LIMPOPO

PROVINCIAL GOVERNMENT

REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF EDUCATION

NATIONAL SENIOR CERTIFICATE EXAMINATION

GRADE 12

PHYSICAL SCIENCES: PHYSICS (P1)

JUNE 2024

MARKS: 150

TIME: 3 hours

This question paper consists of 15 pages and 3-paged data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your NAME in the appropriate space 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 (Start on a new page)

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. Each question has only ONE correct answer.

1.1 A **measure** of the object's resistance to changes in its motion due to a force is called …

A mass

B inertia

C power

D impulse (2)

1.2 A 120 kg astronaut lands on a planet with a radius **three** times that of the Earth and a mass **nine** times that of the Earth. The acceleration due to gravity, *g*, experienced by the astronaut will be …

A nine times the value of *g* on the Earth.

B three times the value of *g* on the Earth.

C the same value of *g* as on the Earth.

D one-third the value of *g* on the Earth. (2)

1.3 A physics learner stands on a scale in an elevator (lift) that is moving downwards at a **constant velocity**.

The reading on the scale, compared to the reading when the elevator is stationary, would be …

A the same.

B greater.

C smaller.

D zero. (2)

1.4 Two statues of Kermit the frog, one made of aluminium and one of brass, are the same size, although the former is 3,2 times lighter than the latter.

Both are dropped at the same moment from the same height of 2 m. Neglect the effects of air resistance.

The two statues hit the ground …

A at nearly the same time with very different speeds.

B at very different times with nearly the same speeds.

C at nearly the same times with nearly the same speeds.

D at very different times with very different speeds. (2)

1.5 Two balls are thrown vertically upwards, one with an *itial* velocity **twice** that of the other.

The ball with **greater** initial velocity will reach a height …

A $\sqrt{2}$ times that of the other.

B 2 times that of the other.

C 4 times that of the other.

D 8 times that of the other. (2)

1.6 A golf ball has one-tenth the mass and five times the speed of a base ball.

Which ONE of the following CORRECTLY represents the **ratio** *golf ball momentum* ($p_{golf\ ball}$) : *base ball momentum* ($p_{base\ ball}$)?

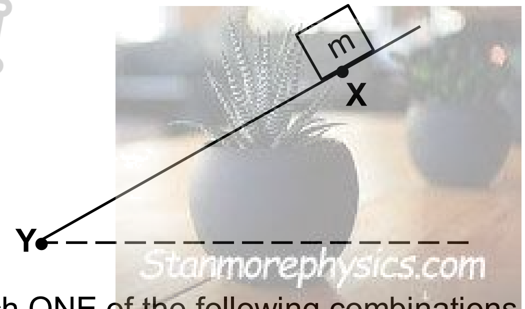
A 2 : 1

B 1 : 2

C 4 : 1

D 1 : 2 (2)

1.7 A block with mass m is released from rest at the top of a frictionless slope, as shown in the diagram below.

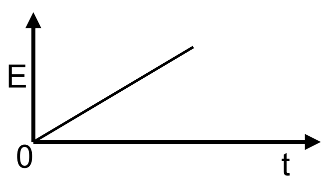


Which ONE of the following combinations is correct for the mechanical energy (E_{mech}) and the gravitational potential energy (E_p) of the block at positions **X** and **Y** respectively?

	MECHANICAL ENERGY	POTENTIAL ENERGY
A	E_{mech} at **X** = E_{mech} at **Y**	E_p at **X** = E_p at **Y**
B	E_{mech} at **X** = E_{mech} at **Y**	E_p at **X** > E_p at **Y**
C	E_{mech} at **X** > E_{mech} at **Y**	E_p at **X** > E_p at **Y**
D	E_{mech} at **X**< E_{mech} at **Y**	E_p at **X** = E_p at **Y**

(2)

1.8 The sketch graph below represents the relationship between energy expended (E) and time elapsed (t)



Which ONE of the following physical quantities is represented by the **gradient** of this graph?

A Velocity

B Momentum

C Impulse

D power (2)

1.9 When a patient moves with an ambulance, the frequency the patient hears is …

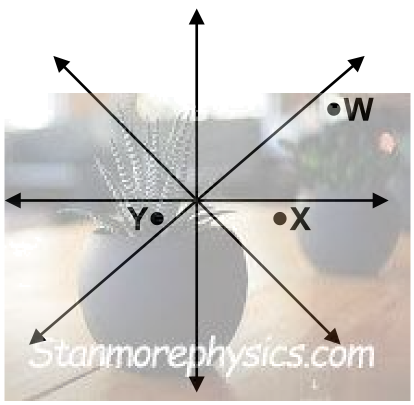
A equal to the source frequency.

B dependent on the sound speed.

C higher than the siren frequency.

D lower than the siren frequency. (2)

1.10. In the sketch below, points **W**, **X** and **Y** are at various distances from a given point charge.



Which ONE of the following statements is MOST accurate?

The electric field is …

A the same at, **W**, **X** and **Y**.

B greatest at point **W**.

C greatest at point **X**.

D greatest at point **Y**. (2)
[20]

QUESTION 2 (Start on a new page)

An astronaut on a space mission lands on a planet **P** with *three* times the mass (m) and *twice* the radius (R) of Earth.

The weight of the astronaut on the Earth's surface is 945 N.

