ALEXANDER ROAD HIGH SCHOOL

June 2022 | **PHYSICAL SCIENCES JUNE PAPER 1** | 3 HOURS

CO, JA, MH, PE | **GRADE 12** | TOTAL = 150

Instructions:

- The question paper consists of 8 questions.
- Answer all the questions.
- Answer section A on the answer sheet provided AND section B on folio sheets.
- A non-programmable calculator may be used.
- Number the answers correctly according to the numbering system.
- Round off to at least two (2) decimal places where necessary.
- A formula sheet has been provided at the end of the question paper.

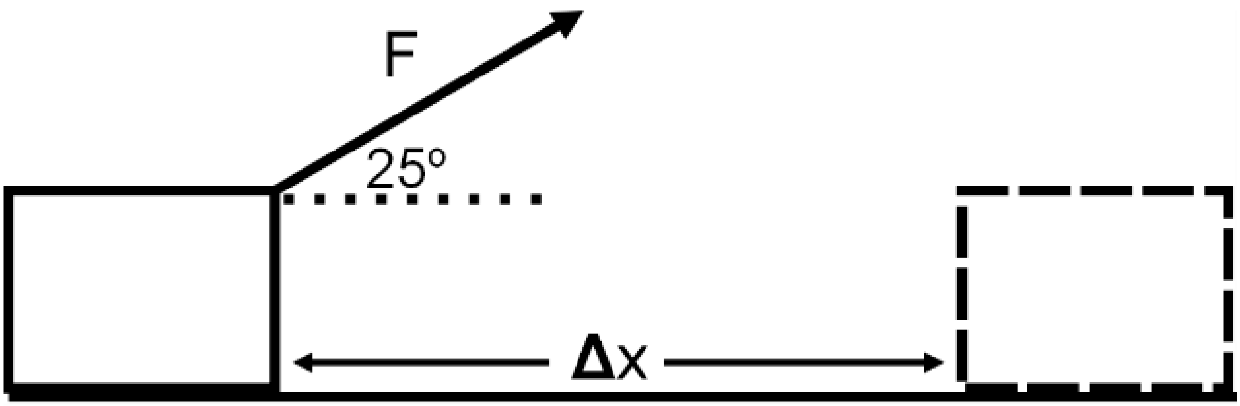
SECTION A

(answer on the answer sheet)

QUESTION 1:

Four possible options are provided as answers to the following questions. Each question has only one correct answer. Choose the correct answer and write the letter (A – D) next to the relevant question number (1.1 – 1.10) on the answer sheet.

1.1 A box is pulled **Δx** meters to the right across a rough horizontal surface by a force **F** acting at an angle of 25° to the horizontal as shown in the diagram below.



