**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

SEPTEMBER 2021

PHYSICAL SCIENCES P1

MARKS: 150

TIME: 3 hours

This question paper consists of 19 pages, including 3 data sheets.

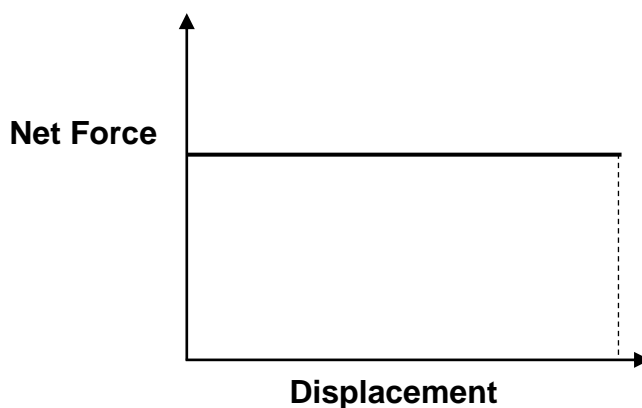**INSTRUCTIONS AND INFORMATION**

1.   Write your full NAME and SURNAME in the appropriate space on the ANSWER BOOK.

2.   The question paper consists of TEN questions. Answer ALL the questions.

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 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.   Show ALL formulae and substitutions in ALL calculations.

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

10.   Give brief motivations, discussions, etc. where required.

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

12.   Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

1.1   The impulse delivered by a net force acting on an object is equal to the …

   A   initial momentum of the object.

   B   final momentum of the object.

   C   change in momentum of the object.
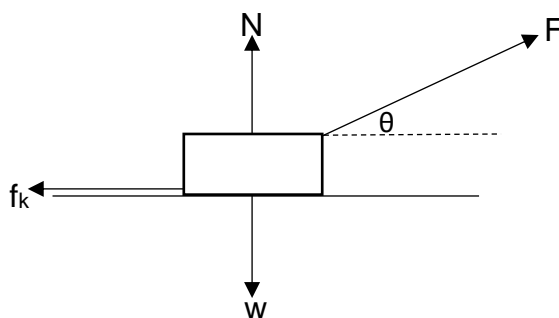
   D   rate of change in momentum of the object.   (2)

1.2   The graph below represents the relationship between the net force exerted on an object and the displacement it undergoes. The force and displacement are in the same direction.

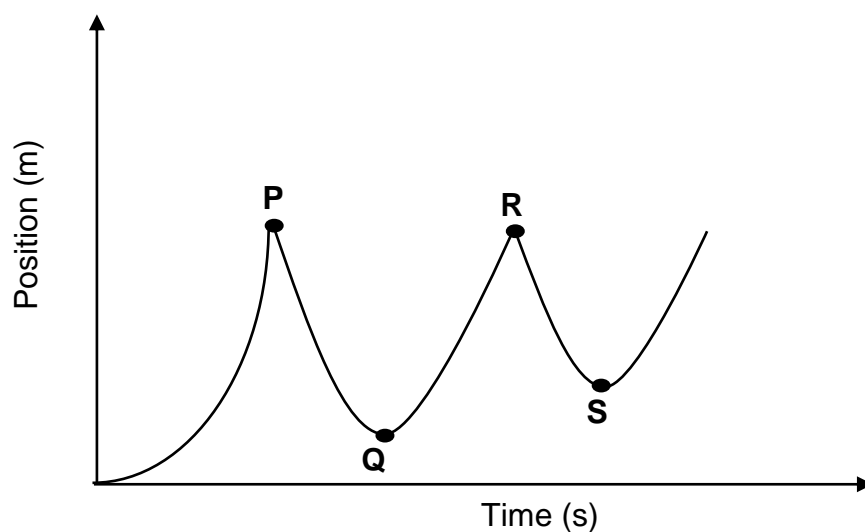Which ONE of the following statements can be deduced from the graph?

   A   The area between the graph and the displacement axis represents the net work done by the force.

   B   The area between the graph and the displacement axis represents the power dissipated by the force.

   C   The gradient of the graph represents the change in kinetic energy of the object.