2.1 Describe, in words, the term *weight* as applied in Physics. (2)

2.2 With reference to classification of physical quantities as *vectors* and *scalars*, distinguish between *weight* and *mass*. (2)

2.3 State *Newton's Law of Universal gravitation* in words. (2)

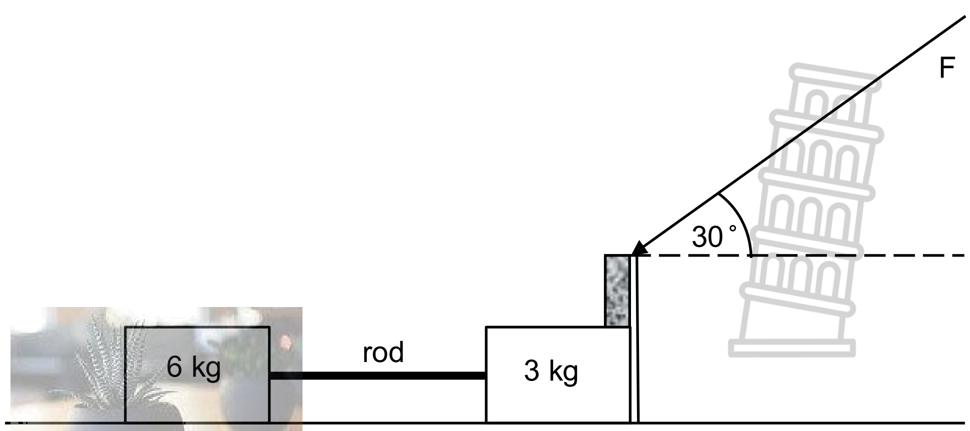
2.4 Calculate the weight of the astronaut when on planet **P**. (5)
[11]

QUESTION 3 (Start on a new page)

3.1 A common say goes, "It's not the fall that hurts, it's the sudden stop".

Use Newton's Law(s) to explain the validity of this statement. (2)

3.2 Two blocks made of the same materials are shown below. A force F = 160 N applied at an angle of 30˚ to the 3 kg block which is connected to the 6 kg block by a massless inextensible rod, as shown in the diagram below.



The applied force causes both blocks to accelerate across a ROUGH floor which has coefficient of kinetic friction of 0,25.

3.2.1 Define the term *kinetic frictional force*. (2)

3.2.2 Calculate the magnitude of the kinetic frictional force acting on the 6 kg block. (3)

3.2.3 Draw a labelled free-body diagram for the 6 kg block. (4)

3.2.4 State, in words, *newton's second law of motion* in terms of acceleration. (2)

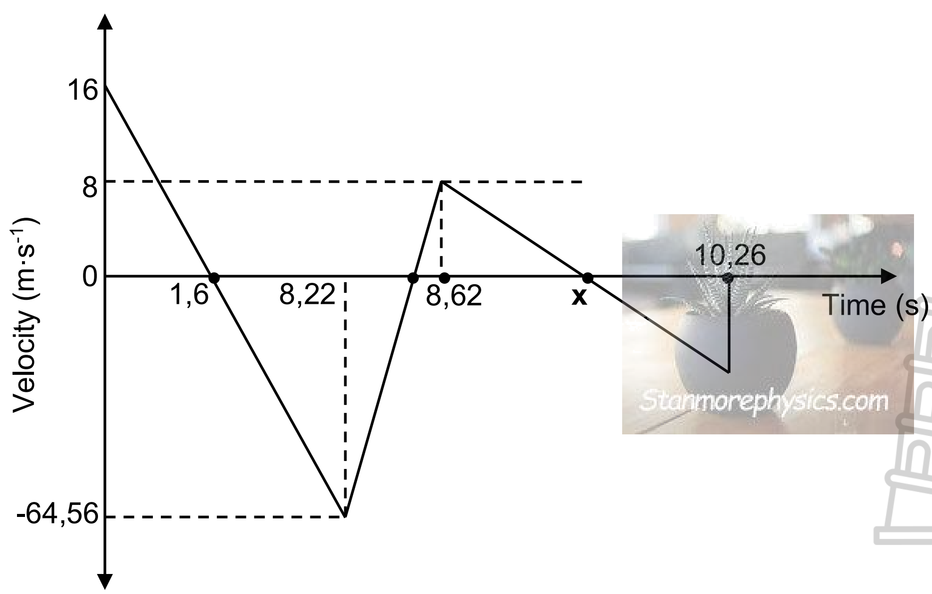
3.2.5 Calculate the tension in the rod connecting the blocks. (7)
[20]

QUESTION 4 (Start on a new page)

A hot air balloon is rising at constant velocity when a tourist leans over the edge and accidentally drops his camera. When the camera lands on the ground it bounces once and then comes to rest.

The velocity-versus-time sketch graph below depicts the entire motion of the camera from the instant it is released until it comes to rest on the ground.

Air resistance has been neglected.



4.1 A camera, while falling, is regarded as a projectile. Explain what is meant by a *projectile*. (2)

4.2 Write down the:

4.2.1 Velocity at which the balloon is ascending when the camera drops. (1)

4.2.2 Time for which the camera is in contact with the ground before bouncing. (1)

4.3 Calculate the:

4.3.1 Value of **x**, shown in the graph (2)

4.3.2 Height of the balloon above ground when the camera is dropped (4)

4.3.3 Maximum height that the camera reaches after it has bounced (3)

4.3.4 Distance between the camera and the hot air balloon at time x (5)

4.4 Sketch a corresponding position-versus-time graph for the entire motion of the camera.
Take the ground as *zero position*

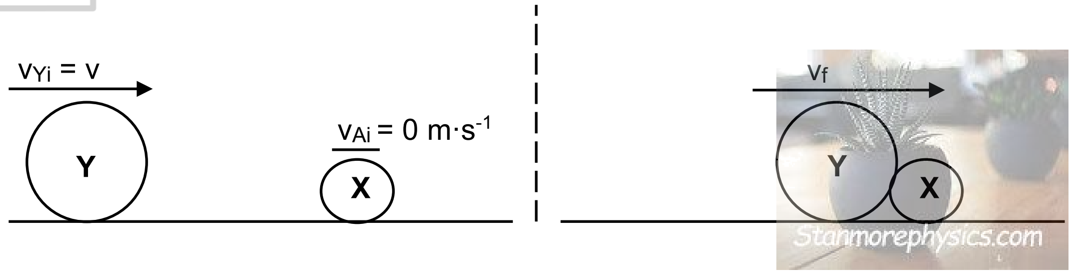
Clearly indicate the values of the following on the graph:

- Height of the balloon when the camera is dropped
- Maximum height that the camera reaches after bouncing
- Time when the camera strikes the ground for the first time
- Time when the camera leaves the ground during bouncing
- Total time taken for the camera to come to rest.

