Western Cape Government

Education

METRO CENTRAL DISTRICT

GRADE 12

PHYSICAL SCIENCES: PAPER 1 (PHYSICS)

SEPTEMBER 2016

MARKS: 150
TIME: 3 hours

**This question paper consists of 15 numbered pages and 2 data sheets.**

INSTRUCTIONS AND INFORMATION

1. Write your name on the first page of your RULED A4 PAPER or ANSWER BOOK.

2. This question paper consists of TEN questions. Answer ALL the questions on your RULED A4 PAPER or ANSWER BOOK.

3. Start EACH question on a NEW SIDE of your RULED A4 PAPER or ANSWER BOOK. Use BOTH sides of the page in order to avoid wasting paper.

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

5. From QUESTION 2 onwards, leave ONE line between two sub-questions, 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

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A–D) next to the question number (1.1–1.10) in the ANSWER BOOK, for example 1.11 E.

1.1   An object is falling at a constant speed near the surface of the earth. Which ONE of the following statements regarding this situation is TRUE?

     A   The direction of the resultant force acting on the object is upward.

     B   The direction of the resultant force acting on the object is downward.

     C   There are no forces acting on the object.

     D   The resultant force acting on the object is zero.   (2)

1.2   A magnet is stuck on a fridge. The following force diagram shows all four forces acting on the magnet.
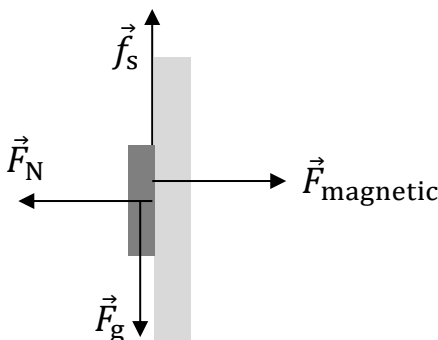
     Consider the following two pairs of forces:

     (i)   the normal force $(\vec{F}_N)$ and the force of magnetic attraction $(\vec{F}_{magnetic})$

     (ii)   the gravitational force $(\vec{F}_g)$ and the static frictional force $(\vec{f}_s)$

     Which of the above pair(s) make up a Newton's third law action-reaction pair of forces?

     A   (i) only

     B   (ii) only

     C   both (i) and (ii)

     D   neither (i) nor (ii)   (2)

1.3 The following velocity-time graph represents the motion of an object moving vertically through the air near the Earth's surface.
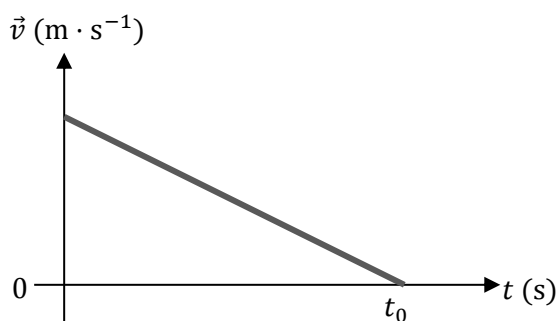
Use the graph to identify the positive direction of motion as well as the significance of time t_0.

	Positive direction	At time t_0 the object…
A	up	… hits the ground
B	down	… hits the ground
C	up	… reaches a maximum height
D	down	… reaches a maximum height

(2)

1.4 Which ONE of the following statements is equivalent to Newton's Second Law of Motion? The net force experienced by an object is equal to…

A the rate of change of momentum of that object

B the change in momentum of that object.

C the impulse experienced by the object.

D the momentum of that object. (2)

1.5 A book is pushed across a rough surface by a force of magnitude F while experiencing a frictional force of magnitude f. The average constant speed of the book is v. Which ONE of the following expressions gives the rate at which the kinetic energy of the book changes?

A $(F + f)v$

B $(F - f)v$

C $(-F - f)v$

D $(Fxf)v$ (2)

1.6   The Doppler effect will occur when:

        A   A listener moves around a stationary source of sound in a circle.

        B   A listener moves in a straight line towards a stationary source of sound.

