KWAZULU-NATAL PROVINCE

EDUCATION
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES P1 (PHYSICS)

PREPARATORY EXAMINATIONS

SEPTEMBER 2021

MARKS : 150

TIME : 3 hours

This question paper consists of 17 pages and 3 data sheets.

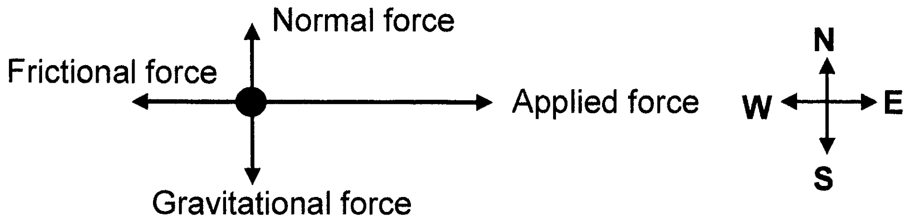
INSTRUCTIONS AND INFORMATION TO CANDIDATES

1. Write your name 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 sub questions, 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 SHEET.
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

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 free-body diagram below shows the relative magnitudes and directions of all the forces acting on an object.



The object is…

A accelerating eastward.

B accelerating westward.

C at rest.

D moving with constant velocity. (2)

1.2 Acceleration due to gravity on the surface of the Earth is **g**. What will be the acceleration due to gravity on the surface of another planet of the SAME mass as that of the Earth, but HALF the radius of the Earth?:

A ½**g**

B **g**

C 2**g**

D 4**g** (2)

1.3 From the top of a building, ball **X** is thrown vertically **upwards** and another ball **Y**, is thrown vertically **downwards**. Both balls are thrown at the same speed. Ignore the effects of friction.
Which ball(s) will have a greater speed when it hits the ground?

A **X**

B **Y**

C **X** and **Y** would have the same speed

D Depends on the mass of the ball. (2)

1.4 In movies, Superman hovers in mid - air, grabs a villain (bad guy), and throws him forward. Superman, however, remains stationary. This is not possible in real life, because it goes against one of the following laws or principles:

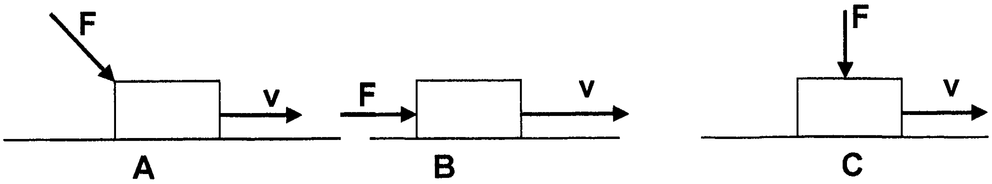
A The principle of conservation of energy

B Newton's first law of motion

C Newton's Universal law of Gravitation

D The principle of conservation of linear momentum (2)

1.5 A force, **F**, acts in three different directions on a box moving with a velocity, **v**, as shown below.



Select the order in which the work done by the force **F** from minimum to maximum

A A; B; C

B C; B; A

C B; C; A

D C; A; B (2)

1.6 A police car, with its siren on, is moving away at constant speed from a stationary observer. The siren emits a sound of constant frequency

Which of the following characteristics, associated with the sound emitted by the siren is/are CORRECT, as perceived by the observer?

(i) The speed remains the same.
(ii) The frequency increases.
(iii) The wavelength increases.
(iv) The frequency decreases

A (iii) only

B (i), (iii) and (iv)

C (i) and (iii) only

D (i) and (ii) only (2)

1.7 A point charge exerts a force of magnitude ***F*** on another point charge. One of the charges is changed to one third and the distance between the charges is doubled. What is the new electrostatic force in terms of ***F***?

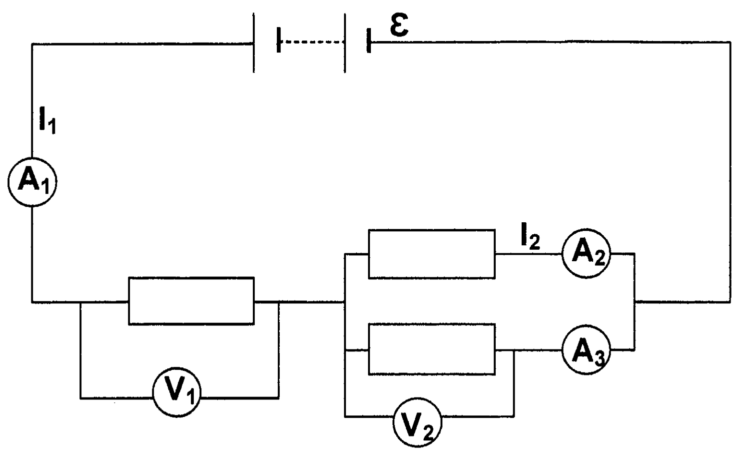
A $\frac{F}{3}$

B $\frac{F}{12}$

C $\frac{3F}{4}$

D $\frac{F}{6}$ (2)

1.8 The sketch below, show a battery of emf **Ɛ,** connected in a circuit containing three resistors. Ignore the internal resistance of the battery.

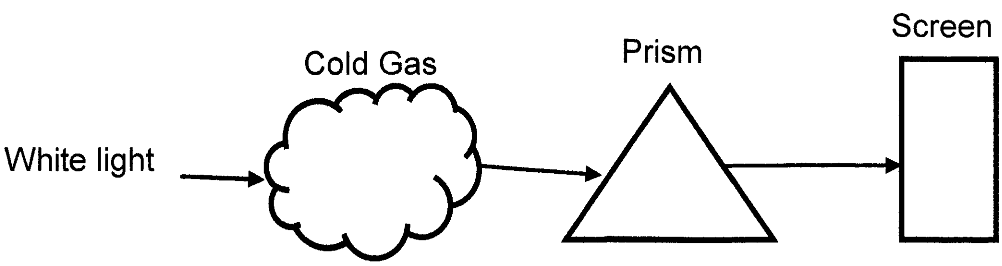


Which ONE of the following combinations best describes the readings of ammeter A_3 and voltmeter V_2?

	Reading on A_3	**Reading on V_2**
A	$I_1 - I_2$	$\varepsilon - V_1$
B	$I_1 - I_2$	$\varepsilon + V_1$
C	$I_1 + I_2$	$\varepsilon + V_1$
D	$I_1 + I_2$	$\varepsilon - V_1$

(2)

1.9 White light is passed through a cold gas, then through a prism as shown in the sketch.



What type of spectrum is observed on the screen?

A Line absorption spectrum

B Line emission spectrum

C Continuous absorption spectrum

D Continuous emission spectrum (2)

 Please turn over

1.10 Which ONE of the following provides evidence that light behaves as a particle?

A Light can be diffracted.

B Light can be refracted.

