higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

# NATIONAL CERTIFICATE (VOCATIONAL)

## PHYSICAL SCIENCE
(First Paper)
**NQF LEVEL 4**

(10021004)

**28 November 2019 (X-Paper)**
**09:00–12:00**

**Nonprogrammable calculators and appropriate mathematical instruments may be used.**

**This question paper consists of 14 pages and a formula sheet of 3 pages.**

**TIME: 3 HOURS**
**MARKS: 150**

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**INSTRUCTIONS AND INFORMATION**

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Write your EXAMINATION NUMBER and CENTRE NUMBER in the appropriate spaces on the ANSWER BOOK.
5. Approximate ALL final answers to TWO decimal places.
6. Show the formulae and substitutions in ALL calculations.
7. Start each question on a NEW page.
8. Write neatly and legibly.

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## SECTION A

### QUESTION 1

Give ONE term for each of the following descriptions. Write only the term next to the question number (1.1–1.5) in the ANSWER BOOK.

1.1 Type of electromagnetic wave used in a remote control device

1.2 Device emitting light through a process of optical amplification based on the set of emission or electromagnetic radiation

1.3 Energy due to motion

1.4 The force acting on a fee-falling body

1.5 Ratio of the speed of a jet plane to the speed of sound in air

(5 × 1) **[5]**

### QUESTION 2

Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–J) next to the question number (2.1–2.5) in the ANSWER BOOK.

| COLUMN A | | COLUMN B | |
|---|---|---|---|
| 2.1 | Device that converts alternating current into direct current | A | momentum |
| 2.2 | Electromagnetic waves with the shortest wavelength | B | newton |
| 2.3 | Apparent change in frequency when there is relative motion between the source and the observer | C | radio waves |
| 2.4 | Product of mass and velocity | D | doping |
| 2.5 | Unit of torque | E | rectifier |
| | | F | impulse |
| | | G | gamma rays |
| | | H | amplifier |
| | | I | newton·metre |
| | | J | Doppler effect |

(5 × 1) **[5]**

## QUESTION 3

Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'True' or 'False' next to the question number (3.1–3.5) in the ANSWER BOOK.

3.1 Frictional forces act in the opposite direction to the direction of motion of an object.

3.2 A pulley system reduces the work done.

3.3 The threshold frequency is the lowest frequency of light that will release photoelectrons from the cathode of a photocell.

3.4 In an electric motor, kinetic energy is converted to electrical energy.

3.5 A p-type semiconductor is negatively charged.

(5 × 2) **[10]**

## QUESTION 4

Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (4.1–4.5) in the ANSWER BOOK.

4.1 Two objects, A and B, fall freely from a position of rest. A falls for time t and B falls for 2t seconds.

The distance fallen by object A is … the distance fallen by object B.

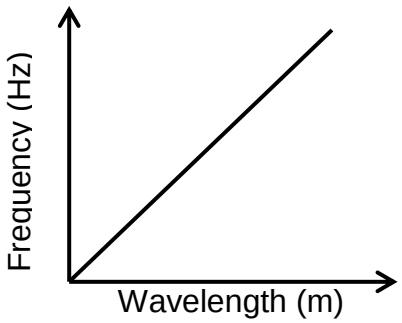
A half
B two times
C four times
D one quarter

4.2 When the speed of a motor car doubles, how does it affect the momentum and kinetic energy of the motor car?

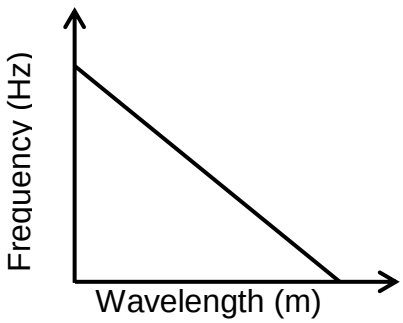
| | MOMENTUM | KINETIC ENERGY |
|---|---|---|
| A | Doubles | Doubles |
| B | Halves | Quadruples |
| C | Halves | Halves |
| D | Doubles | Quadruples |

4.3 Which ONE of the following graphs correctly represents the relationship between the frequency and wavelength of an electromagnetic wave?

