Confidential

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

PHYSICAL SCIENCES: PHYSICS (P1)

MAY/JUNE 2024

MARKS: 150

TIME: 3 hours

This question paper consists of 16 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. You may use appropriate mathematical instruments.
8. Show ALL formulae and substitutions in ALL calculations.
9. Round off your final numerical answers to a minimum of TWO decimal places.
10. Give brief motivations, discussions, etc. where required.
11. You are advised to use the attached DATA SHEETS.
12. 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 A book rests on a table. Which ONE of the following forces will form an action-reaction pair with the weight of the book?

A Force of the Earth on the book

B Force of the book on the Earth

C Force of the book on the table

D Force of the table on the book (2)

1.2 A person is standing on a bathroom scale in a moving lift. Which ONE of the following motions of the lift will result in the SMALLEST reading on the scale?

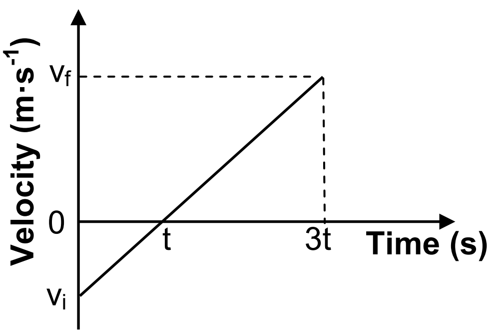
A The lift accelerates upwards.

B The lift accelerates downwards.

C The lift moves upwards at a constant velocity.

D The lift moves downwards at a constant velocity. (2)

1.3 The velocity versus time sketch graph below represents the motion of a ball which was in free fall. The ball struck the ground after 3t seconds.



Which ONE of the following statements is CORRECT?

The ball was …

A dropped from a height above the ground.

B thrown vertically upwards from the ground.

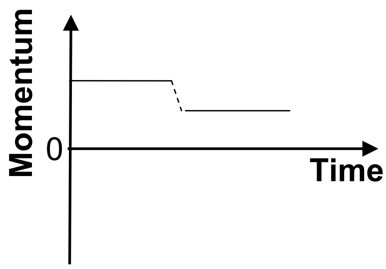
C thrown vertically upwards from a height above the ground.

D thrown vertically downwards from a height above the ground. (2)

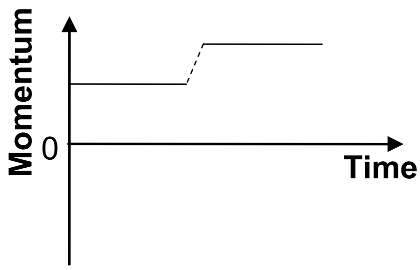
1.4 The vector diagram below shows the initial momentum (p_1), the final momentum (p_2) and the change in momentum (Δp) for a car that moved on a straight horizontal road.

Which ONE of the following sketch graphs CORRECTLY shows the momentum of the car for the time the car moved on the road?

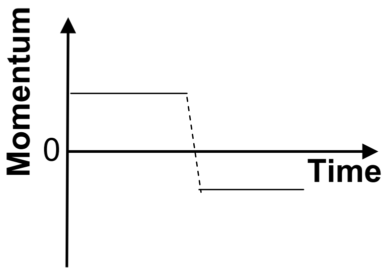
A



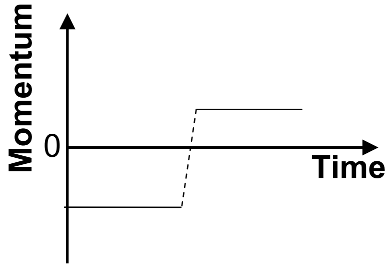
B



C



D



(2)

1.5 A stone of mass m is dropped from a height h above the ground. Ignore the effects of air friction.

Which ONE of the following combinations in the table below CORRECTLY represents the kinetic energy and the total mechanical energy of the stone at the instant the stone has fallen through a distance of ¼ h?

