Pinelands High School

Excellence | Leadership | Innovation

NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES PAPER 1 (PHYSICS)

SEPTEMBER 2015

MARKS: 150
TIME: 3 hours

EXAMINER: A Reynolds
MODERATOR: N Davies

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

INSTRUCTIONS AND INFORMATION

1. Write your name on the first page of your RULED A4 PAPER.
2. This question paper consists of TEN questions. Answer ALL the questions on your RULED A4 PAPER.
3. Start EACH question on a NEW SIDE of your RULED A4 PAPER. Use BOTH sides of the page in order to avoid wasting paper.
4. Number the answers correctly according to the numbering system used in this question paper.
5. From QUESTION 2 onwards, leave ONE line between two subquestions, 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 SHEETS.
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.

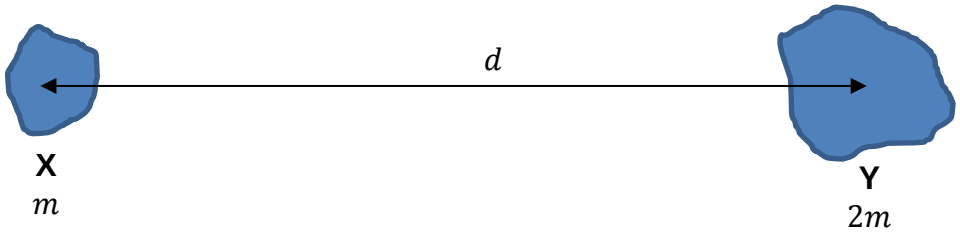
QUESTION 1: MULTIPLE CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A – D) next to the question number (1.1 – 1.10) on your RULED A4 PAPER, for example 1.11 D.

1.1 Four different learners were asked to state Newton's First Law of Motion. Which ONE of the following statements is most correct?

A "Objects resist changes to how they move because of their inertia."
B "Objects resist being in motion which is why they slow down."
C "Only if no forces act on an object will its motion remain constant."
D "Objects tend to remain at rest which is the property of inertia." (2)

1.2 Two asteroids (X and Y) are in deep space. X has mass m and Y has mass $2m$. The distance between their centres of mass is d. The gravitational force experienced by asteroid Y is F.



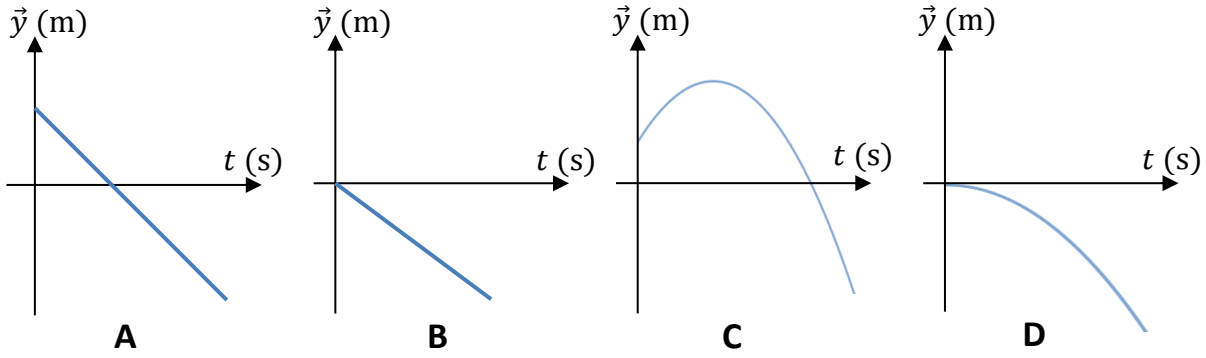
If the distance between the asteroids is halved, what is the force experienced by asteroid X in terms of F?

A $4F$
B $\frac{1}{4}F$
C $2F$
D $\frac{1}{2}F$ (2)

1.3 A ball of mass m is thrown towards a wall with speed v and it rebounds with the same speed v. If the force that the wall exerts on the ball during the collision is F, how long did the collision last?

