the battery.   (1)

9.1.4   Determine the internal resistance of the battery.   (3)

9.2   The circuit diagram below shows a battery with an emf (ε) of 60 V and an
        unknown internal resistance *r,* connected to three resistors.
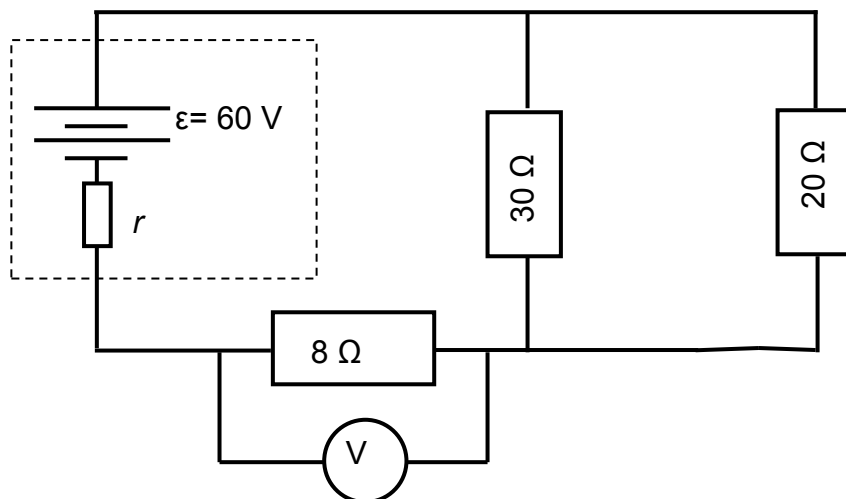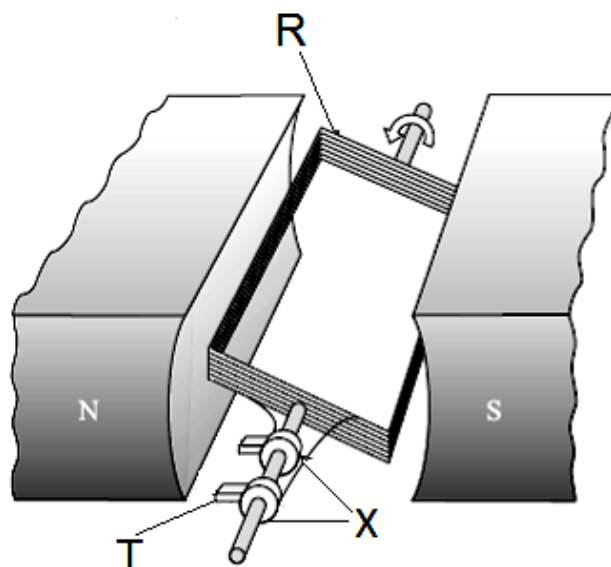

        A voltmeter connected across the 8 Ω resistor reads 21,84 V.

        Calculate the:

        9.2.1   Current in the 8 Ω resistor   (3)

        9.2.2   Equivalent resistance of the resistors in parallel   (2)

        9.2.3   Internal resistance *r* of the battery   (4)

        9.2.4   Heat dissipated in the external circuit in 0,2 seconds   (3)
                                                                                          [20]

QUESTION 10   (Start on a new page.)

10.1   The diagram below shows a simplified version of a generator.

10.1.1   Write down the name of EACH part, **R**, **T** and **X**.   (3)

10.1.2   Give the NAME of the law upon which the operation of the
generator is based.   (1)

10.2   An AC supply is connected to a light bulb. The light bulb lights up with the
same brightness as it does when connected to a 15 V battery.

10.2.1   Write down the rms value of the potential difference of the
AC supply.   (1)

10.2.2   If the resistance of the light bulb is 45 Ω, calculate the maximum
current delivered to the light bulb.   (4)
                                                                                    [9]

QUESTION 11   (Start on a new page.)

