LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF EDUCATION

NATIONAL SENIOR CERTIFICATE
EXAMINATION

GRADE 12

PHYSICAL SCIENCES: PHYSICS (P1)

SEPTEMBER 2022

MARKS: 150

TIME: 3 hours

This question paper consists of 17 pages and 3 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: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A–D) next to the question numbers (1.1-1.10) in the ANSWER BOOK, e.g. 1.11 E.

1.1 A body is moving at CONSTANT velocity. The net force acting on it is…

A constant.

B zero.

C increasing.

D decreasing.

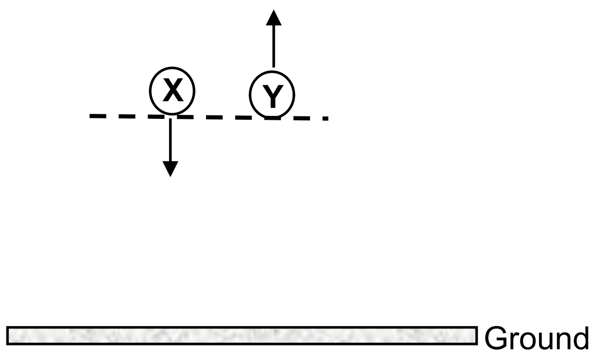
(2)

1.2 An astronaut has mass **m** and weight **w** on Earth. Planet **X** has TWICE the mass and TWICE the radius of Earth. Which ONE of the following combinations best describes the mass and weight of the astronaut on planet **X**?

	MASS	WEIGHT
A	**m**	$\frac{w}{2}$
B	**m**	w
C	2**m**	2w
D	$\frac{\mathbf{m}}{2}$	$\frac{w}{2}$

(2)

1.3 Two IDENTICAL balls, **X** and **Y**, are thrown from a certain height, EACH with the SAME speed. Ball **X** is thrown vertically downwards and ball **Y** vertically upwards, as shown in the diagram below.



How do the speeds and the kinetic energies of the balls compare when they strike the ground?

	SPEEDS	KINETIC ENERGIES
A	$v_X < v_Y$	$E_{k(X)} > E_{k(Y)}$
B	$v_X > v_Y$	$E_{k(X)} > E_{k(Y)}$
C	$v_X = v_Y$	$E_{k(X)} = E_{k(Y)}$
D	$v_X < v_Y$	$E_{k(X)} < E_{k(Y)}$

(2)

1.4 Two masses of 1 kg and 4 kg are moving with EQUAL kinetic energies. The ratio of the magnitudes of their momenta is …

A 1 : 2.

B 4 : 1.

C $\sqrt{2}$: 1.

D 1 : 16.

(2)

1.5 When the NET work done on a moving object is ZERO, the kinetic energy of the object is …

A zero.

B constant.

C increasing.

D decreasing.

(2)

1.6 Spectral lines from the distance star (from a galaxy) moving **away** from Earth are shifted towards:

I lower frequencies.

II high frequencies.

III shorter wavelength.

IV longer wavelength.

Which of the statements above are CORRECT?

A I and II only

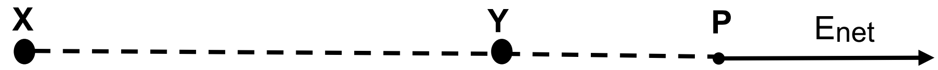
B II and III only

C II and IV only

D I and IV only

(2)

1.7 Two point charges, **X** and **Y**, produce a net electric field (E_{net}) at point **P** which is directed to the RIGHT, as shown in the diagram below.

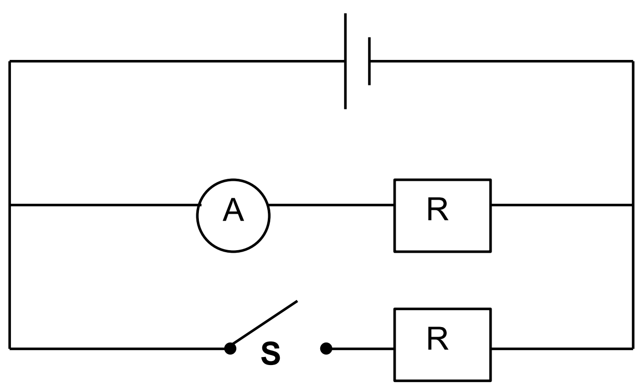


Which ONE of the following combination of charges **X** and **Y** CANNOT have?

	X	**Y**
A	+	+
B	–	+
C	+	–
D	–	–

(2)

1.8 Two IDENTICAL resistors are connected in parallel as shown in the circuit diagram below. The internal resistance of the cell and resistance of the connecting wires can be ignored.



When switch **S** is open, the reading of the ammeter is I.
When the switch **S** is closed, the reading of ammeter will be …

A I.

B 2I.

C $\frac{I}{2}$.

D 0.

(2)

1.9 The following information is given on a house hold electric appliance: 230 V, 500 W.
The value of **230 V** refers to the …

A peak value of the voltage.

B average value of the voltage.

C rms value of the voltage.

D maximum energy dissipated. (2)

1.10 The number of photoelectrons per unit time ejected from a metal surface depends on the …

A intensity of the incident light.

B frequency of the incident light.

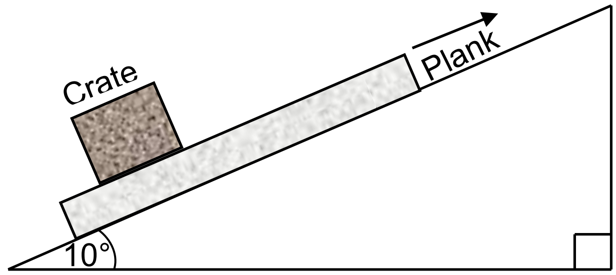
C wavelength of the incident light.

D threshold frequency of the metal. (2)

[20]

QUESTION 2 (Start on a new page)

2.1 A crate is placed on a wooden plank and is pushed upwards over a surface inclined at an angle of 10°, as shown in the diagram below.



The coefficient of static friction between the plank and the crate is 0,35.