        C   A listener and a source of sound are both stationary.

        D   A source of sound moves around a stationary listener in a circle.   (2)

1.7   In the diagram below, Q is a negatively charged object.

   The direction of the electric field line at Point X is:

        A   to the left

        B   up

        C   to the right

        D   down   (2)

1.8   How much will it cost to run a 14 W energy-saving light bulb in a 220 V mains
        circuit for three hours if the cost per kWh is R1,12?

        A   14 x 3 x 220 cents

        B   0,014 x 3 x 220 cents

        C   0,014 x 3 x 112 cents

        D   14 x 220 x 112 cents   (2)

1.9 Choose the option that correctly differentiates between an AC generator and a DC motor.

	The AC generator …	The DC motor …
A	… converts mechanical energy to electrical energy with the aid of slip rings.	… converts electrical energy to mechanical energy with the aid of slip rings.
B	… converts electrical energy to mechanical energy with the aid of slip rings.	… converts mechanical energy to electrical energy with the aid of a split-ring commutator.
C	… converts electrical energy to mechanical energy with the aid of a split-ring commutator.	… converts mechanical energy to electrical energy with the aid of slip rings.
D	… converts mechanical energy to electrical energy with the aid of slip rings.	… converts electrical energy to mechanical energy with the aid of a split-ring commutator.

(2)

1.10 The light from an argon discharge tube is analysed. The following line emission spectrum shows two of the spectral lines observed.
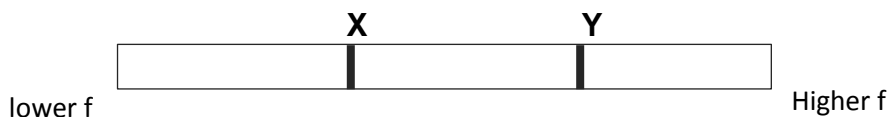
The same spectrum, observed on a distant galaxy, appears to have been *red shifted*.

How will the lines appear to shift compared to the above diagram?

A   **X** will shift left and **Y** will shift right

B   **X** will shift right and **Y** will shift left

C   **X** and **Y** will both shift left

D   **X** and **Y** will both shift right   (2)

[20]

QUESTION 2

A man applies a constant pulling force on a heavy parcel of mass 50 kg using a light inextensible rope which passes over a light frictionless pulley as shown in the diagram below. The coefficient of static friction between the parcel and the rough table surface is 0,34. The magnitude of the maximum static frictional force is 120 N. Ignore the mass of the rope.
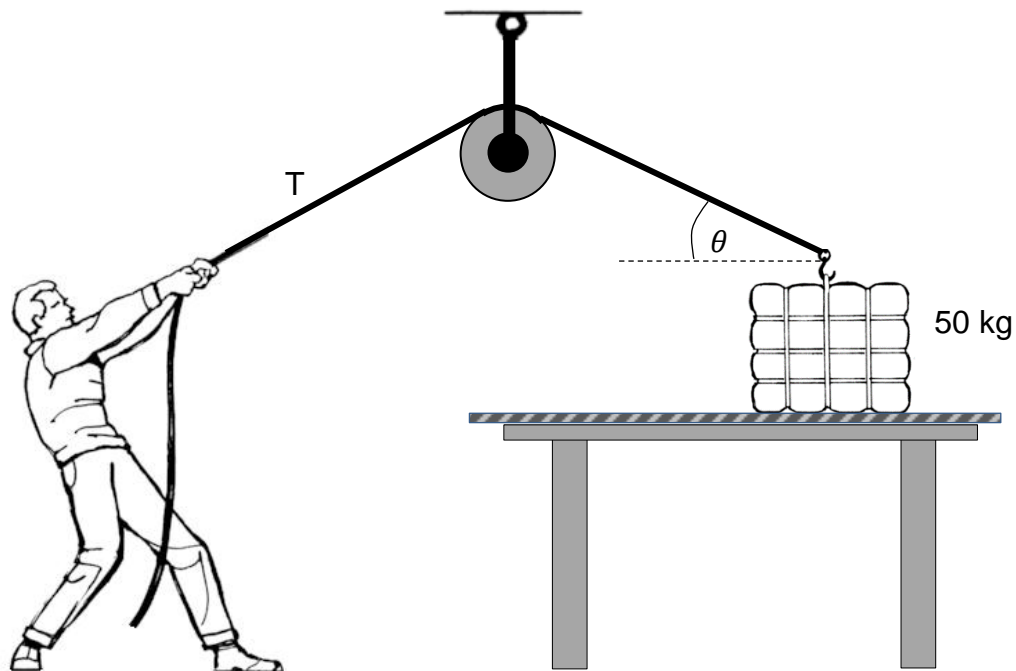

