1. A balloon is filled with air and is attached to a puck. It releases air through a hole at the bottom of the puck. The balloon puck then moves on a horizontal straight track (see Figure 1) and its velocity-time graph is shown in Figure 2.

(a)  
(i) Describe the motion of the balloon puck from time $t = 0$ to $1.4 \text{ s}$.  
(2 marks)

(ii) Explain why the motion of the balloon puck changes at $t = 1.0 \text{ s}$.  
(2 marks)

(b) If the balloon is filled with less air and its initial velocity is still $0.5 \text{ m s}^{-1}$, sketch the corresponding velocity-time graph of the balloon puck in Figure 2.  
(2 marks)
2. Figure 3 shows Player X trying to block the ball from Player Y in a volleyball game. Standing on the ground with his arms fully stretched upwards, Player X’s hands are 2.25 m above the ground. In order to block the ball, Player X has to jump up such that his hands reach a height of 3 m.

\[ \text{Figure 3} \]

*(a) Using Newton’s laws of motion, explain why Player X in Figure 3 can gain an initial speed to leave the ground vertically.

(4 marks)
(b) Player X jumps up vertically and his hands can just reach a height of 3 m. Estimate the initial speed of Player X at the instant he leaves the ground. Assume that air resistance is negligible. 

(2 marks)

(c) Player Z is a teammate of Player X. His hands can also reach a height of 2.25 m when his arms are fully stretched upwards, but he is heavier than Player X. If he jumps up such that his hands just reach a height of 3 m, explain whether the initial vertical speed of Player Z will be the same as Player X.

(2 marks)
3. Read the following passage about thermal flasks and answer the questions that follow.

**Working principles of thermal flasks**

Thermal flasks are used to store hot liquids and can keep them warm for a period of time. Insulating by foam and insulating by vacuum are two common ways of making thermal flasks.

For a thermal flask applying insulation by foam, a layer of foam is used to wrap the container (see Figure 4). Both the foam and the air trapped inside the foam are poor conductors of heat. Also, the air inside the foam is broken into many tiny bubbles, which reduce convection of air inside the foam. Heat transfer through foam is therefore pretty slow.

For a thermal flask applying insulation by vacuum, there is a vacuum between the double glass walls of the container (see Figure 5). The heat insulation of vacuum is better than that of foam. Furthermore, the inner surface of walls of the glass container is painted silvery to reduce heat transfer. As glass is fragile, the glass container is protected by an outer case with an insulated support.

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**Figure 4**

*Diagram showing a thermal flask with foam insulation.*

**Figure 5**

*Diagram showing a thermal flask with vacuum insulation.*

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(a) Explain how the foam reduces heat transfer by conduction and convection. (2 marks)

(b) Explain why the heat insulation of vacuum between the double glass walls is better than that of foam. (2 marks)

(c) State ONE design in the vacuum flask shown in Figure 5 that helps to reduce heat loss by radiation. (1 mark)

(d) Can a thermal flask also store cold liquids and keep them cold for a period of time? Explain your answer. (2 marks)
4. Karen puts 0.12 kg of water at room temperature $T_1$ into the freezer of a refrigerator to make ice cubes. The cooling curve of the water is shown in Figure 6.

Given: specific latent heat of fusion of ice $= 3.34 \times 10^5$ J kg$^{-1}$

Temperature / °C

- $T_1$
- $T_2$
- $T_3$

Time / minute

**Figure 6**

(a) State the physical meaning of temperature $T_2$. 

(1 mark)

(b) Find the latent heat released in the above process. 

(2 marks)
(c) If an ice cube from the freezer is placed at room temperature $T_1$, sketch a graph to show the expected change in temperature of the ice cube in Figure 7.

Temperature / °C

$T_1$

$T_2$

$T_3$

Time / minute

Figure 7
5. Figure 8 shows a playground after raining. Images can be seen on the calm water surface of the wet ground.

![Image of a playground after raining showing images on the water surface.](image)

**Figure 8**

(a) Explain why images can be seen on the calm water surface. 

(b) Figure 9 shows an object $AB$ above the water surface $PQ$.

![Diagram of an object $AB$ above a water surface $PQ$ showing reflected rays and image.](image)

**Figure 9**

In Figure 9,

(i) draw the reflected rays of the incident rays $x$ and $y$;

(ii) hence, draw the image of $AB$. 

(4 marks)
6. John wants to find out the time he takes to run 100 metres. A starter at the starting point uses a horn to emit a sound signal of frequency 425 Hz to notify John to start running. A time keeper presses a stop watch to record the time when he hears the sound signal (see Figure 10). Given that the speed of sound in air is $340 \text{ m s}^{-1}$.

![Diagram](image.png)

**Figure 10**

(a) Find the wavelength of the sound signal emitted by the horn. (2 marks)

(b) (i) Find the time $t$ taken by the sound signal to travel 100 metres. (1 mark)

(ii) As it takes time $t$ for the sound signal to travel from the starter to the time keeper, David suggests the following ways to reduce the time delay $t$:

1. using a horn emitting sound of higher frequency;
2. lowering a flag instead of using a horn to notify the time keeper.

Explain whether each of the above suggestions will work. (4 marks)
7. A teacher conducts an experiment to study the energy conversion of a filament light bulb. A simple circuit is connected (see Figure 11) and the bulb is immersed into 0.09 kg of oil inside a foam cup (see Figure 12). The bulb is lighted up for 300 s, and the temperature of the oil is increased from 20 °C to 42 °C.

![Figure 11](image1.png)

![Figure 12](image2.png)

In the experiment, the ammeter and voltmeter readings are 1.4 A and 12 V respectively. The specific heat capacity of the oil is 2100 J kg\(^{-1}\) °C\(^{-1}\).