	KINETIC ENERGY	TOTAL MECHANICAL ENERGY
A	¾ mgh	¼ mgh
B	¼ mgh	¾ mgh
C	¾ mgh	mgh
D	¼ mgh	mgh

(2)

1.6 The spectrum of helium emitted from a star moving away from Earth is compared to the spectrum of helium found on Earth.

Which ONE of the following statements is CORRECT?

The observed spectral lines from the moving star will have a …

A lower frequency and a longer wavelength.

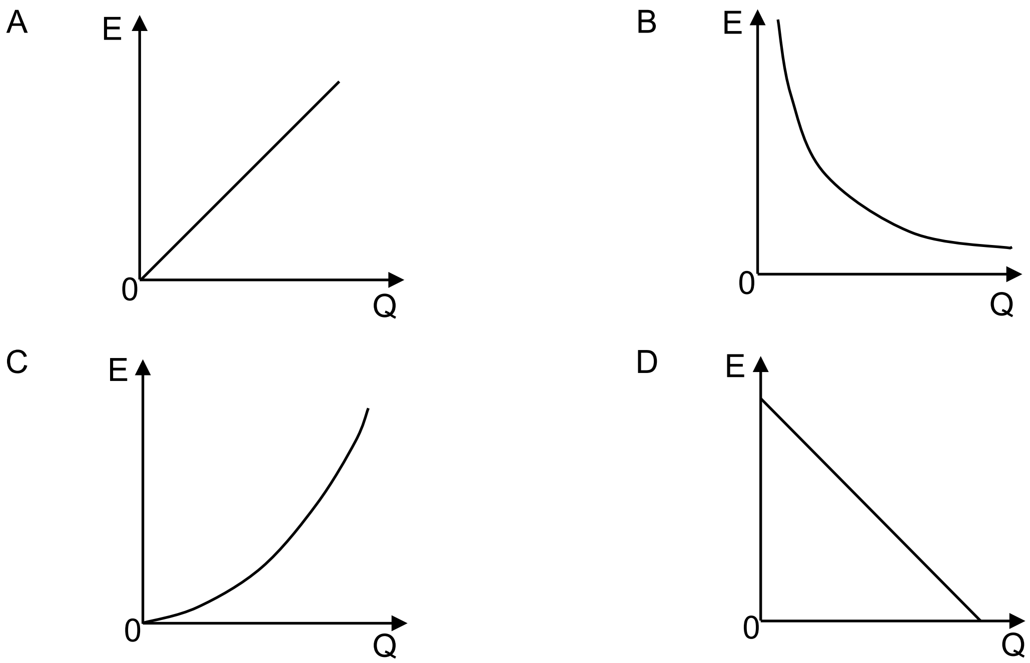
B lower frequency and a shorter wavelength.

C higher frequency and a shorter wavelength.

D higher frequency and a longer wavelength. (2)

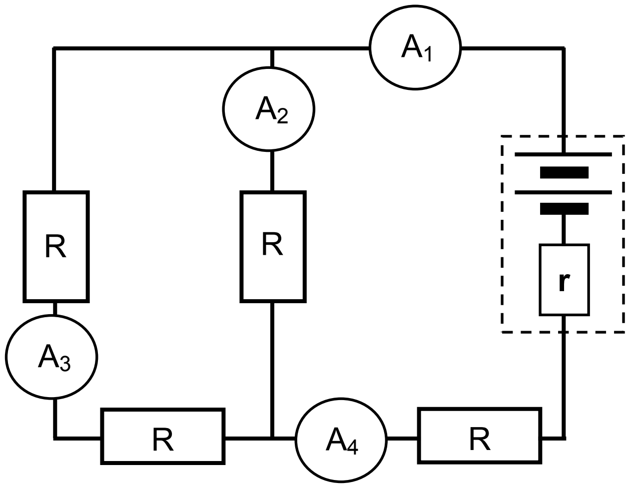
1.7 The magnitudes of electric fields generated by different point charges are measured at a fixed point. For each measurement, the distance between this fixed point and the charges are the same.