(5)
[23]

QUESTION 5 (Start on a new page)

A stationary steel ball **X** is struck head-on by a moving steel ball **Y** that has THREE times the mass of **X**. After the collision, the two steel balls move forward together at a speed which is 75% of steel ball **Y**'s before the collision, as shown in the diagram below.



Assume the two-ball system is isolated.

5.1 Explain what is meant by the term *system* as applied in physics. (2)

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

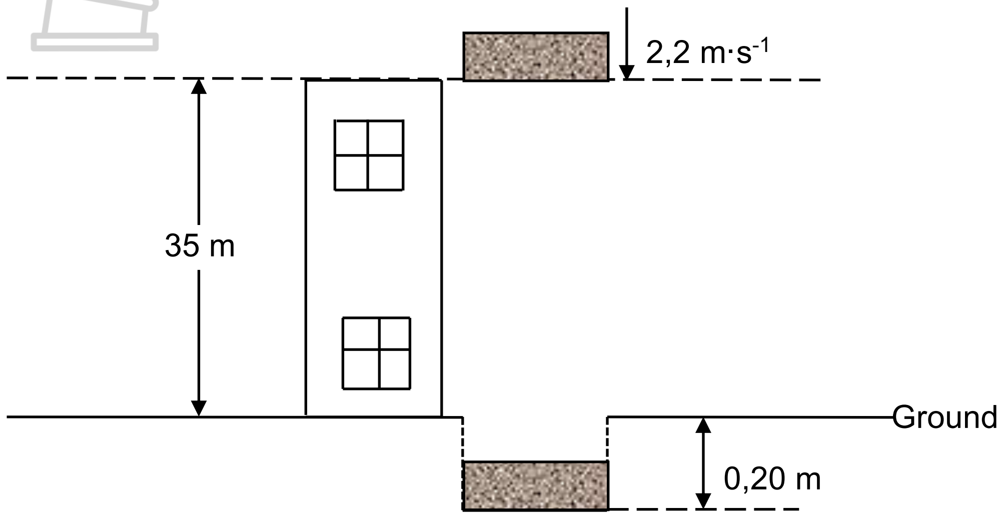
5.3 Show, by means of appropriate calculations, that this collision is in agreement with the principle in QUESTION 5.2 above. (5)

5.4 Is the collision between the two steel balls, **X** and **Y**, ELASTIC or INELASTIC? Use suitable calculations to explain the answer. (5)

[14]

QUESTION 6 (Start on a new page)

A brick of mass 2,4 kg is thrown off a building, 35 m high, with a speed of 2,2 $m \cdot s^{-1}$ vertically downwards. As it falls onto the ground, it penetrates 0,20 m into the ground, as shown in the diagram below.



Ignore the effects of air friction.

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

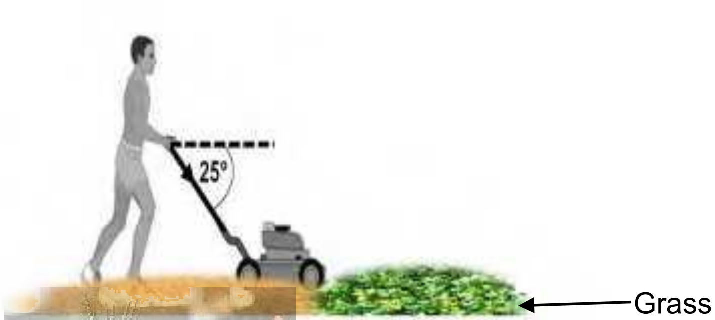
6.2 Using the principle in QUESTION 6.1 above, calculate the speed with which the brick hits the ground. (4)

6.3 Using energy principles, calculate the work done by the frictional force on the brick as it penetrates the ground. (4)

[10]

QUESTION 7 (Start on a new page)

A garden worker pushes a lawn mower of mass 15 kg, at an angle of 25˚ to the horizontal, 20 m across a horizontal strip of lawn, as the diagram below illustrates.



The kinetic frictional force between the lawn mower and the grass is 35 N.

7.1 Define the term *conservative force*. (2)

7.2 Classify frictional force as a CONSERVATIVE FORCE or a NON-CONSERVATIVE FORCE (1)

7.3 Draw a labelled free-body diagram for the lawn mower. (4)

7.4 State the NAME of the force acting on the lawn mower which does ZERO work on it. (1)

The lawn mower moves at *constant velocity*.

7.5 Calculate, using energy principles, the power at which the worker works if he/she mows the strip of lawn in 2,5 minutes. (5)
[13]

QUESTION 8 (Start on a new page)

Water is pumped from a borehole 100 m deep. A pump with a power output of 2 300 W is used.

8.1 Define, in words, the term *power* as applied in physics. (2)

8.2 Calculate the time (in minutes) taken for the pump to bring the 4 500 kg of water to the surface. (5)

[7]

QUESTION 9 (Start on a new page)

9.1 A grade 12 learner is sitting near the open window of a train that is moving at a velocity of 10,0 $m \cdot s^{-1}$ to the East. The learner's uncle stands near he tracks and watches the train move away. The train whistle emits sound of frequency 500,0 Hz. The air is still and the speed of sound is 340 $m \cdot s^{-1}$.