A $\frac{F}{mv}$
B $\frac{F}{2mv}$
C $\frac{mv}{F}$
D $\frac{2mv}{F}$ (2)

1.4 A tourist travelling in a hot air balloon accidentally drops their wallet while the hot air balloon is rising at constant speed. Which ONE of the following graphs correctly shows the position of the wallet as a function of time relative to a stationary observer on the ground? Up has been taken as the positive direction.



1.5 An electric car is travelling at a constant speed. The _____ of the car must also be constant.

A momentum
B velocity
C kinetic energy
D mechanical energy (2)

1.6 The spectrum of a far off galaxy is observed to be red shifted. What does this mean about the shift in the *wavelength* of the spectral lines as well as the *direction of motion* of the galaxy relative to the Earth?

	Wavelengths of spectral lines	**Motion relative to the Earth**
A	longer	towards Earth
B	longer	away from Earth
C	shorter	towards Earth
D	shorter	away from Earth

(2)

1.7 Two charged metal spheres on insulated stands are brought into contact and then separated. The charge on Sphere 2 before the spheres touched was Q_2 and after they touched it was Q_f. What was the charge on Sphere 1 before the spheres touched?

A $2Q_f + Q_2$
B $2Q_f - Q_2$
C $\frac{Q_f + Q_2}{2}$
D $\frac{Q_f - Q_2}{2}$

(2)

1.8 Which ONE of the following is NOT a unit of energy?

A $\mathrm{N \cdot m^{-1}}$
B $\mathrm{kW \cdot h}$
C $\mathrm{W \cdot s}$
D $\mathrm{kg \cdot m^2 \cdot s^{-2}}$ (2)

1.9 Which of the following are properties of graphite that make it a suitable material to use as brushes in electrical motors and generators?

(i) small coefficient of friction (slippery)
(ii) electrical conductor
(iii) lustrous (shiny)
(iv) high melting point

A (i) and (ii) only
B (ii) only
C (i), (ii) and (iv)
D all of (i), (ii), (iii) and (iv) (2)

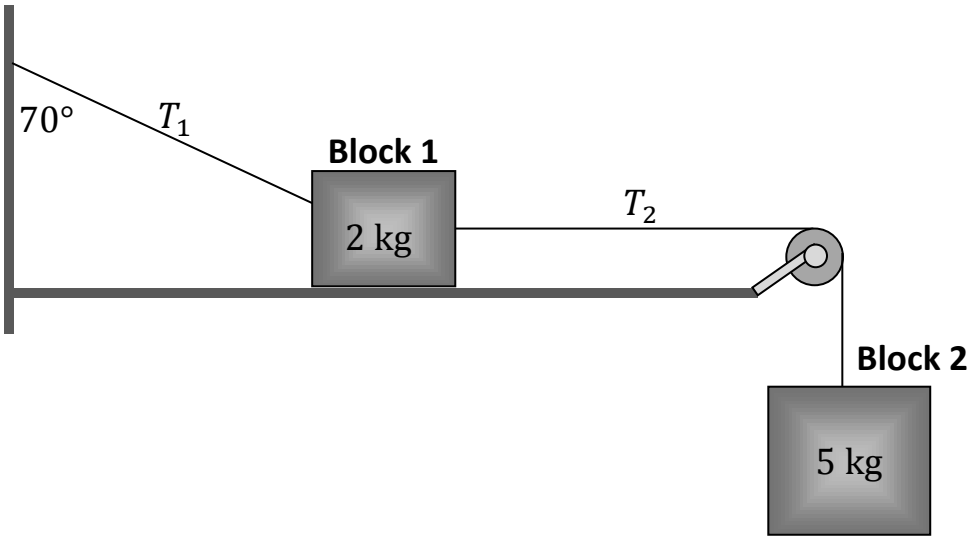
1.10 The photoelectric effect was an important piece of evidence that supports the model that light …

A … is a wave with energy proportional to intensity.
B … is a wave with energy proportional to frequency.
C … is a particle with energy proportional to intensity.
D … is a particle with energy proportional to frequency. (2)

[20]

QUESTION 2 (Start on a new side of a page.)