2.1   Draw a free-body diagram showing all forces exerted on the parcel.   (4)

2.2   State, in words, *Newton's Second Law of Motion*.   (2)

2.3   When the static frictional force is at its maximum, show that the magnitude of the vertical component of the tension force in the rope is 137,06 N.   (5)

2.4   Hence, determine the angle (θ) that the rope forms with the horizontal as well as the magnitude of the tension force in the rope (T).   (4)

2.5   The man now increases the magnitude of his pulling force. Under the action of this new constant force, the parcel begins to slide horizontally along the table.

   2.5.1   How will the magnitude of the normal force change as the parcel slides across the table surface? State only INCREASES, DECREASES or REMAINS THE SAME.   (1)

   2.5.2   Give a reason for your answer to QUESTION 2.5.1.   (2)

[18]

QUESTION 3

A girl is playing in her bedroom with a super bouncy ball which has a mass of 50 g. The girl throws the super bouncy ball straight down towards the ground from an unknown height (h) with a speed of 3 m·s^{-1}. It hits the ground and bounces straight up past her and it reaches its maximum height 0,6 s after bouncing. Ignore the effects of air friction.

$v = 3$ m·s^{-1} $\Delta t = 0,6$ s $h = ?$
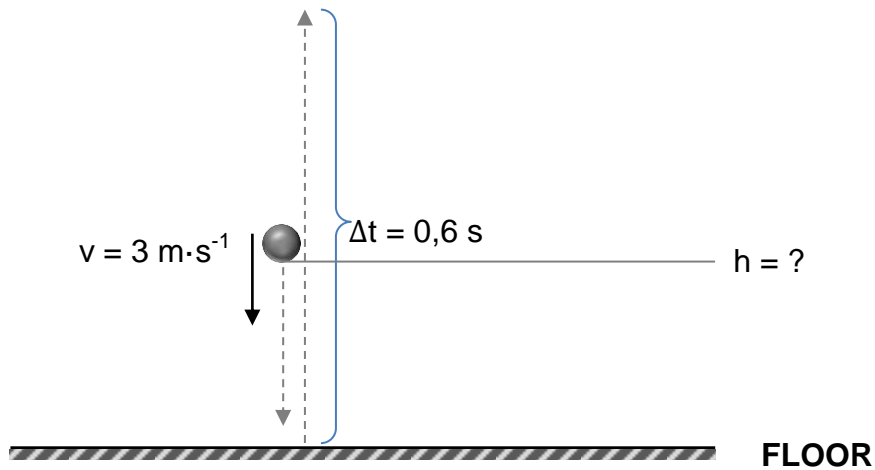
FLOOR

3.1 Calculate the speed with which the ball leaves the floor after bouncing. (3)

3.2 If the ball loses 5% of its kinetic energy during each bounce, calculate the kinetic energy of the ball just before its first bounce. (4)

