basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: PHYSICS (P1)

NOVEMBER 2017

MARKS: 150

TIME: 3 hours

This question paper consists of 19 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 The acceleration due to gravity on Earth is greater than that on the moon.

Which ONE of the following statements is CORRECT?

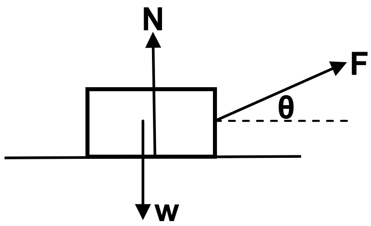
A The weight of an object on Earth is the same as that on the moon.

B The mass of an object on Earth is the same as that on the moon.

C The mass of an object on Earth is greater than that on the moon.

D The weight of an object on Earth is less than that on the moon. (2)

1.2 The force diagram below shows the forces acting on a box.



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

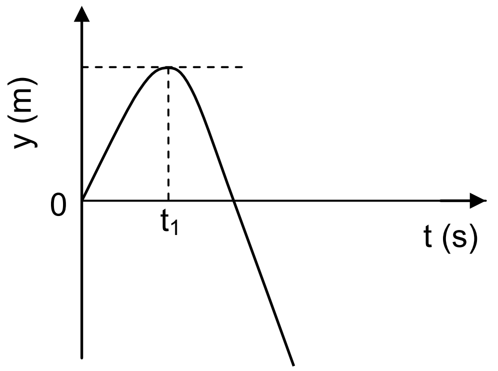
A $N = w + F\cos\theta$

B $N = w + F\sin\theta$

C $N = w - F\cos\theta$

D $N = w - F\sin\theta$ (2)

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

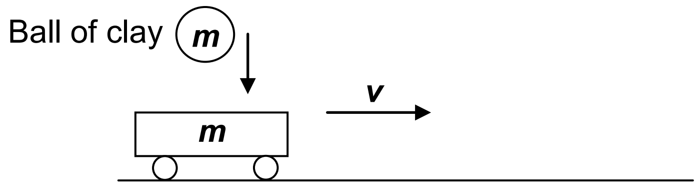


Which ONE of the combinations below regarding the magnitudes of the stone's velocity and acceleration, at time t_1, is CORRECT?

	MAGNITUDE OF VELOCITY (m·s^{-1})	**MAGNITUDE OF ACCELERATION (m·s^{-2})**
A	0	9,8
B	0	0
C	v	0
D	v	9,8

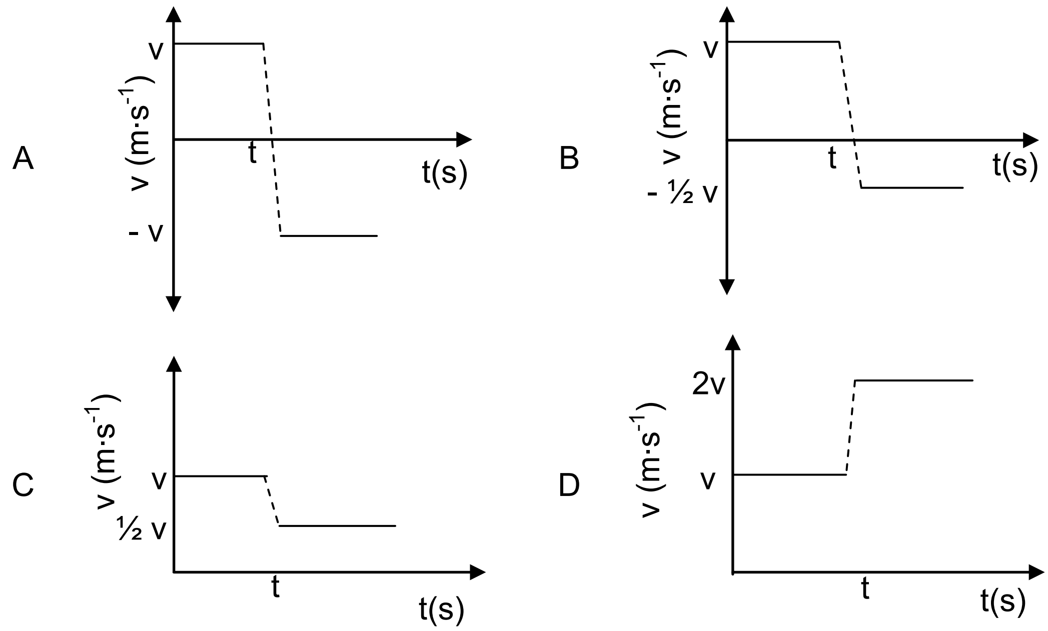
(2)

1.4 A trolley of mass ***m*** is moving at constant velocity ***v*** to the right on a frictionless horizontal surface. A ball of clay, also of mass ***m***, dropped vertically, falls onto the trolley at time t, as shown in the diagram below.