Two blocks of different mass are attached to each other via a light inextensible string which is placed over a massless and frictionless pulley. Block 1 (mass $2\ \text{kg}$) is placed on a smooth surface and attached to the wall by a second string which makes an angle of $70°$ to the vertical as shown in the diagram below. Block 2 (mass $5\ \text{kg}$) is left to hang freely. The entire system is in static equilibrium and all forms of friction can be ignored.



2.1 State *Newton's Second Law of Motion*. (3)

2.2 Draw a free body diagram showing all forces acting on the $2\ \text{kg}$ mass. Your diagram need not be perfectly to scale, but should clearly show the relative sizes and directions of the forces involved. (3)

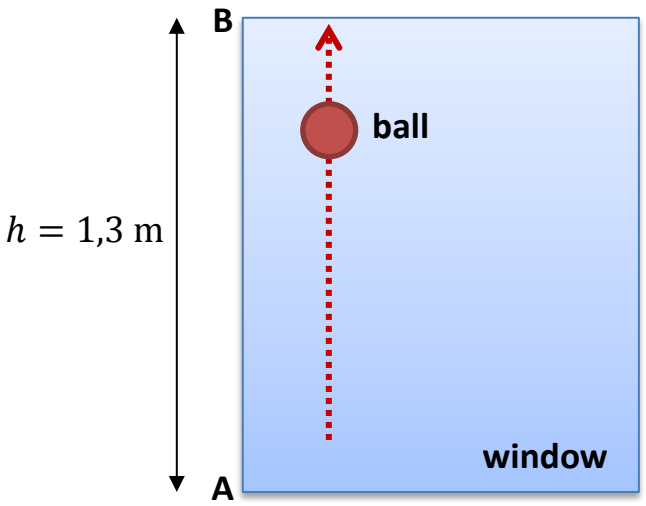
2.3 Determine the magnitude of the normal force exerted on the $2\ \text{kg}$ mass. (8)

[14]

QUESTION 3 (Start on a new side of a page.)

Eustacia is practicing fielding just outside a tall building. She throws a cricket vertically into the air as high as she can from $1{,}9\ \text{m}$ above the ground. Emily is watching from inside the building on the second floor and she sees the cricket ball fly up past the window.

The window has a height of $1{,}3\ \text{m}$ and the ball takes $0{,}08\ \text{s}$ to pass the window. The bottom edge of the window is $4{,}5\ \text{m}$ above the ground. Ignore air resistance.



3.1 Define what is meant by the term *free fall*. (1)

3.2 What is the direction of the force acting on the ball while it moves past the window? (1)

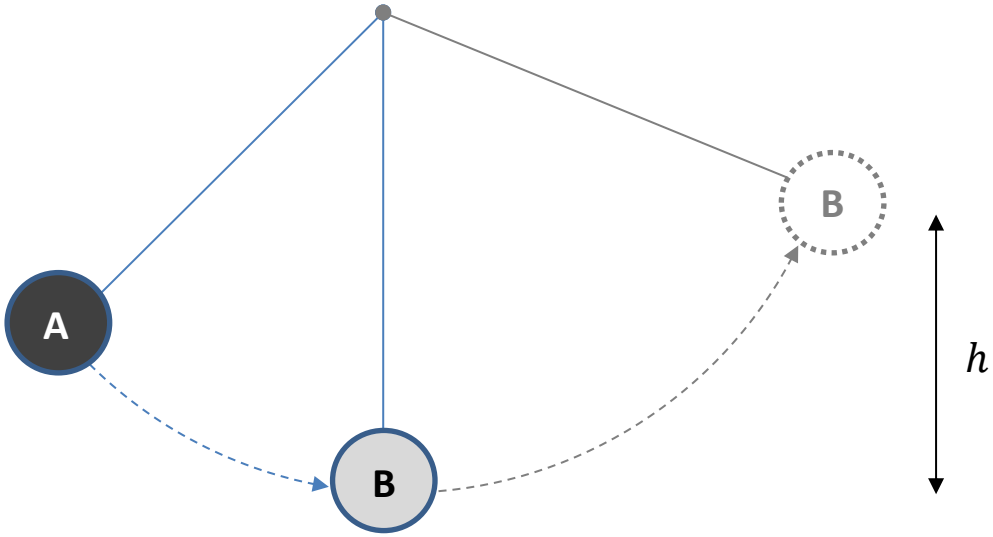
3.3 Determine the velocity of the ball just as it passes the bottom of the window on its way up (Point A in the diagram). (3)

3.4 Determine the height that the ball reaches above its point of release. (5)

[10]

QUESTION 4 (Start on a new side of a page.)