2.1.1 Define the term *static frictional force* in words. (2)

2.1.2 Draw a labelled free-body diagram for the crate as the plank accelerates up the incline. (3)

2.1.3 Calculate the magnitude of the maximum acceleration that the plank can attain before the crate begins to slip backward. (5)

2.2 The radius of Earth is **5 times** and the mass is **153 times** that of planet **X**.

2.2.1 State *Newton's law of universal gravitational* in words. (2)

2.2.2 Calculate the acceleration due to gravity on the surface of planet **X.** (3)

2.2.3 How does the gravitational constant **G** on planet **X** compare with that on the surface of EARTH? Write down only GREATER THAN, LESS THAN, or EQUAL TO. (1)

[16]

QUESTION 3 (Start on a new page)

A stone **X** is projected vertically upwards from the ground with a speed of **3v**. Stone **Y** is also projected vertically upwards with a speed **v**.

Ignore the effects of air resistance.

3.1 Define the term *free fall*. (2)

Stone **X** takes 10 seconds to return to the ground.

3.2 Calculate the time that stone **Y** takes to return to the ground. (4)

Stone **Y** reaches a maximum height of **H** meters.

3.3 Use an appropriate calculation to show that the height (in terms of **H**) that stone **X** reaches is **9H**. (5)

3.4 Sketch a velocity-time graph for the entire motion of stone **X**.

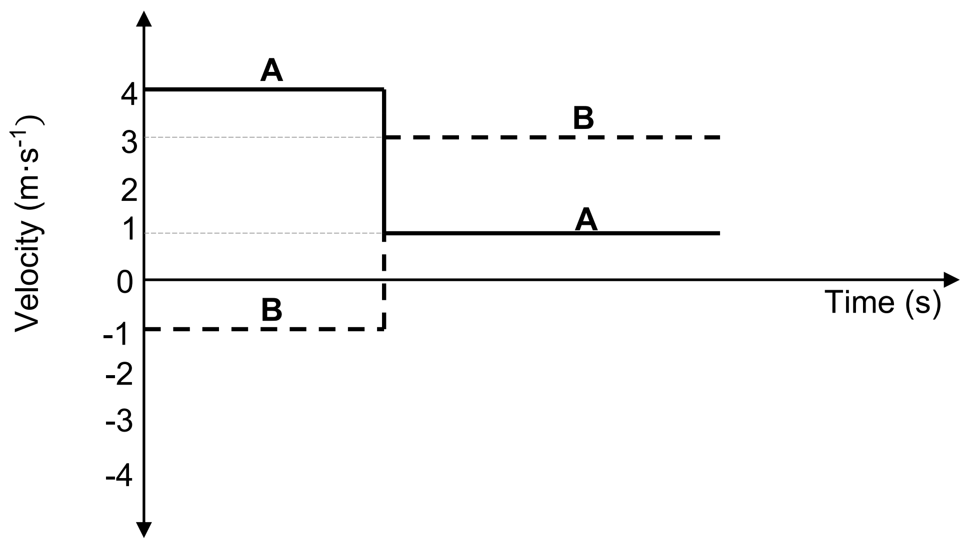
Clearly show the VALUES of the following on the graph:

- Initial and final velocities
- Time when it reaches the maximum height

(3)
[14]

QUESTION 4 (Start on a new page)

Two objects, **A** and **B,** collided in a straight line on a frictionless surface.
In the velocity-time sketch graph below the solid line represents the motion of object **A** and the thick dotted line represents the motion of object **B**.



4.1 Define the term *momentum* in words. (2)

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

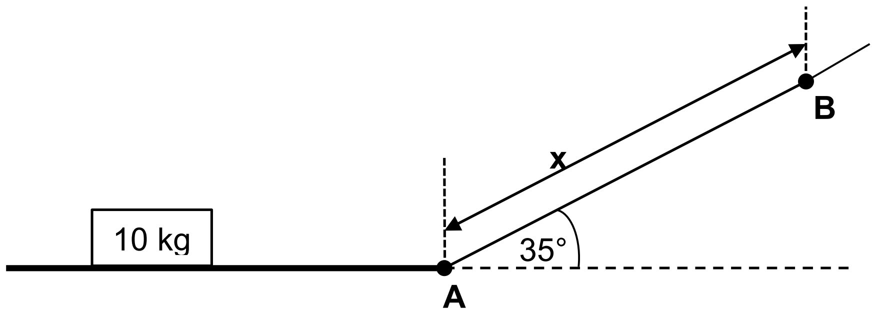
4.3 Show, by means of a suitable calculation, that the **ratio** of the masses of the two objects ($m_A : m_B$) is **4 : 3**. (4)

4.4 Draw vector diagrams (not to scale) to illustrate the relationship between the initial momentum ($\mathbf{p_i}$), final momentum ($\mathbf{p_f}$) and the change in momentum ($\Delta\mathbf{p}$) for object **A**. (3)

[11]

QUESTION 5 (Start on a new page)

A 10 kg block is sliding along a ROUGH surface. The portion of the surface **AB** is inclined at an angle of 35° to the horizontal, as shown in the diagram below.



The block passes point **A** at a speed of 8,84 $m \cdot s^{-1}$. It slides up the incline and comes to REST at point **B** after covering on distance **x**. The frictional force exerted on the block from **A** to **B** is 45 N.

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

5.2 Use the work energy theorem ONLY to calculate the distance **x**, shown in the diagram. (4)

At point **B**, the block ONLY just manages to **remain at rest.**

5.3 Draw a labelled free-body diagram for the block when it is at point **B.** (3)

5.4 Calculate the magnitude of the frictional force acting on the block at point **B.** (3)
[12]

QUESTION 6 (Start on a new page)

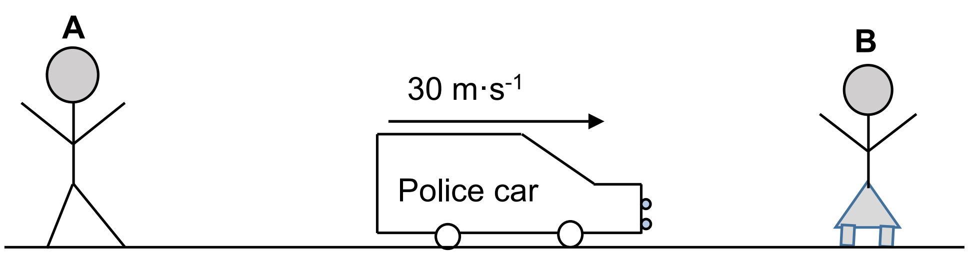
A siren of a STATIONARY police car emits sound with frequency 300 Hz. The speed of sound in air is 340 m·s^{-1}.

