INSTRUCTIONS

1. This paper consists of TWO sections. Both sections are compulsory.

   • SECTION A                      (160 Marks)
     o Answer ALL questions
     o Spend about 14 minutes in Each question.
     o Write your Answers in the spaces provided in this booklet.

   • SECTION B                         (40 Marks)
     o There are 20 Multiple Choices worth 2 marks each.
     o Circle the letter of the best answer.
     o Spend about 35 minutes on this section.

2. There are 35 pages of this booklet plus the formula sheet and periodic table. There are two blank pages, check that you have all the pages.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

TOTAL MARKS 200
Siale is a bike rider. One morning she starts riding from rest and accelerates at 1.2 m s\(^{-2}\) for 14 seconds.

(a) Show that her final velocity after 14 seconds is 16.8 m s\(^{-1}\).

(b) She heads East at a constant speed of 16.8 m s\(^{-1}\), then turns left (heads North), without changing speed.

(b) Draw a vector diagram and use it to calculate the change in her velocity (size and direction).

Siale’s morning ride involves cycling up and down steep hills.

**GRAPH 1: Velocity – time graph for parts of Siale’s journey**
c. Describe the motion shown by the graph above in detail.

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(3 marks)

d. In section A, Siale cycles a distance of 100 m. In section B, she cycles a further 200 m and in section C she cycles a further 50 m. On the axes below, sketch the correctly shaped displacement-time graph for the three sections of Siale’s journey that are illustrated by the velocity-time graph (Graph 1).

(3 marks)

Graph 2: displacement-time graph for part of Siale’s journey

For a different part of the trip, the following is a velocity-time graph for Siale.

Graph 3: Velocity-time graph for part of Siale’s trip

(e. One section of the velocity-time graph for Siale shows acceleration. Calculate the value of the acceleration in that section.

(2 marks)

f. Use the graph to calculate the distance travelled by Siale in the last 30 seconds of the journey.

(2 marks)
Siale then takes her car and rides along a horizontal circular path at constant speed. The radius of the circular track is 28.0 m. It takes 12.0 s to go around the circular track once.

a. Calculate the speed and hence the acceleration of the car.

(3 marks)

b. Explain why the motion of the car would be affected if there was an oil patch on the circular path. (Assume that the oil causes complete loss of friction between the car wheels and the surface of the track.)

In your answer, you should include:

- Describe what it is that provides the force needed to keep the bike going in a circle. State the direction of this force.

- an explanation of the forces acting on the car while it is moving in a circle

- an explanation of the how the motion of the car is affected once it encounters the oil patch.

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Siale is back on her bike and cycles along a uniform bridge that is supported at both ends, as shown in the diagram.

The length of the bridge is 25 m. The mass of Siale and her bike is 72 kg. The mass of the bridge is 760 kg.

c. Draw arrows on the diagram to show the correct position and direction of the weights of Siale, the bridge and also the support forces $F_A$ and $F_B$. (4 marks)

d. Calculate the support force $F_A$ provided by end A and the support force $F_B$ provided by end B of the bridge when Siale is 5 m from end A.

i. $F_A$ (4 marks)

ii. $F_B$ (2 marks)
QUESTION THREE

While Siale is cycling at a speed of 16.8 ms\(^{-1}\), she collides with a soccer ball that is rolling towards her at a speed of 8 ms\(^{-1}\). The soccer ball bounces off in the opposite direction with a speed of 5 ms\(^{-1}\).

a. Calculate Siale’s velocity (size and direction) before and after the collision.

You may ignore any effect of friction.

- Mass of Siale and her bike = 72 kg
- Mass of soccer ball = 0.43 kg.

i. Before Collision

   (2 marks)

ii. After Collision

   (3 marks)

b. Explain what is meant by elastic collision.

   (1 mark)
c. If the soccer ball was in contact with Siale and her bike for 0.03 s, calculate the force of impact on the ball.

(3 marks)

Siale is taking a short water break. She throws a stone from the ground at an angle of 34° to the horizontal with a velocity of 25 ms⁻¹ as shown in the diagram below.

d. Calculate the initial horizontal velocity of the stone.

(2 marks)

e. Determine the time it takes the stone to reach its maximum height.

(3 marks)

f. What is the range of the stone?