Which ONE of the following sketch graphs CORRECTLY shows the relationship between the magnitude of the electric field (E) and the magnitude of the charge (Q)?



(2)

1.8 The diagram below represents a circuit in which all the external resistors have the same resistance.



Which ONE of the ammeters in the circuit will have the LOWEST reading?

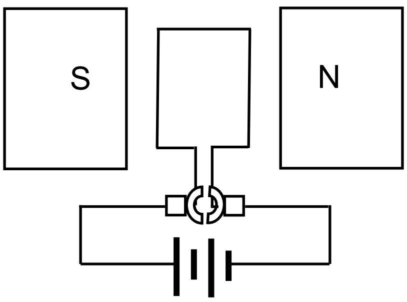
A A_1

B A_2

C A_3

D A_4 (2)

1.9 A simplified diagram of an electrical machine is shown below.



What type of machine is this?

A A DC motor

B An AC motor

C A DC generator

D An AC generator (2)

1.10 Which ONE of the following combinations is CORRECT for a line absorption spectrum in terms of the ENERGY TRANSITIONS OF THE ATOMS and the APPEARANCE OF THE NARROW LINES IN THE SPECTRUM?

	ENERGY TRANSITION OF THE ATOMS	**APPEARANCE OF THE NARROW LINES IN THE SPECTRUM**
A	Higher to lower energy state	Dark lines
B	Lower to higher energy state	Coloured lines
C	Lower to higher energy state	Dark lines
D	Higher to lower energy state	Coloured lines

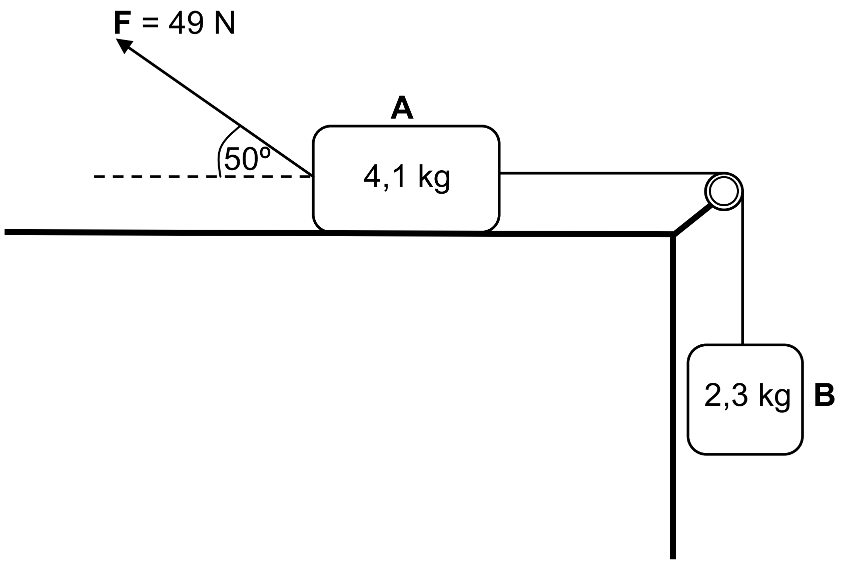
(2)
[20]

QUESTION 2 (Start on a new page.)

Block **A** of mass 4,1 kg is connected to block **B** of mass 2,3 kg by a light inextensible string passing over a frictionless pulley. Block **A** is at rest on a rough horizontal table and block **B** hangs vertically, as shown in the diagram below.

A force **F** of magnitude 49 N is applied on block **A** at an angle of 50º to the horizontal, causing block **A** to accelerate TO THE LEFT from rest along the table.

The coefficient of kinetic friction between the surface of the table and block **A** is 0,35.



