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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: PHYSICS (P1)

FEBRUARY/MARCH 2016

MARKS: 150

TIME: 3 hours

This question paper consists of 14 pages and 3 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the appropriate space in the 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

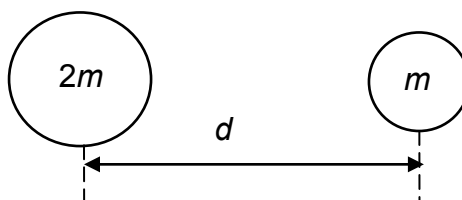
Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A–D) next to the question number (1.1–1.10) in the ANSWER BOOK, for example 1.11 E.

- 1.1 A net force \mathbf{F} which acts on a body of mass m causes an acceleration a . If the same net force \mathbf{F} is applied to a body of mass $2m$, the acceleration of the body will be ...

- A $\frac{1}{4}a$
- B $\frac{1}{2}a$
- C $2a$
- D $4a$

(2)

- 1.2 Two objects of masses $2m$ and m are arranged as shown in the diagram below.



Which ONE of the changes below will produce the GREATEST increase in the gravitational force exerted by the one mass on the other?

- A Double the larger mass.
- B Halve the smaller mass.
- C Double the distance between the masses.
- D Halve the distance between the masses.

(2)

1.3 The statements below describe the motion of objects.

- (i) A feather falls from a certain height inside a vacuum tube.
- (ii) A box slides along a smooth horizontal surface at constant speed.
- (iii) A steel ball falls through the air in the absence of air friction.

Which of the following describes UNIFORMLY ACCELERATED motion CORRECTLY?

- A (i) and (ii) only
- B (i) and (iii) only
- C (ii) and (iii) only
- D (i), (ii) and (iii) (2)

1.4 Airbags in modern cars provide more safety during an accident.

The statements below are made by a learner to explain how airbags can ensure better safety in a collision.

- (i) The time of impact increases.
- (ii) The impact force decreases.
- (iii) The impulse increases.

Which of the statements above are CORRECT?

- A (i) only
- B (ii) only
- C (ii) and (iii) only
- D (i) and (ii) only (2)

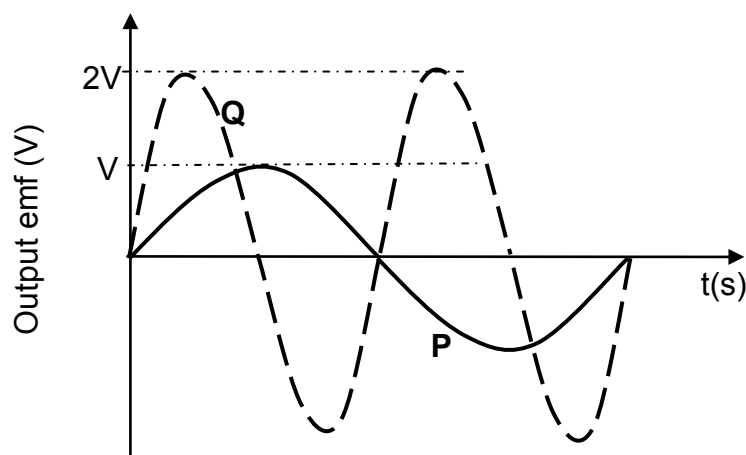
1.5 The work done by a constant force F applied to an object to increase the object's speed from v to $2v$ is W .

The work done by the same force to increase the speed of the object from 0 to v will be ...

- A $\frac{1}{3}W$
- B $\frac{1}{2}W$
- C $2W$
- D $3W$ (2)

- 1.6 Light reaching the Earth from a galaxy moving away is shifted towards ...
- A greater velocities.
 - B higher frequencies.
 - C longer wavelengths.
 - D shorter wavelengths. (2)
- 1.7 P, Q and R are three charged spheres. When P and Q are brought near each other, they experience an attractive force. When Q and R are brought near each other, they experience a repulsive force.
- Which ONE of the following is TRUE?
- A P and R have charges with the same sign.
 - B P and R have charges with opposite signs.
 - C P, Q and R have charges with the same sign.
 - D P, Q and R have equal charges. (2)
- 1.8 The minimum value of the resistance that can be obtained by connecting two $4\ \Omega$ resistors is ...
- A $1\ \Omega$.
 - B $2\ \Omega$.
 - C $3\ \Omega$.
 - D $8\ \Omega$. (2)

- 1.9 Graph **P** represents the output emf of an AC generator. Graph **Q** is the output emf after a change has been made using the SAME generator.

