basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

PHYSICAL SCIENCES: PHYSICS (P1)

MAY/JUNE 2026

MARKS: 150

TIME: 3 hours

This question paper consists of 17 pages and 3 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the appropriate spaces on the ANSWER BOOK.
2. This question paper consists of TEN questions. Answer ALL the 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 subquestions, e.g. between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable calculator.
7. Show ALL formulae and substitutions in ALL calculations.
8. Round off your final numerical answers to a minimum of TWO decimal places.
9. Give brief motivations, discussions etc. where required.
10. You are advised to use the attached DATA SHEETS.
11. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 E.

1.1 The gravitational force experienced by an object on the surface of a planet is inversely proportional to the …

A mass of the planet.

B mass of the object.

C square of the radius of the planet.

D radius of the planet. (2)

1.2 A horizontal force F acts on a block placed on a rough horizontal surface. The block, starting from rest, moves to the right at constant acceleration.

Which ONE of the following statements is CORRECT?

A F is equal to the kinetic frictional force.

B The momentum of the block increases.

C The net work done on the block is zero.

D The normal force is less than the weight of the block. (2)

1.3 Objects A and B are thrown vertically upwards with velocities v and 2v respectively. Object A reaches a maximum height h.

What is the maximum height reached by object B?

Ignore the effects of friction.

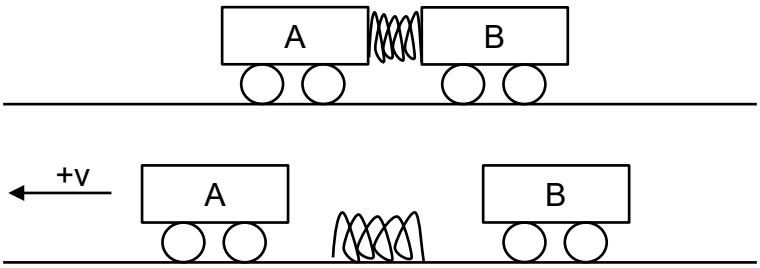
A h

B 2h

C $\frac{1}{2}$h

D 4h (2)

1.4 Two trolleys A and B, of masses m_1 and m_2 respectively, are held at rest on a frictionless surface with a compressed spring between them.



When the trolleys are released, the spring expands and drops. If the velocity of trolley A is now +v, what is the velocity of trolley B?

A $+\frac{m_1}{m_2}v$

B $-\frac{m_1}{m_2}v$

C $+\frac{m_2}{m_1}v$

D $-\frac{m_2}{m_1}v$ (2)

1.5 A motor lifts a load vertically upwards at a constant speed.

Which ONE of the following combinations of the work done by the motor and the power dissipated by the motor, is CORRECT?

	WORK DONE BY THE MOTOR	POWER DISSIPATED BY THE MOTOR
A	Constant	Increases
B	Increases	Increases
C	Increases	Constant
D	Constant	Constant

(2)

1.6 The ratio of the wavelength of sound produced by a stationary source (λ_S) to the wavelength of the sound detected by a listener (λ_L) is 1 : 1,09. The listener is moving at constant velocity.

The frequency of the source is f_S and the frequency detected by the listener is f_L.

Which ONE of the following combinations of f_L and the movement of the listener is CORRECT?

	f_L	MOVEMENT OF THE LISTENER
A	Greater than f_s	Towards the source
B	Greater than f_s	Away from the source
C	Less than f_s	Towards the source
D	Less than f_s	Away from the source

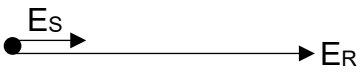
(2)

1.7 R and S are two NEGATIVE point charges of equal magnitude. P is a point to the left of R. Point P and charges R and S are on the same horizontal line.

Which ONE of the following vector diagrams, drawn to scale, of the electric fields E_R due to R, and E_S due to S, at point P, is CORRECT?

A 

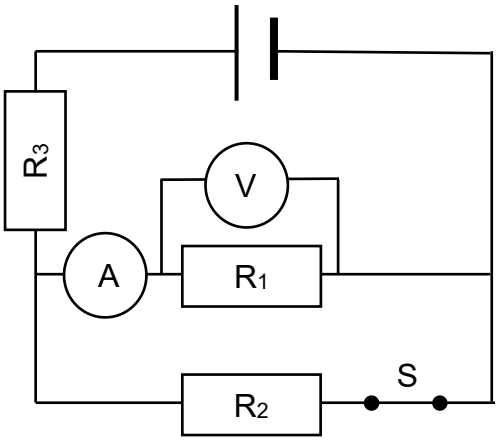
B 

C 

D 

(2)

1.8 The battery in the circuit below has negligible internal resistance. Switch S is closed.



Switch S is now opened. How will the readings on the ammeter and voltmeter be affected?

	AMMETER READING	VOLTMETER READING
A	Decreases	Increases
B	Increases	Decreases
C	Decreases	Decreases
D	Increases	Increases

(2)

1.9 The magnitude of the induced emf in an AC generator can be increased by:

(i) Increasing the strength of the magnetic field
(ii) Increasing the speed at which the coil is rotated
(iii) Increasing the number of turns in the coil

Which of the statements above are CORRECT?

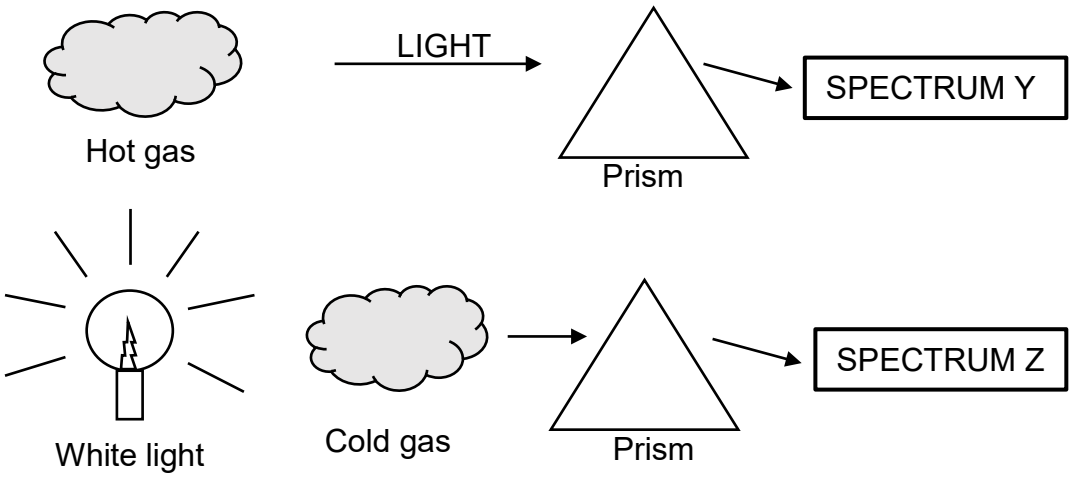
A (i) and (ii) only

B (i) and (iii) only

C (ii) and (iii) only

D (i), (ii) and (iii) (2)

1.10 The simplified diagrams below show how different types of spectra are obtained.



Which ONE of the following statements is CORRECT?

A Y is an emission spectrum and Z is an absorption spectrum.

B Y is an emission spectrum and Z is a continuous spectrum.

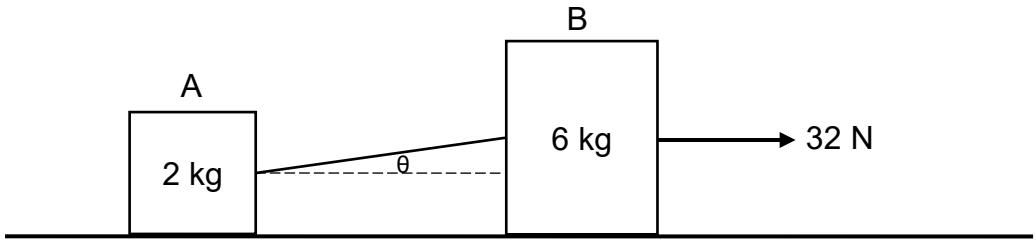
C Y is a continuous spectrum and Z is an absorption spectrum.

D Y is an absorption spectrum and Z is an emission spectrum. (2)

[20]

QUESTION 2 (Start on a new page.)

Two blocks A and B, of masses 2 kg and 6 kg respectively, are placed on a rough horizontal surface and are connected by a light, inextensible string. The string makes an angle θ with the horizontal.



When a horizontal force of 32 N is applied to block B, the blocks accelerate to the right at 0,47 $m \cdot s^{-2}$. Block A now experiences a constant frictional force of 3,74 N.

2.1 State *Newton's Second Law of Motion* in words. (2)

2.2 Draw a labelled free-body diagram showing ALL the forces acting on block B. (5)

2.3 Calculate:

2.3.1 The magnitude of the frictional force acting on block B by applying Newton's Second Law to each block separately (5)

2.3.2 θ, if the coefficient of kinetic friction for block A and the surface is 0,2 (5)

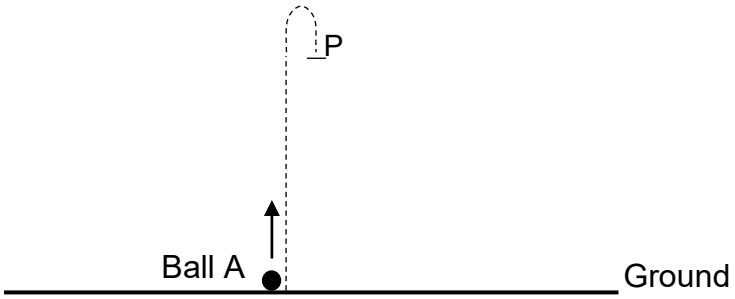
2.4 As the blocks move, the string breaks. Will the kinetic frictional force experienced by block A now be GREATER THAN, LESS THAN or EQUAL TO 3,74 N?

Explain the answer without the use of a calculation. (3)
[20]

QUESTION 3 (Start on a new page.)