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

6.2 Calculate the wavelength of the sound waves. (3)

6.3 Write down the ONE application of the Doppler effect in the medical field. (1)

The police car moves at 30 m·s^{-1} between two stationary observers, **A** and **B**, with its siren on, as shown in the diagram below.



6.4 Calculate the wavelength of the sound as perceived (heard) by:

6.4.1 Observer **B** (4)

6.4.2 Observer **A** (3)

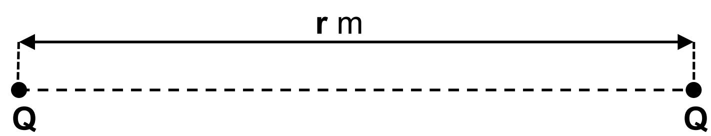
The police car stops with its siren on and observer **B** moves away from it.

6.5 Is the frequency of the sound that observer **B** hears GREATER THAN, LESS THAN, or EQUAL TO the frequency of the source? (1)

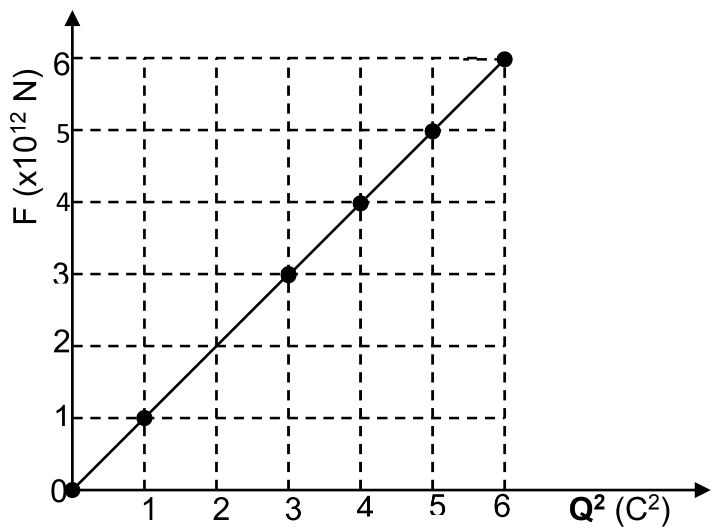
[14]

QUESTION 7 (Start on a new page)

7.1 An investigation is conducted with pairs of IDENTICAL point charges, all placed a distance **r** meters from each other, as shown in the diagram below.



The graph below shows the relationship between the electrostatic FORCE **F**, exerted by one point charge on the other, and the PRODUCT of the two charges, $\mathbf{Q^2}$.



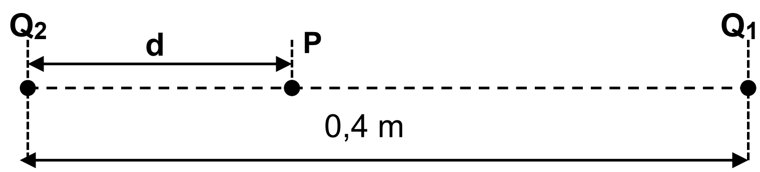
7.1.1 For this investigation, write down the controlled variable. (1)

7.1.2 Write down the relationship between the electrostatic force **F** and the product of the two point charges, $\mathbf{Q^2}$. (1)

7.1.3 **Using the graph**, calculate the value of the gradient of the graph. (3)

7.1.4 Using the mathematical expression of Coulomb's law and the answer to QUESTION 7.1.3, calculate the distance **r** between the charges. (4)

7.2 Two point charges, $\mathbf{Q_1}$ = +8 μC and $\mathbf{Q_2}$ = +2 μC, are separated by a distance of 0,4 m, as shown in the diagram below.



7.2.1 Describe the term *electric field* in words. (2)

The net electric field at **P,** a point between the two charges**,** is ZERO.

7.2.2 Calculate the distance **d** between point **P** and point charge $\mathbf{Q_2}$, as shown in the diagram above. (4)

The two point charges are allowed to touch, and returned to their original positions.

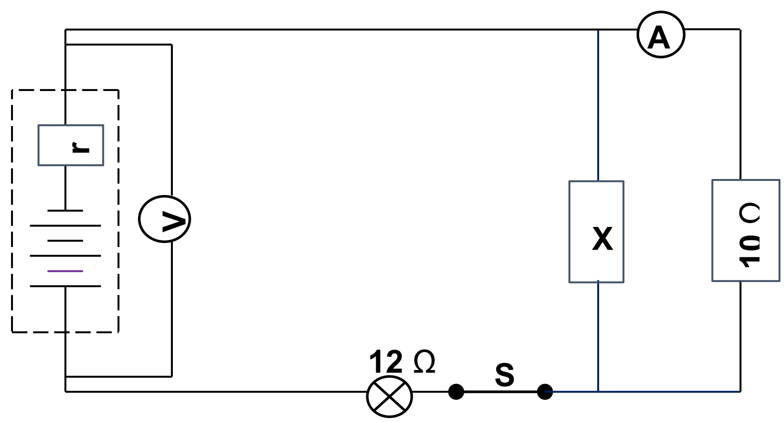
7.2.3 Calculate the number of electrons transferred from one charge to the other when they come into contact. (4)

[19]

QUESTION 8 (Start on a new page)

In the circuit diagram below; an unknown resistor X is connected to a 10 Ω resistor, and a 12 Ω light bulb. This combination is connected to a battery with an internal resistance of 2 Ω.

The resistance of the connecting wires and the ammeter may be ignored.



When switch **S** is closed, the reading on voltmeter, decreases from 24 V to 21,6 V.