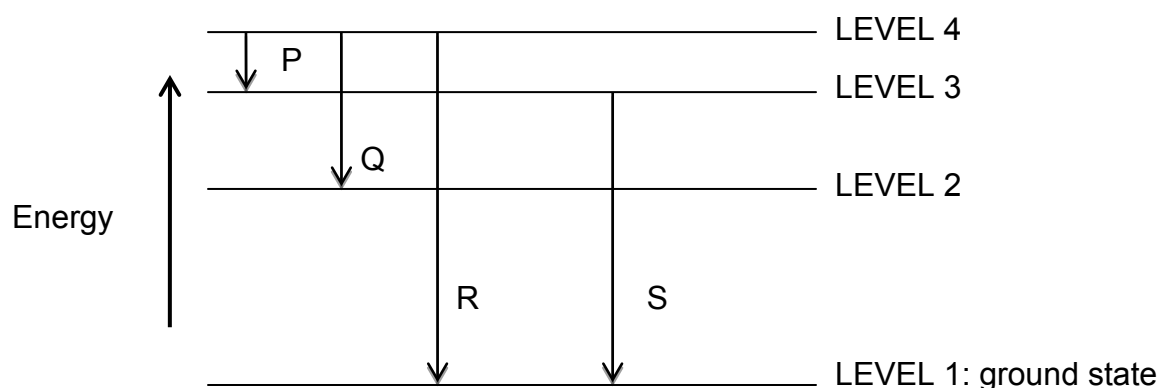


Which ONE of the following changes has been made to the generator to produce graph **Q**?

- A The number of turns of the coil has been doubled.
- B The surface area of the coil has been doubled.
- C The speed of rotation has been doubled.
- D The strength of the magnetic field has been doubled.

(2)

- 1.10 The possible atomic transitions in an excited atom of an element are shown below.



Which transition will produce the spectral line with the longest wavelength?

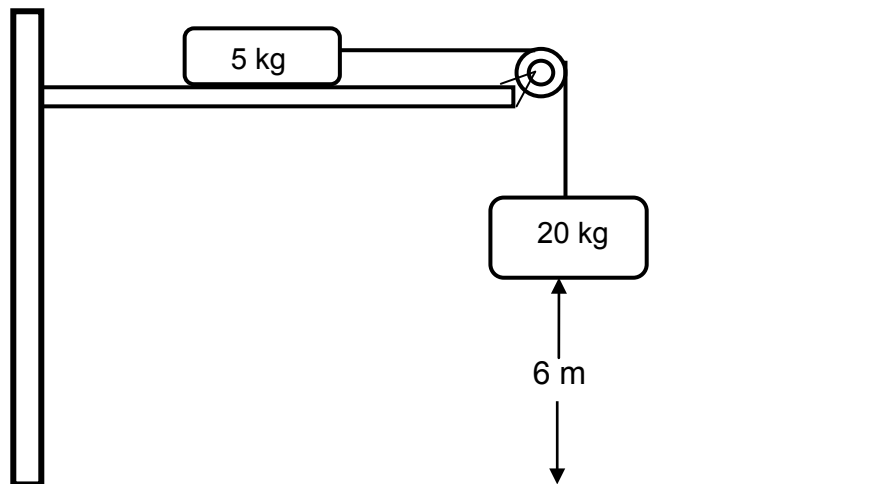
- A P
- B Q
- C R
- D S

(2)
[20]

QUESTION 2 (Start on a new page.)

- 2.1 A 5 kg mass and a 20 kg mass are connected by a light inextensible string which passes over a light frictionless pulley. Initially, the 5 kg mass is held stationary on a horizontal surface, while the 20 kg mass hangs vertically downwards, 6 m above the ground, as shown in the diagram below.

