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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: PHYSICS (P1)

FEBRUARY/MARCH 2018

MARKS: 150

TIME: 3 hours

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

INSTRUCTIONS AND INFORMATION

1. Write your examination number and centre number in the appropriate spaces on the ANSWER BOOK.
2. This question paper consists of 11 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. You are advised to use the attached DATA SHEETS.
9. Show ALL formulae and substitutions in ALL calculations.
10. Round off your FINAL numerical answers to a minimum of TWO decimal places.
11. Give brief motivations, discussions, et cetera where required.
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 A constant horizontal force **F** is applied to a box resting on a horizontal, frictionless surface.

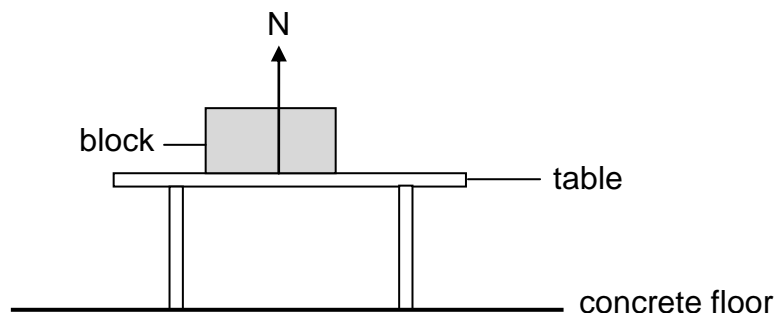
Which ONE of the following statements regarding force **F** is CORRECT?

Force **F** will cause the box to move with ...

- A constant acceleration.
- B constant velocity.
- C constant kinetic energy.
- D constant momentum.

(2)

- 1.2 A block rests on a table. The table stands on a concrete floor. The normal force is represented by **N**, as shown in the diagram below.

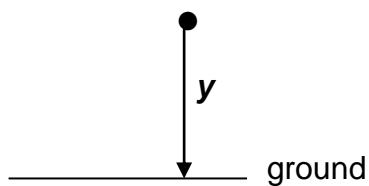


Which ONE of the following forces will form an action-reaction pair with the normal force (**N**)?

- A Force of the block on the Earth
- B Force of the block on the table
- C Force of the table surface on the block
- D Force of the block on the concrete floor

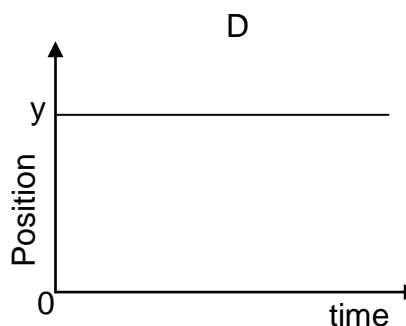
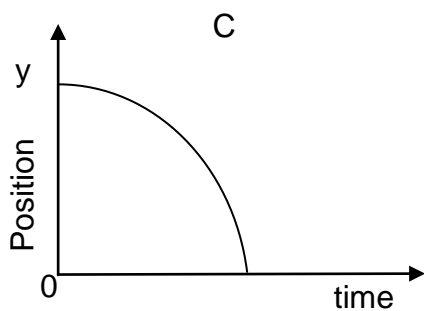
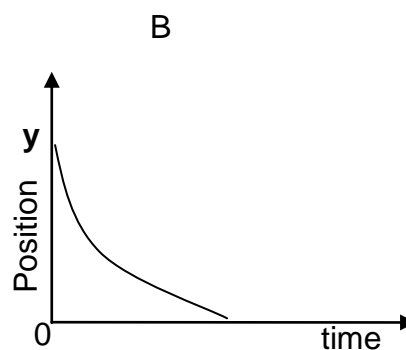
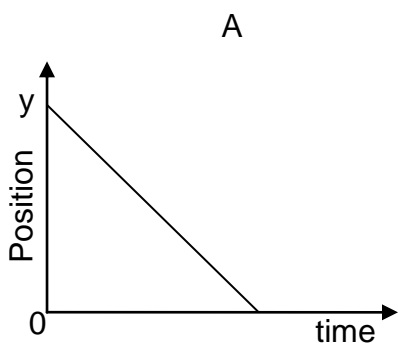
(2)

- 1.3 A small stone is dropped from a height y above the ground. It strikes the ground after time t , as shown in the diagram below.



