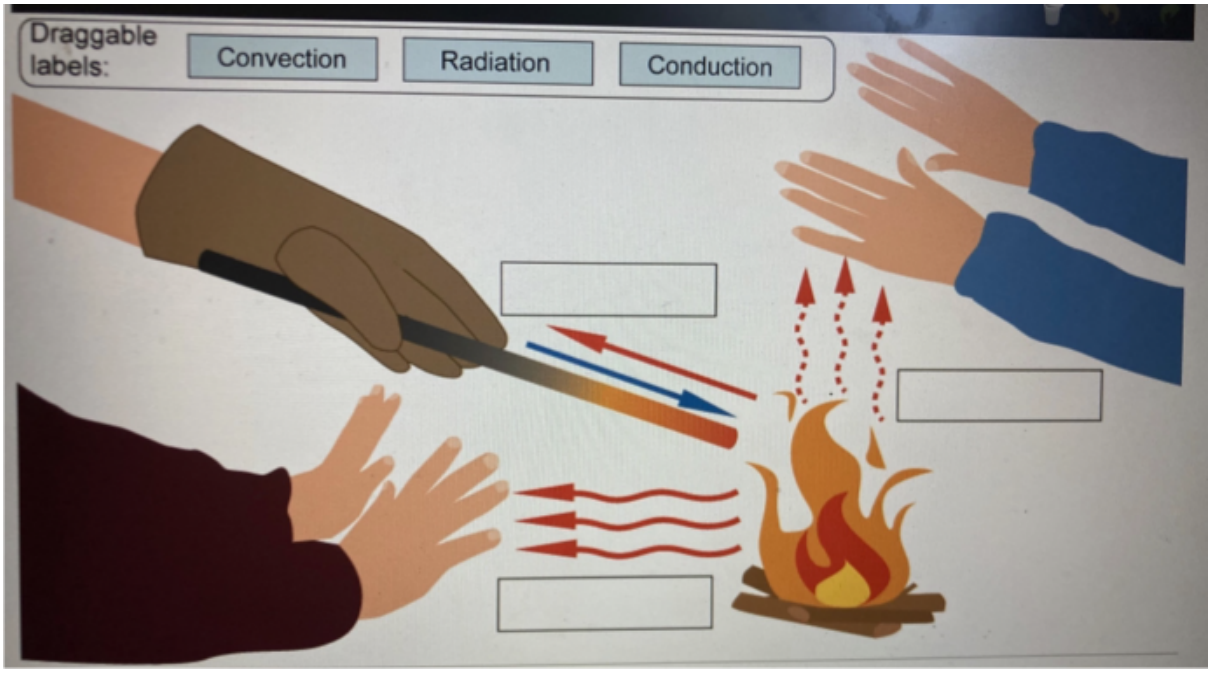
Question 1 (7 marks)

Question 1a (1 mark)

Heat and temperature are different quantities associated with the study of thermal physics.

Heat transfer takes place through three processes: conduction, convection and radiation. **Select** the process for each situation.



Question 1b (2 marks)

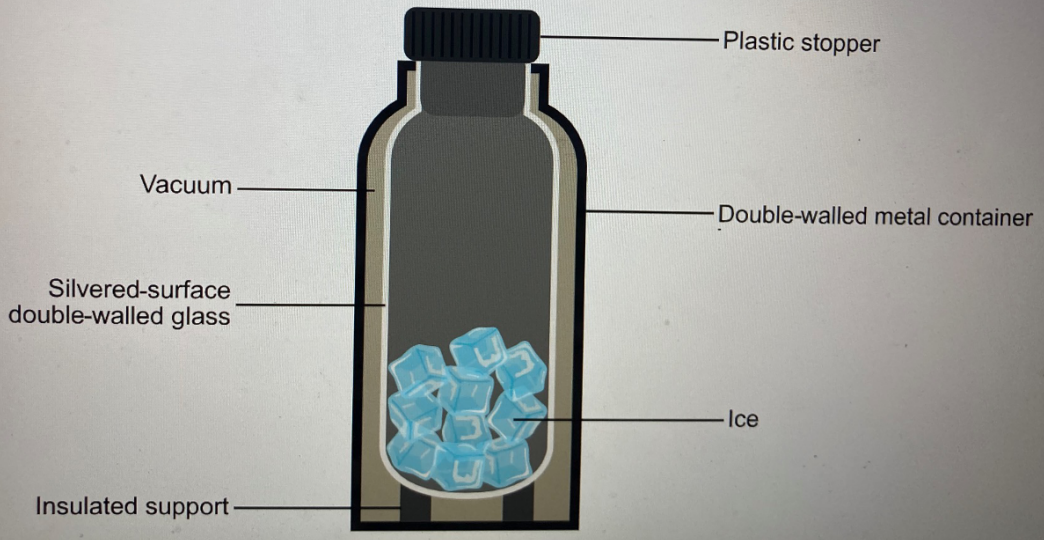
State the units used to measure temperature and heat.

Temperature

Heat

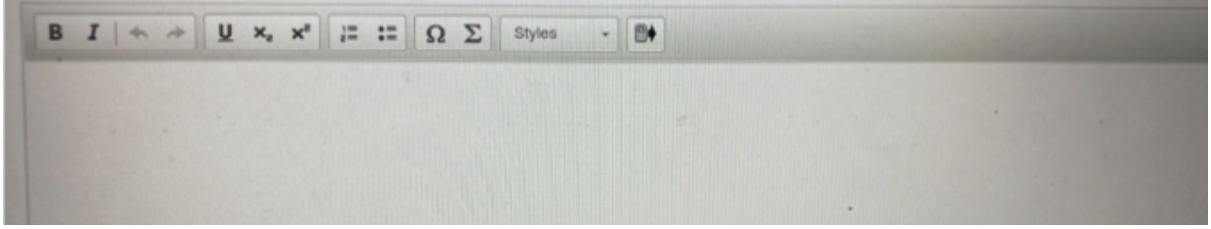
Question 1c (4 marks)

A Dewar flask maintains the temperature of the liquid placed in it for many hours. A diagram of a Dewar flask is shown below.



A student places a mix of ice and water into a Dewar flask and leaves it in the sunshine. Four hours later she returns and finds that the ice has not melted. **Explain** why the ice has not melted.