   D   The gradient of the graph represents the work done by the force.   (2)

1.3   The diagram below shows all the forces acting on an object being pulled to the right by a force **F** acting at an angle θ to the horizontal.

Which ONE of the following expressions can be used to determine the magnitude of the kinetic frictional force (f_k) acting on the object?

A   μ(w + Fsinθ)

B   μ(w – Fsinθ)

C   μ(N – w)

D   μw   (2)

1.4   The position-time graph below represents the motion of a ball from the instant it is released from rest from a certain height above the floor and bounces off the floor a number of times. Ignore the effects of air resistance.

Which point (**P**, **Q**, **R** or **S**) on the graph represents the position-time coordinates of the maximum height reached by the ball after the SECOND bounce?

A   **P**

B   **Q**

C   **R**

D   **S**   (2)

1.5 The kinetic energy of a car moving at velocity **v** is **K**. The velocity of the car changes to **2v**. What is the new kinetic energy of the car?

     A   ¼**K**

     B   ½**K**
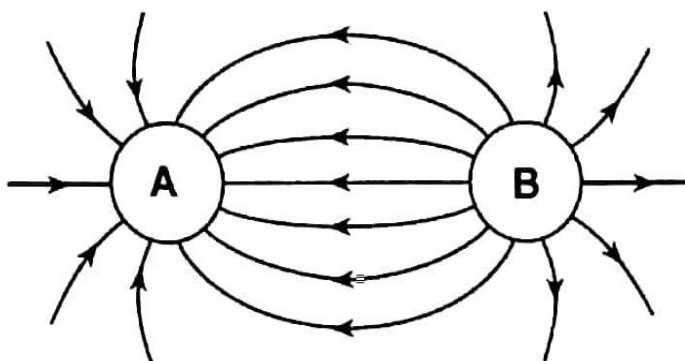
     C   2**K**

     D   4**K**   (2)

1.6 A sound source approaches a stationary observer at constant velocity.

Which ONE of the following describes how the observed frequency and wavelength differ from that of the sound source?

	Observed wavelength	Observed frequency
A	Greater than	Greater than
B	Less than	Less than
C	Less than	Greater than
D	Greater than	Less than

                                                                                   (2)

1.7 The electric field pattern between two charged spheres, **A** and **B**, is shown below.

Which ONE of the following statements regarding the charge on spheres **A** and **B** is CORRECT?

     A   Sphere **A** is negatively charged, and sphere **B** is positively charged.

     B   Sphere **A** is positively charged, and sphere **B** is negatively charged.

     C   Spheres **A** and **B** are both positively charged.

     D   Spheres **A** and **B** are both negatively charged.   (2)
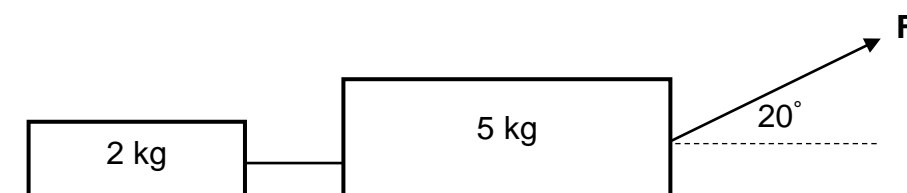
1.8 The SI unit of measurement of the RATE OF FLOW OF CHARGE in a conductor is …

    A   watt.

    B   volt.

    C   ampere.

    D   coulomb.   (2)

1.9 Which ONE of the following changes to the design of an AC generator will increase its maximum emf output?

    A   Change the polarity of the magnets

    B   Use larger slip rings

    C   Use larger brushes

    D   Increase the number of turns on the coil   (2)

1.10 A line emission spectrum is formed when …

    A   electrons in the ground state move to a higher energy state.

    B   electrons in the higher energy state move to a lower energy state.

    C   white light passes through a cold gas.

    D   white light passes through a triangular prism.   (2)

[20]

QUESTION 2

2.1 Two blocks of masses 2 kg and 5 kg are connected by means of a light inextensible string. The blocks are pulled along a rough horizontal surface by a force, **F**. The force makes an angle of 20⁰ with the horizontal. Refer to the diagram below.

