education

Department of Education
FREE STATE PROVINCE

EXAMINATION

GRADE 12

PHYSICAL SCIENCES

PHYSICS (PAPER ONE)

JUNE 2026

MARKS: 150

TIME: 3 HOURS

This paper consists of 14 pages and three information sheets.

INSTRUCTIONS AND INFORMATION

1. Write your name and other information in the appropriate spaces on the ANSWER BOOK.
2. This question paper consists of EIGHT questions. Answer ALL 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 sub-questions, for example between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable pocket 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 where applicable.
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 down only the letter A, B, C or D next to the question number (1.1–1.10) in your ANSWER BOOK.

1.1 Which ONE of the following is FALSE about the action-reaction pair of forces?

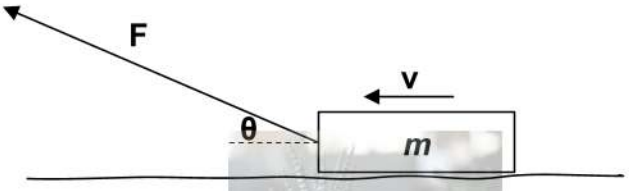
A They act on different objects.

B They have equal magnitudes.

C They act in the same direction.

D They cannot cancel each other. (2)

1.2 The diagram below shows a box of mass ***m*** being pulled at CONSTANT VELOCITY ***v*** to the left by force ***F*** acting at the angle ***θ*** to the horizontal. The surface is *rough*.



This means that for the box, the …

A kinetic frictional force is equal to the vertical component of force ***F*** to the right.

B kinetic frictional force is equal to the horizontal component of force ***F*** to the left.

C static frictional force is equal to the horizontal component of force ***F*** to the right.

D kinetic frictional force is equal to the horizontal component of force ***F*** to the right. (2)

1.3 Consider the equation $\Delta y = v_i\Delta t + \underline{\frac{1}{2}a\Delta t^2}$.

For an object starting from rest, which VECTOR quantity is represented by the underlined part of the equation?

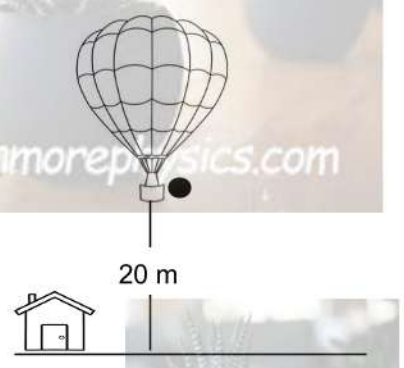
A Displacement.

B Acceleration.

C Distance.

D Velocity. (2)

1.4 A hot-air balloon is rising vertically upward at a constant velocity of 5 $m\cdot s^{-1}$. When the hot-air balloon is 20 m above the ground, the ball is dropped and the hot-air ballon continues to rise at the same constant velocity. Ignore the effects of air friction.



Acceleration of the hot-air ballon is … $m\cdot s^{-2}$.

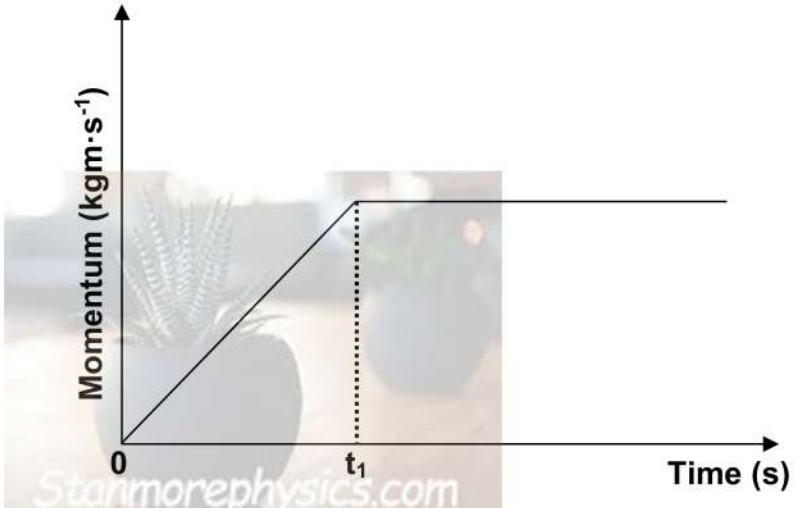
A + 9,8

B - 9,8

C + 5

D 0 (2)

1.5 The graph below shows the changes in momentum of an object over time.



The gradient of the graph between times 0 to t_1 is equal to the …

A impulse.

B net force.

C kinetic energy.

D change in momentum. (2)

1.6 The truck is moving down the steep and suddenly the brakes fail. The driver then moves the truck to the horizontal arrestor bed. Which one of the following quantities decreases as the truck enters the arrestor bed?

A time

B weight

C kinetic energy

D gravitational potential energy (2)

1.7 The force for which the work done in moving an object between two points is dependent of the path taken is ...

A normal force.

B gravitational force.

C conservative force.

D non-conservative force. (2)

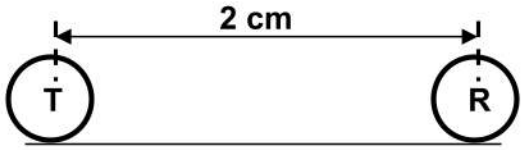
1.8 A crate slides through a *smooth* path **AB** and then enters a *rough* path **BC**. Refer to the diagram below.

Which ONE of the following combinations is CORRECT about the kinetic energy (**K**) of the crate at points **B** and **C** respectively in comparison to the kinetic energy (K_A) of the crate at point **A**?

	At point B.	At point C.
A	K_A is equal to K_B	K_A is equal to K_C
B	K_A is equal to K_B	K_A is greater than K_C
C	K_A is greater than K_B	K_A is less than K_C
D	K_A is less than K_B	K_A is greater than K_C

(2)

1.9 Two metal spheres **T** and **R** with charges ***-2q*** and ***+q*** respectively are placed 2 cm away from each other on an insulated surface as shown below.



The spheres are allowed to make contact and are returned to their original positions.

Consider the following statements regarding the two metal spheres AFTER they made contact and were returned to their original positions:

i) They have equal magnitude of charges.

ii) Each metal sphere still has the original magnitude of charge they had before they made contact.

iii) The electrostatic force they exert on each other is smaller than the electrostatic force they exerted on each other before they made contact.

Which of the above statement(s) is/are CORRECT?