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

9.1.2 Write down the frequency that the learner hears.
Suggest a reason for the answer. (2)

9.1.3 Calculate the percentage change in frequency heard by the learner's uncle. (5)

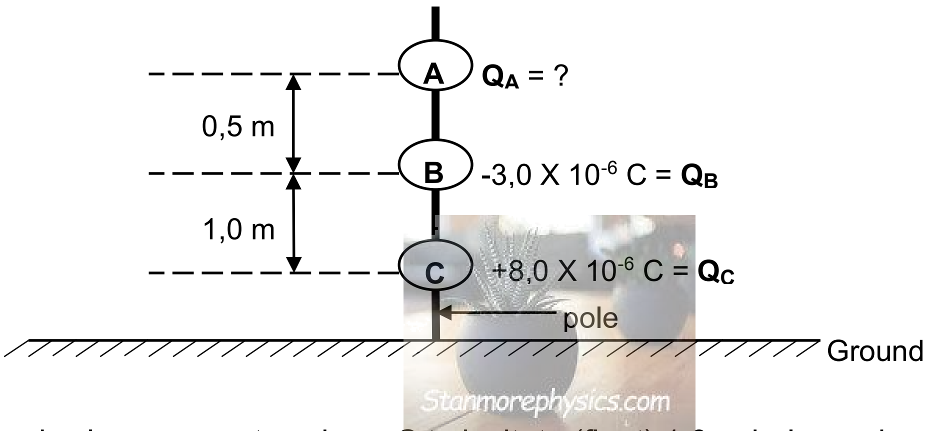
9.2 How fast (in $m \cdot s^{-1}$) should a car move towards the listener for the car's horn to sound 8,7% higher in frequency than when it is stationary?
Take the speed of sound in air as 343 $m \cdot s^{-1}$. (3)

[12]

QUESTION 10 (Start on a new page)

10.1 Two small charged spheres (**A** and **B**) are fixed 0,5 m apart on a vertical pole. The lower sphere, **B**, carries a fixed charge of $-3,0 \times 10^{-6}$ C, and the upper one, **A**, carries a charge that can be adjusted.

A 0,03 kg small sphere, **C**, carrying a charge of $+8,0 \times 10^{-6}$ C, can move freely on the pole below the other two, as shown in the diagram below.



A physics learner wants sphere **C** to levitate (float) 1,0 m below sphere **B**. Neglect the masses of spheres **A** and **B**.

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

10.1.2 Draw a labelled free-body diagram for sphere **C**. (3)

10.1.3 Calculate the charge that sphere **A** must be adjusted to in order to achieve this feat (act of remarkable skill). (5)

10.2 A small metal sphere **M** carries a charge of $+2,4 \times 10^{-9}$ C.

10.2.1 Define, in words, the term *electric field* at a point. (2)

10.2.2 Sketch the electric field pattern associated with sphere **M**. (2)

$3,2 \times 10^{10}$ electrons are now transferred to sphere **M**.

10.2.3 Calculate the electric field at a point 0,125 m from the sphere **M**. (6)

[20]

Grand 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	$9,8\ m\cdot s^{-1}$
Universal gravitational constant *Universele gravitasiekonstant*	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* $W_{nc} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{av} = Fv_{av}$ / $P_{gemid} = Fv_{gemid}$	

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

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*

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

LIMPOPO

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NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: PHYSICS (P1)

JUNE 2024 (Edited Version)

MARKING GUIDLINES

MARKS: 150

These marking guidelines consist of 14 pages.

QUESTION 1

1.1 A / B ✓✓ (2)

1.2 C ✓✓ (2)

1.3 C ✓✓ (2)

1.4 C ✓✓ (2)

1.5 C ✓✓ (2)

1.6 B ✓✓ (2)

1.7 B ✓✓ (2)

1.8 D ✓✓ (2)

1.9 A ✓✓ (2)

1.10 D ✓✓ (2)
[20]

QUESTION 2

2.1 The (gravitational) force the Earth exerts on any object on or near its surface.✓✓ (2)

2.2 Weight is a vector quantity ✓ whereas mass is a scalar quantity. ✓ (2)

2.3 Each particle in the universe attracts every other particle with a gravitational force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.✓✓

OR:

Each body in the universe attracts every other body with a gravitational force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.✓✓ (2)

2.4

OPTION 1:

$F_{g(Earth)} = \frac{GmM}{r^2}$
$= 945$ N

$F_{g(Planet\ P)} = \frac{GmM_P}{R_P^2}$ ✓
$= \frac{Gm(3M)}{(2R)^2}$ ✓
$= \frac{3}{4}\frac{GmM}{r^2}$
$= \frac{3}{4}(945)$ ✓
$= 708,75$ N ✓ downwards. ✓

OPTION 2:

$g_P = \frac{GM_P}{R_P^2}$ ✓
$g_P = \frac{(6,67 \times 10^{-11})(3 \times 5,98 \times 10^{24})}{(2 \times 6,38 \times 10^6)^2}$ ✓
$= 7,349316$ m·s^{-2}
$w_E = mg_E$
$(945) = m(9,8)$

$m = 96,42857$ kg
$w_P = mg_P$
$= (96,42857)(7,349316)$ ✓
$= 708,684$ N ✓ downwards ✓

OPTION 3:

$w_E = mg_E$
$(945) = m(9,8)$ ✓
$m = 96,42857$ kg

$g_P = \frac{G(3M_E)}{(2R_E)^2}$ ✓
$= \frac{3 \cdot GM_E}{4(R_E)^2}$
$= \frac{3}{4}\left(\frac{GM}{R^2}\right)$
$= \frac{3}{4}(9,8)$
$= 7,349316$ m·s^{-2}
$w_P = mg_P$
$= (96,42857)(7,349316)$ ✓
$= 708,684$ N ✓ downwards ✓
Range: (708,75 N – 708,684 N)

(5)

[11]

QUESTION 3

3.1 When you stop suddenly, your velocity changes rapidly, which means a large acceleration✓ of stopping. By Newton's second Law, this means the force that acts on you is also large – experiencing a large force is what hurts you.✓

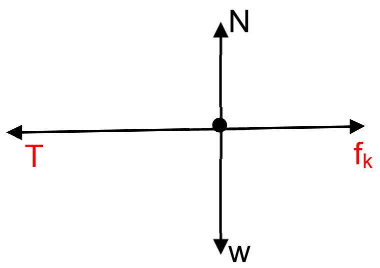
OR:

Sudden stop implies *shorter time*✓of contact with the ground. From $F_{net} = \frac{\Delta p}{\Delta t}$, for the same Δp, shorter Δt means greater F_{net}✓, hence greater injury. (2)

3.2.1 The force that opposes the motion of a moving object relative to a surface. ✓✓ (2)

3.2.2
$f_k = \mu_k N$✓
$f_k = \mu_k mg$
$= (0,25)(6)(9,8)$✓
$= 14,70$ N✓
(3)

3.2.3



Accepted labels	
N✓	Normal force/N/F_N
f_k✓	Kinetic friction / frictional force/ f/ F_f
T✓	$F_{rod\ on\ 6\ kg\ block}$/Thrust/$F_C$
w✓	F_g/mg/weight/gravitational force/$F_{Earth\ on\ block}$

Notes:
- Mark is awarded for label and arrow.
- Do not penalize for length of arrows
- Deduct 1 mark for any additional force.
- If force(s) do not make contact with dot/body: 3/4
- If arrows missing: 3/4

(4)

3.2.4 When a non-zero net/resultant force on an object, the object will accelerate in the direction of the net force at an acceleration that is directly proportional to the net force and inversely proportional to the mass of the object.✓✓ (2)

3.2.5

POSITIVE MARKING FROM 3.2.2	
For the 3 kg block: **Take to the left as positive**	**For the 6 kg block:**
$F_{net} = ma$ $F_x + (-T) + (-f) = ma$ } Any one✓ (160)(cos30°) - T - μ_kN = 3·a (160) (cos30°) ✓-T -(0,25) [(3)(9,8) + 160 sin30°] ✓= 3a✓ (160) (cos30°) - (6a + 14,70) - 27,35 = 3a 96,51406461 = 9a ∴a = 10,7238 m·s^{-2} a = 10,7238 m·s^{-2}	$F_{net} = ma$ T – f = ma T – 14,70 = 6a✓ T = 6·a + 14,70
T = 6(10,7238) + 14,70✓ = 79,0428 N✓	
NB: Also consider to the right as positive!	

(7)

[20]

QUESTION 4

4.1 **An object which has been given an initial velocity and then it moves under the influence of the gravitational force only.**✓✓

OR:

An object upon which the only force acting is the gravitational force. ✓✓ (2)

4.2.1 16 m·s^{-1} ✓(upwards) (1)

4.2.2 0,4 s ✓ (1)

In these calculations, also consider answers for downward positive!

4.3.1

OPTION 1:	OPTION 2:	OPTION 3:
$x = \frac{8,62 + 10,26}{2}$✓ = 9,44 s✓	$v_f = v_i + a\Delta t$ 0 = 8 + (-9,8)Δt Δt = 0,8163265 s x = 8,62 + 0,82✓ = 9,44 s✓	10,26 – x = x – 8,62✓ 10,26 + 8,62 = x + x x = 9,44 s✓

(2)

4.3.2

OPTION 1:	**OPTION 2:**
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $\Delta y = (16)(8,22)$ ✓ $+ \frac{1}{2}(-9,8)(8,22)^2$✓ $\Delta y = -199,\ 566$ m ∴the height is 199, 566 m above the ground✓	$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(-64,56)^2$ ✓$= (16)^2 + 2(-,8)\Delta y$✓ $\Delta y = -199\ 592$ m ∴the height is 199, 592 m above the ground✓
OPTION 3:	**OPTION 4:**
$\Delta y = \frac{1}{2}(v_i + v_f)\Delta t$✓ $= \frac{1}{2}(16 + 1 - 64,56)$ ✓$(8,22)$ ✓ $= -199,\ 582$ m ∴the height is 199, 582 m ✓above the ground	Smaller area $= \frac{1}{2}bh$ $= \frac{1}{2}(1,6)(16)$ ✓ $=12,8$ m Bigger area $= \frac{1}{2}bh$ $= \frac{1}{2}(8,22 - 1,6)64,56)$✓ $= 213,6936$ m ✓ ∴Height = 213,6936 – 12,8936 m ✓ = 200,8936 m ✓
Range: 199,566 m – 200,8936 m	

(4)

4.3.3

OPTION 1:	**OPTION 2:**
Height $= \frac{1}{2}bh$✓ $= \frac{1}{2}(9,44 - 8,62)(8)$ ✓ $= 3,28$ m ∴the height is 3,28 m ✓ Range: 3,265 m to 3,28 m	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $\Delta y = (8)(0,82) + \frac{1}{2}(-9,8)(0,82)^2$✓ $=3,265$ m ∴the height is 3,265 m ✓ Range: 3,265 m to 3,28 m
OPTION 3:	**OPTION 4:**
$\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $\Delta y = \left(\frac{8+0}{2}\right)(0,82)$✓ $= 3,28$ m ∴the height is 3,28 m✓ Range: 3,265 m to 3,28 m	$v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(0)^2 = (8)^2 + 2(-9,8)\Delta y$✓ $\Delta y = 3,265$ m ∴the height is 3,265 m✓ Range: 3,265 m to 3,28 m