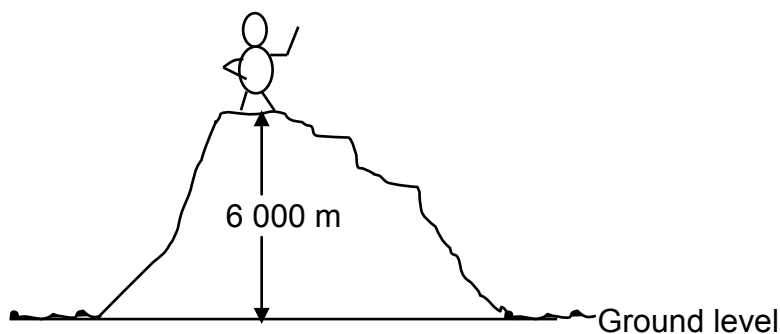
The diagram is not drawn to scale.



When the *stationary* 5 kg mass is released, the two masses begin to move. The coefficient of kinetic friction, μ_k , between the 5 kg mass and the horizontal surface is 0,4. Ignore the effects of air friction.

- 2.1.1 Calculate the acceleration of the 20 kg mass. (5)
- 2.1.2 Calculate the speed of the 20 kg mass as it strikes the ground. (4)
- 2.1.3 At what minimum distance from the pulley should the 5 kg mass be placed initially, so that the 20 kg mass just strikes the ground? (1)

- 2.2 A person of mass 60 kg climbs to the top of a mountain which is 6 000 m above ground level.



- 2.2.1 State Newton's Law of Universal Gravitation in words. (2)
- 2.2.2 Calculate the *difference* in the weight of the climber at the top of the mountain and at ground level. (6)
- [18]

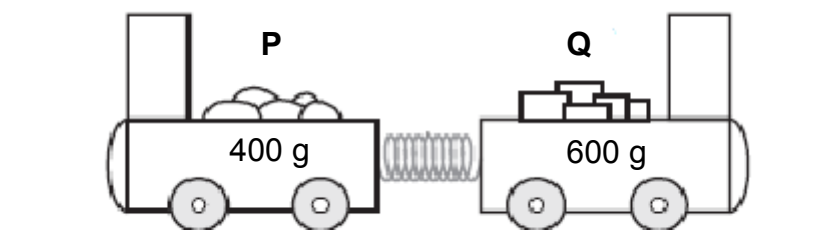
QUESTION 3 (Start on a new page.)

A man throws ball **A** downwards with a speed of $2 \text{ m}\cdot\text{s}^{-1}$ from the edge of a window, 45 m above a dam of water. One second later he throws a second ball, ball **B**, downwards and observes that both balls strike the surface of the water in the dam at the same time. Ignore air friction.

- 3.1 Calculate the:
- 3.1.1 Speed with which ball **A** hits the surface of the water (3)
- 3.1.2 Time it takes for ball **B** to hit the surface of the water (3)
- 3.1.3 Initial velocity of ball **B** (5)
- 3.2 On the same set of axes, sketch a velocity versus time graph for the motion of balls **A** and **B**. Clearly indicate the following on your graph:
- Initial velocities of both balls **A** and **B**
 - The time of release of ball **B**
 - The time taken by both balls to hit the surface of the water
- (5)
- [16]

QUESTION 4 (Start on a new page.)

The diagram below shows two trolleys, **P** and **Q**, held together by means of a compressed spring on a flat, frictionless horizontal track. The masses of **P** and **Q** are 400 g and 600 g respectively.

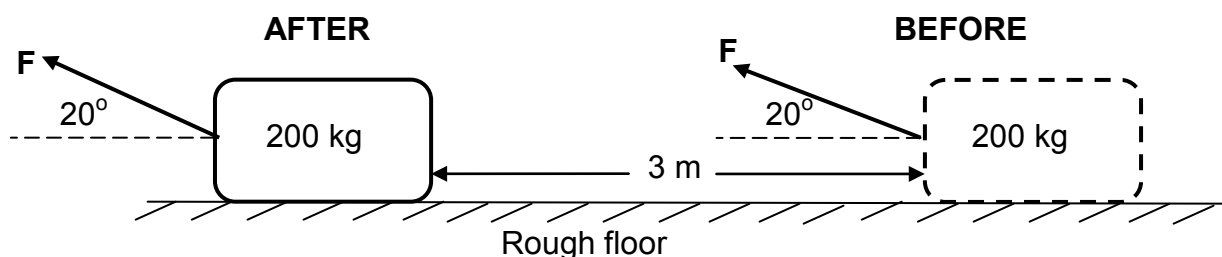


When the trolleys are released, it takes 0,3 s for the spring to unwind to its natural length. Trolley **Q** then moves to the right at $4 \text{ m}\cdot\text{s}^{-1}$.