A i) and iii) only

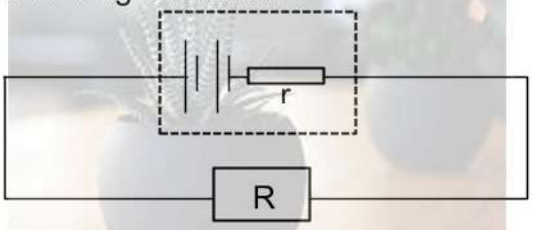
B ii) and iii) only

C i); ii) and iii)

D i) only

(2)

1.10 A battery with internal resistance *r* is connected to one external resistor *R* as shown in the circuit diagram below.



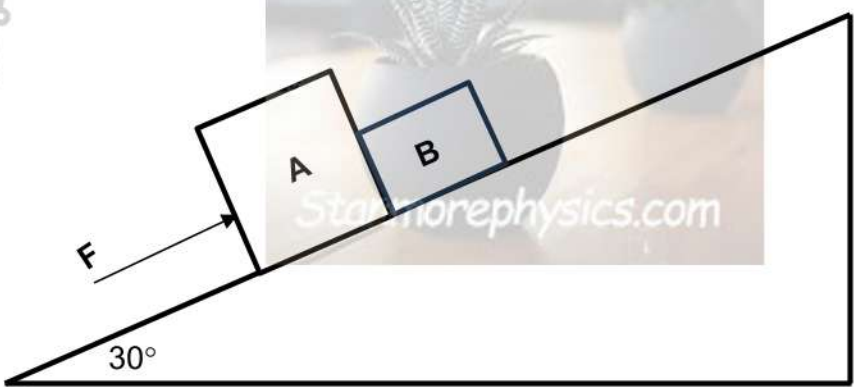
If *R* is **halved**, the energy dissipated inside the battery due to internal resistance will …

A remain the same.
B decrease.
C increase.
D be zero. (2)

[20]

QUESTION 2

Two blocks, **A** and **B** of mass 6 kg and 3 kg respectively are in contact with each other on an inclined plane as shown below.



Force, **F**, applied parallel to the incline, causes the blocks to accelerate up an incline at 2 $m \cdot s^{-2}$.

2.1 Define the term *normal force*. (2)

The magnitude of the kinetic frictional force acting on blocks **A** and **B** is 6,8 N and 3,4 N respectively.

2.2 Draw a labelled free body diagram showing ALL the forces acting on block **B** as it moves up the inclined plane. (4)

2.3 Calculate the magnitude of:

2.3.1 the normal force on block **A**. (2)

2.3.2 force **F** as the system moves up the inclined plane. (5)

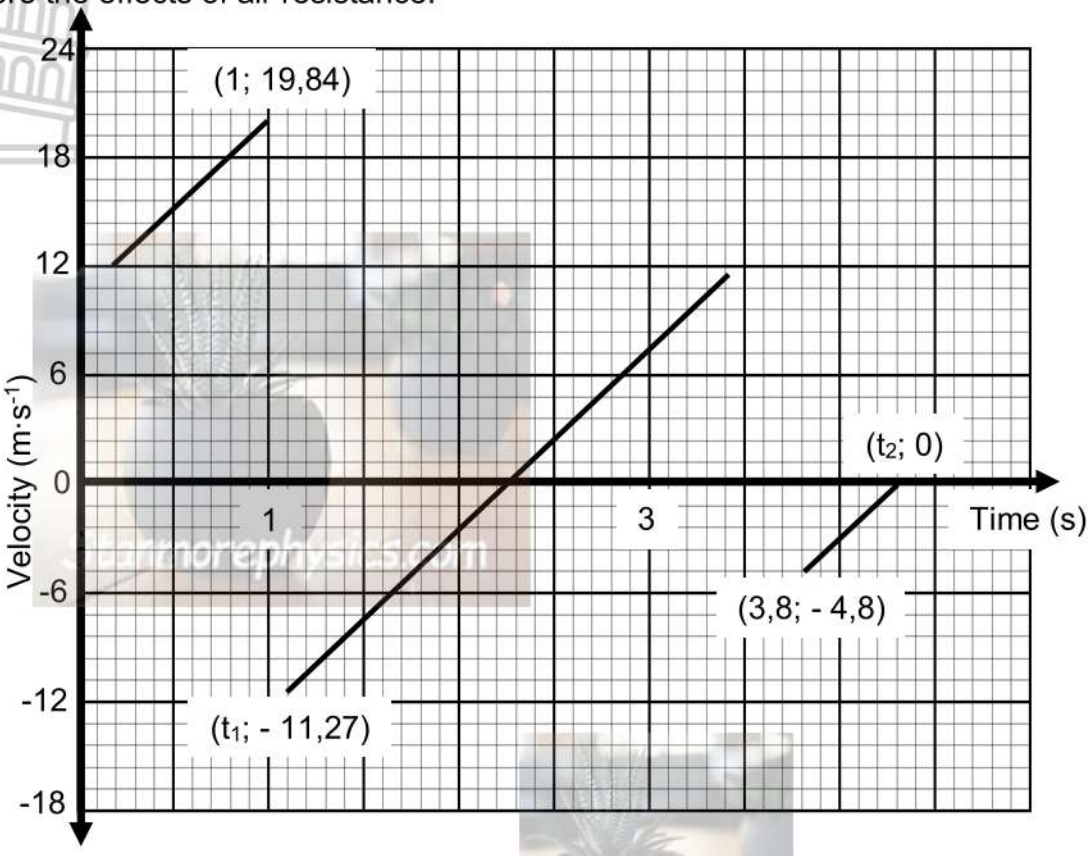
2.4 The angle between the incline and the horizontal is changed to 20°.

2.4.1 How will this change affect the magnitude of the kinetic frictional force on block **B**? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

2.4.2 Explain the answer to question 2.4.1. (2)
[16]

QUESTION 3

A learner studies the motion of a ball and draws a velocity time graph as shown below. She drew it FEW MOMENTS AFTER a ball was projected from a high platform. The ball has a mass of 450 g and bounced several times.
Ignore the effects of air resistance.