(3)

4.3.4 **POSITIVE MARKING FROM QUESTIONS 4.32 and 4.3.3**

OPTION 1:

Height of balloon above the ground after 9,44 s: Δy = (16)(9,44) ✓ + 199,592✓
= 350,632 m✓

Distance apart = 350,632✓ – 3,28
= 347,352 m✓

Range: 437,352 m to 437,36 m

OPTION 2:

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$\Delta y = (11)(9,44) + \frac{1}{2}(0)(9,44)^2$✓
= 151,04 m

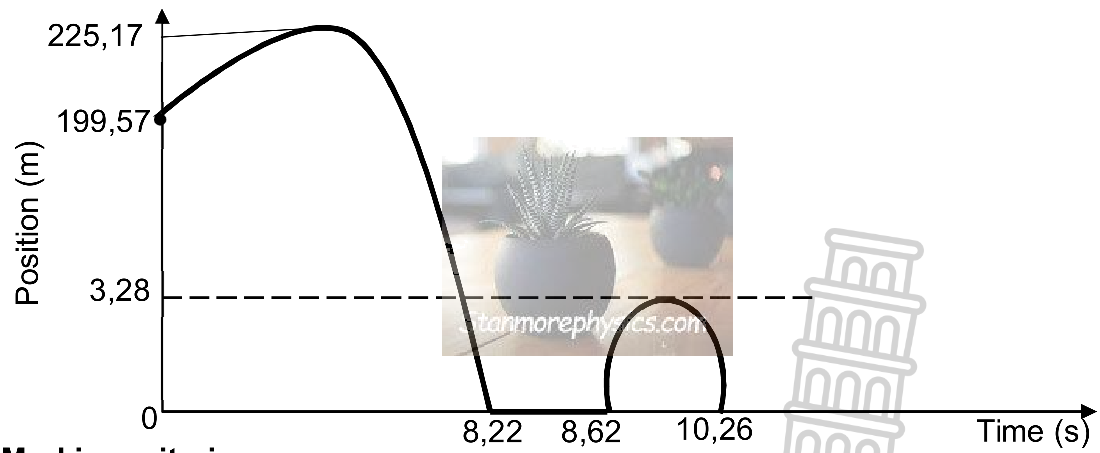
Height above ground = 200,8936 + 151,04✓
= 351,93 m

Distance apart = 351,93 – 3,28 ✓
= 348,65 m ✓

Range: 437,352 m to 437,36 m

(5)

4.4 **POSITIVE MARKING FROM QUESTION 4.3.1 TO QUESTION 4.3.4**



Marking criteria

- Correct shape✓
- Height when the camera is dropped ✓ (199,6 m)
- Time when the camera strikes the ground✓ (8,22 s)
- Time when the camera bounces✓ (8,62 s)
- Total time of motion✓ (10,26 s)

(5)
[23]

QUESTION 5

5.1 A collection of two or more objects that interact with each other.✓✓

OR:

A small part of the universe that we are considering when solving a particular problem.✓✓

OR:

Any object or group of objects that can be separated, in our minds, from the surrounding environment.✓✓

OR:

A collection of objects that can be identified.✓✓ (2)

5.2 The total linear momentum of an isolated system remains constant (is conserved).✓✓ (2)

5.3 **Take to the right as positive:**

$\sum P_i = (m_x v_{x_i} + m_y v_{Y_i})$ **If they equated give 3 / 5**
$= (m)(0) + (3m)(v)$ ✓
$= 3mv$✓

$\sum P_f = (m_X + m_Y)v_f$
$= (m + 3m)\left(\frac{75}{100}v\right)$✓
$= (4m)\left(\frac{3}{4}v\right)$
$= 3mv$✓
∴the collision is in agreement with the principle of conservation of linear momentum since $\sum P_I = \sum P_f$✓

(5)

5.4 Inelastic✓

$E_k = \frac{1}{2}mv^2$✓

$E_{K_i} = \frac{1}{2}m_x v_{xi}^2 + \frac{1}{2}m_y v_{yi}^2$

$= \frac{1}{2}(m)(0)^2 + \frac{1}{2}(3m)v^2$✓

$= \frac{3}{2}mv^2$

$E_{K_f} = \frac{1}{2}(m_x + m_y)v_f^2$

$= \frac{1}{2}(m + 3m)\left(\frac{3}{4}v\right)^2$ ✓

$= \frac{9}{8}mv^2$

∴ The collision is inelastic since $E_{K_i} \neq E_{K_f}$ ✓

(5)

[14]

QUESTION 6

6.1 The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant.✓✓ (2)

6.2

$\sum E_{\text{mech at top}} = \sum E_{\text{mech at bottom}}$

$(E_P + E_K)_{top} = (E_P + E_K)_{bottom}$

$\left(mgh + \frac{1}{2}mv^2\right)_{top} = \left(mgh + \frac{1}{2}mv^2\right)_{bottom}$

} Any one✓

$(2,4)(9,8)(35) + \frac{1}{2}(2,4)(2,2)^2$✓ $= (2,4)(9,8)(0) + \frac{1}{2}(2,4)(v^2)$ ✓

$829,008 = (1,2)v^2$

$v^2 = 690,84$

$v = 26,284\ m{\cdot}s^{-1}$

The speed is $26,284\ m{\cdot}s^{-1}$✓$(26,284\ m{\cdot}s^{-1})$

Also consider calculation based on $W_{nc} = \Delta E_k + \Delta E_p = 0$

(4)