A simplified diagram of an apparatus for an experiment to investigate the photoelectric effect is shown below. Light of a fixed frequency is incident on the cathode of a photoelectric tube. During the experiment the ammeter (**A**) registers the photocurrent.
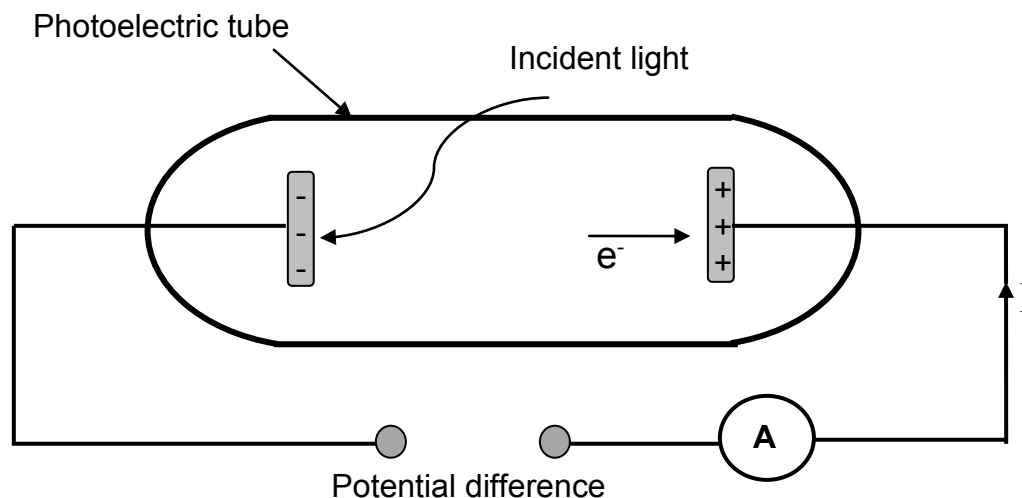
11.1   Define the term *photoelectric effect.*   (2)

The intensity of the incident light is now increased.

11.2   State how this increase in intensity will affect the reading on the ammeter. Choose from INCREASE, DECREASE or REMAIN THE SAME.

Give a reason for the answer.   (3)

When the frequency of the incident light is $5,9 \times 10^{14}$ Hz, the maximum recorded kinetic energy of photoelectrons is $2,9 \times 10^{-19}$ J.

11.3   Calculate the maximum wavelength (threshold wavelength) of the incident light that will emit an electron from the cathode of the photo-electric tube.   (5)

The maximum kinetic energy of the photoelectrons ejected increases when light of a higher frequency is used.

11.4   Use the photoelectric equation to explain this observation.   (2)
                                                                                                      [12]

                                                                                    TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 1 (FISIKA)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Acceleration due to gravity *Swaartekragversnelling*	g	$9,8 \ \text{m·s}^{-2}$
Universal gravitational constant *Universele gravitasiekonstant*	G	$6,67 \times 10^{-11} \ \text{N·m}^2\text{·kg}^{-2}$
Speed of light in a vacuum *Spoed van lig in 'n vakuum*	c	$3,0 \times 10^8 \ \text{m·s}^{-1}$
Planck's constant *Planck se konstante*	h	$6,63 \times 10^{-34} \ \text{J·s}$
Coulomb's constant *Coulomb se konstante*	k	$9,0 \times 10^9 \ \text{N·m}^2\text{·C}^{-2}$
Charge on electron *Lading op elektron*	e	$-1,6 \times 10^{-19} \ \text{C}$
Electron mass *Elektronmassa*	m_e	$9,11 \times 10^{-31} \ \text{kg}$
Mass of the Earth *Massa van die Aarde*	M	$5,98 \times 10^{24} \ \text{kg}$
Radius of the Earth *Radius van die Aarde*	R_E	$6,38 \times 10^6 \ \text{m}$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

MOTION/*BEWEGING*

$v_f = v_i + a\,\Delta t$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ or/*of* $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$v_f{}^2 = v_i{}^2 + 2a\Delta x$ or/*of* $v_f{}^2 = v_i{}^2 + 2a\Delta y$	$\Delta x = \left(\dfrac{v_i + v_f}{2}\right)\Delta t$ or/*of* $\Delta y = \left(\dfrac{v_i + v_f}{2}\right)\Delta t$

