GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

JUNE EXAMINATION
GRADE 12

2023

PHYSICAL SCIENCES (PHYSICS)

(PAPER 1)

TIME: **3 hours**

MARKS: **150**

16 pages and 4 data sheets

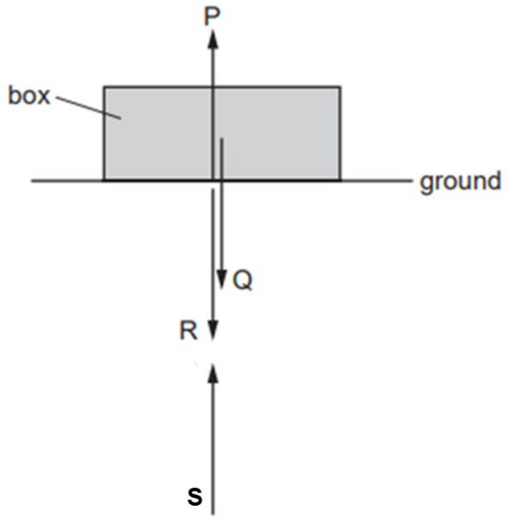
INSTRUCTIONS AND INFORMATION

1. This question paper consists of 9 questions. Answer ALL the questions in the ANSWER BOOK.
2. Start the answers to each question on a NEW page in the ANSWER BOOK.
3. Number the answers correctly according to the numbering system used in this question paper.
4. Leave ONE line open between two sub-sections, for example between QUESTION 2.1 and QUESTION 2.2.
5. You may use a non-programmable calculator.
6. You may use appropriate mathematical instruments.
7. You are advised to use the attached DATA SHEETS.
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. 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 numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 E.

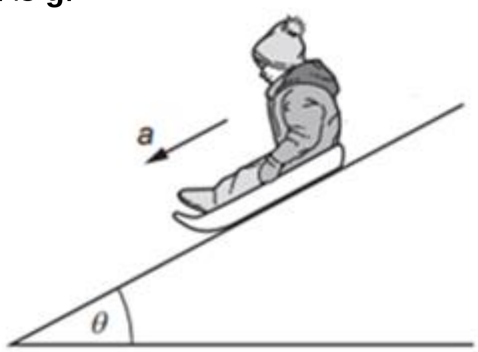
1.1 A box is shown resting on the ground. Newton's Third Law implies that four forces of equal magnitude are involved. These forces are labelled **P**, **Q**, **R** and **S**. Forces **P** and **Q** act on the box. Forces **R** and **S** act on the Earth. For clarity, the forces are shown slightly separated.



Which statement about the forces is correct?

A Force **P** is equal and opposite to force **Q** and both are forces of contact.
B Force **Q** is equal and opposite to force **P** and both are gravitational forces.
C Force **R** is equal and opposite to force **S** and both are forces of contact.
D Force **S** is equal and opposite to force **Q** and both are gravitational forces. (2)

1.2 A child on a sledge slides down a hill with acceleration **a**. The hill makes an angle θ with the horizontal. The total mass of the child and the sledge is **m**. The acceleration of free fall is **g**.

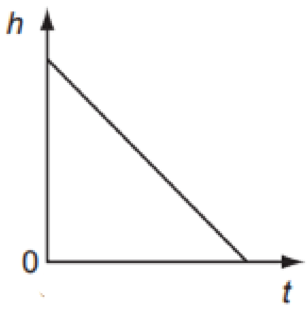


The frictional force **F** is represented by:

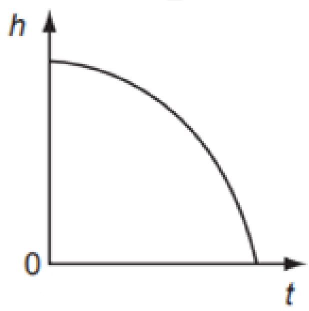
A m(gcos θ - a)
B m(gcos θ + a)
C m(gsin θ - a)
D m(gsin θ + a) (2)

1.3 A small steel ball falls freely under gravity after being released from rest. Which graph best represents the variation of the height **h** of the ball with time **t** when using the ground as reference?