3.3 Using energy principles, determine the height from which the girl threw the ball. (3)

3.4 Using the GROUND AS REFERENCE, sketch a position vs time graph showing the motion of the bouncy ball from the moment the ball is thrown until it reaches its maximum height after the first bounce. (4)
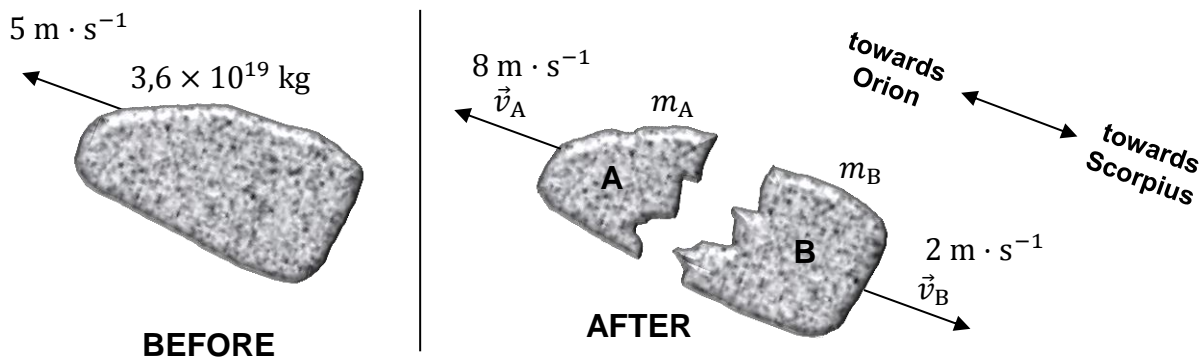
[14]

QUESTION 4

Scientists are investigating the possibility of making use of a subsurface nuclear explosive in order to deflect asteroids from possible collision with the Earth.

Such a nuclear explosive was buried beneath the surface of an asteroid of mass $3,6 \times 10^{19}$ kg. Before detonation, a stationary astronaut on a nearby spacecraft measured the velocity of the asteroid to be 5 m·s^{-1} towards the constellation of Orion. When the explosive was detonated the asteroid split into two fragments, **A** and **B**.

The explosion projected the two fragments **A** and **B** in opposite directions towards the constellations Orion and Scorpius with speeds of $v_A = 8$ m·s^{-1} and $v_B = 2$ m·s^{-1} respectively.

NB. All speeds are measured relative to the spaceship.

$5 \, \mathrm{m \cdot s^{-1}}$

$3,6 \times 10^{19}$ kg

$8 \, \mathrm{m \cdot s^{-1}}$
$\vec{v}_A$
m_A

towards Orion

m_B

towards Scorpius

A

B

$2 \, \mathrm{m \cdot s^{-1}}$
$\vec{v}_B$

BEFORE

AFTER

4.1 State, in words, the *principle of conservation of linear momentum*. (2)

4.2 Show that fragment A has a mass of $2,52 \times 10^{19}$ kg. (5)

4.3 Hence determine the impulse experienced by asteroid fragment A. (3)

4.4 The two fragments move apart from each other and after some time their centres of mass are 150 km apart. Calculate the magnitude of the gravitational force that the two asteroid fragments exert on each other. (4)

[14]

QUESTION 5

A skateboarder is practising a sequence of tricks at the local skate park on a half-pipe. The total mass of the skateboarder and skateboard is 75 kg. The skater leaves point A, 2,4 m above the ground. He skates down the ramp towards point B. He reaches Point B, 1,6 m above the ground, with a speed of 3,75 m·s⁻¹ just by rolling along and without using his feet to push himself along the half-pipe.

The skateboarder has not oiled the wheels of his skateboard for some time, so there is significant friction between the axles and the wheels of the skateboard.

