higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

PHYSICAL SCIENCE

(First paper)

NQF LEVEL 4

(10021004)

26 November 2020
09:00–12:00

A non-programmable calculator may be used

This question paper consists of 14 pages, 3 data sheets and 1 answer sheet.

119Q1N2026

TIME: 3 HOURS
MARKS: 150

INSTRUCTIONS AND INFORMATION

1. Write your EXAMINATION NUMBER and CENTRE NUMBER in the appropriate spaces on the ANSWER BOOK.
2. Answer all the questions.
3. An ANSWER SHEET accompanies Question 12.1. Remember to write your EXAMINATION NUMBER and CENTRE NUMBER on the ANSWER SHEET before tearing it off and placing it inside the front cover of the ANSWER BOOK.
4. Start each question on a new page in the ANSWER BOOK.
5. Number the answers according to the numbering system used in this question paper.
6. You may use appropriate mathematical instruments.
7. Show all formulae and substitutions in all calculations.
8. Round off all final numerical answers to a minimum of TWO decimal places.
9. Give brief motivations, discussions, etc. where required.
10. Use the attached DATA SHEETS.
11. Write neatly and legibly.

SECTION A

QUESTION 1

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

1.1 Joule per second

1.2 Product of mass and change in velocity

1.3 Electromagnetic waves with the longest wavelength

1.4 Electronic device that stores energy in electric fields

1.5 Device that converts electrical energy into mechanical energy

(5 × 1) **[5]**

QUESTION 2

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

COLUMN A		COLUMN B	
2.1	Electronic device that can increase the power of a signal	A	photoelectron
2.2	Electromagnetic waves used to sterilize surgical equipment	B	transistor
2.3	Charge per unit potential difference	C	commutator
2.4	p-n junctions that emit light when a current flows through it	D	farad
2.5	Semiconductor device used to amplify or switch electronic signals	E	slip ring
		F	ultra violet
		G	tesla
		H	LED
		I	henry
		J	amplifier
		K	generator
		L	diode

(5 × 1) **[5]**

QUESTION 3

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

3.1 In a head-on collision between two masses, the force exerted by the larger mass is greater than the force exerted by the smaller mass.

3.2 Torque is directly proportional to the distance from the turning point.

3.3 The penetrating ability of electromagnetic waves increases with an increase in frequency.

3.4 Capacitance is directly proportional to potential difference.

3.5 Ohm's law is applicable to a p-n junction diode.

(5 × 2) **[10]**

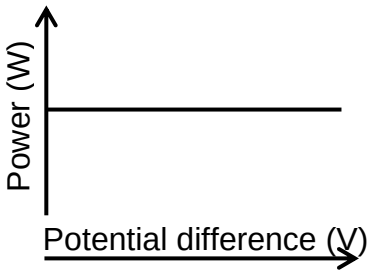
QUESTION 4

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.

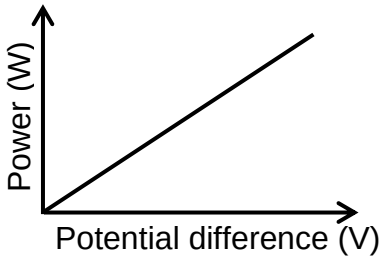
4.1 A variable potential difference is connected to a resistor with a fixed resistance.

Which ONE of the following graphs represents the relationship between the power dissipated by the resistor and the potential difference?

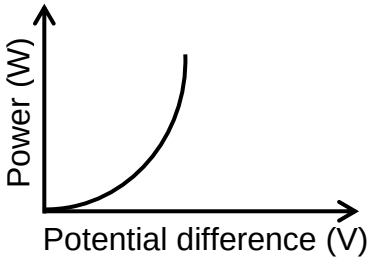
A



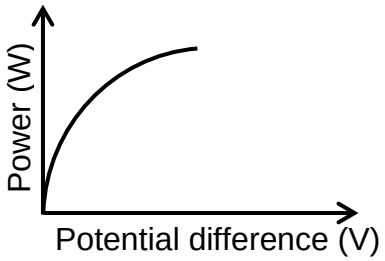
B



C



D



4.2 An object, A, free falls from rest from a height, h, and strikes the ground with a velocity v.

What will the velocity of object A be if it is released from a height of 4h?

A 2v

B 3v

C 4v

D 8v

4.3 The acceleration due to gravity is greater on Earth than on Mars.

Which ONE of the following statements is correct?