The net force along the horizontal is…

A. $F - f_k$

B. $F.\cos(25°) - f_k$

C. $F.\sin(25°) - f_k$

D. $F_N - F_g$

1.2 With reference to the diagram in question 1.1, the work done by **F** is…

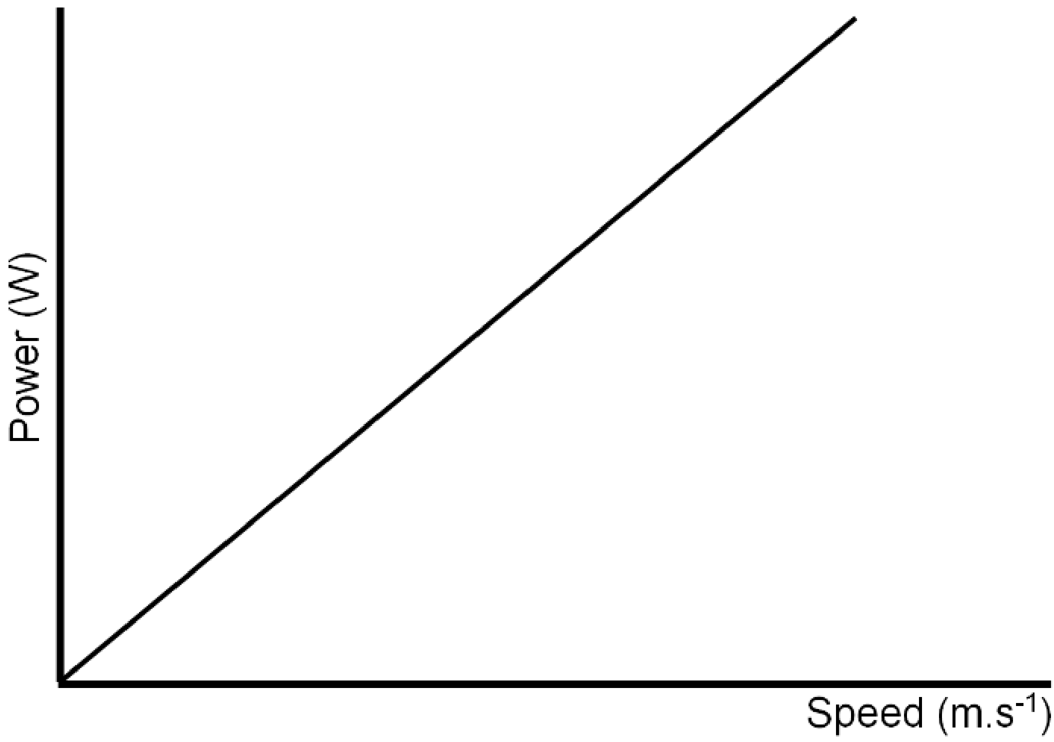
A. F.Δx

B. F.Δx.cos(25°)

C. F.Δx.sin(25°)

D. -F.Δx

1.3 The graph below shows the relationship between the power delivered by the engine of a motorbike and the speed of the motorbike.



What does the gradient of the graph represent?

A. The kinetic energy of the motorbike.

B. The acceleration of the motorbike.

C. The applied force of the engine of the motorbike.

D. The work done by the engine of the motorbike.

1.4 A learner drops a cricket ball from the top of a building. One second later the learner drops a ping pong ball from the same position. As both objects are in free fall, the distance between them will…

A. increase.

B. decrease.

C. initially increase and then stay the same.

D. remain the same.

1.5 A boy sits in a train travelling east at 80 $km.h^{-1}$. A bird flies directly overhead, at a velocity of 10 $km.h^{-1}$ west. Which ONE of the following is the description of how the bird is moving relative to the boy on the train?

	Speed of Bird ($km.h^{-1}$)	**Direction of Bird**
A	70	East
B	70	West
C	90	East
D	90	West

1.6 The kinetic energy of an object with momentum, $\mathbf{p}$, and mass, $\mathbf{m}$, is…

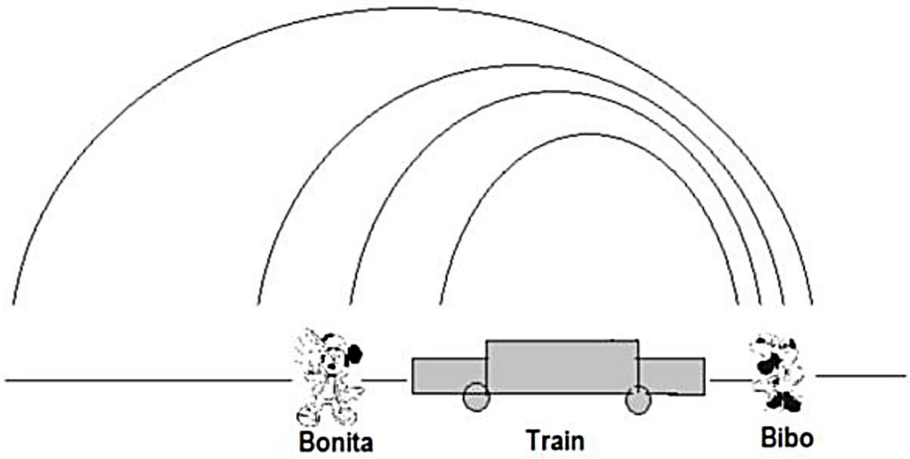
A. $2pm$

B. $\frac{p^2}{m}$

C. $\frac{p^2}{2m}$

D. $\frac{pm}{2}$

1.7 The picture below shows the shape of the sound waves as a train moves from Bonita towards Bibo.



The frequency and pitch of the sound heard by Bonita compared to that heard by Bibo is…

A. smaller sound frequency and lower pitch.

B. smaller sound frequency and higher pitch.

C. greater sound frequency and higher pitch.

D. greater sound frequency and lower pitch.

1.8 The number of excess electrons which will cause a charge of –8 µm on a sphere, is …

A. 5×10^{-25}

B. 5×10^{13}

C. 5×10^{10}

D. 5×10^{-28}

1.9 The work function of zinc is greater than that of magnesium. Which ONE of the following statements about the threshold frequencies of the metals is CORRECT?