The 2 kg and 5 kg blocks experience kinetic frictional forces of 10 N and 15 N respectively.

2.1.1 State Newton's Second Law of motion in words. (2)

2.1.2 Draw a labelled free-body diagram for the 5 kg block. (5)

2.1.3 Calculate the magnitude of force **F** that must be applied at an angle of 20˚ to the horizontal to make the two blocks accelerate at 2 m.s⁻² to the right. (5)

2.2 The earth exerts a force of 1 842,50 N to keep a satellite of mass 200 kg in orbit around the earth as shown in the diagram below.
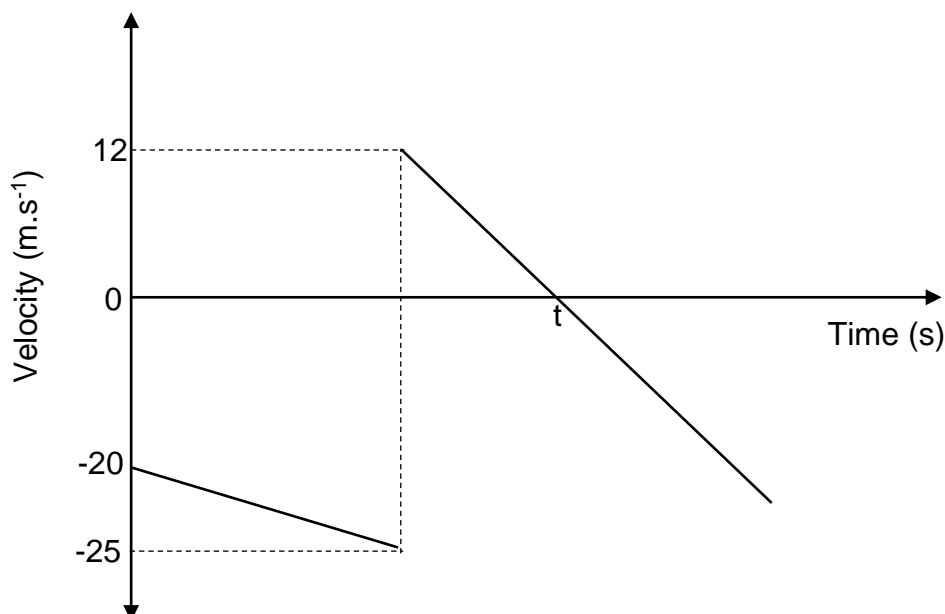

Calculate the distance, above the EARTH'S SURFACE at which the satellite orbits the earth. (5)

[17]

QUESTION 3

The velocity versus time graph below shows the motion of a ball thrown **vertically downwards** from the top of a building and bouncing off the floor as it hits the ground.

Ignore the effects of air friction. TAKE UPWARD MOTION AS POSITIVE.

3.1   Using EQUATIONS OF MOTION ONLY, calculate the:

         3.1.1   Height from which the ball is thrown   (3)

         3.1.2   Time **t** on the graph   (5)

         3.1.3   Magnitude of the displacement of the ball from the moment it is thrown until time **t**   (4)

3.2   Sketch a position versus time graph for the motion of the ball from the moment it is thrown until it reaches its maximum height after the bounce. USE THE GROUND AS THE ZERO POSITION.
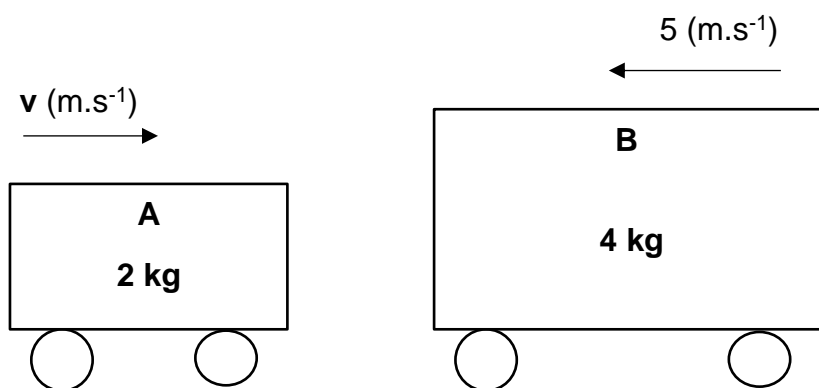
         Indicate the following on the graph:

-    The height from which the ball is thrown
-    Time **t**   (3)

                                                                   [15]

QUESTION 4

The diagram below shows trolley **A** of mass 2 kg travelling at a velocity of **v** m·s^{-1} east on a straight horizontal surface colliding head-on with trolley **B** of mass 4 kg travelling at a velocity of 5 m·s^{-1} west.

After the collision, the two trolleys stick together and move at a velocity of 1,67 m·s^{-1} west. The collision lasted for 0,01 s. Ignore the effects of friction.

5 (m.s^{-1})

v (m.s^{-1})

A		**B**
2 kg		**4 kg**

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

4.2   Calculate the:

4.2.1   Magnitude of the velocity **v** of the trolley **A** before it collided with trolley **B**   (4)
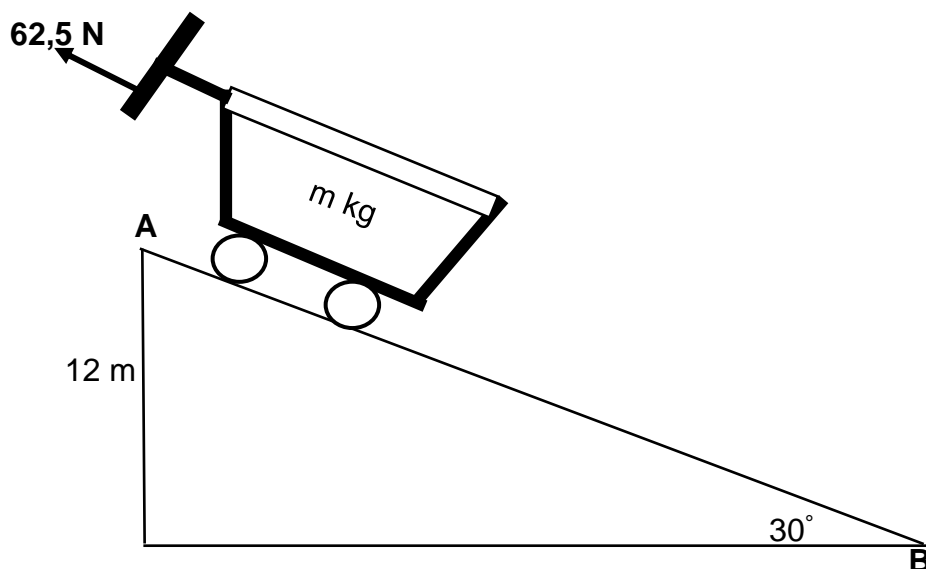
4.2.2   Force that trolley **B** exerts on trolley **A**   (4)

[10]

QUESTION 5

A force of 62,5 N is applied to a trolley of mass **m** kg parallel to the inclined surface as shown to keep it moving down an inclined surface at a CONSTANT VELOCITY. The vertical height of the inclined surface is 12 m. Refer to the diagram below.

A kinetic frictional force of 35,5 N acts on the trolley as it moves down the inclined surface.

5.1 Write down the name of the conservative force acting on the trolley. (1)

5.2 Calculate the work done by the frictional force on the trolley. (4)

5.3 Write down the change in kinetic energy when the trolley reaches the bottom of the inclined surface. (1)

5.4 Use the work-energy theorem to calculate the mass, **m**, of the trolley. (5)

[11]

QUESTION 6

6.1 A stationary sound detector placed at a certain point records 520 sound waves per second from a moving sound source which emits sound waves of frequency 480 Hz.