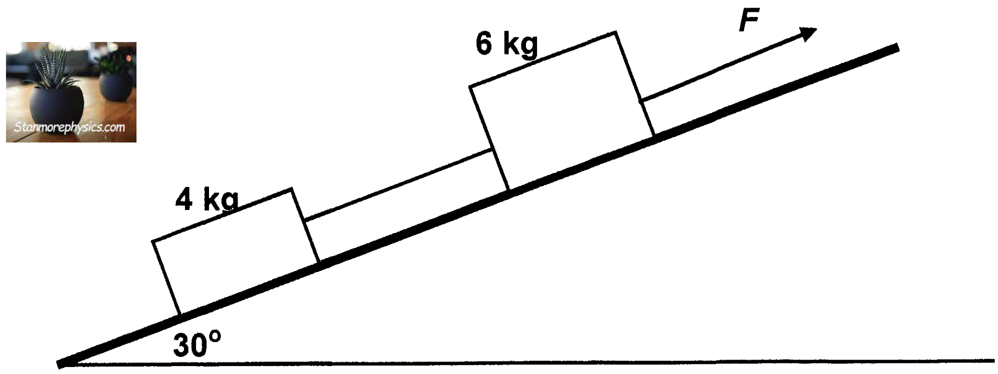
C Light ejects electrons from a metal surface.

D The speed of light increases when it travels in a vacuum. (2)

[20]

QUESTION 2

Two crates of masses 4 kg and 6 kg joined by a light inextensible string, are placed on a rough inclined plane. A force ***F*** pulls on the 6 kg crate such that the systems accelerates up the plane at 2,5 ms^{-2}. The frictional forces exerted by the surface is 1 N for 4 kg crate and 1,5 N for the 6 kg crate.



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

2.2 Draw a labelled free body diagram for the 6 kg crate. (5)

2.3 Calculate the magnitude of the force ***F***, exerted on the 6 kg crate. (5)

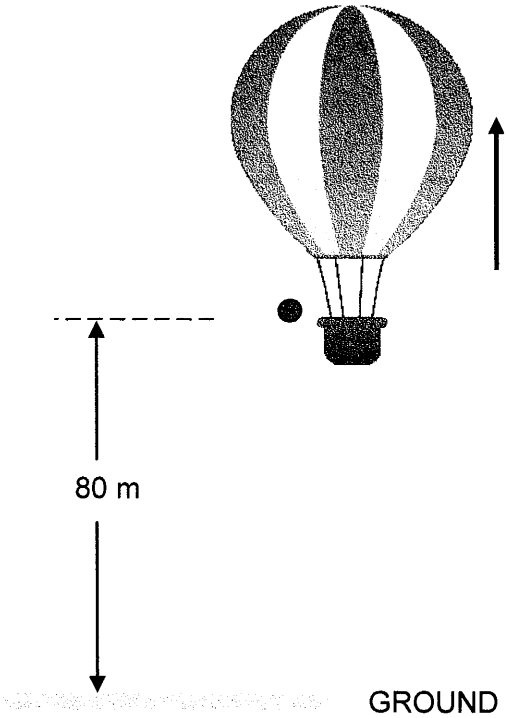
2.4 The string joining the crates now snaps, whilst the same force ***F*** acts on the 6 kg crate.
How will this change affect the following:

2.4.1 The acceleration of the 6 kg crate. (Choose from INCREASES, DECREASES or REMAIN THE SAME) (1)

2.4.2 The motion of the of the 4 kg block. (3)
[16]

QUESTION 3

A hot – air balloon is rising at a constant speed of 4,9 $m \cdot s^{-1}$. At a height of 80 m above the ground, a ball is released.
Ignore the effects of friction.



3.1 Write down the acceleration of the ball:

3.1.1 **Before** it was released (1)

3.1.2 **After** it is released (2)

3.2 Calculate the:

3.2.1 Position of the ball 0,5 s after it was released relative to the ground (4)

3.2.2 Time taken by the ball to reach the ground (4)

3.3 Sketch a velocity – time graph for the motion of the ball from the instant it is released until it reaches the ground.

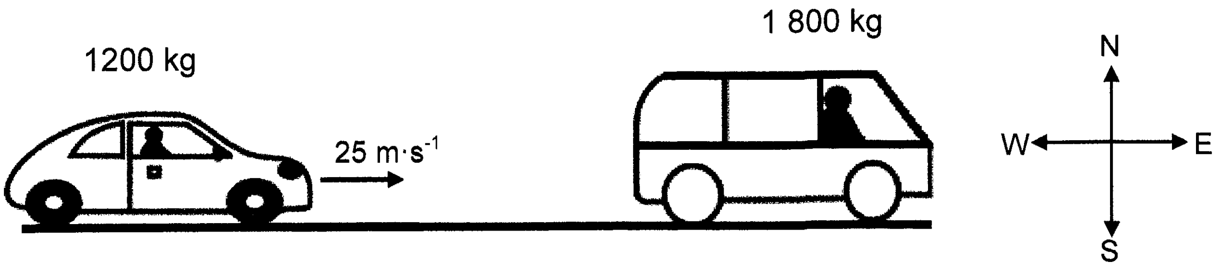
Indicate the following in your graph:

- Initial velocity of the ball
- The time for the entire motion of the ball (3)

[14]

QUESTION 4

A car of mass 1200 kg travelling east with a speed of 25 m·s^{-1}, collides with the van of mass 1800 kg. The van of mass 1800 kg is stationary on a frictionless track. The two vehicles move together as a unit after the collision.



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

4.2 Calculate the speed of the vehicles after the collision. (4)

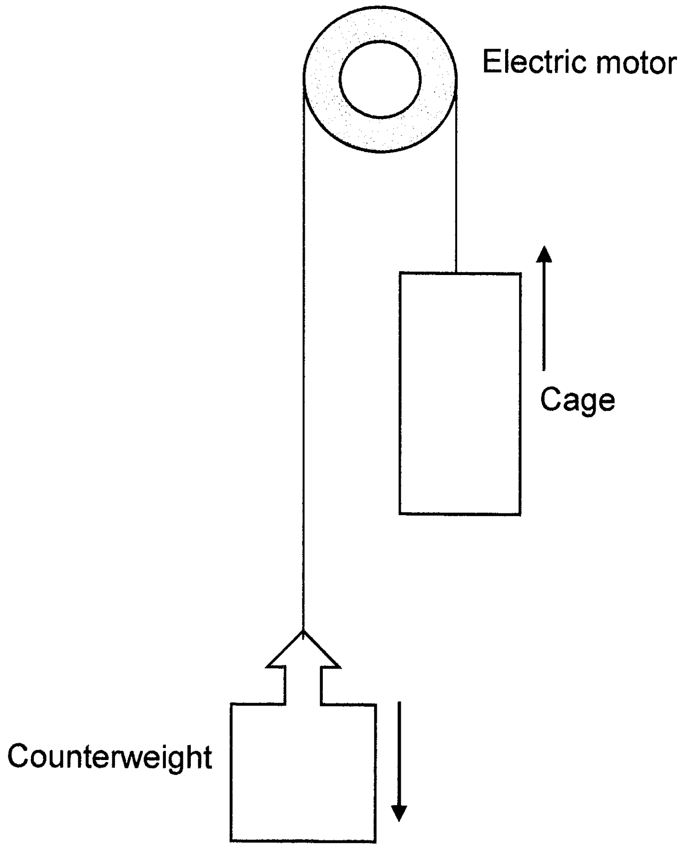
4.3 Determine by means of a relevant calculation whether the collision was ELASTIC or INELASTIC. (5)

After the collision the combination of the vehicles move into a real road and stop, covering a distance of 20 m.