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 **A** while it accelerates to the left. (5)

2.3 Calculate the magnitude of the:

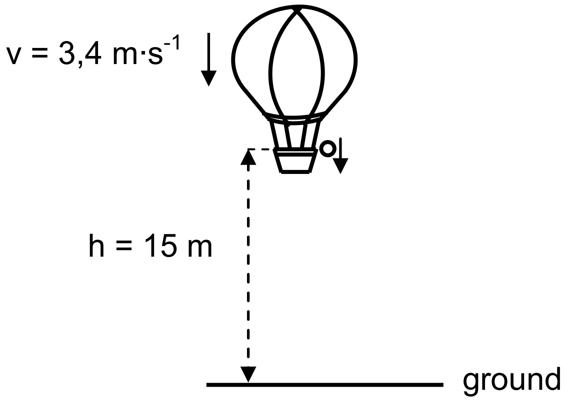
2.3.1 Kinetic frictional force exerted on block **A** (3)

2.3.2 Acceleration of block **A**, by applying Newton's Second Law to each block separately (5)

[15]

QUESTION 3 (Start on a new page.)

A hot-air balloon moves vertically downwards at a constant velocity of 3,4 m·s^{-1}. When the balloon is 15 m above the ground, a small ball is dropped from the balloon. Refer to the diagram below.

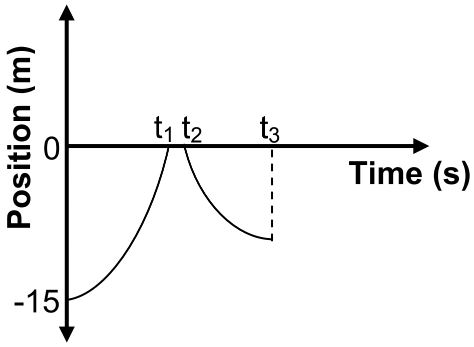


The ball strikes the ground and bounces vertically upwards. The hot-air balloon continues to move downwards at the same constant velocity.

Ignore the effects of air friction acting on the ball.

3.1 Define the term *free fall*. (2)

The sketch graph below (not drawn to scale) represents the positions of the ball relative to the ground from the time the ball is dropped until the time it reaches its maximum height after the first bounce.



3.2 Was the ball in free fall between t_1 and t_2 seconds? Write down either YES or NO. (1)

3.3 Use only EQUATIONS OF MOTION to calculate:

3.3.1 The value of t_1 indicated on the graph (3)

3.3.2 The height of the hot-air balloon above the ground at the instant when the ball struck the ground (4)

3.4 The ball was in contact with the ground for 0,2 s and left the ground with a vertical upward velocity of 7,2 m·s^{-1}.

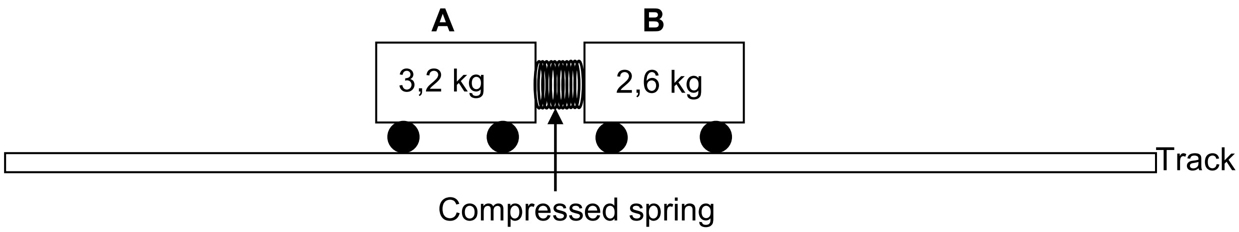
Use only EQUATIONS OF MOTION to calculate the value of t_3 indicated on the graph. (4)

[14]

QUESTION 4 (Start on a new page.)

