



education

Department of
Education
FREE STATE PROVINCE

EXAMINATION

GRADE 12

PHYSICAL SCIENCES
(PAPER 1: PHYSICS)

JUNE 2022

Stanmorephysics

MARKS: 150

TIME: 3 HOURS

This paper consists of 16 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.

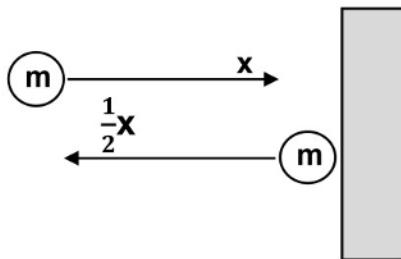
- 1.1 Two balls of masses $\frac{1}{2}m$ and $2m$ are dropped simultaneously from the same height above the ground. Ignore air resistance.



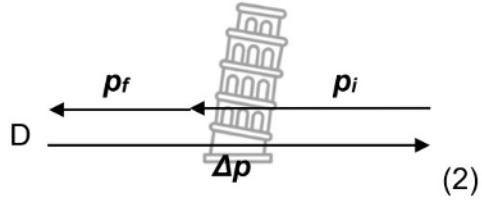
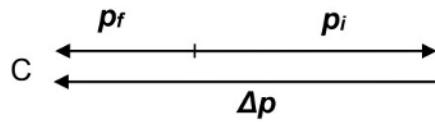
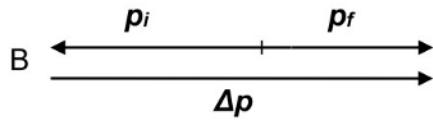
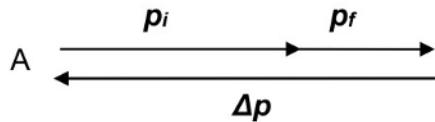
Which ONE of the following physical quantities will be the same for both balls when they strike the ground?

- A Weight
 - B Velocity
 - C Momentum
 - D Kinetic energy
- (2)

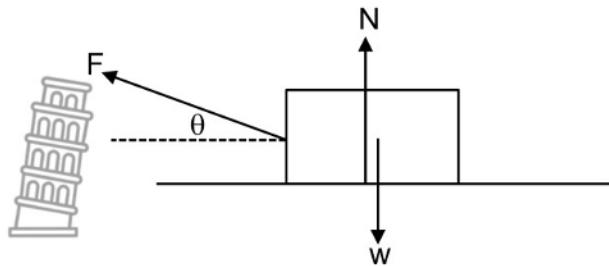
- 1.2 A tennis ball of mass m , travelling east at a velocity of $x \text{ m.s}^{-1}$, hits a wall and bounces back at a velocity of $\frac{1}{2}x \text{ m.s}^{-1}$ as shown below.



Which ONE of the following vector diagrams (not drawn to scale) correctly represents the relationship between initial, final and change in momentum of the tennis ball?



1.3 The diagram below shows the forces acting on a box.



Which ONE of the following equations is correct for the magnitude of the normal force (N)?

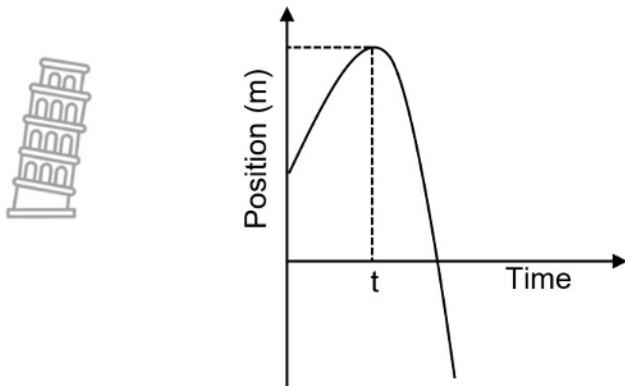
- A $N = w - F\sin\theta$
- B $N = w + F\sin\theta$
- C $N = w - F\cos\theta$
- D $N = w + F\cos\theta$ (2)

1.4 The product of the net force (resultant force) acting on an object and the time the net force acts on the object is the ...

- A power.
- B impulse.
- C momentum.
- D acceleration. (2)



- 1.5 A stone is projected vertically upwards from the top of a building at a speed of $v \text{ m}\cdot\text{s}^{-1}$. The position-time graph below represents the motion of the stone. Ignore the effects of air resistance.

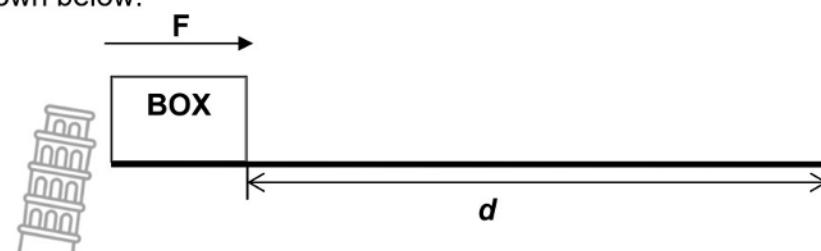


Which ONE of the following combinations regarding the magnitudes of the stone's velocity and acceleration, at time t , is correct?

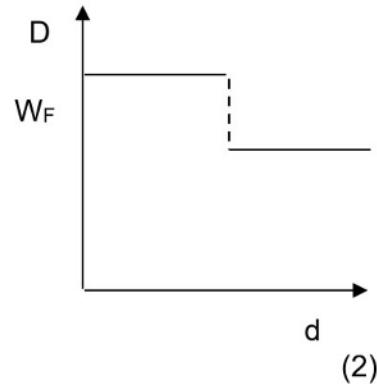
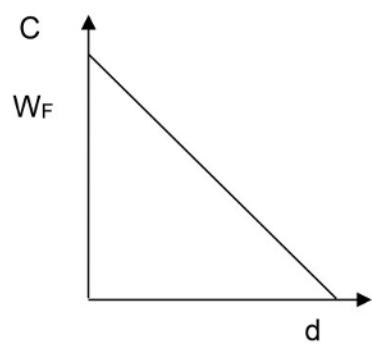
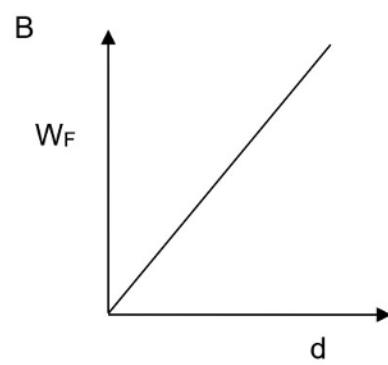
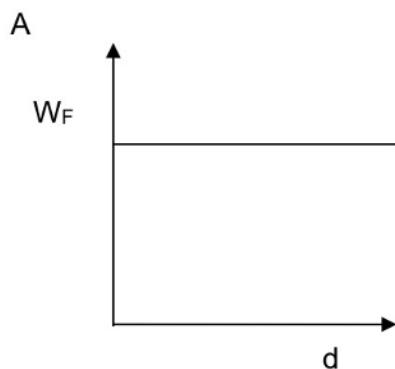
	Magnitude of velocity ($\text{m}\cdot\text{s}^{-1}$)	Magnitude of acceleration ($\text{m}\cdot\text{s}^{-2}$)
A	0	9,8
B	0	0
C	v	0
D	v	9,8

(2)

- 1.6 A constant force F is applied to move a box through a displacement d as shown below.