FORCE/*KRAG*

$F_{net} = ma$	$p = mv$
$f_s{}^{max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = G\dfrac{m_1 m_2}{d^2}$ or/*of* $F = G\dfrac{m_1 m_2}{r^2}$	$g = G\dfrac{M}{d^2}$ or/*of* $g = G\dfrac{M}{r^2}$

WORK, ENERGY AND POWER/*ARBEID, ENERGIE EN DRYWING*

$W = F\Delta x \cos\theta$	$U = mgh$ or/*of* $E_P = mgh$
$K = \dfrac{1}{2}mv^2$ or/*of* $E_k = \dfrac{1}{2}mv^2$	$W_{net} = \Delta K$ or/*of* $W_{net} = \Delta E_k$ $\Delta K = K_f - K_i$ or/*of* $\Delta E_k = E_{kf} - E_{ki}$
$W_{nc} = \Delta K + \Delta U$ or/*of* $W_{nc} = \Delta E_k + \Delta E_p$	$P = \dfrac{W}{\Delta t}$
$P_{ave} = Fv_{ave}$	

WAVES, SOUND AND LIGHT/*GOLWE, KLANK EN LIG*

$v = f\lambda$	$T = \dfrac{1}{f}$
$f_L = \dfrac{v \pm v_L}{v \pm v_s}f_s$ or/*of* $f_L = \dfrac{v \pm v_L}{v \pm v_b}f_b$	$E = hf$ or/*of* $E = h\dfrac{c}{\lambda}$
$E = W_o + E_{k(max)}$ where/*waar* $E = hf$ and/*en* $W_0 = hf_0$ and/*en* $E_{k(max/maks)} = \dfrac{1}{2}mv^2_{max/maks}$	

ELECTROSTATICS/*ELEKTROSTATIKA*

$F = \dfrac{kQ_1Q_2}{r^2}$	$E = \dfrac{kQ}{r^2}$
$E = \dfrac{F}{q}$	$V = \dfrac{W}{q}$
$n = \dfrac{Q}{e}$ or/*of* $n = \dfrac{Q}{q_e}$	

ELECTRIC CIRCUITS/*ELEKTRIESE STROOMBANE*

$R = \dfrac{V}{I}$	emf $(\varepsilon) = I(R + r)$ emk $(\varepsilon) = I(R + r)$
$R_s = R_1 + R_2 + ...$ $\dfrac{1}{R_p} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + ...$	$q = I\,\Delta t$
$W = Vq$ $W = VI\Delta t$ $W = I^2R\Delta t$ $W = \dfrac{V^2\Delta t}{R}$	$P = \dfrac{W}{\Delta t}$ $P = VI$ $P = I^2R$ $P = \dfrac{V^2}{R}$

ALTERNATING CURRENT/*WISSELSTROOM*

$I_{rms} = \dfrac{I_{max}}{\sqrt{2}}$ / $I_{wgk} = \dfrac{I_{maks}}{\sqrt{2}}$ $V_{rms} = \dfrac{V_{max}}{\sqrt{2}}$ / $V_{wgk} = \dfrac{V_{maks}}{\sqrt{2}}$	$P_{average} = V_{rms}I_{rms}$ / $P_{gemiddeld} = V_{wgk}I_{wgk}$ $P_{average} = I_{rms}^2 R$ / $P_{gemiddeld} = I_{wgk}^2 R$ $P_{average} = \dfrac{V_{rms}^2}{R}$ / $P_{gemiddeld} = \dfrac{V_{wgk}^2}{R}$

ANSWER SHEET

CENTRE NUMBER:

EXAMINATION NUMBER:

QUESTION 9.1.2: PLACE THIS GRAPH SHEET IN YOUR ANSWER BOOK.

Graph of potential difference versus current