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PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: PHYSICS (P1)

SEPTEMBER 2023

MARKS: 150

TIME: 3 hours

EPHSCP1

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This question paper consists of 19 pages and 3-paged data sheets.

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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 Which ONE of the following is the CORRECT term for *the gravitational force the Earth exerts on any object on or near its surface?*

A Weight

B Friction

C Tension

D Compression (2)

1.2 The driver of a truck places a suitcase on the level dashboard in front of him. He observes that the suitcase is sliding towards the windscreen. At this instant the truck is probably moving ...

A forward at constant velocity.

B backward and slowing down.

C forward and slowing down.

D backward at constant velocity. (2)

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1.3 A stone is thrown vertically upwards. Which ONE of the following combinations *correctly* represents the stone's **acceleration** and **velocity** *one second before* reaching maximum height?
Assume that air resistance is ignored.

	ACCELERATION	VELOCITY
A	9,8 m□s^{-2} upwards	9,8 m□s^{-1} upwards
B	9,8 m□s^{-2} downwards	9,8 m□s^{-1} upwards
C	9,8 m□s^{-2} upwards	9,8 m□s^{-1} downwards
D	9,8 m□s^{-2} downwards	9,8 m□s^{-1} downwards

(2)

1.4 A car approaches a road with a lower speed limit and the driver slows down the car. The two vectors p_i and p_f below represent its initial and final momenta respectively.

Which ONE of the following vector diagrams CORRECTLY represents the change in momentum (Δp) of the car?

A

B

C

D

(2)

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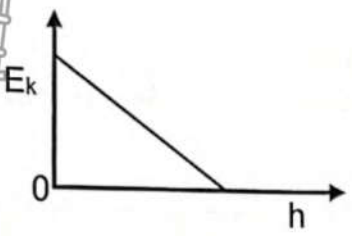
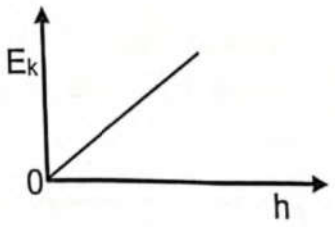
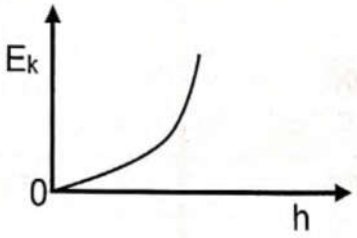
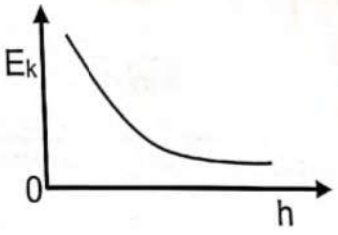
1.5 An object is dropped from a height *h* above ground level. Which ONE of the following graph BEST represents the relationship between its kinetic energy (E_k) and its height above ground level?

A


B


C


D


(2)

1.6 How does the *frequency* and *wavelength* of a wave source change when it moves *towards* the observer?

A The wavelength increases whilst the frequency decreases

B The wavelength decreases whilst the frequency increases

C The wavelength decreases whilst the frequency decreases

D The wavelength increases whilst the frequency increases

(2)

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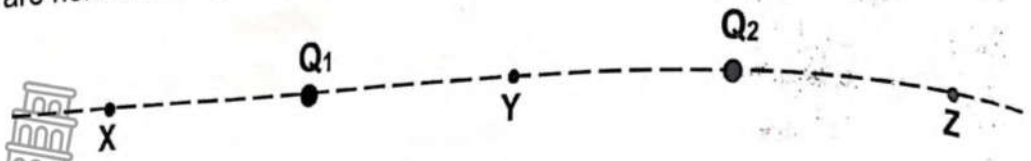
1.7 A *positive* point charge Q_1 and a *negative* point charge Q_2 of equal magnitudes are held at fixed positions, as shown in the diagram below.



S is exactly halfway between Q_1 and Q_2.

Which ONE of the following combinations gives the correct direction of the **net** electric field due to the presence of the charges Q_1 and Q_2 at positions **X**, **Y** and **Z** respectively?

	X	Y	Z
A	Right	Left	Right
B	Right	Right	Left
C	Left	Right	Right
D	Left	Right	Left

(2)