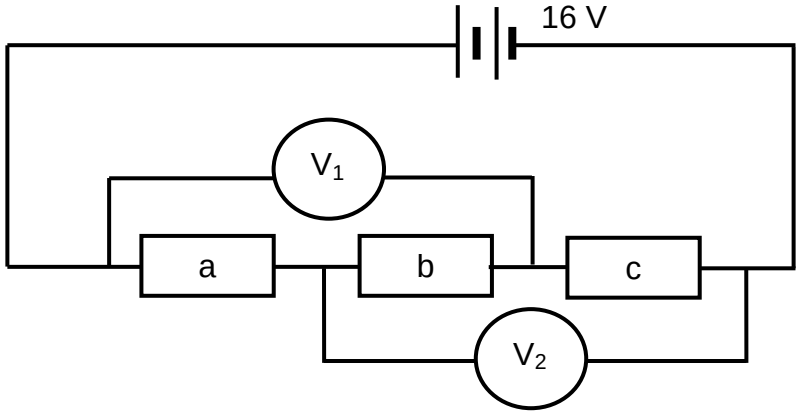
A The weight of an object on Earth is the same as on Mars.

B Ther weight of an object on Earth is less than that on Mars.

C The mass of an object on Earth is the same as that on Mars.

D The mass of an object on Earth is greater than that on Mars.

4.4 A battery with an emf of 16 V and negligible internal resistance is connected in a circuit with three resistors in series. The resistance of **b** is R. The voltmeters V_1 and V_2 record readings of 8 V and 10 V respectively. Ignore the resistance of the connecting wires.



Which ONE of the following is the correct value for the resistance **a**?

A 2R

B 3R

C 4R

D 5R

4.5 The work function of Aluminium is greater than that of Potassium.

Which ONE of the following statements about the threshold frequency of the metals is CORRECT?

A The threshold frequency of Aluminium is greater than that of Potassium.

B The threshold frequency of Aluminium is less than that of Potassium.

C Both Aluminium and Potassium have the same threshold frequency.

D The threshold frequencies of Aluminium and Potassium are independent of their work functions.

(5 × 3) **[15]**

TOTAL SECTION A: 35

SECTION B

QUESTION 5: MEASUREMENTS AND HAZARD SYMBOLS

5.1 The data below was obtained during an investigation into the relationship between the different velocities of a moving sound source and the frequencies detected by a stationary listener for each velocity. The effect of wind was ignored in this investigation.

Experiment number	1	2	3	4
Velocity of the sound source ($m \cdot s^{-1}$)	0	10	20	30
Frequency (Hz) of the sound detected by the stationary listener	900	874	850	827

5.1.1 State the independent variable in this investigation. (1)

5.1.2 What is the frequency of the sound source? (2)

5.1.3 Write a suitable conclusion for this investigation. (2)

5.2 Convert each of the following to the unit indicated:

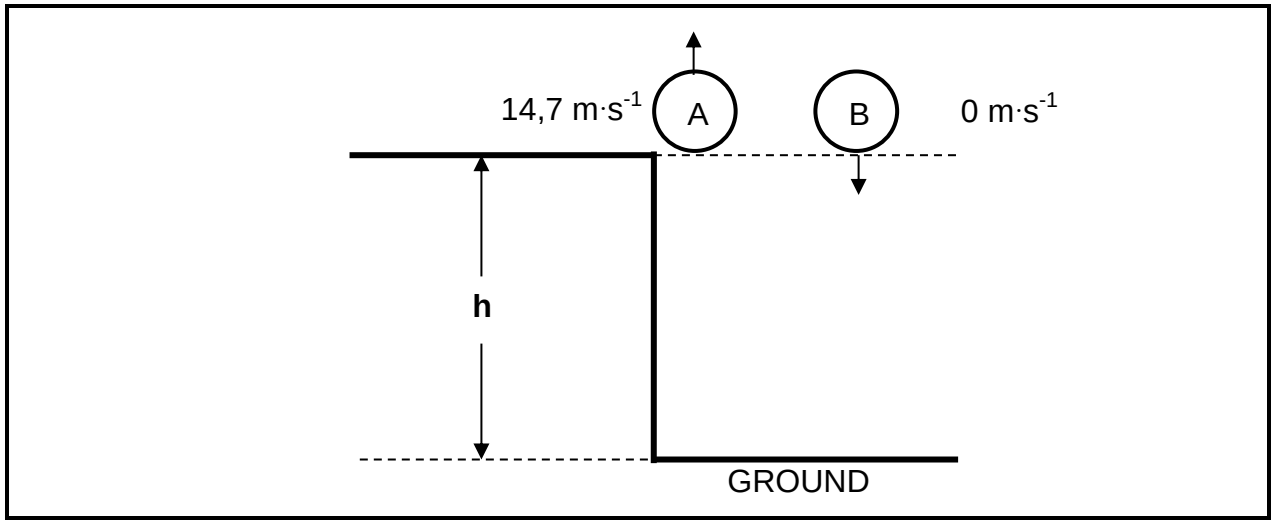
5.2.1 500 nm to m

5.2.2 230 cm^3 to dm^3

(2 × 1) (2)
[7]

QUESTION 6: FREE-FALLING BODIES

A ball**,** A**,** is projected vertically upwards from a height, h, with a speed of 14,7 $m \cdot s^{-1}$. After 1 s, an identical ball, B, is dropped from the same height as ball A as shown in the diagram below. Ball A strikes the ground after 5 s. The diagram is not drawn to scale.