4.4 Calculate the magnitude of the frictional force. (5)
[16]

QUESTION 5

A lift arrangement shown below, comprises an electric motor, a cage and its counterweight. The counterweight moves vertically downwards as the cage moves upwards. The cage and counterweight move at the same constant speed.



The cage, carrying passengers, moves vertically upwards at a constant speed, covering 60 m in 2 minutes. The counterweight has a mass of 900 kg. The total mass of the cage and passengers is 1 300 kg. The electric motor provides the power needed to operate the lift system. Ignore the effects of friction.

5.1 Calculate the work done by the:

5.1.1 Gravitational force on the cage (3)

5.1.2 Counterweight (2)

5.2 Calculate the average power required by the motor to operate the lift arrangement in 2 minutes as explained above. Assume that there are no energy losses due to heat and sound. (5)

[10]

QUESTION 6

A siren is attached to a sea shore that emits sound waves of frequency 755 Hz. A speed boat is travelling with a constant speed away from the shore.

6.1 State *Doppler Effect in words* . (2)

The speed boat travels 45 m in 3 s.

6.2 Calculate the frequency of the sound waves emitted by the siren as heard by a person on the boat.
Take the speed of sound in air as 340 $m \cdot s^{-1}$. (5)

6.3 Write down any two uses of the Doppler Effect. (2)

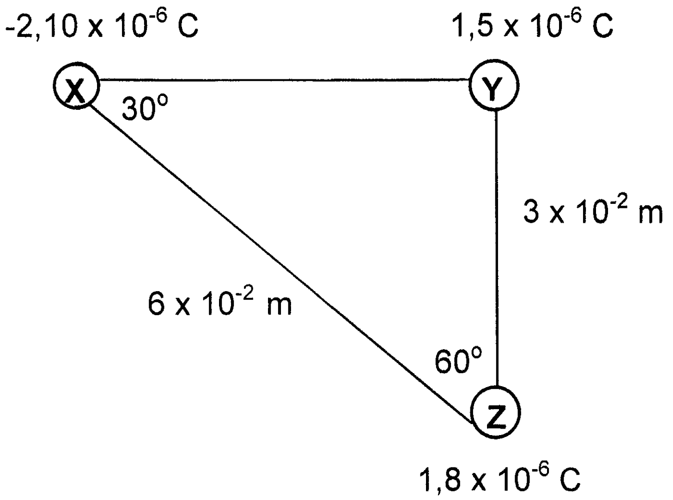
6.4 Spectral lines of star **X** at an observatory are observed to be *red shifted.*

6.4.1 Explain the term *red shifted* in terms of wavelength. (2)

6.4.2 Will the frequency of the light observed from the star INCREASE, DECREASE or REMAIN THE SAME? (1)
[12]

QUESTION 7

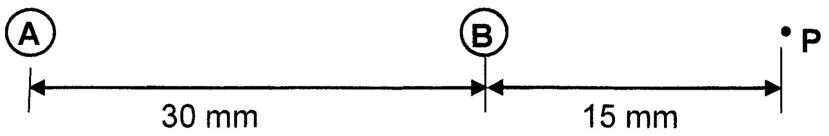
7.1 Three metal spheres **X**, **Y**, and **Z** carrying charges are placed on the vertices of a right angled triangle as shown below.



7.1.1 State *Coulomb's Law* in words (2)

7.1.2 Calculate the magnitude of the net electrostatic force on sphere **Z**. (8)

7.2 Two identical spheres, **A** and **B**, carrying charges +5 μC and -10 μC respectively, are separated by a distance of 30 mm.
P is a point located at a distance of 15 mm from sphere **B** as shown below.



The spheres **A** and **B** are allowed to touch each other and then return to their original positions.

7.2.1 Define *electric field at a point* in words (2)

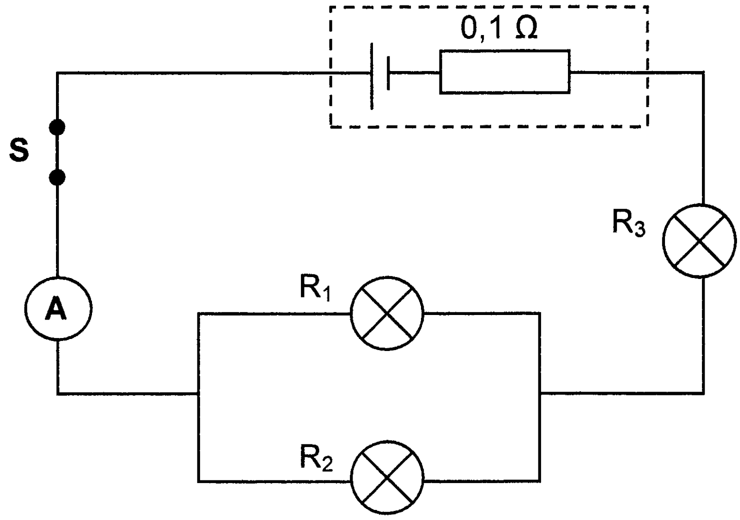
7.2.2 Draw an electric field pattern between spheres **A** and **B, after** touching. (3)

7.2.3 Calculate the magnitude of the net electric field at point **P** (6)

[21]

QUESTION 8

A battery with an internal resistance of 0,10 Ω is connected to the circuit as shown in the sketch below. The three light bulbs in the circuit, R_1, R_2 and R_3, are all identical, with a power rating of 40 W each.
Ignore the resistance of the wires and that of the ammeter.



8.1 Define *emf* in words (2)

Switch **S** is closed. Now bulb R_3 works at optimum condition and the ammeter reads 2 A.