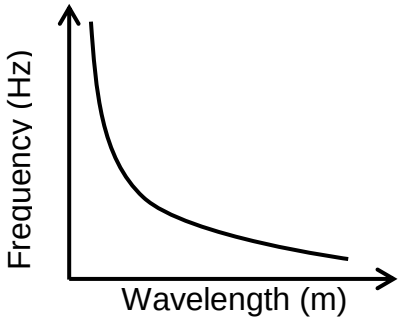
A



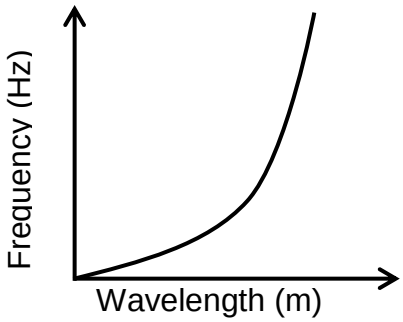

B



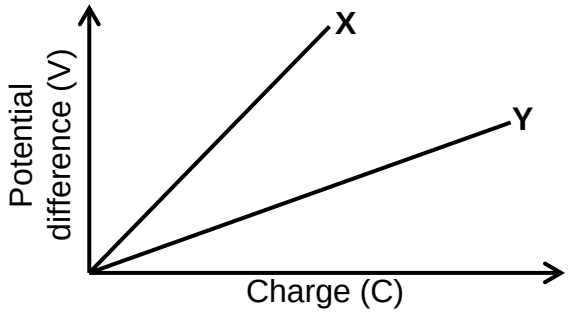

C




D




4.4 The graph shows how the charge stored by each of two capacitors, **X** and **Y**, increases as the potential difference across each capacitor increases.

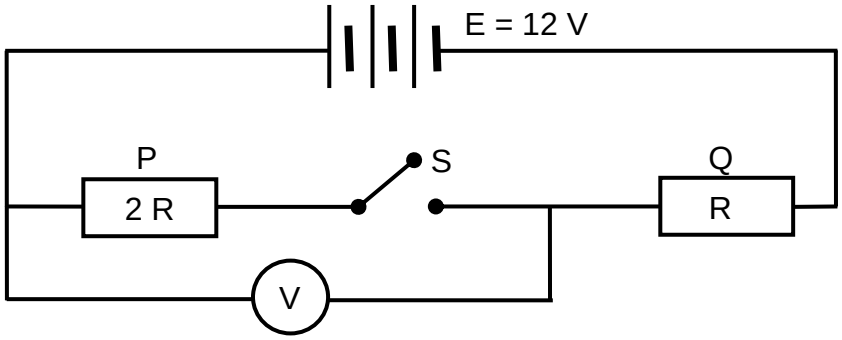



Which ONE of the following statements is CORRECT?

A The capacitance of **X** is equal to that of **Y**.
B The capacitance of **Y** is less than that of **X**.
C The capacitance of **Y** is greater than that of **X**.
D The capacitance of both **X** and **Y** are increasing.

4.5 In the following circuit the battery has an emf of 12 V. The resistance of P is twice the resistance of Q. Both the battery and switch S have negligible internal resistance.




When the switch S is closed, the reading on the voltmeter …

A decreases from 12 V to 8 V.
B decreases from 12 V to 6 V.
C increases from 0 V to 6 V.
D increases from 0 V to 8 V.

(5 × 3) **[15]**

**TOTAL SECTION A: 35**

## SECTION B

## QUESTION 5: MEASUREMENTS AND HAZARD SYMBOLS

Convert each of the following to the unit indicated:

5.1 0,125 m to cm

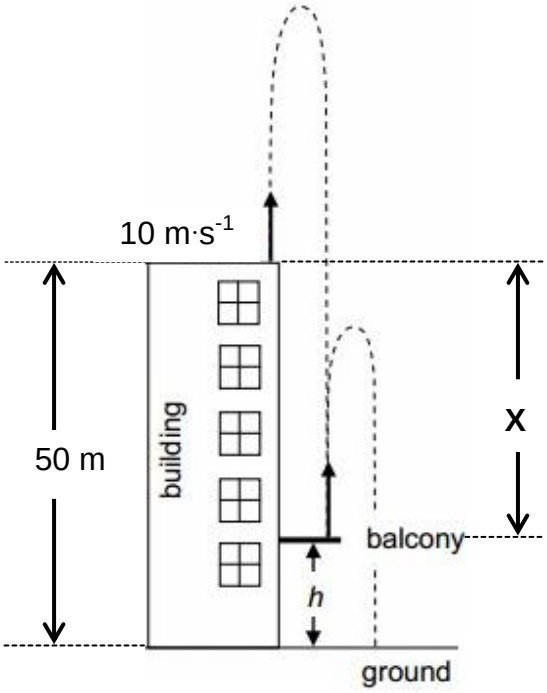
5.2 4 nC to C

5.3 2 kW·h to J

(3 × 1) **[3]**

## QUESTION 6: FREE-FALLING BODIES

A ball is projected vertically upwards at 10 $m \cdot s^{-1}$ from the roof of a building which is 50 m high. The ball reaches the balcony below after 4 s.
The object then bounces off the balcony and strikes the ground 3,6 s after leaving the balcony as illustrated below. Ignore the effects of air resistance.




6.1 What is the magnitude of the acceleration of the ball at its maximum height? (1)

6.2 Determine the time taken for the ball to reach the maximum height above the roof. (3)

6.3 **Calculate:**

6.3.1 The velocity with which the ball strikes the balcony. (3)

6.3.2 The distance **X.** (4)

6.3.3 The velocity with which the ball rebounds from the balcony. (4)

6.4 Sketch a velocity – time graph for the motion of the ball from the moment it was projected from the roof until it strikes the ground. TAKE UPWARDS AS POSITIVE.

Indicate the following values on the graph:
Initial velocity of projection
Velocity at which the ball strikes the balcony
The rebound velocity of the ball from the balcony

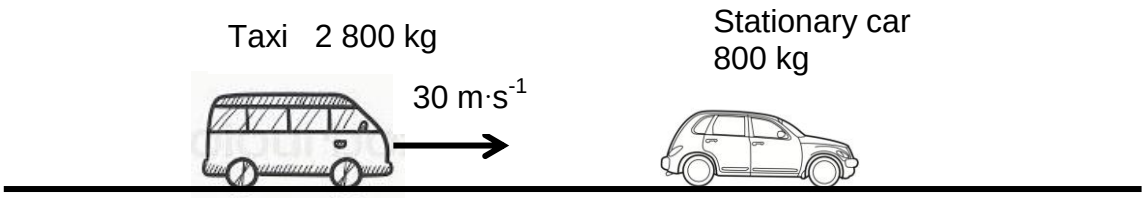
(4)
**[19]**

## QUESTION 7: MOMENTUM

A taxi of mass 2 800 kg, travelling at 30 $m \cdot s^{-1}$ collides with a stationary car of mass 800 kg. After the collision, the wreck of the taxi and car move together some distance before coming to a halt.

Before the accident:




After the accident:


7.1 What is the magnitude of the velocity of the wrecked taxi and car immediately after the accident? (4)

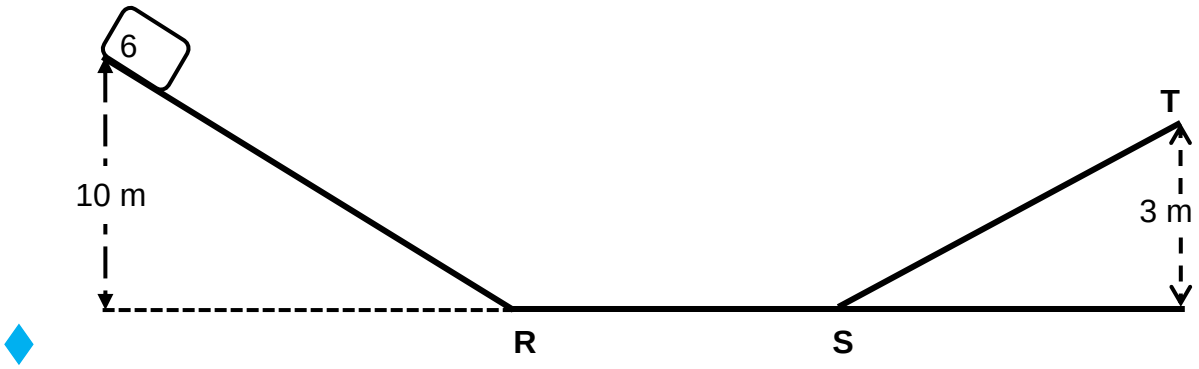
7.2 Is the collision between the taxi and the car ELASTIC or INELASTIC? (1)