    6.1.1 Write down the frequency of the sound waves that the detector records in Hz. (1)

    6.1.2 Define the phenomenon which explains the change in frequency observed. (2)

    6.1.3 Is the sound source moving TOWARDS or AWAY from the observer? Give a reason for your answer. (2)

    6.1.4 Calculate the velocity at which the sound source is moving. Take velocity of sound as 343 m·s⁻¹. (5)

    6.1.5 How would the wavelength of the sound wave produced by the sound source change if the frequency of the sound waves become higher than 480 Hz?

        Write down only INCREASES, DECREASES or STAYS THE SAME. Explain your answer using the wave equation. (2)

6.2 The spectral lines from a distant star are observed to be <u>red shifted</u>. Explain the underlined term. (2)
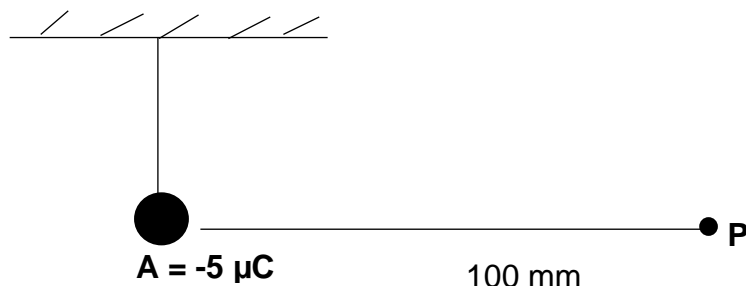
6.3 Write down ONE application of the Doppler effect in the field of medicine. (1)

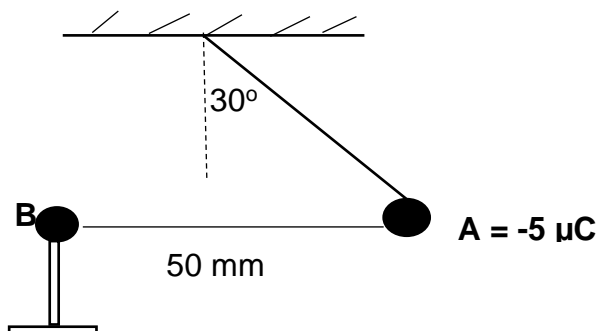   **[15]**

QUESTION 7

7.1   A small sphere **A** carrying a charge of -5 µC hangs vertically from a ceiling by means of an inextensible string. Point **P** is 100 mm to the right of sphere **A** as shown on the **Diagram 1** below.

      DIAGRAM 1

      7.1.1   Did charged sphere **A** LOSE or GAIN electrons to acquire a charge of -5 µC?   (1)

      7.1.2   Calculate the number of electrons lost or gained by charged sphere **A,** to acquire a charge of -5 µC.   (3)

      7.1.3   Calculate the electric field at point **P**, due to charged sphere **A**.   (5)

7.2   An identical sphere **B** carrying an unknown charge placed on an insulated stand is brought closer to sphere **A**. Charged sphere **A** swings to the right and comes to rest so that the string makes an angle of 30° with the vertical and the tension in the string is 25 N. The distance between the two charged spheres is 50 mm as shown on **Diagram 2** below.
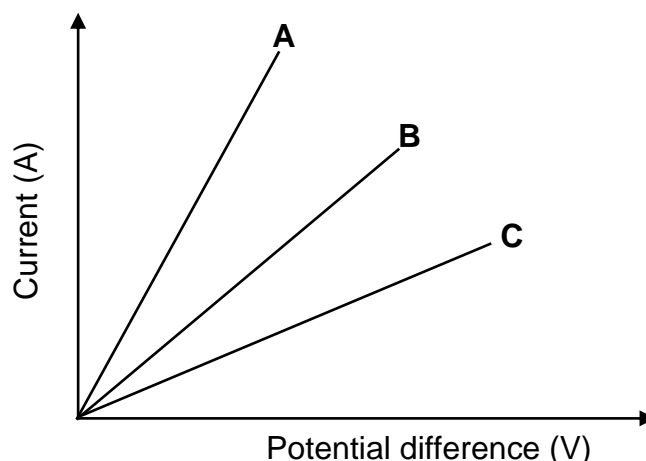
      DIAGRAM 2