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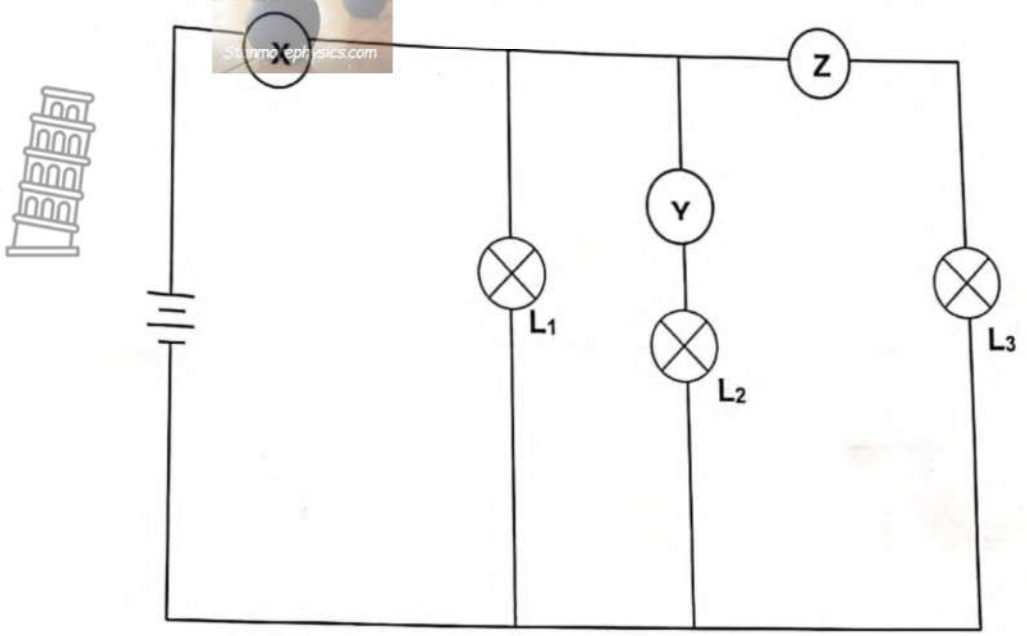
1.8 In the given circuit diagram below, the three light bulbs L_1, L_2 and L_3 are IDENTICAL. X, Y and Z are readings on the ammeters in the circuit.



Which ONE of the following mathematical equations is CORRECT?

A $Y = X - Z$

B $X = 3Y$

C $X = Y + Z$

D $X = Y - Z$ (2)

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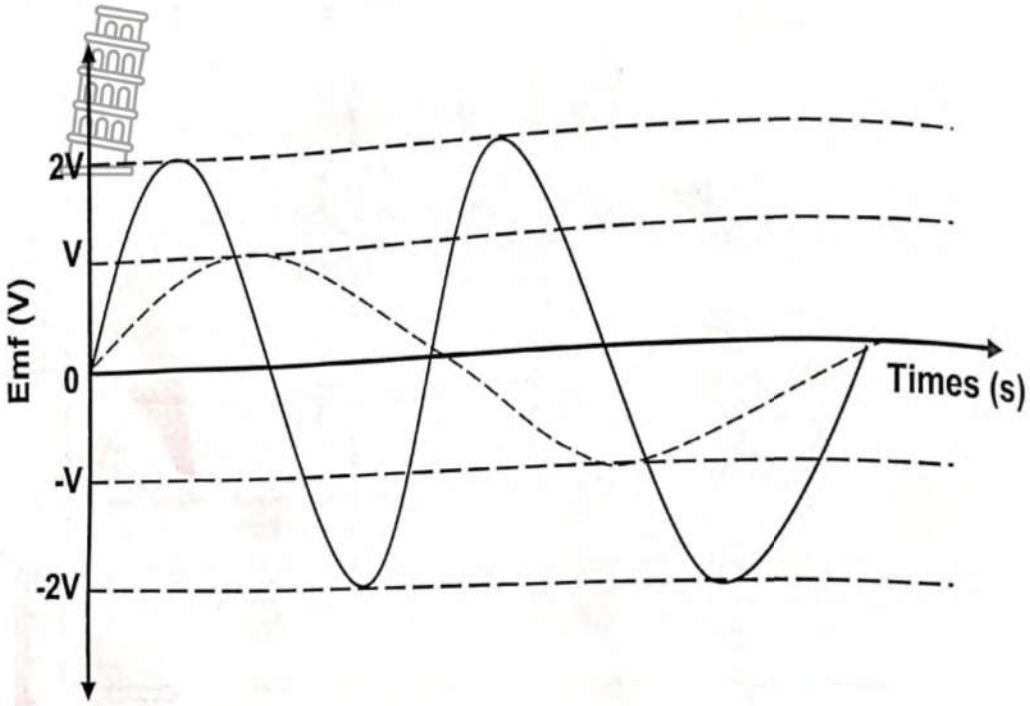
1.9 The solid line in the graph below represents the output of an AC generator. The dotted line represents the output of the same generator after a change has been made to the generator.



Which ONE of the following could be the change made to the generator?

A The number of turns on the coil was halved.

B The strength of the magnetic field was halved.

C The speed of rotation of the coil was halved.

D The surface area of the coil was doubled.

(2)

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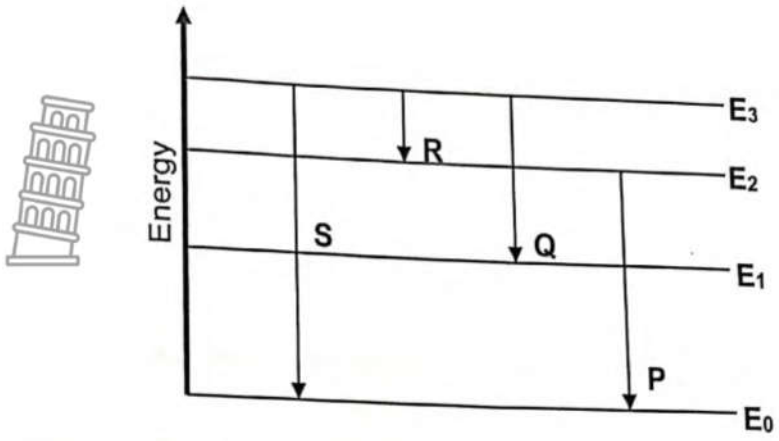
1.10 The diagram below indicates an energy level diagram that corresponds with the four energy levels in an atom.