A. The threshold frequency of zinc is greater than that of magnesium.

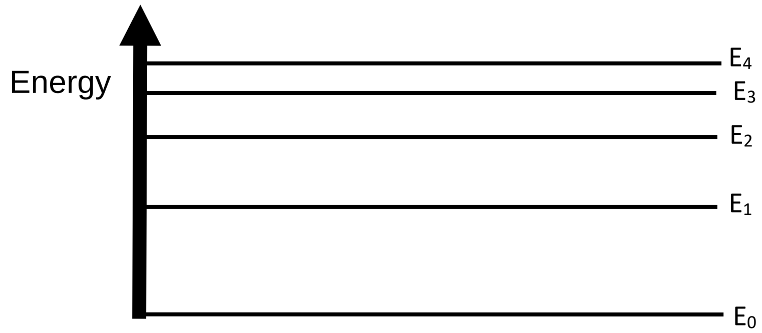
B. The threshold frequency of zinc is smaller than that of magnesium.

C. Both zinc and magnesium have the same threshold frequency.

D. The threshold frequencies of zinc and magnesium are independent of their work functions.

1.10 Some of the energy levels of an atom are represented in the diagram below.

E_0 represents the ground state energy.



Which ONE of the energy transitions below represents the absorption of light of the lowest frequency by the atom?

A. E_0 to E_4

B. E_1 to E_3

C. E_3 to E_4

D. E_0 to E_3

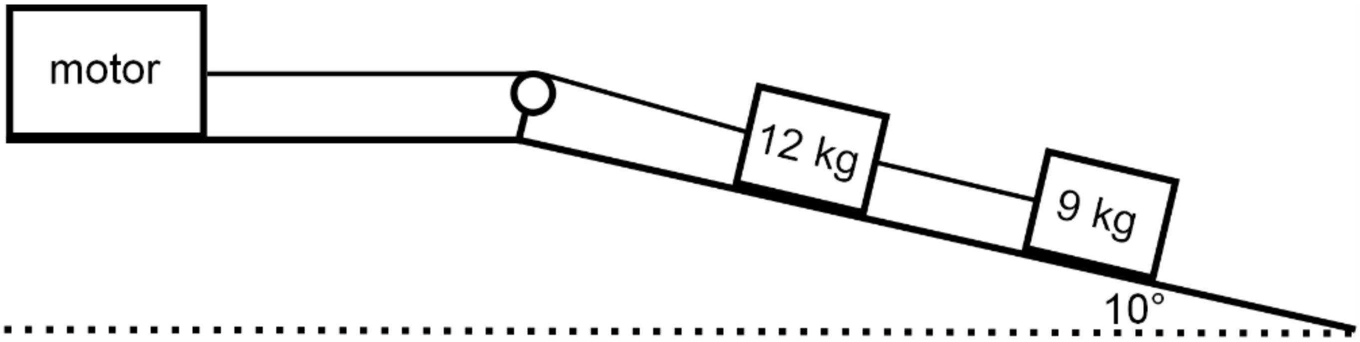
TOTAL SECTION A = [20]

SECTION B

(answer on folio paper)

QUESTION 2:

Two boxes, with masses 12 kg and 9 kg respectively, are joined to each other and a motor by light, inextensible ropes. The motor exerts a force of 120 N on the two-box system causing the two-box system to move up a slope **at a constant velocity**. The slope is inclined at 10° to the horizontal as shown in the diagram below.



The coefficient of kinetic friction between the 9 kg box and the slope is 0,45.