Farheen and Toshka design an experiment to investigate the collision between two pendula. Pendulum A has a mass of $0{,}80\ \text{kg}$ and Pendulum B has a mass of $0{,}65\ \text{kg}$. Pendulum A strikes Pendulum B with a speed of $4{,}5\ \text{m} \cdot \text{s}^{-1}$ and follows its original trajectory with a speed of $0{,}5\ \text{m} \cdot \text{s}^{-1}$ after the collision. Pendulum B is initially stationary and rises to a height h after the collision. Air resistance and friction between the pendulum and the pivot can be ignored.



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

4.2 Calculate the speed of Pendulum B immediately after the collision. (4)

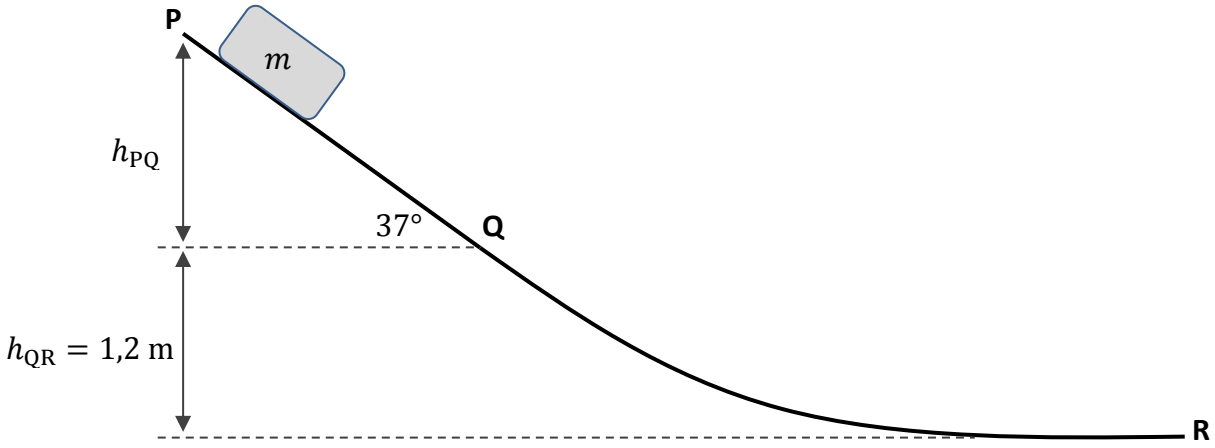
4.3 Perform a suitable calculation to show that the collision is inelastic. (5)

4.4 Determine the height h reached by Pendulum B after the collision. (4)

[15]

QUESTION 5 (Start on a new side of a page.)

A block of mass $25\ \text{kg}$ starts at rest at Point P and slides down a rough slope as shown in the diagram below. The slope is straight from P to Q and inclined at $37°$ to the horizontal. Section QR of the slope is curved and has a height of $1{,}2\ \text{m}$. The block experiences the same coefficient of kinetic friction with all parts of the slope.



5.1 The block travels a distance of $1{,}4\ \text{m}$ while sliding from P to Q. Just as the block passes Q it has a speed of $3{,}5\ \text{m} \cdot \text{s}^{-1}$.