In your answer, you should refer to two features of the flask and use your knowledge and understanding of heat transfer.

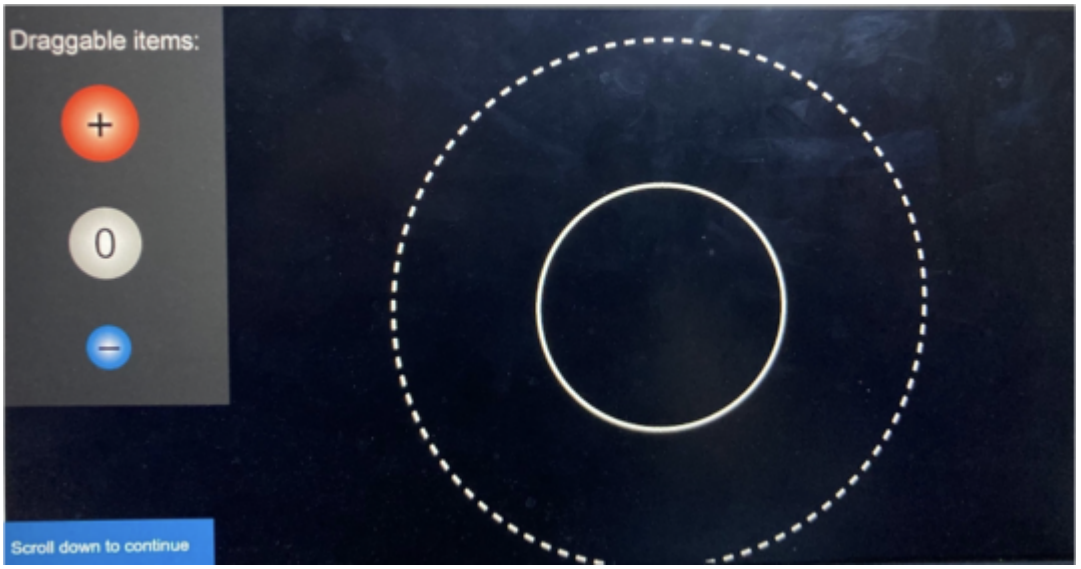


Question 2 (10 marks)

For centuries, atoms were believed to be solid spheres with no internal components. However, as experimental procedures improved, it was found that they contain protons, neutrons and electrons.

Question 2a (1 mark)

A helium atom has 2 protons, 2 neutrons and 2 electrons. **Draw** a diagram to show the structure of an atom of helium.



Question 2b (1 mark)

Select the force that keeps the electron in the atom.

Select
Select
Magnetic force
Gravitational force
Electrostatic force
Frictional force

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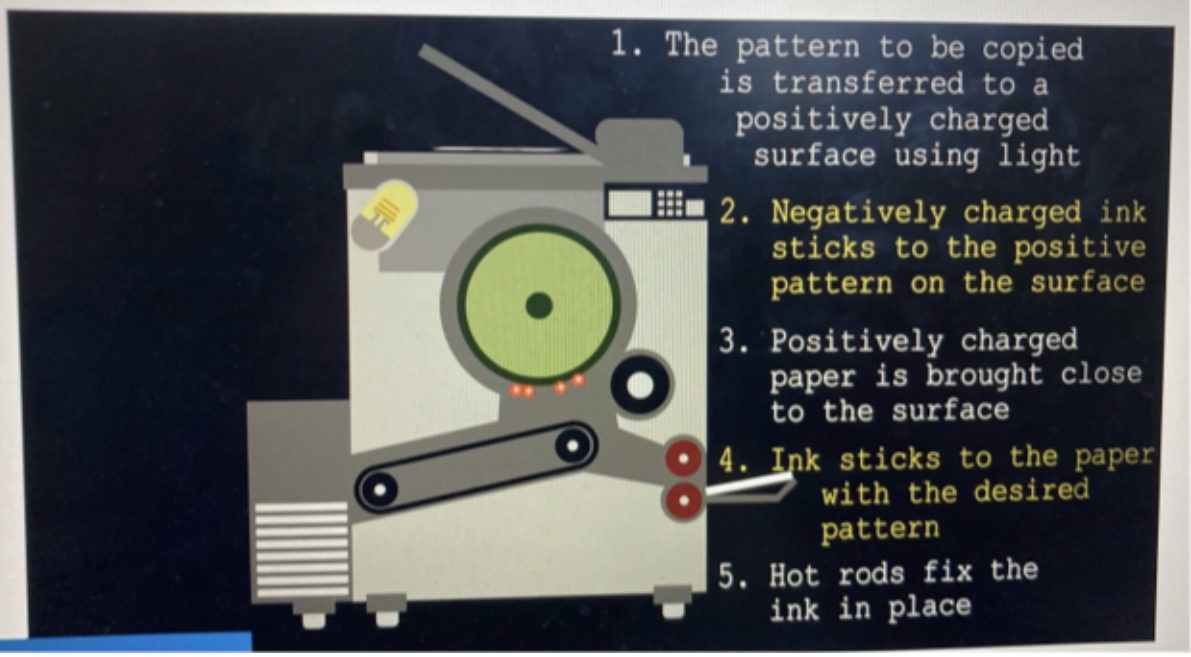
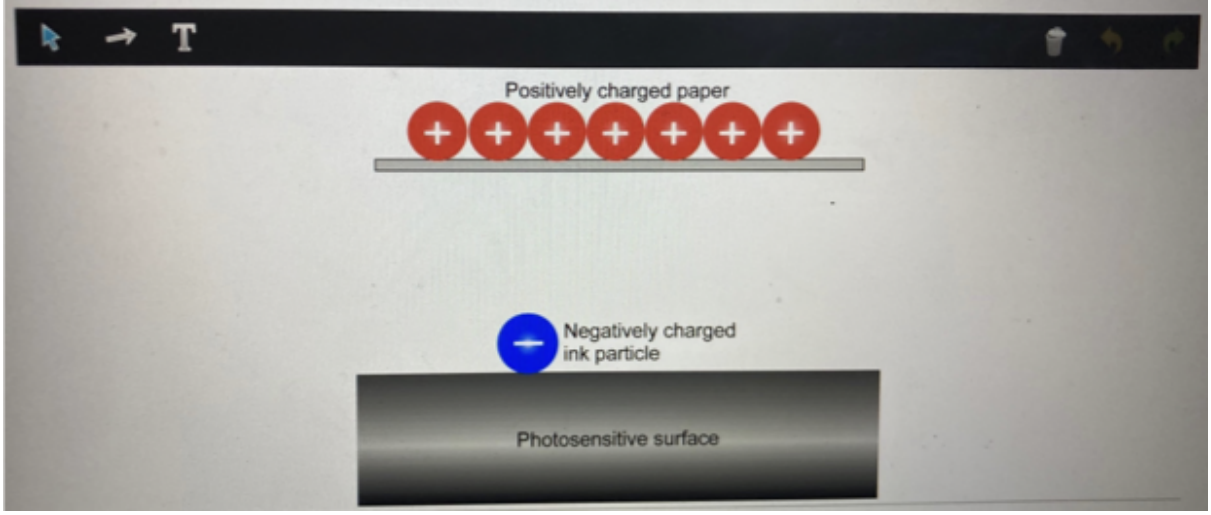
Question 2c (2 marks)