8.2 Calculate the:

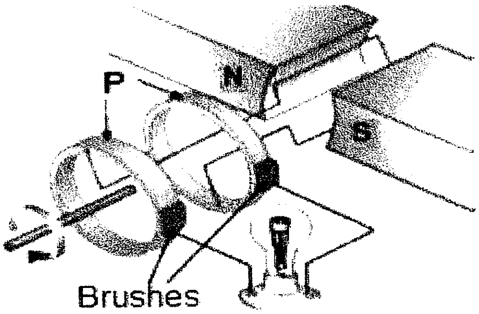
8.2.1 TOTAL EXTERNAL RESISTANCE of the circuit (5)

8.2.2 Emf of the battery (3)

8.2.3 The energy dissipated by the bulb labelled R_3 in 20 minutes (3)
[13]

QUESTION 9

9.1 The sketch below represents a simplified version of a generator used to light up a light bulb. The resistance of the light bulb is 807 Ω

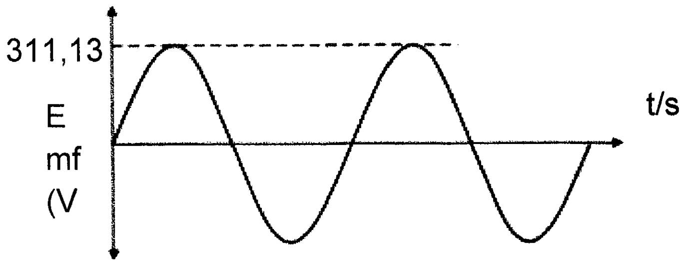


9.1.1 Name the type of generator in the sketch. Choose from AC or DC (1)

9.1.2 Name the part labelled **P** in the sketch. (1)

9.1.3 Write down the principle on which the generator operates. (1)

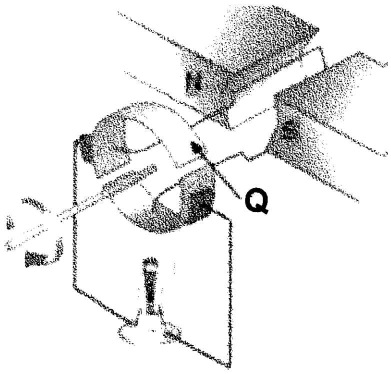
9.2 The graph of output emf versus time obtained when the above generator was in use is shown below.



9.2.1 Define the term *root mean square* of an AC voltage. (2)

9.2.2 Calculate the power dissipated through the light bulb connected to the generator above. (5)

9.3 Some changes were made to the above generator, a new machine, shown below, was obtained.

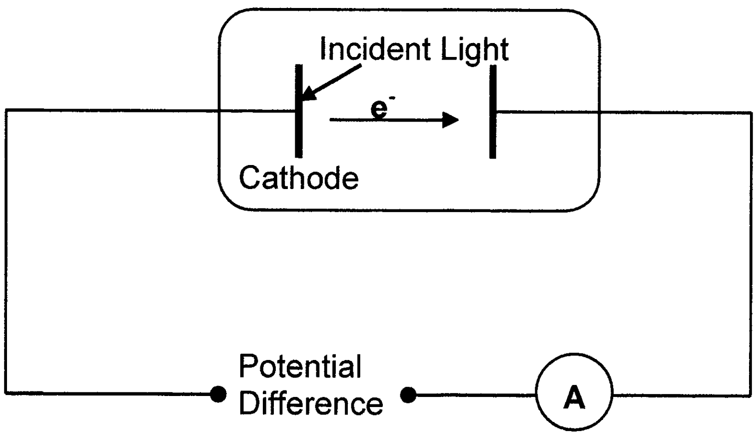


9.3.1 Draw a sketch graph of potential difference versus time obtained from this machine. (2)

9.3.2 Write down the function of the part labelled **Q** in the new machine. (2)
[14]

QUESTION 10

The simplified diagram below illustrates how a cathode emits electrons when light shines on it.



The incident light has an energy of $2{,}12 \times 10^{-18}$ J and the cathode has a threshold frequency of $2{,}21 \times 10^{15}$ Hz.

10.1 Define *threshold frequency.* (2)

The incident light releases $2{,}01 \times 10^{9}$ photo-electrons per second from the cathode.

10.2 Calculate the current flowing through the ammeter. (4)

10.3 The brightness of the incident light is now decreased.
What effect will this change have on the current in QUESTION 10.2?
Choose from INCREASES, DECREASES or REMAIN THE SAME
Give a reason for the answer. (2)

10.4 Calculate the maximum kinetic energy of the photo - electrons. (4)

The cathode is replaced by another one with a higher threshold frequency and the same light was used.

10.5 How does this change affect the kinetic energy of the photoelectrons released?
Choose from INCREASES, DECREASES or REMAIN THE SAME
Give a reason for your answer (2)
[14]

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	$6,67 \times 10^{-11}\ N\cdot m^2\cdot kg^{-2}$
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 electron*	e^-	$-1,6 \times 10^{-19}\ C$
Electron mass *Elektronmassa*	m_e	$9,11 \times 10^{-31}\ kg$
Mass of Earth *Massa van Aarde*	M	$5,98 \times 10^{24}\ kg$
Radius of Earth *Radius van Aarde*	R_E	$6,38 \times 10^6\ m$

TABLE 2: FORMULAE / TABEL 2: FORMULES

MOTION / BEWEGING

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

FORCE / KRAG

$F_{net} = ma$	$p = mv$
$f_{s(max)} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = \frac{Gm_1m_2}{r^2}$	$g = \frac{GM}{r^2}$

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 $W_{nc} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{av} = F \cdot v_{av}$ / $P_{gem} = F \cdot v_{gem}$	

WAVES, SOUND AND LIGHT / GOLWE, KLANK EN LIG

$v = f\lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$	$E = hf$ or/of $E = h\frac{c}{\lambda}$
$E = W_o + E_{k(max)}$ or/of $E = W_o + K_{(max)}$ where/waar 3 $E = hf$ and/en $W_o = hf_o$ 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

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

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GRADE 12

PHYSICAL SCIENCES P1 (PHYSICS)

PREPARATORY EXAMINATIONS

MARKING GUIDELINE

SEPTEMBER 2021

MARKS : 150

TIME: 3 hours

This marking guideline consists of 15 pages.

QUESTION 1: MULTIPLE CHOICE

1.1	A✓✓	(2)
1.2	D✓✓	(2)
1.3	C✓✓	(2)
1.4	D✓✓	(2)
1.5	D✓✓	(2)
1.6	B✓✓	(2)
1.7	B✓✓	(2)
1.8	A✓✓	(2)
1.9	A✓✓	(2)
1.10	C✓✓	(2)
		[20]

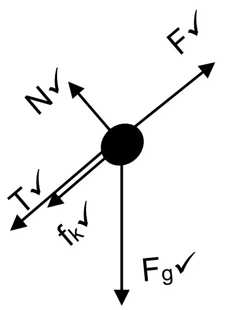
QUESTION 2

2.1 When a resultant/net force acts on an object, the object will accelerate in the direction of the force at an <u>acceleration directly proportional to the force</u> and <u>inversely proportional to the mass of the object</u>✓✓.