Ball A is projected vertically upwards at a velocity of 20 m·s^{-1} from the ground. On its way down, it passes point P with a speed of 6,87 m·s^{-1}.

Ignore the effects of friction.



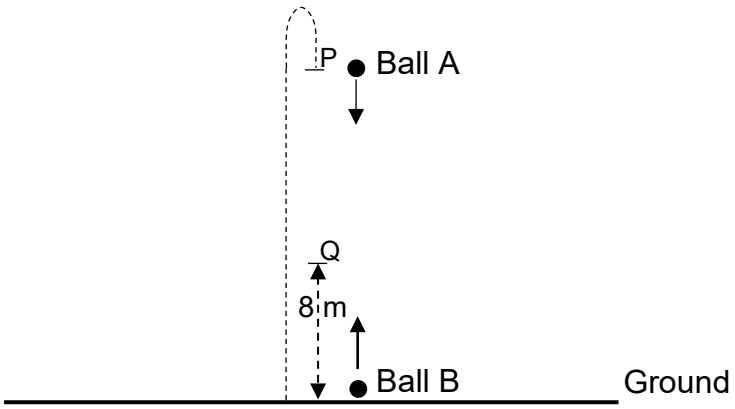
3.1 Define the term *projectile*. (2)

3.2 Using EQUATIONS OF MOTIONS ONLY, calculate the:

3.2.1 Time taken for ball A to reach point P on its way down (3)

3.2.2 The height of point P above the ground (3)

When ball A reaches point P, ball B is projected vertically upwards from the ground. The balls pass each other at point Q which is 8 m above the ground.



3.3 Calculate the speed at which ball B was projected. (5)

3.4 On the same set of axes, sketch the position versus time graph for ball A and ball B from the time ball A was projected until both reach point Q. Take the ground as the zero position. Label the graph for ball A and ball B as A and B respectively.

Indicate the following numerical values on the graph:

- Time taken for ball A to reach point P on its way down
- Height of point P
- Height of point Q

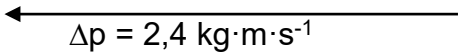
(5)
[18]

QUESTION 4 (Start on a new page.)

Ball A and ball B move towards each other along a horizontal surface. Ball B has a mass of 0,3 kg and an initial speed of 15 $m \cdot s^{-1}$. The balls collide.

The vector shown below represents the change in momentum of ball A.

Ignore the effects of friction.



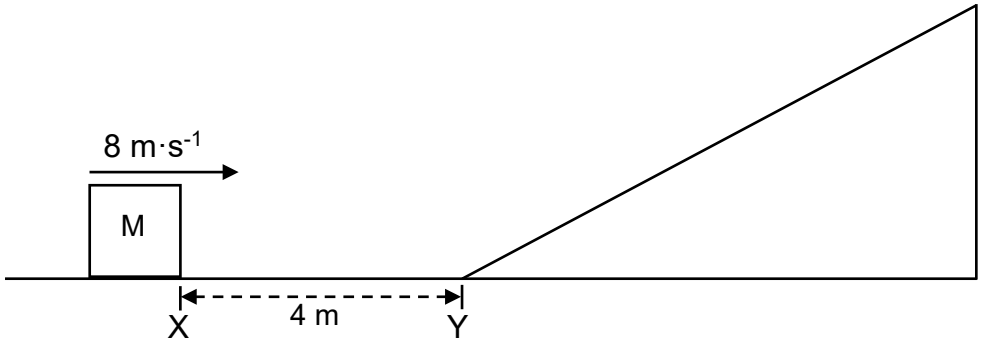
4.1 State the *principle of conservation of linear momentum* in words. (2)

4.2 What was the initial direction of ball A? Choose from LEFT or RIGHT. (2)

4.3 Calculate the velocity of ball B after the collision. (5)
[9]

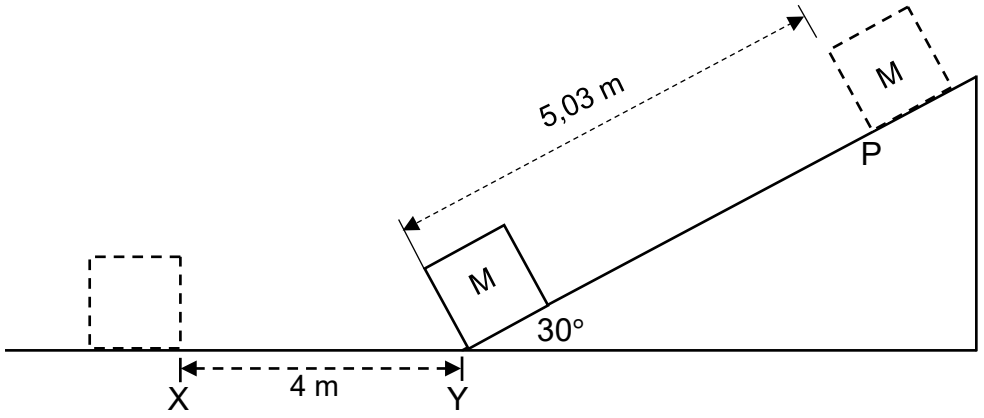
QUESTION 5 (Start on a new page.)

A block of mass M kg moves along a rough horizontal surface while experiencing a constant frictional force of 3 N. It passes point X with a speed of 8 m·s^{-1} and reaches point Y with a speed v_Y. Point Y is 4 m to the right of point X.



5.1 Using ENERGY PRINCIPLES ONLY, show that v_Y^2 is given by $v_Y^2 = 64 - \frac{24}{M}$. (3)

The block then moves up an incline that is at an angle of 30° with the horizontal. The block experiences a constant frictional force of 2 N as it moves a distance of 5,03 m up the incline and comes to rest at point P.



5.2 USING ENERGY PRINCIPLES ONLY, calculate the mass of the block. (5)
[8]

QUESTION 6 (Start on a new page.)

6.1 A stationary sound source (S) produces sound with a frequency of 170 Hz. A listener (L) in a car travelling at a constant speed of 12 m·s^{-1} towards this source, observes the frequency of the sound as x Hz.

Take the speed of sound in air to be 340 m·s^{-1}.

6.1.1 State the *Doppler effect* in words. (2)

6.1.2 Will the observed frequency INCREASE, DECREASE or REMAIN THE SAME if:

(a) The constant speed of the car moving towards the stationary sound source is greater than 12 m·s^{-1} (1)

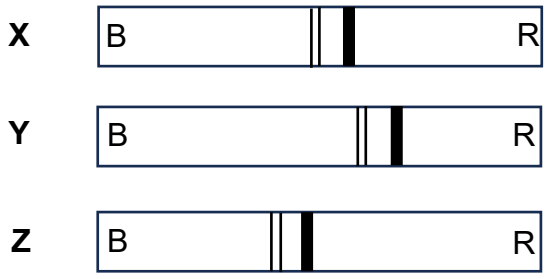
(b) The sound produced by the source is louder (1)

The frequency of the sound source is changed. The listener now travels towards the stationary sound source at a constant speed of 24 m·s^{-1}.

The observed frequency is still x Hz.

6.1.3 Calculate the new frequency of the sound source. (6)

6.2 **X**, **Y** and **Z** are absorption spectra. B and R represent the blue and red ends of the spectra. Spectrum **X** shows the absorption lines of light from the sun.

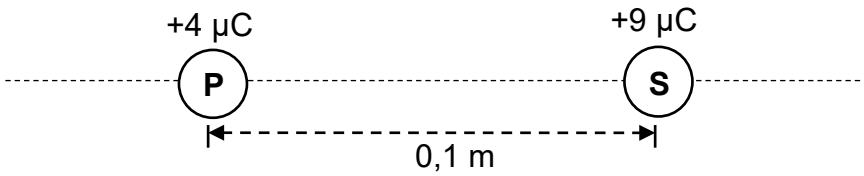


Which spectrum shows the absorption lines of light from another star that is moving AWAY from Earth? Choose from **X**, **Y** or **Z**. Explain the answer. (3)

[13]

QUESTION 7 (Start on a new page.)

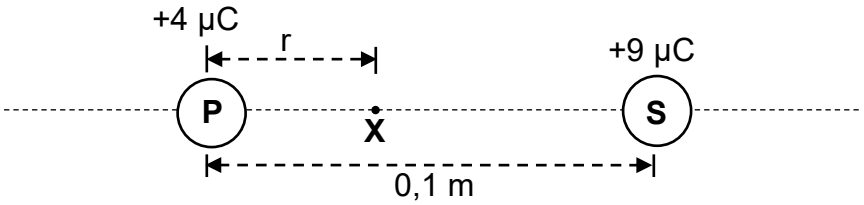
Two small spheres **P** and **S**, carrying charges of +4 μC and +9 μC respectively, are placed 0,1 m apart.



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

7.2 Calculate the magnitude of the electrostatic force experienced by sphere **S**. (3)

X is a point r metres to the right of sphere **P**, as shown in the diagram below.



7.3 Define the term *electric field at a point.* (2)

7.4 Calculate r if the net electric field at point **X** is zero. (5)

7.5 The two spheres are brought into contact and returned to their original positions.

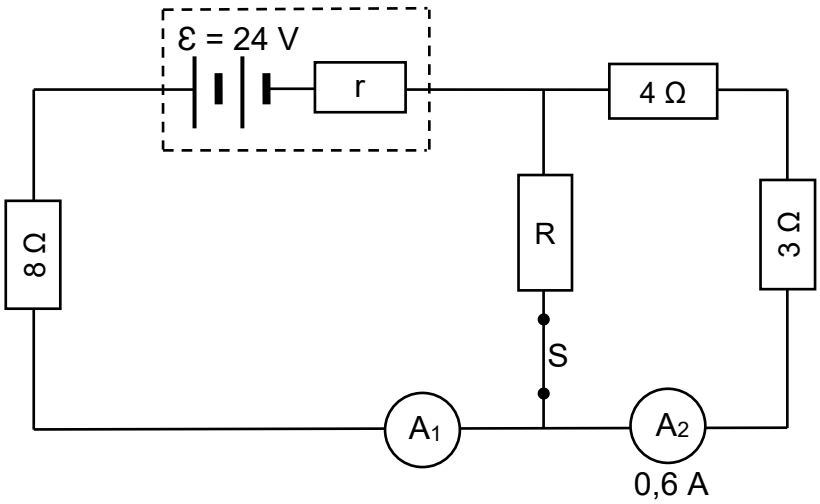
7.5.1 Were electrons transferred from **sphere P to S** or from **sphere S to P** when they were in contact? (1)

7.5.2 At what distance from sphere **P** will the net electric field now still be zero? (1)

[14]

QUESTION 8 (Start on a new page.)