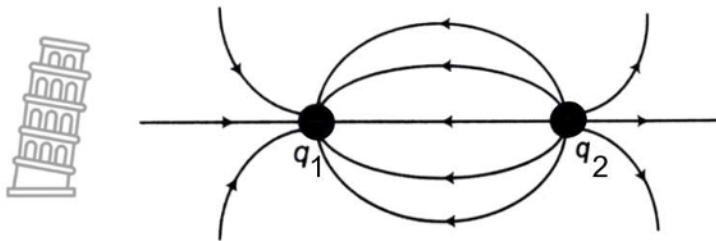


Which ONE of the following graphs shows how the work done by the constant force F (W_F) changes with displacement d ? Ignore friction.



(2)

- 1.7 Consider the electric field pattern of two point charges q_1 and q_2 below, with the three statements numbered (i), (ii), and (iii).



- (i) Both charges have equal magnitudes.
- (ii) Charges q_1 and q_2 are oppositely charged.
- (iii) Charge q_1 is positively charged and charge q_2 is negatively charged.

Which ONE of the following represents one or more INCORRECT statements?

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

- 1.8 Point charge **Z** is a distance x from point **P**. The electric field at **P** due to **Z** is E . What would be the electric field at a point that is HALF the distance of x from **Z**?

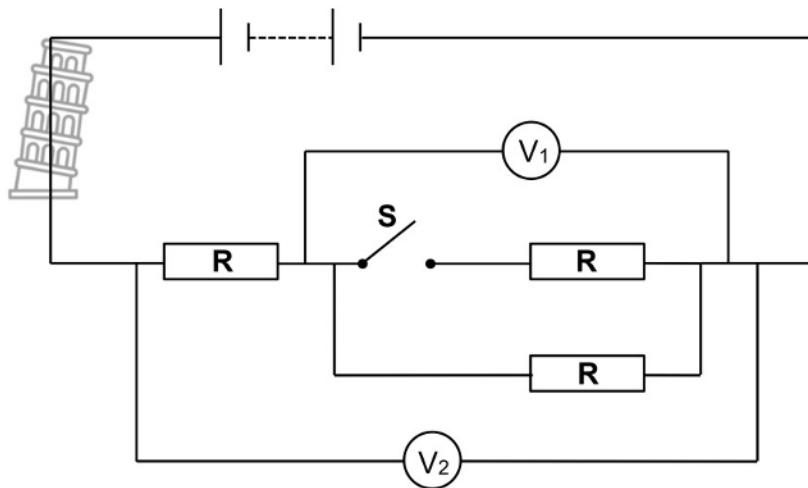
- A $\frac{1}{4}E$
 - B $\frac{1}{2}E$
 - C $2E$
 - D $4E$
- (2)

- 1.9 The minimum value of the resistance that can be obtained by connecting two $4\ \Omega$ resistors is ...

- A $1\ \Omega$.
 - B $2\ \Omega$.
 - C $3\ \Omega$.
 - D $4\ \Omega$.
- (2)



- 1.10 In the circuit diagram below, the three resistors are identical, each with a resistance R . Switch **S** is open and the battery has NEGLIGIBLE internal resistance. Ignore the resistance of the connecting wires.



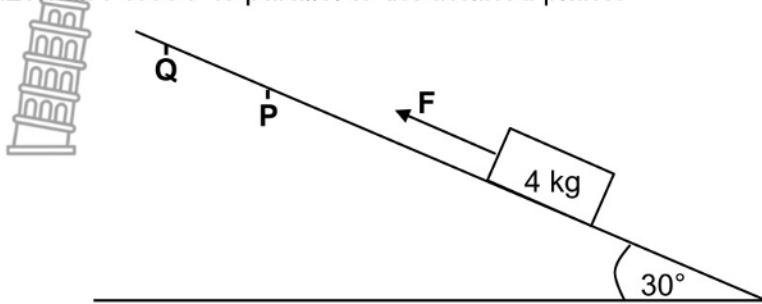
How will the readings on the voltmeters be influenced if switch **S** is closed?

	Voltmeter V_1	Voltmeter V_2
A	Decreases	Decreases
B	Increases	Increases
C	Decreases	Remains the same
D	Increases	Remains the same

(2)
[20]

QUESTION 2

- 2.1 A 4 kg block is pulled by a constant force F up a rough, inclined plane at a CONSTANT SPEED. The inclined plane makes an angle of 30° with the horizontal. Force F is parallel to the inclined plane.



2.1.1 State *Newton's First Law of Motion* in words. (2)

2.1.2 Draw a labelled free-body diagram for the block to show all the forces acting on it. (4)

A constant, kinetic frictional force of 12,5 N acts on the block.

2.1.3 Calculate the magnitude of force F . (5)

Force F is removed when the block reaches point **P**. The block continues to move up the inclined plane and comes to rest momentarily at point **Q**.

2.1.4 Identify the COMPONENTS of the net force on the block as it moves from **P** to **Q**. (2)

2.1.5 Calculate the magnitude of the acceleration of the block from **P** to **Q**. (4)

- 2.2 A satellite, mass 250 kg, is in a circular orbit a certain height above the surface of the earth. The earth exerts a gravitational force of $2,4 \times 10^3$ N on the satellite to keep it in its orbit.

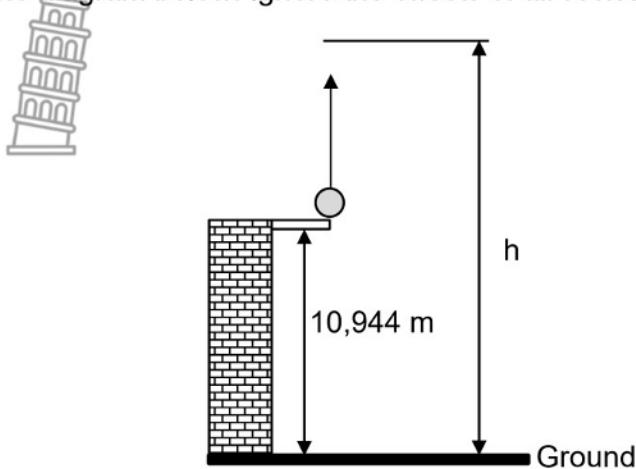
2.2.1 State *Newton's Law of Universal Gravitation* in words. (2)

2.2.2 Calculate the height of the satellite above the surface of the earth. (5) [24]



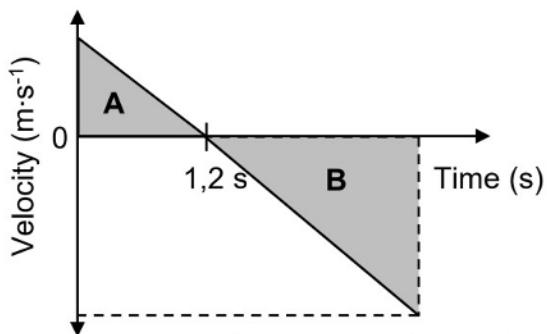
QUESTION 3

- 3.1 A ball is thrown vertically upwards from the top of a building, 10,944 m above the ground. The ball reaches a maximum height h above the ground as shown in the diagram below. Ignore the effects of air resistance.



- 3.1.1 Name the force acting on the ball while it is in free fall. (1)

The motion of the ball, from the instant it is thrown upwards until it hits the ground, is represented by the velocity-time graph below.