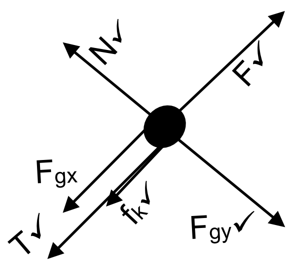
OR

The resultant/net force acting on an object is equal to the rate of change of momentum of the object (in the direction of the net force)✓✓(2 or 0). (2)

2.2



ACCEPT



	Accept the following symbols
F	F_A/F_{app}/$F_{Applied}$
N	F_N/Normal/Normal force
fk	Kinetic friction force/f/F_f/f_r
T	Tension force/F_T
F_g	W/58,8N

Notes
- Mark is awarded for label and arrow.
- Do not penalise for length of arrows.
- Deduct 1 mark for any additional force.
- If force(s) do not make contact with body/dot : *Max:4*/5
- If arrows missing but labels are there: *Max:4*/5

(5)

2.3 **For the 4 kg crate**

$F_{net} = ma$

$T - f - F_{g//} = ma$

$\underline{T - 1 - (9,8)(4)\sin 30^o}$ ✓$= 4(2,5)$

$T = 30,6$ N upwards

For the 6 kg crate

$F_{net} = ma$

$F - f - T - F_{g//} = ma$

$\underline{F - 1,5 - 30,6 - (9,8)(6)\sin 30^o}$ ✓$= 6(2,5)$

$F = 76,5$ N ✓

✓ Any of the two

✓

(5)

2.4.1 INCREASES✓ (1)

2.4.2 The 4 kg block will <u>move upwards/forward</u> (for a brief moment)✓, <u>stop</u>✓ and <u>then slide down</u> the plane / backward✓. (3)

[16]

QUESTION 3

3.1.1 Zero✓ (1)

3.1.2 9,8 $m \cdot s^{-2}$ ✓downwards ✓ (2)

3.2.1 **OPTION 1**

UPWARD POSITIVE	**UPWARD NEGATIVE**
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓
$\Delta y = \underline{(4,9)(0,5) + \frac{1}{2}(-9,8)(0,5)^2}$✓	$\Delta y = \underline{(-4,9)(0,5) + \frac{1}{2}(9,8)(0,5)^2}$✓
$\Delta y = 1,225$ m	$\Delta y = -1,225$ m
Height after 0,5 s = $\underline{80 +}$✓ 1,225	Height after 0,5 s = $\underline{80 +}$✓ 1,225
= 81,23 m✓	= 81,23 m✓
∴The ball is 81,23 m above the ground	∴The ball is 81,23m above the ground

OPTION 2

UPWARD POSITIVE	**UPWARD NEGATIVE**
$v_f = v_i + a\Delta t$ $v_f = 4,9 + (-9,8)(0,5)$ $v_f = 0\ m{\cdot}s^{-1}$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{0 = 4,9^2 + 2(-9,8)\Delta y}$ ✓ $\Delta y = 1,225\ m$ Height after 0,5 s = $\underline{80 +}$ ✓ 1,225 = 81,23 m ✓ ∴The ball is 81,23 m above the ground	$v_f = v_i + a\Delta t$ $v_f = -4,9 + (9,8)(0,5)$ $v_f = 0\ m{\cdot}s^{-1}$ $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $\underline{0 = -4,9^2 + 2(9,8)\Delta y}$ ✓ $\Delta y = -1,225\ m$ Height after 0,5 s = $\underline{80 +}$ ✓ 1,225 = 81,23 m ✓ ∴The ball is 81,23 m above the ground

OPTION 3

UPWARD POSITIVE	**UPWARD NEGATIVE**
$v_f = v_i + a\Delta t$ $v_f = 4,9 + (-9,8)(0,5)$ $v_f = 0\ m{\cdot}s^{-1}$ $\Delta y = \left(\frac{v_f + v_i}{2}\right)\Delta t$ ✓ $[\Delta y = \left(\frac{0 + 4,9}{2}\right) 0,5]$ ✓ $\Delta y = 1,225\ m$ Height after 0,5 s = $\underline{80 +}$ ✓ 1,225 = 81,23m ✓ ∴The ball is 81,23 m above the ground	$v_f = v_i + a\Delta t$ $v_f = 4,9 + (-9,8)(0,5)$ $v_f = 0\ m{\cdot}s^{-1}$ $\Delta y = \left(\frac{v_f + v_i}{2}\right)\Delta t$ ✓ $[\Delta y = \left(\frac{0 - 4,9}{2}\right) 0,5]$ ✓ $\Delta y = -1,225\ m$ Height after 0,5 s = $\underline{80 +}$ ✓ 1,225 = 81,23 m ✓ ∴The ball is 81,23 m above the ground

OPTION 4

$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f$ ✓

$\underline{\frac{1}{2}m(4,9)^2 + m(9,8)(80)}$ ✓ = $\underline{\frac{1}{2}m(0)^2 + m(9,8)h_f}$ ✓

$h_f = 81,225$ m ✓

OPTION 5

$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f$ ✓

$\underline{\frac{1}{2}m(4,9)^2 + m(9,8)(0) = \frac{1}{2}m(0)^2 + m(9,8)h_f}$ ✓

$h = 1,225$ m

Height after 0,5 s = $\underline{80 +}$✓ 1,225
= 81,23 m✓
∴The ball is 81,23 m above the ground

(4)

3.2.2 **OPTION 1**

UPWARDS POSITIVE	UPWARDS NEGATIVE
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ -80 ✓ $= \underline{(4,9)\Delta t + \frac{1}{2}(-9,8)\Delta t^2}$ ✓ $\Delta t = 4,57$ s ✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ 80 ✓ $= \underline{(-4,9)\Delta t + \frac{1}{2}(9,8)\Delta t^2}$ ✓ $\Delta t = 4,57$ s ✓

OPTION 2

UPWARDS POSITIVE	UPWARDS AS NEGATIVE
$v_f^2 = v_i^2 + 2a\Delta y$ $v_f^2 = \underline{(4,9)^2 + 2(-9,8)(-80)}$ ✓ $v_f = -39,9\ m{\cdot}s^{-1}$ $v_f = v_i + a\Delta t$ ✓ $\underline{-39,9 = 4,9 + (-9.8)\Delta t}$ ✓ $\Delta t = 4,57$ s ✓	$v_f^2 = v_i^2 + 2a\Delta y$ $v_f^2 = \underline{(-4,9)^2 + 2(9,8)(80)}$ ✓ $v_f = 39,9\ m{\cdot}s^{-1}$ $v_f = v_i + a\Delta t$ ✓ $\underline{39,9 = -4,9 + (9.8)\Delta t}$ ✓ $\Delta t = 4,57$ s ✓