5.1   State in words, the *work-energy theorem*.   (2)

5.2   Calculate the work done by the gravitational force on the skateboarder as he moves from Point A to Point B.   (4)

5.3   Using the work energy theorem, determine the work done by the frictional force exerted on the skateboard.   (6)

5.4   The skateboarder thinks about constructing an inclined plane to join Points A and B to provide an alternative route between these two points.
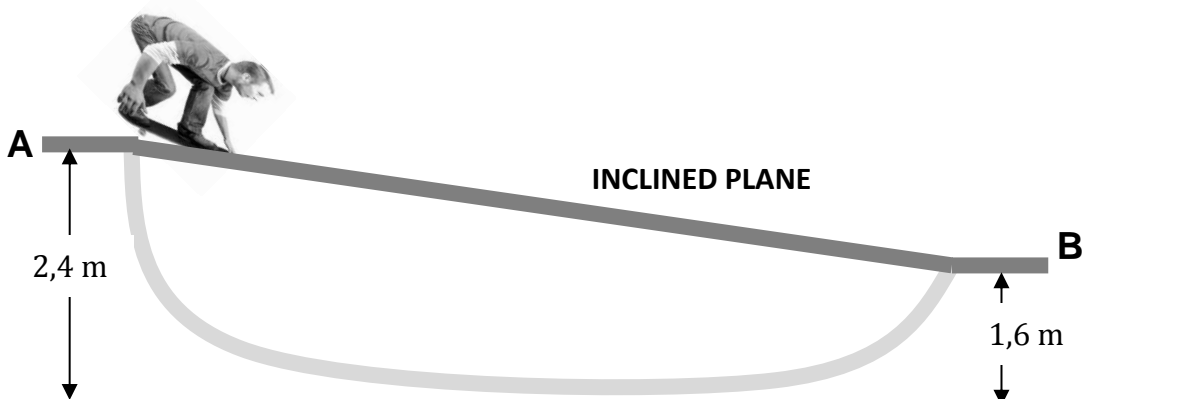
5.4.1   How would the work done by the gravitational force change if he were to roll from Point A to Point B along the inclined plane instead of following the curved track? Answer only INCREASES, DECREASES or REMAINS THE SAME.   (1)

5.4.2   Explain your answer to QUESTION 5.4.1.   (2)

[15]

QUESTION 6

6.1 A police car moves away from an accident scene at a constant speed with its siren on. A paramedic at the accident observes a 7% drop in the frequency of the sound of the siren in comparison to when the car was standing still. Speed of sound in air on that day is 335 m·s^{-1}.

    6.1.1 State in words, the *Doppler effect*. (2)

    6.1.2 Calculate the speed of the car. (4)

6.2 An astronomer on Earth observes the missing frequencies in a line spectrum from a distant galaxy. The frequencies associated with specific elements are all lower than expected.

    6.2.1 With what kind of line spectrum is the astronomer working?
           Answer only ABSORPTION or EMISSION. (1)

    6.2.2 Identify the type of shift seen by the astronomer. (1)

    6.2.3 Is the distant galaxy moving towards or away from our Solar System. (1)

[9]

QUESTION 7

Three charges J, K and L are arranged on a horizontal plane so that angle JKL is a 90° angle. The charges are -4 µC, +2 µC and +8 µC respectively. J and K are 50 mm apart and K and L are 100 mm apart. J and L are fixed in position while K is free to move.

K (+2 µC)   **L** (+8 µC)

⟵——— 100 mm ———⟶

50 mm

J (-4 µC)
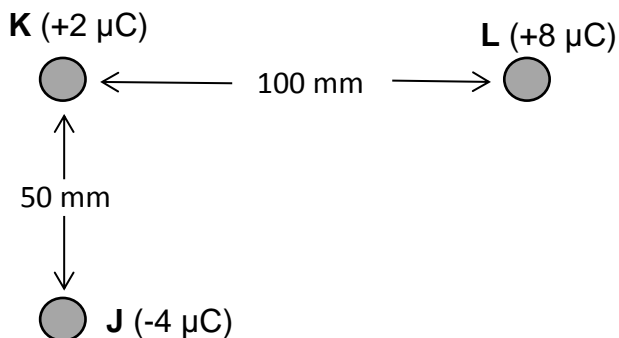
7.1   State in words, *Coulomb's Law*.   (2)

7.2   Calculate the magnitude of the electrostatic force between charges J and K.   (4)

7.3   Draw a free-body diagram showing the electrostatic forces exerted on K due to charges J and L. Also show on the vector diagram how the net force can be determined   (3)

7.4   Calculate the magnitude and direction of the net electrostatic force exerted on K due to charges J and L.   (4)

7.5   Define, in words, *electric field at a point*.   (2)

7.6   Calculate the magnitude of the net electric field at K. Give your answer in scientific notation.   (3)

[18]