Which ONE of the four energy transitions has the SHORTEST wavelength?

A **P**

B **Q**

C **R**

D **S**

(2)
[20]

QUESTION 2 (Start on a new page)

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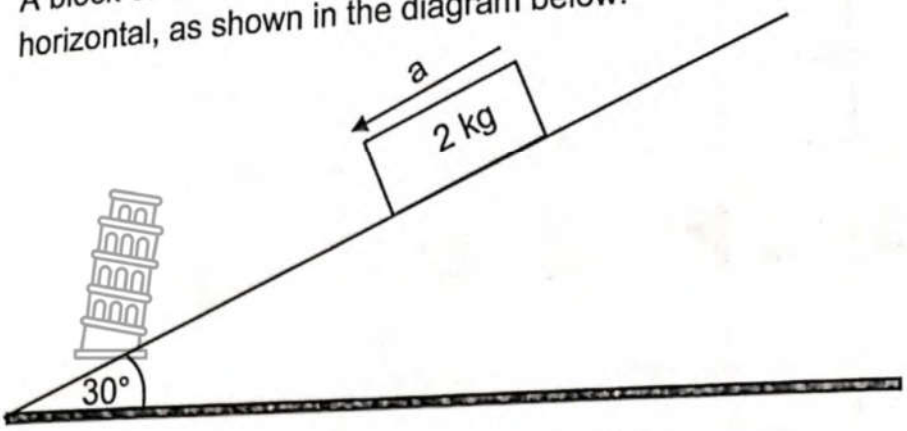
2.1 A block of mass 2 kg is sliding down a plane inclined at an angle of 30° to the horizontal, as shown in the diagram below.



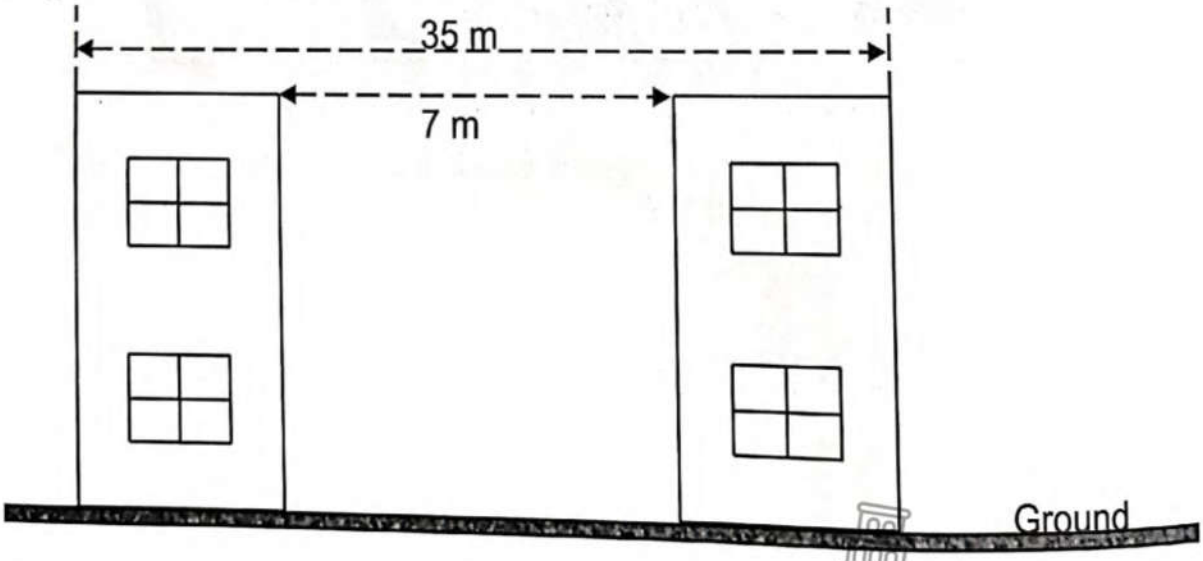
The coefficient of kinetic friction μ_k between the block and the plane is 0,20.

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

2.1.2 Draw a labelled free-body diagram for the block whilst in motion. (3)

2.1.3 Calculate the acceleration of the block. (5)

2.2 In two adjacent buildings of the same size, the two walls nearest one another are 7 m apart and the walls furthest from one another are 35 m apart, as the diagram below illustrates.



Use an appropriate calculation to show that the gravitational force that the two inner walls exert on each other is 25 times bigger than that of the two outer walls on each other (i.e. $F_{g(\text{inner walls})} = 25 \times F_{g(\text{outer walls})}$) (4)

[14]