6.1 What is the acceleration of ball A at its maximum height above the ground? (2)

6.2 Calculate the time taken for ball A to reach its maximum height above the ground. (4)

6.3 Determine the height h. (4)

6.4 Determine the distance between ball A and ball B when ball A is at its maximum height above the ground. (6)

6.5 Sketch a velocity-time graph for ball A from the time it was projected upwards until it strikes the ground. Take upwards as negative.

Indicate the following on the graph:

- Initial velocity of ball A
- Time ball A reaches its maximum height
- Labels on the axis (4)

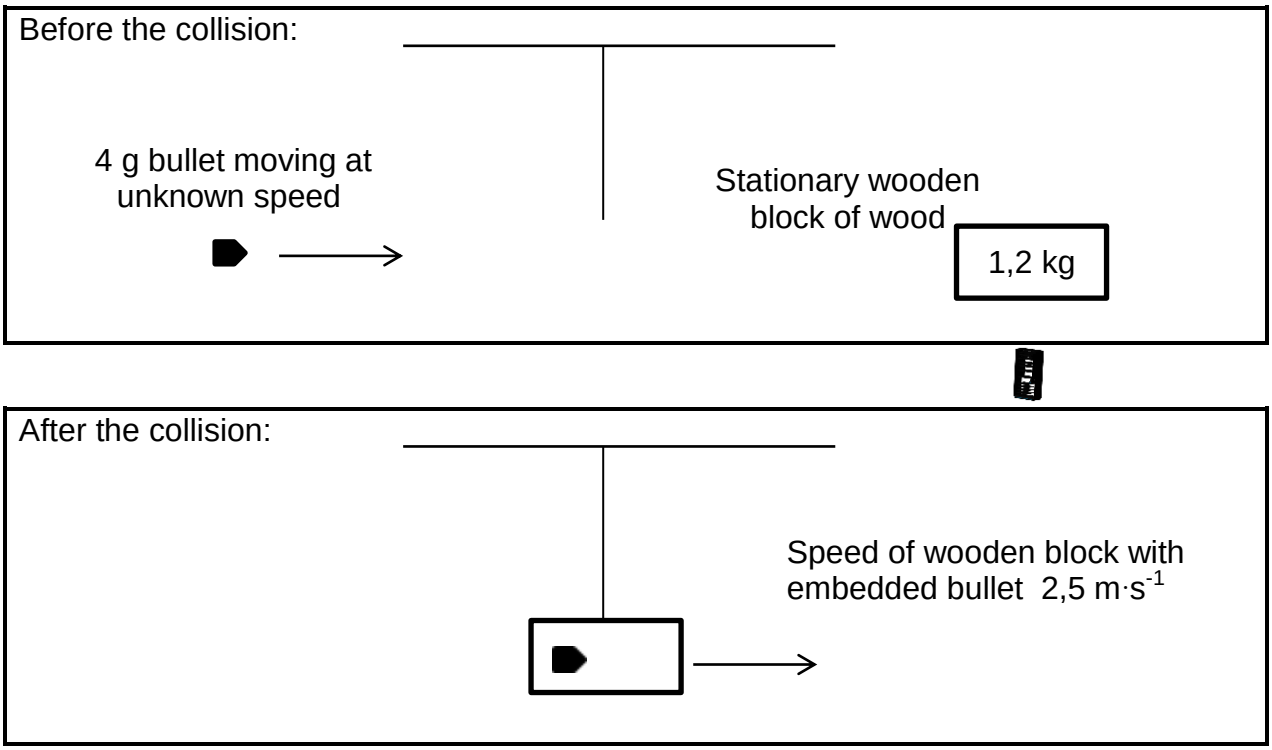
[20]

QUESTION 7: MOMENTUM

A wooden block of mass 1,2 kg is suspended from the ceiling by a weightless string.

When a gun is fired horizontally, a bullet of mass 4 g strikes the stationary wooden block at an unknown speed.