(a) Calculate the energy absorbed by the oil. (2 marks)
(b) Describe the energy conversion when a current passes through the filament light bulb. (1 mark)

(c) (i) Estimate the amount of energy that is converted into light energy in the experiment, and state ONE assumption made in your calculation. (4 marks)

(ii) Hence, determine the percentage of electrical energy consumed by the filament light bulb that is converted into light energy. (2 marks)
8. In a physics lesson, a teacher uses the apparatus shown in Figure 13 to find the range of α particles in the air. Describe the procedures of the experiment.

α source with a holder

counter (for measuring count rate)

GM tube

metre rule

Figure 13

(5 marks)
8. In a physics lesson, a teacher uses the apparatus shown in Figure 13 to find the range of α particles in the air. Describe the procedures of the experiment.

Figure 13

(5 marks)
Section B (36 marks)

Answer ALL questions in this section and write your answers in the spaces provided in this Question-Answer Book.

<table>
<thead>
<tr>
<th>Question No.</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
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<tr>
<td>Marks</td>
<td>9</td>
<td>6</td>
<td>13</td>
<td>8</td>
</tr>
</tbody>
</table>

9. A golf ball, of mass 40 g and initially at rest, is struck with a club in teeing off (see Figure 14). The ball leaves the club with a speed of 44 m s\(^{-1}\). Assume that air resistance is negligible.

![Figure 14](image)

(a) (i) Calculate the change in momentum of the golf ball before and after teeing off. (2 marks)

(ii) The time of impact between the club and the ball during teeing off is 1 ms. Determine the average force acting on the ball during the impact. (2 marks)
(b) Robert finds that the club is harder than the golf ball. He claims that the force exerted on the club is smaller than that exerted on the golf ball during teeing off. Explain whether his claim is correct or not.

(2 marks)

(c) When the golf ball is 2.5 m away from the hole, it is given a sharp horizontal push from rest and just reaches the hole (see Figure 15). Estimate the initial speed of the golf ball if the average resistive force exerted on the ball is 0.03 N.

Figure 15

(3 marks)
10.

In Figure 16, two identical loudspeakers $P$ and $Q$ are connected to a signal generator. Position $A$ is the midpoint of $PQ$. A microphone connected to a CRO is moved along $BC$ to measure the loudness of the sound. The amplitude of the CRO trace increases as the loudness of the sound detected increases. Figure 17 shows the result.

![Diagram](Image)

**Figure 16**

![Graph](Image)

**Figure 17**

(a) (i) Explain why the loudness of the sound varies at different positions along $BC$. (2 marks)

____________________________________________________________________________________

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____________________________________________________________________________________
(a) (ii) State ONE reason why the amplitude of the CRO trace is NOT zero at position X. (1 mark)

(b) If $PY = 5.10\, \text{m}$ and $QY = 5.78\, \text{m}$, find

(i) the path difference at position $Y$ from $P$ and $Q$; (1 mark)

(ii) the wavelength of the sound. (2 marks)
11. A copper rod $PQ$ is hung at rest by insulating threads in a uniform magnetic field pointing into the paper (see Figure 18). The other ends of the threads are connected to a spring balance fixed on the ceiling. The two contacts $P$ and $Q$ at the ends of the copper rod can slide smoothly along two fixed vertical conducting rails $AB$ and $CD$. The rails $AB$ and $CD$ are connected to the positive and the negative terminals of a d.c. power supply respectively. As a result, a current $I$ passes through the copper rod.

Assume that the copper rod always remains horizontal and does not leave the magnetic field throughout the experiment.

![Diagram of copper rod with magnetic field and spring balance]

**Figure 18**

(a) (i) In Figure 18, indicate the direction of the force $F$ acting on the copper rod due to the current passing from $P$ to $Q$.

(1 mark)

(ii) Suggest THREE methods to increase the force $F$.

(3 marks)

(iii) Express the magnitude of force $F$ in terms of the reading $R$ of the spring balance and the weight $W$ of the copper rod.

(1 mark)
(b) A teacher conducts an experiment with the setup in Figure 18 to find out how the reading $R$ of the spring balance changes with the current $I$. Table 2 shows the data collected.

<table>
<thead>
<tr>
<th>$R$ (N)</th>
<th>1.4</th>
<th>1.1</th>
<th>0.8</th>
<th>0.5</th>
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<tbody>
<tr>
<td>$I$ (A)</td>
<td>0.0</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Table 2

(i) Plot a graph of $R$ against $I$ in Figure 19. A scale of 1 cm representing 0.25 N and 0.25 A is used.

(4 marks)

![Figure 19]

(ii) Find the weight of the copper rod.

(1 mark)

(iii) Find the maximum value of $I$ such that the insulating threads remain taut.

(1 mark)

(iv) If the experiment is repeated with a heavier copper rod, sketch a graph of $R$ against $I$ you would expect to obtain in Figure 19, and label it as $L$.

(2 marks)
12. Figure 20 shows a setup to generate electricity. A magnet is set into rotation between two fixed solenoids. The output terminals $X$ and $Y$ are connected to a light bulb.

![Figure 20](image)

*(a) Explain how alternating current is generated in the above setup.*

(4 marks)
(b) The bulb is now removed from the setup. \( X \) and \( Y \) are then connected to the primary coil of a transformer. The secondary voltage output of the transformer is found to be 12 V. If the turns ratio of the primary coil to the secondary coil is 1 : 8, find the primary voltage.

(2 marks)

(c) State the advantages of using
(i) a.c. and
(ii) high voltages
for long distance power transmission.

(2 marks)

END OF PAPER