5.1.1 Draw a free body diagram of all forces acting on the block while it is moving between P and Q. (3)

5.1.2 Show that the coefficient of kinetic friction between the block and the slope is $0{,}1946$. (7)

5.2 The block slides past Q and just comes to rest as it reaches R.

5.2.1 How does the kinetic frictional force experienced by the block change as it slides from Q to R? Consider only the motion before the block comes to rest at R. State only INCREASES, DECREASES or REMAINS THE SAME. (1)

5.2.2 Explain your answer to Question 5.2.1. (2)

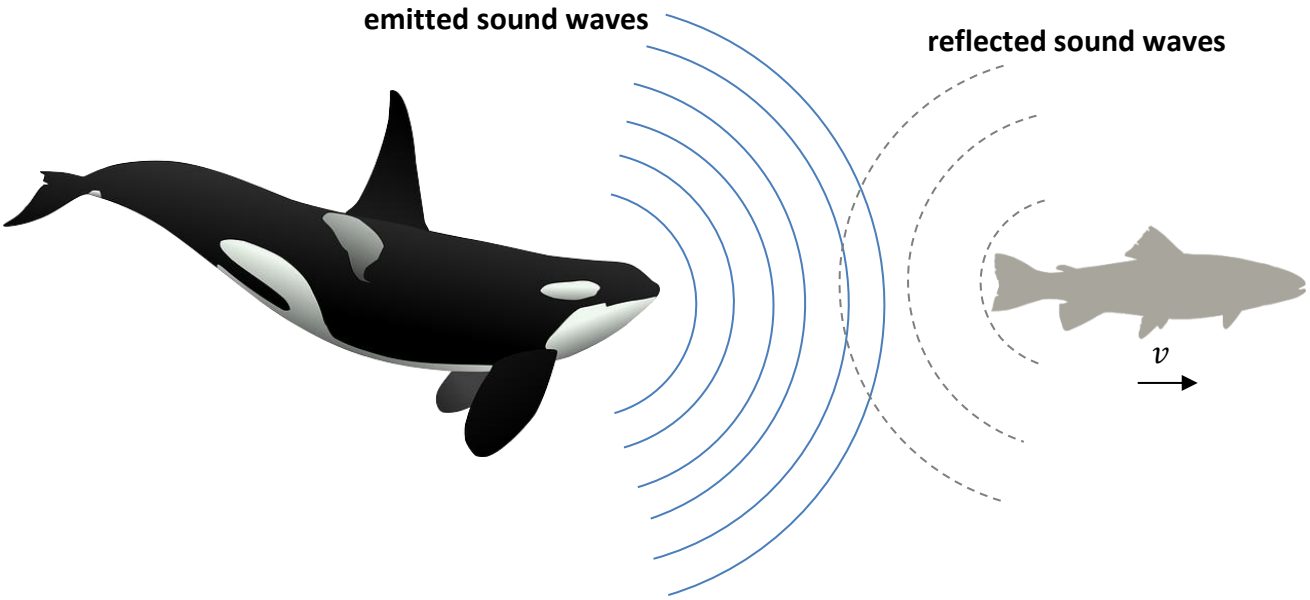
5.2.3 Is the mechanical energy of the block conserved while it slides from Q to R? Explain your answer by referring to the types of forces acting on the block. (2)

5.2.4 Determine the work done on the block by the kinetic frictional force while it slides from Q to R. (5)

[20]

QUESTION 6 (Start on a new side of a page.)

The killer whale (*Orcinus orca*) makes use of underwater sound for navigation, hunting prey and communication. The diagram below shows a particular killer whale sending out an ultrasound wave with a frequency of $50\ \text{kHz}$ towards a large sailfish which it is hunting.



The killer whale is stationary relative to the water when it sends out the ultrasound wave and receives the reflected sound waves from the moving fish. The reflected sound waves picked up by the killer whale have a frequency of $49{,}4\ \text{kHz}$.

Assume that sound travels in water with a speed of $1\ 560\ \text{m} \cdot \text{s}^{-1}$ and that the sailfish is moving at a constant speed relative to the water.

6.1 Name the phenomenon that the killer whale exploits to determine how fast the fish is swimming way from it. (1)

6.2 Determine the speed of the fish relative to the water to the nearest $\text{km} \cdot \text{h}^{-1}$. (6)

6.3 The killer whale remains stationary relative to the water and allows the fish to swim away. The killer whale continues to send out ultrasound waves at $50\ \text{kHz}$ in the direction of the fish.