The ball of clay sticks to the trolley.

Which ONE of the velocity-time graphs below CORRECTLY represents the velocity of the trolley *before* and *after* time t?



(2)

1.5 A person lifts a crate vertically upwards at constant velocity through a distance *h.* The person does work *x* on the crate in time *t*.

The person now lifts the same crate vertically upwards at constant velocity through the same distance, but in time 2*t*.

The work done by the person on the crate will now be …

A ½*x*

B *x*

C 2*x*

D 4*x* (2)

1.6 The wavelengths of light emitted by a distant star appear shorter when observed from Earth. From this we can conclude that the star is …

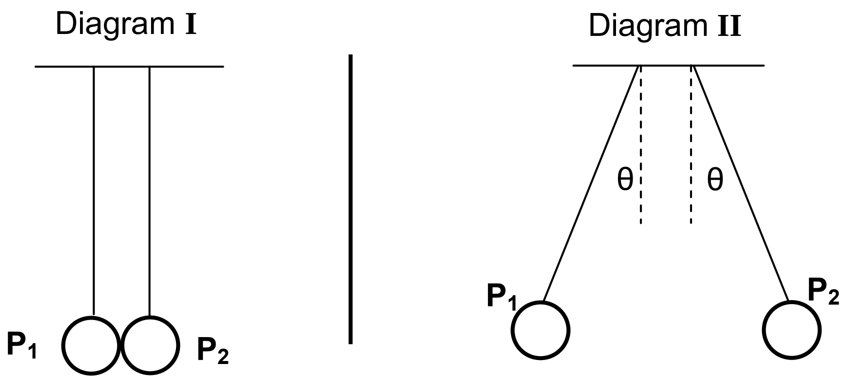
A moving towards Earth and the light is blue shifted.

B moving towards Earth and the light is red shifted.

C moving away from Earth and the light is red shifted.

D moving away from Earth and the light is blue shifted. (2)

1.7 Two identical light graphite-coated spheres, $\mathbf{P_1}$ and $\mathbf{P_2}$, are suspended using identical thin insulated threads. $\mathbf{P_1}$ is charged, but $\mathbf{P_2}$ is neutral. The spheres are then brought into contact with each other, as shown in diagram **I**. Thereafter the spheres assume the positions, as shown in diagram **II**.



Which ONE of the following statements concerning the charges on the spheres possibly explains why the spheres move apart after touching, as shown in diagram **II**?

	SIGN OF CHARGE ON P_1	SIGN OF CHARGE ON P_2	MAGNITUDE OF CHARGES ON P_1 AND P_2
A	+	+	Unequal
B	-	-	Unequal
C	+	-	Equal
D	+	+	Equal

(2)

1.8 When a resistor of resistance R is connected to a battery of emf Ɛ and negligible internal resistance, the power dissipated in the resistor is P.

If the resistor is replaced with a resistor of resistance 2R, without changing the battery, the power dissipated will be …

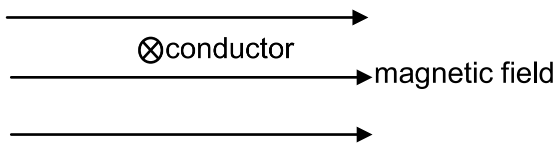
A ¼P

B ½P

C 2P

D 4P (2)

1.9 The diagram below shows a current-carrying conductor lying in a uniform magnetic field directed to the right. The current flows into the page.



Which ONE of the following arrows shows the direction of the force experienced by the conductor due to the magnetic field?

(2)

1.10 Light of a certain frequency is shone onto a metal **M** and electrons are ejected from the surface. The same source of light is shone onto another metal **N**.

The electrons ejected from the surface of metal **N** have a much higher kinetic energy than that from metal **M**.

This means that …

A metal **N** has the same work function as metal **M**.

B metal **N** has a larger work function than metal **M**.

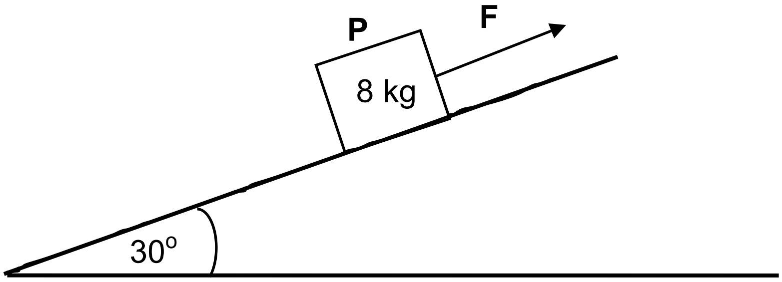
C the threshold frequency of metal **N** is higher than that of metal **M**.