The bullet becomes embedded in the wooden block. Immediately after the collision the wooden block with the embedded bullet has a horizontal speed of 2,5 $m \cdot s^{-1}$



7.1 Define *"elastic collision".* (2)

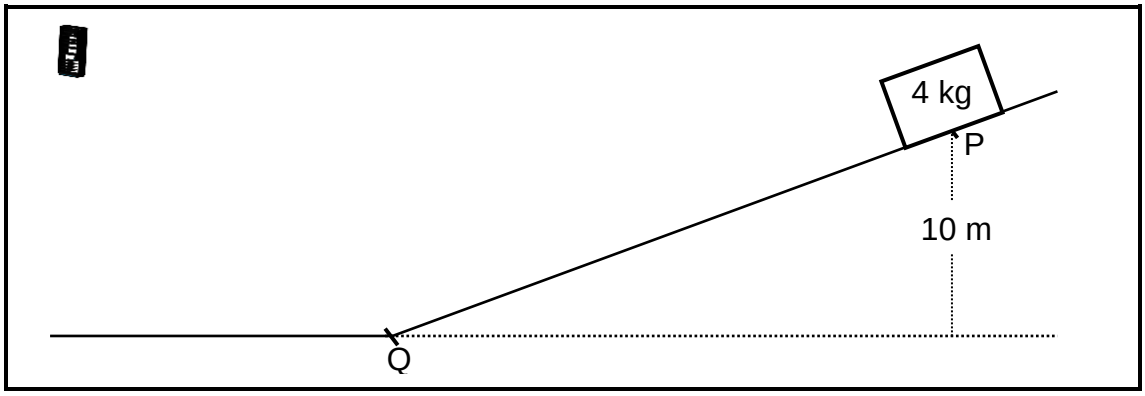
7.2 Calculate the speed of the bullet immediately before the collision with the wooden block. (4)

7.3 After the collision, how will the speed of the wooden block change if the bullet emerged from the block with a speed of 2,5 $m \cdot s^{-1}$?

Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)
[7]

QUESTION 8: WORK, ENERGY AND POWER

8.1 A box of mass 4 kg is released from rest at point P and slides down a rough inclined plane from a height of 10 m. It reaches the ground at point Q at a speed of 13 $m \cdot s^{-1}$. The frictional force on the inclined plane is 3 N.



8.1.1 State the work-energy theorem. (2)

8.1.2 Calculate the work done by the gravitational force acting on the box. (3)

8.1.3 Use the work-energy theorem to calculate the distance PQ. (4)

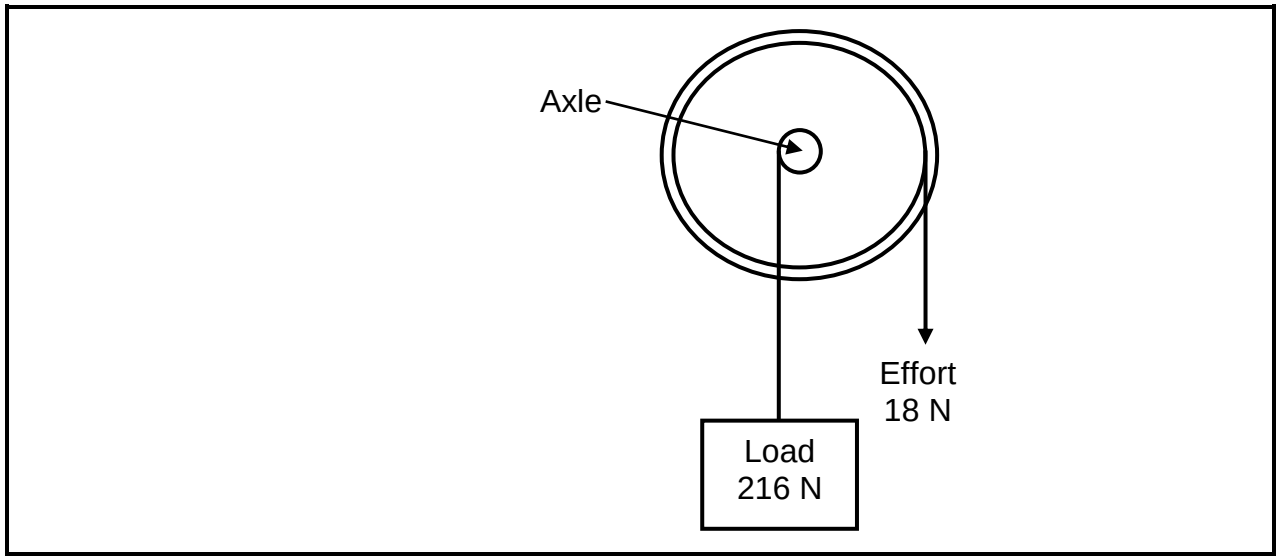
8.2 A crane lifts a load of 2 400 kg to a height of 40 m in 2 minutes. The load is lifted at a constant velocity.