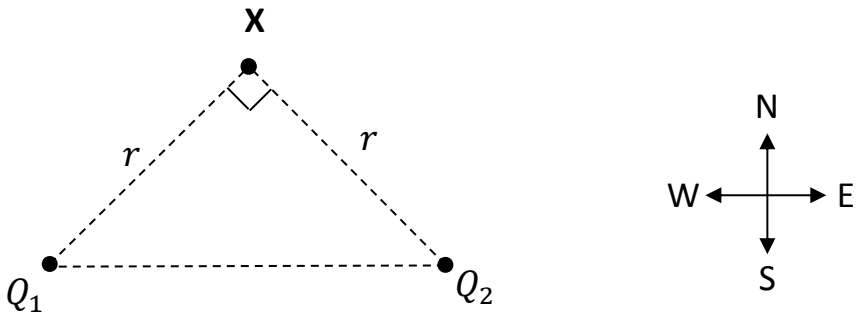
6.3.1 How will the frequency of the reflected waves picked up by the killer whale change as the fish swims away at constant speed? State only INCREASES, DECREASES or REMAINS THE SAME. (1)

6.3.2 Explain your answer to QUESTION 6.3.1. (2)

[10]

QUESTION 7 (Start on a new side of a page.)

Two charges are arranged as illustrated in the diagram below. Charge 1 has a charge of $+2\ \mu C$ and Charge 2 has a charge of $-2\ \mu C$. Position X is a point lying a distance r away from both charges such that the positions of the two charges and Position X form a right-angled triangle.



7.1 Define what is meant by the term *electric field at a point*. (2)

7.2 Draw the electric field pattern due to the two charges. Clearly show Position X in your diagram. (4)

7.3 Through the use of a labelled diagram, show that the magnitude of the net electric field at Position X is given by the following expression:

$$E_{\text{net,X}} = \frac{k}{r^2}\sqrt{Q_1^2 + Q_2^2}$$ (4)

7.4 Charge 3 has a charge of magnitude $6\ \mu C$. It is placed at Position X and it experiences an electrostatic force of $0{,}12\ N$ to the west.

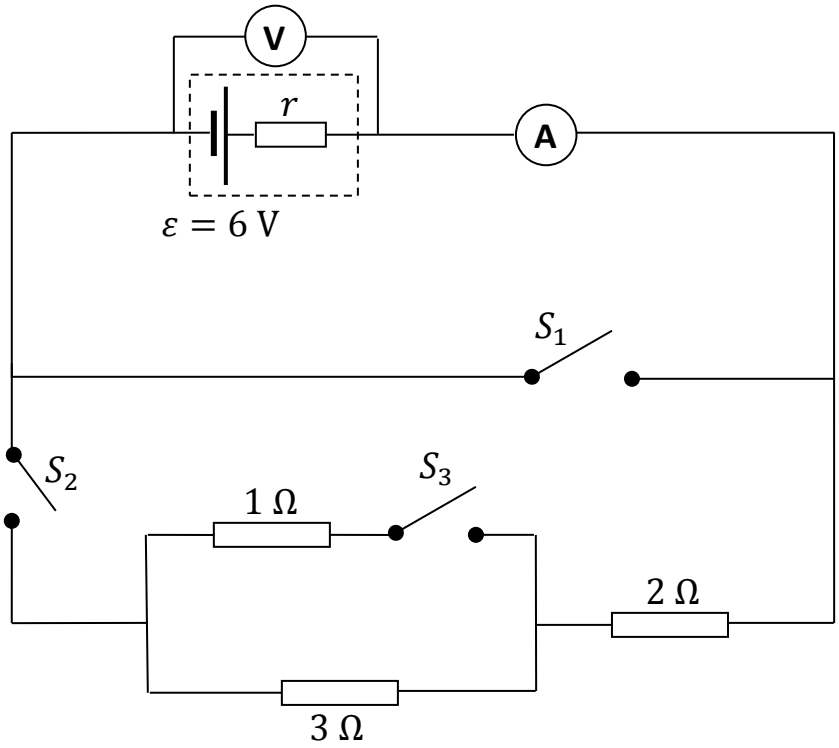
7.4.1 What is the sign of Charge 3? State only POSITIVE or NEGATIVE and provide an explanation for your answer. (3)

7.4.2 Determine the unknown distance r. (6)

[19]

QUESTION 8 (Start on a new side of a page.)