D the threshold frequency of metal **N** is lower than that of metal **M**. (2)
[20]

QUESTION 2 (Start on a new page.)

2.1 An 8 kg block, **P**, is being pulled by constant force **F** up a rough inclined plane at an angle of 30° to the horizontal, at CONSTANT SPEED.

Force **F** is parallel to the inclined plane, as shown in the diagram below.



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

2.1.2 Draw a labelled free-body diagram for block **P**. (4)

The kinetic frictional force between the block and the surface of the inclined plane is 20,37 N.

2.1.3 Calculate the magnitude of force **F**. (5)

Force **F** is now removed and the block ACCELERATES down the plane. The kinetic frictional force remains 20,37 N.

2.1.4 Calculate the magnitude of the acceleration of the block. (4)

2.2 A 200 kg rock lies on the surface of a planet. The acceleration due to gravity on the surface of the planet is 6,0 $m \cdot s^{-2}$.

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

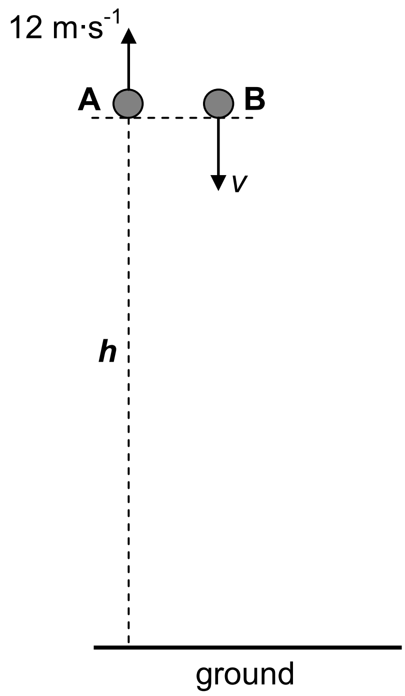
2.2.2 Calculate the mass of the planet if its radius is 700 km. (4)
[21]

QUESTION 3 (Start on a new page.)

Stone **A** is projected vertically upwards at a speed of 12 m·s^{-1} from a height ***h*** *above the ground*. Ignore the effects of air resistance.

3.1 Calculate the time taken for stone **A** to reach its maximum height. (3)

At the same instant that stone **A** is projected upwards, stone **B** is thrown vertically downwards from the same height at an *unknown speed*, *v*. Refer to the diagram below.



When stone **A** reaches its maximum height, the speed of stone **B** is 3*v*.

3.2 Calculate the speed, *v*, with which stone **B** is thrown downwards. (4)

At the instant stone **A** passes its initial position on its way down, stone **B** hits the ground.

3.3 Calculate the height ***h***. (3)

3.4 Sketch velocity-time graphs for the complete motions of stones **A** and **B** on the same set of axes. Label your graphs for stones **A** and **B** clearly.

Show the following on the graphs:

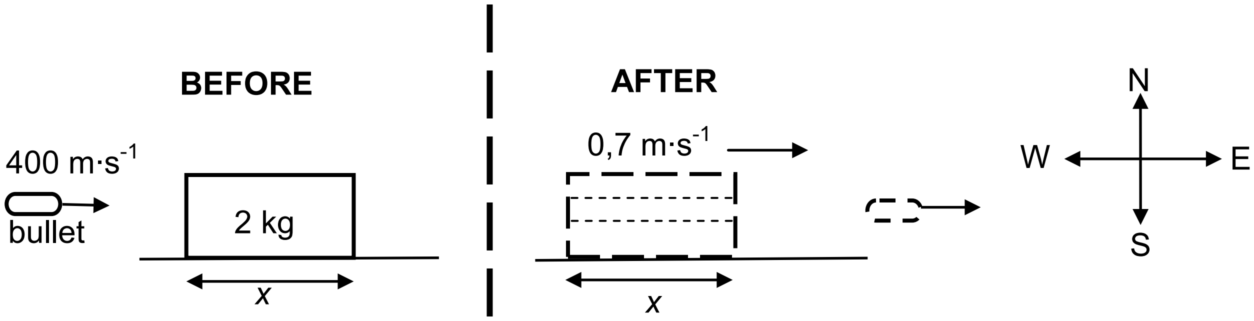
- The time taken for stone **A** to reach its maximum height
- The velocity with which stone **B** is thrown downwards (4)

[14]

QUESTION 4 (Start on a new page.)

A 2 kg block is at rest on a smooth, frictionless, horizontal table. The length of the block is *x*.