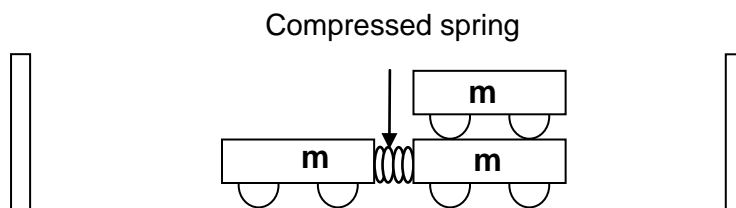
Take upwards as the positive direction and the ground as zero reference. Ignore the effects of air resistance.

Which ONE of the following diagrams shows a correct position-time graph for the motion of the stone?



(2)

- 1.4 Learners perform an experiment using identical trolleys, each of mass m . The trolleys are arranged, as shown in the diagram below. They are initially at rest on a frictionless surface and are connected with a compressed, massless spring.



When the spring is released it falls vertically down and the single trolley moves with momentum p to the left. The magnitude of the momentum of the two trolleys moving to the right will be:

A $2p$

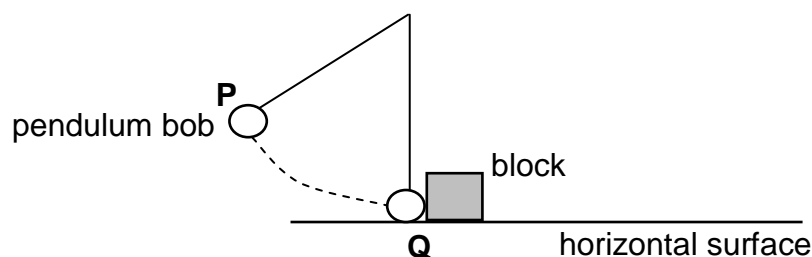
B p

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

D $\frac{1}{4}p$

(2)

- 1.5 A pendulum bob is released from point **P** above a horizontal surface. At the lowest point, **Q**, of its swing, it collides with a stationary block situated on a frictionless horizontal surface, as shown below. Ignore air friction.



Which ONE of the following combinations of **conservation laws** can be used to calculate the speed of the bob at **Q** immediately before and after colliding with the block?

	SPEED AT Q	SPEED AFTER COLLISION
A	Conservation of mechanical energy	Conservation of linear momentum
B	Conservation of linear momentum	Conservation of mechanical energy
C	Conservation of mechanical energy	Conservation of mechanical energy
D	Conservation of linear momentum	Conservation of linear momentum

(2)

1.6 Which ONE of the statements below about the Doppler effect is CORRECT?

- A The Doppler effect is only applicable to sound waves.
- B The Doppler effect can be used to explain the expanding universe.
- C Electrons are ejected from a metal surface by means of the Doppler effect.
- D A stationary listener hears a lower pitch of the sound from a siren of an approaching vehicle because of the Doppler effect.

(2)

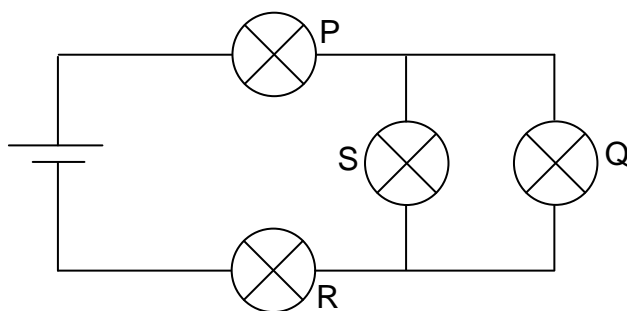
1.7 The magnitude of the electrostatic force on a charge Q_1 due to another charge Q_2 is F . Both charges are now doubled without changing the distance between them.

The magnitude of the new electrostatic force on Q_1 will be:

- A $\frac{F}{2}$
- B $2F$
- C $4F$
- D $6F$

(2)

1.8 Four identical bulbs, **P**, **Q**, **R** and **S**, are connected to a cell in a circuit, as shown below. The cell has negligible internal resistance.