Calculate the power output of the crane. (4)

[13]

QUESTION 9: MECHANICAL ADVANTAGE

A wheel and axle are used to raise a load of 216 N by a force of 18 N applied to the rim of the wheel. The radii of the wheel and axle is 70 cm and 5 cm respectively.



9.1 What is the ideal mechanical advantage (IMA) of this wheel and axle? (3)

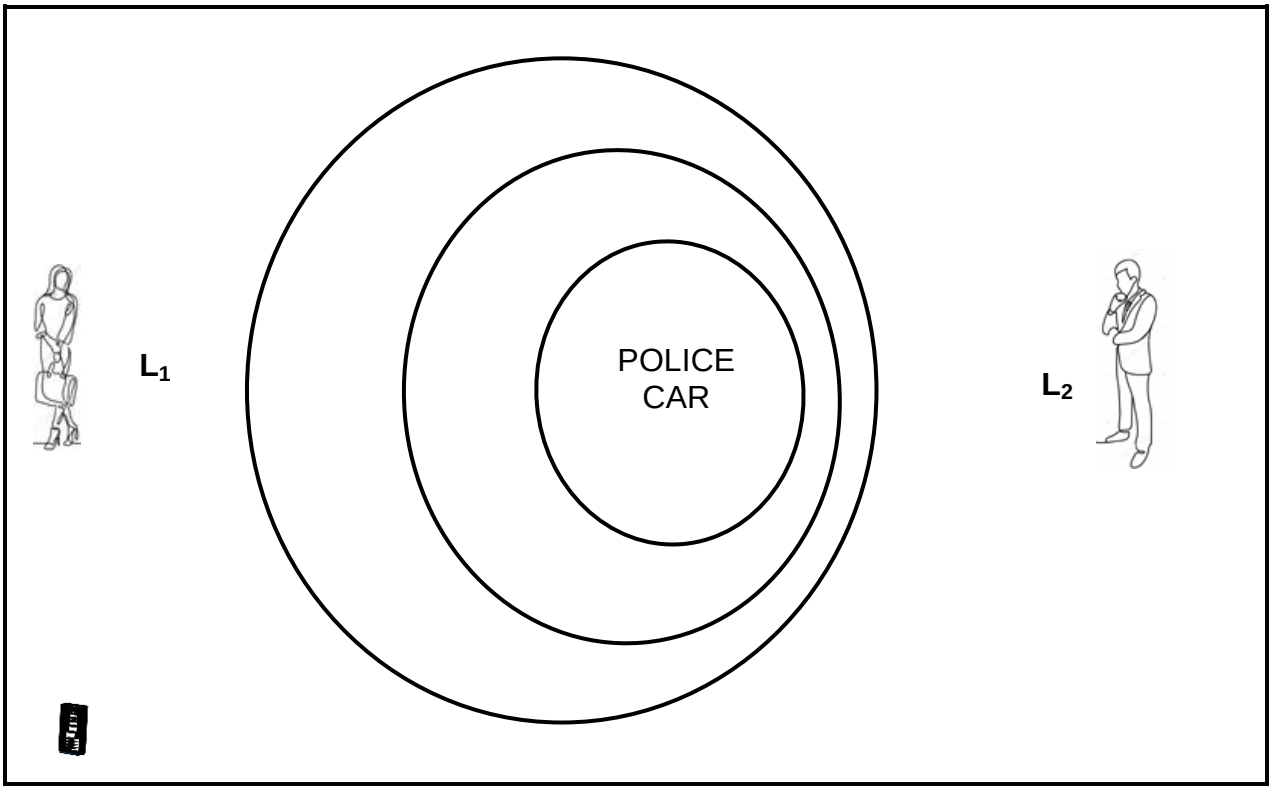
9.2 Determine the actual mechanical advantage (AMA). (3)

9.3 Calculate the efficiency of this machine. (2)

[8]

QUESTION 10: WAVES, LIGHT AND SOUND

The frequency of a police car's siren is 950 Hz. The sketch illustrates the pattern of the siren's sound wave fronts around the moving police car.
L_1 and L_2 are two stationary observers. The distance between the wave fronts of the sound wave heard by L_1 is 0,376 m and that heard by L2 is 0,340 m. Assume that the speed of sound in air is 340 $m \cdot s^{-1}$.