- 4.1 State the *principle of conservation of linear momentum* in words. (2)
- 4.2 Calculate the:
- 4.2.1 Velocity of trolley **P** after the trolleys are released (4)
- 4.2.2 Magnitude of the average force exerted by the spring on trolley **Q** (4)
- 4.3 Is this an elastic collision? Only answer YES or NO. (1)
- [11]**

QUESTION 5 (Start on a new page.)

A constant force F , applied at an angle of 20° above the horizontal, pulls a 200 kg block, over a distance of 3 m, on a rough, horizontal floor as shown in the diagram below.



The coefficient of kinetic friction, μ_k , between the floor surface and the block is 0,2.

- 5.1 Give a reason why the coefficient of kinetic friction has no units. (1)
 - 5.2 State the work-energy theorem in words. (2)
 - 5.3 Draw a free-body diagram indicating ALL the forces acting on the block while it is being pulled. (4)
 - 5.4 Show that the work done by the kinetic frictional force (W_{fk}) on the block can be written as $W_{fk} = (-1\,176 + 0,205 F) \text{ J}$. (4)
 - 5.5 Calculate the magnitude of the force F that has to be applied so that the net work done by all forces on the block is zero. (4)
- [15]**

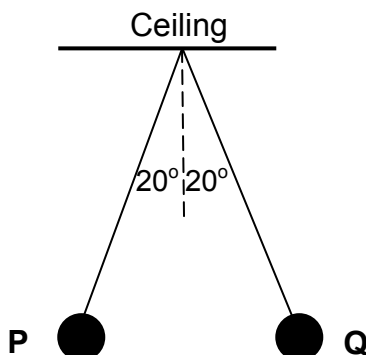
QUESTION 6 (Start on a new page.)

Reflection of sound waves enables bats to hunt for moths. The sound wave produced by a bat has a frequency of 222 kHz and a wavelength of $1,5 \times 10^{-3} \text{ m}$.

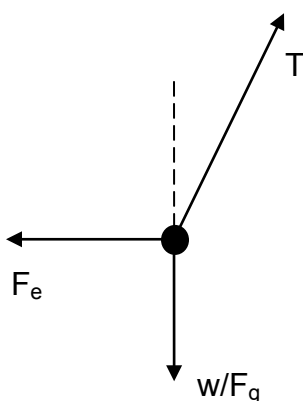
- 6.1 Calculate the speed of this sound wave through the air. (3)
 - 6.2 A stationary bat sends out a sound signal and receives the same signal reflected from a moving moth at a frequency of 230,3 kHz.
 - 6.2.1 Is the moth moving TOWARDS or AWAY FROM the bat? (1)
 - 6.2.2 Calculate the magnitude of the velocity of the moth, assuming that the velocity is constant. (6)
- [10]**

QUESTION 7 (Start on a new page.)

Two identical spherical balls, **P** and **Q**, each of mass 100 g, are suspended at the same point from a ceiling by means of identical light, inextensible insulating strings. Each ball carries a charge of +250 nC. The balls come to rest in the positions shown in the diagram below.



- 7.1 In the diagram, the angles between each string and the vertical are the same. Give a reason why the angles are the same. (1)
- 7.2 State Coulomb's law in words. (2)
- 7.3 The free-body diagram, not drawn to scale, of the forces acting on ball **P** is shown below.

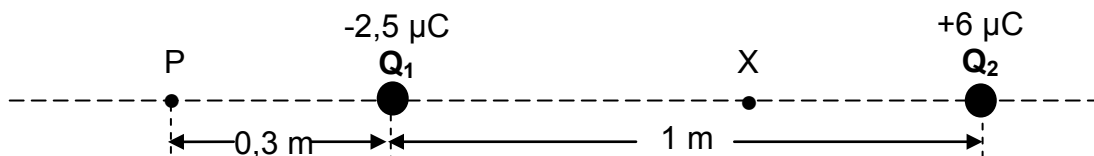


Calculate the:

- 7.3.1 Magnitude of the tension (**T**) in the string (3)
- 7.3.2 Distance between balls **P** and **Q** (5)
- [11]**

QUESTION 8 (Start on a new page.)