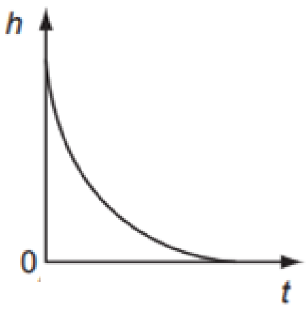
A



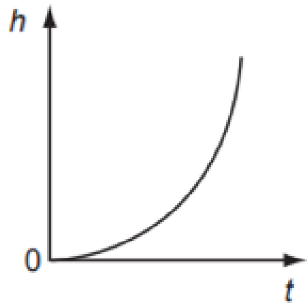
B



C



D

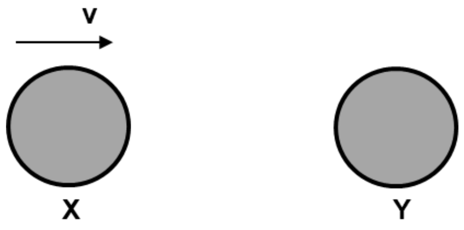


(2)

1.4 If air resistance is negligible, the total mechanical energy of a free-falling body …

A increases.
B decreases.
C becomes zero.
D remains constant. (2)

1.5 The diagram below shows two identical spheres **X** and **Y**. Initially, **X** moves with speed **v** directly towards **Y**, while **Y** is stationary. The spheres collide elastically.



The following occurs:

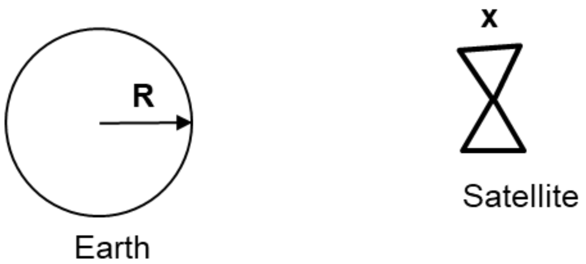
	X	Y
A	Stops	Moves with a speed **v** to the right
B	Moves with a speed **v** to the left	Remains stationary
C	Moves with a speed ½**v** to the left	Moves with a speed ½**v** to the right
D	Moves with a speed ½**v** to the right	Moves with a speed ½**v** to the right

(2)

1.6 The direction of an object's momentum is always the same as the direction of the object's …

A velocity.
B weight.
C inertia.
D potential energy. (2)

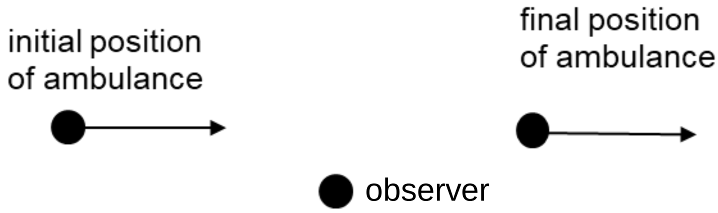
1.7 A satellite orbits Earth at a point **x**. The gravitational force on **x** is a quarter (¼) of the gravitational force it experiences on the surface of the Earth.



If the radius of Earth is **R**, then the height of the satellite ABOVE THE SURFACE of Earth, will be:

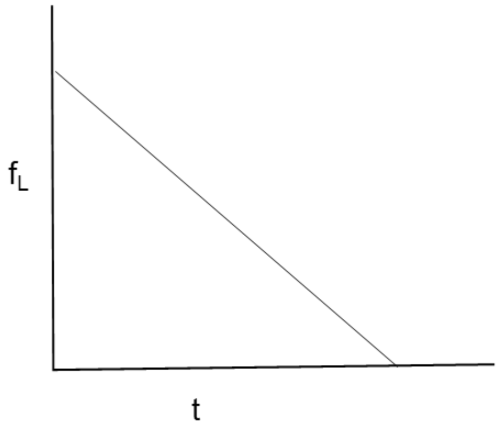
A 4R
B 2R
C R
D ½R (2)

1.8 The warning siren on an ambulance has a frequency of 600 Hz. The speed of sound is 330 m·s^{-1} in air. The ambulance is travelling at a constant velocity of 25 m·s^{-1} towards an observer.