QUESTION 8

A battery is connected to a circuit with four resistors and two switches as shown in the diagram below. When switch S_1 is open and no current flows, the voltmeter reading across the terminals of the battery is 18 V.
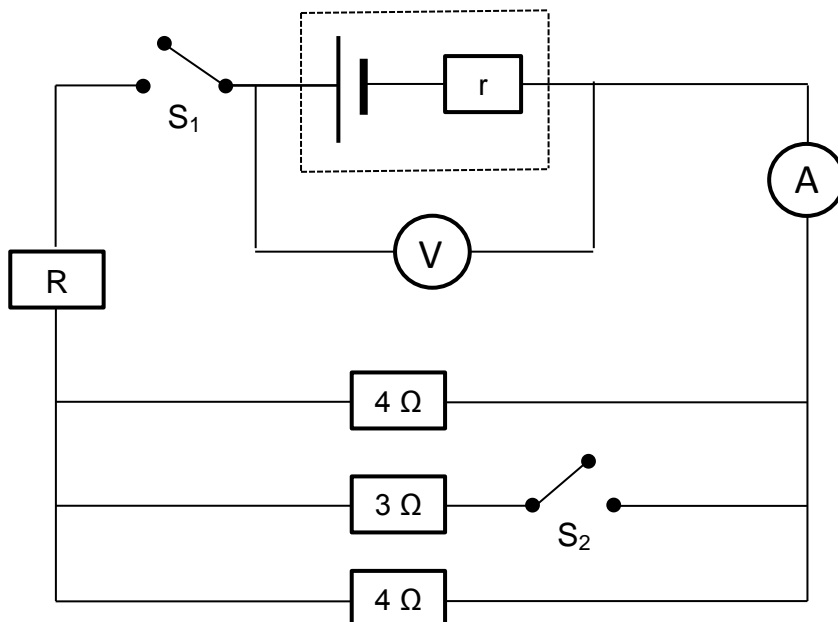
8.1   Write down the term that describes the voltmeter reading when switch S_1
        is open.   (1)

When both switches are closed, the voltmeter reading decreases by 0,9 V and the ammeter reads 4,5 A.

8.2   Write down the term that describes the voltmeter reading when both the
        switches are closed.   (1)

8.3   Calculate the internal resistance of the battery.   (3)

8.4   Which of the resistors in parallel carries the largest current?
        Write down 4 Ω or 3 Ω. Explain your answer.   (3)

8.5   Calculate the resistance of resistor R.   (7)

8.6   Name the one environmental factor that could cause the resistance of R to
        change.   (1)

8.7   Switch S_2 is now opened.
        Will the voltmeter reading INCREASE, DECREASE or STAY THE SAME?
        Explain your answer without doing any calculation.   (4)
                                                                                                      [20]

QUESTION 9

An alternating current (AC) generator installed on a farm produces the following graph of emf against time.
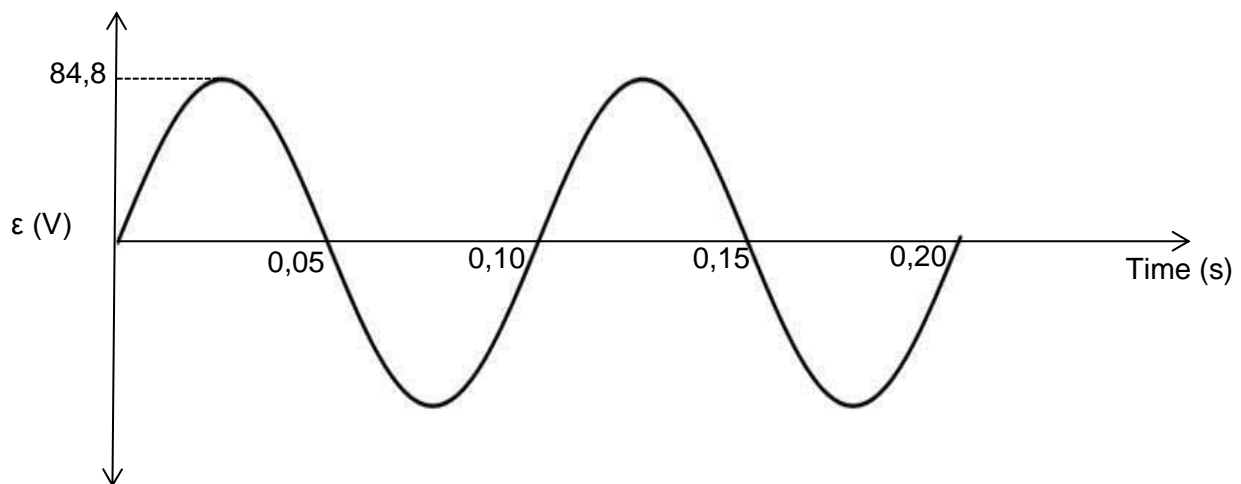