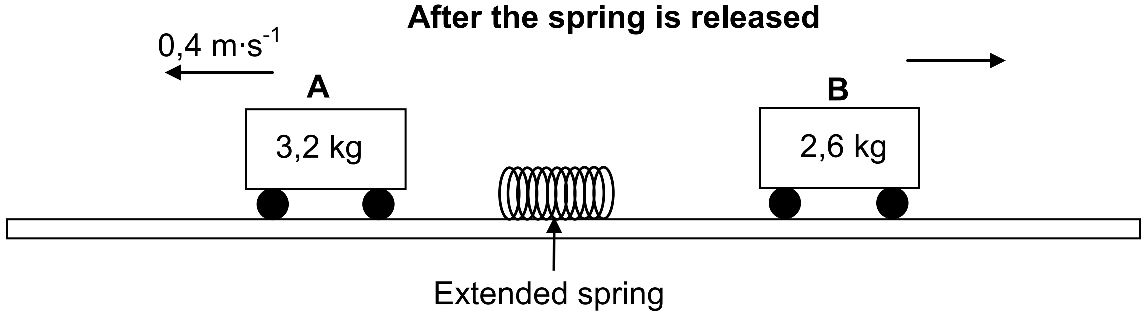
Two trolleys **A** and **B** of mass 3,2 kg and 2,6 kg respectively are held at rest on a straight horizontal, frictionless track, with a compressed spring between them, as shown in the diagram below.

Before the spring is released



After the trolleys are released, the spring extends to its natural length and then falls onto the track. Trolley **A** now moves with a constant velocity of 0,4 m·s^{-1} to the left, while trolley **B** moves with a constant unknown velocity to the right. Trolley **B** reaches the end of the track after 1,3 s.

After the spring is released



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

4.2. Calculate the distance travelled by trolley **B** in 1,3 s. (5)

The average force exerted by the extended spring on each trolley while they were in contact with the spring was 4,2 N.

4.3 Calculate the time it took the spring to extend to its natural length. (3)

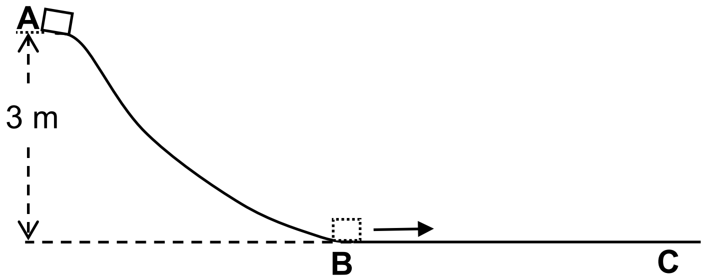
4.4 Trolley **B** is now replaced by trolley **C**, which has a larger mass. The same compressed spring is placed between trollies **A** and **C**. The trolleys are then released. The average force exerted by the extended spring on the trolleys remains at 4,2 N for the same period of time as calculated in QUESTION 4.3.

How does the magnitude of the velocity of trolley **C** compare to the magnitude of the velocity of trolley **B** after the spring has fallen to the track? Write only GREATER THAN, LESS THAN or EQUAL TO. Explain the answer. (3)

[13]

QUESTION 5 (Start on a new page.)

A crate of mass 18 kg, initially at rest, slides down a frictionless slope from point **A** to point **B**. The crate then moves along a rough horizontal surface from point **B** towards point **C**. Point **A** is 3 m above the horizontal surface. See the diagram below.



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

5.2 Using ENERGY PRINCIPLES only, calculate the speed of the crate at point **B**. (3)

A constant frictional force of 40,6 N acts on the crate as it moves from point **B** towards point **C**. The crate comes to rest at point **C**.

5.3 State the *work-energy theorem* in words. (2)

5.4 Using ENERGY PRINCIPLES only, calculate the distance that the crate travelled from point **B** to point **C**. (4)

5.5 The height of the track is now lowered so that point **A** is at a vertical height less than 3 m. The same crate is again released from point **A**.