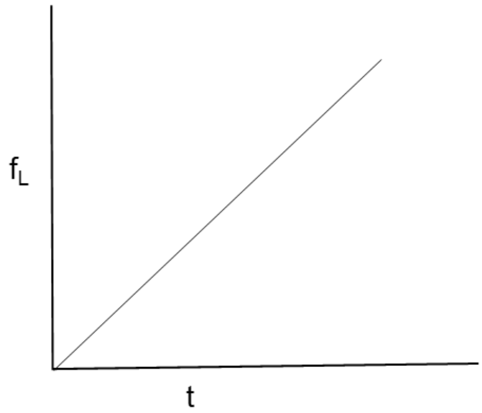


Which graph illustrates the change in observed frequency?

A



B



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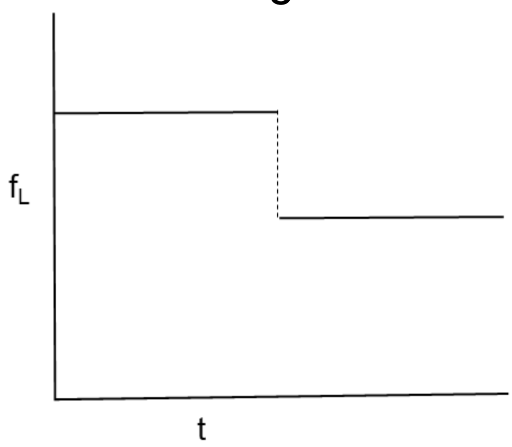

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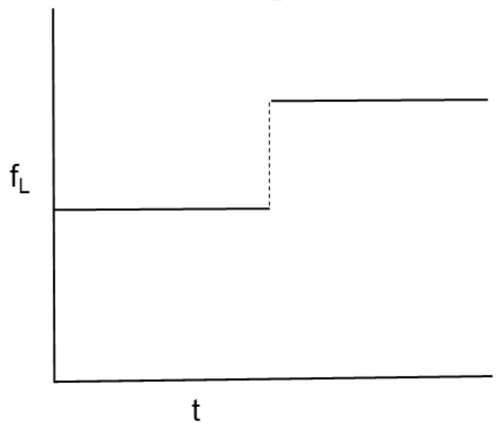
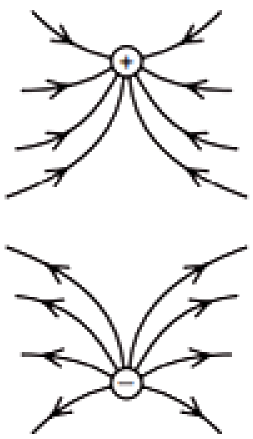


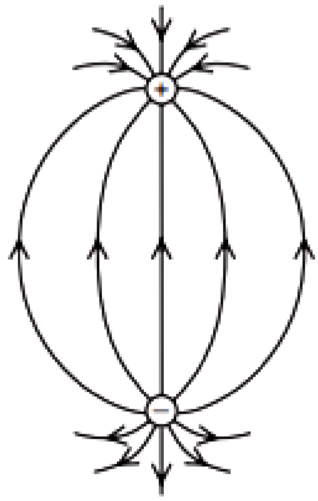
(2)

1.9 Which diagram below best represents the electric field pattern between two point charges of equal magnitude and opposite sign?