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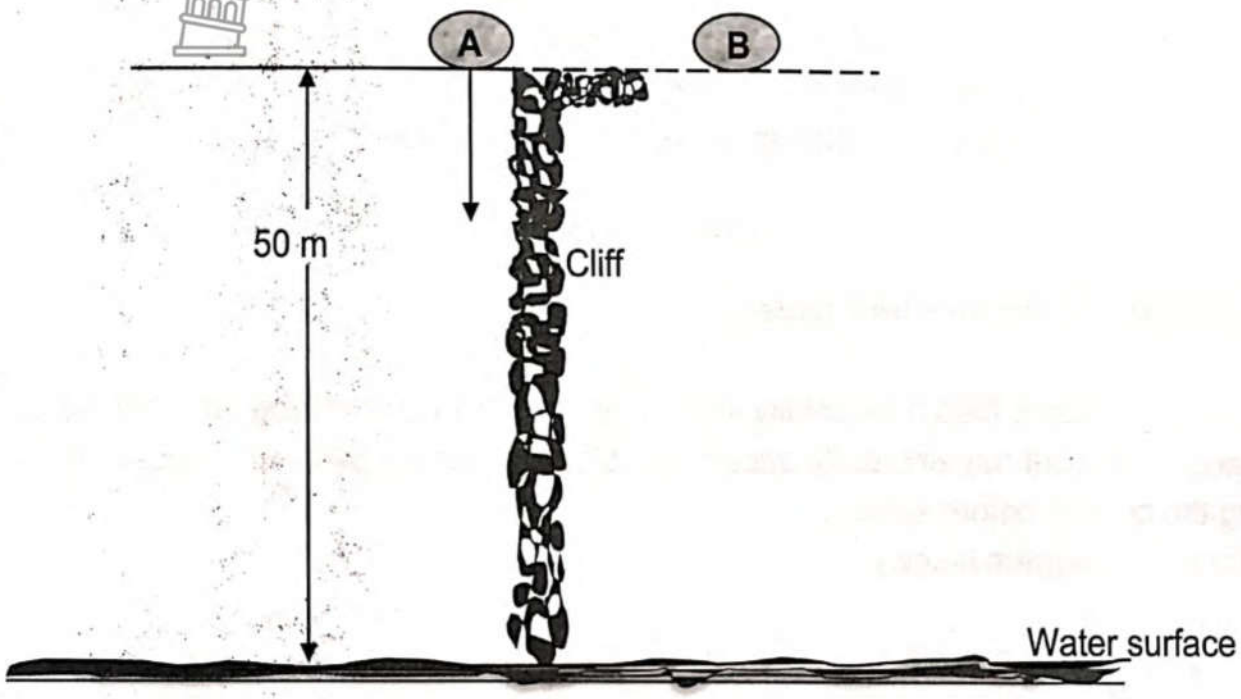
QUESTION 3 (Start on a new page)

A mountain climber throws two identical stones from a high cliff to a pool of water which is 50 m below the cliff. The first stone A is thrown vertically downwards with an initial vertically downwards with a velocity of 2 m□s-1. After 1 s, the second stone is thrown an unknown velocity. Both stones A and B reach the water surface of the pool at the same time.



Neglect the effects of air resistance.

3.1 Explain what is meant by a *projectile*. (2)

3.2 Calculate, by using THE EQUATIONS OF MOTION, the:

3.2.1 Time taken by stone **A** to hit the water (4)

3.2.2 Time taken by stone **B** to hit the water (1)

3.2.3 Initial velocity of stone **B** (3)

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3.3 Sketch, on the same set of axes, position-versus-time graphs for the motions of the two stones from the instant that they are thrown until they hit the water in the pool.
USE THE WATER SURFACE AS THE ZERO REFERENCE.

Clearly show the values of the following on the graphs:

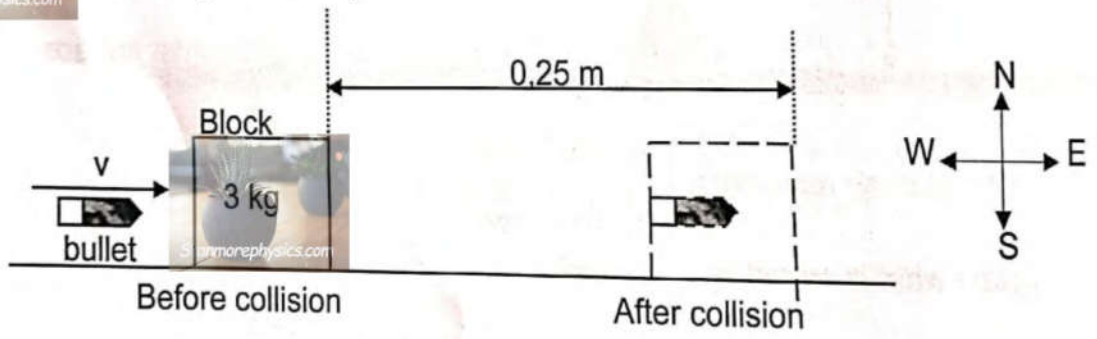
- Time at which the stones hit the water.
- Time at which stone **B** is thrown.
- Initial height of the stones above the water surface.

(4)

[14]

QUESTION 4 (Start on a new page)

A 0,005 kg bullet is fired horizontally into a 3 kg wooden block resting on a horizontal surface. The bullet remains *embedded* in the block, which is observed to slide 0,25 m along the surface before stopping.
(Refer to the diagram below).



The coefficient of kinetic friction between the block and surface is 0,20.

Neglect the effects of air resistance.