10.1 Is the police car moving TOWARDS or AWAY FROM the stationary observer L_1? (1)

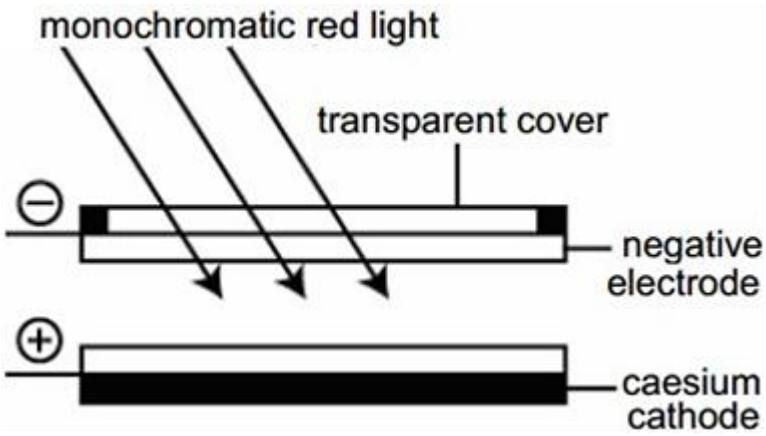
10.2 Give a reason for the answer to QUESTION 10.1. (2)

10.3 Will the frequency of the sound heard by stationary observer L_2 be GREATER THAN, LESS THAN or EQUAL TO to that heard by stationary observer L_1. (2)

10.4 Calculate the speed of the police car. (6)
[11]

QUESTION 11: PHOTOELECTRIC EFFECT

The sketch below shows the components of a photocell used in a camera light meter.



The photocell consists of a caesium cathode with a work function of $3,4 \times 10^{-19}$ J. When monochromatic red light of wavelength 560 nm from a 50 W red light bulb strikes the cathode in the photocell, the light meter registers a small electric current.

11.1 Calculate the energy of a photon of the monochromatic red light. (4)

11.2 Determine the maximum kinetic energy of the ejected photo electrons. (4)

11.3 Will the electric current INCREASE, DECREASE or REMAIN THE SAME when the 50 W red light bulb is replaced by a 100 W red light bulb? (1)

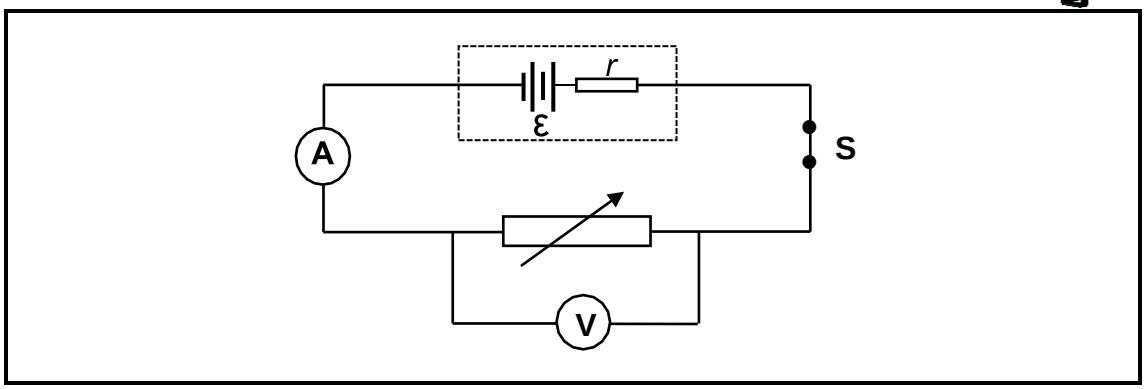
11.4 Will the kinetic energy of the emitted photo electrons INCREASE, DECREASE or REMAIN THE SAME when the 50 W red light bulb is replaced with a 50 W blue light bulb? (1)

11.5 What conclusion about the nature of light can be made from the photoelectric effect? (2)

[12]

QUESTION 12: ELECTRICITY

12.1 An experiment to determine the emf (ε) and internal resistance (*r*) of a battery was conducted. A battery was connected to a rheostat (variable resistor), a low-resistance ammeter and a high-resistance voltmeter as shown in the diagram below.



The data obtained from the experiment is displayed in the table below.