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

2.2 Draw a labelled free-body diagram showing all forces acting on the 12 kg box. (5)

2.3 Calculate the magnitude of the frictional force acting on the 12 kg box as it moves up the slope. (7)

2.4 Hence, calculate the coefficient of kinetic friction between the 12 kg box and the slope. (3)

2.5 Suggest ONE way the value calculated in question 2.4 can be reduced. (1)

2.6 Is the 12 kg box and the 9 kg box made from the same material? Write YES or NO and **give a reason** for your answer. (2)

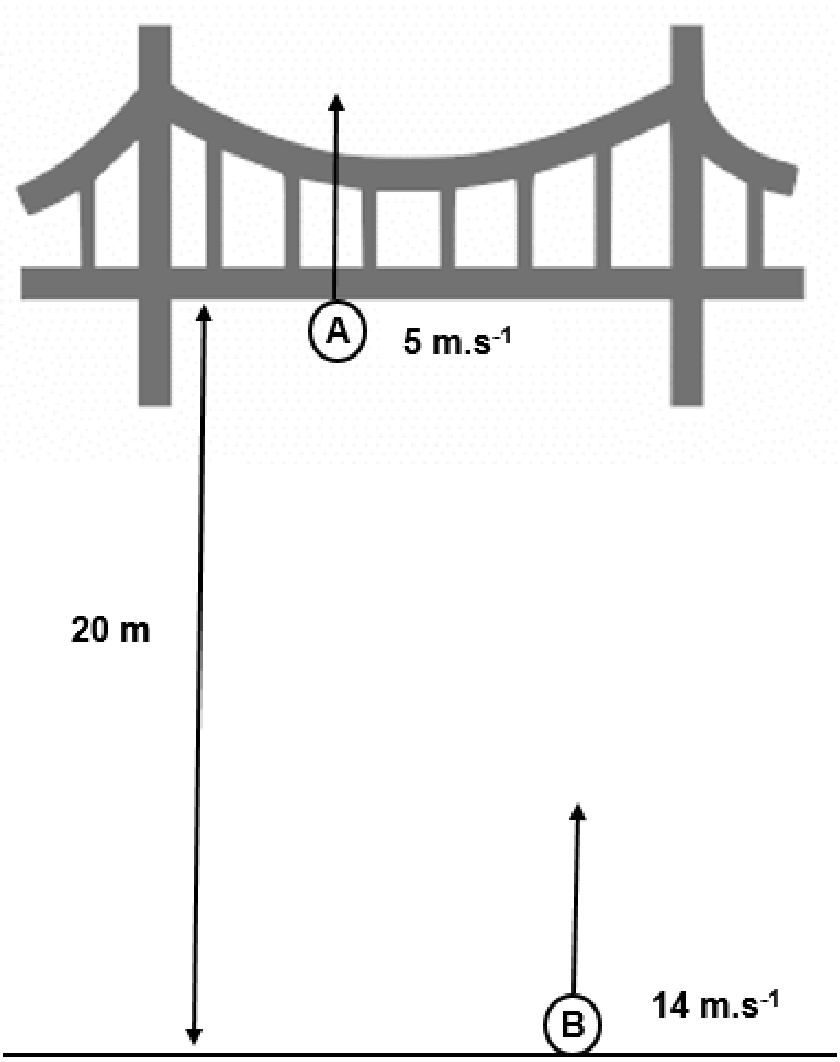
[20]

QUESTION 3:

Kagiso, standing on a bridge, projects a cricket ball (ball A) vertically upwards with an initial velocity of 5 $m.s^{-1}$. The height of the bridge is 20 m.

At the same instant that ball A is thrown upwards from the top of the bridge, another ball B, is projected up from the ground with an initial velocity of 14 $m.s^{-1}$.

Ignore air resistance.



3.1 The cricket ball is a projectile. Define the term *projectile*. (2)

3.2 Calculate the maximum height from the ground that ball A will reach. (4)

3.3 Calculate the height above the ground that the two balls will cross. (7)

3.4 Ball A reaches the ground and bounces back up to a height of 5 m. The velocity with which ball A reaches the ground again after 2 s is 10 $m.s^{-1}$.

The ball bounces again, this time to 2,5 m. 1,4 s after the bounce, ball A reaches the ground with a velocity of 7 $m.s^{-1}$.