The circuit in the diagram below consists of three resistors connected as shown, a voltmeter, an ammeter, three switches and a battery of internal resistance r and with an emf of $6\ \text{V}$.



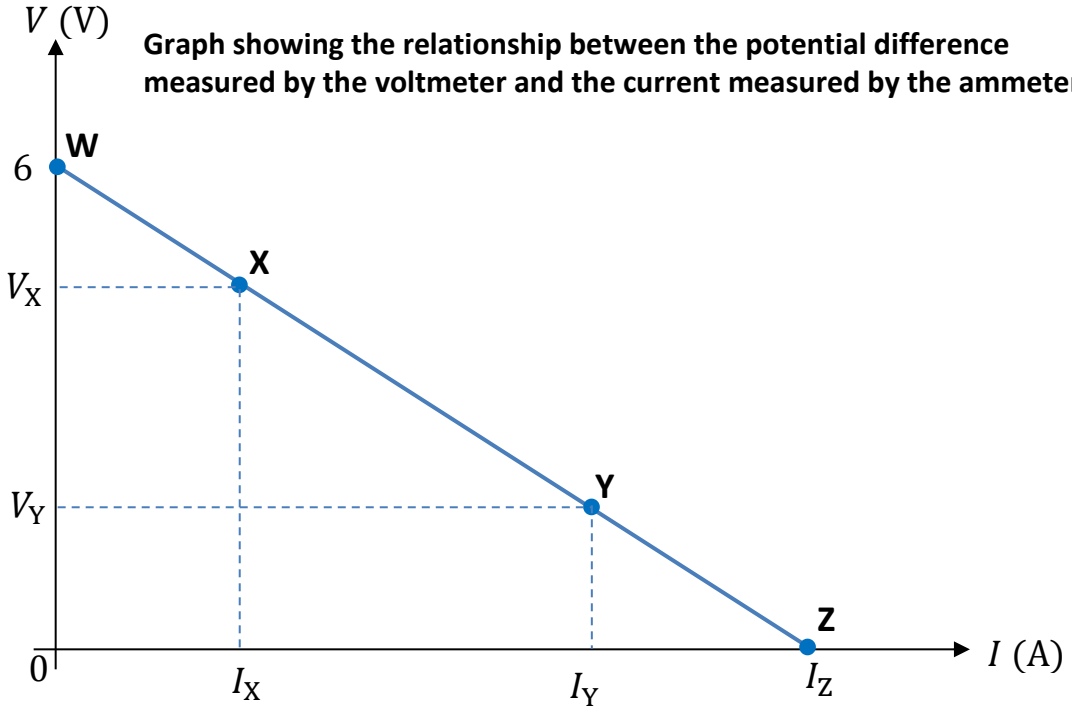
8.1 Explain what is meant by an emf of $6\ \text{V}$. Refer both to the conditions under which it is measured as well as the concepts of energy and charge. (4)

8.2 Explain what is meant by the term *internal resistance*. (2)

8.3 With switch S_2 closed and switch S_3 open, the reading on the ammeter is $1{,}091\ \text{A}$. Determine the internal resistance of the battery to the nearest decimal place. (4)

8.4 With switches S_2 and S_3 both closed, the reading on the ammeter is $1{,}846\ \text{A}$. Calculate the reading on the voltmeter. (3)

The graph below shows four plotted data points W, X, Y and Z obtained using the circuit in this question together with a line of best fit.



Graph showing the relationship between the potential difference measured by the voltmeter and the current measured by the ammeter.