8.1 Write down the term used to describe "**24 V**" (the voltmeter reading). (1)

8.2 Calculate the:

8.2.1 Reading on the ammeter. (5)

8.2.2 Resistance of resistor **X** (4)

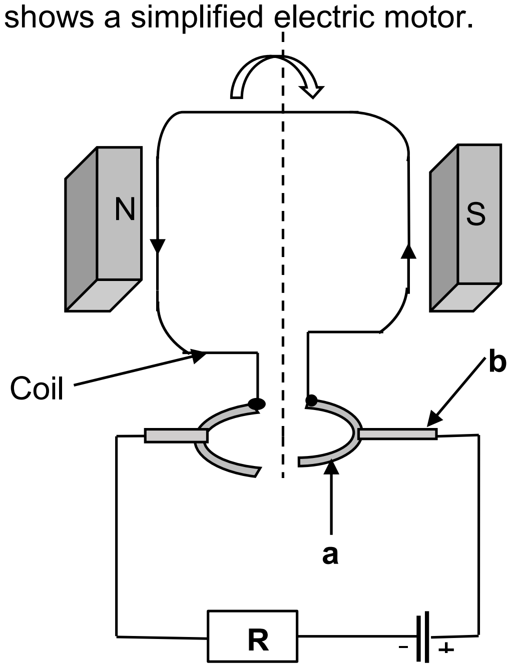
8.3 How would the brightness of the bulb change if resistor **X** burns out? Write down only INCREASE, DECREASE or REMAIN THE SAME. Explain the answer with reference to a relevant *power formula*. (4)

8.4 The cost of electricity is R1,30 per kWh. The bulb is used for 40 minutes per day. Assuming that there are 365 days per year, calculate the cost of running the bulb for 1 year. (4)

[18]

QUESTION 9 (Start on a new page)

9.1 A diagram below shows a simplified electric motor.



9.1.1 Write down the energy conversion which takes place in an electric motor. (1)

9.1.2 Is this an AC or DC electric motor? Give a reason for the answer. (2)

9.1.3 Name the component **b**. (1)

9.1.4 Write down the function of component **a.** (1)

9.1.5 The resistance **R** is now decreased. What is the effect of this change on the speed of the motor? Choose from INCREASES, DECREASES or STAYS THE SAME. Give a reason for the answer. (2)

9.2 A municipality experiences a temporary power shortage. During this period the root mean square (rms) voltage reduced from 220 V to 200 V.

9.2.1 Define the term *rms voltage*. (2)

9.2.2 Calculate the maximum (peak) voltage during the power shortage. (3)
[12]

QUESTION 10 (Start on a new page)

10.1 Photoelectric effect confirms the particle nature of light.

10.1.1 Describe the term *photoelectric effect* in words. (2)

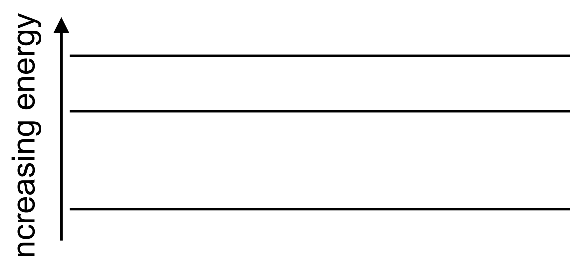
The work function of a metal surface is 5,6 x 10^{-19} J. Light of wavelength 450 nm is incident on the metal surface.

10.1.2 Define the term *work function* of a metal in words. (2)

10.1.3 Besides work function, write down TWO other factors which affect the photoelectric effect. (2)

10.1.4 Determine, by means of an appropriate calculation, whether electrons will be emitted by the photoelectric effect, from the surface. (5)

10.2 Three electron energy levels in an atom are represented in the diagram below.



The wavelength of the spectral lines produced by electron transitions between these three energy levels during emission are 486 nm, 656 nm and 1 880 nm.

Copy the diagram above and, draw arrows to show the electron transitions between the energy levels that would give rise to these wavelengths. Label each arrow with the wavelength of the emitted photon. (3)

[14]

GRAND TOTAL: [150]

DATA FOR PHYSICAL SCIENCES GRADE 12

PAPER 1 (PHYSICS)

TABLE 1: PHYSICAL CONSTANTS*:*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Acceleration due to gravity	g	$9,8\ m\cdot s^{-2}$
Gravitational constant	G	$6,67 \times 10^{-11}\ N\cdot m^2\cdot kg^{-2}$
Radius of Earth	R_E	$6,38 \times 10^6\ m$
Mass of the Earth	M_E	$5,98 \times 10_{24}\ kg$
Coulomb's constant	k	$9,0 \times 10^9\ N\cdot m^2\cdot C^{-2}$
Plank's contant	h	$6,63 \times 10_{-34}\ J\cdot s$
Speed of light in a vacuum	c	$3,0 \times 10^8\ m\cdot s^{-1}$
Charge on electron	e	$-1,6 \times 10^{-19}\ C$
Electron mass	m_e	$9,11 \times 10^{-31}\ kg$

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/*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

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

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

WAVES, SOUND AND LIGHT

$v = f\lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ or $F_L = \frac{V \pm V_L}{V \pm V_b} f_b$	$E = hf$ or/*of* $E = \frac{hf}{\lambda}$
$E = W_o + K_{max}$ or $E = W_o + E_{k(max)}$ where $E = hf$ and $W_0 = hf_0$ and $K_{max} = \frac{1}{2}mv^2_{max}$ / $E_{k(max)} = \frac{1}{2}mv^2_{max}$	
$E = W_o + K_{max}$ *of* $E = W_o + E_{k(max)}$ where $E = hf$ and $W_0 = hf_0$ *en* $K_{max} = \frac{1}{2}mv^2_{max}$ / $E_{k(max)} = \frac{1}{2}mv^2_{max}$	

ELECTROSTATICS

$F = \frac{K Q_1 Q_2}{r^2}$	$E = \frac{KQ}{r^2}$
$V = \frac{W}{q}$	$E = \frac{F}{q}$
$n = \frac{Q}{e}$ or $n = \frac{Q}{q_e}$	

ELECTRIC CIRCUITS

$R = \frac{V}{I}$	Emf (ε) = I(R + r)
$R_s = R_1 + R_2 + \ldots$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$	$q = I\Delta t$

$W = Vq$ $W = VI\Delta t$ $W = I^2R\Delta t$ $W = \frac{V^2 \Delta t}{R}$	$P = \frac{W}{\Delta t}$ $P = Vi$ $P = I^2R$ $P = \frac{V^2}{R}$

ALTERNATING CURRENT

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

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NATIONAL SENIOR CERTIFICATE

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PHYSICAL SCIENCES: PHYSICS (P1)

SEPTEMBER 2022

MARKING GUIDELINES

MARKS: 150

This marking guidelines consist of 15 pages.