- 3.1.2 Consider the areas **A** and **B** shown in the graph above. Write down the numerical value of the physical quantity represented by the DIFFERENCE in areas **A** and **B**. (1)

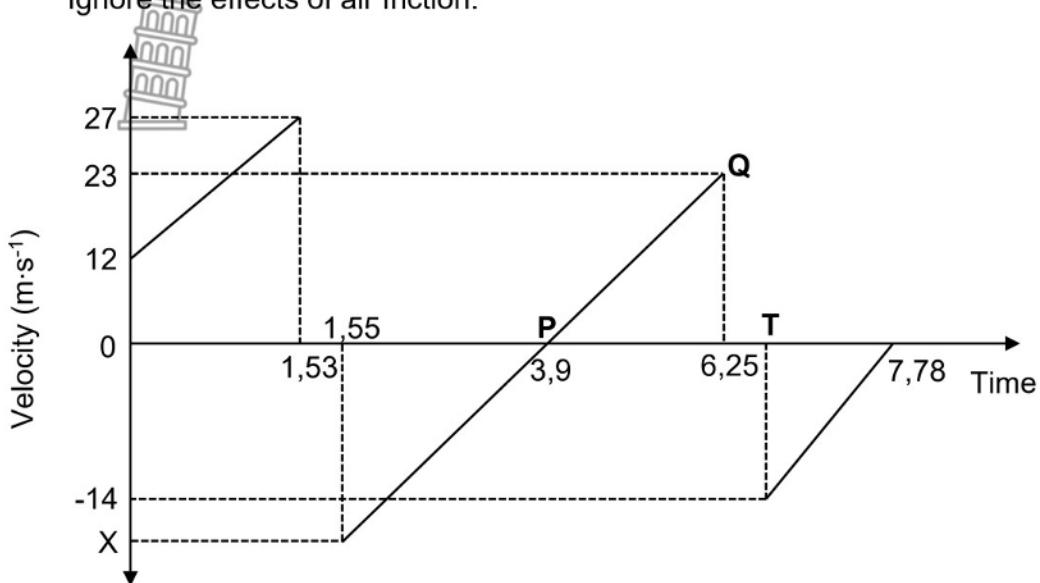
Calculate the:

- 3.1.3 Speed at which the ball is thrown upwards. (3)

- 3.1.4 Height, h , above the ground (4)



- 3.2 Another ball is THROWN VERTICALLY DOWNWARDS from the top of another building and bounces a few times as it hits the ground. The velocity-time graph below describes the motion of the ball from the time it is thrown, up until 7,78 s. Take DOWNWARDS AS THE POSITIVE DIRECTION and the ground as zero reference. The graph is NOT necessarily drawn to scale. Ignore the effects of air friction.



- 3.2.1 Write down the speed with which the ball is thrown downwards. (1)
- 3.2.2 All parts of the graph have the same gradient. Give a reason for this observation. (2)
- 3.2.3 Calculate the height from which the ball is thrown. (3)
- 3.2.4 Calculate the time T shown on the graph. (4)

Write down the following:

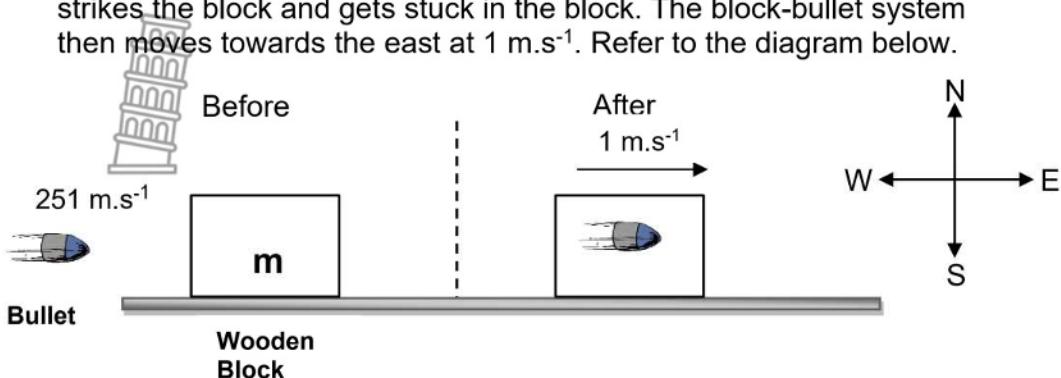
- 3.2.5 Number of times the ball has bounced. (1)
- 3.2.6 How long the ball is in contact with the ground during the first bounce. (1)
- 3.2.7 Time at which the ball reaches its maximum height after the first bounce. (1)
- 3.2.8 Direction in which the ball is moving between points **P** and **Q**. (1)

[23]

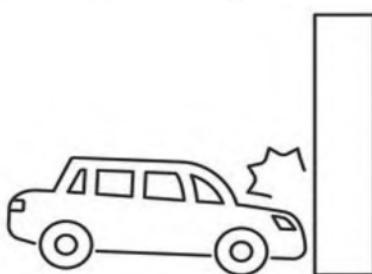


QUESTION 4

- 4.1 A wooden block of unknown mass m is at rest on a smooth, horizontal surface. A bullet of mass 0,02 kg, travelling east at a velocity of 251 m.s^{-1} , strikes the block and gets stuck in the block. The block-bullet system then moves towards the east at 1 m.s^{-1} . Refer to the diagram below.



- 4.1.1 State the principle of *conservation of linear momentum* in words. (2)
- 4.1.2 Calculate mass m of the wooden block. (5)
- 4.1.3 Use calculations to determine whether the collision is elastic or inelastic. (5)
- 4.2 A 90 kg woman drives her 2 410 kg car into a wall at 20 m.s^{-1} as shown below. Airbags have been proven to reduce the chances of serious injuries to drivers and passengers during collisions.



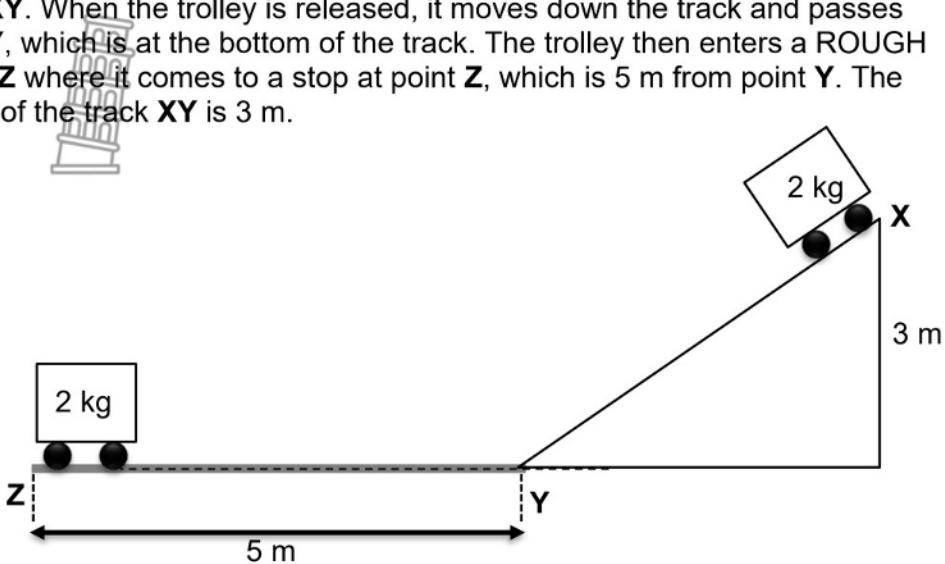
- 4.2.1 Explain, using physics' principles, how airbags can reduce the chances of serious injuries during collisions. (3)

It took the car 0,3 s to come to a stop during the collision.

- 4.2.2 Calculate the net force exerted by the wall on the car during the collision. (4)
- 4.2.3 Give the magnitude and direction of the net force the car exerts on the wall. (2)
- 4.2.4 Name a physics law or principle that you have used to answer QUESTION 4.2.3. (1)

QUESTION 5

A 2 kg trolley is held stationary at point **X**, which is at the top of a frictionless track **XY**. When the trolley is released, it moves down the track and passes point **Y**, which is at the bottom of the track. The trolley then enters a ROUGH path **YZ** where it comes to a stop at point **Z**, which is 5 m from point **Y**. The height of the track **XY** is 3 m.



