



# basic education

Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

**NATIONAL  
SENIOR CERTIFICATE  
NASIONALE  
SENIOR SERTIFIKAAT**

**GRADE/GRAAD 12**

**PHYSICAL SCIENCES: PHYSICS (P1)  
FISIESE WETENSKAPPE: FISIKA (V1)**

**NOVEMBER 2019**

**MARKING GUIDELINES/NASIENRIGLYNE**

**MARKS/PUNTE: 150**

**These marking guidelines consist of 24 pages. /  
Hierdie nasienriglyne bestaan uit 24 bladsye.**

**QUESTION 1/VRAAG 1**

- 1.1 C ✓✓ (2)
- 1.2 A ✓✓ (2)
- 1.3 A ✓✓ (2)
- 1.4 D ✓✓ (2)
- 1.5 B ✓✓ (2)
- 1.6 D ✓✓ (2)
- 1.7 A ✓✓ (2)
- 1.8 B ✓✓ (2)
- 1.9 D ✓✓ (2)
- 1.10 C ✓✓ (2)
- [20]**



**QUESTION 2/VRAAG 2**

**NOTE:** -1 mark for each key word/phrase omitted in the correct context  
**LET WEL:** -1 punt vir elke sleutel woord/frase in die korrekte konteks weggelaat

2.1 When a resultant/net force acts on an object, the object will accelerate in the direction of the force with an acceleration that is directly proportional to the force and inversely proportional to the mass of the object. ✓ ✓  
 Wanneer 'n resultante/netto krag op 'n voorwerp inwerk, sal die voorwerp in die rigting van die krag versnel teen 'n versnelling wat direk eweredig is aan die krag en omgekeerd eweredig aan die massa van die voorwerp.

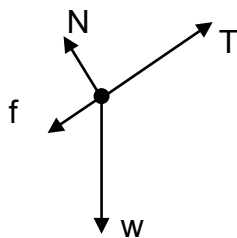
(2)

**OR/OF**

The resultant/net force acting on an object is equal to the rate of change of momentum of the object (in the direction of the resultant/net force.) ✓ ✓  
 Die netto krag wat op 'n voorwerp inwerk is gelyk aan die tempo van verandering van momentum van die voorwerp (in die rigting van die resulterende/netto krag.)

(2)

2.2



**ACCEPT/AANVAAR**

	<b>Accept the following symbols/Aanvaar die volgende simbole.</b>
N ✓	$F_N$ /Normal/ <i>Normaal</i> /Normal force/ <i>Normaalkrag</i> /16,97 N
f ✓	$F_f$ / $f_k$ / $f_r$ / frictional force/ <i>wrywingskrag</i> /kinetic frictional force/ <i>kinetiese wrywingskrag</i>
W ✓	$F_g$ ,/mg/weight/ $F_{\text{Earth on block}}$ /19,6 N/ <i>gravitational force</i> / <i>gewig</i> / $F_{\text{aarde op blok}}$ / <i>gravitasiekrag</i>
T ✓	Tension/ <i>Spanning</i> / $F_T$ / $F_A$ / F / $F_s$

**Notes/Aantekeninge**

- Mark is awarded for label and arrow. /Punt word toegeken vir byskrif en pyltjie
- Do not penalise for length of arrows.  
 Moenie vir die lengte van die pyltjies penaliseer nie.
- Deduct 1 mark for any additional force. /Trek 1 punt af vir enige addisionele krag.
- If force(s) do not make contact with body/dot //Indien krag(te) nie met die voorwerp / kolletjie kontak maak nie: Max./Maks:  $\frac{3}{4}$
- If arrows missing//Indien pyltjies uitgelaat is: Max./Maks:  $\frac{3}{4}$

(4)

2.3

<p>For the 2 kg (P) block/Vir die 2 kg (P) blok:</p> $\left. \begin{aligned} F_{\text{net}} &= ma \\ T + (-w_{\parallel}) + (-f_k) &= ma \\ T - (w_{\parallel} + f_k) &= ma \end{aligned} \right\} \checkmark \text{ Any one/Enige een}$ $T - (2)(9,8)\sin 30^\circ \checkmark - 2,5 \checkmark = 2a \checkmark$ $T - 9,8 - 2,5 = 2a$ $T - 12,3 = 2a \dots\dots\dots(1)$ <p>For the 3 kg (Q) block/Vir die 3 kg (Q) blok:</p> $\left. \begin{aligned} F_x + (-T) + (-w_{\parallel}) &= ma \\ F_x - (T + w_{\parallel}) &= ma \end{aligned} \right\} \checkmark \text{ Any one/Enige een}$ $[40 \cos 25^\circ \checkmark - T - (3)(9,8)\sin 30^\circ \checkmark] \checkmark = 3a$ $36,25 - T - 14,7 = 3a$ $21,55 - T = 3a \dots\dots\dots(2)$ $9,25 = 5a$ $a = 1,85 \text{ m}\cdot\text{s}^{-2} \checkmark$	<p><b>Marking criteria/Nasienriglyne</b></p> <ul style="list-style-type: none"> <li>• Formula/Formule <math>\checkmark</math></li> <li>• Substitution of /vervanging van <math>w_{\parallel}</math> for/vir 2 kg: <math>(2)(9,8)\sin 30^\circ \checkmark</math></li> <li>• Substitution of -2,5 N /Vervanging van -2,5 N <math>\checkmark</math></li> <li>• 2a <b>OR/OF</b> 3a <math>\checkmark</math></li> <li>• Calculate/Bereken <math>F_x</math>: <math>40 \cos 25^\circ \checkmark</math> (<math>40 \sin 65^\circ</math>)</li> <li>• Substitution of /vervanging van <math>w_{\parallel}</math> for/vir for 3 kg: <math>(3)(9,8)\sin 30^\circ \checkmark</math></li> <li>• Left hand side substitution for 3 kg/Linkerkant vervanging vir 3 kg <math>\checkmark</math></li> <li>• Final answer/Finale antwoord: <math>1,85 \text{ m}\cdot\text{s}^{-2} \checkmark</math></li> </ul>
<p><b>Systems Approach (Massless String Approximation / Sisteembenadering (Massalose Tou Benadering) (Max 5/8 marks / Maks 5/8 punte)</b></p> $\left. \begin{aligned} F_{\text{net}} &= ma \\ F_x + (-w_{\parallel}) + (-f_k) &= ma \\ F_x - (w_{\parallel} + f_k) &= ma \end{aligned} \right\} \checkmark \text{ Any one/Enige een}$ $40\cos 25^\circ \checkmark - (5)(9,8)\sin 30^\circ \checkmark - 2,5 \checkmark = 5a$ $a = 1,85 \text{ m}\cdot\text{s}^{-2} \checkmark$	

(8)

2.4

Greater than/groter as  $\checkmark$   
 $F_{\text{net}}$  increases. / $F_{\text{net}}$  neem toe.  $\checkmark$

**ACCEPT/AANVAAR**

There is no friction. /Daar is geen wrywing nie.

**OR/OF**

The surface is smooth / Die oppervlak is glad

(2)  
**[16]**

**QUESTION 3/VRAAG 3**

- 3.1 (Motion during which) the only force acting is the force of gravity. ✓✓  
(Beweging waartydens) die enigste krag wat inwerk gravitasiekrag is.

**(2 or/of 0)****(2)**

3.2

**Marking criteria/Nasienriglyne:**

- Any appropriate formula for  $\Delta y$ /Enige toepaslike formule vir  $\Delta y$  ✓
- Whole substitution to calculate 5,1 m /Hele vervanging om 5,1 m te bereken ✓
- 40 + answer from calculation/antwoord van berekening ✓
- Final answer/Finale antwoord: 45,10 m ✓ (Accept/aanvaar 45,1 m)

**OPTION 1/OPSIE 1****UPWARDS AS POSITIVE/OPWAARTS AS POSITIEF:**

$$v_f^2 = v_i^2 + 2a\Delta y \quad \checkmark$$

$$0 = (10)^2 + (2)(-9,8)\Delta y \quad \checkmark$$

$$\Delta y = 5,10 \text{ m } (5,102 \text{ m})$$

$$\begin{aligned} \text{Height} &= \underline{40} + 5,10 \quad \checkmark \\ &= 45,10 \text{ m } \quad \checkmark \end{aligned}$$

**DOWNWARDS AS POSITIVE/AFWAARTS AS POSITIEF:**

$$v_f^2 = v_i^2 + 2a\Delta y \quad \checkmark$$

$$0 = (-10)^2 + (2)(9,8)\Delta y \quad \checkmark$$

$$\Delta y = -5,10 \text{ m } (5,102)$$

$$\begin{aligned} \text{Height} &= \underline{40} + 5,10 \quad \checkmark \\ &= 45,10 \text{ m } \quad \checkmark \end{aligned}$$

**OPTION 2/OPSIE 2****UPWARDS AS POSITIVE/OPWAARTS AS POSITIEF:**

$$v_f = v_i + a\Delta t$$

$$0 = (10) + (-9,8)\Delta t$$

$$\Delta t = 1,02 \text{ s}$$

$$\begin{aligned} \Delta y &= v_i\Delta t + \frac{1}{2}a\Delta t^2 \quad \checkmark \\ &= \underline{(10)(1,02) + \frac{1}{2}(-9,8)(1,02)^2} \quad \checkmark \\ &= 5,10 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Height} &= \underline{40} + 5,10 \quad \checkmark \\ &= 45,10 \text{ m } \quad \checkmark \end{aligned}$$