READING ON VOLTMETER (V)	READING ON AMMETER (A)
2	0,58
3	0,46
4	0,36
5	0,24
6	0,14

12.1.1 Give ONE factor which must be kept constant during the experiment. (1)

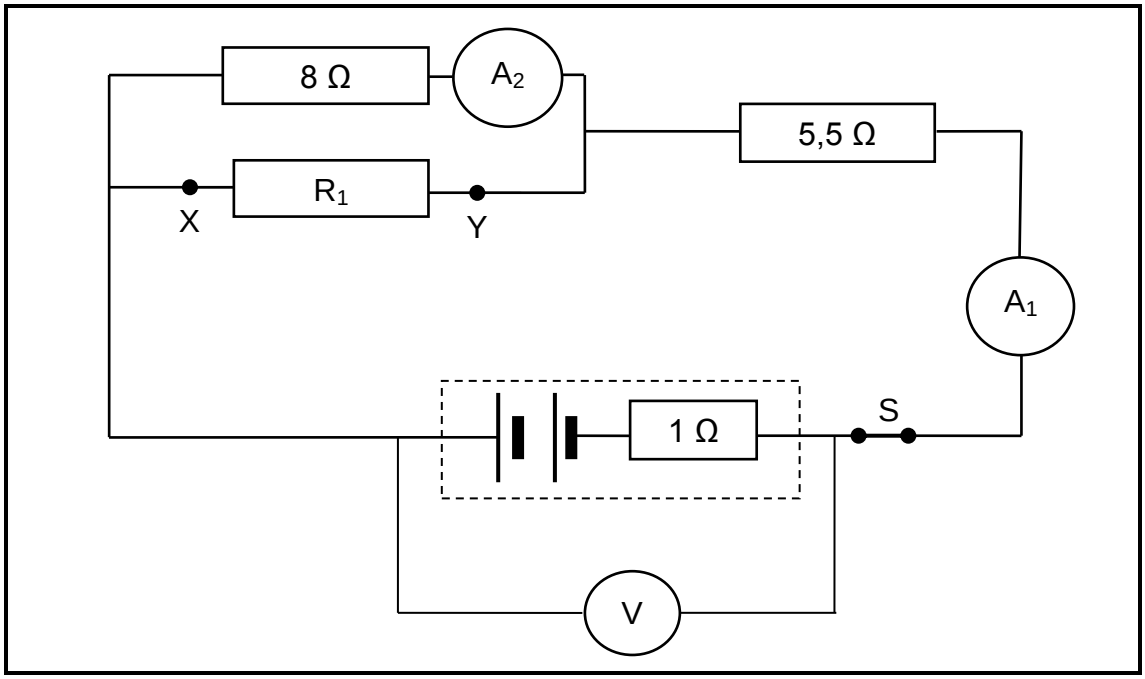
12.1.2 Use the information in the table above and plot a graph of potential difference against current on the graph paper on the ANSWER SHEET (attached). Tear off the ANSWER SHEET and place it inside the front cover of the ANSWER BOOK. (3)

12.1.3 Use the graph drawn in QUESTION 12.1.2 to determine each of the following:

(a) Emf (ε) of the battery (2)

(b) Internal resistance of the battery (3)

12.2 A battery with an internal resistance of 1 Ω and an unknown emf (ε) is connected in a circuit as shown below. A high-resistance voltmeter (V_1) is connected across the battery. A_1 and A_2 represent ammeters of negligible resistance.



When the switch S is closed, the voltmeter across the battery reads 13,8 V and the 5,5 Ω resistor dissipates 7,92 W of power.

12.2.1 Define *electrical power*. (2)

12.2.2 What is the reading on ammeter A_1? (3)

12.2.3 Calculate the potential difference across the parallel network. (4)

12.2.4 Calculate the heat produced by the 8 Ω resistor in 5 minutes. (4)

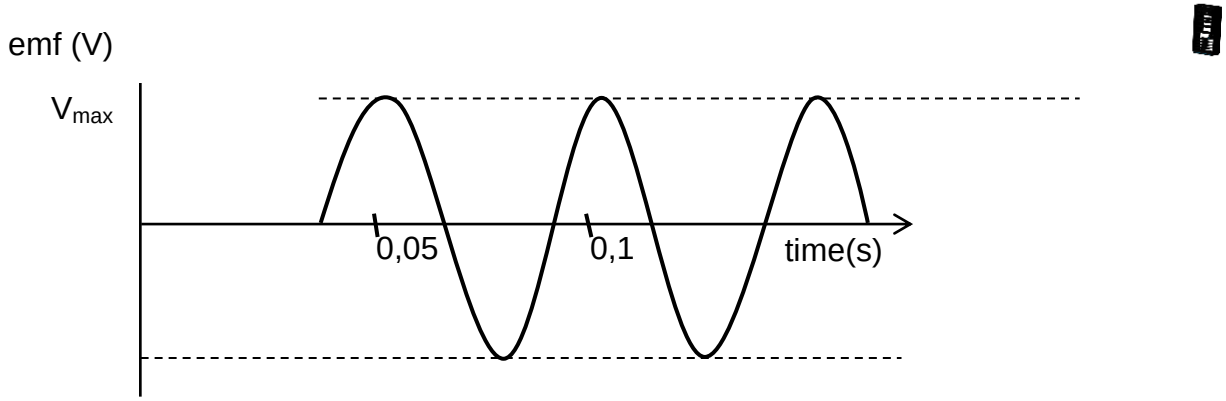
A piece of copper wire was used to join points X and Y.

