KWAZULU-NATAL PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

GRADE 12

NATIONAL SENIOR CERTIFICATE

PHYSICAL SCIENCES P1 (PHYSICS)

PREPARATORY EXAMINATION

SEPTEMBER 2023

MARKS : 150

TIME : 3 Hours

This question paper consists of 16 pages and 3 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your NAME in the appropriate spaces on the ANSWER BOOK.
2. This question paper consists 10 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, for example 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 et cetera 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. Choose the answer and write only the letter (A-D) next to the question number (1.1-1.10) in the ANSWER BOOK, for example 1.11 D.

1.1 Which one of the following quantities is a measure of the inertia of a body?

A Mass

B Net force

C Velocity

D Impulse (2)

1.2 A spaceship has weight **X** on Earth. It is sent into space and lands on a planet which has a mass twice that of Earth and a radius ½ that of Earth. The weight of the spaceship on the planet is...

A 8**X**

B $\frac{1}{2}$**X**

C **X**

D $\frac{1}{4}$**X** (2)

1.3 A ball is dropped vertically downwards from rest and reaches a velocity **v** after it has travelled a distance y. What will be the magnitude of the velocity of the ball after it has travelled a distance 4y? (Ignore all effects of friction.)

A $\frac{1}{2}$**v**

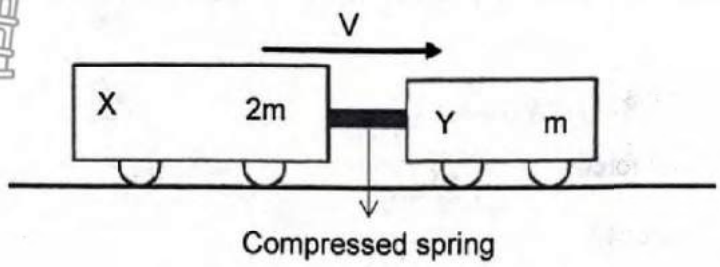
B $\sqrt{2}$**v**

C 2**v**

D 4**v** (2)

1.4 Two trolleys, X and Y, of masses 2m and m respectively, move to the right across a horizontal frictionless surface with a speed v. They are joined by means of a compressed spring. The trolleys are pushed apart when the spring is released and falls to the ground.

The magnitude of the change in momentum of trolley X is p. What is the magnitude of the change in momentum of trolley Y?



A $\frac{1}{2}p$

B $\frac{1}{3}p$

C 2p

D p (2)

1.5 A CONSERVATIVE FORCE is a force...

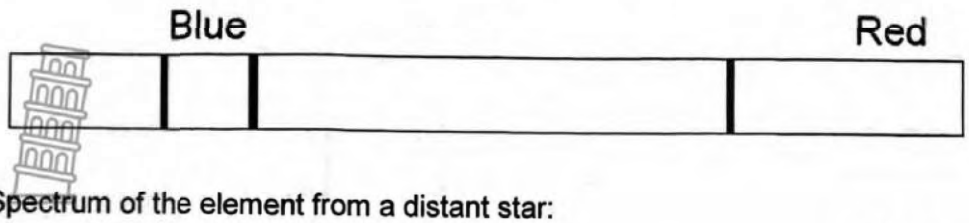
A for which the work done in moving an object between two points is dependent on the path taken.

B for which no work is done in moving an object between two points.

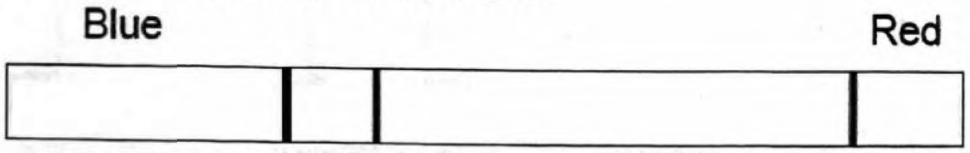
C for which the work done in moving an object between two points is independent of the path taken.

D that always does negative work when an object moves between two points. (2)

1.6 Astronomers obtained the following spectral lines of an element:
Spectrum of the element in a laboratory on Earth:



Spectrum of the element from a distant star:



From this it can be concluded that the ...

A star is moving closer towards Earth.

B Earth is moving towards the stationary star.

C temperature of Earth is increasing.