Accept swapping of  $v_i$  and  $v_f$   
Aanvaar die omruiling van  $v_i$  en  $v_f$

**OR/OF**

$$\begin{aligned} \Delta y &= \left( \frac{v_i + v_f}{2} \right) \Delta t \quad \checkmark \\ &= \left( \frac{10 + 0}{2} \right) (1,02) \quad \checkmark \\ &= 5,10 \text{ m} \end{aligned}$$

**DOWNWARDS AS POSITIVE/AFWAARTS AS POSITIEF:**

$$v_f = v_i + a\Delta t$$

$$0 = (-10) + (9,8)\Delta t$$

$$\Delta t = 1,02 \text{ s}$$

$$\begin{aligned} \Delta y &= v_i\Delta t + \frac{1}{2}a\Delta t^2 \quad \checkmark \\ &= \underline{(-10)(1,02) + \frac{1}{2}(9,8)(1,02)^2} \quad \checkmark \\ &= 5,10 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Height} &= \underline{40} + 5,10 \quad \checkmark \\ &= 45,10 \text{ m } \quad \checkmark \end{aligned}$$

Accept swapping of  $v_i$  and  $v_f$   
Aanvaar die omruiling van  $v_i$  en  $v_f$

**OPTION 3/OPSIE 3****UPWARDS AS POSITIVE/OPWAARTS AS POSITIEF:**

$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$0 = (10) \Delta t + \frac{1}{2}(-9,8) \Delta t^2$$

$$\Delta t = 2,04 \text{ s} \quad \swarrow \frac{1}{2} \Delta t$$

$$\begin{aligned} \Delta y &= v_i \Delta t + \frac{1}{2} a \Delta t^2 \checkmark \\ &= (10)(1,02) + \frac{1}{2}(-9,8)(1,02)^2 \checkmark \\ &= 5,10 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Height} &= 40 + \checkmark 5,10 \\ &= 45,10 \text{ m } \checkmark \end{aligned}$$

**DOWNWARDS AS POSITIVE/AFWAARTS AS POSITIEF:**

$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$0 = (-10) \Delta t + \frac{1}{2}(9,8) \Delta t^2$$

$$\Delta t = 2,04 \text{ s} \quad \swarrow \frac{1}{2} \Delta t$$

$$\begin{aligned} \Delta y &= v_i \Delta t + \frac{1}{2} a \Delta t^2 \checkmark \\ &= (-10)(1,02) + \frac{1}{2}(9,8)(1,02)^2 \checkmark \\ &= -5,10 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Height} &= 40 + \checkmark 5,10 \checkmark \\ &= 45,10 \text{ m } \checkmark \end{aligned}$$

**OPTION 4/OPSIE 4****UPWARDS AS POSITIVE/OPWAARTS AS POSITIEF:**

$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$0 = (10) \Delta t + \frac{1}{2}(-9,8) \Delta t^2$$

$$\Delta t = 2,04 \text{ s} \quad \swarrow \frac{1}{2} \Delta t$$

$$\begin{aligned} \Delta y &= \left( \frac{v_i + v_f}{2} \right) \Delta t \checkmark \\ &= \left( \frac{10 + 0}{2} \right) (1,02) \checkmark \\ &= 5,10 \text{ m} \end{aligned}$$

Accept swopping of  $v_i$  and  $v_f$   
Aanvaar die omruiling van  $v_i$  en  $v_f$

$$\begin{aligned} \text{Height} &= 40 + \checkmark 5,10 \checkmark \\ &= 45,10 \text{ m } \checkmark \end{aligned}$$

**DOWNWARDS AS POSITIVE/AFWAARTS AS POSITIEF:**

$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$0 = (-10) \Delta t + \frac{1}{2}(9,8) \Delta t^2$$

$$\Delta t = 2,04 \text{ s} \quad \swarrow \frac{1}{2} \Delta t$$

$$\begin{aligned} \Delta y &= \left( \frac{v_i + v_f}{2} \right) \Delta t \checkmark \\ &= \left( \frac{-10 + 0}{2} \right) (1,02) \checkmark \\ &= -5,10 \text{ m} \end{aligned}$$

Accept swopping of  $v_i$  and  $v_f$   
Aanvaar die omruiling van  $v_i$  en  $v_f$

$$\begin{aligned} \text{Height} &= 40 + \checkmark 5,10 \checkmark \\ &= 45,10 \text{ m } \checkmark \end{aligned}$$

**OPTION 5/OPSIE 5**

$$E_{(\text{mech/meg})\text{roof/dak}} = E_{(\text{mech/meg})\text{top/bo}}$$

$$(E_p + E_k)_{\text{roof/dak}} = (E_p + E_k)_{\text{top/bo}}$$

$$(mgh + \frac{1}{2}mv^2)_{\text{roof/dak}} = (mgh + \frac{1}{2}mv^2)_{\text{top/bo}}$$

$$[m(9,8)(0) + \frac{1}{2}m(10)^2 = m(9,8)(h) + 0] \checkmark$$

} ✓ Any one/Enige een

$h = 5,10 \text{ m}$

Height =  $40 + 5,10 \checkmark$   
 =  $45,10 \text{ m} \checkmark$

**OPTION 6/OPSIE 6**

$$W_{\text{net}} = \Delta E_k \checkmark$$

$$w\Delta x \cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$(m)(9,8)\Delta x \cos 180^\circ = 0 - \frac{1}{2}m(10)^2 \checkmark$$

$$\Delta x = 5,10 \text{ m}$$

Height =  $40 + 5,10 \checkmark$   
 =  $45,10 \text{ m} \checkmark$

**OPTION 7/OPSIE 7**

$$W_{\text{nc}} = \Delta E_p + \Delta E_k \checkmark$$

$$0 = m(9,8)(h_f - 0) + \frac{1}{2}m(0 - 10^2) \checkmark$$

$$h_f = 5,10 \text{ m}$$

Height =  $40 + 5,10 \checkmark$   
 =  $45,10 \text{ m} \checkmark$

**OPTION 8/OPSIE 8**



**Marking criteria/Nasienriglyne:**

- Appropriate formula/Toegepaste formule ✓
- Substitution left/Vervanging links ✓
- Substitution right/Vervanging regs ✓
- Final answer/Finale antwoord: 45,10 m ✓

$$E_{(\text{mech/meg})\text{roof/dak}} = E_{(\text{mech/meg})\text{top/bo}}$$

$$(E_p + E_k)_{\text{roof/dak}} = (E_p + E_k)_{\text{top/bo}}$$

$$(mgh + \frac{1}{2}mv^2)_{\text{roof/dak}} = (mgh + \frac{1}{2}mv^2)_{\text{top/bo}}$$

$$m(9,8)(40) + \frac{1}{2}m(10)^2 = m(9,8)(h) + 0 \checkmark$$

} ✓ Any one/Enige een

$h = 45,10 \text{ m} \checkmark$

(4)

3.3  $9,8 \text{ m} \cdot \text{s}^{-2} \checkmark$  downwards/afwaarts ✓

(2)

3.4

**Marking criteria/Nasienriglyne**

- Calculation/use of 10,26 m./Berekening/gebruik van 10,26 m. ✓
- Appropriate formula to calculate  $\Delta t$ /Toepaslike formule om  $\Delta t$  te bereken ✓
- Substitution for stone A/Vervanging vir klip A ✓
- Substitution for stone B/Vervanging vir klip B ✓
- Calculating time difference between two stones. /Berekening van tydverskil tussen klippe. ✓
- Final answer/Finale antwoord: 1,34 (s) ✓

**OPTION 1/OPSIE 1****UPWARDS AS POSITIVE/OPWAARTS AS POSITIEF:**

Displacement from roof to meeting point /Verplasing vanaf dak tot ontmoetingspunt =  $-40 + 29,74 = -10,26$  m

**Stone/Klip A**

$$\Delta y_A = v_i \Delta t + \frac{1}{2} a \Delta t^2 \quad \checkmark$$

$$-10,26 \quad \checkmark = 10 \Delta t + \frac{1}{2} (-9,8) \Delta t^2 \quad \checkmark$$

$$\Delta t = 2,79 \text{ s}$$

**Stone/Klip B**

$$\Delta y_B = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$-10,26 = 0 + \frac{1}{2} (-9,8) \Delta t^2 \quad \checkmark$$

$$\Delta t = 1,45 \text{ s (1,447 s)}$$

$$x = 2,79 - 1,45 \quad \checkmark = 1,34 \text{ (s)} \quad \checkmark$$

**OR/OF**

$$[-10,26 = 0(2,79 - x) + \frac{1}{2} (-9,8)(2,79 - x)^2 \quad \checkmark] \quad \checkmark$$

$$x = 1,34 \text{ (s)} \quad \checkmark$$

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$= 0^2 + 2(-9,8)(-10,26)$$

$$v_f = -14,18 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$-14,18 = 0 + (-9,8)\Delta t \quad \checkmark$$

$$\Delta t = 1,45 \text{ s}$$

$$x = 2,79 - 1,45 \quad \checkmark$$

$$= 1,34 \text{ (s)} \quad \checkmark$$

**DOWNWARDS AS POSITIVE/AFWAARTS AS POSITIEF:**

Displacement from roof to meeting point /Verplasing vanaf dak tot ontmoetingspunt =  $40 - 29,74 = 10,26$  m