Take the time of the first bounce as t = 0 s. Draw a velocity vs time graph for ball A from t = 0 s until it reaches the ground at the end of the second bounce. Indicate the velocity of ball A at the start and end of each bounce, the time when it reaches the ground for each bounce and the time it reaches the highest point in each bounce. Ignore the effects of air resistance. (5)

3.5 What does the gradient of the graph in 3.4 represent? (1)

[19]

QUESTION 4:

At a test centre for car manufacturers, engineers want to see the impact of a truck colliding with an oncoming vehicle. The truck of mass 3 500 kg is traveling eastwards at 28 $m.s^{-1}$ when it collides head on with a car traveling westwards at 120 $km.h^{-1}$. The mass of the car is 750 kg. After the collision, the two vehicles are so intertwined that the wreck moves together as one.

4.1 The Law of Conservation of Linear Momentum can be used to calculate the velocity of the wreck after the collision.
State the *Law of Conservation of Linear Momentum* in words. (2)

4.2 Calculate the velocity of the wreck immediately after the collision.
Ignore friction. (5)

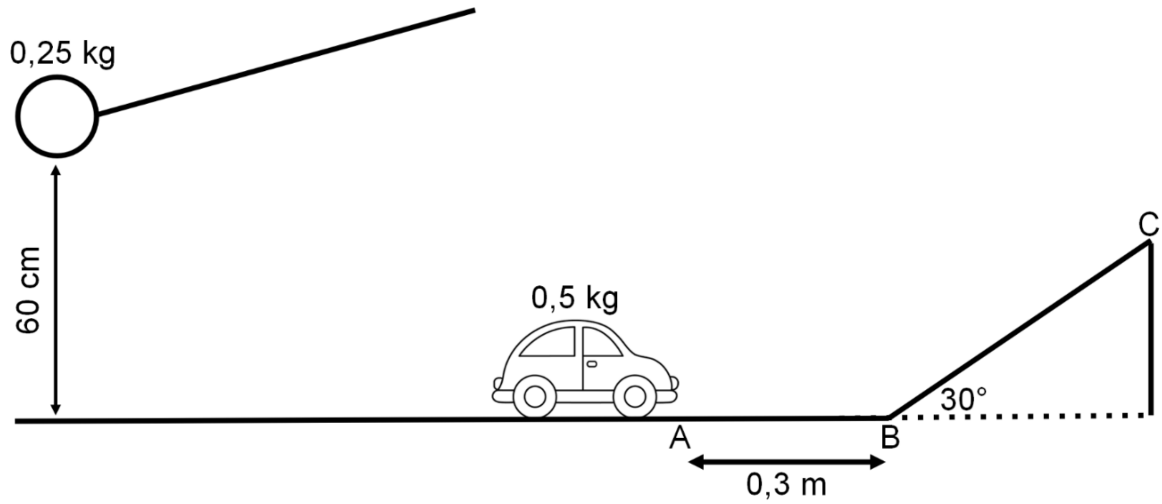
4.3 By using a calculation, determine whether the collision was elastic or inelastic. (6)

4.4 Calculate the magnitude of the impulse that the truck has on the car during the collision. (3)

[16]

QUESTION 5:

A plastic ball with mass 0,25 kg, joined to a frictionless, inextensible rope, is released from a height of 60 cm as shown in the diagram below. Ignore the effects of air resistance. The ball collides with a stationary toy car of mass 0,5 kg. After the collision, the ball immediately stops whilst the toy car moves to the right. Initially the toy car moves across a horizontal surface AB, which is 0,3 m long, before moving up a ramp BC inclined at 30° to the horizontal. A constant frictional force of 1,5 N acts on the toy car as it moves from A to C.