D star is moving away from Earth. (2)

1.7 The magnitude of an electric field at a distance r from a point charge is **E**. The magnitude of the electric field at a distance $2r$ from the same point charge will be ...

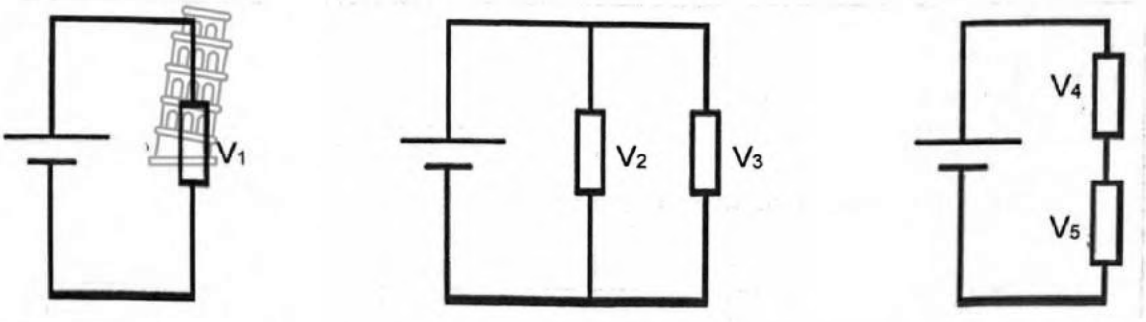
A $\frac{1}{2}$ **E**

B $\frac{1}{4}$ **E**

C 2 **E**

D 4 **E** (2)

1.8 Three circuits with identical resistors and cells are shown in the diagram below. The cells have negligible internal resistance. V_1 to V_5 gives the magnitude of the potential difference across each resistor



Which ONE of the following statements is TRUE for the magnitude of the potential difference across the resistors?

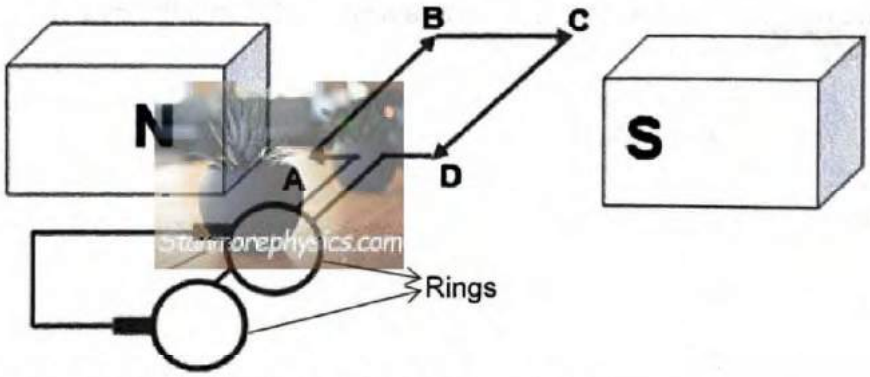
A $V_1 > V_2 = V_3 > V_4 = V_5$

B $V_2 > V_3 > V_1 > V_4 > V_5$

C $V_2 = V_3 > V_1 > V_4 = V_5$

D $V_1 = V_2 = V_3 > V_4 = V_5$ (2)

1.9 A simplified diagram of a generator is shown below.



The arrows indicate the direction of the current in the coil.
When viewed from where the rings are positioned, the coil ABCD is being rotated...

A clockwise.

B anticlockwise.

C clockwise, reaches the vertical position and then reverses its direction.

D anticlockwise, reaches the vertical position and then reverses its direction. (2)

1.10 The photo-electric effect provides evidence that...

A metals contain electrons.

B light has a particle nature.

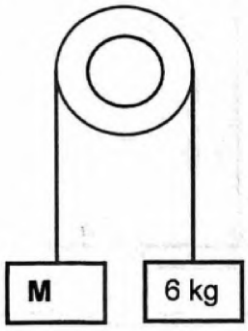
C light has a wave nature.

D metals conduct electricity. (2)

[20]

QUESTION 2

Two blocks of mass **M** kg and 6 kg respectively are connected by a light, inextensible string. The string runs over a light, frictionless pulley.
Initially, both blocks are held stationary, at the same height above the ground.
When the blocks are released, the 6kg block accelerates downwards.