3.1 Define the term *projectile*. (2)

3.2 Was the ball initially projected UPWARDS or DOWNWARDS?
Give a reason for the answer. (3)

3.3 Determine the magnitude of initial velocity of the ball. (2)

3.4 For the first bounce, calculate the:

3.4.1 impulse on the ball. (3)

3.4.2 loss of kinetic energy of the ball. (5)

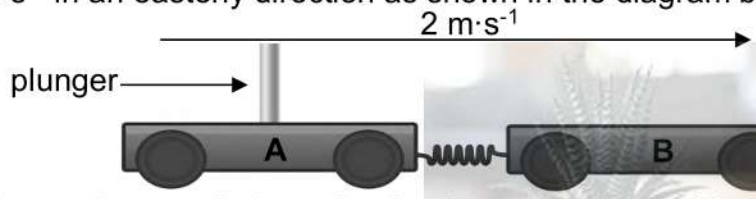
3.5 USING THE EQUATIONS OF MOTION ONLY, calculate the maximum height reached by the ball after the second bounce. (4)

3.6 Draw the position time graph showing the motion of the ball from 0 s to t_2. Take GROUND as reference position and show the maximum height reached by the ball after the second bounce. (4)

[23]

QUESTION 4

The two trolleys **A** and **B** with masses 50 g and 20 g respectively are joined together by a compressed spring. The trolleys are moving on a *smooth surface* with the speed of 2 m·s^{-1} in an easterly direction as shown in the diagram below.



When the plunger is tapped, the spring is released and sound is produced. Trolley **B** then continues to move eastwards with the velocity of 10 m·s^{-1}.

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

4.2 Is the explosion taking place during the separation of the trolleys elastic or inelastic? Give the reason for the answer. (2)

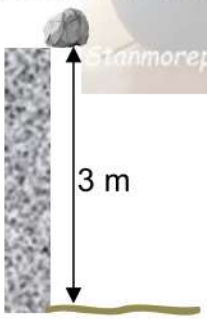
4.3 Calculate the:

4.3.1 velocity of trolley **A** after the spring has been released (4)

4.3.2 change in momentum of trolley **A.** (3)

4.4 Write down the DIRECTION of the change in momentum of trolley **B**. (1)

4.5 A rock of mass 2,5 kg is *dropped* from the top of a 3 m high building. Refer to diagram below.



After reaching the *sand* ground, the rock does not bounce up and takes 0,3 s to come to rest on the ground. Ignore effects of any form friction.

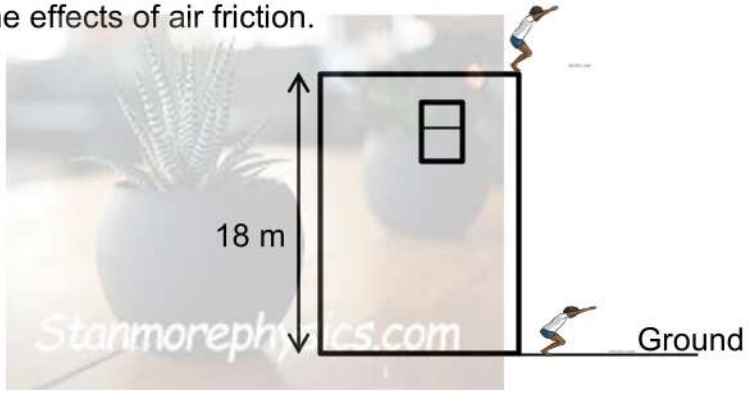
4.5.1 While the rock is falling, the Earth is NOT exerting a force on the rock.
Is the above statement TRUE or FALSE? (1)

4.5.2 Calculate the net force exerted on the rock while in contact with the ground. (6)

[19]

QUESTION 5

5.1 The diagram below shows a man with a mass of 75 kg standing on top of a building that is 18 m high. The man jumps to the ground.
Ignore the effects of air friction.



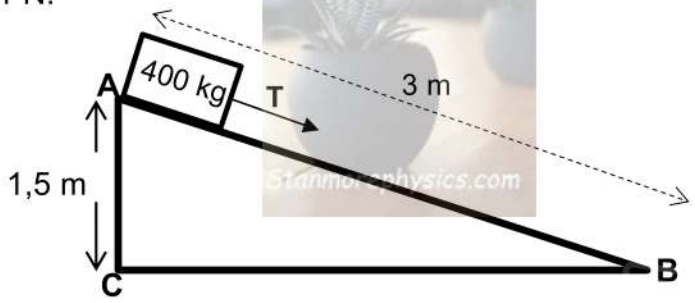
5.1.1 State the *principle of conservation of mechanical energy* in words. (2)

5.1.2 Calculate the speed of a man as he lands on the ground. (4)

The man bends his knees as he lands on the ground.

5.1.3 Give a reason for this action referring to a relevant law of physics. (3)

5.2 The simplified diagram below shows a slide **ABC** at the playground with the sides as shown. The box of mass 400 kg is pulled down the slide **AB** (3 m) from rest at post **A**, all the way to point **B** by tension **T** of magnitude 200 N. The kinetic frictional force experienced by box as it moves from **A** to **B** is 848,71 N.



5.2.1 State the *work-energy theorem*. (2)

5.2.2 Draw a *free-body* diagram showing *only* the conservative force acting on the box as it slides from **A** to **B**. (1)

5.2.3 Using *energy principles only*, calculate the speed of the box when it reaches point **B**. (6)

5.2.4 Calculate the *average power* delivered by tension **T** to move the box from point **A** to **B**. (4)

5.2.5 How would the work done by weight on the box compare if the box takes path **AC** instead of path **AB** to get to the ground?
Write down only GREATER THAN, SMALLER THAN or EQUAL TO. (1)

[23]

QUESTION 6

An ambulance emits sound waves of wavelength 0,50 m. An observer *standing* on the side of the road records sound waves with a wavelength that is 10% longer than the wavelength of the emitted sound. Take the speed of sound in air as 340 $m \cdot s^{-1}$.

6.1 State *Doppler effect* in words. (2)

6.2 Is the ambulance moving TOWARDS or AWAY from the observer? Explain the answer. (2)

6.3 Calculate the:

6.3.1 Frequency of the sound emitted by the ambulance. (3)

6.3.2 The magnitude of the velocity of the ambulance. (5)

6.4 Two diagrams below represent spectral lines of an element.

Diagram 1 represents the spectrum of the same element in the laboratory on Earth.

Diagram 2 represents the spectrum of the same element from a distant star.

Diagram 1

Diagram 2

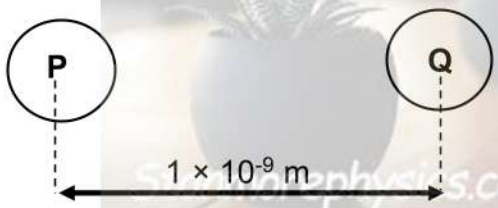
6.4.1 From the observation made in the two diagrams, can it be concluded that the universe is expanding? Write down YES or NO. (1)

6.4.2 Explain the answer to question 6.4.1. (3)

[16]

QUESTION 7

Two charges **P** and **Q** with magnitudes -3 nC and -3 nC exert an electrostatic force (F_e) on each other. There is gravitational force (F_g) that exist between the centres of the two charges. The distance between the centres of the two charges is 1×10^{-9} m.