QUESTION 1

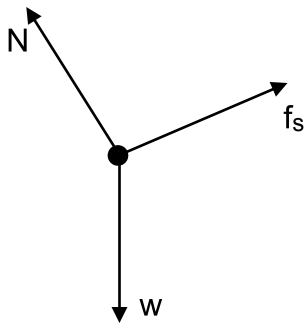
1.1	B ✓✓	(2)
1.2	A ✓✓	(2)
1.3	C ✓✓	(2)
1.4	A ✓✓	(2)
1.5	B ✓✓	(2)
1.6	D ✓✓	(2)
1.7	D ✓✓	(2)
1.8	A ✓✓	(2)
1.9	C ✓✓	(2)
1.10	A ✓✓	(2)

[20]

QUESTION 2

2.1.1 The force that opposes the tendency of motion of a stationary object relative to a surface. ✓✓ (2)

2.1.2



	Accept the following symbols:
N✓	F_N/Normal force/$F_{\text{surface on crate}}$
f_s✓	f/F_f/frictional force/static frictional force
w✓	F_g/mg/weight/gravitational force/$F_{\text{Earth on crate}}$

Take uphill as POSITIVE

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)

2.1.3

$$\left.\begin{array}{l} F_{net} = ma \\ \therefore f_s^{max} + (-mg\sin\theta) = ma^{max} \\ \mu_s F_N - mg\sin\theta = ma^{max} \\ \mu_s\, mg\cos\theta - mg\sin\theta = ma^{max} \end{array}\right\} \text{Any one ✓}$$

$\therefore f_s^{max} - m(9{,}8)(\sin 10°) = ma^{max}$ .....①

But $f_s^{max} = \mu_s N$

$\therefore f_s^{max} = \mu_s(mg\cos\theta)$....②

Subst. ② into ① :

$\therefore \mu_s(mg\cos\theta) - m(9{,}8)(\sin 10°) = m(a^{max})$

$\therefore (0{,}35)\,m(9{,}8)(\cos 10°)$✓$-m(9{,}8)(\sin 10°) = m(a^{max})$

$(\div m)$: $\therefore (0{,}35)(9{,}8)(\cos 10°)$ ✓$- (9{,}8)(\sin 10°)$ ✓$= a^{max}$

$\therefore$the maximum acceleration is 1,676 $m \cdot s^{-2}$ ✓

(5)

2.2.1

Marking criteria -1 mark for each key word/phrase omitted in the correct context.

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 centers. ✓✓

OR:

Every 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. ✓✓ (2)

2.2.2

$$g_E = \frac{GM_E}{R_E^2} = 9{,}8\ \text{m}\cdot\text{s}^{-2}$$

$$g_M = \frac{GM_M}{R_M^2}\ ✓$$

$$= \frac{G\left(\frac{M_E}{153}\right)}{\left(\frac{R_E}{5}\right)^2}\ ✓$$

$$= \frac{25}{153}\ \frac{GM_E}{R_E^2}$$

$$= \frac{25}{153}\ (9{,}8)$$

$$= 1{,}60\ \text{m}\cdot\text{s}^{-2}\ ✓$$

(downwards) (3)

2.2.3 Equal to ✓ (1)

[16]

QUESTION 3

3.1 Motion during which the only force acting on an object is the gravitational force.✓✓ (2)

3.2

OPTION 1:
UPWARDS POSITIVE:

For stone X:	For stone Y:
$\Delta y = v_i\Delta t + \frac{1}{2}a(\Delta t)^2$ ✓ $0 = (3v)(10) + \frac{1}{2}(-9,8)(10)^2$✓ $0 = 30v - 490$ $490 = 30v$ $v = \left(\frac{49}{3}\right)\ m\cdot s^{-1}$	$\Delta y = v_i\Delta t + \frac{1}{2}a(\Delta t)^2$ $0 = \left(\frac{49}{3}\right)\Delta t + \frac{1}{2}(-9,8)(\Delta t)^2$ ✓ $0 = \Delta t\left(\frac{49}{3} - 4,9\Delta t\right)$ $\Delta t = 0$ s or $\Delta t = 3,333$ s $\Delta t = 3,33$ s $(3,333$ s$)$ ✓

(4)

DOWNWARDS POSITIVE:

For stone X:	For stone Y:
$\Delta y = v_i\Delta t + \frac{1}{2}a(\Delta t)^2$ ✓ $0 = (3v)(10) + \frac{1}{2}(9,8)(10)^2$✓ $0 = 30\cdot v + 490$ $-490 = 30\cdot v$ $v = \left(-\frac{49}{3}\right)\ m\cdot s^{-1}$	$\Delta y = v_i\Delta t + \frac{1}{2}a(\Delta t)^2$ $0 = \left(-\frac{49}{3}\right)\Delta t + \frac{1}{2}(9,8)(\Delta t)^2$ ✓ $0 = \Delta t\left(-\frac{49}{3} + 4,9\cdot\Delta t\right)$ $\Delta t = 0$ s or $\Delta t = 3,333$ s $\Delta t = 3,33$ s $(3,333$ s$)$ ✓

OPTION 2: **UPWARDS POSITIVE:**	
For stone X: Consider upward motion: $v_f = v_i + a\Delta t$✓ $\underline{0 = v_i + (-9,8)(5)}$✓ $v_i = 49\ m\cdot s^{-1}$	**For stone Y:** $v_{B_i} = \frac{49}{3}\ m\cdot s^{-1}$ or $16.333\ m\cdot s^{-1}$ Consider upward motion: $v_f = v_i + a\Delta t$ $\underline{0 = 16,333 + (9,8)\Delta t}$✓ $\Delta t = 1,666 (1,67$ s$)$ Δt(total) = 2 x 1,666 = 3,33 s

DOWNWARDS POSITIVE:

For stone X: Consider upward motion: $v_f = v_i + a\Delta t$ ✓ $\underline{0 = v_i + (9,8)(5)}$ ✓ $v_i = -49\ m \cdot s^{-1}$	**For stone Y:** $v_{B_i} = -\frac{49}{3}\ m \cdot s^{-1}$ or $-16.333\ m \cdot s^{-1}$ Consider upward motion: $v_f = v_i + a\Delta t$ $\underline{0 = -16,333 + (9,8)\Delta t}$ ✓ $\Delta t = 1,666 (1,67\ s)$ $\Delta t(total) = 2 \times 1,666 = 3,33\ s$

3.3 **POSITIVE MARKING FROM QUESTION 3.2:**

OPTION 1:
UPWARDS POSITIVE:

For stone Y $\Delta y = v_i\ \Delta t + \frac{1}{2}a(\Delta t)^2$ ✓ $H = \left(\frac{49}{3}\right)\left(\frac{5}{3}\right) + \frac{1}{2}(-9,8)\left(\frac{5}{3}\right)^2$ ✓ $H = \left(\frac{245}{18}\right)m$	**For stone X** $\Delta y = v_i\ \Delta t + \frac{1}{2}a(\Delta t)^2$ $= \underline{(49)(5)}$ ✓ $+ \frac{1}{2}(-9,8)(5)^2$ ✓ $= \frac{245}{2} = 9\left(\frac{245}{18}\right)$ ✓ $= 9H$

DOWNWARDS POSITIVE:

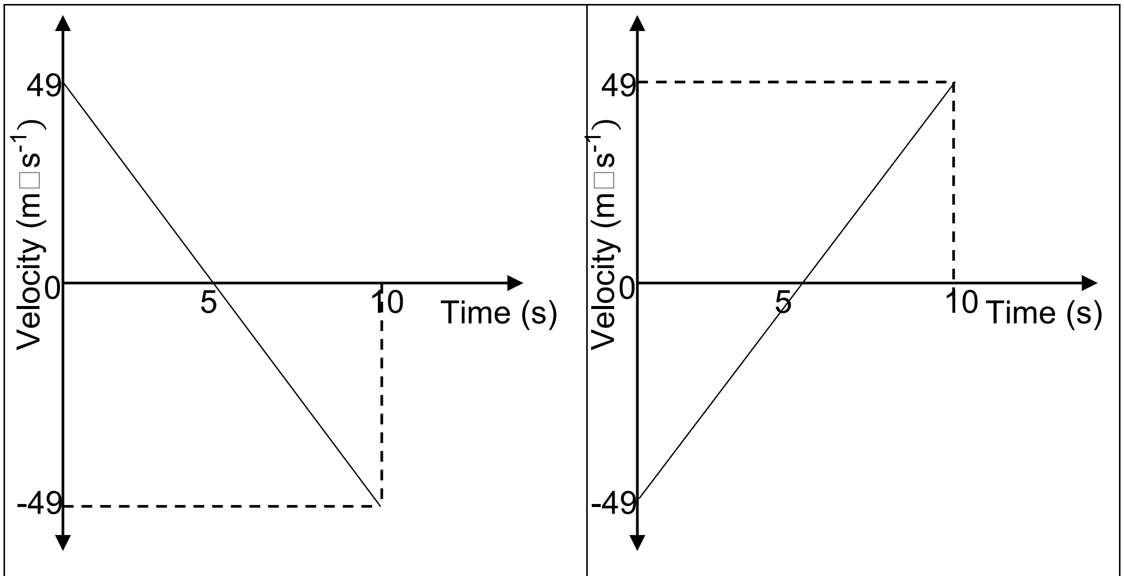
For stone Y $\Delta y = v_i\ \Delta t + \frac{1}{2}a(\Delta t)^2$ ✓ $H = \left(-\frac{49}{3}\right)\left(\frac{5}{3}\right) + \frac{1}{2}(9,8)\left(\frac{5}{3}\right)^2$ ✓ $H = \left(-\frac{245}{18}\right)m$	**For stone X** $\Delta y = v_i\ \Delta t + \frac{1}{2}a(\Delta t)^2$ $= \underline{(-49)(5)}$ ✓ $+ \frac{1}{2}(9,8)(5)^2$ ✓ $= -\frac{245}{2} = 9\left(-\frac{245}{18}\right)$ ✓ $= 9H$

OPTION 2: **UPWARDS POSITIVE:** **For stone Y** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (49)(5)$ ✓ $+ \frac{1}{2}(-9,8)(5)^2$ ✓ $= 122,5\ m$	**For stone X** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $= (16.333)(1,666) + \frac{1}{2}(9,8)(1,666)^2$ ✓ $= 13,61\ m = H$ $13,61 \times 9 = 122,49\ m = 9H (122,5\ m)$ ✓

DOWNWARDS POSITIVE:	For stone X
For stone Y $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (-49)(5)$ ✓ $+ \frac{1}{2}(9,8)(5)^2$ ✓ $= -122,5$ m	$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $= (-16.333)(1,666) + \frac{1}{2}(9,8)(1,666)^2$ ✓ $= -13,61$ m $=$ H $-13,61 \times 9 = -122,49$ m $= 9H(122,5$ m$)$ ✓

(5)

3.4 **POSITIVE MARKING FROM QUESTION 3.2:**



Marking criteria:

- Correct shape (Should intersect t-axis) ✓
- Final velocity and initial velocity shown ✓
- 5 s shown for maximum height ✓

(3)

[14]

QUESTION 4

4.1 The product of an object's mass and its velocity. ✓✓ **(2 or 0)** (2)

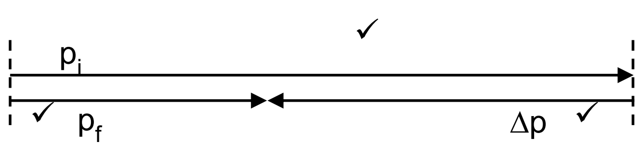
4.2 <u>The total (linear) momentum of an isolated system remains constant</u> (is conserved). ✓✓ (2)