How will the distance now, travelled by the crate along the horizontal surface before it comes to rest, compare to the distance calculated in QUESTION 5.4? Write only GREATER THAN, SMALLER THAN or EQUAL TO. Explain the answer. (3)

[14]

QUESTION 6 (Start on a new page.)

A stationary listener records the frequency of the sound emitted by the siren of a police car. When the car which is travelling at a constant velocity of 26 m·s^{-1}, approaches the listener, the recorded frequency is 615 Hz. The car passes the listener at time t_1 and then moves away from the listener. The recorded frequency now is 526 Hz.

Ignore the effects of wind.

6.1 State the Doppler effect in words. (2)

6.2 Use the information given to calculate the speed of sound in air. (5)

6.3 Calculate the wavelength of the sound emitted by the police siren. (4)

6.4 Sketch the graph of recorded frequency versus time for the motion of the car as it moved towards the listener, passed the listener and then moved away from the listener.

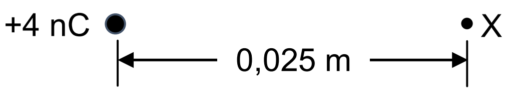
Label time t_1 on the graph.

No values need to be indicated on the frequency axis. (3)

[14]

QUESTION 7 (Start on a new page.)

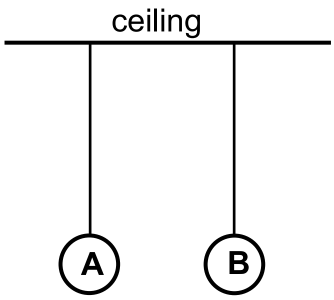
7.1 X is a point 0,025 m away from a +4 nC point charge. See the diagram below.



7.1.1 Draw the electric field pattern due to the +4 nC charge. (2)

7.1.2 Calculate the magnitude of the electric field at point X. (3)

7.2 Two identical neutral polystyrene balls **A** and **B** are suspended from a ceiling by insulated, light inextensible strings of equal length, as shown in the diagram below.



Ball **B** is then given an initial negative charge, Q_B, of unknown magnitude. The balls attract each other, touch and then repel each other. The balls come to rest with their centres 10 cm apart so that each string makes an angle of 9º with the vertical. See the diagrams below.

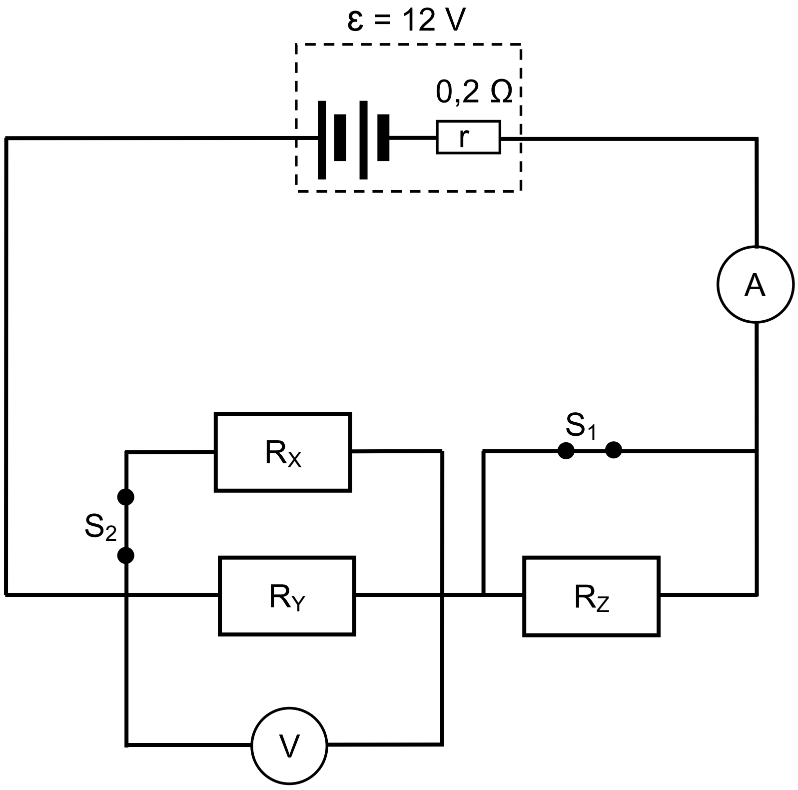
7.2.1 State Coulomb's Law in words. (2)

7.2.2 Calculate the magnitude of the initial charge Q_B given to ball **B** if the mass of each ball was 0,012 kg. (6)

[13]

QUESTION 8 (Start on a new page.)