7.1 Is the gravitational force, F_g, between the two charges, force of ATTRACTION or REPULSION?
Name the law of physics you used to justify the answer. (2)

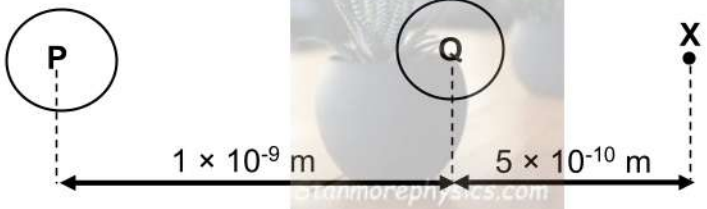
7.2 State *Coulomb's law* in words. (2)

7.3 In which direction (LEFT or RIGHT) is the electrostatic force experienced by charge **P** due to charge **Q**? (1)

7.4 Draw the resultant electric field pattern due to charges **P** and **Q**. (3)

7.5 Calculate the:

7.5.1 magnitude of the electrostatic force, F_e, between **P** and **Q**. (3)

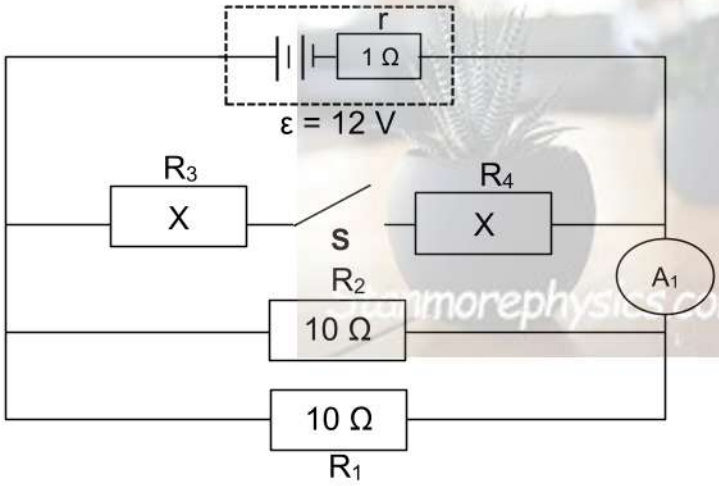


7.5.2 electric field strength due to charge **P** at point **X** which is 5×10^{-10} m to right of charge **Q**. (4)

[15]

QUESTION 8

The diagram below shows a circuit with a battery of emf 12 V, an internal resistance of 1 Ω and external resistors R_1 = 10 Ω, R_2 = 10 Ω, R_3 and R_4 with the same resistance X.



8.1 Write down *Ohm's law* in words. (2)

8.2 Will there be a reading on ammeter A_1 with switch **S** open? Explain the answer. (2)

8.3 Switch **S** is now **closed.** The *total external resistance* of the circuit is 2,2222 Ω.

8.3.1 Will the battery become HOTTER or COLDER. (1)

8.3.2 Calculate the:

(a) resistance of resistor R_4. (4)

(b) reading on ammeter A_1. (6)

A 2 kW electric heater is used in a household. The heater is switched on for 3 hours per day during June month. The cost of electricity from the municipality is R 4,45 per kilowatt-hour (kWh).

8.4 Calculate the total cost of electricity for operating the heater for 30 days. (3)

[18]

GRAND TOTAL: 150

DATA FOR PHYSICAL SCIENCES
GRADE 12 PAPER 1 (PHYSICS)

GEGEWENS VIR FISIESE WETENSKAPPE
GRAAD 12VRAESTEL 1 (FISIKA)

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

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

$F_{net} = ma$	$p = mv$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = G\frac{m_1 m_2}{d^2}$ 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* $E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta K$ 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* $W_{nc} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{ave} = Fv_{ave}$ / $P_{gemid} = Fv_{gemid}$	

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

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

ELECTROSTATICS/*ELEKTROSTATIKA*

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

ELECTRIC CIRCUITS/*ELEKTRIESE STROOMBANE*

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

ALTERNATING CURRENT/*WISSELSTROOM*

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

education

Department of Education
FREE STATE PROVINCE

EXAMINATION/*EKSAMEN*

GRADE/GRAAD 12

PHYSICAL SCIENCES/ *FISIESE WETENSKAPPE*

PHYSICS (PAPER ONE)/ *FISIKA (PAPIER EEN)*

JUNE/*JUNIE* 2026

MARKS/*PUNTE*: 150

UPDATED MARKING GUIDELINE/ *OPGEDATEER MERKRIGLYNE*

Notes/*Aantekeninge*:
Questions/*Vrae* - 2.3.2, 2.4.2, 3.1, 5.1.2(removed/*verwyder*), 5.2.5, 6.3.2, 7.5.2.

This paper consists of 14 pages/
Hierdie dokument bestaan uit 14 bladsye

QUESTION/VRAAG 1

1.1 C ✓✓

1.2 D ✓✓

1.3 A ✓✓

1.4 D ✓✓

1.5 B ✓✓

1.6 C ✓✓

1.7 D ✓✓

1.8 B ✓✓

1.9 A ✓✓

1.10 C ✓✓

[20]

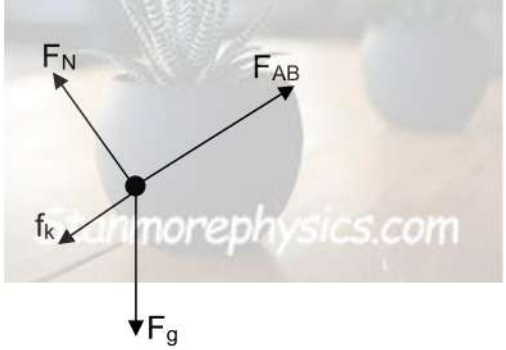
QUESTION/*VRAAG* 2

2.1

Marking Criteria / *Merk kriteria*:
-1 mark for each key word/phrase omitted in the correct context.
-1 punt vir elke sleutel woord/frase in die korrekte konteks weggelaat.

The force or the component of a force which a surface exerts on an object with which it is in contact, and which is perpendicular to the surface. ✓✓ (2)
Die krag of komponent van 'n krag wat 'n oppervlak op 'n voorwerp waarmee dit in kontak is, uitoefen en wat loodreg op die oppervlak is.