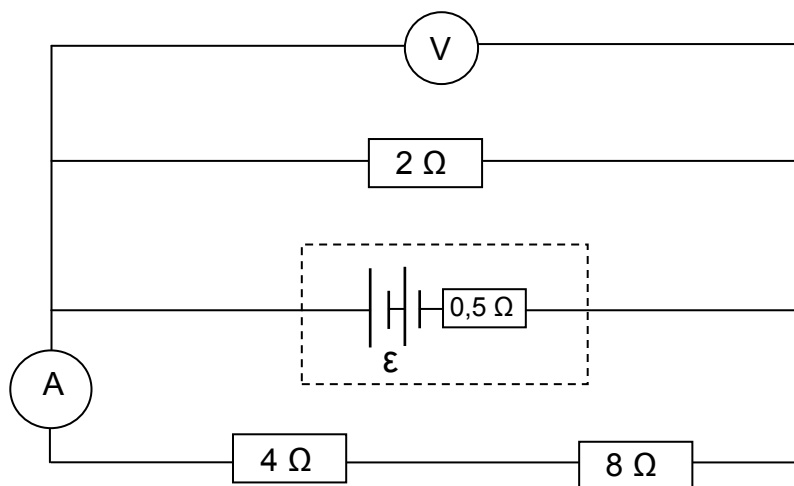
A sphere Q_1 , with a charge of $-2,5 \mu\text{C}$, is placed 1 m away from a second sphere Q_2 , with a charge $+6 \mu\text{C}$. The spheres lie along a straight line, as shown in the diagram below. Point P is located a distance of 0,3 m to the left of sphere Q_1 , while point X is located between Q_1 and Q_2 . The diagram is not drawn to scale.



- 8.1 Show, with the aid of a VECTOR DIAGRAM, why the net electric field at point X *cannot be zero*. (4)
- 8.2 Calculate the net electric field at point P , due to the two charged spheres Q_1 and Q_2 . (6)

[10]**QUESTION 9 (Start on a new page.)**

A battery of an unknown emf and an internal resistance of $0,5 \Omega$ is connected to three resistors, a high-resistance voltmeter and an ammeter of negligible resistance, as shown below.



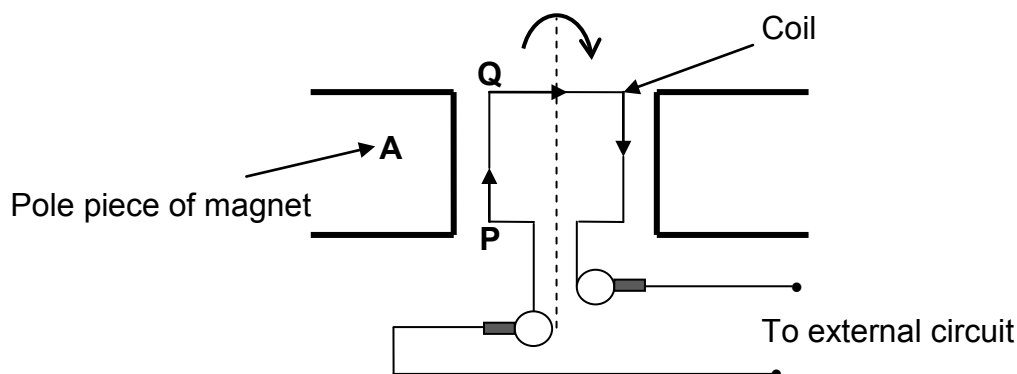
The reading on the ammeter is $0,2 \text{ A}$.

- 9.1 Calculate the:
- 9.1.1 Reading on the voltmeter (3)
- 9.1.2 Total current supplied by the battery (4)
- 9.1.3 Emf of the battery (5)
- 9.2 How would the voltmeter reading change if the 2Ω resistor is removed from the circuit? Write down INCREASE, DECREASE or REMAIN THE SAME. Explain the answer. (3)

[15]

QUESTION 10 (Start on a new page.)