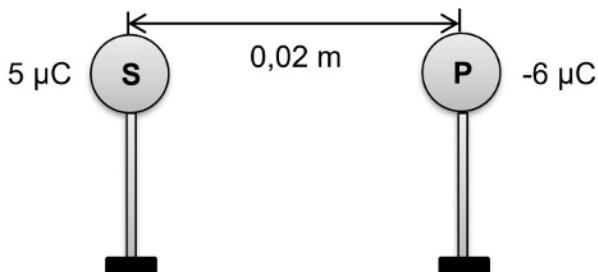
- 5.1 Is the system between points **X** and **Y** isolated? Write down YES or NO and give a reason for your answer. (2)
- 5.2 State the *principle of conservation of mechanical energy* in words. (2)
- 5.3 Calculate the speed of the trolley when it reaches point **Y**. (4)
- 5.4 Draw a free-body diagram showing ALL the forces acting on the trolley as it moves along path **YZ**. (3)
- 5.5 Define the term *non-conservative force*. (2)
- 5.6 Give the NAME of a conservative force acting on the trolley as it moves along path **YZ**. (1)
- 5.7 In which direction is the trolley accelerating as it moves along path **YZ**? Write down FROM **Y** TO **Z** OR FROM **Z** TO **Y**. Give a reason for your choice. (2)
- 5.8 Use energy principles ONLY to calculate the magnitude of the frictional force acting on the trolley as it moves along path **YZ**. (5)
[21]

QUESTION 6

- 6.1 A high-speed train is travelling at an unknown constant speed v when its horn emits a sound with a frequency f . A stationary man waiting at the station hears the frequency of the horn as $1,3f$. Take the speed of sound in air as $343 \text{ m}\cdot\text{s}^{-1}$.
- 
- 6.1.1 Is the train moving towards or away from the man? Give a reason for your answer. (2)
- 6.1.2 Calculate speed v at which the train is travelling. (5)
- 6.1.3 Give ONE application of the Doppler effect in medicine. (1)
- 6.2 Explain the term *red shift*. (2)
[10]

QUESTION 7

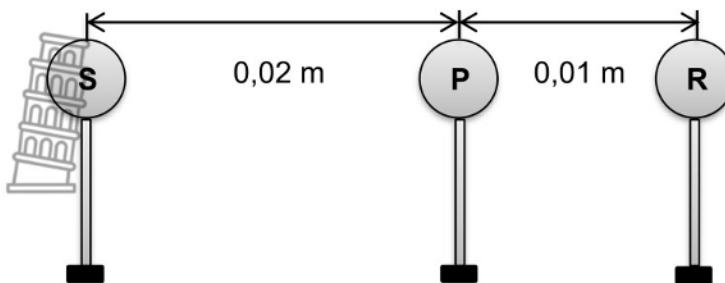
Two charged spheres, **S** and **P**, on insulated stands, with charges of $5 \mu\text{C}$ and $-6 \mu\text{C}$ respectively, are placed $0,02 \text{ m}$ apart, as shown in the diagram below.



- 7.1 State Coulombs' Law in words. (2)
- 7.2 Calculate the magnitude and direction of the electrostatic force that sphere **S** exerts on sphere **P**. (4)



Spheres **S** and **P** are brought into contact with each other and then returned to their original positions. A third, negatively charged, sphere **R** with an UNKNOWN charge is now placed 0,01 m to the right of sphere **P** as shown below.

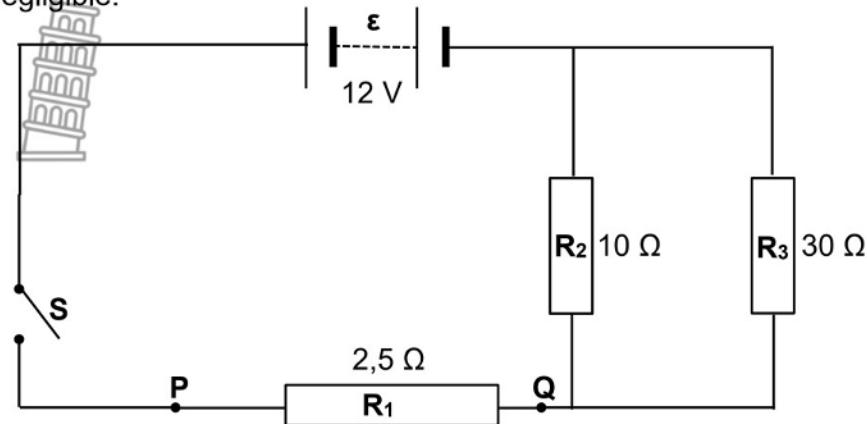


- 7.3 Calculate the magnitude of the NEW charge on **S** after being in contact with **P**. (1)
- 7.4 Draw a free-body diagram showing ALL the electrostatic forces experienced by **P**. (2)
- 7.5 The magnitude of the net electrostatic force experienced by **P** due to **S** and **R** is 84,375 N. Calculate the magnitude of the charge on **R**. (5)
- 7.6 Calculate the magnitude of the net electric field at a point 0,01 m to the LEFT of **R** due to the charges on **S** and **R**. (3)
[17]



QUESTION 8

A battery with an emf of 12 V and negligible internal resistance is connected to three resistors as shown in the circuit diagram below. The resistance of the connecting wires is negligible.



- 8.1 State *Ohm's law* in words. (2)

Switch **S** is closed.

- 8.2 How much energy does the battery transfer to each coulomb of charge? (1)

- 8.3 Calculate the following when switch **S** is closed:

- 8.3.1 The total resistance of the circuit (4)

- 8.3.2 The current in **R**₁ (4)

- 8.4 A wire, with negligible resistance, is used to connect points **P** and **Q**. How will this affect the TOTAL CURRENT in the circuit? Choose from INCREASES, DECREASES or REMAINS THE SAME. Explain the answer. (2)
[13]

GRAND TOTAL: 150

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

**GEGEWENS VIR FISIESE WTENSKAPPE GRAAD 12
 VRAESTEL 1 (FISIKA)**

TABLE 1: PHYSICAL CONSTANTS / TABEL 1: FISIESE KONSTANTES

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



TABLE 1: 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

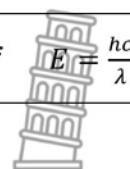
$F_{net} = ma$	$p = mv$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$	$w = mg$
$F = G \frac{m_1 m_2}{d^2}$ or/of $F = G \frac{m_1 m_2}{r^2}$	$g = G \frac{M}{d^2}$ or/of $g = G \frac{M}{r^2}$

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 $W_{nc} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{ave} = Fv_{ave}$ / $P_{gemiddeld} = Fv_{gemiddeld}$	

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/waar	



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

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

ALTERNATING CURRENT / WISSELSTROOM

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





education

Department of
Education
FREE STATE PROVINCE

EXAMINATION / EKSAMEN

GRADE 12 / GRAAD 12

PHYSICAL SCIENCES PAPER 1 FISIESE WETENSKAPPE VRAESTEL 1

MEMORANDUM

JUNE 2022 / JUNIE 2022

MARKS: 150 / PUNTE: 150

TIME: 3 HOURS / TYD: 3 UUR



This memorandum consists of 14 pages.
Hierdie memorandum bestaan uit 14 bladsye.

QUESTION 1 / VRAAG 1

1.1 B ✓✓

1.2 C ✓✓

1.3 A ✓✓

1.4 B ✓✓

1.5 A ✓✓

1.6 B ✓✓

1.7 B ✓✓

1.8 D ✓✓

1.9 B ✓✓

1.10 C ✓✓



[20]

Note about definitions, laws, and principles: Unless otherwise mentioned, one mark is forfeited if any of the underlined key words is omitted.