GROUND

The vertical distance between the blocks, ONE SECOND after they are released, is 1,96 m.

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

2.2 Draw a labelled free-body diagram showling all forces acting on the 6 kg block. (2)

2.3 Calculate the acceleration of the 6 kg block. (5)

2.4 Determine the value of **M** by applying Newton's Second Law to each of the blocks separately. (5)

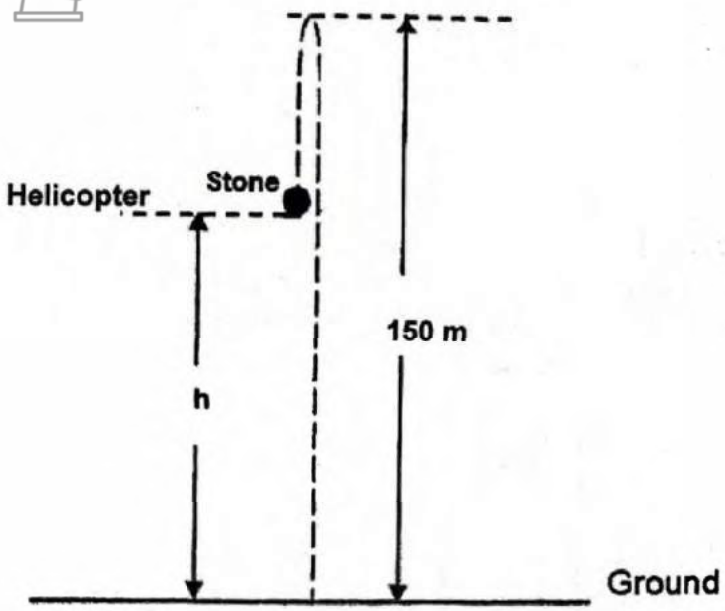
2.5 The string connecting the blocks is now cut. What will be the magnitude of the acceleration of the **M** kg block?
Give a reason for the answer (2)

[16]

QUESTION 3

A helicopter is moving vertically upwards at a constant speed of 8 $m \cdot s^{-1}$. When the helicopter is at height h metres above the ground a stone is dropped from the helicopter. The stone reaches a maximum height of 150 m above the ground.

The diagram below represents the motion of the stone from the instant it was dropped from the helicopter until it struck the ground. Ignore the effects of air resistance.



3.1 Give a reason why the stone is in *free fall* after it was dropped from the helicopter. (2)

3.2 What is the direction of the acceleration of the stone:

3.2.1 When the stone is at its maximum height (1)

3.2.2 Immediately after the stone is dropped from the helicopter (1)

3.3 Calculate:

3.3.1 The maximum height reached by the stone above the point from which it was dropped. (3)

3.3.2 Height **h**. (1)

3.4 Determine the time taken for the stone to reach the ground. (4)

3.5 On the same system of axes, draw a velocity vs time graph for the stone and the helicopter from the instant the stone is dropped until it struck the ground.

Clearly show the following on your graph:

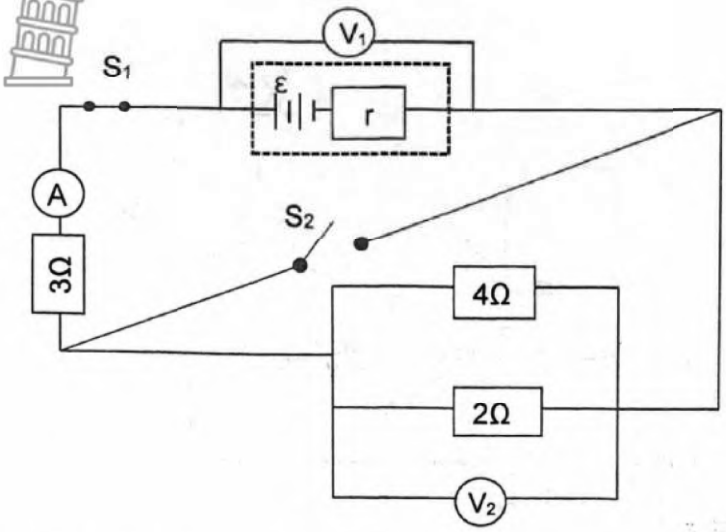
- Initial velocity for both the stone and the helicopter.
- The time taken for the stone to reach the ground.