Which ONE of the following statements about the brightness of bulbs **P**, **Q**, **R** and **S** is CORRECT?

- A **P** burns brighter than **R**.
- B **S** and **Q** burn brighter than **P** and **R**.
- C **P** and **R** burn brighter than **S** and **Q**.
- D ALL the bulbs burn with the same brightness.

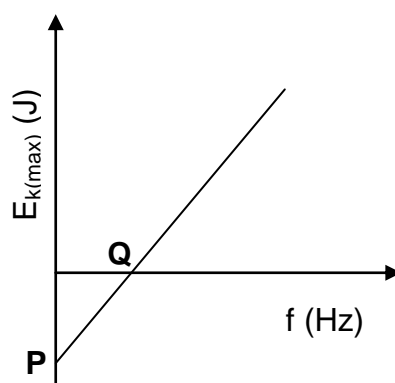
(2)

1.9 Which ONE of the energy conversions below takes place when a **DC** motor is in operation?

- A Kinetic to electrical
- B Heat to mechanical
- C Mechanical to electrical
- D Electrical to mechanical

(2)

1.10 In an investigation on the photoelectric effect, the graph of maximum kinetic energy ($E_{k(\max)}$) versus frequency (f) was obtained for a certain metal, as shown below.



The intercepts, **P** and **Q** respectively, represent ...

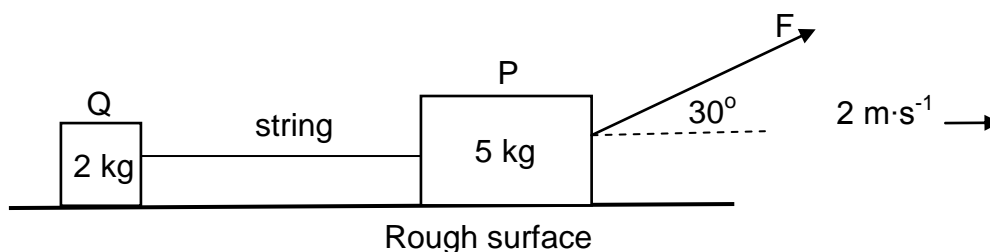
- A Planck's constant and threshold frequency.
- B work function and threshold frequency.
- C threshold frequency and work function.
- D threshold frequency and Planck's constant.

(2)
[20]

QUESTION 2 (Start on a new page.)

Two boxes, **P** and **Q**, resting on a rough horizontal surface, are connected by a light inextensible string. The boxes have masses 5 kg and 2 kg respectively. A constant force **F**, acting at an angle of 30° to the horizontal, is applied to the 5 kg box, as shown below.

The two boxes now move to the right at a **constant speed** of $2 \text{ m}\cdot\text{s}^{-1}$.



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

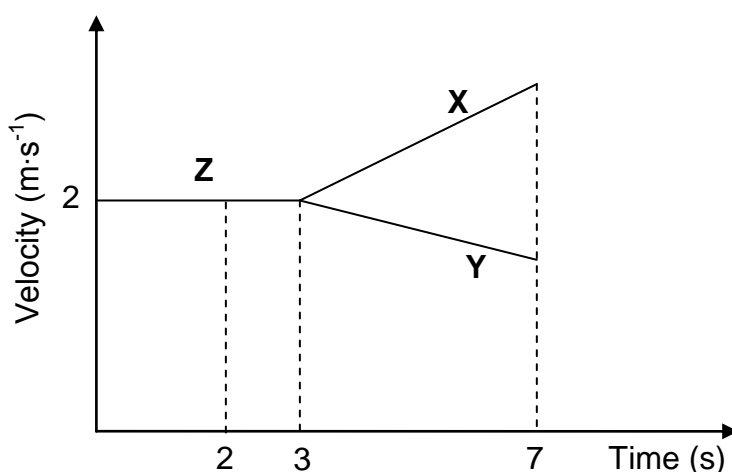
2.2 Draw a labelled free-body diagram for box **Q**. (4)

Box **P** experiences a constant frictional force of 5 N and box **Q** a constant frictional force of 3 N.

2.3 Calculate the magnitude of force **F**. (6)

The string connecting **P** and **Q** suddenly breaks after 3 s while force **F** is still being applied.