Copying machines work using the electric properties of matter. The process can be simplified as follows.



Question 2d (3 marks)

The diagram below shows a negatively charged ink particle and the positively charged paper. **Draw** arrows to represent the **forces acting on** the ink particle. Use the text tool to add **labels** to your arrows.



Outline the importance of the opposite charge of the negatively charged ink particle and the positively charged paper in the process of making a copy.

B I U x_2 x^2 Ω Σ Styles

Question 2e (3 marks)

Explain why the distance between the photosensitive surface of the drum and the paper needs to be small.

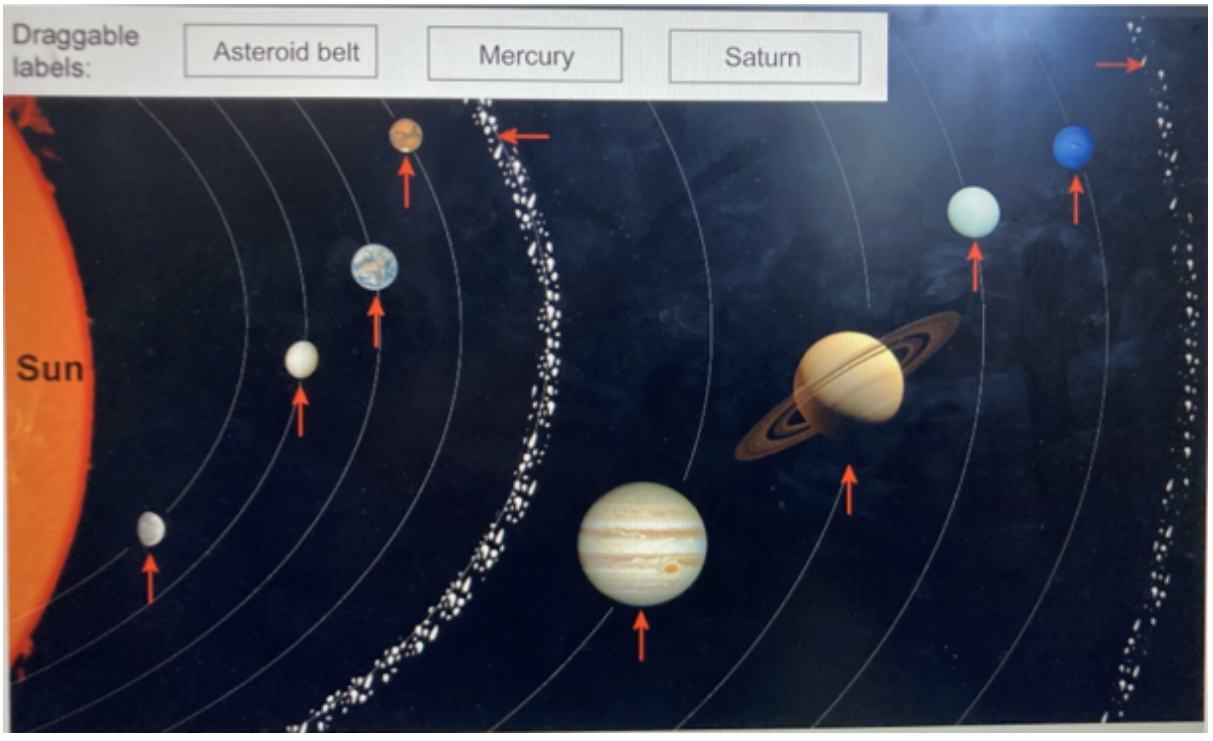
B I U x_2 x^2 Ω Σ Styles

Question 3 (10 marks)

Question 3a (2 marks)

The movement of planets and asteroids in the solar system can be determined by our understanding of the action of gravitational attraction.

The diagram of the solar system below is missing some information. **Label** the diagram.



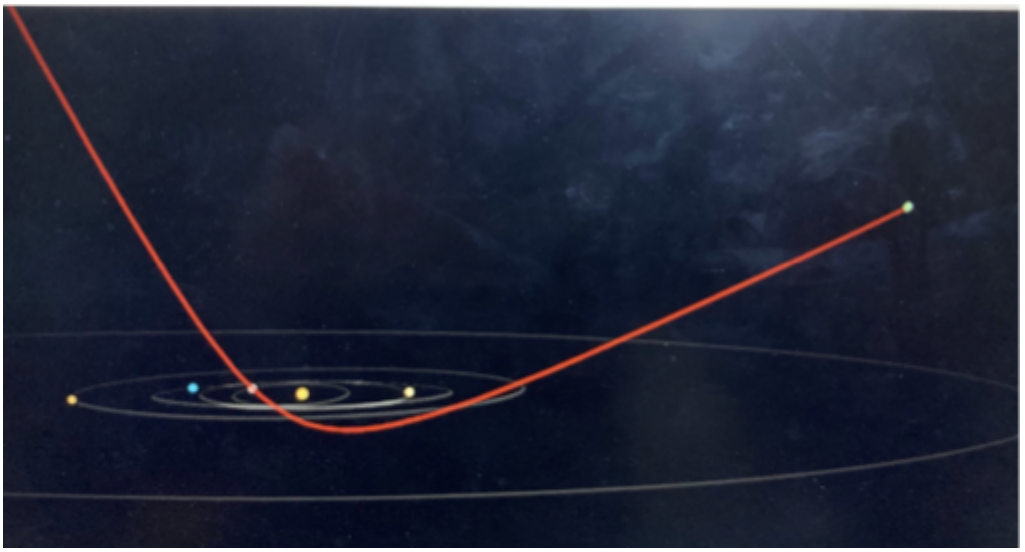
Question 3b (1 mark)

State one factor that determines the size of the force of attraction between objects in the solar system.