8.5 Identify which of the switches (if any) need to be CLOSED in order to obtain:

8.5.1 Data point W. (1)

8.5.2 Data point X. (1)

8.5.3 Data point Y. (1)

8.5.4 Data point Z. (1)

8.6 Switch S_1 is replaced with a high-resistance strip of nichrome wire.

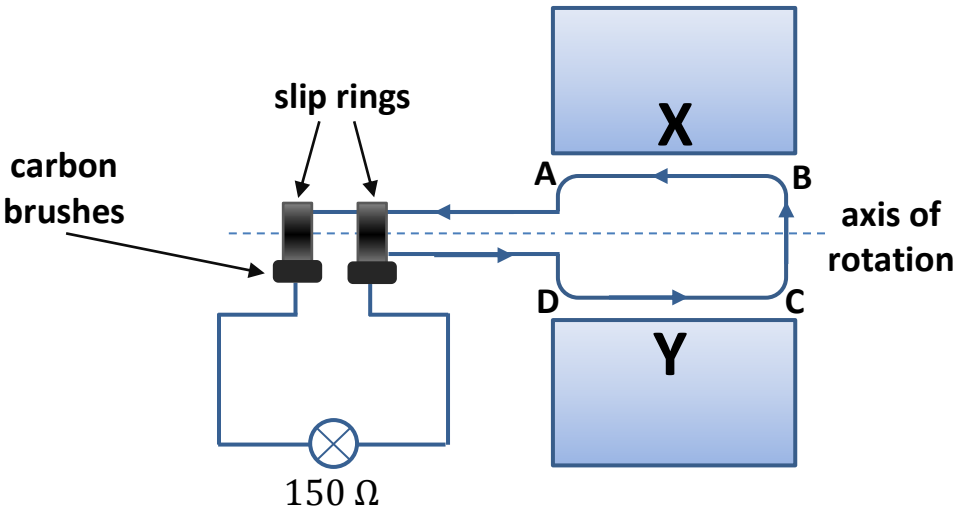
8.6.1 How will the temperature of the battery be affected? State only INCREASES, DECREASES or REMAINS THE SAME. (1)

8.6.2 Explain your answer to QUESTION 8.6.1. (3)

[21]

QUESTION 9 (Start on a new side of a page.)

The diagram below shows a schematic for a certain type of generator as seen from above. Study the diagram and answer the questions that follow.



9.1 Identify the specific type of generator illustrated in the diagram above. (1)

9.2 State the energy conversion that takes place inside a generator. (1)

9.3 When the coil is in the position shown in the diagram, it rotates such that side AB is rotating out of the page. Determine the polarity of the magnets marked X and Y. (1)

9.4 The maximum voltage induced by the generator is $120\ \text{V}$.

9.4.1 Draw a sketch graph of how the induced voltage changes over time. Indicate the maximum voltage on your graph. (2)

9.4.2 Determine the average power dissipated in the $150\ \Omega$ light bulb. (4)

[9]

QUESTION 10 (Start on a new side of a page.)

In an experiment involving the photoelectric effect, UV light is shone on a strip of zinc metal and photoelectrons are emitted. The frequency of the UV light used is above the threshold frequency. The work function of zinc is $6{,}928 \times 10^{-19}$ J.

10.1 Define the term *work function.* (2)

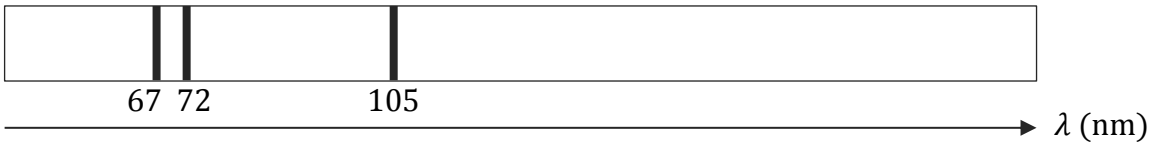
10.2 Calculate the threshold frequency for zinc. (3)

10.3 The UV light source is replaced with one of the same frequency, but a greater intensity.

10.3.1 How will the kinetic energy of the ejected electrons be affected by this change in light source? State only INCREASES, DECREASES or REMAINS THE SAME. (1)

10.3.2 Give a reason for your answer to QUESTION 10.3.1. (2)

10.4 The source of UV light used is an argon discharge tube. When its light is analysed the following line emission spectrum is observed.



In the diagram above dark lines indicate the wavelengths at which light was observed and the white area represents all the wavelengths of light which were not observed.

10.4.1 Which of the three spectral emission lines in the diagram above corresponds to the greatest energy? (1)

10.4.2 Explain the formation of the observed line emission spectrum. (2)

10.4.3 What would you expect the line *absorption* spectrum for argon to look like? (1)

[12]

TOTAL: 150

THE END