4.1 Is frictional force an EXTERNAL FORCE or INTERNAL FORCE? (1)

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

4.3 Calculate the:

4.3.1 Velocity of the block after the bullet has been embedded in it (6)

4.3.2 Initial velocity of the bullet before striking the block (4)

[13]

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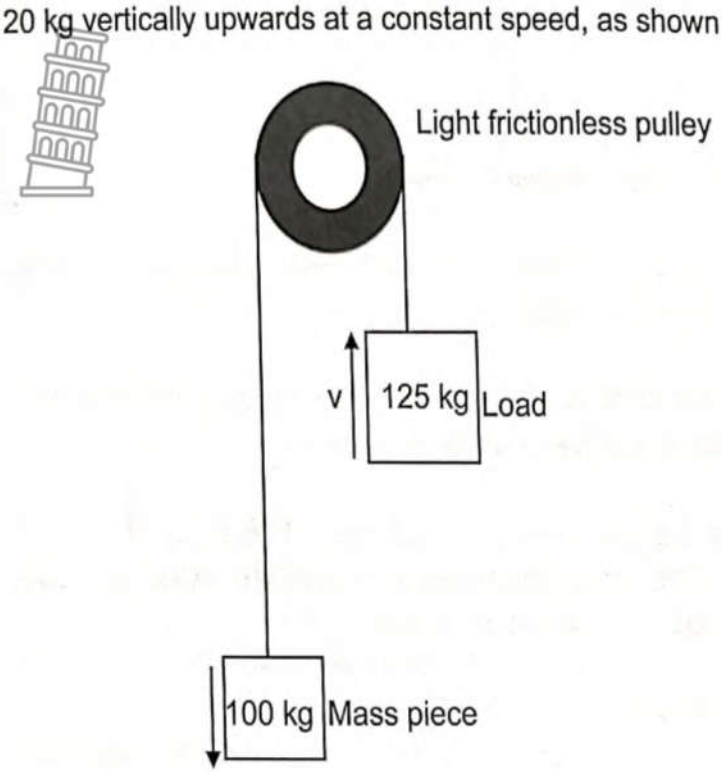
QUESTION 5 (Start on a new page)

A pulley system with a mass piece is operated by an electric motor. It is used to lift a load of 120 kg vertically upwards at a constant speed, as shown in the diagram below.



The load covers a distance of 6,8 m in 0,01 seconds.
Neglect all the effects of friction.

5.1 Define, in words, the term *power* as applied in Physics. (2)

5.2 Calculate the work done by the gravitational force on the load. (3)

5.3 Determine the average power output required by the electric motor to lift the load through 6,8 m in 0,01 seconds. (7)
[12]

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QUESTION 6 (Start on a new page)

6.1 A physics learner's clock radio awakens him/her with a steady and irritating sound of frequency 600 Hz. One morning, it malfunctions and cannot be turned off. In frustration, the learner drops the clock radio out of his/her fourth-story dorm window, 15,0 m from the ground.
Assume the speed of sound is 343 m□s^{-1}. Ignore the effects of air resistance.

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

6.1.2 Calculate the frequency that the learner hears just before the clock radio strikes the ground. (6)

6.1.3 Explain the change in frequency observed by the learner with reference to the *speed of the clock radio*. (3)

6.2 A helium line from the spectrum of the sun has a frequency of 6,20 x 10^{14} Hz, The frequencies of the same helium line from the Earth, which are observed in the line emission spectrum of two stars, are:

Star **X** : 6,24 x 10^{14} Hz

Star **Y** : 6,04 x 10^{14} Hz

6.2.1 Which ONE of the stars (**X** or **Y**) has a red shift? (1)

6.2.2 In which direction **Away from the Earth** or **Towards the Earth** does star **X** move? (1)

[13]

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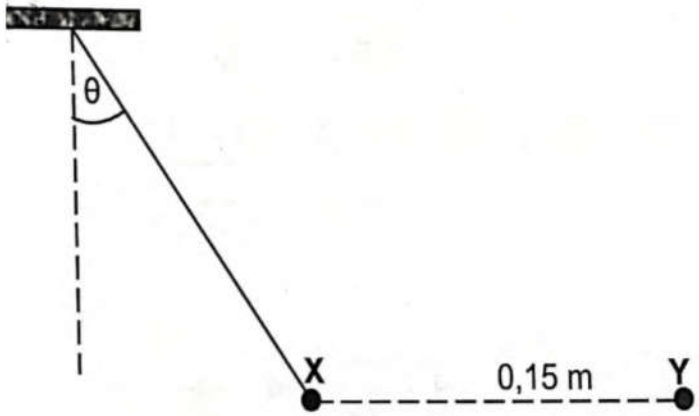
QUESTION 7 (Start on a new page)

7.1 A small sphere **X** having a mass of 8×10^{-2} kg and a charge of $+6 \times 10^{-7}$ C hangs vertically by a thin wire of negligible mass. When the charge **Y** of -9×10^{-7} C is brought closer to the sphere, the wire makes an angle θ to the vertical when brought to rest 0,15 m away from the charge **Y**, as shown in the diagram below.