Learners draw the velocity-time graph for the motion of **P** and **Q** before and after the string breaks, as shown below.



2.4 Write down the time at which the string breaks. (1)

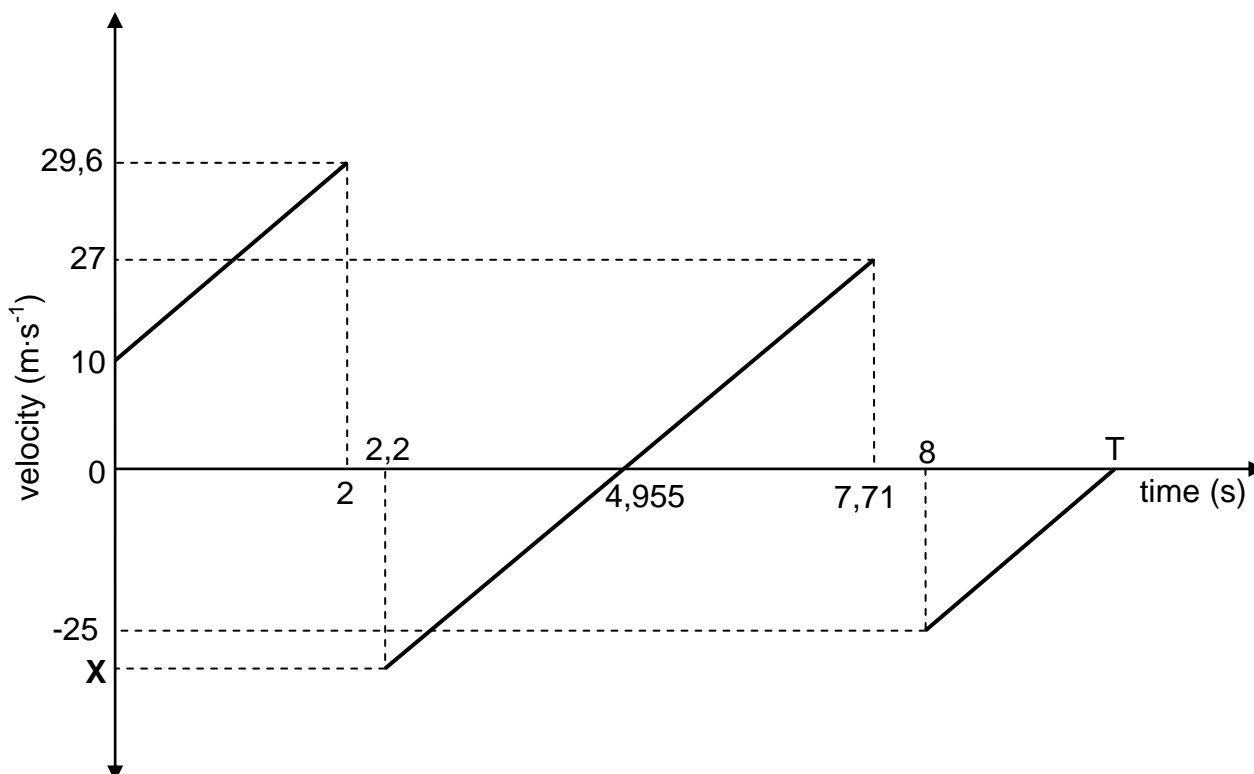
2.5 Which portion (**X**, **Y** or **Z**) of the graph represents the motion of box **Q**, after the string breaks? Use the information in the graph to fully support the answer. (4)

(4)
[17]

QUESTION 3 (Start on a new page.)

A ball is thrown **vertically downwards** from the top of a building and bounces a few times as it hits the ground. The velocity-time graph below describes the motion of the ball from the time it is thrown, up to a certain time **T**.

Take downwards as the positive direction and the ground as zero reference. The graph is NOT drawn to scale. The effects of air friction are ignored.



- 3.1 Write down the speed with which the ball is thrown downwards. (1)
- 3.2 ALL parts of the graph have the same gradient. Give a reason for this. (2)
- 3.3 Calculate the:
 - 3.3.1 Height from which the ball is thrown (3)
 - 3.3.2 Time (T) shown on the graph (4)
- 3.4 Write down the:
 - 3.4.1 Time that the ball is in contact with the ground at the first bounce (1)
 - 3.4.2 Time at which the ball reaches its maximum height after the first bounce (2)
 - 3.4.3 Value of X (1)
- 3.5 Is the collision of the ball with the ground *elastic* or *inelastic*? Give a reason for the answer using information in the graph. (2)

[16]

QUESTION 4 (Start on a new page.)