7.3 By means of calculation, justify the answer to QUESTION 7.2 (6)

**[11]**

## QUESTION 8: WORK, ENERGY AND POWER

A 6 kg block is released at 5 m·s$^{-1}$ from a height of 10 m and slides down a frictionless incline to point **R** as shown in the diagram below. The block then moves along a frictionless horizontal portion **RS** and finally moves up a second rough inclined plane. It comes to a stop at point **T** which is 3 m above the horizontal.




The frictional force between the surface **ST** and the block is 12 N

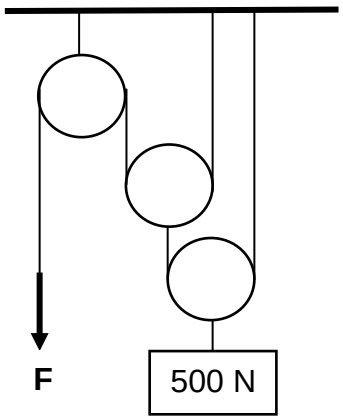
8.1 Using ENERGY PRINCIPLES only, calculate the speed of the block at point **R**. (4)

8.2 Calculate the work done by the force of gravity on the block as it moves up the slope to **T**. (4)

**[8]**

## QUESTION 9: MECHANICAL ADVANTAGE

The pulley system shown below is used to hoist a load of 500 N through a vertical height of 4,2 m using an applied force F.




9.1 What is the ideal mechanical advantage (IMA) of the pulley system? (1)

9.2 If the efficiency of the pulley system is 75%, determine the actual mechanical advantage. (3)

9.3 Calculate the work done by force F. (3)

**[7]**

## QUESTION 10: WAVES, LIGHT AND SOUND

A police van with its siren sounding at a frequency of between 700 Hz and 1 000 Hz is moving at 90 km·h$^{-1}$ towards the scene of a motor vehicle accident.


10.1 Will the driver of the police van observe the Doppler effect? Write only yes or no. (1)

10.2 Give a reason for the answer to QUESTION 10.1 (2)

10.3 Calculate the maximum frequency of the siren heard by a stationary observer at the scene of the accident. Take the speed of sound in air to be 340 m·s$^{-1}$. (5)

10.4 If the police van travels faster, will the frequency of the siren heard by the stationary observer at the scene of the accident be GREATER, SMALLER or REMAIN THE SAME ? (1)