A battery of emf 12 V and internal resistance 0,2 Ω is connected to three resistors, a high-resistance voltmeter and two switches, an ammeter and connecting wires of negligible resistance, as shown in the circuit diagram below. The three resistors have different and unknown resistances.



The resistance of R_Y is TWICE the resistance of R_X.

When both switches are CLOSED, the reading on the ammeter is 5,5 A.

8.1 Give a reason why there is no current through resistor R_Z. (1)

8.2 Calculate the resistance of resistor R_Y. (5)

8.3 Calculate the power dissipated by resistor R_X. (4)

When both switches are now OPENED, the reading on the ammeter is 1,3 A.

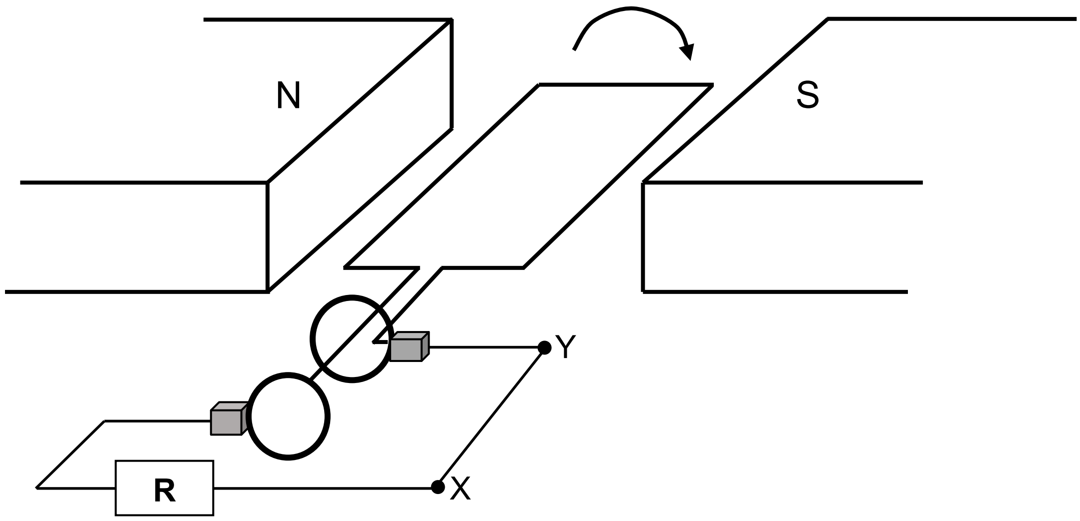
8.4 Calculate the reading on the voltmeter. (3)

Switch S_1 remains OPEN while switch S_2 is now CLOSED.

8.5 Calculate the reading on the ammeter. (6)
[19]

QUESTION 9 (Start on a new page.)

The simplified diagram below represents an AC generator with a coil rotating clockwise. X and Y are two points in the external circuit.



9.1 What is the direction of the current in the external circuit? Write either X to Y or Y to X. (2)

9.2 State the energy conversion that takes place in this generator. (1)

The maximum voltage produced by the generator is 125 V.

9.3 Define the term *root mean square voltage*. (2)

9.4 Calculate the root mean square voltage of the generator. (3)

9.5 The total resistance in the external circuit is 42,4 Ω.

Calculate the maximum current induced. (3)

9.6 The generator induced current at a frequency of 20 Hz. The coil started rotating from the initial position, as shown in the diagram above.