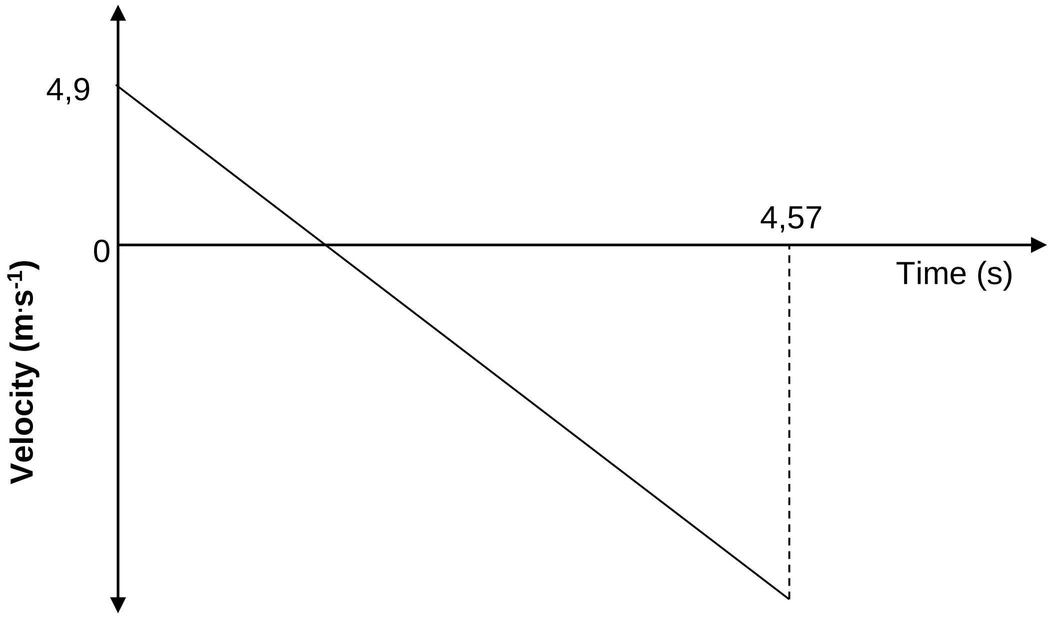
OPTION 3: POSITIVE MARKING FROM QUESTION 3.2.1

Considering ball from the maximum height

UPWARDS POSITIVE	UPWARDS AS NEGATIVE
$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $\underline{-81,23 = (0)\Delta t + \frac{1}{2}(-9,8)\Delta t^2}$ ✓ $\Delta t = 4,07$ s Time to reach ground = $\underline{0,5 +}$ ✓4,07 = 4,57 s ✓	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $\underline{81,23\ ✓ = (0)\Delta t + \frac{1}{2}(9,8)\Delta t^2}$ ✓ $\Delta t = 4,07$ s Time to reach ground = 0,5 + 4,07 = 4,57 s ✓

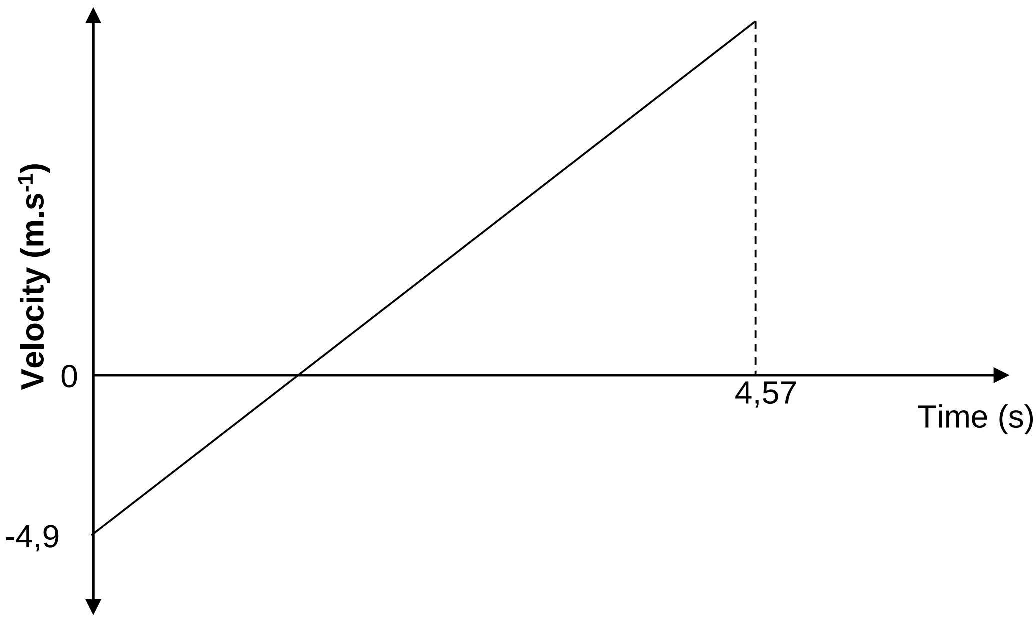
3.3 POSITIVE MARKING FROM Q3.2.2

UPWARD POSITIVE



OR

UPWARD NEGATIVE



CRITERIA FOR MARKING OF GRAPH	
Correct shape	✓
Indication of initial velocity	✓
Indication of the time for the entire motion	✓

(3)
[14]

QUESTION 4

4.1 The <u>total linear momentum</u> in an <u>isolated system</u> is <u>conserved</u>✓✓
(accept "closed" instead of "isolated")

OR

In an <u>isolated system</u>, the <u>total linear momentum before a</u> collision is <u>equal to</u> the <u>total linear momentum after the collision.</u>✓✓ (2)

4.2 p_{total} (before) = p_{total} (after)
$\Sigma p_i = \Sigma p_f$
$m_1v_{i1} + m_2v_{i2} = (m_1 + m_2)v$ ✓

<u>1200 (25) + 1800 (0)</u>✓ = <u>(1200 + 1800)v</u> ✓
v = 10 m·s^{-1}✓.
∴ Speed of the cars after is <u>10 m·s^{-1}</u> (4)

4.3

$\Sigma K_f = ½ (m_1 + m_2)v^2$✓	$\Sigma K_i = ½ m_1 v_{i1}^2 + ½ m_2 v_{i2}^2$
= <u>½ (1200 + 1800) 10 ^{2}</u>✓	= <u>½ (1200)(25)^2 + ½(1800)(0)^2</u>✓
= 150 000 J	= 375 000 J

$\Sigma K_f \neq \Sigma K_i$✓
∴Collision is Inelastic ✓ (5)
<u>NOTE</u>: If it is assumed that $\Sigma K_f = \Sigma K_i$ at the outset, *Max:2/*5

4.4 POSITIVE MARKING FROM QUESTION 4.2

OPTION 1	**OPTION 2**
$v_f^2 = v_i^2 + 2a\Delta y$✓	$\Delta y = \frac{v_f + v_i}{2}\Delta t$ ✓
$0^2 = \underline{(10)^2 + 2a(20)}$ ✓	$20 = \left(\frac{0+10}{2}\right)\Delta t$ ✓
a = - 2,5 m·s^{-2}	Δt = 4 s
$F_{net} = ma$✓	$v_f = v_i + a\Delta t$
$F_f = ma$	0 = 10 + a(4)
F_f = 3000(-2,5) ✓	a = - 2,5 m·s^{-2}
F_f = -7500 N	
∴ Magnitude of frictional force is 7500 N✓	

(5)

[16]

OPTION 3

$\Delta y = \dfrac{v_f + v_i}{2}\Delta t$ ✓

$20 = \left(\dfrac{0+10}{2}\right)\Delta t$ ✓ $\quad \therefore \Delta t = 4$ s

$F_{net} = f = \dfrac{\Delta p}{\Delta t}$

$f = \dfrac{m(v_f - v_i)}{\Delta t}$ ✓

$= \dfrac{3000(0-10)}{4}$

= -7500 N

∴ Magnitude of f is 7500 N✓

OPTION 4

$\left.\begin{array}{l} W_{net} = \Delta E_k \\ f\,\Delta x \cos\theta = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \end{array}\right\}$ ✓