**Stone/Klip A**

$$\Delta y_A = v_i \Delta t + \frac{1}{2} a \Delta t^2 \quad \checkmark$$

$$10,26 \quad \checkmark = -10 \Delta t + \frac{1}{2} (9,8) \Delta t^2 \quad \checkmark$$

$$\Delta t = 2,79 \text{ s}$$

**Stone/Klip B**

$$\Delta y_B = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$10,26 = 0 + \frac{1}{2} (9,8) \Delta t^2 \quad \checkmark$$

$$\Delta t = 1,45 \text{ s (1,447 s)}$$

$$x = 2,79 - 1,45 \quad \checkmark = 1,34 \text{ (s)} \quad \checkmark$$

**OR/OF**

$$[-10,26 = 0(2,79 - x) + \frac{1}{2} (-9,8)(2,79 - x)^2 \quad \checkmark] \quad \checkmark$$

$$x = 1,34 \text{ (s)} \quad \checkmark$$

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$= 0^2 + 2(9,8)(10,26)$$

$$v_f = 14,18 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$14,18 = 0 + (9,8)\Delta t \quad \checkmark$$

$$\Delta t = 1,45 \text{ s}$$

$$x = 2,79 - 1,45 \quad \checkmark$$

$$= 1,34 \text{ (s)} \quad \checkmark$$



**OPTION 2/OPSIE 2****UPWARDS AS POSITIVE/OPWAARTS AS POSITIEF:**

Displacement from roof to meeting point /Verplasing vanaf dak tot ontmoetingspunt =  $-40 + 29,74 = -10,26$  m

Displacement of stone A from max height to meeting point/ Verplasing van klip A vanaf maksimum hoogte tot ontmoetingspunt =  $-15,36$  m

**Stone/Klip A**

$$v_f = v_i + a\Delta t$$

$$0 = 10 + (-9,8)\Delta t$$

$$\Delta t = 1,02 \text{ s}$$

$$\Delta y_A = v_i\Delta t + \frac{1}{2}a\Delta t^2 \checkmark$$

$$-15,36 = 0 + \frac{1}{2}(-9,8)\Delta t^2 \checkmark$$

$$\Delta t = 1,77 \text{ s}$$

$$\Delta t_{\text{tot}} = 1,77 + 1,02 = 2,79 \text{ s}$$

**Stone/Klip B**

$$\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$-10,26 \checkmark = 0 + \frac{1}{2}(-9,8)\Delta t^2 \checkmark$$

$$\Delta t = 1,45 \text{ s (1,447 s)}$$

$$x = 2,79 - 1,45 \checkmark = 1,34 \text{ (s)} \checkmark$$

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$= 0^2 + 2(-9,8)(-10,26)$$

$$v_f = -14,18 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$-14,18 = 0 + (-9,8)\Delta t \checkmark$$

$$\Delta t = 1,45 \text{ s}$$

$$x = 2,79 - 1,45 \checkmark$$

$$= 1,34 \text{ (s)} \checkmark$$

**DOWNWARDS AS POSITIVE/AFWAARTS AS POSITIEF:**

Displacement from roof to meeting point /Verplasing vanaf dak tot ontmoetingspunt =  $40 - 29,74 = 10,26$  m  $\checkmark$

Displacement of ball A from max height to meeting point/ Verplasing van bal A vanaf maksimum hoogte tot ontmoetingspunt =  $15,36$  m

**Stone/Klip A**

$$v_f = v_i + a\Delta t$$

$$0 = -10 + (9,8)\Delta t$$

$$\Delta t = 1,02 \text{ s}$$

$$\Delta y_A = v_i\Delta t + \frac{1}{2}a\Delta t^2 \checkmark$$

$$15,36 = 0 + \frac{1}{2}(9,8)\Delta t^2 \checkmark$$

$$\Delta t = 1,77 \text{ s}$$

$$\Delta t_{\text{tot}} = 1,77 + 1,02 = 2,79 \text{ s}$$

**Stone/Klip B**

$$\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$10,26 = 0 + \frac{1}{2}(9,8)\Delta t^2 \checkmark$$

$$\Delta t = 1,45 \text{ s (1,447 s)}$$

$$x = 2,79 - 1,45 \checkmark = 1,34 \text{ (s)} \checkmark$$

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$= 0^2 + 2(9,8)(10,26)$$

$$v_f = 14,18 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$14,18 = 0 + (9,8)\Delta t \checkmark$$

$$\Delta t = 1,45 \text{ s}$$

$$x = 2,79 - 1,45 \checkmark$$

$$= 1,34 \text{ (s)} \checkmark$$

**OPTION 3/OPSIE 3****UPWARDS AS POSITIVE/OPWAARTS AS POSITIEF:**Displacement of stones A and B from roof to meeting point/*Verplasing van**klippe A en B vanaf dak tot by ontmoetingspunt = - 40 + 29,74*

$$= - 10,26 \text{ m}$$

**Stone/Klip A**

$$v_f = v_i + a\Delta t$$

$$0 = 10 + (-9,8)\Delta t$$

$$\Delta t = 1,02 \text{ s}$$

$$\Delta y_A = v_i\Delta t + \frac{1}{2}a\Delta t^2 \checkmark$$

$$- 10,26 \checkmark = \underline{-10 + \frac{1}{2}(-9,8)\Delta t^2} \checkmark$$

$$\Delta t = 0,75 \text{ s}$$

$$\Delta t_{\text{tot}} = 1,02 + 1,02 + 0,75 = 2,79 \text{ s}$$

**Stone/Klip B**

$$\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$\underline{-10,26 = 0 + \frac{1}{2}(-9,8)\Delta t^2} \checkmark$$

$$\Delta t = 1,45 \text{ s (1,447 s)}$$

$$x = 2,79 - 1,45 \checkmark = 1,34 \text{ (s)} \checkmark$$

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$= 0^2 + 2(-9,8)(-10,26)$$

$$v_f = -14,18 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$\underline{-14,18 = 0 + (-9,8)\Delta t} \checkmark$$

$$\Delta t = 1,45 \text{ s}$$

$$x = 2,79 - 1,45 \checkmark$$

$$= 1,34 \text{ (s)} \checkmark$$

**DOWNWARDS AS POSITIVE/AFWAARTS AS POSITIEF:**Displacement of stones A and B from roof to meeting point/*Verplasing van**klippe A en B vanaf dak tot by ontmoetingspunt = 40 - 29,74 = 10,26 m***Stone/Klip A**

$$v_f = v_i + a\Delta t$$

$$0 = -10 + (9,8)\Delta t$$

$$\Delta t = 1,02 \text{ s}$$

$$\Delta y_A = v_i\Delta t + \frac{1}{2}a\Delta t^2 \checkmark$$

$$10,26 \checkmark = \underline{10 + \frac{1}{2}(9,8)\Delta t^2} \checkmark$$

$$\Delta t = 0,75 \text{ s}$$

$$\Delta t_{\text{tot}} = 1,02 + 1,02 + 0,75 = 2,79 \text{ s}$$

**Stone/Klip B**

$$\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$\underline{10,26 = 0 + \frac{1}{2}(9,8)\Delta t^2} \checkmark$$

$$\Delta t = 1,45 \text{ s (1,447 s)}$$

$$x = 2,79 - 1,45 \checkmark = 1,34 \text{ (s)} \checkmark$$

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$= 0^2 + 2(9,8)(10,26)$$

$$v_f = 14,18 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$\underline{14,18 = 0 + (9,8)\Delta t} \checkmark$$

$$\Delta t = 1,45 \text{ s}$$

$$x = 2,79 - 1,45 \checkmark$$

$$= 1,34 \text{ (s)} \checkmark$$

**OPTION 4/OPSIE 4****UPWARDS AS POSITIVE/OPWAARTS AS POSITIEF:**

Displacement from roof to meeting point /Verplasing vanaf dak tot ontmoetingspunt =  $-40 + 29,74 = -10,26$  m

**Stone/Klip A**

$$\Delta y_A = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$-5,10 = 0 + \frac{1}{2}(-9,8)\Delta t^2$$

$$\Delta t = 1,02 \text{ s}$$

$$\Delta y_A = v_i \Delta t + \frac{1}{2} a \Delta t^2 \checkmark$$

$$-10,26 \checkmark = -10 + \frac{1}{2}(-9,8)\Delta t^2 \checkmark$$

$$\Delta t = 0,75 \text{ s}$$

$$\Delta t_{\text{tot}} = 1,02 + 1,02 + 0,75 = 2,79 \text{ s}$$

**Stone/Klip B**

$$\Delta y_B = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$-10,26 = 0 + \frac{1}{2}(-9,8)\Delta t^2 \checkmark$$

$$\Delta t = 1,45 \text{ s (1,447 s)}$$

$$x = 2,79 - 1,45 \checkmark = 1,34 \text{ (s)} \checkmark$$

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$= 0^2 + 2(-9,8)(-10,26)$$

$$v_f = -14,18 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$-14,18 = 0 + (-9,8)\Delta t \checkmark$$

$$\Delta t = 1,45 \text{ s}$$

$$x = 2,79 - 1,45 \checkmark$$

$$= 1,34 \text{ (s)} \checkmark$$

**DOWNWARDS AS POSITIVE/AFWAARTS AS POSITIEF:**

Displacement from roof to meeting point /verplasing vanaf dak tot by ontmoetingspunt =  $40 - 29,74 = 10,26$  m