A bullet of mass 0,015 kg, travelling east at 400 m·s^{-1}, strikes the block and passes straight through it with constant acceleration. Refer to the diagram below. Ignore any loss of mass of the bullet and the block.



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

The block moves eastwards at 0,7 m·s^{-1} after the bullet has emerged from it.

4.2 Calculate the magnitude of the velocity of the bullet immediately after it emerges from the block. (4)

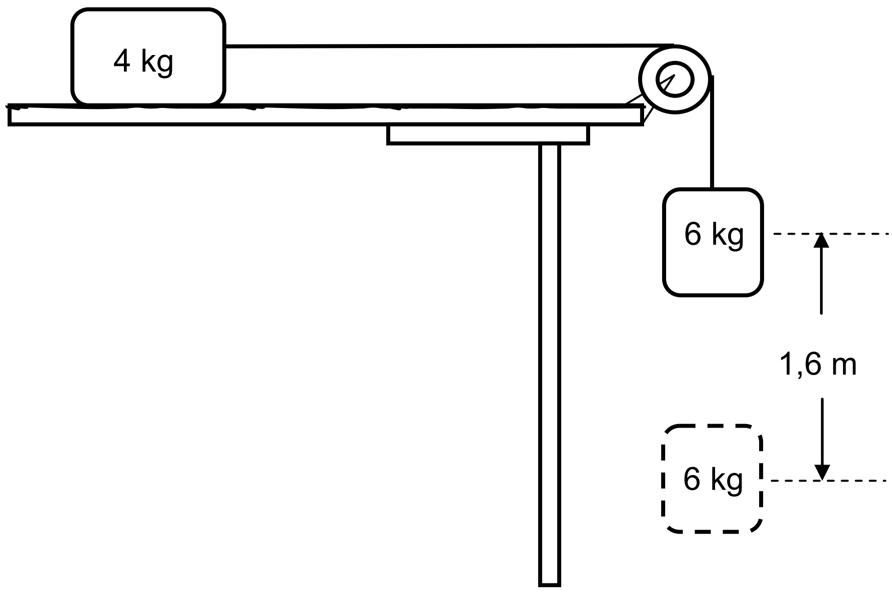
4.3 If the bullet takes 0,002 s to travel through the block, calculate the length, *x*, of the block. (5)

[11]

QUESTION 5 (Start on a new page.)

In the diagram below, a 4 kg block lying on a rough horizontal surface is connected to a 6 kg block by a light inextensible string passing over a light frictionless pulley.

Initially the blocks are HELD AT REST.



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

When the blocks are released, the 6 kg block falls through a vertical distance of 1,6 m.

5.2 Draw a labelled free-body diagram for the 6 kg block. (2)

5.3 Calculate the work done by the gravitational force on the 6 kg block. (3)

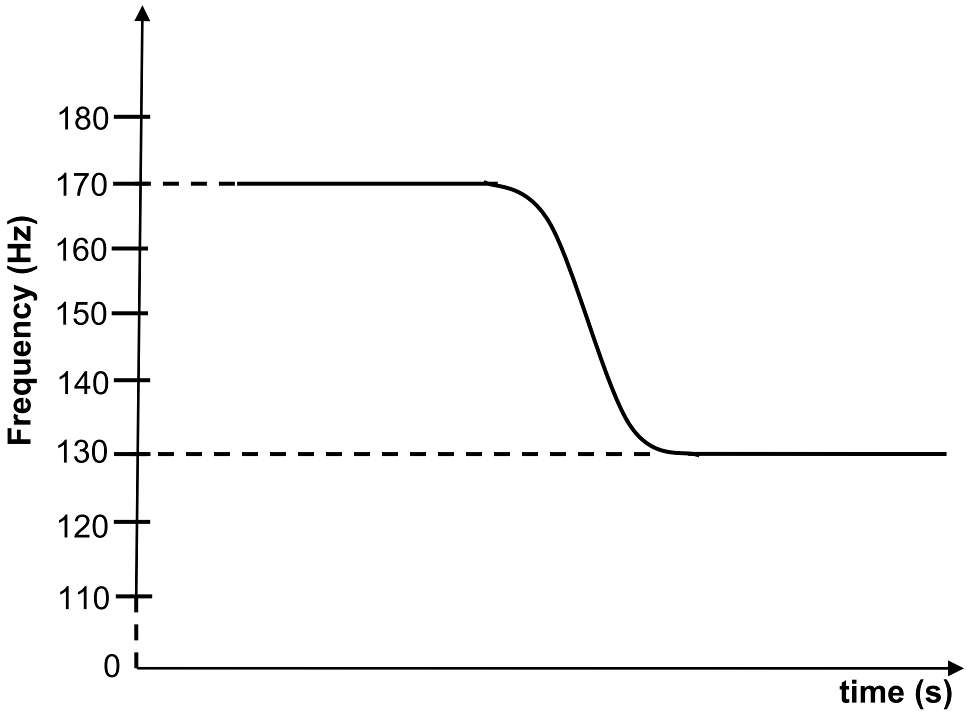
The coefficient of kinetic friction between the 4 kg block and the horizontal surface is 0,4. Ignore the effects of air resistance.