8.1 A battery with an emf of 24 V and an unknown internal resistance (r) is connected to four resistors. When switch S is closed, the reading on ammeter A_2 is 0,6 A.



8.1.1 Explain what is meant by an *emf of 24 V*. (2)

The power dissipated by the 8 Ω resistor is 46,08 W.

8.1.2 Calculate the resistance of resistor R. (6)

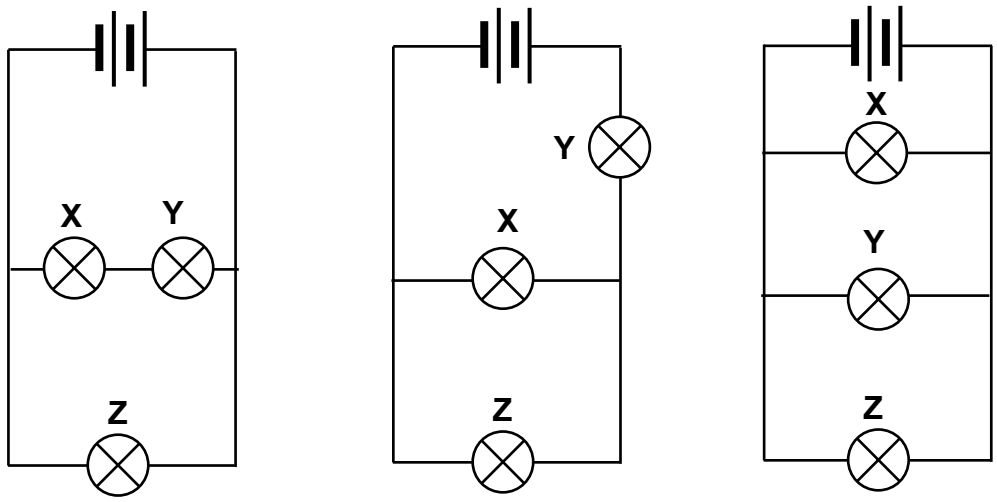
8.1.3 Calculate the internal resistance (r) of the battery. (5)

8.1.4 How does the potential difference across the 4 Ω resistor compare to that across resistor R? Choose from GREATER THAN, LESS THAN or EQUAL TO. Give a reason for the answer. (2)

Switch S is now opened.

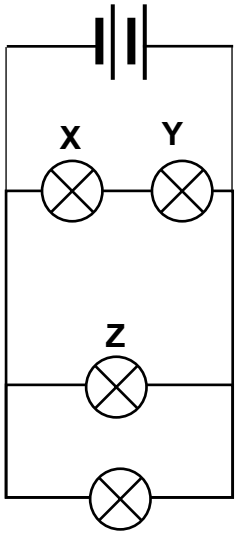
8.1.5 How will the power dissipated by the 8 Ω resistor now be affected? Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

8.2 Different arrangements of three identical light bulbs **X**, **Y** and **Z** are shown in circuits A, B and C below. The batteries are identical with negligible internal resistance.



8.2.1 In which circuit will bulb **X** burn the brightest? Choose from A, B or C. Explain the answer. (3)

In circuit A, an additional identical light bulb is now connected in parallel to bulb **Z**. This is shown below.

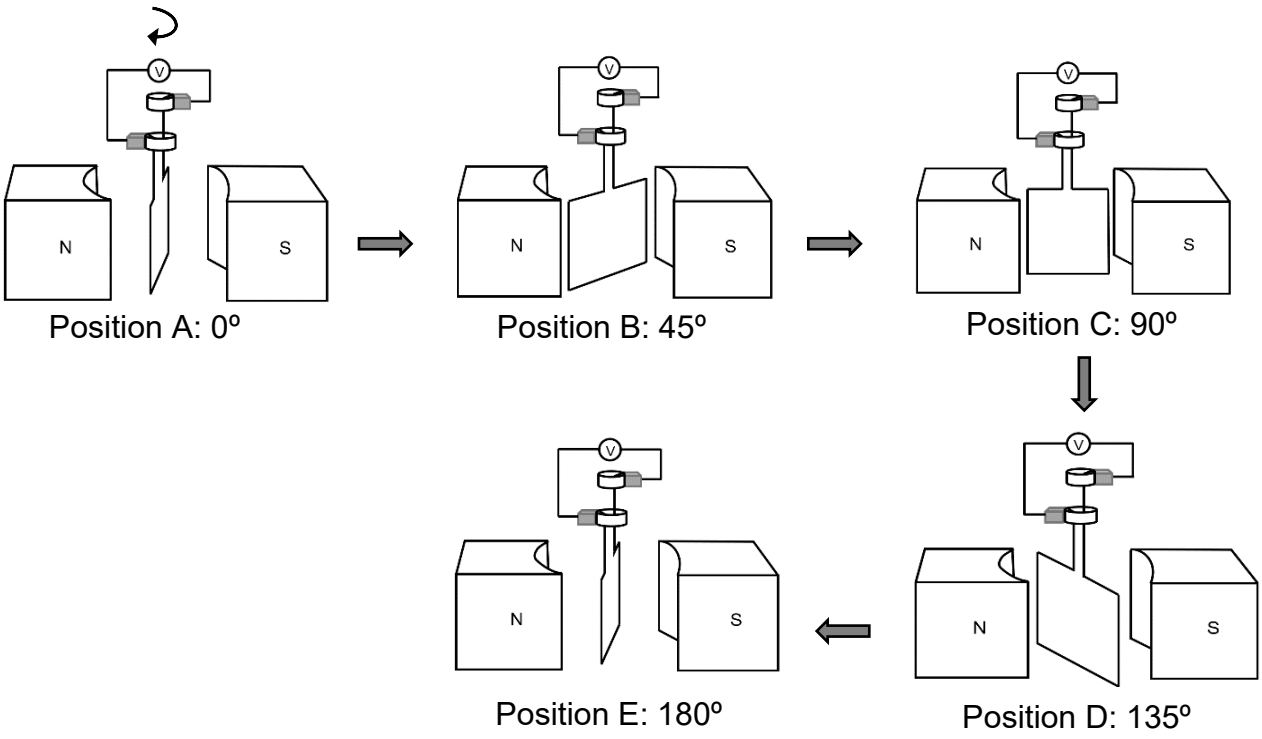


8.2.2 How will the brightness of bulb **X** now be affected? Choose from INCREASES, DECREASES or REMAINS THE SAME. Give a reason for the answer. (2)

[21]

QUESTION 9 (Start on a new page.)

The diagrams below show different positions of the coil, rotating in a clockwise direction, in an AC generator.



9.1 Use the principle of electromagnetic induction to explain how an AC generator works. (2)

9.2 At which position(s) during the rotation of the coil will a maximum emf be induced? (2)

9.3 Draw a graph of the induced emf versus time. Indicate the positions A, B, C, D and E on the graph. (3)

9.4 A 100 Ω resistor is connected to this generator. If the peak voltage produced by the generator is 170 V, calculate the rms current passing through the resistor. (4)

9.5 This generator is now changed to a DC generator. The coil is rotated at the same speed as before.

9.5.1 What change was made to the AC generator to convert it to a DC generator? (1)

9.5.2 State the energy conversion in a DC generator. (1)

9.5.3 Will the peak voltage of this generator still be 170 V? Choose from YES or NO. (1)

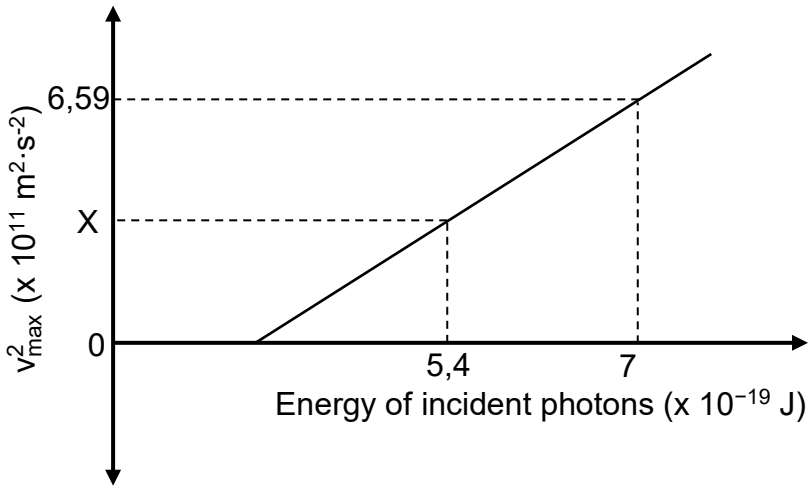
[14]

QUESTION 10 (Start on a new page.)

In an experiment, a metal is identified using the photoelectric effect. Photons of light with different energies are shone onto the metal surface and the corresponding maximum velocities of the ejected electrons are recorded.

The graph below shows the relationship between the square of the maximum velocities of the ejected electrons, v_{max}^2, and the energy of the incident photons.

The value of X is unknown.



10.1 Define the term *work function* of a metal. (2)

One of the metals in the table below was used in this experiment.