**Stone/Klip A**

$$\Delta y_A = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$5,10 = 0 + \frac{1}{2}(9,8)\Delta t^2$$

$$\Delta t = 1,02 \text{ s}$$

$$\Delta y_A = v_i \Delta t + \frac{1}{2} a \Delta t^2 \checkmark$$

$$10,26 \checkmark = 10 + \frac{1}{2}(9,8)\Delta t^2 \checkmark$$

$$\Delta t = 0,75 \text{ s}$$

$$\Delta t_{\text{tot}} = 1,02 + 1,02 + 0,75 = 2,79 \text{ s}$$

**Stone/Klip B**

$$\Delta y_B = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$10,26 = 0 + \frac{1}{2}(9,8)\Delta t^2 \checkmark$$

$$\Delta t = 1,45 \text{ s (1,447 s)}$$

$$x = 2,79 - 1,45 \checkmark = 1,34 \text{ (s)} \checkmark$$

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$= 0^2 + 2(9,8)(10,26)$$

$$v_f = 14,18 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$14,18 = 0 + (9,8)\Delta t \checkmark$$

$$\Delta t = 1,45 \text{ s}$$

$$x = 2,79 - 1,45 \checkmark$$

$$= 1,34 \text{ (s)} \checkmark$$

**OPTION 5/OPSIE 5****UPWARDS AS POSITIVE/OPWAARTS AS POSITIEF:**

Displacement from roof to meeting point /Verplasing vanaf dak tot ontmoetingspunt =  $-40 + 29,74 = -10,26$  m

Displacement of stone A from max height to meeting point/ Verplasing van klip A vanaf maksimum hoogte tot ontmoetingspunt =  $-15,36$  m

**Stone/Klip A**

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$v_f^2 = (0)^2 + (2)(-9,8)(-15,36)$$

$$v_f = -17,35 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$-17,35 = 0 + (-9,8)\Delta t \checkmark$$

$$\Delta t = 1,77 \text{ s}$$

$$\Delta t_{\text{tot}} = 1,02 + 1,77 = 2,79 \text{ (s)}$$

**Stone/Klip B**

$$\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$-10,26 \checkmark = 0 + \frac{1}{2}(-9,8)\Delta t^2 \checkmark$$

$$\Delta t = 1,45 \text{ s (1,447 s)}$$

$$x = 2,79 - 1,45 \checkmark = 1,34 \text{ (s)} \checkmark$$

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$= 0^2 + 2(-9,8)(-10,26)$$

$$v_f = -14,18 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$-14,18 = 0 + (-9,8)\Delta t \checkmark$$

$$\Delta t = 1,45 \text{ s}$$

$$x = 2,79 - 1,45 \checkmark$$

$$= 1,34 \text{ (s)} \checkmark$$

**DOWNWARDS AS POSITIVE/AFWAARTS AS POSITIEF:**

Displacement from roof to meeting point /Verplasing vanaf dak tot ontmoetingspunt =  $40 - 29,74 = 10,26$  m

Displacement of stone A from max height to meeting point/ Verplasing van klip A vanaf maksimum hoogte tot ontmoetingspunt =  $15,36$  m

**Stone/Klip A**

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$v_f^2 = (0)^2 + (2)(9,8)(15,36)$$

$$v_f = 17,35 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$17,35 = 0 + (9,8)\Delta t \checkmark$$

$$\Delta t = 1,77 \text{ s}$$

$$\Delta t_{\text{tot}} = 1,02 + 1,77 = 2,79 \text{ (s)}$$

**Stone/Klip B**

$$\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$10,26 \checkmark = 0 + \frac{1}{2}(9,8)\Delta t^2 \checkmark$$

$$\Delta t = 1,45 \text{ s (1,447 s)}$$

$$x = 2,79 - 1,45 \checkmark = 1,34 \text{ (s)} \checkmark$$

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$= 0^2 + 2(9,8)(10,26)$$

$$v_f = 14,18 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$14,18 = 0 + (9,8)\Delta t \checkmark$$

$$\Delta t = 1,45 \text{ s}$$

$$x = 2,79 - 1,45 \checkmark$$

$$= 1,34 \text{ (s)} \checkmark$$

**OPTION 6/OPSIE 6**

**UPWARDS AS POSITIVE/OPWAARTS AS POSITIEF:**

Displacement from roof to meeting point/Verplasing vanaf dak tot by ontmoetingspunt =  $-40 + 29,74 = -10,26$  m

**Stone/Klip A**

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$v_f^2 = (-10)^2 + (2)(-9,8)(-10,26)$$

$$v_f = -17,35 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$-17,35 = -10 + (-9,8)\Delta t \checkmark$$

$$\Delta t = 0,75 \text{ s}$$

Ball A:  $\Delta t = 1,02 + 1,02 + 0,75 = 2,79$  (s)

**Stone/Klip B**

$$\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$-10,26 \checkmark = 0 + \frac{1}{2}(-9,8)\Delta t^2 \checkmark$$

$$\Delta t = 1,45 \text{ s (1,447 s)}$$

$$x = 2,79 - 1,45 \checkmark = 1,34 \text{ (s)} \checkmark$$

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$= 0^2 + 2(-9,8)(-10,26)$$

$$v_f = -14,18 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$-14,18 = 0 + (-9,8)\Delta t \checkmark$$

$$\Delta t = 1,45 \text{ s}$$

$$x = 2,79 - 1,45 \checkmark$$

$$= 1,34 \text{ (s)} \checkmark$$

**DOWNWARDS AS POSITIVE/AFWAARTS AS POSITIEF:**

Displacement from roof to meeting point/Verplasing vanaf dak tot by ontmoetingspunt =  $40 - 29,74 = 10,26$  m

**Stone/Klip A**

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$v_f^2 = [(10)^2 + (2)(9,8)(10,26)$$

$$v_f = 17,35 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$17,35 = 10 + (9,8)\Delta t \checkmark$$

$$\Delta t = 0,75 \text{ s}$$

Ball A:  $\Delta t = 1,02 + 1,02 + 0,75 = 2,79$  (s)

**Stone/Klip B**

$$\Delta y_B = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$10,26 \checkmark = 0 + \frac{1}{2}(9,8)\Delta t^2 \checkmark$$

$$\Delta t = 1,45 \text{ s (1,447 s)}$$

$$x = 2,79 - 1,45 \checkmark = 1,34 \text{ (s)} \checkmark$$

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$= 0^2 + 2(9,8)(10,26)$$

$$v_f = 14,18 \text{ m}\cdot\text{s}^{-1}$$

$$v_f = v_i + a\Delta t$$

$$14,18 = 0 + (9,8)\Delta t \checkmark$$

$$\Delta t = 1,45 \text{ s}$$

$$x = 2,79 - 1,45 \checkmark$$

$$= 1,34 \text{ (s)} \checkmark$$

(6)

3.5.1 d  $\checkmark$  **Accept / Aanvaar** ( 0 – e; 0 – d; d – e)

(1)

3.5.2 a  $\checkmark$

(1)

3.5.3 f  $\checkmark$

(1)

3.5.4 c  $\checkmark$

(1)

[18]

**QUESTION 4/VRAAG 4**

4.1 **NOTE:** -1 mark for each key word/phrase omitted in the correct context.  
**LET WEL:** -1 punt vir elke sleutelwoord/frase weggelaat in die korrekte konteks.

Isolated system is a system on which the resultant/net external force is zero. ✓✓

Geïsoleerde sisteem is 'n sisteem waarop die resultante / netto eksterne krag nul is.