5.4 Use **energy principles** to calculate the speed of the 6 kg block when it falls through 1,6 m while still attached to the 4 kg block. (5)
[12]

QUESTION 6 (Start on a new page.)

A police car moving at a constant velocity with its siren on, passes a stationary listener.

The graph below shows the changes in the frequency of the sound of the siren detected by the listener.



6.1 State the Doppler Effect in words. (2)

6.2 Write down the frequency of the sound detected by the listener as the police car:

6.2.1 Approaches the listener (1)

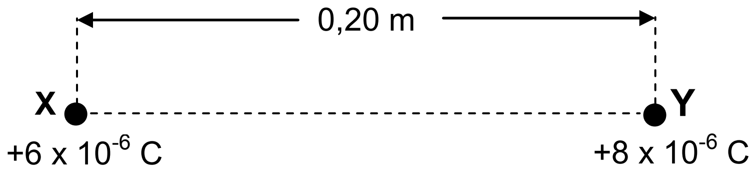
6.2.2 Moves away from the listener (1)

6.3 Calculate the speed of the police car. Take the speed of sound in air to be 340 m·s^{-1}. (6)

[10]

QUESTION 7 (Start on a new page.)

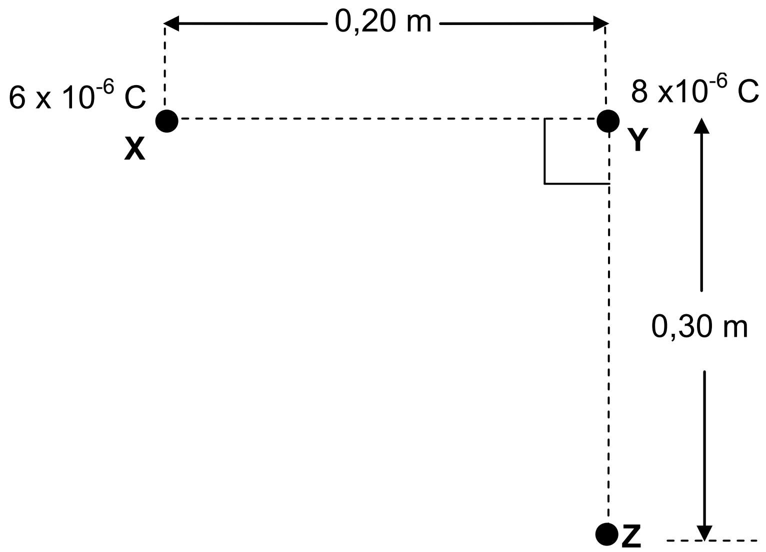
Two small spheres, **X** and **Y**, carrying charges of $+6 \times 10^{-6}$ C and $+8 \times 10^{-6}$ C respectively, are placed 0,20 m apart in air.



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

7.2 Calculate the magnitude of the electrostatic force experienced by charged sphere **X**. (4)

A third sphere, **Z**, of unknown **negative** charge, is now placed at a distance of 0,30 m below sphere **Y**, in such a way that the line joining the charged spheres **X** and **Y** is perpendicular to the line joining the charged spheres **Y** and **Z**, as shown in the diagram below.

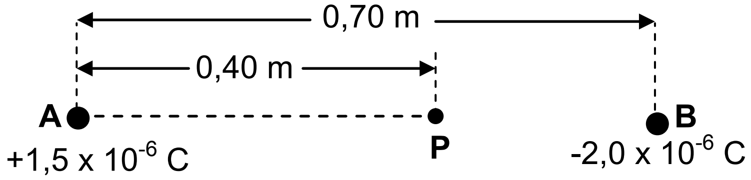


7.3 Draw a vector diagram showing the directions of the electrostatic forces **and** the net force experienced by charged sphere **Y** due to the presence of charged spheres **X** and **Z** respectively. (3)

7.4 The magnitude of the net electrostatic force experienced by charged sphere **Y** is 15,20 N. Calculate the charge on sphere **Z**. (4)
[13]

QUESTION 8 (Start on a new page.)

A and **B** are two small spheres separated by a distance of 0,70 m. Sphere **A** carries a charge of +1,5 x 10^{-6} C and sphere **B** carries a charge of -2,0 x 10^{-6} C.