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

7.1.2 Draw a labelled free-body diagram for the sphere **X** when at rest. (3)

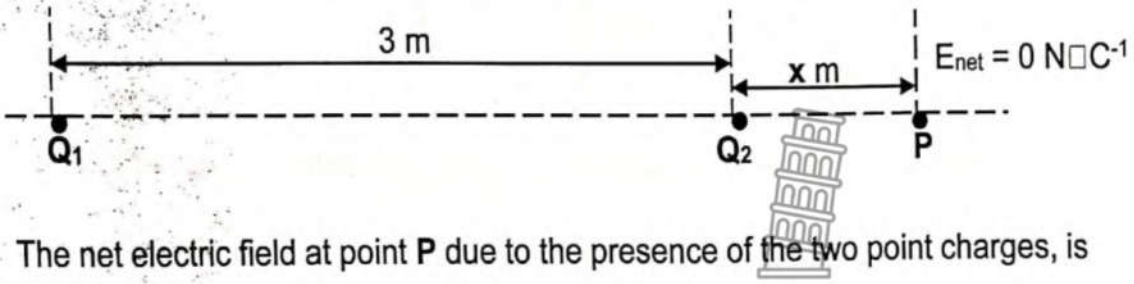
Calculate the:

7.1.3 Electrostatic force exerted by sphere **X** on charge **Y** (3)

7.1.4 Angle θ shown in the diagram (4)

7.1.5 Tension in the wire (2)

7.2 Two point charges, Q_1 and Q_2, with charges -16×10^{-7} C and $+4 \times 10^{-7}$ C respectively, are placed 3 m apart as shown in the diagram below.



The net electric field at point **P** due to the presence of the two point charges, is ZERO.
Determine the value of **x**, shown in the diagram. (5)
[19]

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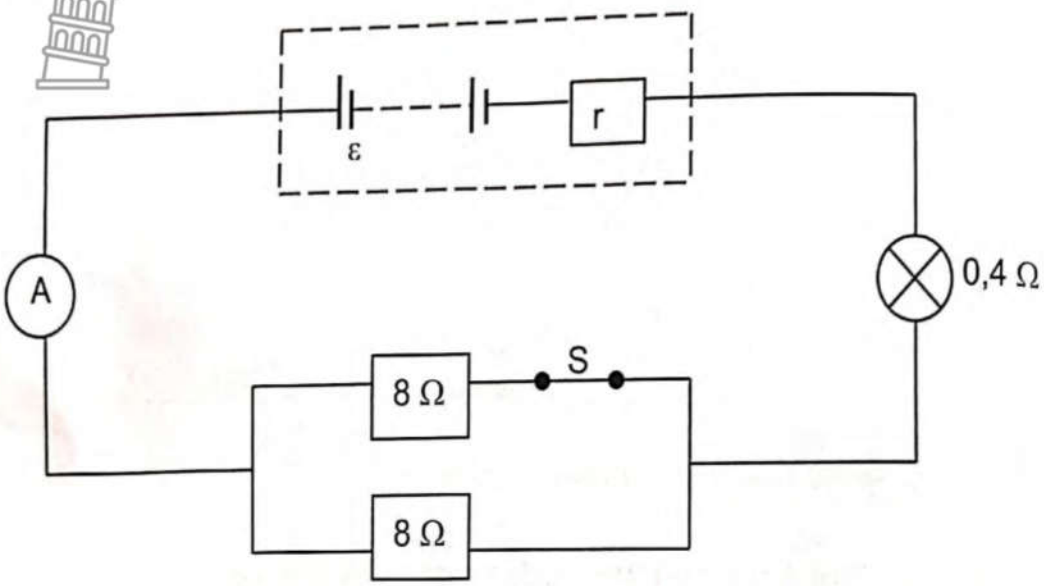
QUESTION 8 (Start on a new page)

Grade 12 Physics learners are conducting an experiment to determine the emf (ε) and internal resistance (r) of a battery. They have access to an ammeter *but do not have a voltmeter.*

They setup the circuit shown in the diagram below.



8.1 Define the term *emf* of a battery. (2)

8.2 State the purpose of placing the switch next to the **8 Ω** resistor. (2)

The results of the experiment are shown in the table below.

	AMMETER READING
Switch open	4 A
Switch closed	6 A

8.3 Use the results from the experiment to determine the: (use $\varepsilon = I(R + r)$)

8.3.1 Internal resistance of the battery (5)

8.3.2 emf of the battery (2)

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8.4 Calculate the:

8.4.1 Power dissipated in the battery when the switch is closed (2)

8.4.2 Energy dissipated in the bulb in 6 minutes when the switch is open (3)

8.5 How is the brightness of the bulb affected when the switch is opened? State only BRIGHTER, DIMMER or NO CHANGE.

Explain the answer. (3)

[19]

QUESTION 9 (Start on a new page)