**OR/OF**

Isolated system is one that has no net / external force acting on it.  
'n Geïsoleerde stelsel is een wat geen netto eksterne krag het wat daarop inwerk nie. (2)

4.2.1  $p = mv$  ✓  
 $24 = m (480)$  ✓  
 $m = 0,05 \text{ kg}$  ✓

Note: p and v must have the same sign  
Let wel: p en v moet dieselfde tekens hê (3)

4.2.2 **Marking criteria/Nasienriglyne**

- Appropriate formula including  $F_{net}$  or  $W_{net}$ . /Toepaslike formule wat  $F_{net}$  of  $W_{net}$  insluit. ✓
- Substitutions/Vervangings ✓✓
- Final answer/Finale antwoord: 2 000 N ✓
- Correct direction/Korrekte rigting: west or left/Wes of links ✓

**POSITIVE MARKING FROM QUESTION 4.2.1**  
**POSITIEWE NASIEN VANAF VRAAG 4.2.1**

**OPTION 1/OPSIE 1**

$F_{net}\Delta t = \Delta p$   
 $F_{net}\Delta t = (p_{bullet})_f - (p_{bullet})_i$   
 $F_{net}\Delta t = (mv_{bullet})_f - (mv_{bullet})_i$  } ✓ Any one/Enige een  
 $F_{net}(0,01) \checkmark = (0,05)(80) - 24 \checkmark$  or/of  $(0,05)(80) - (0,05)(480)$   
 $F_{net} = -2\,000 \text{ N}$   
 $F_{net} = 2\,000 \text{ N} \checkmark$  west/wes ✓

**OPTION 2/OPSIE 2**

$v_f = v_i + a\Delta t$   
 $80 = 480 + a(0,01) \checkmark$   
 $a = -40\,000 \text{ m}\cdot\text{s}^{-2}$   
 $F_{net} = ma \checkmark$   
 $= (0,05)(-40\,000) \checkmark$   
 $= -2\,000 \text{ N}$   
 $F_{net} = 2\,000 \text{ N} \checkmark$  west/wes ✓

**OPTION 3/OPSIE 3**

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

$$= \frac{480 + 80}{2} (0,01)$$

$$= 2,80 \text{ m}$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$(80)^2 = (480)^2 + 2a(2,80) \checkmark$$

$$a = -40\,000 \text{ m}\cdot\text{s}^{-2}$$

$$F_{\text{net}} = ma \checkmark$$

$$= (0,05)(-40\,000) \checkmark$$

$$= -2\,000 \text{ N}$$

$$F_{\text{net}} = 2\,000 \text{ N} \checkmark \text{ west/wes} \checkmark$$

$$W_{\text{net}} = \Delta K \checkmark$$

$$F_{\text{net}} \Delta x \cos \theta = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$F_{\text{net}} (2,80) \cos 0^\circ \checkmark = \frac{1}{2} (0,05) (80^2 - 480^2) \checkmark$$

$$F_{\text{net}} = -2\,000 \text{ N}$$

$$F_{\text{net}} = 2\,000 \text{ N} \checkmark \text{ west/wes} \checkmark$$

**OR/OF**

$$F_{\text{net}} (2,80) \cos 180^\circ \checkmark = \frac{1}{2} (0,05) (80^2 - 480^2) \checkmark$$

$$F_{\text{net}} = 2\,000 \text{ N} \checkmark \text{ west/wes} \checkmark$$

(5)  
[10]**QUESTION 5**

5.1

**Note:** -1 mark for each key word/phrase omitted in the correct context.**Let Wel:** -1 punt vir elke sleutelwoord/frase weggelaat in die korrekte konteks.**IF:** The word "work" is omitted - 0 marks.**INDIEN:** Die woord "arbeid" uitgelaat is - 0 punte.

A conservative force is a force for which the work done (in moving an object between two points) is independent of the path taken. ✓✓

'n Konserwatiewe krag is 'n krag waarvoor die arbeid wat verrig is (om 'n voorwerp tussen twee punte te beweeg) onafhanklik is van die pad wat gevat word.

**OR/OF**

A conservative force is a force for which the work done in moving an object in a closed path is zero.

'n Konserwatiewe krag is 'n krag waarvoor die arbeid verrig om 'n voorwerp in 'n geslote pad te beweeg, nul is.

(2)

5.2 Gravitational (force)/Gravitasiekrag ✓

**ACCEPT/AANVAAR:** Gravitation /Gravity /Gravitasie /Weight /Gewig

(1)

5.3 No/Nee ✓

There is friction/non-conservative force (doing work)/It is not isolated system. ✓

Daar is wrywing/nie konserwatiewe krag (wat arbeid verrig)./Dit is nie 'n geïsoleerde sisteem nie.

**OR/OF**

The net work done by the non-conservative forces is not zero./Die netto arbeid deur die nie-konserwatiewe kragte is nie nul nie. ✓

(2)

5.4

<b>OPTION 1/OPSIE 1</b>	<b>OPTION 2/OPSIE 2</b>
$E_p = mgh \checkmark$ $= (1,8)(9,8)(1,5) \checkmark$ $= 26,46 \text{ J} \checkmark$	$W_w = -\Delta E_p \checkmark$ $(1,8)(9,8)(h - 0)\cos 180^\circ = -(E_{pA} - E_{p(\text{ground})})$ $(1,8)(9,8)(1,5)(-1) = -E_{pA} \checkmark$ $E_p = 26,46 \text{ J} \checkmark$  <b>OR/OF</b> $W = F\Delta x \cos\theta$ $= mg\Delta h \cos\theta$ $= (1,8)(9,8)(1,5)\cos 0^\circ \checkmark$ $= 26,46 \text{ J} \checkmark$

(3)

5.5

**POSITIVE MARKING FROM QUESTION 5.4 /****POSITIEWE NASIEN VANAF VRAAG 5.4****OPTION 1/OPSIE 1**

$$W_{nc} = \Delta K + \Delta U$$

$$W_f = \frac{1}{2}m(v_f^2 - v_i^2) + mg(h_f - h_i) \checkmark \text{ Any one/Enige een}$$

$$= \frac{1}{2}(1,8)(4^2 - 0,95^2) \checkmark + (0 - 26,46) \checkmark$$

$$= -12,87 \text{ J} \checkmark$$

**OPTION 2/OPSIE 2**

$$W_{net} = \Delta K$$

$$W_f + W_g = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \checkmark \text{ Any one/Enige een}$$

$$W_f + mgh = \frac{1}{2}m(v_f^2 - v_i^2)$$

$$W_f + mgh = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$W_f + 26,46 \checkmark = \frac{1}{2}(1,8)[(4)^2 - (0,95)^2] \checkmark$$

$$W_f = -12,87 \text{ J} \checkmark \text{ (-12,872 J) } \checkmark$$

**OPTION 3/OPSIE 3**

$$E_{(\text{mech/meg})A} = E_{(\text{mech})B} - W_f$$

$$(E_p + E_k)_A = (E_p + E_k)_B - W_f \checkmark \text{ Any one/Enige een}$$

$$(mgh + \frac{1}{2}mv^2)_A = (mgh + \frac{1}{2}mv^2)_B - W_f$$

$$26,46 + \frac{1}{2}(1,8)(0,95^2) \checkmark = 0 + \frac{1}{2}(1,8)(4^2) - W_f \checkmark$$

$$W_f = -12,87 \text{ J} \checkmark$$

(4)

5.6

$$W_{net} = 0 \text{ (J) / zero} \checkmark$$

(1)

**[13]****QUESTION 6/VRAAG 6**6.1 Doppler effect/Doppler-effek  $\checkmark$ 

(1)

6.2 (Q): (records sounds with) longer period/ longer time per wave / lower frequency.

(Q): (teken klank aan met) langer periode / langer tyd per golf / laer frekwensie.

**OR/OF**P: (records sounds with) shorter period/ shorter time per wave / higher frequency.  $\checkmark$ 

P: (teken klank aan met) korter periode/ korter tyd per golf / hoër frekwensie.

**ACCEPT/AANVAAR**

(Q): longer wavelength. /P: shorter wavelength.

(Q): langer golflengte./P: korter golflengte het.

(1)



6.3 **OPTION 1/OPSIE 1**

$$f = \frac{1}{T} \checkmark = \frac{1}{17 \times 10^{-4}} \checkmark = 5,88 \times 10^2 = 588,24 \text{ Hz} \checkmark$$

<b>OPTION 2/OPSIE 2</b>	<b>OPTION 3/OPSIE 3</b>
$\text{speed} = \frac{\text{distance}}{\text{time}}$ $340 = \frac{\text{distance}}{25,5 \times 10^{-4}}$ Distance = 0,867 m Distance = $1 \frac{1}{2} \lambda$ $\therefore \lambda = 0,578 \text{ m}$ $v = f\lambda \checkmark$ $340 = f(0,578) \checkmark$ $f = 588,24 \text{ Hz} \checkmark$	$v = \frac{\lambda}{T}$ $340 = \frac{\lambda}{17 \times 10^{-4}}$ $\therefore \lambda = 0,578 \text{ m}$ $v = f\lambda \checkmark$ $340 = f(0,578) \checkmark$ $f = 588,24 \text{ Hz} \checkmark$

(3)

6.4 **POSITIVE MARKING FROM QUESTIONS 6.2 AND 6.3.**

**POSITIEWE NASIEN VANAF VRAE 6.2 EN 6.3**

Do not penalise if  $10^{-4}$  is again omitted. *!Moenie penaliseer indien  $10^{-4}$  weer uitgelaat is nie.*

<p><b>OPTION 1/OPSIE 1</b></p> $f = \frac{1}{18 \times 10^{-4}} \checkmark = 5,56 \times 10^2 = 555,56 \text{ Hz}$ $f_L = \frac{v \pm v_L}{v \pm v_s} f_s \checkmark \quad \text{OR/OF} \quad f_L = \frac{v}{v + v_s} f_s$ $555,56 \checkmark = \left( \frac{340}{340 + v} \right) 588,24 \checkmark$ $v = 20 \text{ m} \cdot \text{s}^{-1} \checkmark$ Range/Gebied 19,57 – 20,09 $\text{m} \cdot \text{s}^{-1}$
<p><b>OPTION 2/OPSIE 2</b></p> $f_L = \frac{1}{18 \times 10^{-4}} \checkmark$ $f_L = \frac{v \pm v_L}{v \pm v_s} f_s \checkmark \quad \text{OR/OF} \quad f_L = \frac{v}{v + v_s} f_s$ $\frac{1}{18 \times 10^{-4}} \checkmark = \left( \frac{340}{340 + v} \right) \frac{1}{17 \times 10^{-4}} \checkmark$ $v = 20 \text{ m} \cdot \text{s}^{-1} \checkmark$ Range/Gebied 19,57 – 20,09 $\text{m} \cdot \text{s}^{-1}$