P is a point between spheres **A** and **B** and is 0,40 m from sphere **A**, as shown in the diagram above.

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

8.2 Calculate the magnitude of the net electric field at point **P**. (4)

8.3 A point charge of magnitude 3,0 x 10^{-9} C is now placed at point **P**.

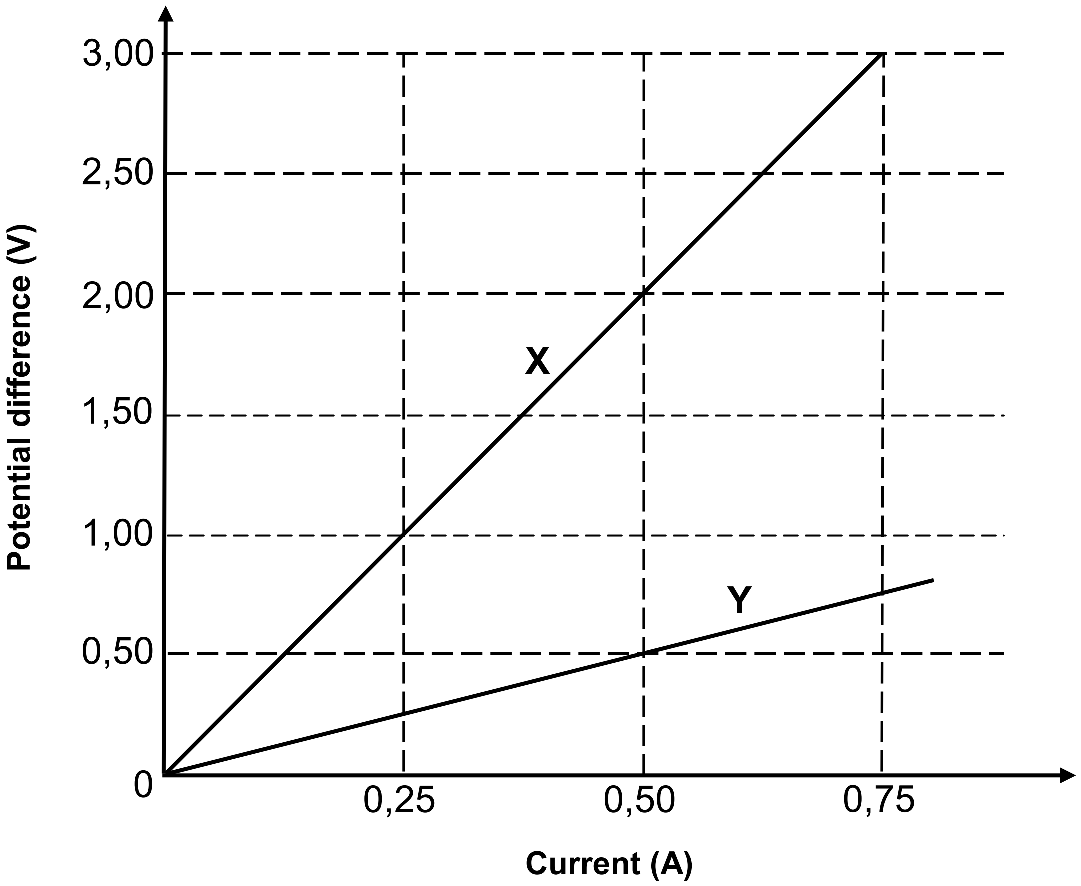
Calculate the magnitude of the electrostatic force experienced by this charge. (3)
[9]

QUESTION 9 (Start on a new page.)

9.1 Learners investigated the relationship between potential difference (V) and current (I) for the combination of two resistors, $\mathbf{R_1}$ and $\mathbf{R_2}$. In one experiment, resistors $\mathbf{R_1}$ and $\mathbf{R_2}$ were connected in parallel. In a second experiment, resistors $\mathbf{R_1}$ and $\mathbf{R_2}$ were connected in series.

The learners then plotted graph **X**, the results of one of the experiments, and graph **Y**, the results of the other experiment, as shown below.