2.2



(4)

Accept the following symbols./*Aanvaar die volgende simbole*:	
F_N ✓	N / Normal / *Normaal* / Normal force / *Normaalkrag*
f_k ✓	F_f / f / f_r / / F_w / frictional force/*wrywingskrag*/kinetic frictional force / *kinetiese wrywingskrag*
F_g ✓	w / mg / weight / $F_{Earth\ on\ B}$ / 29,4 N / gravitational force / gewig / $F_{aarde\ op\ B}$ / gravitasiekrag
F_{AB} ✓	F / F_A / Applied force / *Toegepaste krag* / F_T

Notes/Aantekeninge:
- Mark awarded for label and arrow./*Punt toegeken vir byskrif en pyltjie.*
- Do not penalise for length of arrows since drawing is not to scale./*Moenie vir die lengte van die pyltjies penaliseer nie aangesien die tekening nie volgens skaal is nie.*
- Any other additional force(s)/*Enige ander addisionele krag(te)*: Max/*Maks* 3/4

2.3.1 $N = F_{g\perp}$
$N = mg\cos\theta$
$N = \underline{6\times9,8\times\cos30°}$ ✓
$N = 50,92$ N ✓ (2)

2.3.2

Option 1/ Opsie 1- Up the incline/Op teen die helling: + ve

For block B/*Vir blok B*

$F_{net} = ma$
$F_{AB} + f_k + F_{g//} = ma$
$F_{AB} - 3{,}4 - 3\times9{,}8\sin30° \checkmark = 3\times2$
$F_{AB} = 24{,}1$ N

$F_{AB} = - F_{BA}$

✓Any one/*Enige een*

✓Both/ *Albei*

For block A/Vir blok A

$F_{net} = ma$
$F + f_k + F_{g//} + F_{BA} = ma$
$F - 6{,}8 - 6\times9{,}8\sin30° - 24{,}1\checkmark = 6\times2$
$F = 72{,}3$ N ✓

Option 2/ Opsie 2- Up the incline/Op teen die helling: - ve

For block B/*Vir blok B*

$F_{net} = ma$
$F_{AB} + f_k + F_{g//} = ma$
$F_{AB} + 3{,}4 + 3\times9{,}8\sin30° \checkmark = 3\times-2$
$F_{AB} = - 24{,}1$ N

$F_{AB} = - F_{BA}$

✓Any one/*Enige een*

✓Both/ Albei

For block A/Vir blok A

$F_{net} = ma$
$F + f_k + F_{g//} + F_{BA} = ma$
$F + 6{,}8 + 6\times9{,}8\sin30° + 24{,}1\checkmark = 6\times-2$
$F = - 72{,}3$ N
$F = 72{,}3$ N ✓ (5)

NOTE/*LET WEL*
- If one system of blocks (sum of masses and frictions), then give 2/6 max. (correct formula and answer)
- *As een stelsel van blokke (som van massas en wrywings), gee dan 2/6 maks. (korrekte formule en antwoord)*

2.4.1 INCREASES/*TOENEEM*✓ (1)

2.4.2 - If the angle of the inclination decreases, $F_{g\perp}$ increases✓given $F_{g\perp}=mg\cos\theta$.
- Given $N = F_{g\perp}$, if $F_{g\perp}$ increases then N also increases.✓
- According to $f_k = \mu_k N$ for constant μ_k, ✓ if N increases then f_k also increases. (3)
- *As die hellingshoek afneem, $F_{g\perp}$ toeneem gegewe $F_{g\perp}=mg\cos\theta$.*
- *Gegewe $N = F_{g\perp}$, as $F_{g\perp}$ toeneem, neem N ook toe.*
- *Volgens $f_k = \mu_k N$ vir konstante μ_k, as N toeneem, dan neem f_k ook toe.*

[17]

QUESTION/*VRAAG* 3

3.1 An object which has been given an initial velocity and then it moves under the influence of the gravitational force only.✓✓
'n voorwerp waaraan 'n beginsnelheid gegee is en wat dan slegs onder die invloed van die gravitasiekrag beweeg. (2/0)

3.2 DOWNWARDS✓, Velocity increases✓✓ (3)
AFWAARTS, Snelheid neem toe

3.3

Option/*Opsie* 1

Gradient/Gradiënt = $\frac{\Delta v}{\Delta t}$

$9,8 = \frac{19,84 - v_i}{1 - 0}$ ✓

$v_i = 10,04\ m\cdot s^{-1}$✓

Option/*Opsie* 2

$v_f = v_i + a\Delta t$
$19,84 = v_i + 9,8\times 1$✓
$v_i = 10,04\ m\cdot s^{-1}$✓

Option/*Opsie* 3

Extrapolating from the graph/ Ekstrapolasie vanaf die grafie
$v_i = 10,04\ m\cdot s^{-1}$✓✓ **(10,00 to 10,06)**

(2)

3.4.1 **Option 1/ Opsie 1: down/*af* +ve**

Impulse/*Impuls* = $F_{net}\Delta t$
= Δp
= $m(v_f - v_i)$
✓Any one/*Enige een*
= $\underline{0,45(-11,27 - 19,84)}$✓
= - 14 N·s
Impulse/*Impuls*= 14 N·s upwards/*opwaarts*✓

Option 2/ Opsie 2: down/*af* -ve

Impulse/*Impuls* = $F_{net}\Delta t$
= Δp
= $m(v_f - v_i)$
✓Any one/*Enige een*
= $\underline{0,45(11,27 - (-19,84))}$✓
= 14 N·s
Impulse/*Impuls*= 14 N·s upwards/*opwaarts*✓

(3)

3.4.2

Marking Criteria/*Nasienkriteria*:

- Correct formula for/*Korrekte formule vir* E_{Ki}/ E_{Kf} ✓
- Correct substitution to calculate E_{Ki} ✓
  Korrekte substitusie om E_{Ki} *te bereken*
- Correct substitution to calculate E_{Kf} ✓
  Korrekte substitusie om E_{Kf} *te bereken*
- Correct calculation for/*Korrekte berekening vir* $E_{Klost/verlore}$ ✓
- Correct final answer./*Korrekte finale antwoord.* ✓

$E_{K(before/voor)} = \frac{1}{2}mv_i^2$ ✓
$= \frac{1}{2}(0,45)(19,84)^2$ ✓
$= 88,56576$ J