METAL	WORK FUNCTION (x 10^{-19} J)
Barium	4
Chromium	5
Aluminium	7

10.2 Use a suitable calculation to identify the metal used. (4)

10.3 Calculate X. (5)

10.4 How will the maximum velocities of the ejected electrons change when the intensity of the incident light is increased? Choose from INCREASES, DECREASES or REMAINS THE SAME. Give a reason for the answer. (2)

[13]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 1 (FISIKA)

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

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

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

MOTION/*BEWEGING*

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

FORCE/*KRAG*

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

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

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

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

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

ELECTROSTATICS/*ELEKTROSTATIKA*

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

ELECTRIC CIRCUITS/*ELEKTRIESE STROOMBANE*

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

ALTERNATING CURRENT/*WISSELSTROOM*

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

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SENIORSERTIFIKAAT-EKSAMEN/
NASIONALE SENIORSERTIFIKAAT-EKSAMEN

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

MAY/JUNE/*MEI/JUNIE* 2026

MARKING GUIDELINES/*NASIENRIGLYNE*

MARKS/*PUNTE*: 150

These marking guidelines consist of 22 pages.
Hierdie nasienriglyne bestaan uit 22 bladsye.

QUESTION 1/*VRAAG 1*

1.1	C ✓✓	(2)
1.2	B ✓✓	(2)
1.3	D ✓✓	(2)
1.4	B ✓✓	(2)
1.5	C ✓✓	(2)
1.6	D ✓✓	(2)
1.7	C ✓✓	(2)
1.8	D ✓✓	(2)
1.9	D ✓✓	(2)
1.10	A ✓✓	(2)

[20]

QUESTION 2/*VRAAG 2*

2.1

Marking criteria/*Nasienkriteria*
If any of the underlined key words/phrases in the **correct context** is omitted, deduct 1 mark/*Indien enige van die onderstreepte sleutelwoorde/frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

When a resultant/net force acts on an object, the object will accelerate in the direction of the force. The acceleration is directly proportional to the (resultant/net) force and inversely proportional to the mass of the object. ✓✓

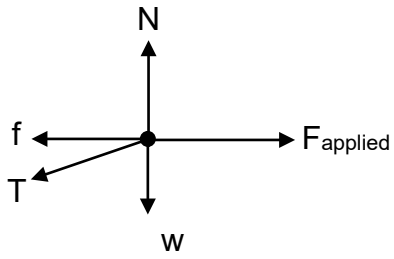
Wanneer 'n resulterende/netto krag op 'n voorwerp inwerk, sal die voorwerp in die rigting van die krag versnel. Die versnelling is direk eweredig aan die netto krag en omgekeerd eweredig aan die massa van die voorwerp

OR/*OF*

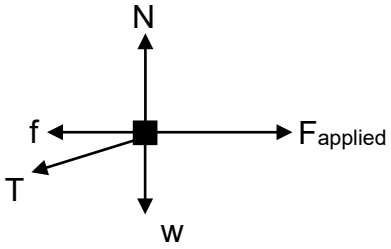
The net force acting on an object is equal to the rate of change of momentum of the object (in the direction of the net force). ✓✓(**2 OR 0**)

Die netto krag wat op 'n voorwerp inwerk is gelyk aan die tempo van verandering in momentum van die voorwerp (in die rigting van die krag) (2)

2.2



Accept/ *Aanvaar:*



Accepted labels/*Aanvaarde benoemings*	
w	F_g /F_w /weight /mg /gravitational force / 58,8 N *F_g /F_w /gewig /mg /gravitasiekrag* / 58,8 N
T	F_T /F_{string} /*F_{tou}* /F_t /tension /*spanning* /*F_s*
f	F_f /f_k /(kinetic) friction /*(kinetiese) wrywing* / 24,5 N /*F_w*
N	F_N /Normal (Force) /F_{normal} /*$F_{normaal}$* /*Normaal*
$F_{applied}$	F_A / F_{app} / 32 N / F / $F_{horizontal}$

Notes/*Aantekeninge*

- Mark awarded for label and arrow./*Punt toegeken vir benoeming en pyltjie.*
- Do not penalise for length of arrows since drawing is not to scale./*Moenie vir die lengte van die pyltjies penaliseer nie aangesien die tekening nie volgens skaal is nie.*
- Any other additional force(s)/*Enige ander addisionele krag(te):* Max/*Maks* $^4/_5$
- If everything correct, but no arrows/*Indien alles korrek, maar geen pyltjies*: Max/*Maks* $^4/_5$
- If force(s) do not make contact with the dot /*Indien krag(te) nie met die kolletjie kontak maak nie*: Max/*Maks* $^4/_5$

(5)

2.3.1

Note: If T is used instead of $T_{horizontal}$ max: $^{3}/_{5}$

OPTION 1/*OPSIE 1*

RIGHT AS POSITIVE/ *REGS AS POSITIEF*

For 2 kg:

$F_{net} = ma$
$T_{horizontal} + f = ma$ } ✓ Any one/*Enige een*

$T_{horizontal} - 3,74$ ✓ $= (2)(0,47)$

$T_{horizontal} = 4,68$ N

T_x **OR** $T_{horizontal}$ **OR** $T\cos\theta$

For 6 kg:

$F_{net} = ma$
$F_A + f + T_{horizontal} = ma$ }

$32 - f - 4,68$ ✓ $= (6)(0,47)$

$f = 24,5$ N ✓

✓ both/*beide*

OPTION 2/*OPSIE 2*

LEFT AS POSITIVE/ *LINKS AS POSITIEF*

For 2 kg:

$F_{net} = ma$
$T_{horizontal} + f = ma$ } ✓ Any one/*Enige een*

$T_{horizontal} + 3,74$ ✓ $= (2)(-0,47)$

$T_{horizontal} = -4,68$ N

T_x **OR** $T_{horizontal}$ **OR** $T\cos\theta$

For 6 kg:

$F_{net} = ma$
$F_A + f + T_{horizontal} = ma$
$-32 + f + 4,68$ ✓ $= (6)(-0,47)$

$f = 24,5$ N ✓

✓ both/*beide*

(5)

2.3.2

POSITIVE MARKING FROM QUESTION 2.3.1 for 4,68 N /
POSITIEWE NASIEN VANAF VRAAG 2.3.1 vir 4,68 N
RIGHT AS POSITIVE /*REGS AS POSITIEF*

OPTION 1/*OPSIE 1*

$f_k = \mu_k N$

$3,74 = 0,2N$ ✓

$N = 18,7$ N

✓ either / *enige*

$N = mg - T\sin\theta$

$18,7 = 2(9,8) - T\sin\theta$ ✓

$T\sin\theta = 0,9$

OPTION 2/*OPSIE 2*

$f_k = \mu_k N$ ✓

✓ ✓

$3,74 = 0,2\,[2(9,8) - T\sin\theta]$ ✓

$T\sin\theta = 0,9$

OPTION 3/*OPSIE 3*

$T_y = w - N$ ✓

$T_y = (2)(9,8) -$ ✓ $\frac{3,74}{0,2}$ ✓

$T_y = 0,9$ N

$T\cos\theta = 4,68$

$\frac{T\sin\theta}{T\cos\theta} = \frac{0,9}{4,68}$ ✓

$\tan\theta = \frac{0,9}{4,68}$

$\theta = 10,89°$ ✓

OR

$T^2 = T_x^2 + T_y^2$

$T^2 = (4,68)^2 + (0,9)^2$ ✓

$T = 4,77$ N

$T\cos\theta = 4,68$

$4,77\cos\theta = 4,68$

$\theta = 10,89°$ ✓

OPTION 4/*OPSIE 4*

$4,68\tan\theta = T_Y$

$N = w - T_Y$

$= mg - 4,68\tan\theta$

$= (2)(9,8) - 4,68\tan\theta$ ✓

$= 19,6 - 4,68\tan\theta$

✓ either / *enige*

$f_k = \mu_k N$

$3,74 = 0,2$ ✓ $(19,6 - 4,68\tan\theta)$ ✓

$\theta = 10,89°$ ✓

NOTE/*NOTA*: LEFT AS POSITIVE/*LINKS AS POSITIEF*
The values 3,74; 0,9 and 4,68 are negative
Die waardes 3,74; 0,9 en 4,68 is negatief

(5)

2.4 Greater than ✓

- The normal force increases ✓
- Friction is directly proportional to normal force / f α N / when normal force increases friction also increases (For the same μ) ✓

Toeneem

- *Die normaalkrag neem toe*
- *Wrywing is direk eweredig aan die normaalkrag* / f α N / *wanneer normaalkrag toeneem sal wrywing ook toeneem (Vir dieselfde μ)*

(3)
[20]

QUESTION 3/*VRAAG 3*

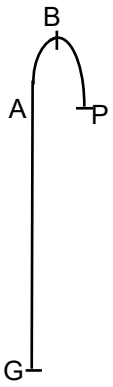
3.1 An object (that has been given an initial velocity and) on which the only force acting is the gravitational force / weight. ✓✓ **(2 or 0)**

'n Voorwerp (waaraan 'n beginsnelheid gegee word en) wat onder die invloed van slegs gravitasiekrag / gewig beweeg.