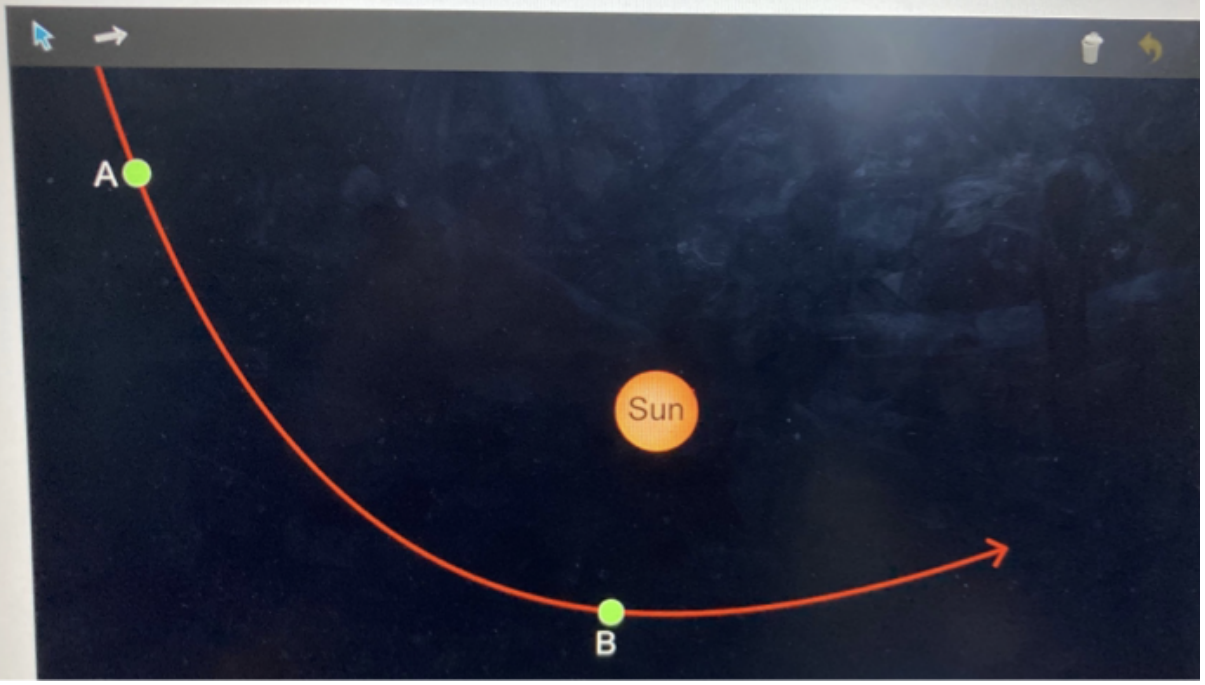
B I | U x_2 x^2 | Ω Σ | Styles

Question 3c (3 marks)

Not all objects observed in the solar system move around the Sun as planets do. In 2017, scientists discovered an object that would visit our solar system only once. The scientists named the object Oumuamua.



Draw arrows to represent the force of attraction that the Sun exerts on Oumuamua at the positions A and B shown in the diagram.



Question 3d (2 marks)

The estimated volume of Oumuamua is 281 000 m^3. The typical density of an asteroid is 2000 kgm^{-3}. **Calculate** the mass of Oumuamua.

B I U x_2 x^2 Ω Σ Styles

Question 3e (2 marks)

At its closest, Oumuamua was 1.5 x10^{11} m away from the Sun. At this distance the gravitational field strength is 0.1 N kg^{-1}. Using the formula sheet and your answer to part (d), **calculate** the force of attraction experienced by Oumuamua.

B I U x_2 x^2 Ω Σ Styles

Question 4 (15 marks)

The video below is about body flying.

Video Script

Video Script

Body flying is a way for people to experience the adventure of sky diving, without jumping out of a plane. Air is blown through large tubes at high speed and this allows people to float above the ground. Rather than falling fast through the air, fast air travels past the person.

The drag force this creates must be large enough to balance the weight of the person.

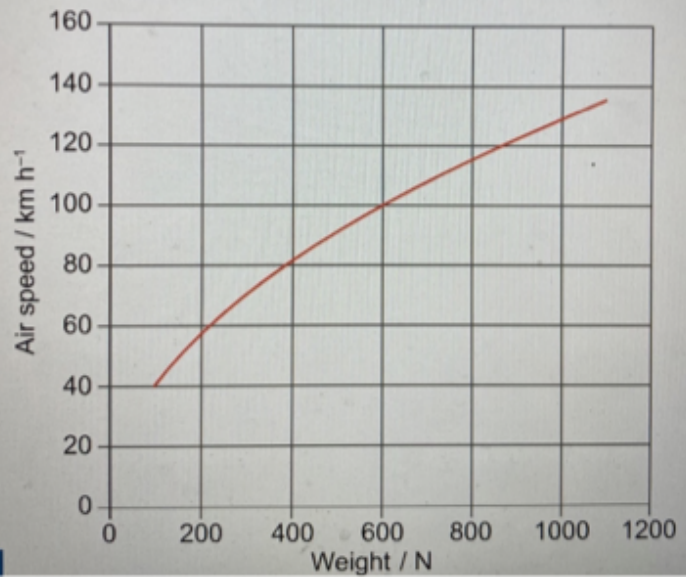
As both children and adults can experience body flying, it is important to know how fast the air must flow to keep the person floating safely.

To determine this relationship between air speed and weight we can model body flying using balls of different weights in a controlled stream of air in the lab.

Question 4a (2 marks)

The graph below shows the air speed needed for people with different body weights to float above the ground.

Graph showing the weight supported by different air speeds



Using the graph, **state** the air speed needed for a 600 N person to float above the ground.