(4)

[16]

QUESTION 8.

A battery with an unknown emf (ε) and internal resistance (r) is connected in a circuit, as shown below. The ammeter and connecting wires have negligible resistance. V_1 and V_2 are high-resistance voltmeters



When switch S_1 is **closed** and switch S_2 is **open**, the ammeter reads 2,48 A.

8.1 Define the term *emf of a battery*. (2)

8.2 Calculate the:

8.2.1 reading on voltmeter V_2 (4)

8.2.2 energy transferred to the 3Ω resistor in 1,5 minutes (3)

With BOTH switches S_1 and S_2 **closed**, the ammeter reads 3,43 A.

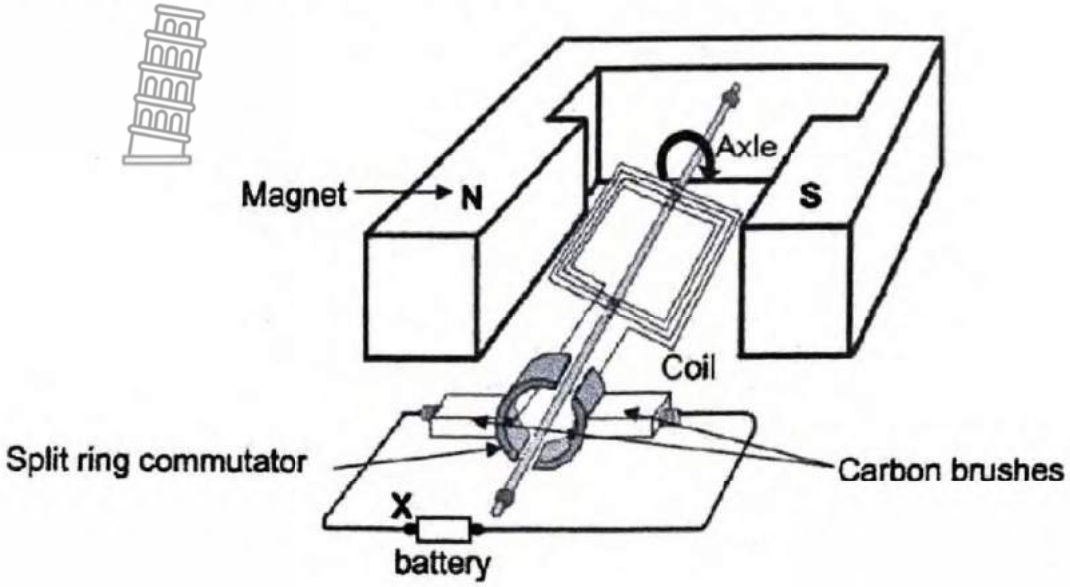
8.3 How will the reading on the voltmeter, V_1, be affected? Choose from INCREASES, DECREASES or REMAINS THE SAME?
Explain the answer. (3)

8.4 Determine the emf of the battery. (5)

8.5 The battery is now replaced with another battery that has the SAME emf but a GREATER internal resistance. How will the reading on V_1 be affected when both switches are closed?
Choose from INCREASES, DECREASES or REMAINS THE SAME
Explain the answer. (3)
[20]

QUESTION 9.

9. 1 The diagram below represents a simplified sketch of a DC electric motor.



9.1.1 The coil rotates in a clockwise direction as indicated in the diagram above. What is the polarity of the pole of the battery labelled X? Choose from POSITIVE or NEGATIVE (2)