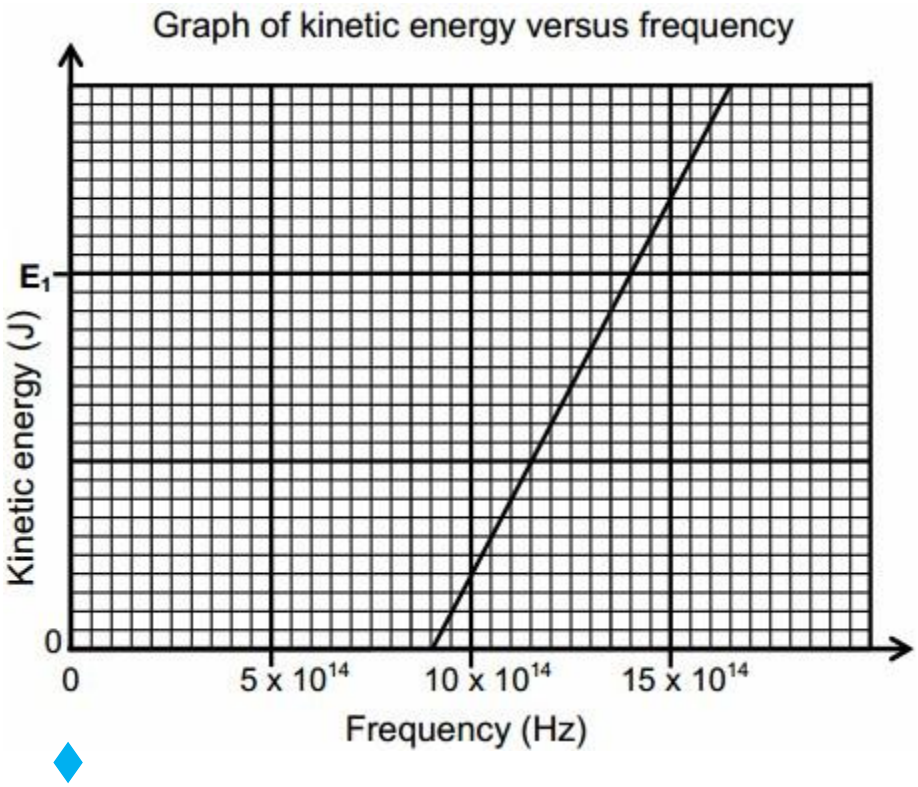
**[9]**

## QUESTION 11: PHOTOELECTRIC EFFECT

11.1 The energy of a photon of an electromagnetic wave is $2,4 \times 10^{-19}$ J.

What is the wavelength of this wave? (4)

11.2 During an investigation, light of different frequencies is shone onto the metal cathode of a photocell. The kinetic energy of the emitted photoelectrons is measured. The graph below shows the results obtained.




11.2.1 Write an investigative question for this experiment. (2)

11.2.2 What is the independent variable for this experiment? (1)

11.2.3 Determine the work function of the cathode of this photocell. (3)

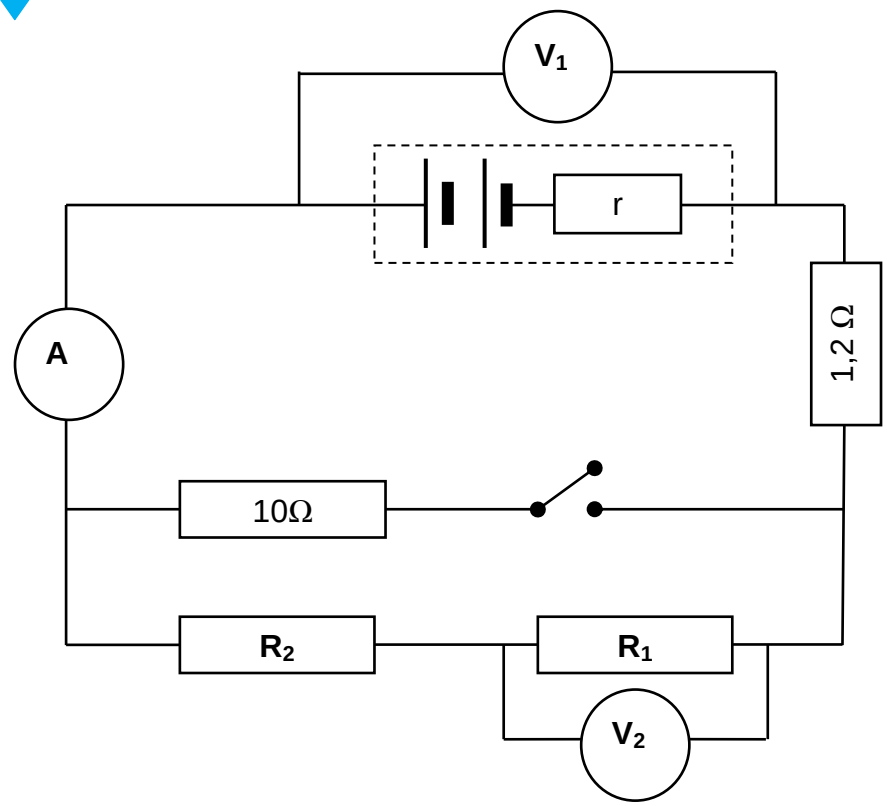
11.2.4 Calculate the kinetic energy of the photo-electrons at position $E_1$ on the graph. (4)

11.2.5 How would the kinetic energy calculated in QUESTION 11.2.4 be affected if light of higher intensity is used. Write only INCREASES, DECREASES or REMAINS THE SAME. (1)

**[15]**

## QUESTION 12: ELECTRICITY

12.1 In the circuit diagram shown below the battery has an emf of 12 V and an internal resistance r. When the switch S is open, the ammeter reads 2 A and the voltmeter $V_2$ reads 3 V.