6.3 **POSITIVE MARKING FROM QUESTION 6.2**

OPTION 1:

$W_{nc} = \Delta E_k + \Delta E_p$
$W_f = \frac{1}{2}m(v_f^2 - v_i^2) + mg(h_f - h_i)$ } Any one ✓

$= \frac{1}{2}(2,4)(0^2 - 26,284^2)$ ✓ $+ (2,4)(9,8)(0 - 0,20)$ ✓
$= -829,0183872 - 4,704$
$= -833,7224$ J
∴ The work done by the frictional force is -833,7224 J ✓ (-833,72 J)
Range: -833,47 to -833,72 J

OPTION 2:

$W_{net} = \Delta E_k$
$W_f + W_w = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$
$W_f + mg\Delta y\cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$ } Any one ✓

$W_f + (2,4)(0,20)(9,8)(\cos 0°)$ ✓ $= \frac{1}{2}(2,4)(0)^2 - \frac{1}{2}(2,4)(26,284)^2$ ✓
$W_f + 4,704 = -829,0183872$
$W_f = -833,7224$ J
∴ The work done by the frictional force is -833,7224 J ✓ (-833,72 J)
Range: -833,47 to -833,72 J

OPTION 3:

$W_{net} = \Delta E_k$
$F_{net}\Delta\cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$ } Any one ✓

$F_{net}(0,20)(\cos 180°) = \frac{1}{2}(2,4)(0)^2 - \frac{1}{2}(2,4)(26,284)^2$ ✓
Fnet(-0,20) = -829,0183872
Fnet = 4 145,091936
$f + (-w) = F_{net}$
$f - mg = F_{net}$
f – (2,4)(9,8) = 4 145,091936
f = 4 168,611936
$W_f = f\Delta y\cos\theta$
$W_f = (4, 168, 611936)(0,20)(\cos 180°)$ ✓
$W_f = -833,7224$ J
∴ The work done by the frictional force is -833,7224 J ✓ (-833,72 J)
Range: -833,47 to -833,72 J

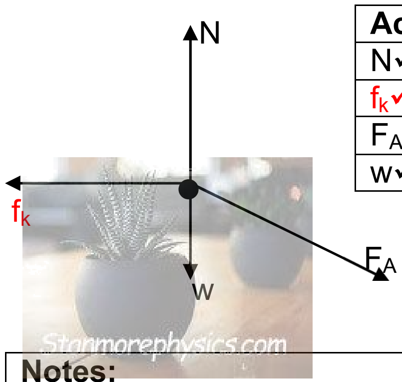
(4)
[10]

QUESTION 7

7.1 A force for which the work done in moving an object between two points is independent of the path taken.✓✓ (2)

7.2 Non-conservative force. ✓ (1)

7.3



Accepted labels	
N✓	Normal force/ F_N/$F_{surface\ on\ lawn\ mower}$
f_k✓	Kinetic friction/f/F_f
F_A✓	Applied force/$F_{applied}$
w✓	F_g/mg/weight/gravitational force/$F_{Earth\ on\ lawn\ mower}$

Notes:
- Mark is awarded for label and arrow.
- Do not penalize for length of arrows
- Deduct 1 mark for any additional force.
- If force(s) do not make contact with dot/body: 3/4
- If arrows missing: 3/4

(4)

7.4 Normal force/Gravitational force✓ (1)

7.5

OPTION 1

$W_{net} = \Delta E_K$ } Any one✓
$W_N + W_w + W_F + W_{F_A} = E_{K_f} - E_{K_i}$

$0 + 0 + f \cdot \Delta x \cdot \cos\theta + W_{F_A} = 0 - 0$

$(35)(20)(\cos 180°) + W_{F_A} = 0$✓

$-700 + W_{F_A} = 0$

$\therefore W_{F_A} = 700$ J

$P = \frac{W}{\Delta t}$✓

$= \frac{700}{2,5 \times 60}$✓

$= 4,6667$ W✓(4,67 W)

OPTION 3

Calculations may also be based on:

$W_{nc} = \Delta E_k + \Delta E_p$

OPTION 2

$W_{net} = \Delta E_K$ } Any one✓
$W_N + W_w + W_F + W_{F_A} = E_{K_f} - E_{K_i}$

$0 + 0 + f \cdot \Delta x \cdot \cos\theta + W_{F_A} = 0 - 0$

$(35)(20)(\cos 180°) + W_{F_A} = 0$✓

$-700 + W_{F_A} = 0$

$\therefore W_{F_A} = 700$ J

$W_{F_A} = F_A \Delta x \cos\theta$

$700 = F_A(20)\cos 0°$

$F_A = 35$ N

$P_{ave} = Fv_{ave}$✓

$= F\left(\frac{\Delta x}{\Delta t}\right)$

$= (35)\left(\frac{20}{2,5 \times 20}\right)$✓

$= 4,6667$ W✓(4,67 W)

(5)

[13]

QUESTION 8

8.1 The rate at which work is done or energy is expended\transferred.✓✓ (2)

8.2

OPTION 1:	OPTION 2:
Work done, $W = E_P$ $W = mgh$ $W = (4500)(9,8)(100)$✓ $W = 4,41 \times 10^6$ J $P = \frac{W}{\Delta t}$✓ $2\ 300$✓ $= \frac{441\ 0000}{\Delta t}$✓ $\Delta t = 1\ 917,\ 391304$ s $\Delta t = 31,96$ min✓	$F_{net} = ma$ $F_{pump} + (-w) = 0$ $F_{pump} = mg$ $=(4500)(9,8)$ ✓ $F_{pump} = 44100$ N $P_{ave} = Fv_{ave}$ ✓ 2300 ✓$= (44100)\left(\frac{\Delta y}{\Delta t}\right)$ $2300 = (44100)\left(\frac{100}{\Delta t}\right)$✓ $\Delta t = 1\ 917,\ 391304$ s $\Delta t = 31,96$ min✓