B I U x_2 x^2 Ω Σ Styles

Question 4b (3 marks)

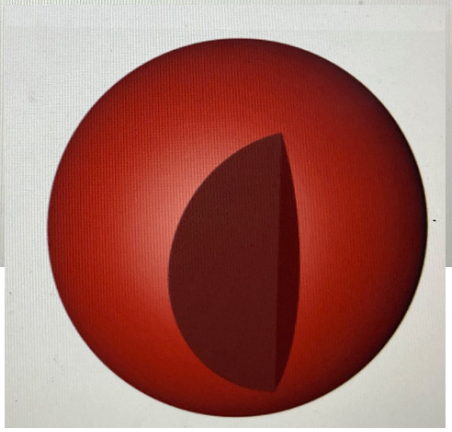
In the video above, you have seen that we can model real-life situations using simple lab equipment. You have been asked to investigate the relationship between the weight of a ball and the air speed needed for it to float. In this way you can answer the research question:

> How does increasing the weight of a ball affect the air speed needed to keep it floating?

As you have seen in the video, when the ball is floating, the relationship can be summarized in the following equation:

$$\text{Weight of ball} = \text{constant} \times \text{CSA} \times \text{air speed}^2$$

where CSA is cross-sectional area of the ball.



A list of variables that are important in this experiment is provided below. **Select** the description that best describes each.

Quantity	Independent variable	Dependent variable	Control variable
Air speed	☐	☐	☐
CSA	☐	☐	☐
Shape	☐	☐	☐
Weight	☐	☐	☐

Question 4c (3 marks)

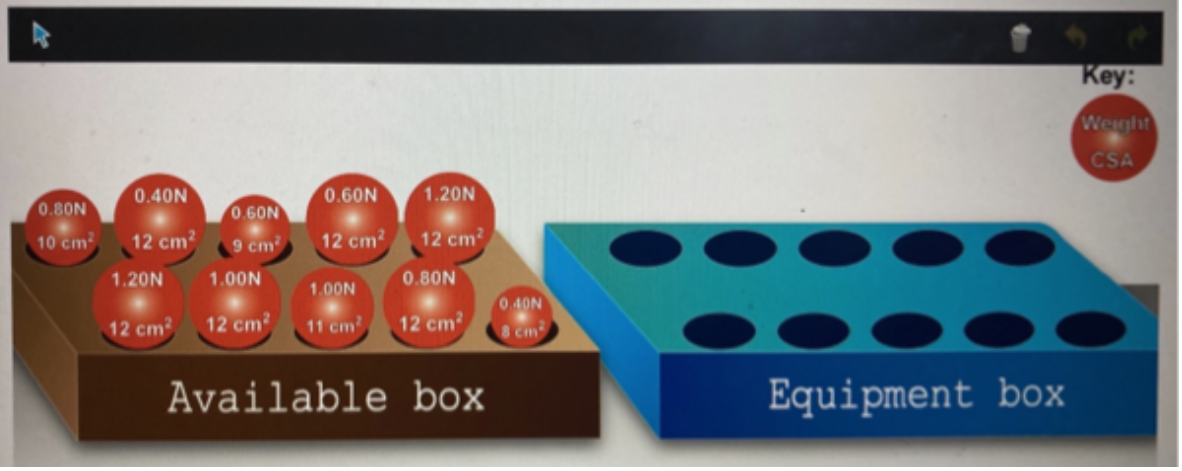
Use the information contained in the video and the equation above to **formulate** and **explain** a testable hypothesis that could address the research question given above.

B I | U x_2 x^2 | Ω Σ | Styles

Question 4d (3 marks)

You have a box of balls which contains a variety of different CSA.

Select the balls you will use for this experiment and place them in the equipment box.



Question 4e (2 marks)

Justify the selection you have made in part (d).

B I U x_2 x^2 Ω Σ Styles

Question 4f (2 marks)

State how many trials you will record. **Justify** your answer.

B I U x_2 x^2 Ω Σ Styles

Question 5 (14 marks)

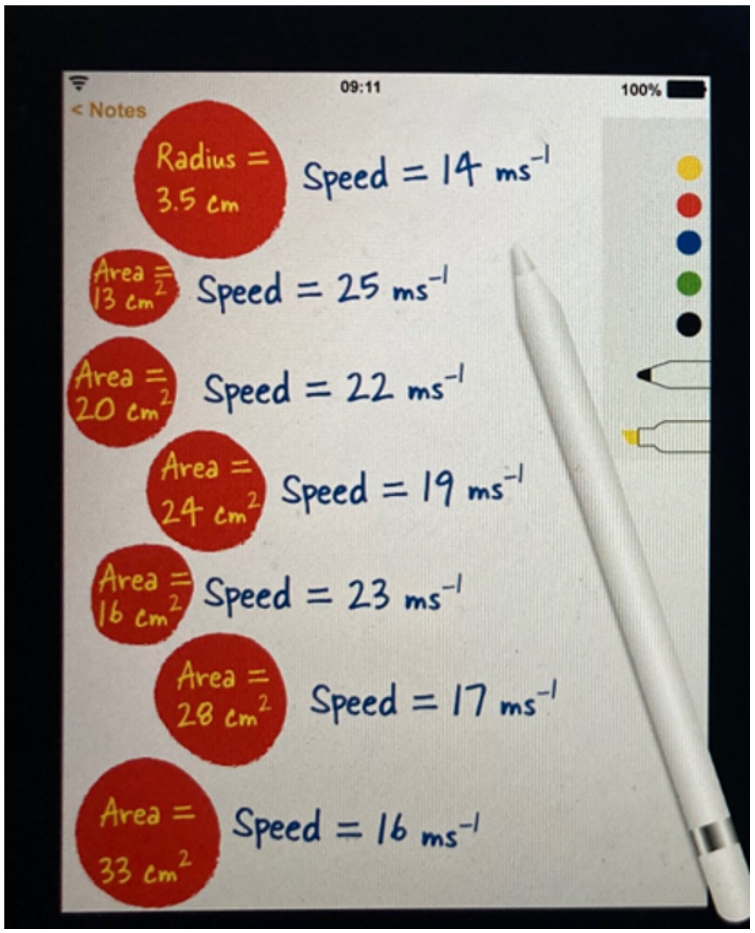
A student chooses to investigate the effect that the CSA of the ball has on the air speed needed to keep it floating. He proposes the following hypothesis, using the same equation as in question 4.

$$\text{Weight of ball} = \text{constant} \times \text{CSA} \times \text{air speed}^2$$

His hypothesis is:

> According to my research I know that the CSA of the ball is inversely proportional to the square of the air speed flowing past it. I can write this as the following equation:
>
> $$CSA \sim \frac{1}{air\ speed^2}$$
>
> This means that as the CSA of the ball increases, the air speed needed for the ball to float can be reduced.