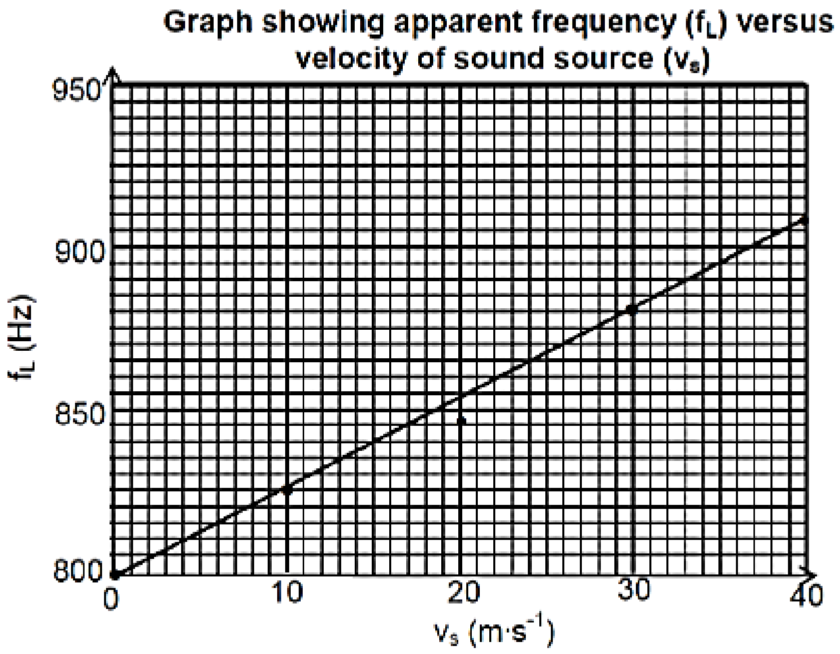


5.1	Calculate the kinetic energy of the ball just before it collides with the toy car.	(3)
5.2	The collision between the ball and the toy car is elastic. What is the kinetic energy of the car just after the collision?	(1)
5.3.1	State the *work-energy theorem* in words.	(2)
5.3.2	Use the work-energy theorem to calculate the speed of the toy car at point B.	(4)
5.4.1	Define the term *conservative force*.	(2)
5.4.2	Name the conservative force acting on the toy car as it moves up ramp BC.	(1)
5.4.3	**Use energy principles** to determine the length the ramp BC needs to be so that the car just stops at point C. Assume that the speed of the car at point B is 2 $m.s^{-1}$.	(6)
5.5	Calculate the power needed to raise the ball from horizontal surface AB back to its original height of 60 cm in 0,7 s.	(3)

[22]

QUESTION 6:

6.1 The graph below shows the relationship between the apparent frequency of the sound heard by a STATIONARY listener ($\mathbf{f_L}$) and the velocity of the source ($\mathbf{v_s}$) which is travelling TOWARDS the listener.



6.1.1 State the Doppler effect in words. (2)

6.1.2 Use the information in the graph above to calculate the speed of sound in air. (5)

6.1.3 Sketch a rough graph of apparent frequency ($\mathbf{f_L}$) versus velocity ($\mathbf{v_s}$) of the sound source if the source was moving AWAY from the listener. It is not necessary to use numerical values for the graph. (2)

6.2 The Doppler effect also has applications in light. Fully explain why a distant star's colour appears to be more orange than the yellow colour it actually emits. (3)

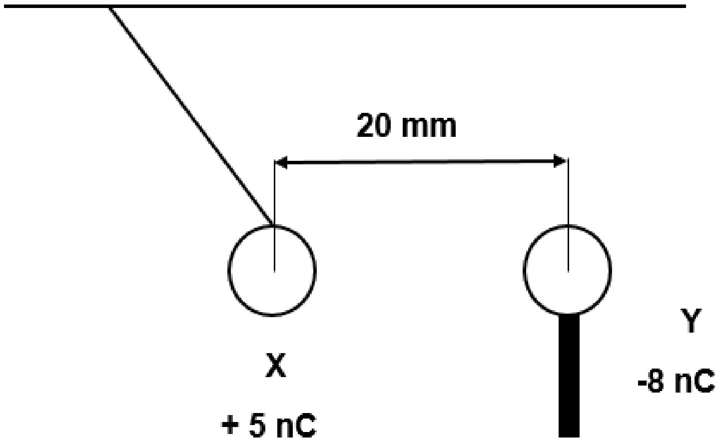
6.3 Name one medical application of the Doppler effect. (1)

6.4 Another application of the Doppler effect is radar speed trapping used by traffic control officers. Calculate the speed of a car, in $km.h^{-1}$, if the measured frequency is 8 GHz. The speed of a radar beam is the same as the speed of light, and the frequency of the radar beam leaving the radar gun is 7,999999 GHz.
(1 GHz = 10^9 Hz). (4)

[17]

QUESTION 7:

Sphere X, with charge of +5 nC, is hanging from the ceiling by a string. Sphere Y, with a charge of -8 nC, attracts sphere X to the right. Sphere X comes to rest 20 mm away from sphere Y as shown in the diagram below.