$E_{K(after/na)} = \frac{1}{2}mv_f^2$
$= \frac{1}{2}(0,45)(-11,27)^2$ ✓
$= 28,5779025$ J

$E_{K(lost)} = E_{K(before/voor)} - E_{K(after/na)}$
$= 88,56576 \text{ J} - 28,5779025 \text{ J}$ ✓
$= 60$ J

$E_{K(lost)} = 60$ J (lost/verlore) ✓

(5)

3.5

Marking Criteria / *Nasienriglyn*:
- Correct formula for calculating Δy / *korrekte formule om Δy te bereken* ✓
- Correct substitution in the formula / korrekte vervanging in formule ✓✓
- Final answer with correct SI unit /*Finale antwoord met korrekte SI eenheid* ✓
- **RANGE (1,1 m – 1,2 m)**

Option/*Opsie* 1: down/*af* +ve

$v_f^2 = v_i^2 + 2a\Delta y$✓
0✓$= (-4,8)^2 + 2\times 9,8\Delta y$✓
$\Delta y = -1,18$ m
∴height/*hoogte* = 1,18 m✓

Option/*Opsie* 2: down/*af* -ve

$v_f^2 = v_i^2 + 2a\Delta y$✓
0✓$= (4,8)^2 + 2\times(-9,8)\Delta y$✓
$\Delta y = 1,18$ m
∴height/*hoogte* = 1,18 m✓

Option/*Opsie* 3: down/*af* +ve

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓
$\Delta y = -4,8\times(4,3 - 3,8)$✓ $+\frac{1}{2}\times 9,8\times(4,3 - 3,8)^2$✓
$\Delta y = -1,18$m
∴height/*hoogte* = 1,18 m✓

Option/*Opsie* 4: down/*af* -ve

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓
$\Delta y = 4,8\times(4,3 - 3,8)$✓ $+\frac{1}{2}\times -9,8\times(4,3 - 3,8)^2$✓
$\Delta y = 1,18$m
∴height/*hoogte* = 1,18 m✓

Option/*Opsie* 5: down/*af* +ve

$\Delta y = \frac{(v_i + v_f)}{2}\Delta t$✓
$\Delta y = \frac{(-4,8 + 0)}{2}$✓$\times(4,3 - 3,8)$✓
$\Delta y = -1,2$ m
∴height/*hoogte* = 1,2 m✓

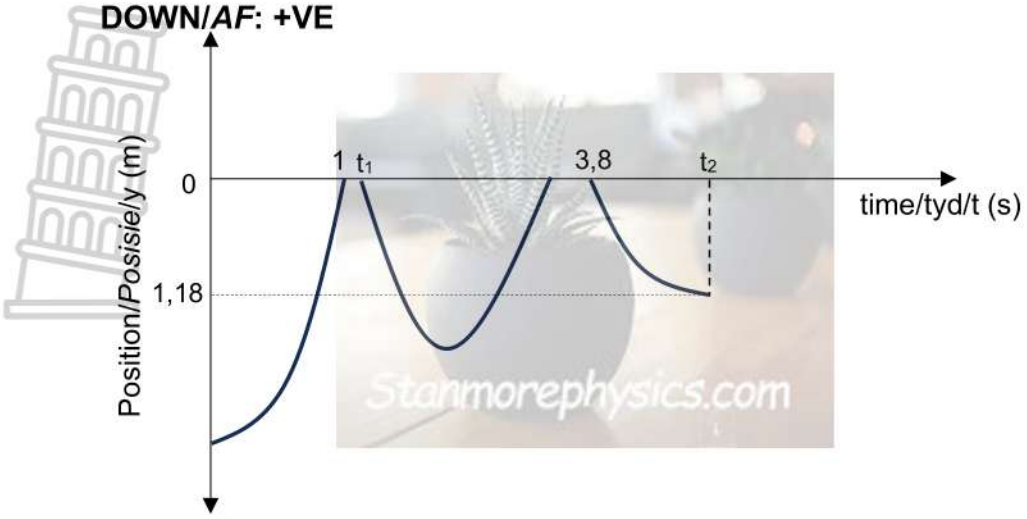
Option/*Opsie* 6: down/*af* -ve

$\Delta y = \frac{(v_i + v_f)}{2}\Delta t$✓
$\Delta y = \frac{(4,8 + 0)}{2}$✓$\times(4,3 - 3,8)$✓
$\Delta y = 1,2$ m
∴height/*hoogte* = 1,2 m✓

(4)

3.6 **POSITIVE MARKING FROM 3.5/*POSITIEF NASIEN VAN 3.5***

DOWN/*AF*: +VE



(4)

Marking Criteria/*Nasienkriteria*:	
• Correct labels and units for both position and time axes. *Korrekte byskrifte en eenhede vir beide posisie- en tyd asse.*	✓
• Correct shape from 0 to t_1 s. *Korrekte vorm vanaf 0 tot t_1 s.*	✓
• Two maximum heights from t_1 s to t_2 with decreasing magnitudes. *Twee maksimum hoogtes van t_1 s tot t_2 met afnemende groote.*	✓
• Correct second maximum 1,18 m indicated. (POSITIVE MARKING FROM 4.5). *Korrek sekonde maksimum 1,18 m aangedui.* *(POSITIEWE NASIEN VANAF 4.5).*	✓
NOTES/ NOTAS: • Up taken as positive: (maximum marks $^3/_4$). *Op as positief geneem: (maksimum punte $^3/_4$).* • Ground NOT taken as reference (maximum marks $^3/_4$). *Grond NIE as verwysing geneem nie (maksimum punte $^3/_4$).* If both notes are applicable (maximum marks $^2/_4$). *Indien beide notas van toepassing is (maksimum punte $^2/_4$).*	

[23]

QUESTION/*VRAAG* 4

4.1. The total linear momentum ofan isolated system remains constant (is conserved).✓✓ (2/0)
Die totale lineêre momentum in 'n geïsoleerde sisteem bly konstant (behoue).