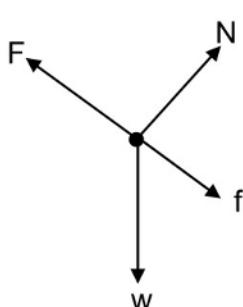
Aantekening omtrent definisies, wette en beginsels: Tensy anders aangedui, word een punt verbeur indien enige van die onderstreepte sleutelwoorde uitgelaat is.

QUESTION 2 / VRAAG 2

2.1.1 A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force acts on it. ✓✓

'n Liggaam sal in sy toestand van rus of beweging teen konstante snelheid volhard, tensy 'n nie-nul resulterende/netto krag daarop inwerk. (2)

2.1.2



Accepted labels / Aanvaarbare byskrifte

w	F _g /F _w /weight/mg / gravitational force
✓	F _g /F _w /gewig/mg/gravitasiekrag
F	F _T /T/tension/F _{applied} / Applied force
✓	F _T /T/spanning/F _{toegepas} / Toegepaste krag
f	(Kinetic) friction / F _f /12,5 N/f _k
✓	(Kinetiese) wrywing / F _f /12,5 N/f _k
N	F _{normal} /Normal/F _N
✓	F _{normaal} /Normaal/F _N

Notes/Aantekeninge

- Mark is awarded for label and arrow. / Punt word toegeteken vir byskrif en pyl.
- Do not penalise for length of arrows since drawing is not to scale.
Moenie vir die lengte van die pyle penaliseer nie aangesien die tekening nie volgens skaal is nie.
- Any other additional force(s) / Enige ander addisionele krag(te) Max/ Maks $\frac{3}{4}$
- Force(s) do not make contact with body:
Krag(te) maak nie met die voorwerp kontak nie: Max/Maks $\frac{3}{4}$

(4)

2.1.3

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

$$F + w_{\parallel} + f = ma$$

$$F - (4)(9,8)\sin 30^\circ \checkmark - 12,5 \checkmark = 0 \checkmark$$

$$F = 32,1 \text{ N} \checkmark$$



(5)

2.1.4 w_{\parallel} ✓ ; f ✓ (Words or correct symbols are fine.)

(Woorde of korrekte simbole is in orde.)

(2)

2.1.5

OPTION 1 / OPSIE 1

$$\begin{aligned} F_{\text{net}} &= ma \\ W_{\parallel} + f &= ma \\ -(4)(9,8)\sin 30^{\circ} - 12,5 \checkmark &= 4a \checkmark \\ a = -8,025 \text{ m}\cdot\text{s}^{-2} \checkmark & \\ \therefore \text{Magnitude/Grootte} &= 8,025 \text{ m}\cdot\text{s}^{-2} \checkmark \end{aligned}$$

OR: Underlined part = -32,1; positive marking from Q2.1.3.

OF: Onderstreepte deel = -32,1;
positiewe nasien vanaf V2.1.3.

OPTION 2 / OPSIE 2

$$\begin{aligned} F_{\text{net}} &= ma \\ W_{\parallel} + f &= ma \\ (4)(9,8)\sin 30^{\circ} + 12,5 \checkmark &= 4a \checkmark \\ a = +8,025 \text{ m}\cdot\text{s}^{-2} \checkmark & \\ \therefore \text{Magnitude/Grootte} &= 8,025 \text{ m}\cdot\text{s}^{-2} \checkmark \end{aligned}$$

OR: Underlined part = +32,1; positive marking from Q2.1.3.

OF: Onderstreepte deel = +32,1;
positiewe nasien vanaf V2.1.3.

(4)

- 2.2.1 Each **body** in the universe attracts every other **body** with a force that is directly proportional to the product of their masses ✓ and inversely proportional to the square of the distance between their centres. ✓

OR

Every **particle** in the universe attracts every other **particle** with a force that is directly proportional to the product of their masses ✓ and inversely proportional to the square of the distance between them. ✓

Elke liggaam in die heelal trek elke ander liggaam aan met 'n krag direk eweredig aan die produk van hul massas en omgekeerd eweredig aan die kwadraat van die afstand tussen hul middelpunte.

OF

Elke deeltjie in die heelal trek elke ander deeltjie aan met 'n krag direk eweredig aan die produk van hul massas en omgekeerd eweredig aan die kwadraat van die afstand tussen hulle.

(2)

2.2.2

OPTION 1 / OPSIE 1

$$\begin{aligned} F &= G \frac{m_1 m_2}{r^2} \checkmark \\ 2,4 \times 10^3 \checkmark &= \frac{(6,67 \times 10^{-11})(250)(5,98 \times 10^{24})}{r^2} \checkmark \\ r = 6,4458 \times 10^6 \text{ m} & \end{aligned}$$

$$\begin{aligned} r &= R_E + h \\ 6,4458 \times 10^6 &= 6,38 \times 10^6 + h \checkmark \\ h &= 6,58 \times 10^4 \text{ m} \checkmark \end{aligned}$$

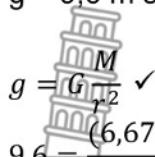


OPTION 2 / OPSIE 2

$$w = mg$$

$$2,4 \times 10^3 = 250\text{g} \checkmark$$

$$g = 9,6 \text{ m}\cdot\text{s}^{-2}$$



$$g = \frac{G}{r^2} \checkmark$$

$$9,6 = \frac{(6,67 \times 10^{-11})(5,98 \times 10^{24})}{r^2} \checkmark$$

$$r = 6,4458 \times 10^6 \text{ m}$$

$$r = R_E + h$$

$$6,4458 \times 10^6 = 6,38 \times 10^6 + h \checkmark$$

$$h = 6,58 \times 10^4 \text{ m} \checkmark$$

(5)
[24]

QUESTION 3 / VRAAG 3

- 3.1.1 Weight/Gravity / Gravitational force. ✓
 Gewig/Gravitasie/Gravitasiekrag/Swaartekrag

(1)

- 3.1.2 10,944 (m) ✓

(1)

3.1.3

OPTION 1 / OPSIE 1

Upwards + / Opwaarts +

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

$$0 = v_i + (-9,8)(1,2) \checkmark$$

$$v_i = 11,76 \text{ m}\cdot\text{s}^{-1}$$

$$\therefore \text{speed/spoed} = 11,76 \text{ m}\cdot\text{s}^{-1} \checkmark$$

OPTION 2 / OPSIE 2

Downwards + / Afwaarts +

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

$$0 = v_i + (9,8)(1,2) \checkmark$$

$$v_i = -11,76 \text{ m}\cdot\text{s}^{-1}$$

$$\therefore \text{speed/spoed} = 11,76 \text{ m}\cdot\text{s}^{-1} \checkmark$$

(3)

- 3.1.4 POSITIVE MARKING FROM 3.1.3. / POSITIEWE NASIEN VANAF 3.1.3.

OPTION 1 / OPSIE 1

Upwards + / Opwaarts +

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

$$0 = 11,76^2 + 2(-9,8)\Delta y \checkmark$$

$$\Delta y = 7,056 \text{ m}$$

$$h = 7,056 + 10,944 \checkmark = 18 \text{ m} \checkmark$$

OPTION 2 / OPSIE 2

Downwards + / Afwaarts +

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

$$0^2 = (-11,76)^2 + 2(9,8)\Delta y \checkmark$$

$$\Delta y = -7,056 \text{ m}$$

$$h = 7,056 + 10,944 \checkmark = 18 \text{ m} \checkmark$$

OPTION 3 / OPSIE 3

Upwards + / Opwaarts +

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

$$= (11,76)(1,2) + \frac{1}{2}(-9,8)(1,2^2) \checkmark$$

$$= 7,056 \text{ m}$$

$$h = 7,056 + 10,944 \checkmark = 18 \text{ m} \checkmark$$

OPTION 4 / OPSIE 4

Downwards + / Afwaarts +

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

$$= (-11,76)(1,2) + \frac{1}{2}(9,8)(1,2^2) \checkmark$$

$$= -7,056 \text{ m}$$

$$h = 7,056 + 10,944 \checkmark = 18 \text{ m} \checkmark$$

(4)

Note about question 3.2: Downward as positive was given.