(6)  
[11]

**QUESTION 7/VRAAG 7**

7.1.1 Positive/Positief ✓ (1)

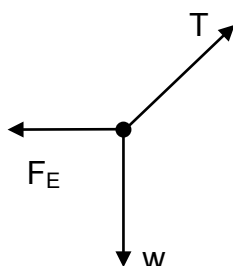
7.1.2 **Marking criteria/Nasienriglyne:**

- Appropriate formula /Toepaslike formule ✓
- Whole substitution Hele vervanging ✓
- Final answer/finale antwoord:  $2,26 \times 10^{-6} \text{ C}$  ✓

<b>OPTION 1/OPSIE 1</b>	<b>OPTION 2/OPSIE 2</b>
$F = \frac{kQ_1Q_2}{r^2} \checkmark$ $3,05 = \frac{(9 \times 10^9)(6 \times 10^{-6})Q}{0,2^2} \checkmark$ $Q = 2,26 \times 10^{-6} \text{ C} \checkmark$ $(2,259 \times 10^{-6} \text{ C})$	$E = \frac{kQ}{r^2}$ $= \frac{(9 \times 10^9)(6 \times 10^{-6})}{0,2^2}$ $= 1,35 \times 10^6 \text{ N} \cdot \text{C}^{-1}$ $F = Eq \checkmark$ $3,05 = (1,35 \times 10^6)q \checkmark$ $q = 2,26 \times 10^{-6} \text{ N} \checkmark$

(3)

7.1.3



<b>Accepted labels/Aanvaarde benoemings</b>	
W ✓	$F_g / F_w / \text{weight} / mg / \text{gravitational force}$ $F_g / F_w / \text{gewig} / mg / \text{gravitasiekrag}$
T ✓	$F_T / \text{tension} / \text{spanning}$
$F_E / F \checkmark$	Electrostatic force/ Coulomb force/ $F_{E \text{ Field}} / F_{x \text{ on } Y} /$ 3,05 N Elektrostatiese krag/ Coulombkrag

**Notes/Aantekeninge**

- Mark is awarded for label and arrow. /Punt word toegeken vir byskrif en pyltjie.
- Do not penalise for length of arrows.  
Moenie vir die lengte van die pyltjies penaliseer nie.
- Deduct 1 mark for any additional force /Trek 1 punt af vir enige addisionele krag
- If force(s) do not make contact with dot /Indien krag(te) nie met die kolletjie kontak maak nie: Max/Maks  $\frac{2}{3}$
- If arrows missing/Indien pyltjies uitgelaat word: Max/Maks  $\frac{2}{3}$

(3)

7.1.4

$F_{\text{net}} = 0$   
 $F_E = T \sin 10^\circ$   
 $F_E = T \cos 80^\circ$   
 $[3,05 = T \sin 10^\circ \checkmark] \checkmark$ 
[IF /INDIEN  $T \cos 10^\circ = 3,05 (\frac{1}{3})$ ]

**OR/OF**

$[3,05 = T \cos 80^\circ \checkmark] \checkmark$ 
[IF/INDIEN  $T \sin 80^\circ = 3,05 (\frac{1}{3})$ ]

$T = 17,56 \text{ N} \checkmark (17,564 \text{ N})$

(3)

7.2.1

**Marking criteria/Nasienriglyne**

-1 mark for each key word/phrase omitted in the correct context.  
-1 punt vir elke sleutelwoord/frase weggelaat in die korrekte konteks.

The electric field at a point is the (electrostatic) force experienced per unit positive charge placed at that point. ✓✓

Die elektriese veld by 'n punt is die (elektrostatiese) krag wat per positiewe eenheidslading wat by die punt geplaas is, ondervind word.

[IF the word “unit” or phrase “positive charge” is omitted in this definition: -1 for each **INDIEN** die woord “eenheid” of frase “positiewe lading” uitgelaat is in hierdie definisie: -1 vir elk]

**OR/OF**

The electric field at a point is the (electrostatic) force experienced by a UNIT positive charge placed at that point. ✓✓

Die elektriese veld by 'n punt is die (elektrostatiese) krag wat deur 'n positiewe EENHEIDSlading wat by die punt geplaas is, ondervind word.

[If “UNIT” is omitted in this definition, then 0 marks.

Indien “EENHEIDS” uitgelaat word in hierdie definisie, dan 0 punte.]

(2)

7.2.2

**OPTION 1/OPSIE 1**

Electric field at **M** due to **A** ( $+2 \times 10^{-5}$  C):

$$E_A = \frac{kQ}{r^2} \checkmark$$

$$= 9 \times 10^9 \frac{(2 \times 10^{-5})}{(0,2)^2} \checkmark$$

$$= 4,5 \times 10^6 \text{ N} \cdot \text{C}^{-1}$$



Electric field at **M** due to **B** ( $-4 \times 10^{-5}$  C):

$$E_B = \frac{kQ}{r^2} \quad \text{OR/OF} \quad q_B = 2q_A$$

$$= 9 \times 10^9 \frac{(4 \times 10^{-5})}{(0,2)^2} \checkmark \quad E_B = 2E_A \checkmark$$

$$= 9 \times 10^6 \text{ N} \cdot \text{C}^{-1} \quad = 9 \times 10^6 \text{ N} \cdot \text{C}^{-1}$$

$$E_{\text{net}} \text{ at } \mathbf{M} = E_A + E_B$$

$$= (4,5 \times 10^6 + 9 \times 10^6) \checkmark$$

$$= 1,35 \times 10^7 \text{ N} \cdot \text{C}^{-1} \checkmark \text{ to the right/na regs/towards B/na B}$$

/away from A / weg vanaf A ✓

**OPTION 2/OPSIE 2**

Net electrostatic force at **M** / Netto elektrostatische krag by **M**

$$F_{\text{net}} = \frac{kQ_1Q_2}{r^2} + \frac{kQ_1Q_2}{r^2}$$

If/Indien  $F = \frac{kQ}{r^2}$  Max/Maks  $\frac{2}{6}$

$$= \frac{(9 \times 10^9)(2 \times 10^{-5})q}{(0,2)^2} + \frac{(9 \times 10^9)(4 \times 10^{-5})q}{(0,2)^2} \checkmark \text{ (any one/ enige een)}$$

$$= 4,5 \times 10^6 q + 9 \times 10^6 q$$

$$= 1,35 \times 10^7 q \text{ N}$$

$$F_{\text{net}} = E_{\text{net}}q \checkmark$$

$$1,35 \times 10^7 q \checkmark = E_{\text{net}}q$$

$$E_{\text{net}} = 1,35 \times 10^7 \text{ N} \cdot \text{C}^{-1} \checkmark \text{ to the right/na regs } \checkmark \text{ /towards B / na B}$$

(6)

[18]

**QUESTION 8/VRAAG 8**

- 8.1 (Maximum) energy provided (work done) ✓ by a battery per coulomb / unit charge passing through it. ✓  
 (Maksimum) energie verskaf (arbeid verrig) deur 'n battery per coulomb/eenheidlading wat daardeur beweeg.

**ACCEPT/AANVAAR:**

The reading on a voltmeter connected across a battery when there is no current/ in an open circuit. ✓✓

Lesing op 'n voltmeter oor 'n battery as daar geen stroom is nie

(2)

- 8.2 13 V ✓

(1)

- 8.3.1

$R = \frac{V}{I} \checkmark$ $5,6 = \frac{10,5}{I} \checkmark$ $I = 1,88 \text{ A} \checkmark (1,875 \text{ A})$	<b>Marking criteria/Nasienriglyne:</b> <ul style="list-style-type: none"> <li>• Appropriate formula/Toepaslike formule ✓</li> <li>• Whole substitution/Hele vervanging ✓</li> <li>• Final answer/Finale antwoord: 1,88 A ✓</li> </ul>
--	---

(3)

- 8.3.2

<b>POSITIVE MARKING FROM QUESTION 8.3.1.</b>	
<b>POSITIEWE NASIEN VANAF VRAAG 8.3.1</b>	
<b>OPTION 1</b> $P = VI \checkmark$ $= (10,5)(1,88) \checkmark$ $= 19,74 \text{ W} \checkmark (19,688 \text{ W})$	<b>OPTION 2</b> $P = I^2R \checkmark$ $= (1,88)^2(5,6) \checkmark$ $= 19,79 \text{ W} \checkmark (19,688 \text{ W})$
<b>OPTION 3</b> $P = \frac{V^2}{R} \checkmark$ $= \frac{10,5^2}{5,6} \checkmark$ $= 19,69 \text{ W} \checkmark (19,688 \text{ W})$	

(3)