12.1.1 State Ohm's law. (2)

12.1.2 Calculate the value of resistance $R_1$. (3)

12.1.3 Determine the value of $R_2$ if it dissipates 12 W of power. (3)

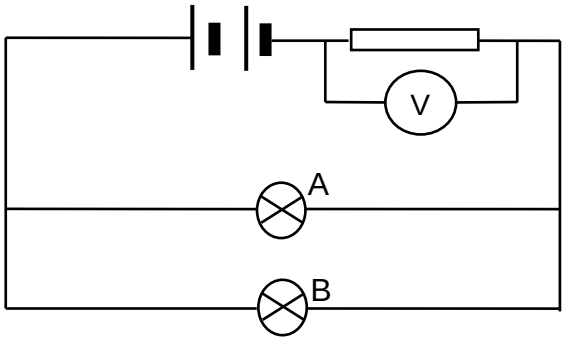
12.1.4 What is the value of the internal resistance of the battery? (4)

12.1.5 If the switch S is closed, how will each of the following change? Choose from INCREASES, DECREASES or REMAINS THE SAME.

(a) The reading on the ammeter A.
(b) The power dissipated by the battery.
(c) The reading on the voltmeter $V_1$. (3 × 2) (6)

12.2 In the circuit below the battery has negligible internal resistance. Bulb A glows/burns brighter than bulb B.




12.2.1 Which bulb, A or B, has a higher resistance? (1)

12.2.2 With reference to an appropriate formula, give an explanation for the answer to QUESTION 12.2.1. (3)

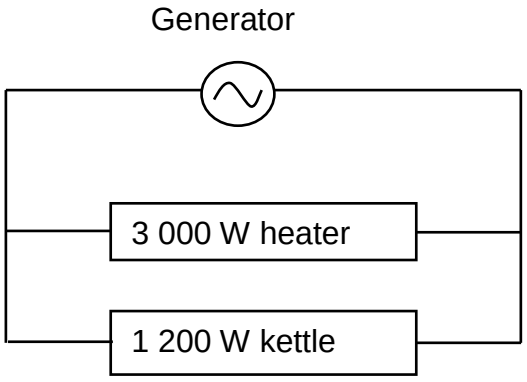
12.2.3 If bulb A fuses/burns out, will the reading on the voltmeter V INCREASE, DECREASE or REMAIN THE SAME? (1)

12.2.4 Give an explanation for the answer to QUESTION 12.2.3. (2)

**[25]**

## QUESTION 13: ELECTRIC MOTORS

An AC generator is operating at a maximum emf of 311,13 V. It is connected across a heater (3 000 W) and a kettle (1 200 W) as shown in the diagram below. Both the heater and kettle are operating at optimal conditions.




13.1 State TWO methods by which the current produced by a generator may be increased. (2 × 2) (4)

13.2 Which energy conversion occurs in a generator? (2)

13.3 What is the rms voltage across the heater? (3)

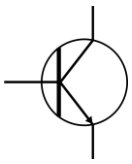
13.4 Calculate the resistance of the kettle. (3)

**[12]**

## QUESTION 14: ELECTRONICS

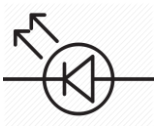
14.1 What does each of the following electronic symbols represent:

14.1.1



(1)

14.1.2



(1)

14.2 A parallel-plate capacitor is connected to a 12 V battery. Each plate of the parallel-plate capacitor has an area of 30 $cm^2$ and a gap of 0,25 cm.