NOTE: If reference to freefall/gravity : $^{0}/_{2}$

NOTA: *Indien verwys na vryval of gravitasie:* $^{0}/_{2}$ (2)

3.2.1



OPTION 1/*OPSIE 1 G-P*

UPWARDS AS POSITIVE/ ***OPWAARTS AS POSITIEF***	**DOWNWARDS AS POSITIVE/** ***AFWAARTS AS POSITIEF***
$v_f = v_i + a\Delta t$ ✓ $-6,87 = 20 + (-9,8)\Delta t$ ✓ $\Delta t = 2,74$ s ✓	$v_f = v_i + a\Delta t$ ✓ $6,87 = -20 + (9,8)\Delta t$ ✓ $\Delta t = 2,74$ s ✓

OPTION 2/*OPSIE 2 G-P*

UPWARDS AS POSITIVE/ ***OPWAARTS AS POSITIEF***	
$v_f^2 = v_i^2 + 2a\Delta y$ $(-6,87)^2 = (20)^2 + 2(-9,8)\Delta y$ $\Delta y = 18$ m	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $18 = (-6,87)\Delta t + \frac{1}{2}(-9,8)(\Delta t)^2$ ✓ $\Delta t = 2,74$ s ✓
	$\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $18 = \left(\frac{20 + (-6,87)}{2}\right)\Delta t$ ✓ $\Delta t = 2,74$ s ✓
DOWNWARDS AS POSITIVE/ ***AFWAARTS AS POSITIEF***	
$v_f^2 = v_i^2 + 2a\Delta y$ $(6,87)^2 = (-20)^2 + 2(9,8)\Delta y$ $\Delta y = -18$ m	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $-18 = (6,87)\Delta t + \frac{1}{2}(9,8)(\Delta t)^2$ ✓ $\Delta t = 2,74$ s ✓
	$\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $-18 = \left(\frac{(-20) + 6,87}{2}\right)\Delta t$ ✓ $\Delta t = 2,74$ s ✓

OPTION 3/*OPSIE 3*	
UPWARDS AS POSITIVE/ ***OPWAARTS AS POSITIEF***	**DOWNWARDS AS POSITIVE/** ***AFWAARTS AS POSITIEF***
$v_f = v_i + a\Delta t$✓ $0 = (20) + (-9{,}8)\,\Delta t$ $\Delta t = 2{,}04$ s ✓both $v_f = v_i + a\Delta t$ $-6{,}87 = (0) + (-9{,}8)\,\Delta t$ $\Delta t = 0{,}7$ s $\Delta t = 2{,}04 + 0{,}7 = 2{,}74$ s✓	$v_f = v_i + a\Delta t$✓ $0 = (20) + (9{,}8)\,\Delta t$ $\Delta t = 2{,}04$ s ✓both $v_f = v_i + a\Delta t$ $6{,}87 = (0) + (9{,}8)\,\Delta t$ $\Delta t = 0{,}7$ s $\Delta t = 2{,}04 + 0{,}7 = 2{,}74$ s✓

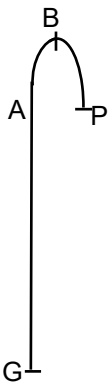
(3)

3.2.2

NOTE: If calculated in Q3.2.1 (Option 2) award 3 marks for answer (18m)
Accept if calculation was done from P - G
NOTA: *Indien reeds bereken in V3.2.1 (opsie 2) gee 3 punte vir antwoord (18 m). Aanvaar indien berekening gedoen is van P - G*
[RANGE/*GEBIED*: 17,96 – 18,01]

OPTION 1/*OPSIE 1 G–P*

UPWARDS AS POSITIVE/ ***OPWAARTS AS POSITIEF***	**DOWNWARDS AS POSITIVE/** ***AFWAARTS AS POSITIEF***
$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(-6{,}87)^2 = (20)^2 + 2(-9{,}8)\Delta y$ ✓ $\Delta y = 18$ m ✓	$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(6{,}87)^2 = (-20)^2 + 2(9{,}8)\Delta y$ ✓ $\Delta y = -18$ m $\Delta y = 18$ m ✓



OPTION 2/*OPSIE 2 G–A*

UPWARDS AS POSITIVE/ ***OPWAARTS AS POSITIEF***	**DOWNWARDS AS POSITIVE/** ***AFWAARTS AS POSITIEF***
$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(6{,}87)^2 = (20)^2 + 2(-9{,}8)\Delta y$ ✓ $\Delta y = 18$ m ✓	$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(-6{,}87)^2 = (-20)^2 + 2(9{,}8)\Delta y$ ✓ $\Delta y = -18$ m $\Delta y = 18$ m ✓

POSITIVE MARKING FROM QUESTION 3.2.1
POSITIEWE NASIEN VANAF VRAAG 3.2.1
OPTION 3/*OPSIE 3 G-P*

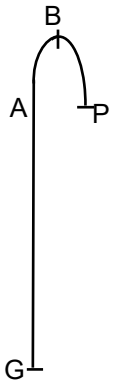
UPWARDS AS POSITIVE/ ***OPWAARTS AS POSITIEF***	**DOWNWARDS AS POSITIVE/** ***AFWAARTS AS POSITIEF***
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓ $= (20)(2{,}74) + \frac{1}{2}(-9{,}8)(2{,}74)^2$ ✓ $\Delta y = 18{,}01$ m ✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓ $= (-20)(2{,}74) + \frac{1}{2}(9{,}8)(2{,}74)^2$ ✓ $\Delta y = -18{,}01$ m $\Delta y = 18{,}01$ m ✓

OPTION 4/*OPSIE 4*

UPWARDS AS POSITIVE/ ***OPWAARTS AS POSITIEF***	**DOWNWARDS AS POSITIVE/** ***AFWAARTS AS POSITIEF***
$\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $= \left(\frac{20 + (-6{,}87)}{2}\right)2{,}74$ ✓ $\Delta y = 18$ m ✓	$\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $= \left(\frac{(-20) + 6{,}87)}{2}\right)2{,}74$ ✓ $\Delta y = -18$ m $\Delta y = 18$ m ✓

OPTION 5/*OPSIE 5*

UPWARDS AS POSITIVE/ ***OPWAARTS AS POSITIEF***	**DOWNWARDS AS POSITIVE/** ***AFWAARTS AS POSITIEF***
G-B $v_f = v_i + a\Delta t$ $0 = 20 + (-9{,}8)\Delta t$ $\Delta t = 2{,}04$ s **B-P** $2{,}74 - 2{,}04 = 0{,}7$ s Difference in time: $= 2{,}04 - 0{,}7 = 1{,}34$ s **G-A** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(20)(1{,}34) + \frac{1}{2}(-9{,}8)(1{,}34)^2}$ ✓ $\Delta y = 18$ m ✓ **OR/*OF*** **P-G** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(-6{,}87)(1{,}34) + \frac{1}{2}(-9{,}8)(1{,}34)^2}$ ✓ $\Delta y = -18$ m $\Delta y = 18$ m ✓	**G-B** $v_f = v_i + a\Delta t$ $0 = -20 + (9{,}8)\Delta t$ $\Delta t = 2{,}04$ s **B-P** $2{,}74 - 2{,}04 = 0{,}7$ s Difference in time: $= 2{,}04 - 0{,}7 = 1{,}34$ s **G-A** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(-20)(1{,}34) + \frac{1}{2}(9{,}8)(1{,}34)^2}$ ✓ $\Delta y = -18$ m $\Delta y = 18$ m ✓ **OR/*OF*** **P-G** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= \underline{(6{,}87)(1{,}34) + \frac{1}{2}(9{,}8)(1{,}34)^2}$ ✓ $\Delta y = 18$ m ✓



OPTION 6/*OPSIE 6*

UPWARDS AS POSITIVE/ ***OPWAARTS AS POSITIEF***	**DOWNWARDS AS POSITIVE/** ***AFWAARTS AS POSITIEF***
$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = (20)^2 + 2(-9{,}8)\Delta y$ $\Delta y = 20{,}41$ m ✓both $v_f^2 = v_i^2 + 2a\Delta y$ $(-6{,}87)^2 = (0)^2 + 2(-9{,}8)\Delta y$ $\Delta y = -2{,}41$ m Height = 20,41 − 2,41 = 18 m ✓	$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $0 = (-20)^2 + 2(9{,}8)\Delta y$ $\Delta y = -20{,}41$ m ✓both $v_f^2 = v_i^2 + 2a\Delta y$ $(6{,}87)^2 = (0)^2 + 2(9{,}8)\Delta y$ $\Delta y = 2{,}41$ m Height = 20,41 − 2,41 = 18 m ✓

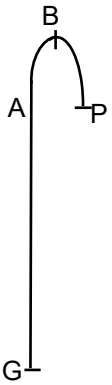
(3)

3.3

POSITIVE MARKING FROM Q3.2.2/*POSITIEWE NASIEN VANAF V3.2.2*

OPTION 1/*OPSIE 1*

UPWARDS AS POSITIVE/ *OPWAARTS AS POSITIEF*	**DOWNWARDS AS POSITIVE/** *AFWAARTS AS POSITIEF*
BALL A	**BALL A**
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$8 = (20)\Delta t + \frac{1}{2}(-9,8)\Delta t^2$ ✓	$-8 = (-20)\Delta t + \frac{1}{2}(9,8)\Delta t^2$ ✓
$\Delta t = 3,63$ s	$\Delta t = 3,63$ s
$3,63 - 2,74$ ✓ $= 0,89$ s	$3,63 - 2,74$ ✓ $= 0,89$ s
BALL B	**BALL B**
$y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓
$8 = v_i(0,89) + \frac{1}{2}(-9,8)(0,89)^2$ ✓	$-8 = v_i(0,89) + \frac{1}{2}(9,8)(0,89)^2$ ✓
$v_i = 13,35$ m·s^{-1} ✓	$v_i = -13,35$ m·s^{-1}
	$v_i = 13,35$ m·s^{-1} ✓



OPTION 2/*OPSIE 2*

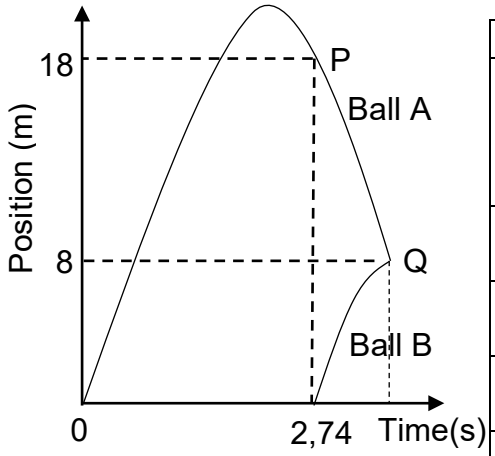
UPWARDS AS POSITIVE/ *OPWAARTS AS POSITIEF*	**DOWNWARDS AS POSITIVE/** *AFWAARTS AS POSITIEF*
BALL A	**BALL A**
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$8 - 18$ ✓ $= (-6,87)\Delta t + \frac{1}{2}(-9,8)\Delta t^2$ ✓	$-8 + 18$ ✓ $= (6,87)\Delta t + \frac{1}{2}(9,8)\Delta t^2$ ✓
$-10 = (-6,87)\Delta t + \frac{1}{2}(-9,8)\Delta t^2$	$10 = (6,87)\Delta t + \frac{1}{2}(9,8)\Delta t^2$
$\Delta t = 0,89$ s	$\Delta t = 0,89$ s
BALL B	**BALL B**
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓
$8 = v_i(0,89) + \frac{1}{2}(-9,8)(0,89)^2$ ✓	$-8 = v_i(0,89) + \frac{1}{2}(9,8)(0,89)^2$ ✓
$v_i = 13,35$ m·s^{-1} ✓	$v_i = -13,35$ m·s^{-1}
	$v_i = 13,35$ m·s^{-1} ✓