GRAPHS OF POTENTIAL DIFFERENCE VERSUS CURRENT FOR THE COMBINATION OF TWO RESISTORS IN SERIES AND IN PARALLEL



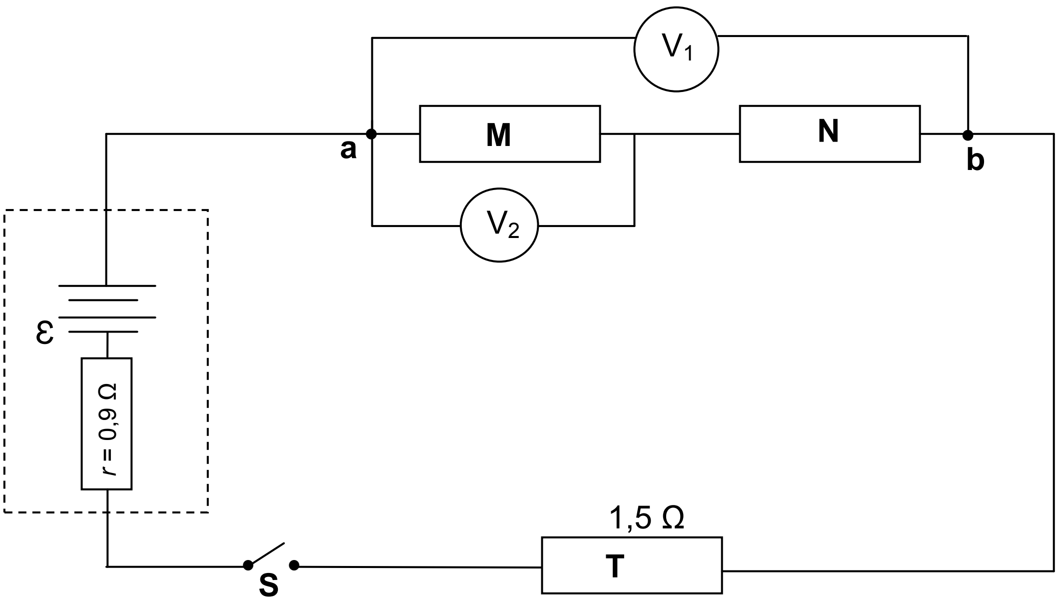
9.1.1 State Ohm's law in words. (2)

9.1.2 What physical quantity does the gradient (slope) of the V-I graph represent? (1)

9.1.3 Calculate the gradient (slope) of graph **X**. (2)

9.1.4 Determine the resistance of resistor $\mathbf{R_1}$. (4)

9.2 The circuit below consists of three resistors, **M**, **N** and **T**, a battery with emf $\mathcal{E}$ and an internal resistance of 0,9 Ω. The effective resistance between points **a** and **b** in the circuit is 6 Ω. The resistance of resistor **T** is 1,5 Ω.



When switch **S** is closed, a high-resistance voltmeter, V_1, across **a** and **b** reads 5 V.

Calculate the:

9.2.1 Current delivered by the battery (3)

9.2.2 Emf ($\mathcal{E}$) of the battery (4)

Voltmeter V_2 reads 2,5 V when the switch is closed.

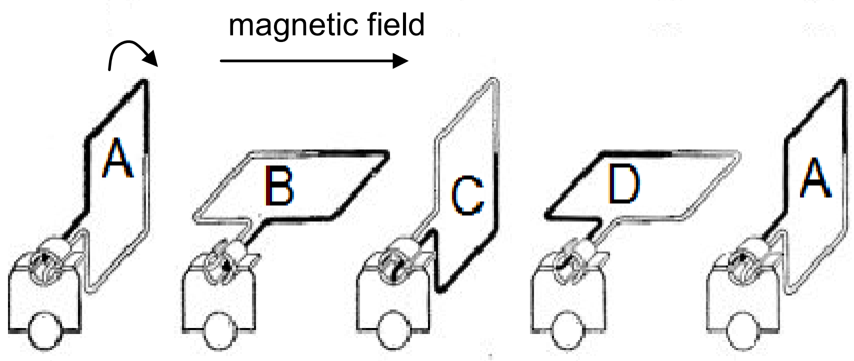
9.2.3 Write down the resistance of **N**. (No calculations required.) Give a reason for the answer. (2)

[18]

QUESTION 10 (Start on a new page.)

10.1 The diagram below shows different positions (**ABCDA**) of the coil in a **DC** generator for a complete revolution. The coil is rotated clockwise at a constant speed in a uniform magnetic field.

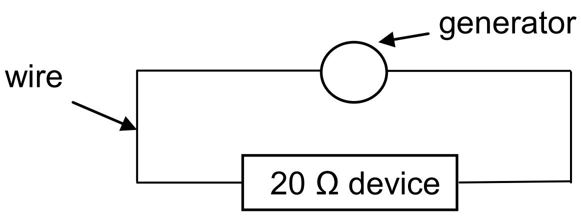
The direction of the magnetic field is shown in the diagram below.



10.1.1 Write down the energy conversion that takes place during the operation of the DC generator. (1)

10.1.2 Sketch a graph to show how the induced emf of the generator varies with time. Clearly indicate positions **A**, **B**, **C**, **D** and **A** on the graph. (2)

10.2 A small AC generator, providing an rms voltage of 25 V, is connected across a device with a resistance of 20 Ω. The wires connecting the generator to the device have a total resistance of 0,5 Ω. Refer to the diagram below.