____________________________________________________________________________

(1 mark)
QUESTION FOUR

(14 Marks)

Siale’s car is towed away by a tow truck. The rope attached to the car makes an angle of 42° with the horizontal. The rope pulls the car with a force of 850 N. The car moves a distance of 45 m along the horizontal road during a time of 15 s. See diagram below.

a. Calculate:

(i) the work done by the tow truck on the car.

(ii) the power produced by the tow truck while it is moving the car.

P.8

3
A weightlifter takes 2 seconds to lift 150 kg to a height of 2 metres from the ground. If friction is ignored and $g = 10 \, \text{ms}^{-2}$,

b. Calculate:

i. the gain in gravitational potential energy of the 150 kg mass.

(2 marks)

ii. the speed of the 150 kg mass when it hits the ground after being dropped from the height of 2 metres.

(2 marks)

c. A 0.5 kg mass hanging from the end of a spring extends the spring by 25 cm as shown in the diagram below. (use $g = 10 \, \text{ms}^{-2}$)

i. Calculate the potential energy stored in the spring, at an extension of 25 cm.

(3 marks)
A rubber balloon is filled to a volume of 1 litre (1 x 10⁻³ m³). The temperature inside the balloon is currently at 27°C. If the balloon is left in the sun for some time and its temperature rises to 47°C.

d. Find the new volume of the balloon. (Assume that the pressure remains the same.)

(3 marks)

e. Change 27°C to degree Kelvin.

(1 mark)
Siale is back at school and she is experimenting with some brine (salt water). She measured out 0.5 kg of brine into a beaker and froze it with a thermometer immersed in the brine. The beaker was then heated at a constant rate using a Bunsen burner. Siale measured the temperature at regular intervals. Siale plotted the following graph of her results.

a. Name the phase (state of matter) of the brine during section R of the graph.

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(1 mark)

b. For section S of the graph, explain what happens to the heat energy supplied in relation to the temperature and the phase of the contents of the beaker.

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(2 marks)

c. To melt the frozen brine, 170 kJ of energy is needed. Calculate the total amount of heat energy that would be needed to raise the temperature of 0.5 kg of frozen brine from -10°C to 110°C. The specific heat capacity of liquid brine is 3200 Jkg⁻¹(°C⁻¹).

(3 marks)
Siale uses a convex lens to project the image of a candle flame onto a screen.

d. Draw TWO appropriate rays on the diagram below to show where the clear image of the candle flame would be formed. Draw the image in the correct position.

(3 marks)

e. What are the nature of the image found in (a) above.

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(2 marks)

f. The candle flame is 2.0 cm high and 13.0 cm away from the lens. The focal length of the lens is 6.0 cm. Calculate the height of the candle flame's image.

(3 marks)
The diagram shows two different sorts of wave motions (A and B) carrying energy in the direction shown.

![Diagram of wave motions A and B]

**g.** Name the type of wave is represented by each:

- **A:** ________________________
- **B:** ________________________

(2 marks)

The diagram shows waves in the sea approaching the tip of a peninsula. The lines represent the crests of the waves. The water on the right hand side of the peninsula is calm.

![Diagram of waves approaching a peninsula]

**h.** Complete the diagram to show the pattern produced by the waves as they pass the tip of the peninsula.

(2 marks)
QUESTION SIX

Siale noticed a puddle of water with oil floating on top. The diagram below shows a ray of light travelling from air as it meets the air-oil interface.

![Diagram showing light path through air, oil, and water](image)

a. Complete the path of the ray of light in the above diagram to show what happens to the ray as it enters the oil, and then the water. (3 marks)

b. The ray of light meets the air-oil interface at an angle of incidence of 40°, as shown on the diagram above. Calculate the angle of refraction when the ray goes into the oil. (2 marks)

c. Calculate the critical angle of the oil-water interface. (2 marks)
The diagram below shows a ray of red light striking side A of a glass prism. The ray of light enters the prism and strikes the side B at an angle of incidence greater than the critical angle of glass in air. It then leaves the prism through the side C.

(d) On the diagram above, complete the path of the ray through the prism and show how it leaves the side C. (4 marks)

(e) What is the physical name for the phenomenon that is taking place at side B of the prism?

_______________________________________________ (1 mark)

(f) State the TWO conditions for the phenomenon named in (e) above.

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____________________________________________________________________________ (2 marks)

g. The ray of red light is now replaced by a ray of white light and a spectrum is observed at side C. What is the order of colours observed? Start with the colour that bends the least.