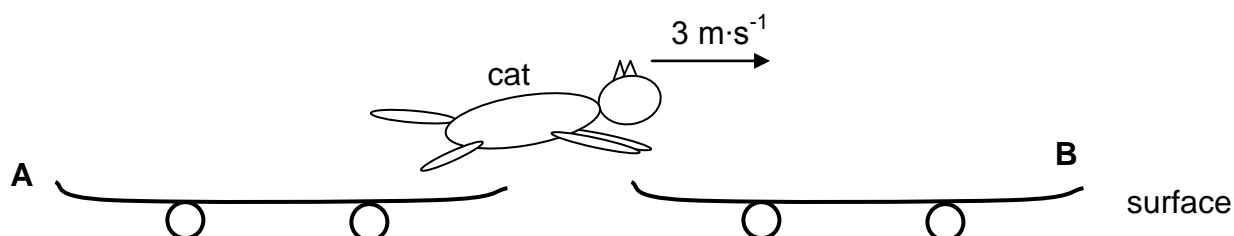
The diagram below shows two skateboards, **A** and **B**, initially at rest, with a cat standing on skateboard **A**. The skateboards are in a straight line, one in front of the other and a short distance apart. The surface is flat, frictionless and horizontal.



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

EACH skateboard has a mass of 3,5 kg. The cat, of mass 2,6 kg, jumps from skateboard **A** with a horizontal velocity of $3 \text{ m}\cdot\text{s}^{-1}$ and lands on skateboard **B** with the same velocity of $3 \text{ m}\cdot\text{s}^{-1}$.

Refer to the diagram below.



- 4.2 Calculate the velocity of skateboard **A** just after the cat has jumped from it. (5)

Immediately after the cat has landed, the cat and skateboard **B** move horizontally to the right at $1,28 \text{ m}\cdot\text{s}^{-1}$.

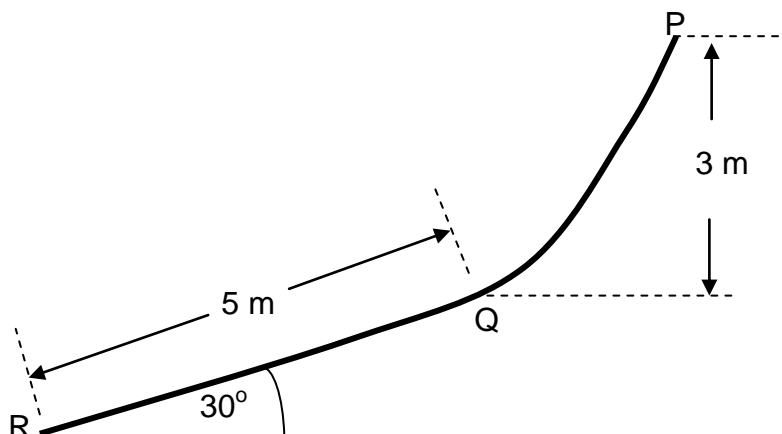
- 4.3 Calculate the magnitude of the impulse on skateboard **B** as a result of the cat's landing. (3)

[10]

QUESTION 5 (Start on a new page.)

A slide, **PQR**, at an amusement park consists of a curved *frictionless* section, **PQ**, and a section, **QR**, which is rough, straight and inclined at 30° to the horizontal. The starting point, **P**, is 3 m above point **Q**. The straight section, **QR**, is 5 m long.

A learner, with mass 50 kg, starting from rest at **P**, slides down section **PQ**, then continues down the straight section, **QR**.



- 5.1 State the law of conservation of mechanical energy in words. (2)
- 5.2 Calculate the speed of the learner at **Q**. (4)
- 5.3 Draw a labelled free-body diagram for the learner while he/she is on section **QR**. (3)

The coefficient of kinetic friction (μ_k) between the learner and the surface of section **QR** is 0,08.