4.2 Inelastic ✓, energy is lost in the form of sound.✓ (2)
Onelastiese, energie gaan verlore in die vorm van klank.

4.3.1

Option 1/*Opsie 1*: east/*oos* +ve

$\Sigma p_i = \Sigma p_f$✓
$(0,05 + 0,02)\times 2$✓ $= 0,05 \times v_{fA} + 0,02\times 10$✓
$v_{fA} = -1,2\ m\cdot s^{-1}$
$v_{fA} = 1,2\ m\cdot s^{-1}$ west/*wes*✓

Option 2/*Opsie 2*: east/*oos* -ve

$\Sigma p_i = \Sigma p_f$✓
$(0,05 + 0,02)\times -2$✓ $= 0,05 \times v_{fA} + 0,02\times -10$✓
$v_{fA} = 1,2\ m\cdot s^{-1}$
$v_{fA} = 1,2\ m\cdot s^{-1}$ west/*wes*✓

(4)

4.3.2 **POSITIVE MARKING FROM 4.3.1/*POSITIEF NASIEN VAN 4.3.1***

Option 1/*Opsie 1*: east/*oos* +ve	**Option 2/*Opsie 2*: east/*oos* -ve**
$\Delta p = m(v_f - v_i)$✓ $= 0,05\times(-1,2 - 2)$✓ $= -0,16\ kgm\cdot s^{-1}$ $\Delta p = 0,16\ kgm\cdot s^{-1}$ west/*wes*✓	$\Delta p = m(v_f - v_i)$✓ $= 0,05\times(-1,2 - (-2))$✓ $= 0,16\ kgm\cdot s^{-1}$ $\Delta p = 0,16\ kgm\cdot s^{-1}$ west/*wes*✓

(3)

4.4 **POSITIVE MARKING FROM 4.3.2/*POSITIEF NASIEN VAN 4.3.2***
East/*Oos*.✓ (1)

4.5.1 FALSE/*VALS*✓ (1)

4.5.2

Option 1/ Opsie 1: down/*af* +ve

$v_f^2 = v_i^2 + 2a\Delta y$
$v_f^2 = (0)^2 + 2\times 9,8\times 3$✓
$v_f = 7,668\ m\cdot s^{-1}$
$F_{net}\Delta t = \Delta p$✓
$F_{net}\times 0,3$ ✓$= 2,5\ (0 - 7,668)$✓
$F_{net} = -63,9\ N$
$F_{net} = 63,9\ N$✓ upwards/*opwaarts*✓

Option 2/ Opsie 2: down/*af* -ve

$v_f^2 = v_i^2 + 2a\Delta y$
$v_f^2 = (0)^2 + 2\times -9,8\times -3$✓
$v_f = -7,668\ m\cdot s^{-1}$
$F_{net}\Delta t = \Delta p$✓
$F_{net}\times 0,3$ ✓$= 2,5\ (0 - (-7,668))$✓
$F_{net} = 63,9\ N$✓ upwards/*opwaarts*✓

(6)
[19]

QUESTION/*VRAAG* 5

5.1.1 The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. (2/0)
Die totale meganiese energie (som van gravitasie potensiële energie en kinetiese energie) in 'n geslote sisteem bly konstant.

5.1.2 REMOVED/*VERWYDER*

5.1.3 - Bending the knees increase the (contact) time/ time/Δt to come to rest.✓
- According to $F_{net} = \frac{\Delta p}{\Delta t}$, for constant Δp✓, if Δt increases then F_{net} decreases. ✓
- The chances of serious injuries are then reduced. (3)
- *Deur die knieë te buig, verhoog die (kontak) tyd/tyd/Δt om tot rus te kom.*
- *Volgens $F_{net} = \frac{\Delta p}{\Delta t}$ vir konstante Δp, as Δt toeneem, neem F_{net} af.*
- *Die kanse op ernstige beserings word dan verminder.*

5.2.1

Marking Criteria / *Merk kriteria*:
-1 mark for each key word/phrase omitted in the correct context.
-1 punt vir elke sleutel woord/frase in die korrekte konteks weggelaat.

The net work done on an object is equal to the change in object's change in kinetic energy OR the work done on an object by a net force is equal to the change in the object's kinetic energy.✓✓ (2)
Die netto arbeid verrig op 'n voorwerp is gelyk aan die verandering in kinetiese energie van die voorwerp OF die arbeid verrig op die voorwerp deur 'n netto krag is gelyk aan die verandering in kinetiese energie van die voorwerp.

5.2.2

F_g/w/3920 N (1)

5.2.3 **OPTION/*OPSIE* 1**

$W_{net} = \Delta K$ ✓

$W_T + W_f + W_{Fg//} = \frac{1}{2}m(v_B^2 - v_A^2)$

$200\times3\cos0^\circ + 848,71\times3\cos180^\circ + 400\times9,8\times\frac{1,5}{3}\times3\cos0^\circ = \frac{1}{2}\times400(v_B^2 - 0)$ ✓

$v_B = 4,44\ m\cdot s^{-1}$ ✓

OPTION/*OPSIE* 2

$W_{nc} = \Delta K + \Delta U$ ✓

$W_T + W_f = \frac{1}{2}m(v_B^2 - v_A^2) + mg(h_B+h_A)$

$200\times3\cos0^\circ + 848,71\times3\cos180^\circ = \frac{1}{2}\times400(v_B^2 - 0) + 400\times9,8(0 - 1,5)$ ✓

$v_B = 4,44\ m\cdot s^{-1}$ ✓ (6)

5.2.4 **POSITIVE MARKING FROM 5.2.3 /*POSITIEF NASIEN VAN 5.2.3.***

$P_{ave} = F\cdot v_{ave}$ ✓

$P_{ave} = 200\times(\frac{0 + 4,44}{2})$ ✓

$P_{ave} = 444\ W$ ✓

Accept/*Aanvaar*

$P = \frac{W_T}{\Delta t}$ ✓

$P = \frac{200\times3\cos0^\circ}{1,351351351}$ ✓

$P = 444\ W$ ✓

$\Delta x = (\frac{v_i+v_f}{2})\times\Delta t$

$3 = (\frac{0+4,44}{2})\times\Delta t$

$\Delta t = 1,351351351\ s$ (4)

5.2.5 EQUAL TO/*GELYK AAN* ✓✓ (2)
[20]

QUESTION/*VRAAG* 6

6.1

Marking Criteria / *Merk kriteria*:
-1 mark for each key word/phrase omitted in the correct context.
-1 punt vir elke sleutel woord/frase in die korrekte konteks weggelaat.

The change in frequency of the sound detected by a listener, because the sound source and the listener have different velocities relative to the medium of sound propagation. ✓✓ (2)
Die verandering in frekwensie (of toonhoogte) van die klank waargeneem deur 'n luisteraar omdat die klankbron en die luisteraar verskillende snelhede relatief tot die medium waarin die klank voortgeplant word het.
Accept: The change in frequency/pitch of the sound detected by a listener due to relative motion between the (sound) source and the listener.
Aanvaar: *Die verandering in frekwensie/toonhoogte van die klank waargeneem deur 'n luisteraar as gevolg van relatiewe beweging tussen klankbron en luisteraar.*

6.2 AWAY✓
Observed wavelength is longer than actual wavelength OR
Observed frequency is smaller than the actual frequency.✓ (2)
WEG
Waargenome golflengte is langer as die werklike golflengte OF
Waargenome frekwensie is kleiner as die werklike frekwensie.