9.1   What is the period for one rotation of the armature of the generator?   (1)

9.2   Calculate the root mean square voltage (V_{rms}) for this generator.   (2)

9.3   An ohmic light bulb rated 100 V; 40 W is supplied with energy from this generator.

       9.3.1   Calculate the resistance of the light bulb.   (3)

       9.3.2   Describe the brightness of the light bulb under these conditions. Choose from TOO BRIGHT, CORRECT BRIGHTNESS or TOO DIM. Explain your answer.   (2)

9.4   Draw a graph of current strength vs. time over the same time interval. Do not show any values on the y-axis.   (2)

[10]

QUESTION 10

A group of physicists perform an experiment where they shine five different light sources (A, B, C, D and E) onto the platinum cathode of a photocell.

They measure the maximum kinetic energies of the ejected photoelectrons and produce the following graph of their results.
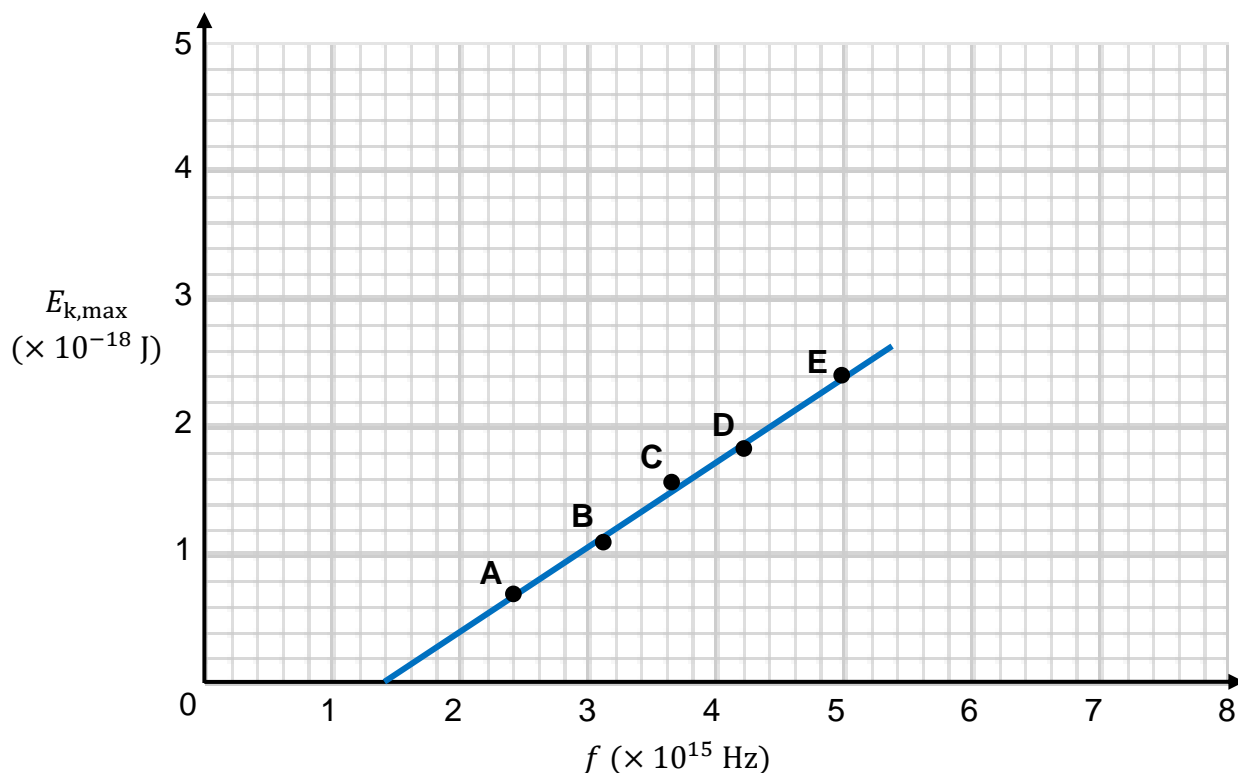
10.1   What does the gradient of the above graph represent?   (1)