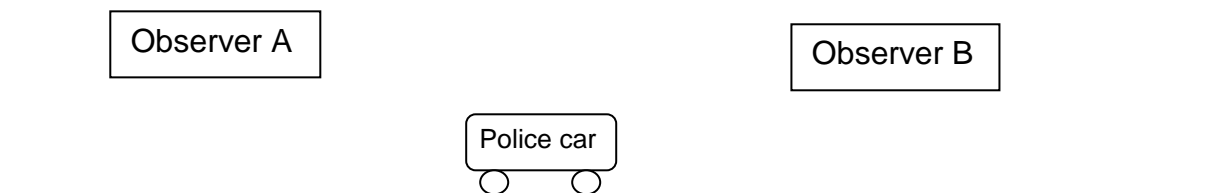
- 5.4 Calculate the magnitude of the kinetic frictional force acting on the learner when the learner is on section **QR**. (3)
- 5.5 Use energy principles to calculate the speed of the learner at point **R**. (5)
- [17]**

QUESTION 6 (Start on a new page.)

A police car is moving at a constant speed on a straight horizontal road. The siren of the car emits sound of constant frequency.

EACH of two observers, **A** and **B**, standing some distance apart on the same side of the road, records the frequency of the detected sound.

Observer **A** records a frequency of 690 Hz and observer **B** records a frequency of 610 Hz.

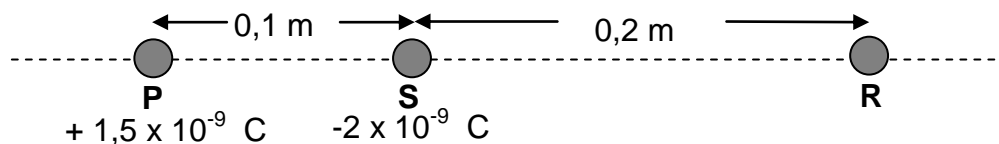


- 6.1 State the Doppler Effect in words. (2)
- 6.2 In which direction is the car moving? Choose from TOWARDS A or AWAY FROM A. Give a reason for the answer. (2)
- 6.3 Determine the speed of the police car. Take the speed of sound in air as 340 m.s^{-1} . (6)
- 6.4 Name ONE application of the Doppler effect. (1)
- [11]**

QUESTION 7 (Start on a new page.)

Two point charges, **P** and **S**, are placed a distance 0,1 m apart. The charge on **P** is $+1,5 \times 10^{-9}$ C and that on **S** is -2×10^{-9} C.

A third point charge, **R**, with an unknown positive charge, is placed 0,2 m to the right of point charge **S**, as shown in the diagram below.



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

7.2 Draw a labelled force diagram showing the electrostatic forces acting on **R** due to **P** and **S**. (2)

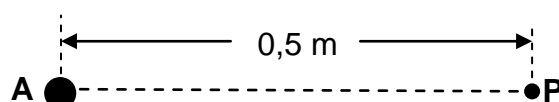
7.3 Calculate the magnitude of the charge on **R**, if it experiences a net electrostatic force of $1,27 \times 10^{-6}$ N to the left.

Take forces directed to the right as positive.

(7)
[11]

QUESTION 8 (Start on a new page.)

P is a point 0,5 m from charged sphere **A**. The electric field at **P** is 3×10^7 N·C⁻¹ directed towards **A**. Refer to the diagram below.



8.1 Draw the electric field pattern due to charged sphere **A**. Indicate the sign of the charge on the sphere in your diagram. (2)

8.2 Calculate the magnitude of the charge on sphere **A**. (3)

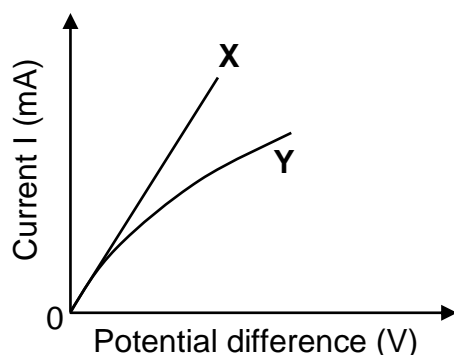
Another charged sphere, **B**, having an excess of 10^5 electrons, is now placed at point **P**.