$\underline{f\,(20)\cos 180^o}$ ✓ = $\underline{\frac{1}{2}(3000)(0)^2 - \frac{1}{2}(3000)(10)^2}$✓

f = 7500 N ✓

(4)

[16]

QUESTION 5

5.1.1 **OPTION 1**

$W = F\Delta x\cos\theta$✓

$W_{gravity} = mg\Delta y\cos\theta$

$\underline{= (1\,300)(9{,}8)(60)\cos180^o}$✓

= - 764 400 J✓ (-7,64 x10^5 J)

OPTION 2

$W = -\Delta E_p$✓

= $\underline{-(1300)(9{,}8)(60 - 0)}$ ✓

= - 764 400 J✓ (-7,64 x10^5 J)

-1 mark if either negative is omitted

(3)

5.1.2 $W_{counterweight} = mg\Delta y\cos\theta$

= $\underline{(900)(9{,}8)(60)\cos0^o}$ ✓

= 529 200 J (5,29 x 10^5 J) ✓ (2)

5.2

OPTION 1
POSITIVE MARKING FROM 5.1.1 AND 5.1.2

$W_{net} = \Delta E_K$

$\left.\begin{array}{l} W_{gravity} + W_{countweight} + W_{motor} = 0 \\ W_{motor} = -(W_{gravity} + W_{countweight}) \end{array}\right\}$ ✓

$\underline{-764\,400 + 529\,200}$ ✓ $+ W_{motor} = 0$

$\therefore W_{motor} = 235\,200$ J

OPTION 2

$F_{motor} = T_{right} - T_{left}$

$= 1300(9,8) - 900(9,8)$

$= 3920$ N

$W_{motor} = F_{motor}\,\Delta y \cos 0$ ✓

$= (3920)(60)\cos 0$ ✓

$= 235\,200$ J

$P_{ave\ motor} = \dfrac{W}{\Delta t}$ ✓

$P_{ave\ motor} = \dfrac{235200}{120}$ ✓

$= 1960$ W ✓ (5)

[10]

QUESTION 6

6.1 The <u>change in frequency</u> (or pitch) of the sound detected by a listener because the <u>sound source and the listener have different velocities</u> <u>relative to the medium of sound propagation</u>. ✓✓ (2)

6.2

$v = \dfrac{d}{\Delta t}$ $\quad v = \dfrac{45}{3}$ ✓ $\quad \therefore v_L = 15$ m·s^{-1}

$f_L = \dfrac{v \pm v_L}{v \pm v_S} f_S$ / $f_L = \dfrac{v - v_L}{v} f_S$

$f_L = \left(\dfrac{340 - 15}{340 + 0}\right) 755$ ✓ ✓

$f_L = 721,69$ Hz ✓ (5)

6.3 Any two ✓✓

- Ultrasound waves (to measure the heartbeat of a foetus in the womb).
- Doppler flowmeter (to measure the rate of blood flow)
- Traffic management systems, (especially speed control)
- Radar, (allowing for the tracking of weather systems)
- Astronomy, (where the application of the red-shift and blue-shift of light from the stars has revolutionised our understanding of the universe) (2)

6.4.1 The spectral lines (light) from the star are shifted towards longer wavelengths. ✓✓ (2)

6.4.2 Decrease ✓ (1)

[12]

QUESTION 7

7.1.1 The magnitude of the electrostatic force exerted by one point charge (Q_1) on another point charge (Q_2) is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them✓✓ (2)

NB DO NOT MARK QUESTION 7.1.2. MAX MARK FOR QUESTION 7 WILL BE 13. CONVERT THIS MARK TO 21 USING THE CONVERSION TABLE PROVIDED AT THE END OF THESE GUIDELINES

7.1.2 $F = k\dfrac{q_1 q_2}{r^2}$ ✓

$F_{YZ} = 9\times10^9 \left(\dfrac{1{,}5\times10^{-6}\times1{,}8\times10^{-6}}{(3\times10^{-2})^2}\right)$ ✓

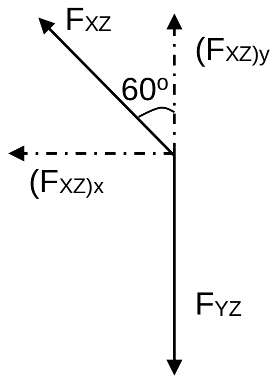
$F_{YZ} = 27$ N downwards.

$F_{XZ} = 9\times10^9 \left(\dfrac{2{,}1\times10^{-6}\times1{,}8\times10^{-6}}{(6\times10^{-2})^2}\right)$ ✓

$F_{AC} = 9{,}45$ N at 60° to the vertical

But F_{XZ} has two perpendicular components i.e. F_{XZx} and F_{XZy}

Vector diagram



$F_{YZx} = F_{YZ}\text{Sin}60°$

$F_{YZx} = 9{,}45\text{Sin}60°$✓

$F_{ACx} = 8{,}184$ N to the left

$F_{YZy} = F_{YZ}\text{Cos}60°$

$F_{YZy} = 9{,}45\text{Cos}60°$✓

$F_{ACy} = 4{,}725$ N upwards

$F_{net\ x} = 8{,}814$ N to the left

$F_{net\ y} = \underline{27 - 4{,}725}$✓ $= 22{,}275$ N downwards

$(F_{net})^2 = (F_{net\ x})^2 + (F_{net\ y})^2$

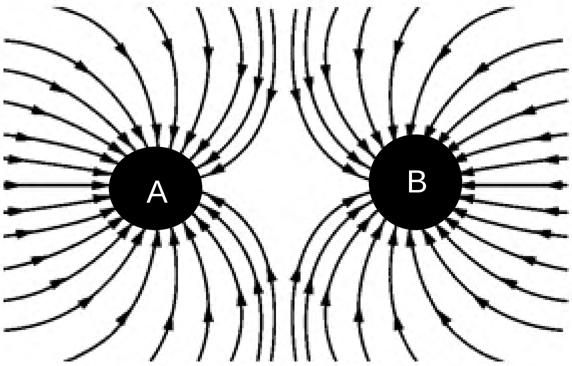
$(F_{net})^2 = (8{,}814)^2 + (22{,}275)^2$✓

$F_{net} = \sqrt{(8{,}814^2 + 22{,}275^2)}$

$F_{net} = 23{,}73$ N✓ (8)

7.2.1 The electric field at a point is the (electrostatic) force experienced per unit positive charge placed at that point. ✓✓ (2)

7.2.2



CRITERIA FOR MARKING THE ABOVE ELECTRIC FIELD PATTERN	
Correct direction of field lines	✓
Shape of the electric field lines (At least 4 lines on each sphere)	✓
No field lines crossing each other/No field lines inside the spheres	✓

(3)