OPTION 3/*OPSIE 3*

UPWARDS AS POSITIVE/ *OPWAARTS AS POSITIEF*	**DOWNWARDS AS POSITIVE/** *AFWAARTS AS POSITIEF*
BALL A	**BALL A**
$v_f^2 = v_i^2 + 2a\Delta x$	$v_f^2 = v_i^2 + 2a\Delta x$
$v_f^2 = (-6,87)^2 + 2(-9,8)\boxed{(8 - 18)}$ ✓	$v_f^2 = (6,87)^2 + 2(9,8)\boxed{(18 - 8)}$ ✓
$v_f = -15,59$ m·s^{-1}	$v_f = 15,59$ m·s^{-1}
$v_f = v_i + a\Delta t$	$v_f = v_i + a\Delta t$
$-15,59 = -6,87 + (-9,8)\Delta t$ ✓	$15,59 = 6,87 + 9,8\Delta t$ ✓
$\Delta t = 0,89$ s	$\Delta t = 0,89$ s
BALL B	**BALL B**
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓	$y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓
$8 = v_i(0,89) + \frac{1}{2}(-9,8)(0,89)^2$ ✓	$-8 = v_i(0,89) + \frac{1}{2}(9,8)(0,89)^2$ ✓
$v_i = 13,35$ m·s^{-1} ✓	$v_i = 13,35$ m·s^{-1} ✓

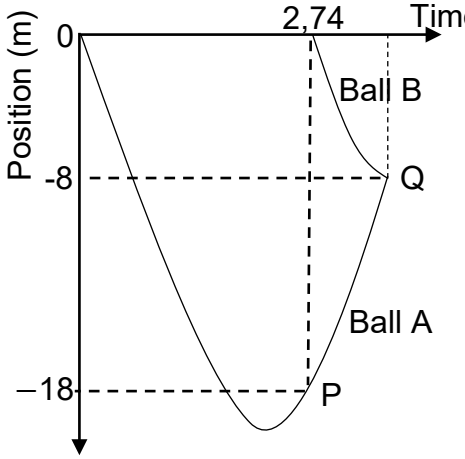
(5)

3.4 **POSITIVE MARKING FROM QUESTION 3.2.1, 3.2.2 AND 3.3**
POSITIEWE NASIEN VANAF VRAAG 3.2.1, 3.2.2 EN 3.3
OPTION 1/*OPSIE 1* UPWARDS AS POSITIVE/*OPWAARTS AS POSITIEF*



Criteria for graph/*Kriteria vir grafiek*	
Total time taken for ball A to reach P on its way down (2,74 s) *Totale tyd vir bal A om P te bereik op pad ondertoe (2,74 s)*	✓
Height of point P (18 m) *Hoogte van punt P (18 m)*	✓
The two graphs meet at point Q (8 m and t > 2,74 s) *Twee grafieke ontmoet by punt Q (8 m en t > 2,74 s)*	✓
Correct shape of the graph for ball A up to point Q *Korrekte vorm vir grafiek van bal A tot by punt Q*	✓
Correct shape of the graph for ball B starting at 2,74 s up to point Q *Korrekte vorm vir grafiek van bal B begin by 2,74 s tot by punt Q*	✓
NOTE: No labels max $^4/_5$ ***NOTA**: Geen benoeming maks $^4/_5$*	

OPTION 2/*OPSIE 2* DOWNWARDS AS POSITIVE/*OPWAARTS AS POSITIEF*



Criteria for graph/*Kriteria vir grafiek*	
Total time taken for ball A to reach P on its way down (2,74 s) *Totale tyd vir bal A om P te bereik op pad ondertoe (2,74 s)*	✓
Height of point P (18 m) *Hoogte van punt P (18 m)*	✓
The two graphs meet at point Q (8 m and t > 2,74 s) *Twee grafieke ontmoet by punt Q (8 m en t > 2,74 s)*	✓
Correct shape of the graph for ball A up to point Q *Korrekte vorm vir grafiek van bal A tot by punt Q*	✓
Correct shape of the graph for ball B starting at 2,74 s up to point Q *Korrekte vorm vir grafiek van bal B begin by 2,74 s tot by punt Q*	✓
NOTE: No labels max $^4/_5$ ***NOTA**: Geen benoeming maks $^4/_5$*	

(5)
[18]

QUESTION 4/*VRAAG 4*

4.1

Marking criteria/*Nasienkriteria*
If any of the underlined key words/phrases in the **correct context** is omitted deduct 1 mark./*Indien enige van die onderstreepte sleutelwoorde/frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

The total (linear) momentum in an isolated system remains constant/is conserved. ✓✓
Totale (lineêre) momentum in 'n geïsoleerde sisteem bly konstant/behoue (2)

NOTE: If "closed" instead of "isolated" indicated max: $^1/_2$
Any reference to mechanical energy $^0/_2$

NOTA: *Indien geslote in plaas van geïsoleerde sisteem maks:* $^1/_2$
Enige verwysing na meganiese energie $^0/_2$

4.2 Right / *Regs* ✓✓ (2)

4.3

OPTION 1/*OPSIE 1*

$\Sigma p_i = \Sigma p_f$
$-\Delta p_A = \Delta p_B$ ✓Any one/*Enige een*
$-(m_A v_{fA} - m_A v_{iA}) = m_B v_{fB} - m_B v_{iB}$
$-(2,4)$ ✓ $= (0,3)v_f - (0,3)(15)$ ✓
$-2,4 = (0,3)v_f - 4,5$
$v_f = 7\ m{\cdot}s^{-1}$ ✓ left / *links* ✓ (5)

OPTION 2/*OPSIE 2*

$\Delta p_B = mv_f - mv_i$ ✓
$-(2,4)$ ✓ $= (0,3)v_f - (0,3)(15)$ ✓
$v_f = 7\ m{\cdot}s^{-1}$ ✓ left / *links* ✓

NOTE: Mark for the formula is ONLY awarded if in reference to ball B
NOTA: *Punt vir die formule word SLEGS toegeken indien verwys word na bal B*

[9]

QUESTION 5/*VRAAG 5*

5.1

$W_{net} = \Delta E_K$
$W_{nc} = \Delta E_K + \Delta E_p$
$W_f = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
✓Any one/*Enige een*

$\underline{(3)(4)\cos 180^\circ}$ ✓ $= \underline{\frac{1}{2}M[v_Y^2 - (8)^2]}$ ✓ + 0

$$v_Y^2 = 64 - \frac{24}{M}$$

(3)

5.2

OPTION 1/*OPSIE 1*

$W_{net} = \Delta E_K$
$W_f + W_{Fg} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$f\Delta x\cos\theta + F_{g//}\Delta x\cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$f\Delta x\cos\theta + mg\Delta x\sin\varphi\cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
✓Anyone/*Enige een*

$\underline{(2)(5,03)\cos 180^\circ}$✓ + $\underline{M(9,8)(5,03)\sin 30^\circ\cos 180^\circ}$✓ = $\boxed{\frac{1}{2}M[0^2 - (64 - \frac{24}{M})]}$✓

M = 3 kg✓

OR

$\boxed{M(9,8)(5,03)\cos 120^\circ}$

OR

$\underline{2)(5,03)\cos 180^\circ}$✓ + $\underline{M(9,8)(2,515)\cos 180^\circ}$✓ = $\boxed{\frac{1}{2}M[0^2 - (64 - \frac{24}{M})]}$✓

M = 3 kg ✓

OPTION 2/*OPSIE 2*

$W_{nc} = \Delta E_K + \Delta E_p$
$W_f = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mg(h_f - h_i)$
$f\Delta x\cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mg(h_f - h_i)$
✓Anyone/*Enige een*

$\underline{(2)(5,03)\cos 180^\circ}$✓ = $\boxed{\frac{1}{2}M[0^2 - (64 - \frac{24}{M})]}$✓ + $\underline{M(9,8)(2,515 - 0)}$ ✓

M = 3 kg✓

OPTION 3/*OPSIE 3*

$W_{net} = \Delta E_K$
$W_f + W_{Fg} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$f\Delta x\cos\theta + F_g\Delta x\cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$f\Delta x\cos\theta + mg\Delta x\sin\varphi\cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
✓Anyone/*Enige een*

$\underline{(2)(5,03)\cos 180^\circ}$✓ + $\underline{M(9,8)(5,03)\sin 30^\circ\cos 180^\circ}$✓ = $\boxed{\frac{1}{2}M[0^2 - (v_Y^2)]}$✓

M = 3 kg✓

OR

$\underline{M(9,8)(5,03)\cos 120^\circ}$

OPTION 4/*OPSIE 4*

$F_{net} = f + F_{g//}$

$F_{net} = 2 + M(9,8)\sin 30^o$

$W_{net} = \Delta E_K$
$W_{net} = ½ m(v_f^2 - v_i^2)$ ✓Anyone/*Enige een*

✓
$2 + M(9,8)\sin 30°\,(5,03)\cos 180^o$✓ $= ½ M(0 - (64 - \frac{24}{M}))$✓

$M = 3$ kg ✓

(5)
[8]

QUESTION 6/*VRAAG 6*

6.1.1

Marking criteria/*Nasienkriteria*
If any of the underlined key words/phrases in the **correct context** is omitted deduct 1 mark./*Indien enige van die onderstreepte sleutelwoorde/frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

The change in frequency/pitch (of the sound) detected by a listener, because the (sound) source and the listener have different velocities relative to the medium of (sound) propagation. ✓✓

Die verandering in frekwensie/toonhoogte (van 'n klank) waargeneem deur 'n luisteraar omdat die (klank)bron en luisteraar verskillende snelhede het relatief tot die medium waarin die (klank) voortplant.