The following diagrams show two types of generators

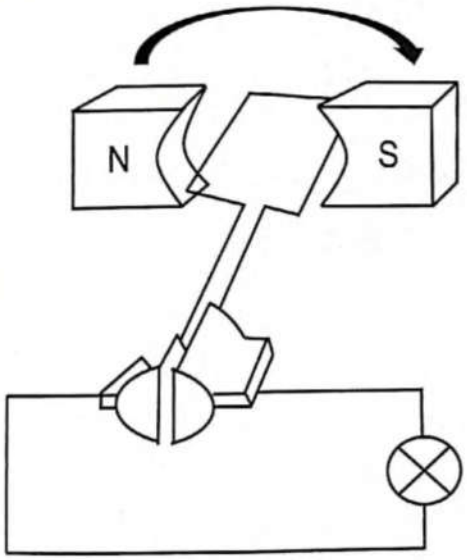

Diagram **X**

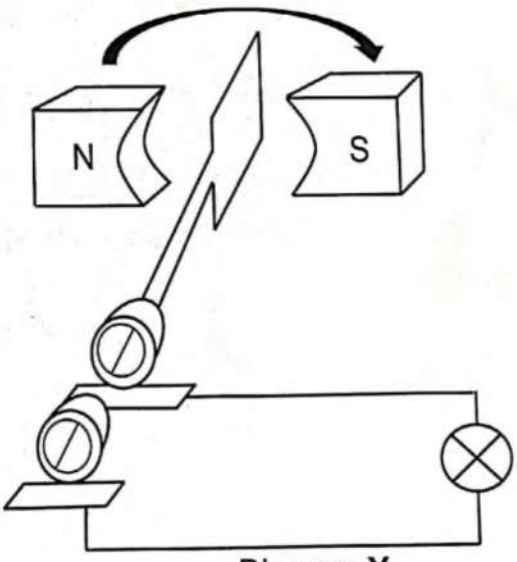

Diagram **Y**

9.1 Write down the energy conversion which takes place in a generator. (1)

9.2 Write down the type of generator represented by:

9.2.1 Diagram **X** (1)

9.2.2 Diagram **Y** (1)

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9.3 State the difference between the two generators by referring to the **components**, shown in the diagrams, of which they consist. (2)

9.4 The generator in diagram **Y** produces a potential difference with root-mean-square (rms) value of 220 V.

9.4.1 Define, in words, the term *rms* voltage. (2)

9.4.2 Calculate the peak (maximum) potential difference of the generator. (3)

9.4.3 Sketch a graph of potential difference-versus-time to indicate one full rotation of the coil.

Clearly indicate the values of the following on the graph:

- The *rms* value
- The peak potential difference (3)

[13]

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QUESTION 10 (Start on a new page)

In a photoelectric effect experiment, the maximum kinetic energy of the photoelectrons ejected from a certain metal surface is $4,48 \times 10^{-19}$ J. When the wavelength of the incident light is increased by 50%, the maximum kinetic energy decreases to 1.76×10^{-19} J.

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

10.2 Prove, by means of an appropriate calculation, that the work function of the cathode is **$3,68 \times 10^{-19}$ J**. (6)

10.3 Hence find the initial wavelength of incident light. (2)

10.4 How does EACH of the following affect the maximum kinetic energy of the photoelectrons?
(State only INCREASES, DECREASES or REMAINS THE SAME).

10.4.1 Using incident light of *shorter* wavelength (1)

10.4.2 Using a photocathode with a *higher* work function (1)

10.4.3 Using incident light of *greater* intensity (1)

[13]

GRAND TOTAL: [150]

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GRADE 12

PHYSICAL SCIENCES: PHYSICS (P1)

ERRATA SEPTEMBER 2023

MARKING GUIDLINES

These Errata marking guidelines consist of 6 pages.

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Errata Marking Guidelines

QUESTION 1

1.10 **Accept**: letter **S**

QUESTION 2

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

2.1.2 Marks allocation:

$F_{net} = ma$ $mg\sin\theta - \mu_k \cdot mg\cos\theta = ma$ Any one✓ $(2)(9,8)(\sin 30°)$✓ $- (0,20)(2)(9,8)(\cos 30°)$ ✓$= (2)\cdot a$✓ $\therefore a = 3,20259\ m\cdot s^{-2}$ $(3,20\ m\cdot s^{-2})$downhill✓

(2)

2.2

OPTION 1:	**OPTION 2:**
Mark awarded for: $F_{g(inner\ walls)} = \frac{Gm_1m_2}{(7)^2}$	Factor (n) $= \frac{35\ m}{7\ m}$ ✓ $= 5$ $F_{g(inner\ walls)} = \frac{Gm_1m_2}{(r)^2}$✓ $F_{g(inner\ walls)} = \frac{Gm_1m_2}{\left(\frac{1}{5}r\right)^2}$✓ $F_{g(inner\ walls)} = \frac{Gm_1m_2}{\frac{1}{25}r^2}$✓ $= 25\left(\frac{Gm_1m_2}{(r)^2}\right)$

(4)

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QUESTION 3

3.1 **Accept:** An object upon which the only force acting is the gravitational force.

3.2.1

OPTION 2:	**OPTION 3:**
$\Delta y = \left(\frac{v_f + v_i}{2}\right)\Delta t$ $(50) = \left(\frac{31{,}36877 + 2}{2}\right)\Delta t$ $\therefore \Delta t = 2{,}997$ s or $\Delta t = (3{,}00$ s)	Marks allocation: $\Delta y = v_i\,\Delta t + \frac{1}{2}a(\Delta t)^2$ ✓ 50✓ $= (2)\Delta t + \frac{1}{2}(9{,}8)\Delta t^2$✓ $\therefore t = 2{,}997$ s✓$(3{,}00$ s)