      7.2.1   Is the charge on sphere **B** POSITIVE or NEGATIVE? Give a reason for your answer.   (2)

      7.2.2   Calculate the magnitude of the charge on sphere **B**.   (6)

                                                                       [17]
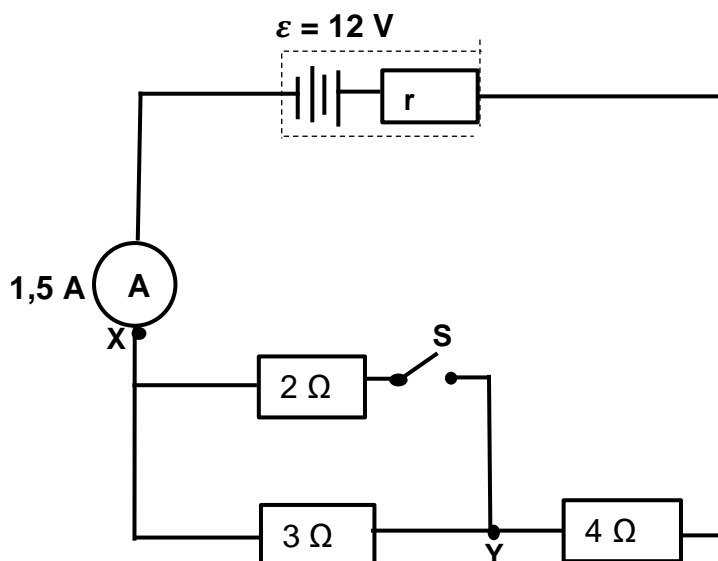
QUESTION 8

8.1 A group of Grade 12 learners want to determine an efficient conductor which can be used as the heating coil for a kettle that they are constructing for their Eskom Expo project.

They connected each of the three conductors (**A**, **B** and **C**) in a circuit and measured the current passing through the conductor and the potential difference across the conductors. Their results are as shown on the graph below.

8.1.1 Name any TWO variables that must be kept constant for a fair investigation. (2)

8.1.2 Write down the physical quantity represented by the gradient of each graph. (1)

8.1.3 Which ONE of the conductors is efficient enough to be used as a heating coil in a kettle? Give a reason for your answer. (2)

8.2 The circuit diagram below represents a combination of resistors in series and parallel. The battery has an emf of 12 V and an unknown internal resistance **r**.

With switch **S** OPEN, the reading on ammeter **A** is 1,5 A. Calculate the:

8.2.1   Total resistance of the circuit   (3)

8.2.2   Internal resistance of the battery   (4)

8.2.3   Energy dissipated by the 3 Ω resistor in 3 minutes   (3)

8.3   Switch **S** is now CLOSED.

How will EACH of the following be affected? Write down only INCREASES, DECREASES or REMAINS THE SAME.

8.3.1   The total resistance of the circuit.   (1)

8.3.2   The reading on ammeter **A**.   (1)

8.4   A conducting wire of negligible resistance is now connected between points **X** and **Y** as shown on the diagram above. What effect will this have on the temperature of the battery?

Write down only INCREASES, DECREASES or REMAINS THE SAME. Explain your answer.   (3)

[20]

    Please turn over

QUESTION 9

AC generators at coal-fired power stations supply most of the electrical energy needed in our country.