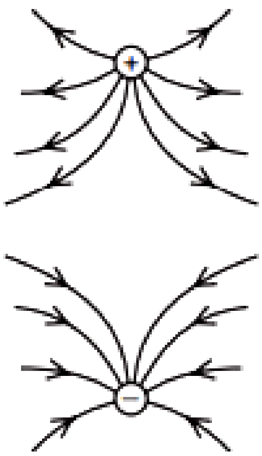
A



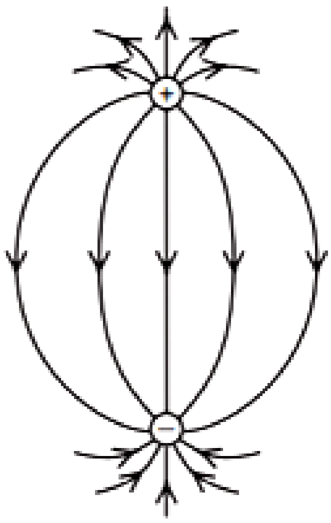
B



C



D



(2)

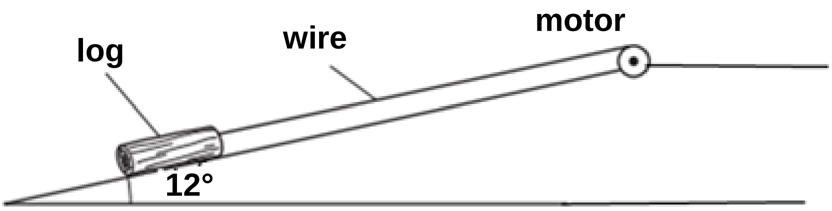
1.10 Which of the following represents the correct units for electric field strength?

A T
B $N \cdot C^{-1}$
C $J \cdot C^{-1}$
D $N \cdot m^{2} \cdot C^{-2}$ (2)

[20]

QUESTION 2 (Start on a new page.)

A log of mass **m** kg is pulled up a slope by a light non-elastic wire of negligible mass, attached to a motor, as shown in the diagram below.



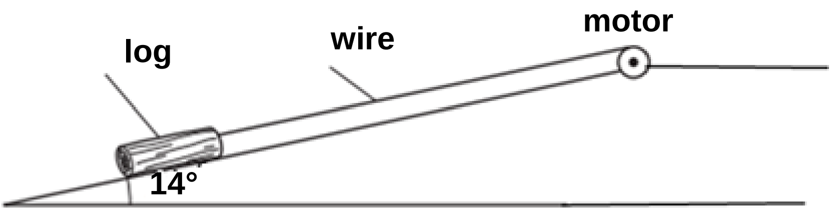
The angle that the slope makes with the horizontal is 12°. The kinetic coefficient of friction between the log and the surface is 0,3. The tension in the wire is 1 570 N while the log moves up the slope with a constant velocity.

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

2.2 Draw a labelled, free-body diagram to show all the forces acting on the log. (4)

2.3 Calculate the mass of the log. (5)

2.4 The angle of the slope is increased to 14°.



Identify the effect of this increased angle on each of the following:
(Write only INCREASES, DECREASES or REMAINS THE SAME.)

2.4.1 Kinetic coefficient of friction between the log and the surface (1)

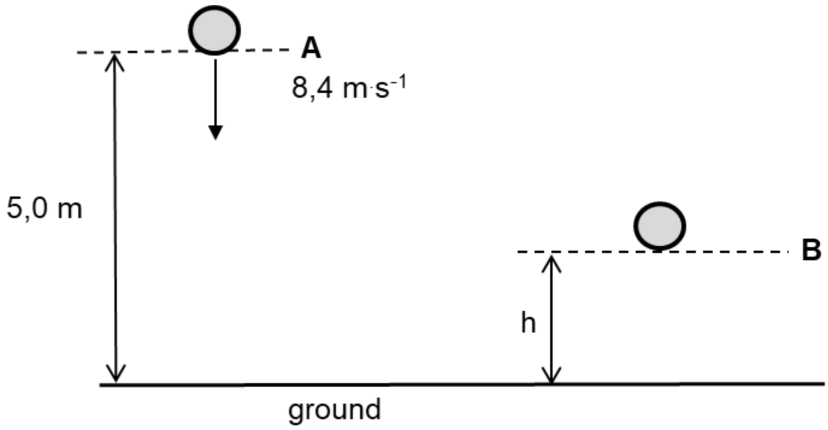
2.4.2 Frictional force (1)

2.5 The wire snaps and the log slides down the slope until it stops.

Give a reason why this cannot be seen as free fall or projectile motion. (2)
[15]

QUESTION 3 (Start on a new page.)