OR / *OF*

An (apparent) change in (observed/detected) frequency/pitch as a result of the relative motion between a (sound) source and an observer.

Die (skynbare) verandering in (waargenome) frekwensie/toonhoogte as gevolg van relatiewe beweging tussen die (klank)bron en die luisteraar. (2)

6.1.2 (a) Increase / *Neem toe* ✓ (1)

6.1.2 (b) Remain the same / *Bly dieselfde* ✓ (1)

6.1.3

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

$f_L = \frac{v + v_L}{v} f_s$

✓ Any one/*Enige een*

$x/f_L = \frac{340 + 12}{340}$ ✓ (170) ✓

$= 176$ Hz

$f_L = \frac{v + v_L}{v} f_s$

✓

$176 = \frac{340 + 24}{340} f_s$ ✓

$f_s = 164{,}4$ Hz ✓

NOTE: 170 substitution is only awarded with the 12 $m.s^{-1}$
***NOTA**: 170 vervanging slegs met 12 $m.s^{-1}$*

(6)

6.2 Y✓

- The spectral lines are shifted towards the red end of the spectrum/the spectral lines are red shifted, ✓
- Indicating longer wavelengths / lower frequencies. ✓

Y

- *Die spektrumlyne is verskuif na die rooi punt van die spektrum/die spektrumlyne ondergaan rooiverskuiwing,*
- *Wat 'n langer golflengte / kleiner frekwensie aandui*

ACCEPT: The spectral lines are shifted away from the blue end of the spectrum, ✓ indicating longer wavelengths / lower frequencies. ✓
***AANVAAR:** Die spektrumlyne verskuif weg van die blou kant van die spektrum, wat 'n langer golflengte / kleiner frekwensie aandui*

(3)
[13]

QUESTION 7/*VRAAG 7*

7.1

Marking criteria/*Nasienkriteria*
If any of the underlined key words/phrases in the **correct context** is omitted deduct 1 mark./*Indien enige van die onderstreepte sleutelwoorde/frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

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

Die grootte van die elektrostatiese krag (wat een puntlading op 'n ander puntlading uitoefen) is direk eweredig aan die produk van die (groottes van die) ladings en omgekeerd eweredig aan die kwadraat van die afstand tussen die ladings

NOTE: If reference to masses $^0/_2$

***NOTA:** Indien verwysing na massas $^0/_2$*

(2)

7.2

$F = \frac{kQ_1Q_2}{r^2}$ ✓

$F = \frac{(9 \times 10^9)(4 \times 10^{-6})(9 \times 10^{-6})}{(0,1)^2}$ ✓

$F = 32,4$ N ✓ (3)

7.3

Marking criteria/*Nasienkriteria*
If any of the underlined key words/phrases in the **correct context** is omitted deduct 1 mark./*Indien enige van die onderstreepte sleutelwoorde/frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

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 eenheidspositiewe-lading wat by daardie punt geplaas is, ondervind word (2)

7.4

OPTION 1/*OPSIE 1*

$E_P = \frac{kQ}{r^2}$ ✓

$= \frac{(9 \times 10^9)(4 \times 10^{-6})}{(r)^2}$ ✓

$E_S = \frac{kQ}{r^2}$

$= \frac{(9 \times 10^9)(9 \times 10^{-6})}{(0,1 - r)^2}$ ✓

$\frac{(9 \times 10^9)(4 \times 10^{-6})}{(r)^2} \overset{✓}{=} \frac{(9 \times 10^9)(9 \times 10^{-6})}{(0,1 - r)^2}$ $[E_P = E_S]$

$\sqrt{\frac{(9 \times 10^9)(4 \times 10^{-6})}{(r)^2}} = \sqrt{\frac{(9 \times 10^9)(9 \times 10^{-6})}{(0,1 - r)^2}}$

$r = 0,04$ m ✓

OPTION 2/*OPSIE 2*

$F = \frac{kQ_1Q_2}{r^2}$ ✓

$\frac{(9 \times 10^9)(4 \times 10^{-6})(1)}{(r)^2}$ ✓ $\overset{✓}{=} \frac{(9 \times 10^9)(9 \times 10^{-6})(1)}{(0,1 - r)^2}$ ✓

$r = 0,04$ m ✓

NOTE: mark for the formula is ONLY awarded provided 1 or q is substituted as a test charge.
***NOTA**: punt vir formule SLEGS toegeken indien 1 of q vervang is as die toetslading* (5)

7.5.1 P to/*na* S ✓ (1)

7.5.2 0,05 m ✓ **ACCEPT/*AANVAAR***: $\frac{0,1}{2}$ m (1)
[14]

QUESTION 8/*VRAAG 8*

8.1.1 A maximum of 24 J of energy is transferred per unit/coulomb charge by the battery. ✓✓ (**2 or 0**)
24 J maksimum energie word per eenheidslading oorgedra deur die battery (2)

8.1.2

OPTION 1/*OPSIE 1*

$P = I^2R$ ✓
$46,08 = I^2(8)$ ✓
$I = 2,4$ A
$2,4 - 0,6$ ✓ $= 1,8$ A
$V_p = IR_p$
$V_P = (0,6)(7)$ ✓
$V_p = 4,2$ V
$R = \frac{V}{I}$
$= \frac{4,2}{1,8}$ ✓
$= 2,33\ \Omega$ ✓

OPTION 2/*OPSIE 2*

$P = I^2R$ ✓
$46,08 = I^2(8)$ ✓
$I = 2,4$ A
$0,6$ ✓ $= \frac{R}{R+7}$ ✓ $(2,4)$ ✓
$R = 2,33\ \Omega$ ✓

NOTE: 2,4 is awarded a mark in conjunction with the specific ratio used
***NOTA**: 2,4 se punt toegeken saam met spesifieke verhouding*

OPTION 3/*OPSIE 3*

$P = I^2R$ ✓
$46,08 = I^2(8)$ ✓
$I = 2,4$ A
$2,4 - 0,6$ ✓ $= 1,8$ A
$IR = I_TR_p$
$(1,8)R$ ✓ $= (2,4)\left(\frac{7R}{R+7}\right)$ ✓
$1,8R(7 + R) = (2,4)(7R)$
$R = 2,33\ \Omega$ ✓

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$
$\frac{1}{R_p} = \frac{1}{R} + \frac{1}{7}$
$R_P = \frac{7R}{7+R}$

$V = IR$
$V_P = I_T R_p$

(6)

8.1.3

POSITIVE MARKING FROM QUESTION 8.1.2
POSITIEWE NASIEN VANAF VRAAG 8.1.2

OPTION 1/*OPSIE 1*

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ **OR/*OF*** $R_p = \frac{R_1R_2}{R_1 + R_2}$

$\frac{1}{R_p} = \frac{1}{2,33} + \frac{1}{7}$ ✓ **OR /*OF*** $R_p = \frac{(2,33)(7)}{2,33 + 7}$

$R_p = 1,75\ \Omega$

$R_{ext} = 1,75 + 8$
$= 9,75\ \Omega$ ✓ Any one/*Enige een*

OPTION 2/*OPSIE 2*

$V = IR$

$4,2 = 2,4R$ ✓

$R = 1,75\ \Omega$

$R_{ext} = 1,75 + 8$
$= 9,75\ \Omega$ ✓ Any one/*Enige een*

$\varepsilon = I(R + r)$ ✓

$\underline{24 = 2,4(9,75 + r)}$ ✓

$r = 0,25\ \Omega$ ✓

OPTION 3/*OPSIE 3*

$\varepsilon = I(R + r)$ ✓

$\underline{24 = 2,4([8 + R_P] + r)}$ ✓

$2 = Rp + r$

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ **OR/*OF*** $R_p = \frac{R_1R_2}{R_1 + R_2}$

$\frac{1}{R_p} = \frac{1}{2,33} + \frac{1}{7}$ ✓ **OR /*OF*** $R_p = \frac{(2,33)(7)}{2,33 + 7}$

$R_p = 1,75\ \Omega$

$R_T = R_P + r$

$\underline{2 = 1,75 + r}$ ✓

$r = 0,25\ \Omega$ ✓

OPTION 4/*OPSIE 4*

$R_{8\Omega} = \frac{V_{8\Omega}}{I_T}$

$8 = \frac{V_{8\Omega}}{2,4}$ ✓

$V_{8\Omega} = 19,2$ V

$V_{ext} = 19,2 + 4,2$

$= 23,4$ V

$\varepsilon = I(R + r)$ ✓ **OR** $\varepsilon = V_{ext} + V_{int}$

$24 = 23,4 + V_{int}$ ✓

$V_{int} = 0,6$ V

$r = \frac{V_{int}}{I_T}$

$= \frac{0,6}{2,4}$ ✓

$= 0,25\ \Omega$ ✓

NOTE: If r is calculated in Q8.1.2, allocate marks for Q8.1.3 in Q8.1.2
NOTA: *Indien r reeds bereken is in V8.1.2, ken punte toe vir V8.1.3 in V8.1.2*

(5)

8.1.4 Less than ✓
The sum of the potential difference across the 4 Ω and 3 Ω resistors is equal to the potential difference across R. ✓ **OR** $V_{4\Omega} + V_{3\Omega} = V_R$

Kleiner as
Die som van die potensiaalverskil oor die 4 Ω en 3 Ω resistors is gelyk aan die potensiaalverskil oor weerstand R. ***OF*** $V_{4\Omega} + V_{3\Omega} = V_R$ (2)

8.1.5 Decreases ✓ *Neem af* (1)

8.2.1 C ✓
- V_x has the highest voltage / is the same as the emf of the battery ✓
- Power is directly proportional to voltage / $P \alpha V^2$ (R_X remains constant) ✓

OR

- I_X is the highest
- Power is directly proportional to current / $P \alpha I^2$ (R_X remains constant)

NOTE: The third mark can only be awarded provided the second mark is awarded. (3)