Calculate the capacitance of this capacitor. (4)
**[6]**

**TOTAL SECTION B: 115**
**GRAND TOTAL: 150**

**FORMULA SHEET**

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

| NAME/*NAAM* | SYMBOL/*SIMBOOL* | VALUE/*WAARDE* |
|---|---|---|
| Acceleration due to gravity<br>*Swaartekragversnelling* | g | $9{,}8\ m{\cdot}s^{-2}$ |
| Speed of light in a vacuum<br>*Spoed van lig in 'n vakuum* | c | $3{,}0 \times 10^{8}\ m{\cdot}s^{-1}$ |
| Planck's constant<br>*Planck se konstante* | h | $6{,}63 \times 10^{-34}\ J{\cdot}s$ |
| Gravitational constant<br>*Swaartekragkonstante* | G | $6{,}67 \times 10^{-11}\ N{\cdot}m^{2}{\cdot}kg^{-2}$ |
| Coulomb's constant<br>*Coulomb se konstante* | k | $9{,}0 \times 10^{9}\ N{\cdot}m^{2}{\cdot}C^{-2}$ |
| Charge on electron<br>*Lading op elektron* | $e^-$ | $-1{,}6 \times 10^{-19}\ C$ |
| Electron mass<br>*Elektronmassa* | $m_e$ | $9{,}11 \times 10^{-31}\ kg$ |
| Permittivity of free space<br>*Permittiwiteit van vry ruimte* | $\varepsilon_0$ | $8{,}85 \times 10^{-12}\ F{\cdot}m^{-1}$ |
| Permeability of free space<br>*Permeabiliteit van vry ruimte* | $\mu_0$ | $4\pi \times 10^{-7}\ T{\cdot}m{\cdot}A^{-1}$ |

## 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 $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ |
| $v_f^2 = v_i^2 + 2a\Delta x$ or $v_f^{\ 2} = v_i^{\ 2} + 2a\Delta y$ | $\Delta x = \left(\frac{v_f + v_i}{2}\right)\Delta t$ or $\Delta y = \left(\frac{v_f + v_i}{2}\right)\Delta t$ |

### FORCE/*KRAG*

| | |
|---|---|
| $F_{net} = ma$ | $p = mv$ |
| $F\Delta t = \Delta p = mv_f - mv_i$ | $F_g = mg$ |

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

| | |
|---|---|
| $W = F\Delta x$ | $U = E_P = mgh$ |
| $K = E_k = \frac{1}{2}mv^2$ | $W = \Delta K = \Delta E_k = E_{kf} - E_{ki}$ |
| $P = \frac{W}{\Delta t}$ | $P = Fv$ |

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

| | |
|---|---|
| $v = f\lambda$ or/*of* $v = v\lambda$ | $T = \frac{1}{f}$ or/*of* $T = \frac{1}{v}$ |
| $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ | $E = hf$ or/*of* $E = hv$ or/*of* $E = h\frac{c}{\lambda}$ |
| $\lambda = \frac{h}{mv}$ | $\sin\theta = \frac{m\lambda}{a}$ |
| $hf = W_0 + \frac{1}{2}mv^2 = hf_0 + \frac{1}{2}mv^2$ | |

### MATTER AND MATERIALS/*MATERIE EN MATERIALE*

| | |
|---|---|
| $F = k\Delta x$ | Stress/*Spanning* $= \frac{F}{A}$ |
| Strain/*Vervorming* $= \frac{\Delta x}{\ell}$ | |

## ELECTRICITY AND MAGNETISM/*ELEKTRISITEIT EN MAGNETISME*

| | |
|---|---|
| $I_{rms} = \frac{I_{max}}{\sqrt{2}}$ / $I_{wgk} = \frac{I_{maks}}{\sqrt{2}}$<br>$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ / $V_{wgk} = \frac{V_{maks}}{\sqrt{2}}$ | $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$ |
| $\Phi = BA$ | $P_{average} = V_{rms}I_{rms}$ / $P_{gemiddeld} = V_{wgk}I_{wgk}$<br>$P_{average} = \frac{V_{rms}^2}{R}$ / $P_{gemiddeld} = \frac{V_{wgk}^2}{R}$<br>$P_{average} = I_{rms}^2R$ / $P_{gemiddeld} = I_{wgk}^2R$ |

## ELECTROSTATICS/*ELEKTROSTATIKA*

| | |
|---|---|
| $F = \frac{kQ_1Q_2}{r^2}$ | $E = \frac{kQ}{r^2}$ |
| $E = \frac{V}{d}$ | $U = \frac{kQ_1Q_2}{r}$ |
| $E = \frac{F}{q}$ | $Q = It$ |
| $C = \frac{Q}{V}$ | $C = \frac{\varepsilon_0 A}{d}$ |

## ELECTRIC CIRCUITS/*ELEKTRIESE STROOMBANE*

| | |
|---|---|
| $R = \frac{V}{I}$ | $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$ |
| $R_s = R_1 + R_2 + \ldots$ | emf/*emk*($\varepsilon$) = I(R + r) |