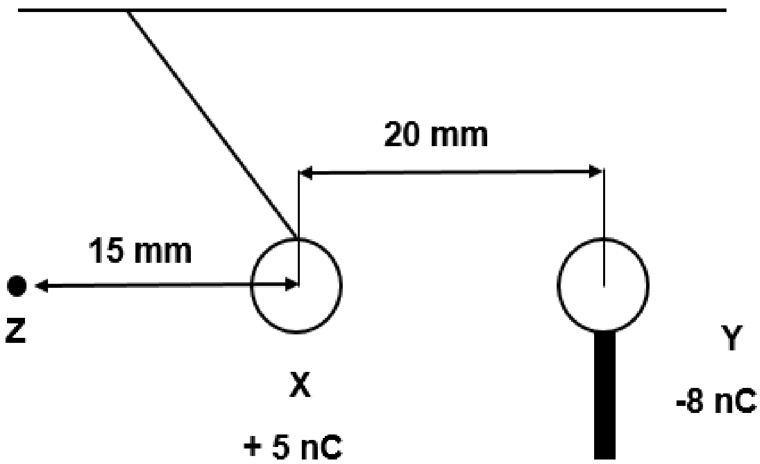


7.1 State *Coulomb's Law* in words. (2)

7.2 Draw the resultant electric field pattern produced by spheres X and Y. (3)

7.3 Calculate the magnitude of the electrostatic force that sphere X exerts of sphere Y. (4)

Z is a point 15 mm to the left of sphere X as indicated on the diagram below.



7.4 Calculate the net electric field at point Z. (5)

7.5 Calculate the magnitude of the force experienced by a sodium ion (Na^+) placed at point Z. (4)

[18]

QUESTION 8:

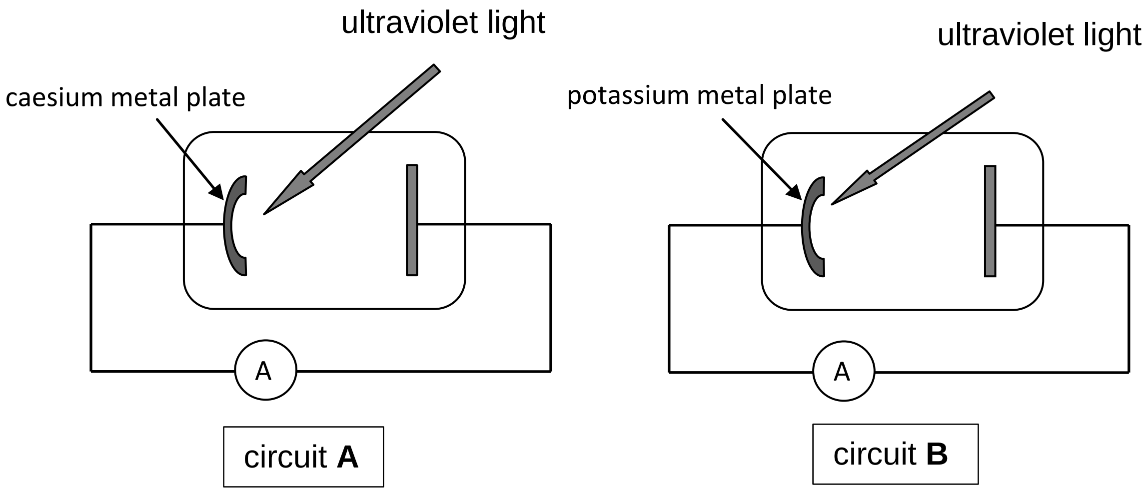
8.1 The threshold frequencies of caesium and potassium metals are given in the table below.