6.3.1 $v = f\lambda$ ✓
$340 = f \times 0,5$ ✓
$f = 680$ Hz ✓ (3)

6.3.2 **POSITIVE MARKING FROM 6.3.1/*POSITIEF NASIEN VAN 6.3.1***

$\lambda_L = 0,5 + 0,1 \times 0,5$ ✓
$= 0,55$ m
$v = f\lambda$
$340 = f \times 0,55$ ✓
$f_L = 618,1818182$ Hz

$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ ✓ OR/*OF* $f_L = \frac{v}{v + v_S} f_S$

$618,1818182$ ✓ $= \frac{340}{340 + v_S}$ ✓ $\times 680$ ✓
$v_S = 34$ m·s^{-1} ✓ (7)

6.4.1 YES/*JA*✓ (1)

6.4.2 - Spectral lines are red-shifted/shifted towards the red-end of the spectrum.✓
- Spectral lines shifted towards the end of longer wavelength or smaller frequency.✓
- According to Doppler's effect, if observed frequency decreases, the distant star is moving away.✓
∴ The universe is expanding. (3)
- *Spektrale lyne is na rooi verskuif/verskuif na die rooi einde van die spektrum.*
- *Spektrale lyne verskuif na die einde van langer golflengte of kleiner frekwensie.*
- *Volgens die Doppler-effek, as die waargenome frekwensie afneem, beweeg die veraf ster weg.*
∴*Die heelal is besig om uit te brei.* **[18]**

QUESTION/*VRAAG 7*

7.1 ATTRACTION✓ -ve
Newton's Law of Universal Gravitation✓ (2)
AANTREKKING
Newton se Universele Gravitasiewet

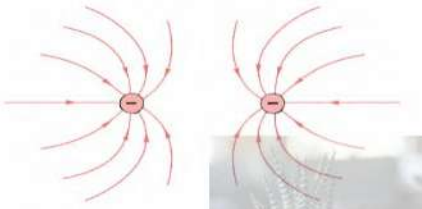
7.2

Marking Criteria / *Merk kriteria*:
-1 mark for each key word/phrase omitted in the correct context.
-1 punt vir elke sleutel woord/frase in die korrekte konteks weggelaat.

The magnitude the electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them.✓✓ (2)
Die grootte van die elektrostatiese krag wat een puntlading op 'n ander puntlading uitoefen, is direk eweredig aan die produk van die groottes van die ladings en omgekeerd eweredig aan die kwadraat van die afstand tussen hulle.

7.3 LEFT/ *LINKS*✓ (1)

7.4



(3)

Marking Criteria / *Merk kriteria*	
Correct direction of the field lines/ *Korrek rigting van die veldlyne*	✓
Field lines do not cross each other and touch the charges/ *Veldlyne kruis mekaar nie en raak nie aan die ladings nie*	✓
Correct shape/ *Korrek vorm*	✓

7.5.1
$$F_e = \frac{kQ_1Q_2}{r^2}\checkmark$$
$$= \frac{9\times10^{9} \times 3\times10^{-9} \times 3\times10^{-9}}{(1\times10^{-9})^2}\checkmark$$
$$= 8{,}1\times10^{10}\text{N}\checkmark$$ (3)

7.5.2
$$E_P = \frac{kQ_P}{r^2}\checkmark$$
$$= \frac{9\times10^{9} \times 3\times10^{-9}}{(1\times10^{-9} + 5\times10^{-10})^2}\checkmark\checkmark$$
$$= 1{,}2\times10^{19}\text{N}\cdot\text{C}^{-1}\text{ left/}\textit{links}\checkmark$$ (4)
[15]

QUESTION/*VRAAG* 8

8.1 The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature. (2/0)
Die potensiaalverskil oor 'n geleier is direk eweredig aan die stroom in die geleier by konstante temperatuur.

8.2 Yes✓, there is a complete closed circuit with the battery allowing current to pass through A_1.✓ (2)
Ja, daar is 'n volledig geslote stroombaan met die battery wat stroom deur A_1 laat vloei.

8.3.1 HOTTER/*WARMTER*✓ (1)

8.3.2 a)

$$\frac{1}{R_{p/ext}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \checkmark$$

$$\frac{1}{2,222} \checkmark = \frac{1}{10} + \frac{1}{10} + \frac{1}{2X} \checkmark$$

$$\frac{1}{2X} = \frac{1}{4}$$

$$\therefore X/R_4 = 2\ \Omega \checkmark$$

(4)

b)

$$\varepsilon = I(R+r) \checkmark$$

$$12 = I(2,2222+1) \checkmark$$

$$I_T = 3,724\ A$$

OPTION/*OPSIE* 1

Calculate /*Bereken* $V_{ext/ekt}$

$$R = \frac{V}{I}$$

$$2,2222 = \frac{V}{3,724} \checkmark$$

$$V = 8,275\ V$$

Current through R_1/R_2
Stroom deur R_1/R_2

$$R = \frac{V}{I}$$

$$10 = \frac{8,275}{I} \checkmark$$

$$I = 0,8275\ A$$

Calculate A_1 reading
Bereken A_1 lesing

$A_1 = 0,8275A \times 2$ ✓
$= \mathbf{1,66\ A}$ ✓

Range/*Reeks* (1,64A - 1,67A)

OPTION/*OPSIE* 2

Calculate /*Bereken* $V_{ext/ekt}$

$$R = \frac{V}{I}$$

$$2,2222 = \frac{V}{3,724} \checkmark$$

$$V = 8,275\ V$$

Current through 2X
(Positive marking from 8.3.2a)
Stroom deur 2X
(Positiewe merk van 8.3.2a)

$$R = \frac{V}{I}$$

$$4 = \frac{8,275}{I} \checkmark$$

$$I_{2X} = 2,07\ A$$

Calculate A_1 reading
Bereken A_1 lesing

$A_1 = 3,724 - 2,07$ ✓
$= \mathbf{1,66\ A}$ ✓

Range/*Reeks* (1,64A - 1,67A)

(6)

8.4 Cost = kWh × tariff
Cost = 2×(3×30)✓ × R4,45✓
Cost = R801✓ (3)

[18]

GRAND TOTAL /*GROOTTOTAAL*: 150