(5)
[7]

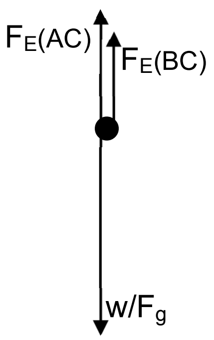
QUESTION 9		
9.1.1	<u>The apparent change in frequency (or pitch) of sound detected by the listener</u>✓ because the sound source and the listener have different velocities relative to the medium of sound propagation.✓ OR <u>The apparent change in frequency (or pitch) of sound detected by the listener</u>✓ as a result of the relative motion between the sound source and the listener.✓	(2)
9.1.2	$f_{learner} = 500,0$ Hz ✓ No relative motion between the learner and the train.✓ OR Dopper effect was not observed.✓	(2)
9.1.3	<u>OPTION 1</u> $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ $= \left(\frac{340 - 0}{340 + 10}\right)$✓$(500,0)$✓ $= \left(\frac{340}{350}\right)(500,0)$ $= 485,7143$ Hz <u>OPTION 2</u> $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ $= \left(\frac{340 - 0}{340 + 10}\right)$✓$(500,0)$✓ $= \left(\frac{340}{350}\right)(500,0)$ $= 485,7143$ Hz	

	$\Delta f = 500{,}0 - 485{,}71431$ ✓ $= 14{,}2857$ Hz $\% \Delta f = \frac{14{,}2857}{500{,}0} \times 100$ $= 2{,}86\ \%$ ✓	$\% \Delta f = \frac{485{,}7143}{500{,}0} \times 100$ $= 97{,}14286\ \%$ $\% \Delta f = 100 - 97{,}14286$ ✓ $= 2{,}86\ \%$ ✓	(5)
9.2	$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ $\left(f_s + \frac{8{,}7}{100} f_s\right) = \left(\frac{343 + 0}{343 - v_s}\right) f_s$ $f_s\left(1 + \frac{8{,}7}{100}\right)$ ✓ $= \frac{343 \cdot f_s}{343 - v_s}$ ✓ $f_s (1{,}087) = \frac{343}{343 - v_s} f_s$ $(1{,}087)(343 - v_s) = 343$ $343 - v_s = 315{,}5474$ $343 - 315{,}5474 = v_s$ $v_s = 27{,}4526\ m \cdot s^{-1}$ ✓ $(27{,}45\ m \cdot s^{-1})$		(3)
			[12]

QUESTION 10

10.1.1 The magnitude of the electrostatic force exerted by one stationary point charge (Q_1) on another stationary point charge (Q2) is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them.✓✓
(if the word point is omitted, … square of the distance between their centers) (2)

10.1.2



Accepted labels	
$F_E(BC)$ ✓	Electrostatic force / coulomb's force
$F_E(AC)$ ✓	Electrostatic force / coulomb's force
w ✓	F_g/mg/weight/gravitational force

Notes:

- Mark is awarded for label and arrow.
- Do not penalize for length of arrows
- Deduct 1 mark for any additional force.
- If force(s) do not make contact with dot/body: 2/3
- If arrows missing: 2/3

(3)

10.1.3

$F_{net,y} = 0$

$F_E(AC) + F_E(BC) + (F_C^g) = 0$

$F = \frac{KQ_1Q_2}{r^2}$ ✓

$\frac{KQ_CQ_B}{r_{BC}^2} + \frac{KQ_CQ_A}{r_{AC}^2} - mg = \underline{0}$ ✓

$\frac{(9 \times 10^9)(8 \times 10^{-6})(3 \times 10^{-6})}{(1,0)^2} + \frac{(9 \times 10^9)(8 \times 10^{-6})Q_A}{(1,5)^2}$ ✓ $-(0,03)(9,8)$ ✓ $= 0$

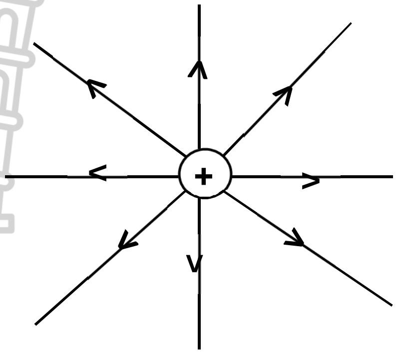
$0,216 + 32\ 000 \cdot Q_A - 0,294 = 0$

$32\ 000 \cdot Q_A = 0,078$

$Q_A = -2,4375 \times 10^{-6}$ C ✓ ($-2,4375 \times 10^{-6}$ C) (5)

10.2.1 The electrostatic force experienced per unit positive charge placed at that point.✓✓ (2)

10.2.2



- Shape✓
- Direction✓

(2)

10.2.3

$n = \frac{Q}{e}$ or $n = \frac{Q}{q_e}$

$3{,}2 \times 10^{10} = \frac{Q}{-1{,}6 \times 10^{-19}}$ ✓

$Q = -5{,}12 \times 10^{-19}$ C

$Q_M = -5{,}12 \times 10^{-19} + 2{,}4 \times 10^{-19}$ ✓

$= -2{,}72 \times 10^{-19}$ C

$E = \frac{KQ}{r^2}$ ✓

$= \frac{(9 \times 10^9)(2{,}72 \times 10^{-9})}{(0{,}125)^2}$ ✓

$= 1\ 566{,}72\ N{\cdot}C^{-1}$ ✓ ($1\ 567 \times 10^3\ N{\cdot}C^{-1}$), towards sphere M ✓

(6)

[20]

Grand total: [150]