3.2.2 **POSITIVE MARKING FROM 3.2.1**

$\Delta t = 2{,}997 - 1 = 1{,}997$ s✓

$\Delta t = 3{,}00 - 1 = 2{,}00$ s✓

3.2.3 **POSITIVE MARKING FROM 3.2.2 FOR:**

$\Delta t = 2{,}00$ s

$\Delta y = v_i\Delta t + \frac{1}{2}a\,(\Delta t)^2$

$50 = v_i(2) + \frac{1}{2}(9{,}8)(2)^2$

$\therefore v_i = 15{,}20$ m·s^{-1}

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QUESTION 4

4.3.1
Marks allocation:

OPTION 1	**OPTION 2:**
$F_{net} = ma$ Any one✓ $-f_k = ma$ $-\mu_K N = ma$ $-(0,20)(0,005 + 3)$✓ $(9,8) = (0,005+3)a$✓ $\therefore a = -1,96\ m\cdot s^{-2}$ $v_f^2 = v_i^2 + 2a\Delta x$✓ $(0)^2 = v_i^2 + 2(-1,96)(0,25)$ ✓ $V_i = 0,98995\ m\cdot s^{-1}$ $(0,99\ m\cdot s^{-1})$✓	$f_k = \mu_K N$ Any one✓ $= \mu_K mg$ $(0,2)(0,005 + 3)$✓ $(9,8)$ $F_k = 5,8898$ N, westwards $W_{net} = \Delta E_K$✓ $fk\Delta x\cos\theta = \frac{1}{2} m \left(v_f^2 - v_i^2\right)$ $(5,8898)(0,25)$ ✓$\cos 180° = \frac{1}{2}(3,00)\left(0^2 - v_i^2\right)$✓ $V_i = 0,99\ m\cdot s^{-1}$, eastwards✓

(6)

4.3.2

POSITIVE MARKING FROM 4.3.1 **Marks allocation:**
$\sum p_i = \sum p_f$ Any one✓ $m_b v_{b_i} + m_B v_{B_i} = (m_b - m_B) v_f$ $(0,005)v_{b_i} + (3)(0)$✓ $= (0,005+3)(0,98995)$✓ $v_{b_i} = 594,96\ m\cdot s^{-1}$ Eastwards. ✓

(4)

QUESTION 5

5.2

OPTION 1 and 2:
Consider m = 120 kg: $w = F\Delta y\cos\theta$ Any one✓ $w_W = mg\Delta y\cos\theta$ $= (120)(98)\cos 180°$ ✓ $= -7996,80$ J✓

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5.3

POSITIVE MARKING FROM 5.2		
OPTION 2:	**OPTION 3:**	**OPTION 4:**
Consider mass = 120 kg: $W_{net} = \Delta E_k$✓ $W_{motor} + 6664 - (8330) = 0$ $W_{motor} = 1332{,}80$ J $P = \frac{W}{\Delta t}$ $P = \frac{1332{,}80}{0{,}01}$ = 1332 80 W	(m = 120 kg) $F_{net} = ma = 0$ $W_{motor} + F_{mp} + (-F_{load}) = 0$ ✓ $W_{motor}+(125)(9{,}8)$✓$-(100)(9{,}8)$✓$=0$ $F_{motor} = 245$ N $v_{ave} = \frac{\Delta x}{\Delta t}$ $= \frac{6{,}8}{0{,}01}$ ✓ $= 680\ m{\cdot}s^{-1}$ $P_{ave} = Fv_{ave}$ = (245)(680) = 166600 W✓	$F_{net} = ma = 0$ $W_{motor}+(120)(9{,}8)-(100)(9{,}8) = 0$ $F_{motor} = 196$ N $v_{ave} = \frac{\Delta x}{\Delta t}$ $= \frac{6{,}8}{0{,}01}$ $= 680\ m{\cdot}s^{-1}$ $P_{ave} = Fv_{ave}$ = (196)(680) = 1332 80 W

QUESTION 6

6.1.2

OPTION 2:	**OPTION 3:**	**OPTION 4:**
For calculating v_s: $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ $15{,}0 = \left(\frac{0 + v_f}{2}\right)(1{,}7496)$✓ $v_f = 14\ m{\cdot}s^{-1}$	$v_f^2 = v_i^2 + 2a\Delta y$ $=(0)^2 + 2(9{,}8)(15{,}0)$ $v_f = 14\ m{\cdot}s^{-1}$	$F_{net}\Delta t = \Delta p$ $mg{\cdot}\Delta t = m(v_i - v_f)$ $(9{,}8)(1{,}7496) = v_f - 0$ $v_f = 14\ m{\cdot}s^{-1}$

6.1.3 **Bullet 3:**

Frequency heard by the listener decreases.

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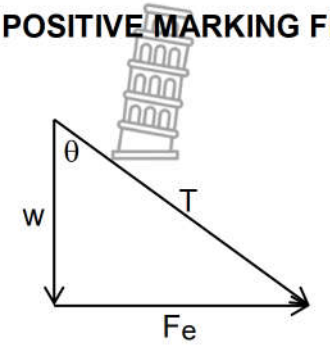
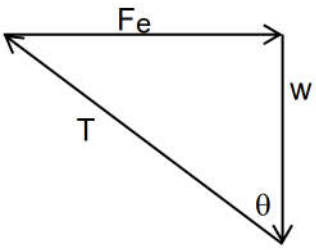
QUESTION 7

7.1.3 $k = 9 \times 10^9$

7.1.4 **POSITIVE MARKING FROM 7.1.3**





OPTION 3:

$w = mg$
$= (8 \times 10^{-2})(9,8)$
$= 0,764$ N