In his method, the student collects one set of data. His results are shown below.

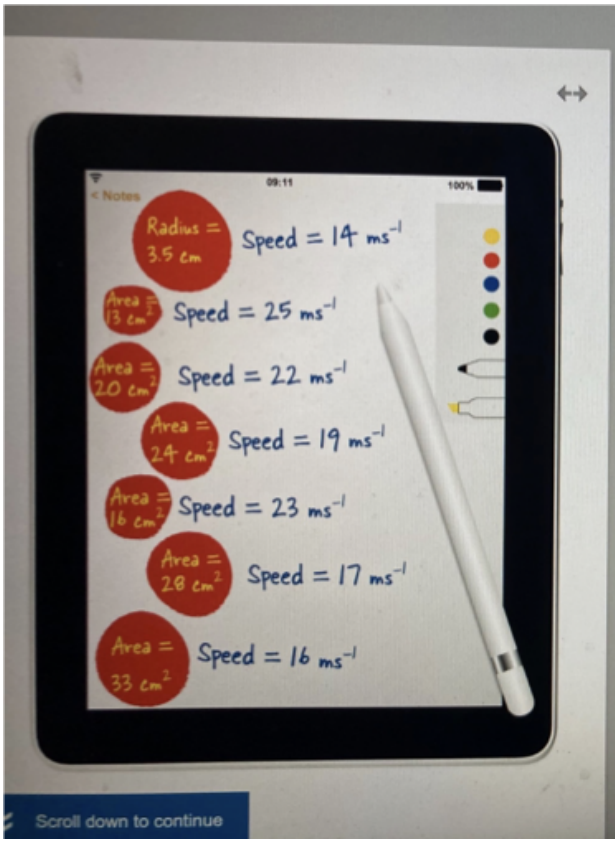


Question 5a (1 mark)

State the question that the student is investigating.

B I U x_2 x^2 Ω Σ

Styles



Scroll down to continue

Question 5b (1 mark)

The student has recorded the first value as radius rather than area. The student used the equation:

$$\text{area} = \pi r^2$$

to calculate the CSA. **Select** which of the following values would be most appropriate to present the CSA in a results table.

Select

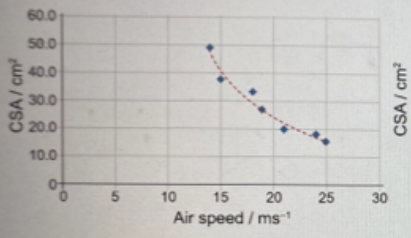
Question 5c (4 marks)

Organize and **present** the data into a table. In your answer, you should include the result from part (b).

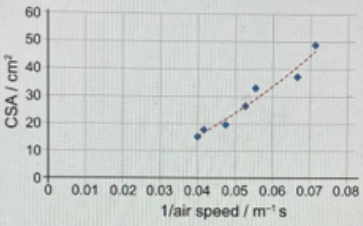
Question 5d (3 marks)

The student draws three graphs of the data he has collected. **Select** the most appropriate graph to determine the relationship between CSA and air speed. **Justify** your choice.

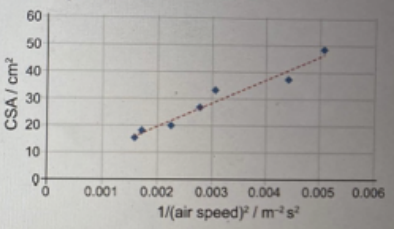
Graph A



Graph B



Graph C



Graph A : ○ Graph B: ○ Graph C: ○

Justification:

B I U x_2 x^2 Ω Σ Styles

Question 5e (3 marks)

The student's hypothesis was:

According to my research I know that the CSA of the ball is inversely proportional to the square of the air speed flowing past it. I can write this as the following equation:

$$CSA \sim \frac{1}{air\ speed^2}$$

This means that as the CSA of the ball increases, the air speed needed for the ball to float can be reduced.

Explain if the data supports the hypothesis.

B I U x_2 x^2 Ω Σ Styles

Question 5f (2 marks)

The student's results do not all sit on the line of best fit.

Describe what change should be made to the method and state how this change would improve the results.

B I U x_2 x^2 Ω Σ Styles

Question 6 (20 marks)

A second student decides to perform a different experiment. She chooses to model how boats float in water. She knows that the weight of the boat floating in a liquid and the volume of the boat below water will be linked by the equation below.

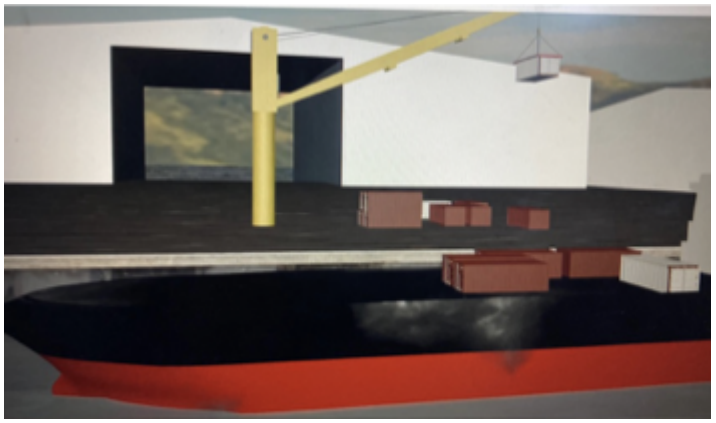
Weight of the boat = density of the liquid x gravitational field strength x volume of the boat below the water

Her hypothesis is:

According to my research, I know that as the weight of the boat increases, the volume of the boat below the water will increase proportionally. I can write this as the following equation:

Weight of the boat ~ volume of the boat below the water

This means that as the weight of the boat doubles the volume of the boat under the water will also double.



The student collects the data found in the table below.