4.3

OPTION 1	**OPTION 2**
$\sum p_i = \sum p_f$ $m_A v_{A_i} + m_B v_{B_i} = m_A v_{A_f} + m_B v_{B_f}$ $\Big\}$ Any one✓ $m_A(4) + m_B(-1)$ ✓ $= m_A(1) + m_B(3)$ ✓ $4m_A - m_A = 3m_B + m_B$ $3m_A = 4m_B$ ✓ $\frac{m_A}{m_B} = \frac{4}{3}$ $m_A : m_B = 4:3$	$\Delta p_A = -\Delta p_B$ $m_A(v_{A_f} - v_{A_i}) = m_B(v_{B_f} - v_{B_i})$ $\Big\}$ Any one✓ $m_A(1-4)$ ✓ $= -m_A(3-(-1))$ ✓ $m_A(-3) = -m_B(4)$ $m_A(-3) = m_B(4)$ ✓ $\frac{m_A}{m_B} = \frac{-4}{-3} = \frac{4}{3}$ $m_A : m_B = 4:3$
Marking criteria: • Formula • Right hand substitution into formula • Left hand substitution into formula • This step: $m_A(-3) = m_B(4)$	

(4)

4.4



(3)

Criteria	mark
• Large initial momentum in the same direction as final momentum	✓
• Small final momentum in the same direction as initial momentum	✓
• Change in momentum in the opposite direction	✓

[11]

QUESTION 5

5.1 The net work done on an object is equal to the change in the object's kinetic energy. ✓✓

OR:

The work done on an object by the net force is equal to the change in the object's kinetic energy. ✓✓ (2)

OPTION 1:

5.2

$W_{net} = \Delta E_K$ OR $W_f + W_w + W_N = \Delta E_K$

$f\Delta x\cos\theta + mg\Delta x(\cos\theta) + 0 = \frac{1}{2}m(v_f^2 - v_i^2)$

Any one✓

$\underline{(45)(\Delta x)(\cos 180°) + (10)(9,8)(\Delta x)(\cos 125°)}$ ✓ $+ 0 = \frac{1}{2}(10)(0^2 - 8,84^2)$✓

$-45\Delta x - 56,2105\Delta x = -390,728$

$\Delta x = 3,86$ m

x = 3,86 m✓ (4)

NB: The work done by the gravitational force W_w can also be calculated as follows:

$W_w = mg\sin\theta\Delta x\cos$
$= (10)(9,8)(\sin 35°)x\cos 180°$
$= (-56,2105x)$J

OR: $W_w = -\Delta E_p$
$= mg(h_i - h_f)$
$= (10)(9,8)(0 - x\sin 35°)$
$= (-56,2105x)$J

OPTION 2:

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

$W_f = mg(h_f - h_i) + \frac{1}{2}m(v_f^2 - v_i^2)$

$f\underline{\Delta x}\cos\theta = mg(h_f - h_i) + \frac{1}{2}m(v_f^2 - v_i^2)$

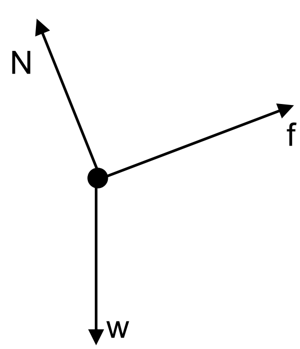
Any one✓

$\underline{(45)x\cos 180° = (10)(9,8)(x\sin 35° - 0)}$✓ $+ \frac{1}{2}(10)(0^2 - 8,84^2)$✓

$-45x = 56,2105x - 390,728$

x = 3,86 m✓

5.3



Accepted labels	
N✓	F_N /Normal force/F_{normal}
f✓	f/F_f / frictional force/ f_s
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)

5.4

OPTION 1:	OPTION 2:
$f_s = w_{\parallel} = mg\sin\theta$ ✓ $=(10)(9,8)(\sin 35°)$ ✓ $f_s = 56,21$ N ✓	$\mu_s = \tan\theta = \tan 35° = 0,7002$ $f_s = \mu_s N = \mu_s mg\cos\theta$ (ANY ONE) ✓ $=(0,7002)(10)(9.8)(\cos 35°)$ ✓ $=56,21$ N ✓

(3)
[12]

QUESTION 6

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

6.2

$v = f_s\lambda$ ✓ $340 = (300)\lambda$ ✓ $\lambda = 1,13$ m ✓

(3)

6.3 **ANY ONE:**
- To monitor the heartbeat of a foetus (unborn baby). ✓
- To measure the rate of blood flow. ✓

(1)

6.4.1

OPTION 1:	OPTION 2:
$f_L = \left(\frac{v \pm v_L}{v \pm v_S}\right) f_s$ ✓ $= \left(\frac{340}{340-30}\right)(300)$ ✓ $= 329,032$ Hz $v = f_L\lambda$ $340 = (329,032)\lambda$ ✓ $\lambda = 1,033$ m ✓	$\lambda_B = \frac{v - v_S}{f_s}$ ✓ $= \frac{340-30 ✓}{300 ✓}$ $= 1,03$ m ✓

(4)

6.4.2

OPTION 1:	OPTION 2:
$f_L = \left(\frac{v \pm v_L}{v \pm v_S}\right) f_s$ $= \left(\frac{340}{340+30}\right) (300)$ ✓ ✓ $= 275{,}676$ Hz $v = f\lambda$ $(340) = (275{,}676)\lambda$ $\lambda = \frac{340}{275{,}676}$ $= 1{,}23$ m ✓	$\lambda_A = \left(\frac{V - V_S}{f_s}\right)$ ✓ $= \left(\frac{340+30}{300}\right)$ ✓ $= 1{,}23$ m ✓

(3)

6.5 Less than✓ (1)

[14]

QUESTION 7

7.1.1 Distance (between the point charges)/medium/air✓ (1)

7.1.2 The electrostatic force is directly proportional to the product of charges.✓ (1)

7.1.3

gradient $= \frac{\Delta F}{\Delta Q^2}$ $= \frac{(4-3) \times 10^{12}}{\Delta Q^2}$ ✓ $= \frac{1 \times 10^{12}}{1}$ ✓ $= 1 \times 10^{12}$ N□C^{-2} ✓	**NOTE:** accept any value from the graph

(3)