Aantekening omtrent vraag 3.2: Afwaarts as positief is gegee.

3.2.1 $12 \text{ m}\cdot\text{s}^{-1}$ ✓ (1)

- 3.2.2 The (gravitational) acceleration ✓ of the object remains constant. ✓ OR
 The gradient of the graph ✓ represents the (gravitational) acceleration of the object. ✓



Die (gravitasie)versnelling van die voorwerp bly konstant. **OF**
 Die gradiënt van die grafiek verteenwoordig die (gravitasie)versnelling van die voorwerp. (2)

3.2.3	OPTION 1 / OPSIE 1	OPTION 2 / OPSIE 2
	$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $27^2 = 12^2 + 2(9,8)\Delta y$ ✓ $\Delta y = 29,85 \text{ m}$ ✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $\Delta y = (12)(1,53) + \frac{1}{2}(9,8)(1,53)^2$ ✓ $= 29,83 \text{ m}$ ✓
OPTION 3 / OPSIE 3	OPTION 4 / OPSIE 4	
$\Delta y = \left[\frac{v_i + v_f}{2} \right] \Delta t$ ✓ $= \left[\frac{12 + 27}{2} \right] (1,53)$ ✓ $= 29,84 \text{ m}$ ✓	Similar correct formulae are acceptable. <i>Soortgelyke korrekte formules is aanvaarbaar.</i>	$h = \frac{1}{2}(\text{ewewydige sye})(\Delta t)$ $h = \frac{1}{2}(\text{parallel sides})(\Delta t)$ ✓ $= \frac{1}{2}(12 + 27)(1,53)$ ✓ $= 29,84 \text{ m}$ ✓

(3)

3.2.4 $v_f = v_i + a\Delta t$ ✓
 $0 = -14 + (9,8)\Delta t$ ✓
 $\Delta t = 1,4286 \text{ s}$ (1,43 s)
 $T = 7,78 - 1,4286$ ✓ = 6,3514 s ✓ (6,35 s) (4)

3.2.5 2 ✓ (1)

3.2.6 0,02 s ✓ (1)

3.2.7 3,9 s ✓ (1)

3.2.8 Downwards ✓ / Afwaarts (1)
 [23]



QUESTION 4 / VRAAG 4

- 4.1.1 The total linear momentum of an isolated system remains constant / is conserved. ✓✓ [Note: "closed system" is not acceptable.]

Die totale lineêre momentum in 'n geïsoleerde sisteem bly konstant / behoue. [Aantekening: "geslote sisteem" is nie aanvaarbaar nie.]

(2)

4.1.2

OPTION 1 / OPSIE 1	OPTION 2 / OPSIE 2
East + / Oos + $\Sigma p_i = \Sigma p_f$ ✓ $m_1 v_{i1} + m_2 v_{i2} = (m_1 + m_2) v_f$ $(0,02)(251) \checkmark + 0 \checkmark = (0,02 + m)(1) \checkmark$ $m = 5 \text{ kg}$ ✓	West + / Wes + $\Sigma p_i = \Sigma p_f$ ✓ $m_1 v_{i1} + m_2 v_{i2} = (m_1 + m_2) v_f$ $(-0,02)(251) \checkmark + 0 \checkmark = (0,02 + m)(-1) \checkmark$ $m = 5 \text{ kg}$ ✓

(5)

4.1.3 POSITIVE MARKING FROM 4.1.2. / POSITIEWE NASIEN VANAF 4.1.2.

$$\begin{aligned}
 \Sigma E_{ki} &= \frac{1}{2} m_1 v_{i1}^2 + \frac{1}{2} m_2 v_{i2}^2 & \Sigma E_{kf} &= \frac{1}{2} (m_1 + m_2) v_f^2 \\
 &= \frac{1}{2} (5)(0)^2 + \frac{1}{2} (0,02)(251)^2 \checkmark & &= \frac{1}{2} (5 + 0,02)(1)^2 \checkmark \\
 &= 630,01 \text{ J} & &= 2,51 \text{ J}
 \end{aligned}$$

Inelastic / Onelasties ✓

Note: If learners start with $\Sigma E_{ki} = \Sigma E_{kf}$:
 Maximum 2/5 for correct substitutions for "before" and "after."

Aantekening: Indien leerders begin met $\Sigma E_{ki} = \Sigma E_{kf}$:
 Maksimum 2/5 vir korrekte instellings vir "voor" en "na".

(5)

- 4.2.1 • $F_{net} = \frac{\Delta p}{\Delta t}$ ✓
 • Δt increases ✓ due to the airbags.
 • F_{net} decreases for the same Δp. ✓
 OR F_{net} decreases because $F \propto \frac{1}{\Delta t}$.

The indirect proportionality must be mentioned instead of "same Δp" to earn the third mark.

- $F_{net} = \frac{\Delta p}{\Delta t}$ ✓
 • Δt neem toe ✓ a.g.v. die lugsakke.
 • F_{net} verminder vir dieselfde Δp. ✓
 OR F_{net} verminder omdat F ∝ 1/Δt.

Die omgekeerde eweredigheid moet genoem word in plaas van "dieselde Δp" om die derde punt te verdien.

(3)

4.2.2

OPTION 1 / OPSIE 1	OPTION 2 / OPSIE 2
Right + / Regs + $F_{net} \Delta t = \Delta p \checkmark$ $F_{net}(0,3) \checkmark = (2500)(0 - 20) \checkmark$ $F_{net} = -1,667 \times 10^5 N$  $F_{net} = 1,667 \times 10^5 N$, left / backwards / away from the wall / opposite to the car's direction of motion \checkmark links / terugwaarts / weg vanaf die muur / teenoorgesteld aan die motor se bewegingsrigting	Left + / Links + $F_{net} \Delta t = \Delta p \checkmark$ $F_{net}(0,3) \checkmark = (2500)(0 - (-20)) \checkmark$ $F_{net} = +1,667 \times 10^5 N$ 
OPTION 3 / OPSIE 3	OPTION 4 / OPSIE 4
Right + / Regs + $a = \frac{\Delta v}{\Delta t}$ $= \frac{0 - 20}{0,3} \checkmark$ $= -66,667 m \cdot s^{-2}$ $F_{net} = ma \checkmark$ $= (2500)(-66,667) \checkmark$ $= -1,667 \times 10^5 N$ <div style="border: 1px solid black; padding: 5px; display: inline-block;"> OR/OF $v_f = v_i + a\Delta t$ </div>	Left + / Links + $a = \frac{\Delta v}{\Delta t}$ $= \frac{0 - (-20)}{0,3} \checkmark$ $= +66,667 m \cdot s^{-2}$ $F_{net} = ma \checkmark$ $= (2500)(66,667) \checkmark$ $= 1,667 \times 10^5 N$ <div style="border: 1px solid black; padding: 5px; display: inline-block;"> OR/OF $v_f = v_i + a\Delta t$ </div> $F_{net} = 1,667 \times 10^5 N$, left / backwards / away from the wall / opposite to the car's direction of motion \checkmark links / terugwaarts / weg vanaf die muur / teenoorgesteld aan die motor se bewegingsrigting

(4)

4.2.3 POSITIVE MARKING FROM 4.2.2 FOR MAGNITUDE

POSITIEWE NASIEN VANAF 4.2.2 VIR GROOTTE

$$1,667 \times 10^5 N \checkmark$$

right / forward / towards the wall / same as the car's direction of motion \checkmark

regs / voorwaarts / na die muur toe / dieselfde as die motor se

bewegingsrigting

(2)

4.2.4 Newton's third law of motion \checkmark / Newton se derde bewegingswet

(1)

[22]



QUESTION 5 / VRAAG 5

5.1 NEGATIVE MARKING. / NEGATIEWE NASIEN.

Yes ✓ There is no friction on the trolley. / Only weight is doing work on the trolley. ✓

Ja Daar is geen wrywing op die trollie nie. / Slegs gewig verrig arbeid op die trollie. (2)

5.2 Note: The term "closed" is not acceptable here.

Aantekening: Die term "geslote" is nie hier aanvaarbaar nie.