METAL	THRESHOLD FREQUENCY
Caesium	$5,07 \times 10^{14}$ Hz
Potassium	$5,55 \times 10^{14}$ Hz

8.1.1 Define the term *work function* in words. (2)

8.1.2 Which ONE of the two metals in the table has the higher work function? Give a reason for the answer by referring to the information in the table. (2)

The simplified diagrams below show two circuits, **A** and **B**, containing photocells. The photocell in circuit **A** contains a caesium metal plate, while the photocell in circuit **B** contains a potassium metal plate.



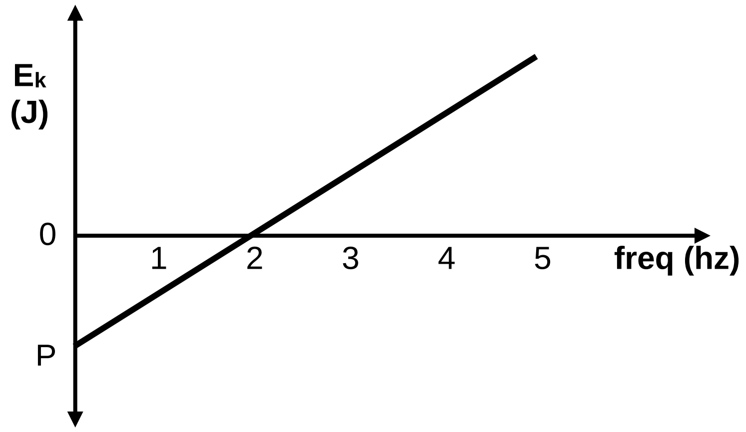
Ultraviolet light with the same intensity and wavelength of $5,5 \times 10^{-7}$ m is incident on the metal plate in EACH of the photocells and the ammeter in circuit **A** registers a current.

8.1.3 By means of a calculation, determine whether the ammeter in circuit **B** will also register a current. (3)

8.1.4 Calculate the maximum kinetic energy of an ejected electron in circuit **A**. (5)

8.1.5 How will the ammeter reading in circuit **A** change if intensity of the incident light increases?
Choose from: INCREASES, DECREASES or REMAINS THE SAME. (1)

8.2 A separate experiment is conducted to determine how the kinetic energy of the photoelectron is affected by the frequency of the radiation. The following graph is obtained:



8.2.1 What quantities can be determined from:

a) the x-axis intercept?

b) the y-axis intercept? (2)

8.2.2 Use the values in the graph to calculate the value of P. (3)

[18]

TOTAL SECTION B = [130]

GRAND TOTAL = [150]

Formula Sheet

Physical Constants:

Name	Symbol	Value
Acceleration due to gravity	g	$9{,}8\ m.s^{-2}$
Gravitational constant	G	$6{,}67 \times 10^{-11}\ N.m^2.kg^{-2}$
Speed of light in a vacuum	c	$3{,}0 \times 10^{8}\ m.s^{-1}$
Planck's constant	h	$6{,}63 \times 10^{-34}\ J.s$
Coulomb's constant	k	$9{,}0 \times 10^{9}\ N.m^2.C^{-2}$
Charge on electron	e	$-1{,}6 \times 10^{-19}\ C$
Electron mass	m_e	$9{,}11 \times 10^{-31}\ kg$

Formulae:

MOTION

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

FORCE

$F_{net} = ma$	$w = mg$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
$p = mv$	$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$

$F = G\frac{m_1 m_2}{r^2}$	$g = G\frac{M}{r^2}$

WORK, ENERGY AND POWER

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

WAVES, SOUND AND LIGHT

$v = f\lambda$	$T = \frac{1}{f}$
$E = hf$ or $E = \frac{hc}{\lambda}$	$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$
$E = W_0 + E_{k(max)}$ $E = hf$ and $W_0 = hf_0$ and $E_{k(max)} = \frac{1}{2}mv_{max}^2$	

ELECTROSTATICS

$F = \frac{kQ_1 Q_2}{r^2}$	$n = \frac{Q}{q_e}$
$E = \frac{F}{q}$	$E = \frac{kQ}{r^2}$