C
- *V_x het die hoogste potensiaalverskil/ is dieselfde as die emk van die battery*
- *Drywing is direk eweredig aan die potensiaalverskil / $P \alpha V^2$ (R_x bly konstant)*

OF

- *I_X is die hoogste*
- *Drywing is direk eweredig aan stroom / $P \alpha I^2$ (R_x bly konstant)*

NOTA*: Die derde punt kan slegs toegeken indien die tweede punt toegeken is*

8.2.2 REMAINS THE SAME ✓ *BLY DIESELFDE*
- V_X / I_X does not change ✓ *V_p / I_X verander nie*

(2)
[21]

QUESTION 9/*VRAAG 9*

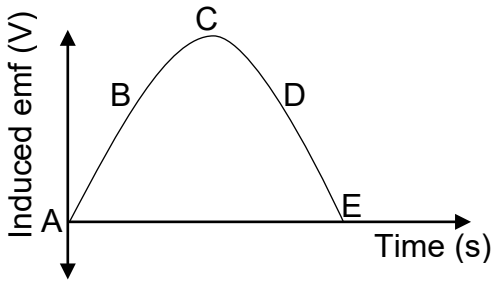
9.1

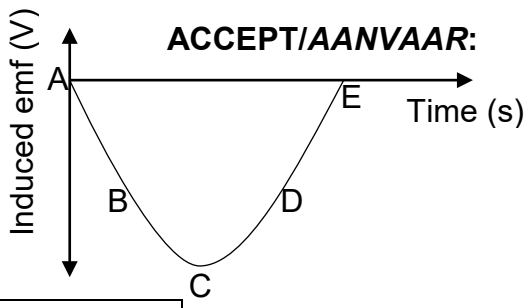
Marking criteria/*Nasienkriteria*
If any of the underlined key words/phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte sleutelwoorde/frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

A change in magnetic flux linkage/linked to the coil induces an emf/current in the coil. ✓✓
'n Verandering in magnetiese vloedkoppeling/koppeling tussen magneetveld en spoel induseer 'n emk/stroom. (2)

9.2 C ✓✓ **(2 OR 0)**
NOTE/*NOTA*: Accept/*Aanvaar* 90° (2)

9.3





Criteria for marking/*Kriteria vir nasien*	
Correct shape (sine graph)/*Korrekte vorm (singrafiek)*	✓
Positions A, C, E correct/*Posisies A, C en E korrek*	✓
Positions B, D correct/*Posisies B en D korrek*	✓
NOTE: If DC graph drawn max $^2/_3$ ***NOTA**: Indien GS grafiek geteken maks $^2/_3$*	

(3)

9.4

OPTION 1/*OPSIE 1*

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$
$= \frac{170}{\sqrt{2}}$ ✓
$= 120{,}21$ V

$R = \frac{V}{I}$ ✓
$100 = \frac{120{,}21}{I}$ ✓
$I_{rms} = 1{,}2$ A ✓

OPTION 2/*OPSIE 2*

$R = \frac{V}{I}$
$100 = \frac{170}{I_{max}}$ ✓
$I_{max} = 1{,}7$ A

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓
$= \frac{1{,}7}{\sqrt{2}}$ ✓
$= 1{,}2$ A ✓

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ $= \frac{170}{\sqrt{2}}$ ✓ $= 120{,}21$ V $P_{ave} = \frac{V_{rms}^2}{R}$ $= \frac{(120{,}21)^2}{100}$ $= 144{,}5$ W	**OPTION 3/*OPSIE 3*** $P = I_{rms}^2 R$ ✓ $144{,}5 = I_{rms}^2\ (100)$ ✓ $I_{rms}^2 = 1{,}2$ A ✓ **OPTION 4/*OPSIE 4*** $P_{ave} = V_{rms} I_{rms}$ ✓ $144{,}5 = 120{,}2 \times I_{rms}$ ✓ $I_{rms} = 1{,}20$ A ✓

(4)

9.5.1 Replace the slip rings with a split ring/ commutator ✓
Vervang die sleepringe met 'n splitring/ kommutator (1)

9.5.2 Mechanical/Kinetic (energy) to electrical (energy) ✓
Meganiese/Kinetiese na elektriese (energie) (1)

9.5.3 Yes✓
Ja (1)
[14]

QUESTION 10/*VRAAG 10*

10.1

Marking criteria/*Nasienkriteria*
If any of the underlined key words/phrases in the **correct context** is omitted, deduct 1 mark./*Indien enige van die onderstreepte sleutelwoorde/frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

The minimum energy that an electron in the metal needs to be emitted /ejected from the metal surface. ✓✓

Die minimum energie benodig vir 'n elektron in 'n metaal om vanaf die oppervlak vrygestel te word.

NOTE: If frequency is referred to $^0/_2$
***NOTA**: Indien na frekwensie verwys word $^0/_2$* (2)

10.2

OPTION 1/*OPSIE 1*

$E = W_0 + E_{k(max)}$ ✓

$7 \times 10^{-19} = W_0 + \frac{1}{2}(9{,}11 \times 10^{-31})(6{,}59 \times 10^{11})$ ✓✓

$W_0 = 4 \times 10^{-19}$J

Barium ✓

OPTION 2/*OPSIE 2* (if X was calculated first/*Indien X eerste bereken is*)

$$\text{Gradient} = \frac{\Delta v_{max}^2}{\Delta\text{Energy of the incident light}}$$

$$\frac{2}{m} = \frac{6{,}59 \times 10^{11} - X}{7 \times 10^{-19} - 5{,}4 \times 10^{-19}}$$

$$\frac{2}{9{,}11 \times 10^{-31}} = \frac{6{,}59 \times 10^{11} - X}{7 \times 10^{-19} - 5{,}4 \times 10^{-19}}$$

$X = 3{,}08$ Accept/*Aanvaar* $3{,}08 \times 10^{11}$ $(m^2 \cdot s^{-2})$

$E = W_0 + E_{k(max)}$ ✓

$5{,}4 \times 10^{-19} = W_0 + \frac{1}{2}(9{,}11 \times 10^{-31})(3{,}08 \times 10^{11})$ ✓✓

$W_0 = 4{,}0 \times 10^{-19}$ J

Barium ✓ (4)

10.3

POSITIVE MARKING FROM 10.2/POSITIEWE NASIEN VANAF 10.2

Range/*Gebied*: [3,07 – 3,08]

NOTE: If 10.3 is answered in 10.2, allocate marks as per 10.3

***NOTA:** Indien 10.3 reeds beantwoord is in 10.2, ken punte toe soos by 10.3*

OPTION 1/*OPSIE 1*

$E = W_0 + E_{k(max)}$
$E = W_0 + \frac{1}{2}mv_{max}^2$ ✓ Any one/*Enige een*

$5{,}4 \times 10^{-19}$ ✓ $= 4 \times 10^{-19}$ ✓ + $\frac{1}{2}(9{,}11 \times 10^{-31})v_{max}^2$ ✓

$X = 3{,}07$ ✓ **ACCEPT:** $3{,}07 \times 10^{11}$ $(m^2 \cdot s^{-2})$

OPTION 2/*OPSIE 2*

$E = W_0 + E_{k(max)}$ ✓

$7 \times 10^{-19} = W_0 + \frac{1}{2}(9{,}11 \times 10^{-31})(6{,}59 \times 10^{11})$ ✓.... Eq1

$5{,}4 \times 10^{-19} = W_0 + \frac{1}{2}(9{,}11 \times 10^{-31})(X \times 10^{11})$ ✓ Eq2

$1{,}6 \times 10^{-19} = \frac{1}{2}(9{,}11 \times 10^{-31})(6{,}59 \times 10^{11} - X \times 10^{11})$ ✓ **[Subtract Eq1 – Eq2]**

$X = 3{,}08$ ✓ **ACCEPT:** $3{,}08 \times 10^{11}$ $(m^2 \cdot s^{-2})$

OPTION 3/*OPSIE 3*

$$\text{Gradient} = \frac{\Delta v^2}{\Delta\text{Energy of the incident light}}$$

$$\frac{2}{m} \checkmark = \frac{6{,}59 \times 10^{11} - X}{7 \times 10^{-19} - 5{,}4 \times 10^{-19}} \checkmark$$

$$\frac{2}{9{,}11 \times 10^{-31}} \checkmark = \frac{6{,}59 \times 10^{11} - X}{7 \times 10^{-19} - 5{,}4 \times 10^{-19}}$$

$X = 3{,}08$ ✓ **ACCEPT:** $3{,}08 \times 10^{11}$ $(m^2 \cdot s^{-2})$

OPTION 4/*OPSIE 4*

$$\text{Gradient} = \frac{\Delta v^2}{\Delta \text{Energy of the incident light}}$$

$$\frac{6{,}59 \times 10^{11} - 0 \quad \checkmark}{7 \times 10^{-19} - 4 \times 10^{-19} \checkmark} = \frac{X \times 10^{11} - 0 \quad \checkmark}{5{,}4 \times 10^{-19} - 4 \times 10^{-19} \checkmark}$$

$X = 3{,}08$ ✓ **ACCEPT:** 3,08 x 10^{11} ($m^2 \cdot s^{-2}$) (5)

10.4 Remains the same ✓

- The intensity only affects the number of photoelectrons emitted per second. ✓
  OR
- Light intensity has no effect on kinetic energy/ velocity of the emitted electrons.
  OR
- The kinetic energy of the emitted photoelectrons remains the same.
  OR
- Only the frequency/ wavelength/ energy of the incident light affects the maximum kinetic energy.

Bly dieselfde

- *Die intensiteit beïnvloed slegs die aantal foto-elektrone vrygestel per sekonde.*
  OF
- *Die ligintensiteit het geen effek op kinetiese energie /spoed van vrygestelde elektrone nie*
  OF
- *Die kinetiese energie van die vrygestele foto-elektrone bly dieselfde*
  OF
- *Slegs die frekwensie/golflengte/energie van die invallende lig beïnvloed die maksimum kinetiese energie*

(2)
[13]

TOTAL/*TOTAAL*: 150