9.1   State the energy conversion that takes place when this generator is in operation.   (2)

9.2   State ONE structural difference between an AC generator and a DC generator.   (1)

9.3   Draw a sketch graph of potential difference versus time for this AC generator. Clearly label the axes and indicate V_{max} on the potential difference axis.   (2)
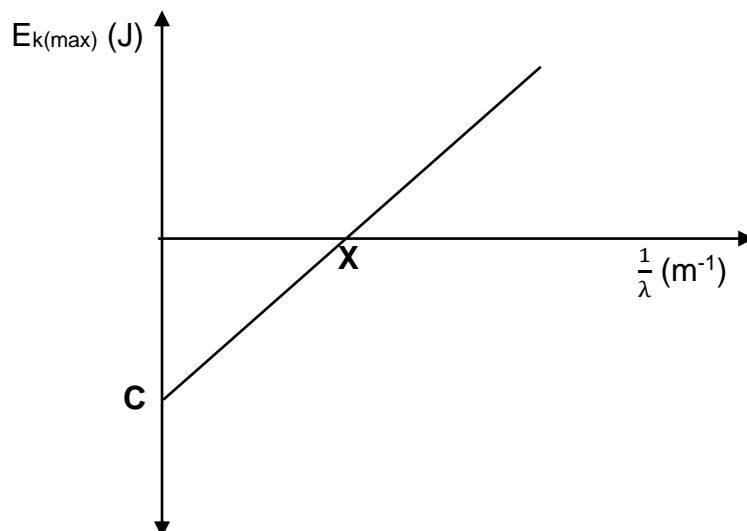
An electric appliance is rated 2 000 W, 230 V. The appliance is connected to an alternating current power source.

Calculate the:

9.4   Maximum current (I_{max}) produced by the generator   (4)

9.5   Peak voltage (V_{max}) output of the generator   (3)

[12]

QUESTION 10

A group of learners conducted an experiment to determine the relationship between the inverse of wavelength $\left(\dfrac{1}{\lambda}\right)$ of incident photons on a metal and the maximum kinetic energy ($E_{k(max)}$) of emitted photoelectrons from the metal plate surface. They presented their results as shown on the graph below.

10.1 Which physical quantity is represented by the letter **C** (the intercept on the vertical axis) on the graph? Use a suitable equation to explain the answer. (3)

10.2 Light photons of frequency of 6,16 x 10^{14} Hz are incident on a metal plate and photoelectrons are released with maximum kinetic energy of 5,6 x 10^{-20} J.

Calculate the magnitude of the physical quantity represented by the letter **X** on the graph. (5)

10.3 The brightness of the incident light is now increased. What effect will this change have on the following? (Write down only INCREASES, DECREASES or REMAINS THE SAME.)

10.3.1 The gradient of the graph. Explain your answer. (2)

10.3.2 The maximum kinetic energy of the released photoelectrons. Draw a graph of the relationship between brightness of incident photons and maximum kinetic energy of photoelectrons to explain your answer. (3)

[13]

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 gravitasiekonstante*	G	$6,67 \times 10^{-11} \text{ N·m}^2 \cdot \text{kg}^{-2}$
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	$9,0 \times 10^9 \text{ N·m}^2 \cdot \text{C}^{-2}$
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 earth / *Massa op aarde*	M	$5,98 \times 10^{24} \text{ kg}$
Radius of earth / *Radius van aarde*	R_E	$6,38 \times 10^3 \text{ km}$

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*

$F_{net} = ma$	$p = mv$
$f_s^{\,max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = \dfrac{Gm_1 m_2}{d^2}$	$g = G\,\dfrac{M}{d^2}$

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* $W_{nc} = \Delta E_k + \Delta E_p$	$P = \dfrac{W}{\Delta t}$
$P_{ave} = Fv_{ave}$	

ELECTROSTATICS/*ELEKTROSTATIKA*

$F = \dfrac{kQ_1 Q_2}{r^2}$	$E = \dfrac{kQ}{r^2}$
$E = \dfrac{V}{d}$	$E = \dfrac{F}{q}$
$V = \dfrac{W}{q}$	$n = \dfrac{Q}{q_e}$

ELECTRIC CIRCUITS/*ELEKTRIESE STROOMBANE*

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

ALTERNATING CURRENT/*WISSELSTROOM*

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

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

$v = f\lambda$	$T = \dfrac{1}{f}$
$f_L = \dfrac{v \pm v_L}{v \pm v_s} f_s \quad f_L = \dfrac{v \pm v_L}{v \pm v_b} f_b$	$E = hf$ or/*of* $E = h\dfrac{c}{\lambda}$
$E = W_o + E_k$ where/*waar* $E = hf$ and/*en* $W_0 = hf_0$ and/*en* $E_k = \dfrac{1}{2}mv^2$ or/*of* $K_{max} = \dfrac{1}{2}mv_{max}^2$	

Please turn over