9.1.2 State the energy conversion that takes place in the electric motor. (2)

9.1.3 Name the component that ensures that the coil rotates continuously in ONE DIRECTION. (1)

9.1.4 Name the fundamental principle on which the motor work. (1)

9.2 An electrical device is marked 200 W ; 220 V. The 220 V refers to the rms voltage.

9.2.1 Define *rms voltage.* (2)

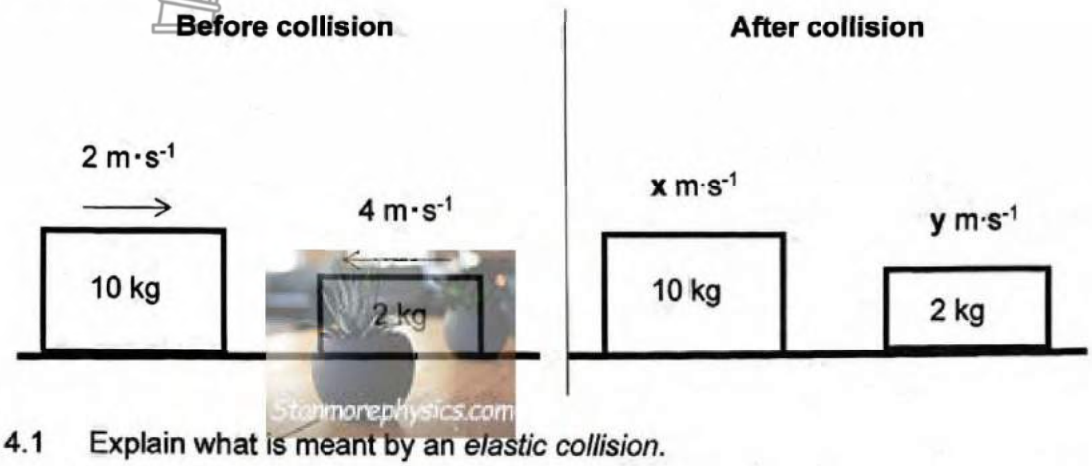
9.2.2 Calculate the resistance of the device. (3)

[11]

QUESTION 4

A 10 kg block travelling at 2 m·s^{-1} to the right collides with a 2 kg block travelling at 4 m·s^{-1} to the left as shown in the diagram below. The collision is ELASTIC.

After the collision the 10 kg block has a velocity **x** m·s^{-1} and the 2 kg block has a velocity of **y** m·s^{-1}.
Ignore the effects of friction.



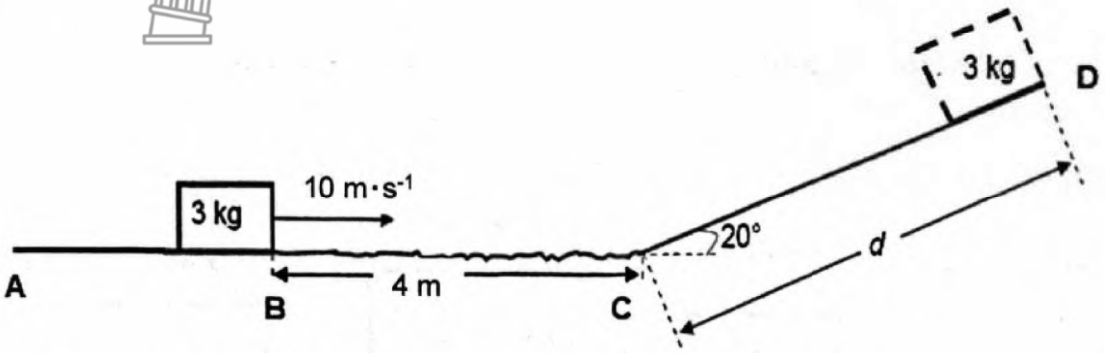
4.1 Explain what is meant by an *elastic collision*. (2)

4.2 Determine the velocity of each block after the collision. (7)

[9]

QUESTION 5

A 3 kg block slides at a constant velocity of 10 m·s^{-1} from point A to point B along a smooth horizontal surface. It then moves a distance of 4 m from point B to point C along a rough horizontal surface. The block then moves up a frictionless incline which makes an angle of 20° with the horizontal, as shown in the diagram below.



The block moves a distance *d* up the incline before coming to rest at point D.

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

The block passes point C with a speed of 3,5 m·s^{-1}.

5.2 Use ENERGY PRINCIPLES only to calculate the work done by the frictional force (4)

5.3 Draw a vector diagram to show all the forces acting on the block that are parallel to the incline, while the block is sliding from point C to point D. (1)

5.4 Using ENERGY PRINCIPLES only, calculate the distance *d*. (5)

5.5 How will the answer to QUESTION 5.4 be affected if the angle of the incline is now increased?
Choose from INCREASES, DECREASES or REMAINS THE SAME (1)

[13]

QUESTION 6

An ambulance, with its siren on, is moving at a constant speed along a straight horizontal road towards a stationary detector. The detector registers sound waves with a frequency of 450 Hz as the ambulance approaches it. As the ambulance moves away from the detector, the detector registers sound waves with a frequency of 385 Hz.