10.1 A simplified sketch of an AC generator is shown below.



The coil of the generator rotates clockwise between the pole pieces of two magnets. At a particular instant, the current in the segment **PQ** has the direction shown above.

10.1.1 Identify the magnetic pole **A**.
Only write NORTH POLE or SOUTH POLE. (1)

10.1.2 The coil is rotated through 180° .
Will the direction of the current in segment **PQ** be from **P** to **Q** or **Q** to **P**? (1)

10.2 An electrical device is connected to a generator which produces an rms potential difference of 220 V. The maximum current passing through the device is 8 A.

Calculate the:

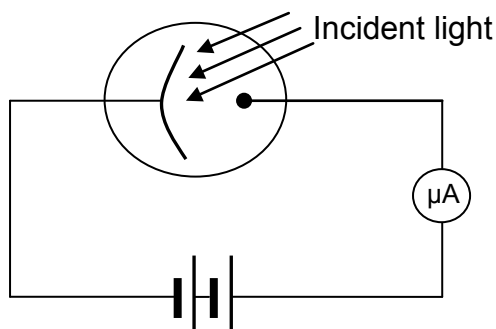
10.2.1 Resistance of the device (5)

10.2.2 Energy the device consumes in two hours (5)
[12]

QUESTION 11 (Start on a new page.)

An investigation was conducted to determine the effects of changes in frequency AND intensity on the current generated in a photoelectric cell when light is incident on it.

The apparatus used in the investigation is shown in the simplified diagram below.



The results of the experiment are shown in the table below.

EXPERIMENT	FREQUENCY (Hz)	INTENSITY (Cd)	CURRENT (μA)
A	$4,00 \times 10^{14}$	10	0
B	$4,50 \times 10^{14}$	10	0
C	$5,00 \times 10^{14}$	10	0
D	$5,01 \times 10^{14}$	10	20
E	$5,01 \times 10^{14}$	20	40
F	$6,50 \times 10^{14}$	10	30

11.1 Define the term *work function*. (2)

11.2 Identify an independent variable. (1)

The threshold frequency for the metal used in the photocell is $5,001 \times 10^{14}$ Hz.

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

11.4 Calculate the maximum speed of an emitted electron in experiment F. (5)

In experiments D and E, the current doubled when the intensity was doubled at the same frequency.

11.5 What conclusion can be made from this observation? (2)
[12]

TOTAL: 150

**DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)**

**GEGEWENS VIR FISIIESE WETENSKAPPE GRAAD 12
VRAESTEL 1 (FISIKA)**

TABLE 1: PHYSICAL CONSTANTS/TABEL 1: FISIIESE KONSTANTES

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

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

FORCE/KRAG

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

WORK, ENERGY AND POWER/ARBEID, ENERGIE EN DRYWING

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

WAVES, SOUND AND LIGHT/GOLWE, KLANK EN LIG

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

ELECTROSTATICS/ELEKTROSTATIKA

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

ELECTRIC CIRCUITS/ELEKTRIESE STROOMBANE

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

ALTERNATING CURRENT/WISSELSTROOM

$I_{\text{rms}} = \frac{I_{\text{max}}}{\sqrt{2}} \quad / \quad I_{\text{wgk}} = \frac{I_{\text{maks}}}{\sqrt{2}}$ $V_{\text{rms}} = \frac{V_{\text{max}}}{\sqrt{2}} \quad / \quad V_{\text{wgk}} = \frac{V_{\text{maks}}}{\sqrt{2}}$	$P_{\text{ave}} = V_{\text{rms}}I_{\text{rms}} \quad / \quad P_{\text{gemiddeld}} = V_{\text{wgk}}I_{\text{wgk}}$ $P_{\text{ave}} = I_{\text{rms}}^2R \quad / \quad P_{\text{gemiddeld}} = I_{\text{wgk}}^2R$ $P_{\text{ave}} = \frac{V_{\text{rms}}^2}{R} \quad / \quad P_{\text{gemiddeld}} = \frac{V_{\text{wgk}}^2}{R}$
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