7.2.3

$$Q = \frac{Q_1 + Q_2}{2}$$

$$Q = \frac{5 \times 10^{-6} + (-10 \times 10^{-6})}{2} \checkmark$$

$= -2,5 \times 10^{-6}$ C ($-2,5$ μC)

$$E = k\frac{Q}{r^2} \checkmark$$

$$E_{AP} = 9 \times 10^9 \left(\frac{2,5 \times 10^{-6}}{0,045^2}\right) \checkmark$$

$E_{QP} = 1,11 \times 10^7 \text{ N·C}^{-1}$ to the left

$$E_{BP} = 9 \times 10^9 \left(\frac{2,5 \times 10^{-6}}{0,015^2}\right) \checkmark$$

$E_{BP} = 1,00 \times 10^8 \text{ N·C}^{-1}$ to the left

$E_{net} = E_{AP} + E_{BP}$

$E_{net} = 1,11 \times 10^7 + \checkmark 1,00 \times 10^8$

$E_{net} = 1,11 \times 10^8 \text{ N·C}^{-1} \checkmark$ (6)

[21]

QUESTION 8

8.1 (Maximum) energy provided (work done) by a battery per coulomb/unit charge passing through it ✓✓ (2)

8.2.1

<table>
<tr><td colspan="2">OPTION 1</td><td colspan="2">OPTION 2</td></tr>
<tr><td colspan="2">P = I^2R✓
40 = 2^2R_3✓

R_3 = 10 Ω</td><td colspan="2">$P_s = V_3I$✓
40 = $V_3(2)$
V_3= 20 V
∴ $R_3 = \frac{V_3}{I} = \frac{20}{2}$✓ = 10 Ω</td></tr>
<tr><td>$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$
$\frac{1}{R_P} = (\frac{1}{10} + \frac{1}{10})$✓
R_P = 5 Ω

$R_{EXT} = R_P + R_s$
R_{EXT} = 5 + 10✓
R_{EXT} = 15 Ω✓</td><td colspan="2">$R_P = (\frac{1}{R_1} + \frac{1}{R_2})^{-1}$
$R_P = (\frac{1}{10} + \frac{1}{10})^{-1}$✓
R_P = 5 Ω

$R_{EXT} = R_P + R_s$
R_{EXT} = 5 + 10✓
R_{EXT} = 15 Ω✓</td><td>$R_P = \frac{R_1R_2}{R_1+R_2}$
$R_P = \frac{(10)(10)}{10+10}$✓
R_P = 5 Ω

$R_{EXT} = R_P + R_s$
R_{EXT} = 5 + 10✓
R_{EXT} = 15 Ω✓</td></tr>
</table>

(5)

8.2.2 POSITIVE MARKING FROM QUESTION 8.2.1

Ɛ = I(R + r) ✓

Ɛ = 2(15 + 0,1) ✓

Ɛ = 30,2 V ✓

(3)

8.2.3

OPTION 1	**OPTION 2 (Positive marking from Q8.2.1)**
W = P x t✓ W = 40 x 20 x 60✓ W = 48000 J✓	W = I^2Rt✓ W = $(2)^2(10)(20 \times 60)$✓ W = 48000 J✓

(3)

[13]

QUESTION 9

9.1.1 AC (generator) ✓ (1)

9.1.2 Slip rings✓ (1)

9.1.3 (Faraday's Law of) Electromagnetic induction✓ (1)

9.2.1 The rms value of AC is the DC potential difference which dissipates the same amount of energy as AC. ✓✓ (2 OR 0) (2)

9.2.2 **OPTION 1**

$V_{RMS} = \frac{V_{Max}}{\sqrt{2}}$ ✓

$V_{RMS} = \frac{311{,}13}{\sqrt{2}}$ ✓

$V_{RMS} = 220{,}00$ V

$P_{ave} = \frac{V_{RMS}^2}{R}$ ✓

$P_{ave} = \frac{220^2}{807}$ ✓

$P_{ave} = 59{,}98$ W✓

OPTION 2

$I_{max} = \frac{V_{Max}}{R}$ ✓

$= \frac{311{,}13}{807}$ ✓

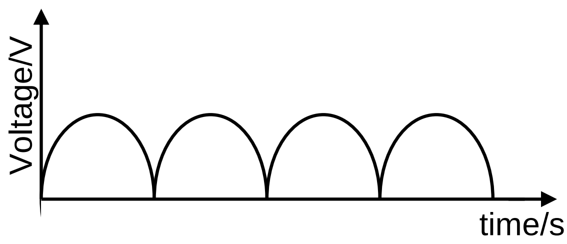
$= 0{,}3855$ A

$P_{ave} = \frac{I_{max} V_{max}}{2}$ ✓

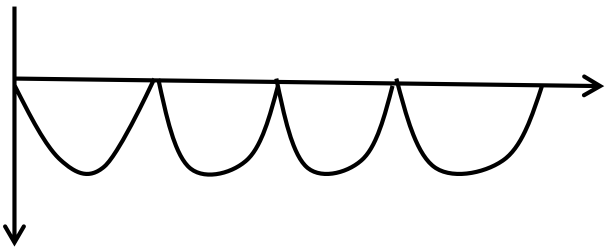
$P_{ave} = \frac{311{,}13 \times 0{,}3855}{2}$ ✓

$P_{ave} = 59{,}97$ W✓ (5)

9.3.1



OR



CRITERIA FOR MARKING THE ABOVE GRAPH	
Correct shape	✓
At least one complete cycle	✓

(2)

9.3.2 (Commutator) allows the induced current to flow in the same direction / in one direction in the external circuit✓✓ (2)

[14]

QUESTION 10

10.1 Threshold frequency, f_o, is the minimum frequency of light needed to emit electrons from a certain metal surface. ✓✓ (2 or 0) (2)

10.2 $Q = nq_e$

$Q = 2,01 \times 10^{9} \times 1,6 \times 10^{-19}$ ✓

$Q = 3,22 \times 10^{-10}$ C

$I = \frac{Q}{\Delta t}$ ✓

$I = \frac{3,22 \times 10^{-10}}{1}$ ✓

$I = 3,22 \times 10^{-10}$ A ✓ (4)

10.3 Decreases ✓

When the intensity of the light is decreased, the <u>number of photons per second will decrease</u> ✓ (2)

10.4 $E = W_o + K_{max}$
$E = hf_o + K_{max}$ ✓

$2,12 \times 10^{-18}$ ✓ $= (6,63 \times 10^{-34})(2,21 \times 10^{15})$ ✓ $+ K_{max}$

$K_{max} = 6,55 \times 10^{-19}$ J ✓ (4)

10.5 Decreases ✓

More energy is used to release the electrons. ✓

OR

Work function is greater. ✓ (2)

[14]

TOTAL: 150

CONVERSION OF MARKS FOR QUESTION 7

MARK OBTAINED OUT OF 13	CONVERTED MARK OUT OF 21
0	0
1	2
2	3
3	5
4	6
5	8
6	10
7	11
8	13
9	15
10	16
11	18
12	19
13	21