Assume that the speed of sound in air is 340 $m \cdot s^{-1}$.

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

6.2 Calculate:

6.2.1 The speed of the ambulance. (6)

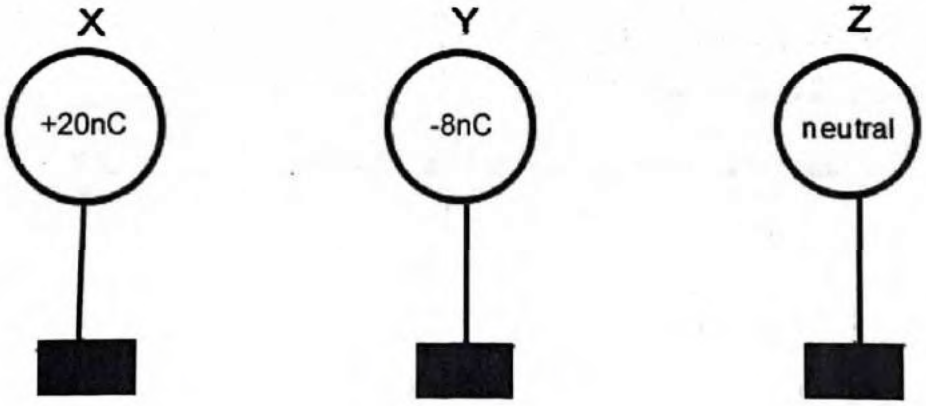
6.2.2 The frequency of the sound waves emitted by the siren . (2)

6.3 What will be the frequency of the sound waves heard by the driver of the ambulance? (1)

[11]

QUESTION 7

Three small identical metal spheres, **X**, **Y** and **Z** are mounted on insulated stands as shown. **X** carries a charge of +20nC, **Y** carries a charge of -8nC and **Z** is neutral.



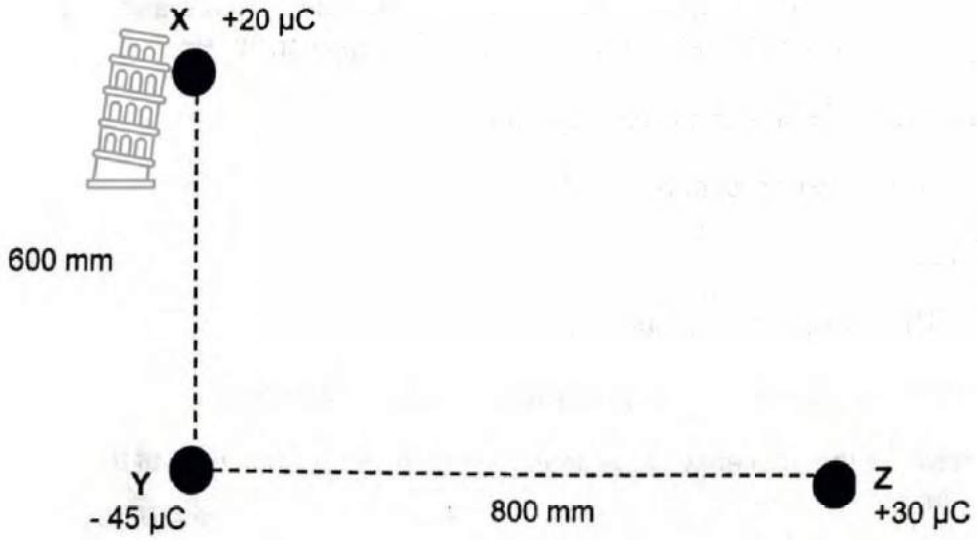
7.1 Give a reason why the metal spheres are mounted on insulated stands. (1)

7.2 Sphere **X** is first brought into contact with sphere **Y**. Sphere **X** is moved and then brought into contact with sphere **Z**, and then separated.

7.2.1 Calculate the net charge on each sphere after they are separated. (3)

7.2.2 Which of the three spheres undergoes a small net increase in mass? Give a reason for the answer. (2)

7.3 Three point charges, **X**, **Y** and **Z** of magnitudes +20 μC, -45 μC and +30 μC respectively are placed so that they form a right angle as shown below.
X and **Y** are 600 mm apart, whilst **Y** and **Z** are 800 mm apart.