Weight of the boat / N	Volume of the boat below the water / cm^3
0.5	50
1.1	110
2.0	200
4.2	420

Question 6a (3 marks)

Identify the type of graph that the student should draw of this data. **State** the quantities that should be presented on the graph.

B I U x_2 x^2 Ω Σ Styles

Question 6b (2 marks)

The results support the relationship given in the hypothesis. Without drawing the graph, **describe** two features of the graph that would support the hypothesis.

B I U x_2 x^2 Ω Σ Styles

Question 6c (4 marks)

Discuss two improvements to the method and data collected that would benefit the scientific investigation.

Improvement 1:

Effect:

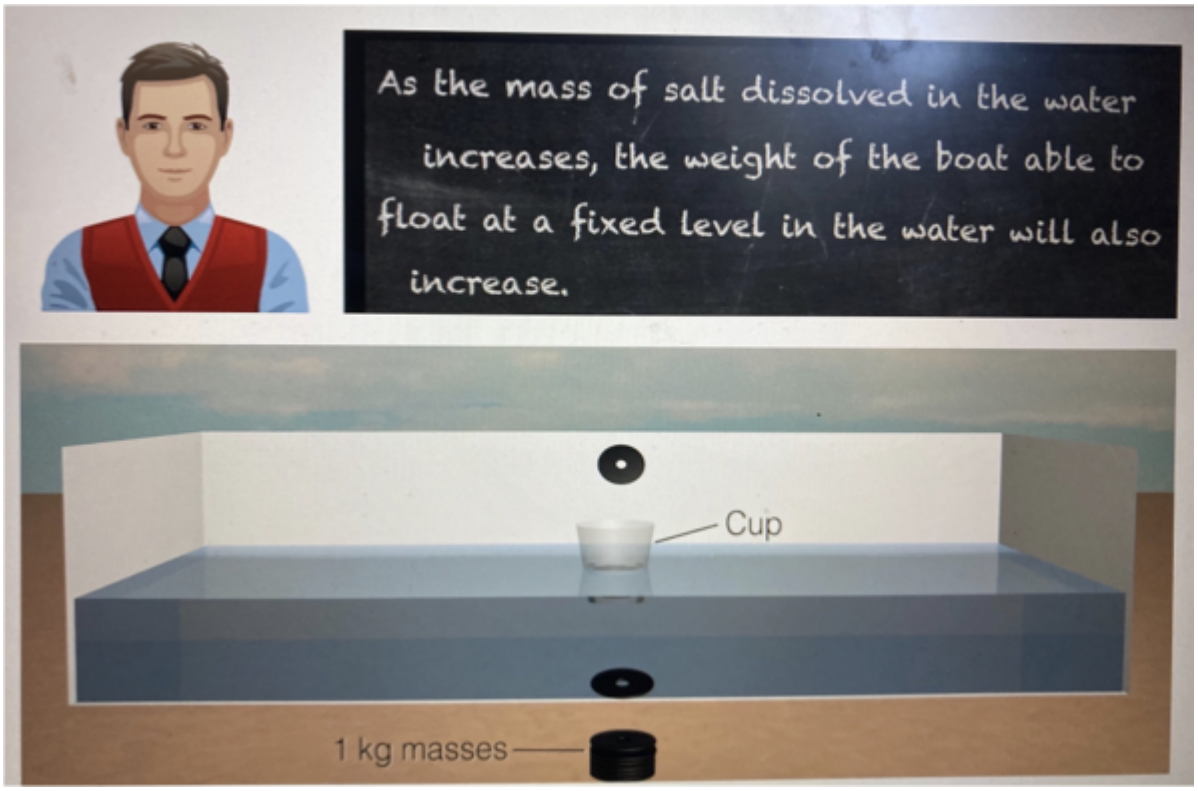
Improvement 2:

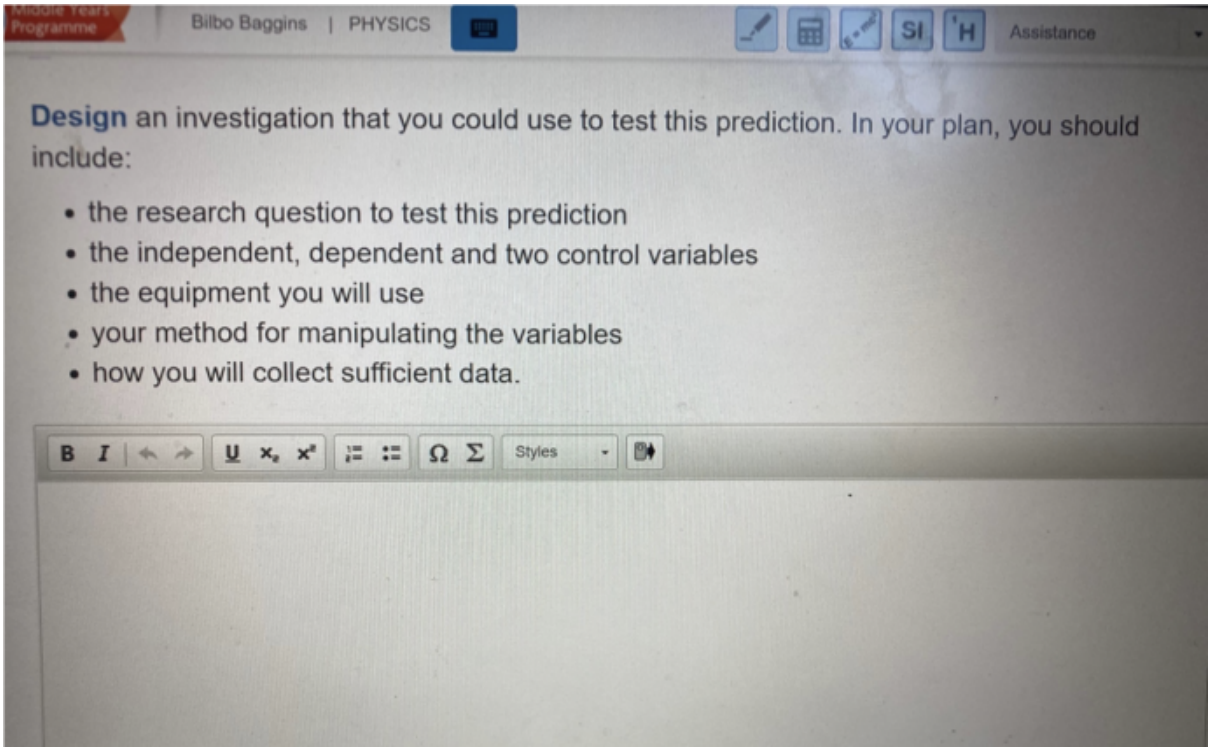
Effect:

Question 6d (11 marks)

You decide to extend the experiment and investigate how the density of sea water affects the weight of a boat able to float. The student changes the density of water by changing the mass of salt dissolved in the water.