- 8.3.3

<b>POSITIVE MARKING FROM QUESTIONS 8.2 AND 8.3.1.</b>	
<b>POSITIEWE NASIEN VANAF VRAAG 8.2 EN 8.3.1</b>	
<b>OPTION 1/OPSIE 1</b> $\mathcal{E} = I(R + r) \checkmark$ $13 = 1,88(5,6 + r) \checkmark$ $r = 1,31 \Omega \checkmark (1,31 - 1,33 \Omega)$	<b>OPTION 2/OPSIE 2</b> $r = \frac{V_{\text{internal}}}{I} \checkmark$ $= \frac{2,5}{1,88} \checkmark$ $= 1,33 \Omega \checkmark (1,31 - 1,33 \Omega)$
<b>OPTION 3/OPSIE 3</b> $\mathcal{E} = V_{\text{ext}} + V_{\text{int}}$ $13 = 10,5 + V_{\text{int}}$ $V_{\text{int}} = 2,5 \text{ V}$ $V_{\text{int}} = Ir \checkmark$ $2,5 = (1,88)r \checkmark$ $r = 1,31 \Omega \checkmark (1,31 - 1,33 \Omega)$	

(3)

8.4.1 Decreases/Neem af ✓

$V_{\text{internal resistance}}$ /Internal volts increase ✓  
 $V_{\text{interne weerstand}}$ /Interne volts neem toe

(2)

8.4.2

<b>Marking criteria/Nasienriglyne</b>			
<ul style="list-style-type: none"> <li>Formula/Formule <math>\mathcal{E} = I(R + r)</math> ✓</li> <li>Correct substitution into/ Korrekte vervanging in <math>\mathcal{E} = I(R + r)</math> ✓</li> <li>Substitution of values into <math>R_p</math> formula/Vervanging van waarde van <math>R_p</math> in formule ✓</li> <li>Halving value of <math>R_{2X}</math>/Halvering van waarde van <math>R_{2X}</math> ✓</li> <li>Final answer/Finale antwoord: <math>1,49 \Omega</math> ✓ Range/Gebied: <math>1,46 \Omega - 1,49 \Omega</math></li> </ul>			
<b>POSITIVE MARKING FROM QUESTIONS 8.2 AND 8.3.3</b>			
<b>POSITIEWE NASIEN VANAF VRAE 8.2 EN 8.3.3</b>			
<p><b>OPTION 1/OPSIE 1</b></p> $\mathcal{E} = I(R + r) \checkmark$ $13 = 4(R_{\text{ext}} + 1,31) \checkmark$ $R_{\text{ext}} = 1,94 \Omega \text{ (1,92 } \Omega)$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{1,94} = \frac{1}{5,6} + \frac{1}{R_2} \checkmark$ $R_2 = 2,97 \Omega \text{ (2,92 } \Omega)$ $X = \frac{1}{2}(2,97) \checkmark$ $= 1,49 \Omega \checkmark \text{ (1,46 - 1,49 } \Omega)$	<p><b>OPTION 2/OPSIE 2</b></p> $\mathcal{E} = I(R + r) \checkmark$ $13 = 4(R_{\text{ext}} + 1,31) \checkmark$ $R_{\text{ext}} = 1,94 \Omega \text{ (1,92 } \Omega)$ $R_p = \frac{R_1 R_2}{R_1 + R_2}$ $1,94 = \frac{5,6 R_2}{5,6 + R_2} \checkmark$ $R_2 = 2,97 \Omega \text{ (2,92 } \Omega)$ $X = \frac{1}{2}(2,97) \checkmark$ $= 1,49 \Omega \checkmark \text{ (1,46 - 1,49 } \Omega)$		
<p><b>OPTION 3/OPSIE 3</b></p> $\mathcal{E} = I(R + r) \checkmark$ $13 = 4(R_{\text{ext}} + 1,31) \checkmark$ $R_{\text{ext}} = 1,94 \Omega \text{ (1,92 } \Omega)$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ $\left[ \frac{1}{1,94} = \frac{1}{5,6} + \frac{1}{2X} \right] \checkmark$ $X = 1,49 \Omega \checkmark \text{ (1,46 - 1,49 } \Omega)$	<p><b>OPTION 4/OPSIE 4</b></p> $\mathcal{E} = I(R + r) \checkmark$ $13 = 4(R_{\text{ext}} + 1,31) \checkmark$ $R_{\text{ext}} = 1,94 \Omega \text{ (1,92 } \Omega)$ $R_p = \frac{R_1 R_2}{R_1 + R_2}$ $\left[ 1,94 = \frac{(5,6)(2X)}{5,6 + 2X} \right] \checkmark$ $X = 1,49 \Omega \checkmark$		
<p><b>OPTION 5/OPSIE 5</b></p> $\mathcal{E} = I(R + r) \checkmark$ $V_{\text{ext}} = 13 - (4)(1,31) \checkmark$ $= 7,76 \text{ V}$ $V_p = IR_{5,6}$ $7,76 = I(5,6)$ $I_{5,6\Omega} = 1,37 \text{ A}$ $I_T = I_{2X} + I_{5,6}$ $4 = I_{2X} + 1,37$ $I_{2X} = 2,63 \text{ A}$ $V = IR_{2X}$ $[7,76 = (2,63)2X] \checkmark$ $X = 1,46 \Omega \checkmark$	<p><b>OPTION 6/OPSIE 6</b></p> $\mathcal{E} = I(R + r) \checkmark$ $V_{\text{ext}} = 13 - (4)(1,31) \checkmark$ $V_{\text{ext}} = 7,76 \text{ V}$ $I_{5,6\Omega} = \frac{7,76}{5,6} = 1,39 \text{ A}$ $I_{2X} = 4 - 1,39 = 2,61 \text{ A}$ <table border="0" style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;"> <math display="block">V_{2X} = I_{2X}R_{2X}</math> <math display="block">[7,76 = (2,61)2X] \checkmark</math> <math display="block">2X = 2,97 \Omega</math> <math display="block">X = 1,49 \Omega \checkmark</math> </td> <td style="width: 50%; vertical-align: top;"> <math display="block">V_X = I_X R_X</math> <math display="block">3,88 \checkmark = (2,61)R_X \checkmark</math> <math display="block">R_X = 1,49 \Omega \checkmark</math> </td> </tr> </table>	$V_{2X} = I_{2X}R_{2X}$ $[7,76 = (2,61)2X] \checkmark$ $2X = 2,97 \Omega$ $X = 1,49 \Omega \checkmark$	$V_X = I_X R_X$ $3,88 \checkmark = (2,61)R_X \checkmark$ $R_X = 1,49 \Omega \checkmark$
$V_{2X} = I_{2X}R_{2X}$ $[7,76 = (2,61)2X] \checkmark$ $2X = 2,97 \Omega$ $X = 1,49 \Omega \checkmark$	$V_X = I_X R_X$ $3,88 \checkmark = (2,61)R_X \checkmark$ $R_X = 1,49 \Omega \checkmark$		

**OPTION 7/OPSIE 7**

$$\mathcal{E} = I(R + r) \checkmark$$

$$V_{\text{ext}} = \frac{13 - (4)(1,31)}{1} \checkmark$$

$$= 7,76 \text{ V}$$

$$V_{\text{ext}} = IR_{\text{ext}}$$

$$7,76 = (4) \left( \frac{1}{2X} + \frac{1}{5,6} \right)^{-1} \checkmark$$

$$X = 1,48 \Omega \checkmark$$

(5)  
[19]**QUESTION 9/VRAAG 9**

9.1

9.1.1 DC/GS ✓

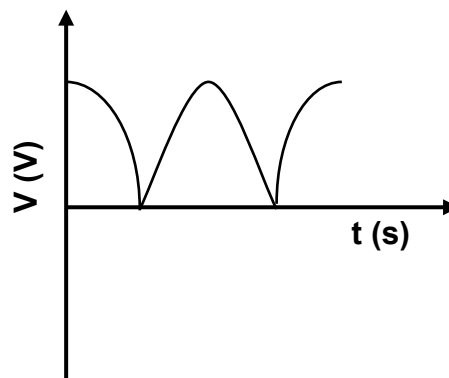
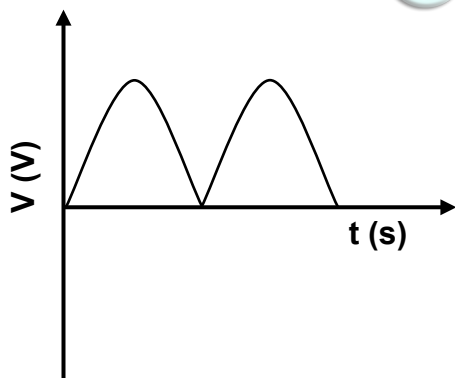
(1)

9.1.2

**NOTE:** -1 mark for each key word/phrase omitted in correct context.**LET WEL:** -1 punt vir elke sleutel woord/frase weggelaat in die korrekte konteks.Emf is induced as a result of change of magnetic flux (linked) with the coil. ✓✓*Emk word geïnduseer as gevolg van verandering van die magnetiese vloedkoppeling.*

(2)