A soft ball is thrown vertically down towards the ground whereafter it bounces back up as illustrated in the sketch below.



When the ball reaches point **A**, it has a speed of 8,4 $m \cdot s^{-1}$. The height of **A** is 5,0 m above the ground. The ball hits the ground and bounces up to a maximum height at position **B**. Assume that the air resistance is negligible.

3.1 Explain the term *projectile motion*. (2)

3.2 Calculate the speed of the ball as it hits the ground. (3)

3.3 Show, by calculation that the time for the ball to reach the ground is 0,47 s. (3)

3.4 The ball bounces vertically upwards with a speed of 4,2 $m \cdot s^{-1}$ as it leaves the ground. The time the ball is in contact with the ground is 0,20 s.

3.4.1 What is the magnitude and direction of the acceleration of the ball at point **B**? (2)

3.4.2 Calculate the maximum height that the ball reaches after the first bounce off the floor. (3)

3.4.3 Sketch a velocity time graph for the motion from the moment that the ball passes **A** until it reaches position **B**.

Clearly indicate the following on your graph:

- The velocity of the ball at **A**
- The velocity of the ball as it hits the ground
- Time taken for the ball to reach the ground **and** leave the ground
- The velocity at the maximum height of point **B** (6)

3.5 The soft ball is replaced by a very hard ball. How would this affect the following: (Write only INCREASES, DECREASES or REMAINS THE SAME.)

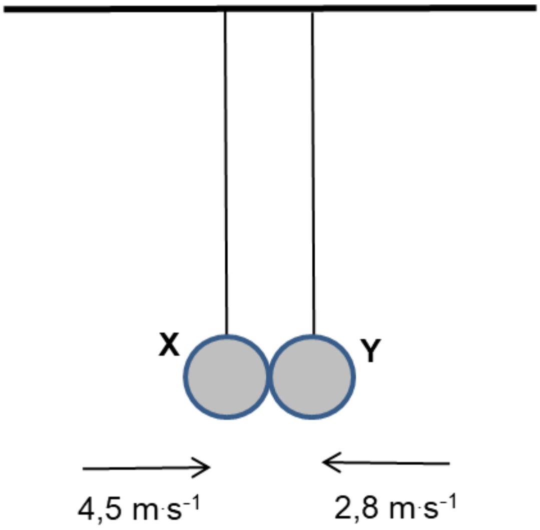
3.5.1 The contact time when the ball bounces on the ground (1)

3.5.2 The height of the ball after it strikes the ground
Explain the answer. (2)

[22]

QUESTION 4 (Start on a new page.)

Ball **X**, with a mass of 50 g, and ball **Y**, with a mass twice that of **X**, are supported by long strings from a ceiling, as shown in the diagram below.



The balls are each pulled back and released so that they move towards each other. When the balls collide at the position shown in the diagram above, the strings are vertical. The balls rebound in opposite directions. The velocity of ball **X** after the collision is 2,1 $m \cdot s^{-1}$ to the left. Ignore all effects of friction.