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

7.3.2 Calculate the magnitude of the net electrostatic force exerted on **Y** by **X** and **Z**. (5)

Point charge Y is now removed.

7.3.3 Define *electric field at a point*. (2)

7.3.4 Calculate the magnitude of the net electric field at the original position of Y. (3)

[18]

QUESTION 8.

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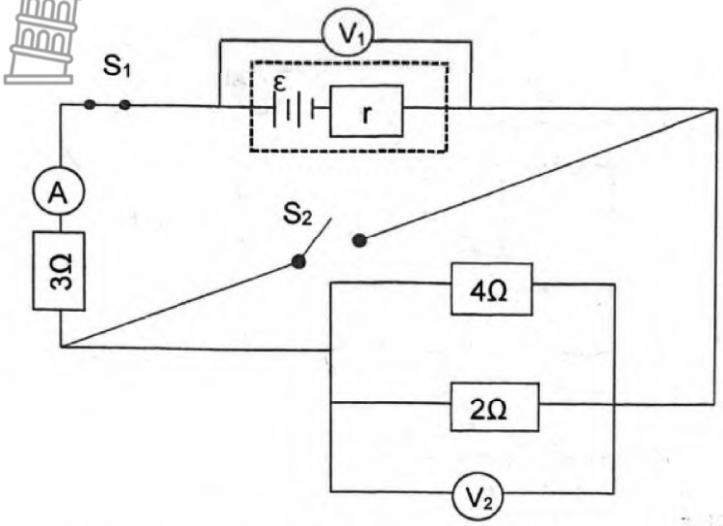

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8.1 Define the term *emf of a battery*. (2)

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8.2.1 reading on voltmeter V_2 (4)

8.2.2 energy transferred to the 3Ω resistor in 1,5 minutes (3)

With BOTH switches S_1 and S_2 **closed**, the ammeter reads 3,43 A.

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8.5 The battery is now replaced with another battery that has the SAME emf but a GREATER internal resistance. How will the reading on V_1 be affected when both switches are closed?
Choose from INCREASES, DECREASES or REMAINS THE SAME
Explain the answer. (3)
[20]

QUESTION 9.

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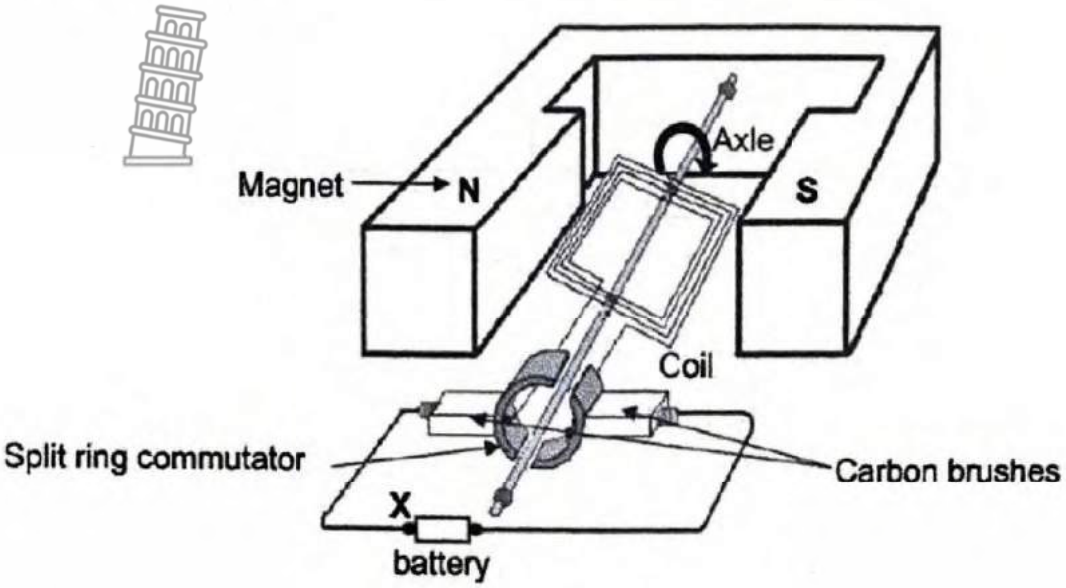