Your teacher suggests the following prediction:


As the mass of salt dissolved in the water increases, the weight of the boat able to float at a fixed level in the water will also increase.
Cup
1 kg masses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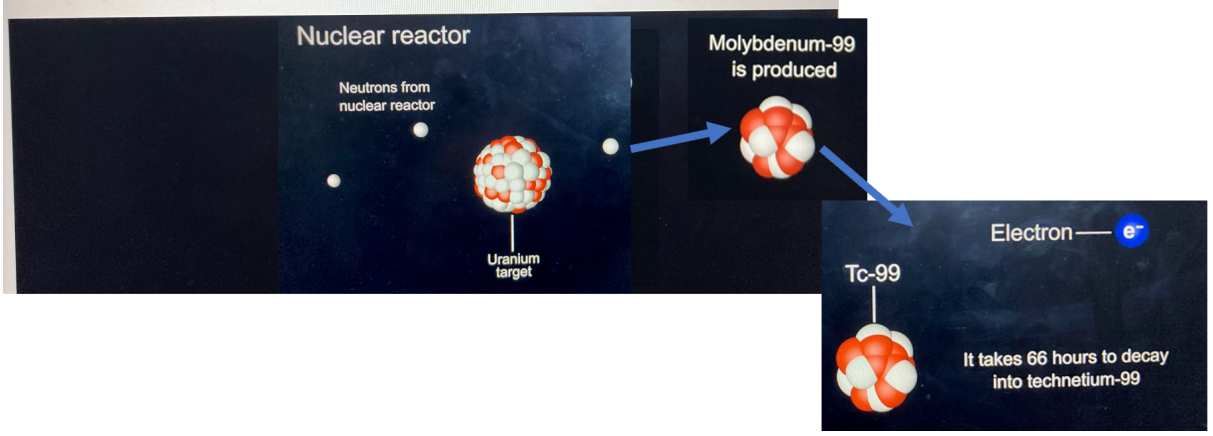
Design an investigation that you could use to test this prediction. In your plan, you should include:
• the research question to test this prediction
• the independent, dependent and two control variables
• the equipment you will use
• your method for manipulating the variables
• how you will collect sufficient data.
Styles

Question 7 (13 marks)

Over 10 000 hospitals around the world use radioisotopes. About 90 % of their use is in trying to diagnose an illness. The most common radioactive isotope used in helping to make diagnoses is technetium-99.

The process of producing technetium begins in a nuclear reactor. A uranium isotope is bombarded by neutrons which produces molybdenum-99 (Mo-99). The half-life of Mo-99 is 66 hours, after this time it decays into technetium-99 (Tc-99).



Tc-99 emits gamma rays which have enough energy to be detected by a gamma camera. Tc-99 has a half-life of about 6 hours. When injected into the human body, the Tc-99 allows for medically useful images to be produced.

Question 7a (2 marks)

Outline why a half-life of 6 hours is useful for producing medical images.

B I U x_2 x^2 Ω Σ Styles

Question 7b (2 marks)

Outline the two advantages a gamma-emitting isotope would have when used for detection purposes in the human body rather than alpha and beta emitters.

B I U x_2 x^2 Ω Σ Styles

Question 7c (9 marks)

The source of Tc-99 is produced in nuclear reactors. Most of these reactors are over 50 years old and are due to be decommissioned. This would cause a global shortage of Tc-99. In the future, Tc-99 could be produced in new nuclear power stations or by using new technologies such as cyclotrons and linear accelerators.

	 Nuclear reactor	 Cyclotron	 Linear accelerator
Location	Long distance from cities	Inside a hospital	Inside a hospital
Area supplied	6-day radius Across multiple countries	1-day radius Use in small number of local hospitals	6-day radius Across multiple countries
Product	Mo-99 produced which decays to Tc-99	Tc-99 produced directly	Mo-99 produced which decays to Tc-99
Hazard	Uses radioactive uranium (U-238) Radioactive waste produced	No radioactive waste	Uses uranium compounds Virtually no radioactive waste with long half-life is produced
Other information	Large size, approximately the size of a factory Takes a week to produce Tc-99 Lifetime of nuclear reactors is coming to an end Can also be used to generate electricity	Small size, approximately the size of a small car Takes 6 hours to produce Tc-99 Modern equipment that can be easily maintained Can be used to generate radioisotopes for other areas of research	Medium size, approximately the size of a school bus Takes 24 hours to produce Tc-99 Modern equipment that can be easily maintained Can be used for other areas of research

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You are an adviser to a government agency. Using the information above, **discuss** and **evaluate** which method you think should be used to produce Tc-99 in a country of your choice. In your answer, you should include:

- the advantages of your chosen method for your country
- the disadvantages of your chosen method for your country
- a conclusion.

B I U x_2 x^2 Ω Σ Styles

Scroll down to continue

Question 8 (11 marks)

In 1987, a forgotten radiotherapy source was stolen from an abandoned hospital in Brazil. By the time the authorities had been alerted, 249 people who had been in contact with the stolen source were found to have very high levels of radioactive material either in or on their bodies. Four people died from being exposed to the radioactive isotope. Houses that had been contaminated had to be demolished and the topsoil had to be removed due to contamination. The International Atomic Energy Agency called it *"one of the world's worst radiological incidents"*.

Using radioactive materials for diagnoses and treatment helps many patients but there are also risks attached to its use. **Discuss** and **evaluate** the implications of using radioactive materials in medicine. In your answer, you should include:

- an advantage and a disadvantage of using radioactive materials in medicine for a hospital
- the political implications for governments of using radioactive materials
- the environmental implications
- a concluding appraisal.

B I U x_2 x^2 Ω Σ Styles