8.3 Calculate the electrostatic force experienced by sphere **B**. (6)
[11]

QUESTION 9 (Start on a new page.)

- 9.1 The two graphs below show the relationship between current and potential difference for two different conductors, **X** and **Y**.

Graphs of I versus V for two different conductors, **X** and **Y**

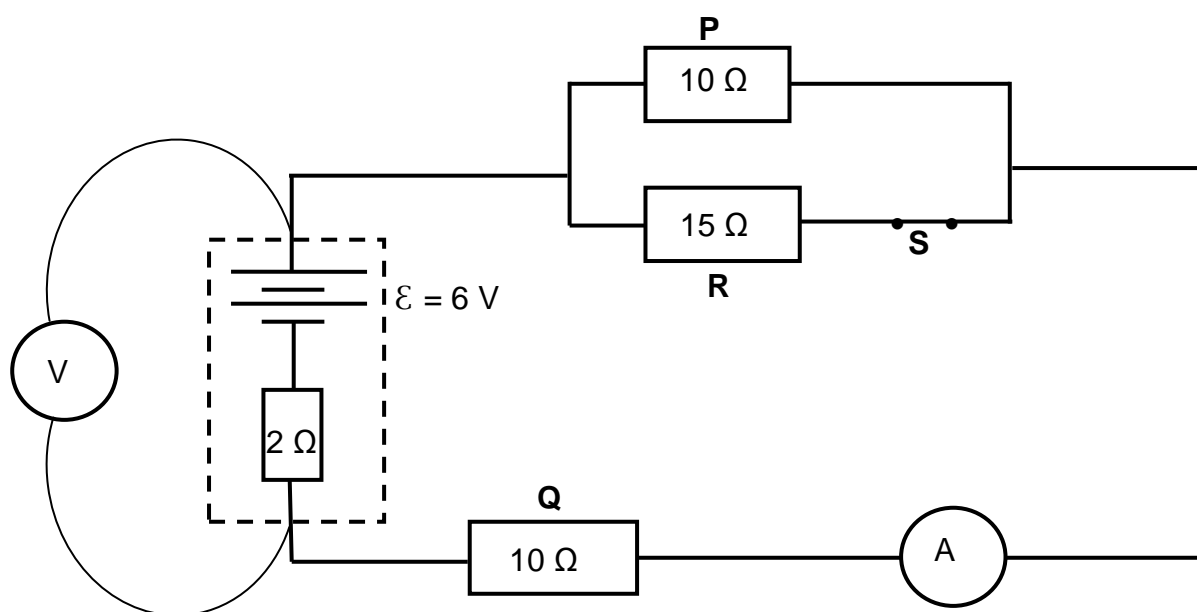


- 9.1.1 State Ohm's law in words. (2)

- 9.1.2 Which ONE of the two conductors, **X** or **Y**, is ohmic?

Refer to the graph and give a reason for the answer. (2)

- 9.2 In the diagram below, a battery with an emf of 6 V and an internal resistance of $2\ \Omega$, is connected to three resistors **P**, **Q** and **R**. A voltmeter **V** is connected across the battery. The ammeter **A** has a negligible resistance.



- 9.2.1 Calculate the ammeter reading when switch **S** is closed. (5)

The switch **S** is now open.

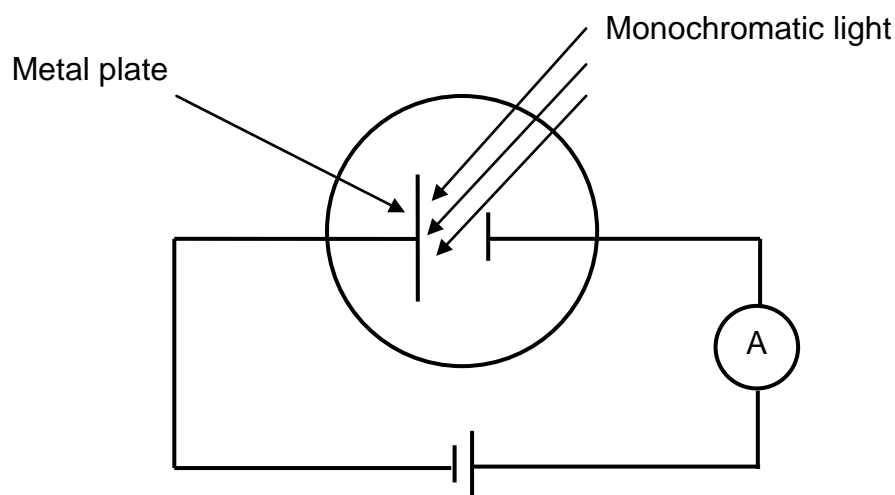
- 9.2.2 Will the ammeter reading in QUESTION 9.2.1 INCREASE, DECREASE or REMAIN THE SAME? Give a reason for the answer. (2)
- 9.2.3 How will the voltmeter reading now compare with the voltmeter reading when the switch is closed? Choose from INCREASE, DECREASE or REMAIN THE SAME. (1)
- 9.2.4 Explain the answer to QUESTION 9.2.3. (3)
- [15]**