Sketch a graph of induced current versus time for two complete rotations of the coil.

Indicate the following on the graph:

- The time taken for two rotations
- The maximum current induced by the generator (4)

[15]

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	$6,67 \times 10^{-11}\ N \cdot m^2 \cdot kg^{-2}$
Radius of the Earth *Radius van die Aarde*	R_E	$6,38 \times 10^{6}\ m$
Mass of the Earth *Massa van die Aarde*	M_E	$5,98 \times 10^{24}\ kg$
Speed of light in a vacuum *Spoed van lig in 'n vakuum*	c	$3,0 \times 10^{8}\ m \cdot s^{-1}$
Planck's constant *Planck se konstante*	h	$6,63 \times 10^{-34}\ J \cdot s$
Coulomb's constant *Coulomb se konstante*	k	$9,0 \times 10^{9}\ N \cdot m^2 \cdot C^{-2}$
Charge on electron *Lading op elektron*	e	$-1,6 \times 10^{-19}\ C$
Electron mass *Elektronmassa*	m_e	$9,11 \times 10^{-31}\ kg$

QUESTION 10 (Start on a new page.)

10.1 Define the term *photoelectric effect*. (2)

10.2 Light of wavelength 4,7 x 10^{-7} m is shone onto the surface of a piece of caesium metal. If the threshold frequency of caesium is 4,37 x 10^{14} Hz, calculate the maximum speed of an electron ejected from the surface of the metal. (5)

10.3 A simple electroscope consists of a zinc disc, a metal stem and a thin length of gold foil. When the electroscope is neutral, the foil hangs vertically, as shown in DIAGRAM 1 below. When the electroscope is negatively charged, the foil is repelled from the stem, as shown in DIAGRAM 2 below.

Neutral electroscope

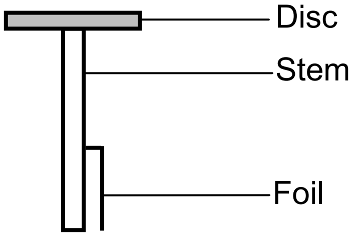


DIAGRAM 1

Negatively charged electroscope

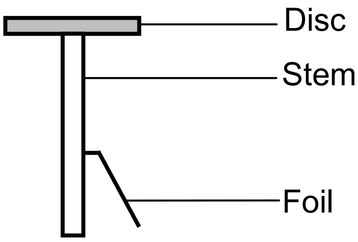


DIAGRAM 2

When ultraviolet light is shone on the disc of the negatively charged zinc electroscope, the foil collapses towards the stem (hangs vertically).

10.3.1 How does the frequency of the ultraviolet light compare to the threshold frequency of zinc? Write only HIGHER THAN, LOWER THAN or EQUAL TO. (1)

10.3.2 Explain why the foil of the electroscope collapses. (3)

Green light is now shone on another negatively charged zinc electroscope. The foil does not collapse.

10.3.3 Will the foil collapse if the intensity of the green light is increased? Write either YES or NO. Give a reason for the answer. (2)
[13]

TOTAL: 150

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

MOTION/*BEWEGING*

$v_f = v_i + a\Delta t$	$\Delta x = v_i\Delta t + ½a\Delta t^2$ or/*of* $\Delta y = v_i\Delta t + ½a\Delta t^2$
$v_f^2 = v_i^2 + 2a\Delta x$ 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*

$F_{net} = ma$	$p = mv$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = G\frac{m_1m_2}{d^2}$ or/*of* $F = G\frac{m_1m_2}{r^2}$	$g = G\frac{M}{d^2}$ 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* $E_p = mgh$
$K = ½mv^2$ or/*of* $E_k = ½mv^2$	$W_{net} = \Delta K$ 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* $E_k = ½mv^2_{max}$ or/*of* $K_{max} = ½mv^2_{max}$	

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

ALTERNATING CURRENT/*WISSELSTROOM*

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