10.2   Define the term *threshold frequency.*   (2)

10.3   Use the x-intercept of the graph in order to calculate the work function of the metal.   (3)

10.4   In one of the experiments the brightness of one of the light sources was increased. How would this affect… (Answer only INCREASES, DECREASES or REMAINS THE SAME for both of the following subquestions.)

      10.4.1   the number of electrons ejected per second?   (1)

      10.4.2   the kinetic energy of the ejected electrons?   (1)

10.5   Calculate the speed of an ejected electron when light source E is used.   (4)

                                                        [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*

$F_{net} = ma$	$p = mv$
$F_{net}\Delta t = m\Delta v$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = \dfrac{Gm_1m_2}{r^2}$	$g = \dfrac{GM}{r^2}$
$\mu_k = \dfrac{f_k}{N}$	$\mu_s = \dfrac{f_{s(maks)}}{N}$

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*

$v = f\lambda$	$T = \dfrac{1}{f}$
$f_L = \dfrac{v \pm v_L}{v \pm v_s} f_s$	$E = hf$ or/*of* $E = \dfrac{hc}{\lambda}$
$E = W_o + K_{max}$ or/*of* $E = W_o + E_{k(max)}$ where/*waar* $E = hf$ and/*en* $W_0 = hf_0$ and/*en* $K_{max} = \dfrac{1}{2}mv_{max}^2$ or/*of* $E_{k(max)} = \dfrac{1}{2}mv_{max}^2$	

ELECTROSTATICS / *ELEKTROSTATIKA*

$F = \dfrac{kQ_1Q_2}{r^2}$ $(k = 9{,}0 \times 10^9 \, N \cdot m^2 \cdot C^{-2})$	$E = \dfrac{kQ}{r^2}$ $(k = 9{,}0 \times 10^9 \, N \cdot m^2 \cdot C^{-2})$
$E = \dfrac{F}{q}$	$V = \dfrac{W}{q}$
$n = \dfrac{Q}{e}$ of/*or* $n = \dfrac{Q}{q_e}$	

CURRENT ELECTRICITY / *STROOMELEKTRISITEIT*

$R = \dfrac{V}{I}$	$emk(\varepsilon) = I(R + r)$
$R_s = r_1 + r_2 + r_3 + ...$ $\dfrac{1}{R_p} = \dfrac{1}{r_1} + \dfrac{1}{r_2} + \dfrac{1}{r_3} + ...$	$q = I\Delta t$
$W = Vq$ $W = VI\Delta t$ $W = I^2R\Delta t$ $W = \dfrac{V^2\Delta t}{R}$	$P = \dfrac{W}{\Delta t}$ $P = VI$ $P = I^2R$ $P = \dfrac{V^2}{R}$

ALTERNATING CURRENT / *WISSELSTROOM/*

$I_{rms} = \dfrac{I_{max}}{\sqrt{2}}$ $V_{rms} = \dfrac{V_{max}}{\sqrt{2}}$	$P_{ave} = V_{rms}I_{rms}$ $P_{ave} = I_{rms}^2R$ $P_{ave} = \dfrac{V_{rms}^2}{R}$