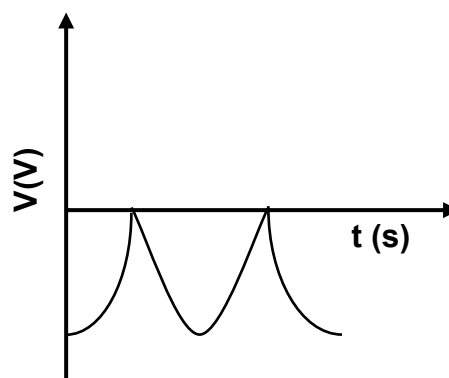
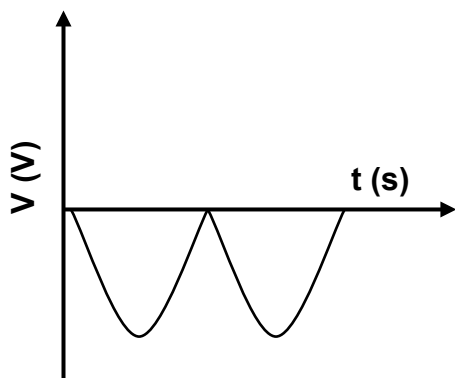
9.1.3

**POSITIVE MARKING FROM QUESTION 9.1.1****POSITIEWE NASIEN VANAF VRAAG 9.1.1**

OR/OF

**Marking criteria for graph:**

Correct shape <i>Korrekte vorm</i>	✓
One complete cycle/ <i>Een volledige siklus</i>	✓



(2)

9.2.1 The AC potential difference/voltage which dissipates the same amount of energy ✓ as DC potential difference. ✓

Die WS potensiaalverskil/spanning wat dieselfde hoeveelheid energie verbruik as GS potensiaalverskil/spanning

**OR/OF**

(The rms value of AC is) the DC potential difference/voltage which dissipates the same amount of energy ✓ as AC potential difference/voltage. ✓

Dit is die GS potensiaalverskil/spanning wat dieselfde hoeveelheid energie verbruik as WS potensiaalverskil/spanning.

(2)

9.2.2

<p><b>OPTION 1 / OPSIE 1</b></p> $W = \frac{V^2}{R} \Delta t \checkmark$ $500 = \frac{V^2}{200} (10) \checkmark$ $V = V_{rms} = 100 \text{ V}$ $V_{rms} = \frac{V_{max}}{\sqrt{2}} \checkmark$ $100 = \frac{V_{max}}{\sqrt{2}} \checkmark$ $V_{max} = 141,42 \text{ V} \checkmark$	<p><b>OPTION 2 / OPSIE 2</b></p> $W = I^2 R \Delta t$ $500 = I^2 (200)(10)$ $I = I_{rms} = 0,5 \text{ A}$ $P_{ave} = V_{rms} I_{rms} \checkmark$ $\frac{500}{10} = V_{rms} (0,5) \checkmark$ $V_{rms} = 100 \text{ V}$ $V_{rms} = \frac{V_{max}}{\sqrt{2}} \checkmark$ $100 = \frac{V_{max}}{\sqrt{2}} \checkmark$ $V_{max} = 141,42 \text{ V} \checkmark$	<p><b>OPTION 3 / OPSIE 3</b></p> $P_{ave} = I_{rms}^2 R$ $\frac{500}{10} = I_{rms}^2 (200)$ $I_{rms} = 0,5 \text{ A}$ $P_{ave} = V_{rms} I_{rms} \checkmark$ $\frac{500}{10} = V_{rms} (0,5) \checkmark$ $V_{rms} = 100 \text{ V}$ $V_{rms} = \frac{V_{max}}{\sqrt{2}} \checkmark$ $100 = \frac{V_{max}}{\sqrt{2}} \checkmark$ $V_{max} = 141,42 \text{ V} \checkmark$	<p><b>OPTION 4 / OPSIE 4</b></p> $R = \frac{V_{rms}}{I_{rms}} \checkmark$ $200 = \frac{V_{rms}}{0,5} \checkmark$ $V_{rms} = 100 \text{ V}$ $V_{rms} = \frac{V_{max}}{\sqrt{2}} \checkmark$ $100 = \frac{V_{max}}{\sqrt{2}} \checkmark$ $V_{max} = 141,42 \text{ V} \checkmark$
<p><b>OPTION 5 / OPSIE 5</b></p> $P_{ave} = \frac{V_{rms}^2}{R} \checkmark$ $\frac{500}{10} = \frac{V_{rms}^2}{200} \checkmark$ $V_{rms} = 100 \text{ V}$ $V_{rms} = \frac{V_{max}}{\sqrt{2}} \checkmark$ $100 = \frac{V_{max}}{\sqrt{2}} \checkmark$ $V_{max} = 141,42 \text{ V} \checkmark$	<p><b>OPTION 6 / OPSIE 6</b></p> $P_{ave} = \frac{P_{max}}{2} \checkmark$ $\frac{500}{10} = \frac{P_{max}}{2} \checkmark$ $P_{max} = 100 \text{ W}$ $P_{max} = \frac{V_{max}^2}{R} \checkmark$ $100 = \frac{V_{max}^2}{200} \checkmark$ $V_{max} = 141,42 \text{ V} \checkmark$	<p><b>OPTION 7 / OPSIE 7</b></p> $P = \frac{W}{\Delta t} = \frac{500}{10}$ $= 50 \text{ W}$ $P_{ave} = \frac{V_{rms}^2}{R} \checkmark$ $50 = \frac{V_{rms}^2}{200} \checkmark$ $V_{rms} = 100 \text{ V}$ $V_{rms} = \frac{V_{max}}{\sqrt{2}} \checkmark$ $100 = \frac{V_{max}}{\sqrt{2}} \checkmark$ $V_{max} = 141,42 \text{ V} \checkmark$	<p><b>OPTION 8 / OPSIE 8</b></p> $P_{ave} = I_{rms}^2 R \checkmark$ $\frac{500}{10} = I_{rms}^2 (200) \checkmark$ $I_{rms} = 0,5 \text{ A}$ $I_{rms} = \frac{I_{max}}{\sqrt{2}}$ $0,5 = \frac{I_{max}}{\sqrt{2}}$ $I_{max} = 0,71 \text{ A}$ $V_{max} = I_{max} R \checkmark$ $= (0,71)(200) \checkmark$ $= 142 \text{ V} \checkmark$

(5)

[12]

**QUESTION 10/VRAAG 10**

10.1

**Note:** -1 mark for each key word/phrase omitted in correct context.**Let Wel:** -1 punt vir elke sleutel woord/frase weggelaat in die korrekte konteks.

The process whereby electrons are ejected from a metal / surface when light (of suitable frequency) is incident on that surface. ✓✓

Die proses waarby elektrone vanaf 'n (metaal)oppervlak vrygestel word wanneer lig (van geskikte frekwensie) daarop skyn/inval. (2)

10.2

7,48 x 10<sup>-19</sup> (J) ✓E = W<sub>o</sub> + E<sub>k(max)</sub> (= W<sub>o</sub> + ½mv<sub>max</sub><sup>2</sup>) ✓

When/Wanneer E<sub>k(max)</sub> = 0 / v = 0 / v<sup>2</sup> = 0 / E = W<sub>o</sub> / W<sub>o</sub> is the y-intercept / is die y-afsnit ✓ (3)

10.3

Mass (of photo-electron)/Massa (van foto-elektron)/m ✓

**ACCEPT/AANVAAR:**

½m (1)

10.4

**OPTION 1/OPSIE 1**

Gradient = ½m

11,98 x 10<sup>-19</sup> / 7,48 x 10<sup>-19</sup> ✓

X - 0 ✓

= ½(9,11 x 10<sup>-31</sup>) ✓

X = 0,9879 ✓ (0,99 or 0,988)

**ACCEPT/AANVAAR**X = 0,9879 x 10<sup>12</sup> (m<sup>2</sup>·s<sup>-2</sup>)**POSITIVE MARKING FROM 10.2/POSITIEWE NASIEN VANAF 10.2****OPTION 2/ OPSIE 2**E = W<sub>o</sub> + E<sub>k(max)</sub> } ✓ Any one / Enige eenE = W<sub>o</sub> + ½mv<sub>(max)</sub><sup>2</sup> }11,98 x 10<sup>-19</sup> ✓ = 7,48 x 10<sup>-19</sup> ✓ + ½(9,11 x 10<sup>-31</sup>) v<sup>2</sup> ✓ [or/of ½(9,11 x 10<sup>-31</sup>)X]4,5 x 10<sup>-19</sup> = 4,56 x 10<sup>-31</sup>v<sup>2</sup>v<sup>2</sup> = 0,9868 x 10<sup>12</sup>X/v<sup>2</sup> = 0,9868 ✓ (0,99)Range/gebied (0,9868 – 0,9879 / 9,87 x 10<sup>11</sup> – 9,88 x 10<sup>11</sup>)**ACCEPT/AANVAAR:**X = 0,9868 x 10<sup>12</sup> (m<sup>2</sup>·s<sup>-2</sup>) / 9,868 x 10<sup>11</sup> (m<sup>2</sup>·s<sup>-2</sup>) (5)

10.5.1

Remains the same / Bly dieselfde ✓ (1)

10.5.2

Increases / Neem toe ✓ (1)

**[13]****TOTAL/TOTAAL:****150**