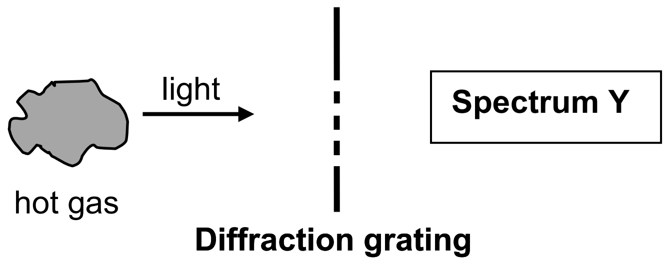


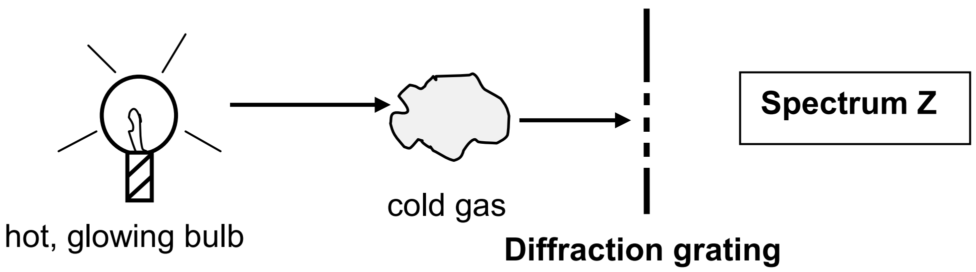
10.2.1 Write down the total resistance of the circuit. (1)

10.2.2 Calculate the average power delivered to the *device*. (5)
[9]

QUESTION 11 (Start on a new page.)

11.1 A teacher in a science class explains how different types of spectra are obtained. The teacher uses the simplified diagrams shown below for the explanation.





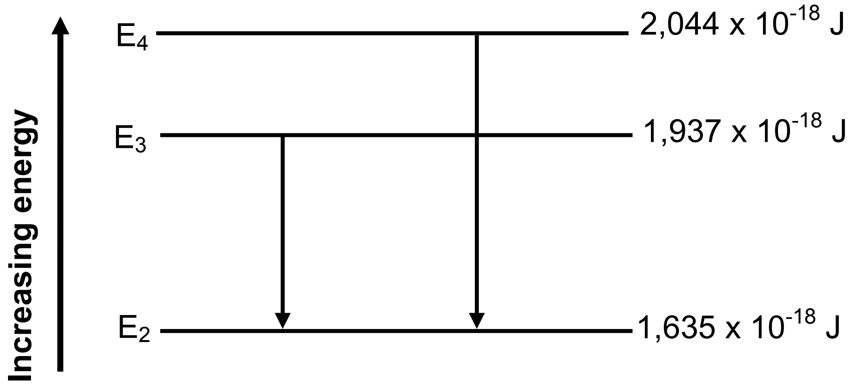
Name the type of spectrum of:

11.1.1 **Y** (1)

11.1.2 **Z** (1)

11.2 In an excited atom, electrons can 'jump' from lower energy levels to higher energy levels. They can also 'drop' from higher energy levels to lower energy levels.

The diagram below (not drawn to scale) shows some of the transitions for electrons in an excited atom.



11.2.1 Do the transitions indicated in the diagram lead to ABSORPTION or EMISSION spectra? (1)

11.2.2 Calculate the frequency of the photon produced when an electron in an excited atom makes a transition from $\mathbf{E_4}$ to $\mathbf{E_2}$, as shown in the diagram. (4)

The threshold frequency of a metal, Q, is $4,4 \times 10^{14}$ Hz.

11.2.3 Calculate the kinetic energy of the most energetic electron ejected when the photon produced in QUESTION 11.2.2 is incident on the surface of metal Q. (4)

Another metal, R, has a threshhold frequency of $7,5 \times 10^{14}$ Hz.

11.2.4 Will the photon produced in QUESTION 11.2.2 be able to eject electrons from the surface of metal R? Write down only YES or NO.

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	$6,67 \times 10^{-11}\ N\cdot m^2\cdot kg^{-2}$
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	$9,11 \times 10^{-31}\ kg$

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

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* $E = \frac{hc}{\lambda}$
$E = W_o + E_{k(max)}$ or/*of* $E = W_o + K_{max}$ where/*waar* $E = hf$ and/*en* $W_0 = hf_0$ and/*en* $E_{k(max)} = \frac{1}{2}mv^2_{max}$ or/*of* $K_{max} = \frac{1}{2}mv^2_{max}$	

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*

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