The total mechanical energy (sum of kinetic energy and gravitational potential energy) in an isolated system remains constant. ✓✓

Die totale meganiese energie (som van gravitasie-potensiële energie en kinetiese energie) in 'n geïsoleerde sisteem bly konstant. (2)

5.3

OPTION 1 / OPSIE 1

$$E_m(X) = E_m(Y) \checkmark$$

$$mgh + \frac{1}{2}mv^2 = mgh + \frac{1}{2}mv^2$$

$$(2)(9,8)(3) + \frac{1}{2}(2)(0)^2 \checkmark = (2)(9,8)(0) + \frac{1}{2}(2)v_y^2 \checkmark$$

$$v_y = 7,668 \text{ m.s}^{-1} \checkmark$$

OPTION 2 / OPSIE 2

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

$$mg\Delta y \cos\theta = K_f - K_i$$

$$(2)(9,8)(3)(\cos 0^\circ) \checkmark = \frac{1}{2}(2)v_y^2 - 0 \checkmark$$

$$v_y = 7,668 \text{ m.s}^{-1} \checkmark$$

OPTION 4 / OPSIE 4

$$\text{Down} + / \text{Af} +$$

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

$$= 0^2 \checkmark + 2(9,8)(3) \checkmark$$

$$v_y = 7,668 \text{ m.s}^{-1} \checkmark$$

OPTION 3 / OPSIE 3

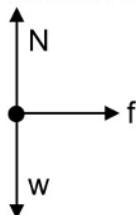
$$W_{nc} = \Delta K + \Delta U \checkmark$$

$$0 \checkmark = \left[\frac{1}{2}(2)v_y^2 - 0 \right] + [0 - (2)(9,8)(3)] \checkmark$$

$$v_y = 7,668 \text{ m.s}^{-1} \checkmark$$

(4)

5.4 Notes: As for Q2.1.2. / Aantekeninge: Soos vir V2.1.2.



Accepted labels / Aanvaarbare byskrifte	
w ✓	F_g/F_w /weight/mg / gravitational force
f ✓	(Kinetic) friction / F_f/f_k
N ✓	F_{normal}/F_N /Normal force
	$F_{normaal}/F_N$ /Normaal/F _N



(3)

- 5.5 A force for which the work done in moving an object between two points depends on the path taken.✓✓

'n Krag waarvoor die arbeid verrig om 'n voorwerp tussen twee punte te beweeg, afhanglik is van die roete wat gevolg word.

(2)

- 5.6 **NOTE:** No mark if the symbol is given.

Aantekening: Geen punt as die simbool gegee is.

Gravitational force / Gravity/Weight ✓

Swaartekrag/Gravitasiekrag/Gewig

(1)

- 5.7 **NEGATIVE MARKING. / NEGATIEWE NASIEN.**

Z to Y ✓

Speed/velocity of the trolley decreases. ✓

OR The net force on the trolley is from Z to Y.

OR The net force on the trolley has the same direction as the (force of) friction on the trolley.

Z na Y

Spoed/snelheid van die trollie verminder.

OF Die netto krag op die trollie is van Z na Y.

Of Die netto krag op die trollie het dieselfde rigting as die wrywing(skrag) op die trollie.

(2)



5.8 POSITIVE MARKING FROM 5.3. / POSITIEWE NASIEN VANAF 5.3.

OPTION 1 / OPSIE 1

$$\begin{aligned}
 W_{\text{net}} &= \Delta K \checkmark \\
 W_f &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\
 f\Delta x \cos\theta &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\
 f(5)(\cos 180^\circ) \checkmark &= \frac{1}{2}(2)(0^2) \checkmark - \frac{1}{2}(2)(7,668^2) \checkmark \\
 f &= 11,7596 \text{ N} \checkmark
 \end{aligned}$$

OPTION 2 / OPSIE 2

$$\begin{aligned}
 W_{\text{net}} &= \Delta K \checkmark \\
 W_f &= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \\
 &= \frac{1}{2}(2)(0^2) \checkmark - \frac{1}{2}(2)(7,668^2) \checkmark \\
 &= -58,798 \text{ J}
 \end{aligned}$$

$$\begin{aligned}
 W_f &= f\Delta x \cos\theta \\
 -58,798 &= f(5)(\cos 180^\circ) \checkmark \\
 f &= 11,7596 \text{ N} \checkmark
 \end{aligned}$$

OPTION 3 / OPSIE 3

$$\begin{aligned}
 W_{\text{nc}} &= \Delta K + \Delta U \checkmark \\
 W_f &= \left(\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2\right) + 0 \\
 f(5)(\cos 180^\circ) \checkmark &= \frac{1}{2}(2)(0^2) - \frac{1}{2}(2)(7,668^2) \checkmark + 0 \checkmark \\
 f &= 11,7596 \text{ N} \checkmark
 \end{aligned}$$

OPTION 4 / OPSIE 4

$$\begin{aligned}
 W_f &= f\Delta x \cos\theta \checkmark \\
 -\cancel{(2)(9,8)(3)} \checkmark &= f(5)(\cos 180^\circ) \checkmark \\
 f &= 11,76 \text{ N} \checkmark
 \end{aligned}$$

(5)
[21]



QUESTION 6 / VRAAG 6

6.1.1 NEGATIVE MARKING / NEGATIEWE NASIEN

Towards ✓

The observed frequency is higher than the actual/source frequency. ✓

OR $f_L > f_s$

Nader aan

Die waargenome frekwensie is hoër as die werklike/bron frekwensie.

OF $f_L > f_s$

(2)

6.1.2

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s \checkmark$$

$$1,3f \checkmark = \left[\frac{343}{343 - v_s} \right] \checkmark f \checkmark$$

$$v_s = 79,1538 \text{ m} \cdot \text{s}^{-1} \checkmark$$

(5)

6.1.3 To measure the heartbeat of a foetus. ✓

OR To measure rate of blood flow.

OR Correct alternative.

Om die hartklop van 'n fetus te monitor.

OF Om die tempo van bloedvloei te meet.

OF Korrekte alternatief.

(1)

6.2 The red shift is the movement of the spectral lines (of light) towards the red end ✓ of the spectrum with longer wavelengths/smaller frequency. ✓

Die rooi verskuiwing is die beweging van die spektraallyne (van lig) na die rooi kant van die spektrum met langer golflengtes/kleiner frekwensies. (2)

[10]



QUESTION 7 / VRAAG 7

- 7.1 The magnitude of the electrostatic force exerted by one point charge (Q_1) on another point charge (Q_2) is directly proportional to the product of the magnitude of the charges and inversely proportional to the square of the distance between them. ✓

Die grootte van die elektrostasiese krag wat een puntlading (Q_1) op 'n ander puntlading (Q_2) uitoefen, is direk eweredig aan die produk van die groottes van die ladings en omgekeerd eweredig aan die kwadraat van die afstand (r) tussen hulle.