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____________________________________________________________________________ (2 marks)
Siale was then asked to design an interference experiment to measure the speed of sound. One of the windows of the laboratory faced out over the playing fields. Siale set the signal generator to a frequency of 2680 Hz, connected two speakers S1 and S2 as shown on the diagram below, and aimed the sound from them out of this window.

Siale’s friend walked along the line AB and marked the positions at which the sounds were loudest. From these marks, they estimated that the distance between adjacent positions of loud sound was 5.60 m.

The diagram (not to scale) shows the distances they used.

a. Explain why the sound the students heard varied in loudness.

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(3 marks)

b. Using information from the diagram, show that the students calculated the wavelength of sound to be 0.126 m.

(3 marks)

c. Use your answer for part b, to calculate the speed of sound.

(2 marks)
d. One of the labels on the loudspeaker reads ‘240V, 1200 W’, what is the maximum working current of this loudspeaker?

A display mirror is mounted on a sloped surface in a shop. Light from a lamp in the ceiling is incident on the mirror, as shown in the diagram below.

On the above diagram:

(i) Draw a normal at the point of incidence, and then draw an arrow to show the approximate path of the reflected ray.  

(ii) Label the angle of incidence and the angle of reflection.  

e. State the TWO Laws of reflection.
An experiment performed by Robert Millikan in 1909 determined the size of the charge on an electron. Millikan put a charge on a tiny drop of oil, and measured how strong an applied electric field had to be in order to stop the oil drop from falling. The diagram below shows a simplified version of the apparatus he used:

Millikan used x-rays to produce a negative charge on the oil drops.

a. Explain why the battery is connected as shown in the diagram.

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(2 marks)

b. In terms of forces, state the conditions necessary for the oil drop to be held stationary between the horizontal plates.

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(2 marks)

c. On one occasion, Millikan used an oil drop of mass $2.54 \times 10^{-5}$ kg with a charge of $3.6 \times 10^{-9}$ C. The plates were $4.8 \times 10^{-4}$ m apart. Calculate the voltage needed to hold the oil drop stationary between the two plates. Start by working out the weight force of the oil drop using $F_g = mg$ and $g = 9.8$ N kg$^{-1}$.

(4 marks)
Siale uses an electrostatic duster to clean an office. The electrostatic duster is designed to pick up dust particles easily from surfaces. The duster has fine nylon fibres attached to a stem, which is made of a non-conducting material.

d. While dusting a table, the fibres on the duster become positively charged. Describe what causes the fibres to become charged.

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(2 marks)

e. When Siale lifts the duster off the table surface she notices that the nylon fibre on the duster point away from each other, as shown in the diagram below. Explain why the nylon fibres on the duster point away from each other.

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(2 marks)

Siale has two light bulbs, the label on one of the light bulbs reads 12 V 5 W 28.8 Ω. The label on the second bulb reads 12 V 18 W 8 Ω. The two bulbs are connected in parallel to a 12 V power supply, as shown.

![Circuit Diagram]

f. Calculate the effective resistance of the circuit above.

(2 marks)

g. Calculate the energy transferred by the 18 W bulb if it is left on for 3 minutes.

(2 marks)
Siale connects three identical (12 V, 18 W, 8 Ω) lamps in series to a 12 V power supply. She notices that all three of them glow with the same brightness. Siale then reconnects the circuit, as shown in the diagram below.

a. Calculate the current drawn from the power source when the circuit is connected as shown in the circuit above (Lamp A in series with the source, Lamp B and Lamp C parallel to each other).

b. Discuss why Lamp A is brighter than Lamps B and C, even though they are all identical lamps (12 V, 18 W). You may use calculations to justify your answer.

c. Calculate the voltage across Lamp C.

d. Calculate the current through Lamp C.
The diagram below shows a metal rod that is free to roll along, across two parallel metal rails. The rails and the rod are in a magnetic field that is directed into the page. The ends of the rails are connected to a 12.0 V power supply.

e. State and explain what happens to the metal rod when the power supply is switched on.

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(2 marks)

f. Calculate the electromagnetic force experienced by the metal rod when the power supply is switched on.