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

4.2 Calculate the velocity of ball **Y** immediately after the collision. (5)

4.3 Is the collision ELASTIC or INELASTIC?

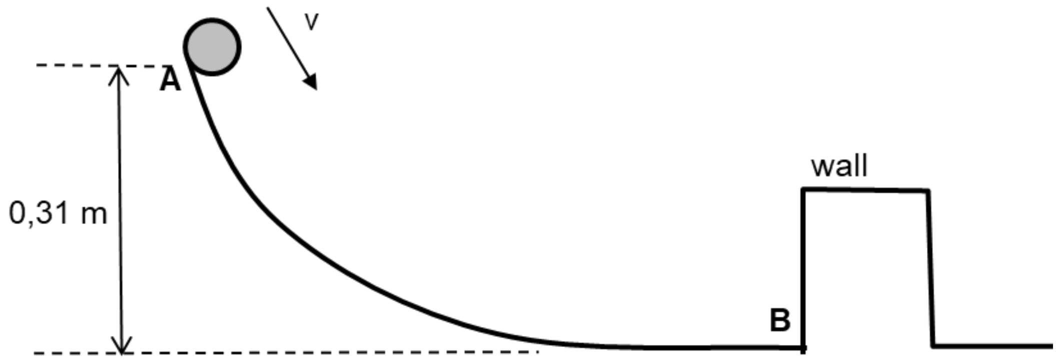
Explain the answer by means of suitable calculations. (5)

4.4 Ball **X** and **Y** are replaced by two identical balls. How would this affect the conservation of the momentum of the system if the initial velocities remain the same?
(Write only INCREASES, DECREASES or REMAINS THE SAME.)

Explain the answer. (3)
[15]

QUESTION 5 (Start on a new page.)

A ball of mass 0,03 kg moves along a curved track, as shown in the diagram below.



The speed of the ball is **v** when it is at point **A** at a height of 0,31 m. The ball moves down the frictionless track and collides with a vertical wall at point **B**. The kinetic energy of the ball just before the collision with the wall, is 0,12 J. After the collision the ball rebounds up the track. Ignore all frictional forces.

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

5.2 Calculate the speed **v** of the ball at point **A**. (4)

5.3 The change in momentum of the ball due to the collision with the wall is 0,096 $kg \cdot m \cdot s^{-1}$. The ball is in contact with the wall for a time of 0,02 s.

For the ball hitting the wall, calculate:

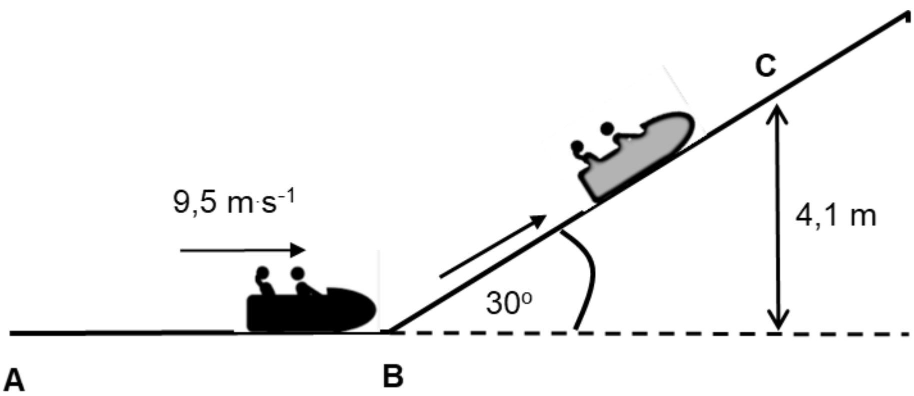
5.3.1 The speed immediately after the collision (4)

5.3.2 The magnitude of the average force on the wall (4)

[14]

QUESTION 6 (Start on a new page.)

The diagram below shows a fairground carriage moving at a constant speed of 9,5 $m \cdot s^{-1}$ over a frictionless surface. The total mass of the people and the carriage is 600 kg. The carriage moves up a slope inclined at 30° to the horizontal. The carriage comes to a stop after travelling up the rough slope to a vertical height of 4,1 m at point **C**.



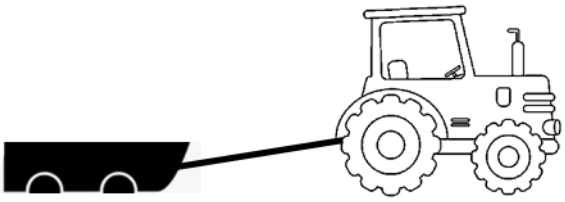
6.1 State the *work-energy theorem*, in words. (2)

6.2 Calculate the kinetic energy of the carriage and passengers as they reach point **B**. (3)

6.3 Draw a labelled, free-body diagram of all the forces that act on the carriage while moving up the slope. (3)

6.4 Use energy principles and calculate the frictional force between point **B** and **C**. (5)

6.5 A small tractor is rated at 9 kW and pulls an empty carriage across the ground at a constant speed with a horizontal force of 300 N.