QUESTION 10 (Start on a new page.)

- 10.1 Learners want to build a small **DC** motor as a project.
- Write down THREE essential components that are needed for the building of the motor. (3)
- 10.2 An electrical device with a resistance of $11\ \Omega$ is connected to an **AC** source with an rms voltage of 240 V.
- 10.2.1 Define the term *rms voltage*. (2)
- 10.2.2 Calculate the maximum (peak) current passing through the device. (4)
- [9]**

QUESTION 11 (Start on a new page.)

- 11.1 In the diagram below, monochromatic light is incident on the metal plate of a photocell. A sensitive ammeter shows a reading.



- 11.1.1 How does the energy of the photons of the incident light compare to the work function of the metal plate?
Choose from GREATER THAN, LESS THAN or EQUAL TO.

Give a reason for the answer.

(2)

- 11.1.2 When a change is made to the monochromatic light, the reading on the ammeter increases.

A learner makes the following statement with regard to this change:

The increase in the ammeter reading is due to an increase in the energy of the incident photons.

Give a reason why this statement is INCORRECT.

(2)

- 11.1.3 What does the photoelectric effect tell us about the nature of light?

(1)

- 11.2 Ultraviolet radiation is incident on the surface of sodium metal. The threshold frequency (f_0) for sodium is $5,73 \times 10^{14}$ Hz. The maximum speed of an electron emitted from the metal surface is $4,19 \times 10^5 \text{ m}\cdot\text{s}^{-1}$.

- 11.2.1 Define or explain the term *threshold frequency*.

(2)

Calculate the:

- 11.2.2 Work function of sodium

(3)

- 11.2.3 Frequency of the incident photon

(3)

[13]

TOTAL: 150

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

**GEGEWENS VIR FISIIESE WETENSKAPPE GRAAD 12
VRAESTEL 1 (FISIKA)**

TABLE 1: PHYSICAL CONSTANTS/TABEL 1: FISIIESE KONSTANTES

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

TABLE 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

$F_{\text{net}} = ma$	$p = mv$
$f_s^{\text{max}} = \mu_s N$	$f_k = \mu_k N$
$F_{\text{net}} \Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = G \frac{m_1 m_2}{d^2}$ 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 $E_k = \frac{1}{2} mv^2$	$W_{\text{net}} = \Delta K$ or/of $W_{\text{net}} = \Delta E_k$ $\Delta K = K_f - K_i$ or/of $\Delta E_k = E_{kf} - E_{ki}$
$W_{\text{nc}} = \Delta K + \Delta U$ or/of $W_{\text{nc}} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{\text{ave}} = Fv_{\text{ave}}$ / $P_{\text{gemid}} = Fv_{\text{gemid}}$	

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 $E = \frac{hc}{\lambda}$
$E = W_o + E_{k(\text{max})}$ or/of $E = W_o + K_{\text{max}}$ where/waar $E = hf$ and/en $W_o = hf_0$ and/en $E_{k(\text{max})} = \frac{1}{2} mv_{\text{max}}^2$ or/of $K_{\text{max}} = \frac{1}{2} mv_{\text{max}}^2$	

ELECTROSTATICS/ELEKTROSTATIKA

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

ELECTRIC CIRCUITS/ELEKTRIESE STROOMBANE

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

ALTERNATING CURRENT/WISSELSTROOM

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