**You are given the following information:**
- Strength of magnetic field = 0.85 × 10⁻³ T
- Length of metal rod = 25.0 × 10⁻² m
- Distance between parallel metal rails = 18.5 × 10⁻² m
- Resistance of wires, rails and rod = 35.4 Ω
- Voltage of power supply = 12.0 V

(2 marks)
The power supply is removed and a wire is connected to the metal rails. The metal rod is given a gentle push so that it rolls freely to the right, as shown in the diagram. The magnetic field is still directed into the page.

g. Calculate the voltage induced across the metal rod as it moves through the magnetic field.

You are given the following information:
- Strength of magnetic field = $0.85 \times 10^{-3}$ T
- Length of metal rod = $25.0 \times 10^{-2}$ m
- Distance between parallel metal rails = $18.5 \times 10^{-2}$ m
- Speed of metal rod = $2.5$ m s$^{-1}$

(2 marks)

h. State the direction of the induced current. Explain your answer.

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(2 marks)
QUESTION TEN  

A paint droplet with a charge of $-4.8 \times 10^{-13}$ C is moving at 12.1 ms$^{-1}$ through the earth’s magnetic field as shown in the diagram below. The earth’s magnetic field is perpendicular to the paint droplet’s velocity and has strength of 0.071 mT.

a. State the direction of the force acting on the paint droplet as it enters the magnetic field.

b. Carefully draw on the diagram above the path of the oil droplet as it moves through the earth’s magnetic field.

c. Calculate the size of the force acting on the paint droplet.
Geiger and Marsden performed a series of experiments under the direction of Ernest Rutherford which led to a new model of the atom.

d. For each of the conclusions given below, state which observation from the experiment provides evidence that:

(i) Most of the mass of the atom is concentrated in a tiny region which Rutherford called the nucleus.

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(1 mark)

(ii) The nucleus is positively charged.

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(1 mark)

The Technetium 99 decays by emitting low energy beta particles.

e. Describe TWO important differences between the gamma emission and the beta emission.

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(2 marks)
The half life of Technetium 99 m is 6 hours.

12 mg \((12 \times 10^{-3} \text{ g})\) of Technetium 99 m is injected into a patient and starts to decay into Technetium 99.

f. Calculate the amount of Technetium 99 m present in the patient after 24 hours.

\[
\frac{12 \times 10^{-3}}{2^4} = \frac{12 \times 10^{-3}}{16} = 0.75 \times 10^{-3} \text{ g}
\]

(g) Complete the equation showing alpha decay for radium-226.

\[
{}^{226}_{88}\text{Ra} \rightarrow \ldots \text{Rn} + \alpha
\]

(h) The frequency of a photon will have to be more than the threshold frequency if an electron is to be released. Discuss this statement in terms of the underlying physical principles.

...
1. A marble rolls off a 1.0 m high horizontal table with an initial velocity of 4.0 m s⁻¹. How long will it take the marble to hit the floor?
   (A) 0.20 s  
   (B) 0.25 s  
   (C) 0.45 s  
   (D) 3.20 s

2. When photons with energy \( E \) strike a metal surface, electrons may be emitted. The maximum kinetic energy \( E_k \) of the electrons is given by \( E_k = E - W \) where \( W \) is a constant for the metal. Which of the following graphs shows the relationship between the maximum kinetic energy of these electrons and the wavelength of the photons (\( \lambda \)).

3. An electric motor is constructed using a square coil and a uniform magnetic field of strength 0.45 T. The coil has 3 turns and sides of 10 cm. A current of 0.5 A flows through the coil. What is the maximum torque experienced by the coil as it rotates?
   (A) \( 2.25 \times 10^{-3} \text{ Nm} \)  
   (B) \( 6.75 \times 10^{-3} \text{ Nm} \)  
   (C) 22.5 Nm  
   (D) 67.5 Nm
4. The diagram shows a model of a transformer in a circuit.

Which of the following correctly identifies Part 1 and Part 2 and the function of this transformer?

<table>
<thead>
<tr>
<th>Part 1</th>
<th>Part 2</th>
<th>Function of transformer</th>
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<tbody>
<tr>
<td>(A) Primary coil</td>
<td>Secondary coil</td>
<td>Step-up</td>
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<tr>
<td>(B) Secondary coil</td>
<td>Primary coil</td>
<td>Step-down</td>
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<tr>
<td>(C) Primary coil</td>
<td>Secondary coil</td>
<td>Step-down</td>
</tr>
<tr>
<td>(D) Secondary coil</td>
<td>Primary coil</td>
<td>Step-up</td>
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</tbody>
</table>

5. A charged particle, q, enters a uniform magnetic field B at velocity v. The particle follows a circular path of radius r as shown.