6.5.1 Define a *non-conservative force*. (2)

6.5.2 Calculate the time that it would take the tractor to tow the empty carriage a distance of 850 m. (4)

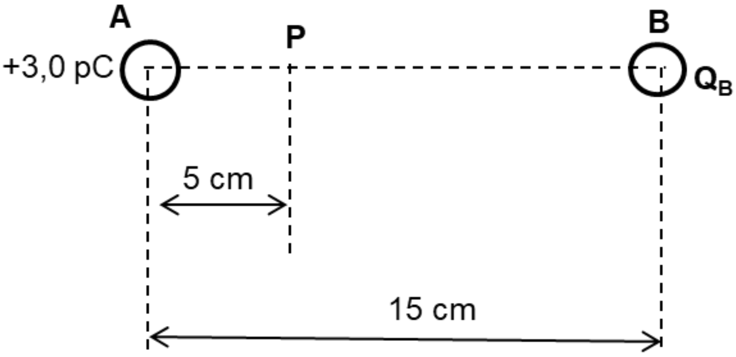
6.5.3 How would the time change if a tractor with a greater power output was used?
(Write down only INCREASES, DECREASES or REMAINS THE SAME.)

Explain the answer. (3)

[22]

QUESTION 7 (Start on a new page.)

Two charged spheres, **A** and **B** are placed 15 cm apart in a vacuum. Sphere **A** has a charge of +3,0 pC and sphere **B** has an unknown positive charge. The arrangement is illustrated in the diagram below.



Point **P** lies on the line joining the charged spheres at a distance of 5,0 cm from sphere **A**.

7.1 Describe an *electric field*. (2)

7.2 The net electric field strength at point **P** is zero. Calculate the charge of sphere **B**. (5)

7.3 State *Coulomb's Law* in words. (2)

7.4 Charge **B** is replaced by a negative charge of magnitude -12 pC. Calculate the magnitude of the electrostatic force between charged spheres **A** and **B**. (3)

7.5 How would the magnitude of the force calculated in QUESTION 7.4 be affected, if the distance between the charges is decreased?
(Write only INCREASES, DECREASES or REMAINS THE SAME.)

Explain the answer. (3)

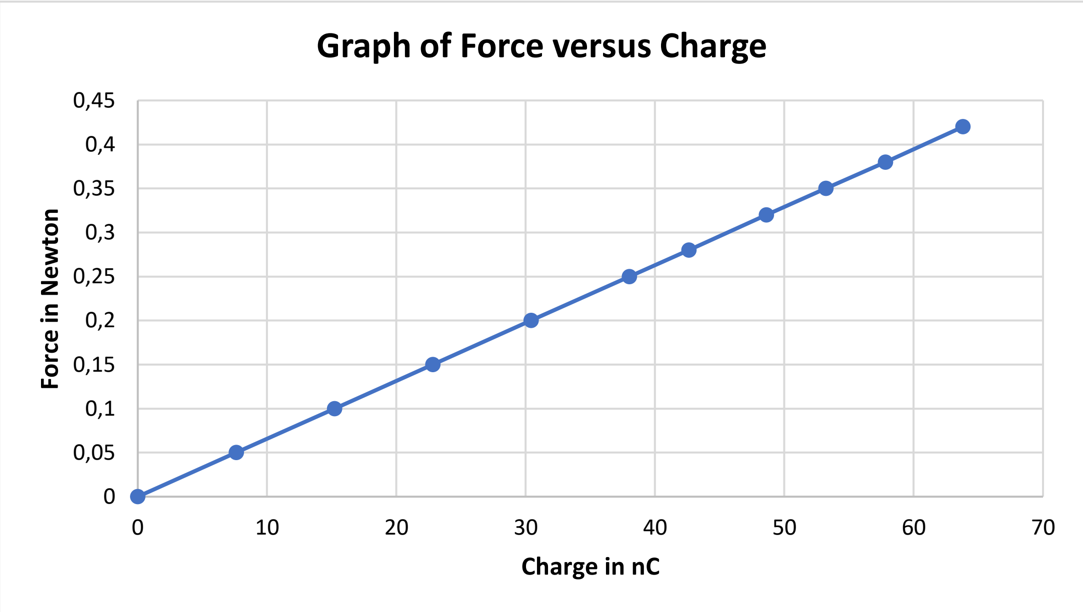
[15]