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9.1.3 Name the component that ensures that the coil rotates continuously in ONE DIRECTION. (1)

9.1.4 Name the fundamental principle on which the motor work. (1)

9.2 An electrical device is marked 200 W ; 220 V. The 220 V refers to the rms voltage.

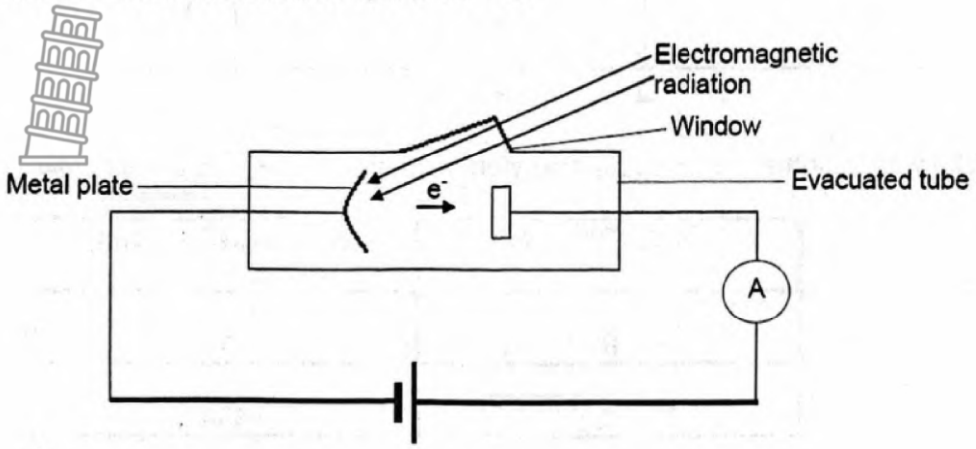
9.2.1 Define *rms voltage*. (2)

9.2.2 Calculate the resistance of the device. (3)

[11]

QUESTION 10

The simplified diagram of a photocell below shows a metal plate that emits electrons when a certain frequency of electromagnetic radiation is incident on it.
The metal plate has a work function of $7,57 \times 10^{-19}$ J.



10.1 Define *threshold frequency* (2)

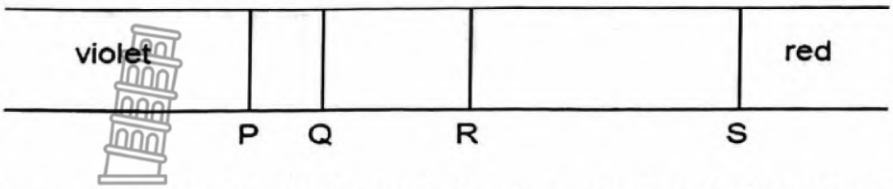
10.2 Light of wavelength 200 nm is incident on the metal plate. Determine the maximum speed of the released photo-electron. (6)

10.3 Electromagnetic radiation with a shorter wavelength but the same intensity is now used.
What effect will this have on each of the following?
(Choose from INCREASES, DECREASES or REMAINS THE SAME.)

10.3.1 The reading on the ammeter.
Explain the answer (3)

10.3.2 The kinetic energy of the released photo-electrons.
Give a reason for the answer (2)

10.4 Four emission lines **P**, **Q**, **R** and **S** in the hydrogen spectrum are shown in the diagram below.



The wavelengths of these four emission lines are given in the table below.

EMISSION LINE	WAVELENGTH (nm)
P	410
Q	434
R	486
S	658

Which emission line is produced by the transition from the highest energy level to the ground state energy level? Explain the answer. (3)

[16]

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 gravitasiekonstant*	G	$6{,}67 \times 10^{-11}\ N{\cdot}m^2{\cdot}kg^{-2}$
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	$9{,}11 \times 10^{-31}\ kg$
Mass of Earth *Massa van Aarde*	M	$5{,}98 \times 10^{24}\ kg$
Radius of Earth *Radius van Aarde*	R_E	$6{,}38 \times 10^{6}\ m$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

MOTION/*BEWEGING*

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

FORCE/*KRAG*

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

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

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

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* $E = h\frac{c}{\lambda}$
$E = W_o + E_{k(max)}$ *or/of* $E = W_o + K_{max}$ *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*

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