(2)

7.2

$$\begin{aligned} F &= \frac{kQ_1Q_2}{r^2} \checkmark \\ &= \frac{(9 \times 10^9)(5 \times 10^{-6})(6 \times 10^{-6})}{0,02^2} \checkmark \\ &= 675 \text{ N} \\ F &= 675 \text{ N towards S OR attractive } \checkmark \\ &\quad \text{na S toe OF aantrekend} \end{aligned}$$

(4)

7.3

$$\begin{aligned} Q_S &= \frac{5 \mu\text{C} + (-6 \mu\text{C})}{2} \\ &= -0,5 \mu\text{C} \checkmark \end{aligned}$$

OR/OF

$$\begin{aligned} Q_S &= \frac{5 \times 10^{-6} \text{ C} + (-6 \times 10^{-6} \text{ C})}{2} \\ &= -5 \times 10^{-7} \text{ C} \checkmark \end{aligned}$$

(1)

7.4

$$\begin{array}{c} F_{RP} \checkmark \\ \longleftrightarrow \\ F_{SP} \checkmark \end{array}$$

(2)

7.5

OPTION 1 / OPSIE 1

$$\begin{aligned} F_{RP} &= \frac{kQ_RQ_P}{r^2} \\ &= \frac{(9 \times 10^9)(5 \times 10^{-7})Q_R}{0,01^2} \checkmark \\ &= 4,5 \times 10^7 Q_R \end{aligned}$$

$$\begin{aligned} F_{SP} &= \frac{kQ_SQ_P}{r^2} \\ &= \frac{(9 \times 10^9)(5 \times 10^{-7})(5 \times 10^{-7})}{0,02^2} \checkmark \\ &= 5,625 \text{ N} \end{aligned}$$

For the **net force to the left**, with **right positive**:
Vir die netto krag na links, met regs positief:

$$\begin{aligned} F_{\text{net}} &= F_{RP} + F_{SP} \\ -84,375 \checkmark &= (-4,50 \times 10^7)Q_R + 5,625 \checkmark \\ Q_R &= 2 \times 10^{-6} \text{ C} \checkmark \end{aligned}$$

OR/OF

For the **net force to the left**, with **left positive**:
Vir die netto krag na links, met links positief:

$$\begin{aligned} F_{\text{net}} &= F_{RP} + F_{SP} \\ 84,375 \checkmark &= (4,50 \times 10^7)Q_R + (-5,625) \checkmark \\ Q_R &= 2 \times 10^{-6} \text{ C} \checkmark \end{aligned}$$



Max 3/5 for option 2. The net force cannot be to the right. Test it by using the value of Q_R to calculate the net force. It differs from the given value in the question paper.

Maks 3/5 vir opsie 2. Die netto krag kan nie na regs wees nie. Toets dit deur die waarde van Q_R te gebruik om die netto krag te bereken. Dit verskil van die gegewe waarde in die vraestel.

OPTION 2 / OPSIE 2

$$\begin{aligned} F_{RP} &= \frac{kQ_R Q_P}{r^2} \\ &= \frac{(9 \times 10^9)(5 \times 10^{-7})Q_R}{0,01^2} \checkmark \\ &= 4,5 \times 10^7 Q_R \end{aligned}$$

$$\begin{aligned} F_{SP} &= \frac{kQ_S Q_P}{r^2} \\ &= \frac{(9 \times 10^9)(5 \times 10^{-7})(5 \times 10^{-7})}{0,02^2} \checkmark \\ &= 5,625 N \end{aligned}$$

For the **net force to the right, with right positive:**
Vir die netto krag na regs, met regs positief:

$$\begin{aligned} F_{\text{net}} &= F_{RP} + F_{SP} \\ 84,375 &= (-4,50 \times 10^7)Q_R + 5,625 \checkmark \\ Q_R &= -1,75 \times 10^{-6} C \end{aligned}$$

OR/OF

For the **net force to the right, with left positive:**
Vir die netto krag na links, met links positief:

$$\begin{aligned} F_{\text{net}} &= F_{RP} + F_{SP} \\ -84,375 &= (4,50 \times 10^7)Q_R + (-5,625) \checkmark \\ Q_R &= -1,75 \times 10^{-6} C \checkmark \end{aligned}$$

(5)

7.6 POSITIVE MARKING FROM 7.3. / POSITIEWE NASIEN VANAF 7.3.

$$\begin{aligned} E_{\text{net}} &= \frac{F_{\text{net}}}{Q_P} \checkmark \\ &= \frac{84,375}{5 \times 10^{-7}} \checkmark \\ &= 1,6875 \times 10^8 N \cdot C^{-1} \checkmark \end{aligned}$$

(3)
 [17]



QUESTION 8 / VRAAG 8

- 8.1 The potential difference across a conductor is directly proportional to the current in the conductor ✓ at constant temperature. ✓

Die potensiaalverskil oor 'n geleier is direk eweredig aan die stroom in die geleier by konstante temperatuur. (2)

- 8.2 12 J ✓ (1)

8.3.1

$\frac{1}{R_p} = \frac{1}{R_2} + \frac{1}{R_3} \quad \checkmark$ $\frac{1}{R_p} = \frac{1}{10} + \frac{1}{30} \quad \checkmark$ $R_p = 7,5 \Omega$	OR/OF	$R_p = \frac{R_2 \times R_3}{R_2 + R_3} \quad \checkmark$ $= \frac{10 \times 30}{10 + 30} \quad \checkmark$ $= 7,5 \Omega$
		$R_T = R_p + R_1$ $= 7,5 + 2,5 \quad \checkmark$ $= 10 \Omega \quad \checkmark$

(4)

- 8.3.2 POSITIVE MARKING FROM 8.3.1. / POSITIEWE NASIEN VANAF 8.3.1.

$R = \frac{V}{I} \quad \checkmark$ $10 \quad \checkmark = \frac{12}{I_{R1}} \quad \checkmark$ $I_{R1} = 1,2 A \quad \checkmark$

(4)

- 8.4 NEGATIVE MARKING. / NEGATIEWE NASIEN.

I_T increases ✓ because total resistance decreases ✓.

I_T neem toe (toeneem) omdat totale weerstand afneem.

(2)
[13]

GRAND TOTAL / GROOTTOTAAL: 150

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Addendum

3.1.4



$$\begin{aligned} \text{Area of } A &= \frac{1}{2}bh \\ &= \frac{1}{2}(11,76)(1,2) \checkmark \\ \Delta y &= 7,056 \text{ m} \\ h &= 7,056 + 10,944 = 18 \text{ m } \checkmark \end{aligned}$$

$\left(\frac{3}{4}\right)$

$$\begin{aligned} y &= \left(\frac{v_i+v_f}{2}\right)\Delta t \checkmark \\ &= \left(\frac{11,76+0}{2}\right)(1,2) \checkmark \\ \Delta y &= 7,056 \text{ m} \\ h &= 7,056 + 10,944 = 18 \text{ m } \checkmark \end{aligned}$$

(4)

3.2.4

$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{12 - 27}{0 - 1,53} \checkmark \\ &= 9,8039 \\ 9,8039 &= \frac{0 - (-14)}{7,78 - T} \checkmark \\ T &= 6,63 \text{ s } \checkmark \end{aligned}$$

$\left(\frac{3}{4}\right)$

3.2.7 Accept both 3,9 s and 2,35 s \checkmark

(1)

7.2 Accept: $F = 675 \text{ N left}/links \checkmark$

(1)

7.6 $E_{\text{net}} = E_R - E_S$

$$\begin{aligned} &= \frac{kQ}{r^2} - \frac{kQ}{r^2} \checkmark \\ &= 9 \times 10^9 \left[\frac{2 \times 10^{-6}}{0,01^2} - \frac{5 \times 10^{-7}}{0,02^2} \right] \checkmark \\ &= 1,6875 \times 10^8 \text{ NC}^{-1} \checkmark \end{aligned}$$



(3)