QUESTION 8 (Start on a new page.)

An experiment is conducted to investigate the relationship between the force experienced by a charge if the electric field strength is kept constant. The table of results is given below.

Force in N	0	0,05	0,1	0,15	0,2	0,25	0,28	0,35	**X**
Charge in ($\times 10^{-9}$ C)	0	7,6	15,2	22,8	30,4	38	42,6	53,2	63,8

The following graph is obtained.



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

8.2 Give the relationship between *force* and *charge*.

Explain the answer. (2)

8.3 Use the information above and calculate the:

8.3.1 Gradient of the graph (3)

8.3.2 Value of **X** (4)

8.4 Sketch the electric field pattern around the charge if it had been a negative charge. (3)

[14]

QUESTION 9 (Start on a new page.)

9.1 One way to tell if a mosquito is about to bite is to listen to the Doppler effect of the sound emitted by the mosquito as it is flying. The buzzing of a mosquito's wings emits sound at a frequency of 1 050 Hz. The speed of sound is 330 $m \cdot s^{-1}$ in air.

9.1.1 State the *Doppler effect for sound*, in words. (2)

9.1.2 If you hear a frequency of 1 034 Hz, does this mean that the mosquito is coming in for a landing or that it has just bitten you and is flying away? Explain your answer. (3)

9.1.3 Calculate the speed of the mosquito when you hear the frequency of 1 034 Hz. (5)

9.2 The Doppler effect has many other uses.

9.2.1 One of the uses of the Doppler effect is in the field of Astronomy. While studying the stars, a red shift emission is observed. Is the star moving away from the earth or towards the earth? (1)

9.2.2 Another use of the Doppler effect is in the medical field. Give TWO uses of the Doppler flow meter on humans. (2)
[13]

TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Acceleration due to gravity	g	$9{,}8\ m\cdot s^{-2}$
Universal gravitational constant	G	$6{,}67 \times 10^{-11}\ N\cdot m^2\cdot kg^{-2}$
Speed of light in a vacuum	c	$3{,}0 \times 10^{8}\ m\cdot s^{-1}$
Planck's constant	h	$6{,}63 \times 10^{-34}\ J\cdot s$
Coulomb's constant	k	$9{,}0 \times 10^{9}\ N\cdot m^2\cdot C^{-2}$
Charge on electron	e	$1{,}6 \times 10^{-19}\ C$
Electron mass	m_e	$9{,}11 \times 10^{-31}\ kg$
Mass of earth	M	$5{,}98 \times 10^{24}\ kg$
Radius of earth	R_E	$6{,}38 \times 10^{6}\ m$

TABLE 2: FORMULAE

MOTION

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

FORCE

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

WORK, ENERGY AND POWER

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

WAVES, SOUND AND LIGHT

$v = f\lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_b} f_b$	$E = hf$ or $E = h\frac{c}{\lambda}$
$E = W_o + E_{k(max)}$ or $E = W_o + K_{max}$ where $E = hf$ and $W_0 = hf_0$ and $E_{k(max)} = \frac{1}{2}mv^2_{max}$ or $K_{max} = \frac{1}{2}mv^2_{max}$	

ELECTROSTATICS

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

ELECTRIC CIRCUITS

$R = \frac{V}{I}$	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

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