7.1.4

$F = \frac{KQ_1Q_2}{r^2}$ ✓

$\frac{F}{Q^2} = \frac{k}{r^2}$

1×10^{12} ✓ $= \frac{9 \times 10^9}{r^2}$ ✓

$r^2 = 9 \times 10^{-3}$

$r = 0{,}09487$ m ($0{,}095$ m)✓

NOTE: If $F = \frac{KQ^2}{r^2}$ is used, then maximum: $\frac{3}{4}$

(4)

7.2.1 A region of space in which an electric charge experiences a force. ✓✓ (2)

7.2.2

$E = \frac{kQ}{r^2}$ ✓

$E_{net,p} = 0$

$\frac{kQ_1}{r^2}$ ✓ $= \frac{kQ_2}{r^2}$

$\frac{(9 \times 10^9)(8 \times 10^{-6})}{(0,4-d)^2} = \frac{(9 \times 10^9)(2 \times 10^{-6})}{d^2}$ ✓

ACCEPT: If 10^{-6} is omitted since it appears on both sides.

$\frac{d^2}{(0,4-d)^2} = \frac{(2 \times 10^{-6})}{(8 \times 10^{-6})}$

$= 0,25$

$\frac{d}{0,4-d} = 0,5$

$d = 0,1333$ m

∴The distance is 0,1333 m ✓ (4)

7.2.3

OPTION 1:	OPTION 2:
$Q_{new} = \frac{Q_1 + Q_2}{2}$ $= \frac{8 \times 10^{-6} + 2 \times 10^{-6}}{2}$ ✓ $= 5 \times 10^{-6}$ C $n = \frac{Q}{e}$ ✓ $n = \frac{5 \times 10^{-6} - 8 \times 10^{-6}}{-1,6 \times 10^{-19}}$ ✓ $n = 1,875 \times 10^{13}$ electrons ✓	$Q_{new} = \frac{Q_1 + Q_2}{2}$ $= \frac{8 \times 10^{-6} + 2 \times 10^{-6}}{2}$ ✓ $= 5 \times 10^{-6}$ C $n = \frac{Q}{e}$ ✓ $n = \frac{5 \times 10^{-6} - 2 \times 10^{-6}}{-1,6 \times 10^{-19}}$ ✓ $n = 1,875 \times 10^{13}$ electrons ✓

(4)

[19]

QUESTION 8

8.1 Emf✓ (1)

8.2.1

$V_{lost} = Ir$ $24 - 21,6$✓ $= I(2)$ $I = 1,2$ A $I_{total} = 1,2$ A $V_{12\,\Omega} = IR = (1,2)(12)$✓ $= 14,4$ V $V_{10\,\Omega} = 21,6 - 14,4 = 7,2$ V $I_{10\,\Omega} = \frac{V}{R}$ ✓$= \frac{7,2}{10}$ ✓$= 0,72$ A✓ $I_A = 0,72$ A

(5)

8.2.2

$I_X = 1,2$✓ $- 0,72$ $= 0,48$ A $R_X = \frac{V}{I}$ ✓$= \frac{7,2}{0,48}$ ✓ $= 1,50\ \Omega$✓

(4)

8.3

POSITIVE MARKING FROM QUESTION 8.2.1
$P = I^2R$✓ $= (1,2)^2$✓ (12)✓ $= 17,28$ W✓

(4)

8.4 Decreases ✓

- Total resistance in the circuit increases. ✓
- Current in the circuit decreases $\left(I \propto \frac{I}{R}\right)$. ✓
- $P = I^2R$; when R is constant, P decreases ✓

(4)

[18]

QUESTION 9

9.1.1 From electrical energy to mechanical energy. ✓ (1)

9.1.2 Clockwise. ✓ (2)

9.1.3 (carbon) brush✓✓ (1)

9.1.4 It reverses the direction of the current in the coil after each half-cycle. ✓ (1)

9.1.5 Increases. ✓
The current increases✓ (2)

9.2.1 The rms potential difference is the AC potential difference which dissipates/produces the same amount of energy as an equivalent DC potential difference✓✓
ACCEPT:
The rms voltage is the DC potential difference which dissipates/produces the same amount of energy as the equivalent AC potential difference✓✓ (2)

9.2.2 $V_{rms} = \frac{V_{rms}}{\sqrt{2}}$✓
$200 = \frac{V_{rms}}{\sqrt{2}}$✓
$V_{rms} = (200)(\sqrt{2})$
$V_{rms} = 282,8427$ V✓ (3)

[12]

QUESTION 10

10.1.1 The process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface. ✓✓ (2)

10.1.2 The minimum energy that an electron in the metal needs to be emitted from the metal surface.✓✓ (2)

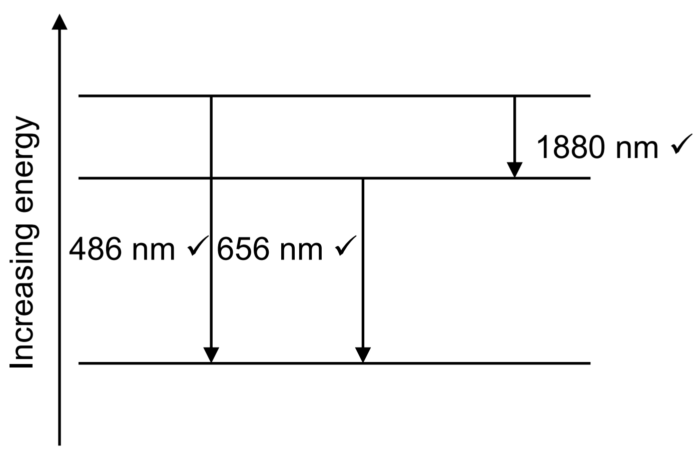
10.1.3 (a) Frequency (of the incident light). ✓ (1)
(b) Frequency (of the incident light).✓ (1)

10.1.4

$E = hf$ $E = \frac{hc}{\lambda}$ ✓ $\therefore E = \frac{(6{,}63 \times 10^{-34})(3 \times 10^{8})}{(450 \times 10^{-9})}$ ✓ ✓ $E = 4{,}42 \times 10^{-19}$ J ✓ Since photon energy is less than the work function of the metal, so, no emission occurs. ✓

(5)

10.2.



[14]

TOTAL: 150