12.2.5 Will the reading on V_1 INCREASE, DECREASE or REMAIN THE SAME? (1)

12.2.6 Explain the answer to QUESTION 12.2.5. (3)
[26]

QUESTION 13: ELECTRIC MOTORS

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



13.1 State ONE change that will be recorded on this graph if the speed of rotation of the armature decreases. (1)

13.2 State the structural change that must be made to this generator to produce direct current (DC). (2)

13.3 Calculate the maximum/peak voltage (V_{max}) for this generator if the V_{rms} is 140 V. (3)
[6]

QUESTION 14: ELECTRONICS

14.1 Draw the symbol for a light-emitting diode. (1)

14.2 A laptop computer which operates at 18 V is connected to a 220 V power supply.

14.2.1 Which type of transformer is required in the laptop, for the computer to function as specified? (1)

14.2.2 The current in the secondary coil of the transformer is 2,8 A.

Calculate the current in the transformer's primary circuit. Assume that the transformer is 100 % efficient. (3)
[5]

TOTAL SECTION B: 115
GRAND TOTAL: 150

DATA FOR NC(V) PHYSICAL SCIENCE LEVEL 4
PAPER 1 (PHYSICS)

GEGEWENS VIR NC(V) WETENSKAP VLAK 4
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 $m \cdot s^{-2}$
Speed of light in a vacuum *Spoed van lig in 'n vakuum*	c	$3,0 \times 10^{8}$ $m \cdot s^{-1}$
Plank's constant *Planck se konstante*	h	$6,63 \times 10^{-34}$ J·s
Coulomb's constant *Coulomb se konstante*	k	$9,0 \times 10^{9}$ $N \cdot m^{2} \cdot C^{-2}$
Charge on electron *Lading op elektron*	e	$-1,6 \times 10^{-19}$ C
Electron mass *Elektronmassa*	m_e	$9,11 \times 10^{-31}$ kg
Permittivity of free space *Permittiwiteit van vry ruimte*	ε_o	$8,85 \times 10^{-12}$ $F \cdot m^{-1}$

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/*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*

$F_{net} = ma$	$p = mv$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$W = mg$

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

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

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* $E = \frac{hc}{\lambda}$
$E = W_o + E_{k(max)}$ or/*of* $E = W_o + K_{max}$ where/*waar* $E = hf$ and/*en* $W_o = hf_o$ and/*en* $E_{k(max)} = \frac{1}{2}mv_{max}^2$ or/*of* $K_{max} = \frac{1}{2}mv_{max}^2$	

ELECTRICITY AND ELECTRONICS/*ELEKTRISITEIT EN ELEKTRONIKA*

$R = \frac{V}{I}$	$\text{emf}(\varepsilon) = I\,(R + r)$ $\text{emk}(\varepsilon) = I\,(R + r)$
$R_s = R_1 + R_2 + \ldots$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + ..$	$q = I\Delta t$
$W = Vq$ $W = VI\Delta t$ $W = I^2R\Delta t$ $W = \frac{V^2\Delta t}{R}$	$P = \frac{W}{\Delta t}$ $P = VI$ $P = I^2R$ $P = \frac{V^2}{R}$
$\frac{V_p}{V_s} = \frac{N_p}{N_s}$ and/*en* $\frac{N_p}{N_s} = \frac{I_s}{I_p}$	
$C = \frac{Q}{V}$	$C = \epsilon_o \frac{A}{d}$
$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ / $I_{wgk} = \frac{I_{maks}}{\sqrt{2}}$ $V_{rms} = \frac{V_{max}}{\sqrt{2}}$ / $V_{wgk} = \frac{V_{maks}}{\sqrt{2}}$	$P_{ave} = V_{rms}I_{rms}$ / $P_{gemiddeld} = V_{wgk}I_{wgk}$ $P_{ave} = I^2{}_{rms}R$ / $P_{gemiddeld} = I^2{}_{wgk}R$ $P_{ave} = \frac{V^2_{rms}}{R}$ / $P_{gemiddeld} = \frac{V^2_{wgk}}{R}$

ANSWER SHEET

EXAMINATION NUMBER: | | | | | | | | | | | | |

CENTRE NUMBER: | | | | | | | | | | |

Carefully tear off this page and place it inside the front cover of the ANSWER BOOK.