If the magnitude of the magnetic field was doubled and the other variables were kept constant, what would the new radius be?

(A) \( \frac{r}{4} \)

(B) \( \frac{r}{2} \)

(C) 2r

(D) 4r
6. The diagrams show possible ways to connect the coils and rotor of a DC motor to a DC power supply. In which circuit will the rotor turn in a clockwise direction?

7. A ball was thrown upward at an angle of 45°. It landed at the same height as thrown. Which graph best represents the kinetic energy of the ball during its time of flight?
8. An object is placed in front of a concave mirror. The arrangement is shown below.

If a real image is formed at the same position as that of the object, the position of the object is:

(A) at C.
(B) at F.
(C) beyond C.
(D) between C and F.

9. The diagram shows a wave passing through the gap in a barrier. The pattern produced by the wave after passing through the barrier is shown

This property of waves is called _____________.

(A) Diffraction
(B) Dispersion
(C) Refraction
(D) Diffusion
10. A force of 10 Newtons acts on a 4 kg body which is at rest. The acceleration produced on the body is

(A) 0.4 ms$^{-2}$
(B) 2.5 ms$^{-2}$
(C) 3 ms$^{-2}$
(D) 40 ms$^{-2}$

11. Two masses of 3 kg and 6 kg are separated by a distance of 2 m as shown in the diagram.

If the force of attraction on the 3 kg mass is 10 Newtons, what is the force of attraction on the 6 kg mass?

(A) 2.5
(B) 5
(C) 10
(D) 20

12. A brown matured coconut has a mass of 2 kg and is hanging 25 metres above the ground. What is its gravitational potential energy with respect to the ground? (Take $g = 10 \text{ m/s}^2$)

(A) 500 J
(B) 250 J
(C) 50 J
(D) 20 J

13. The earth receives heat and light from the sun every day. The method of heat transmission from the earth is known as

(A) conduction.
(B) convection.
(C) diffusion.
(D) radiation.

14. A water wave has an amplitude of 2 m. It is travelling to the right at 80 m$^{-1}$ with a frequency of 20 Hz. Calculate the wavelength of the wave.

(A) 2 m
(B) 4 m
(C) 0.4 m
(D) 1,600 m
15. What is the frequency of a photon whose energy is $3.8 \times 10^{-26}$ Joule?  
\[ (h = 6.63 \times 10^{-34}\text{Js}) \]

- (A) $2.5 \times 10^{-59}$ Hz  
- (B) $5.7 \times 10^7$ Hz  
- (C) $1.7 \times 10^{-10}$ Hz  
- (D) $5.7 \times 10^{57}$ Hz

16. The diagram below represents shallow water waves of constant wavelength passing through two small openings, A and B, in a barrier.

Which statement best describes the interference at the point marked with the solid dot?

- (A) It is destructive with shorter wavelengths.  
- (B) It is destructive with smaller amplitude.  
- (C) It is constructive with longer wavelengths.  
- (D) It is constructive with larger amplitude.

17. As light travels from one medium to another, which of the following does not change?

- (A) Its velocity.  
- (B) Its frequency.  
- (C) Its wavelength.  
- (D) Its momentum.

18. Four forces are applied to an object as shown below.

What is the magnitude of the resultant force?

- (A) 2.0 N  
- (B) 2.8 N  
- (C) 4.0 N  
- (D) 5.6 N
19. The diagram below shows a current $I$ in a conductor directed as shown. A small positive charge $+q$ is observed at $P$ to be moving at a horizontal velocity $v$ away from the conductor.

Which one of these arrows best gives the direction of the magnetic force on the moving charge $+q$ at this instant?

(A) ↑ (into page)  
(B) ↓ (out of page)  
(C) → (right)  
(D) ← (left)

20. A 1 kg mass moves to the right and makes a glancing collision with a stationary 4 kg mass. After the collision the 4 kg mass is observed to move in a direction perpendicular to the path of the 1 kg mass as shown below.

Which vector best represents the total momentum of the masses after collision?

A.  
B.  
C.  
D. →
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<thead>
<tr>
<th>PARTS</th>
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<tbody>
<tr>
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