Question 1 (8 marks)

Mammals need to keep their body temperature within a given range, a concept called thermoregulation. This question is about the physics of heat transfer used in thermoregulation.

Question 1a (1 mark)

Select which of these animals is better adapted to living in cold conditions.

A

Pig:
smooth, light coloured skin

B

Zebra:
short, smooth black and white fur

C

Polar bear:
thick, long, white fur

D

Buffalo:
short, grey hair

©

Select

Question 1b (2 marks)

Reindeer have fur with hollow hairs. **Outline** how this feature enables reindeer to keep warm in cold weather.

©

B I U Styles

Question 1c (2 marks)

The Arctic fox is another animal adapted to living in cold conditions while its distant cousin, the fennec fox, has evolved to live in a hotter desert environment.

©

Outline how the colour of the Arctic fox's fur and the size of the fennec fox's ears help with thermoregulation. You should use scientific language in your answer.

Question 1d (3 marks)

One method of thermoregulation in dogs is evaporation from their wet tongue and nose.

©

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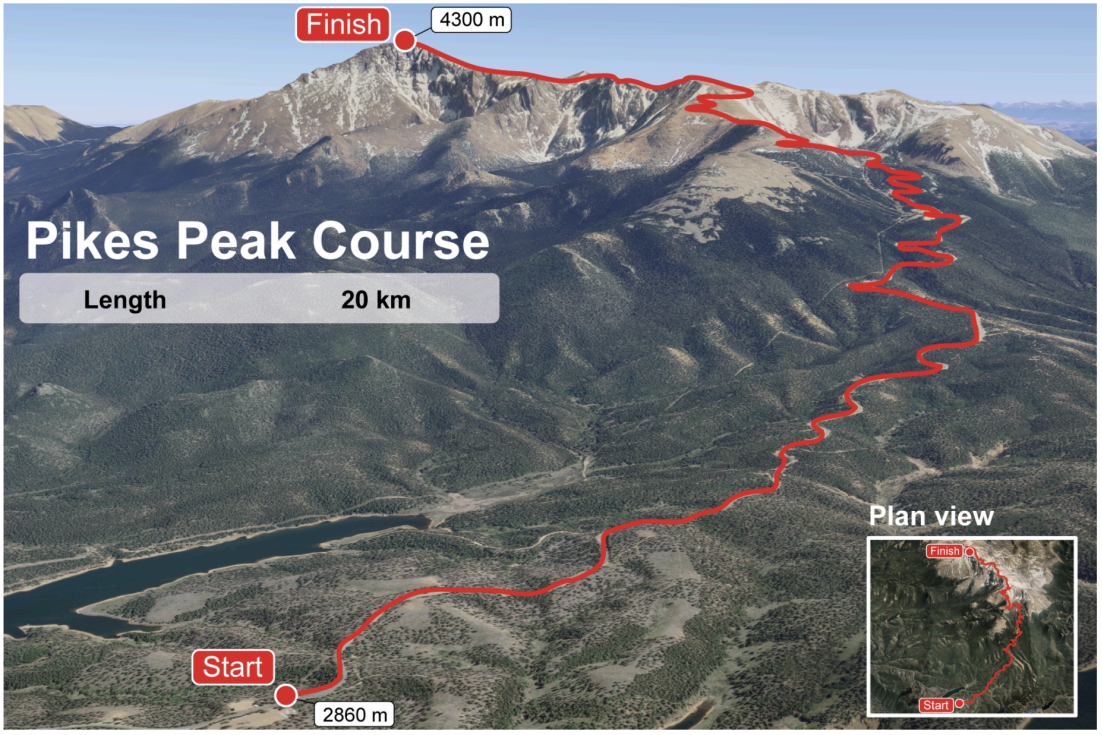
Explain how the process of evaporation will lead to a cooling effect in a dog.

B I U Styles Ω Σ

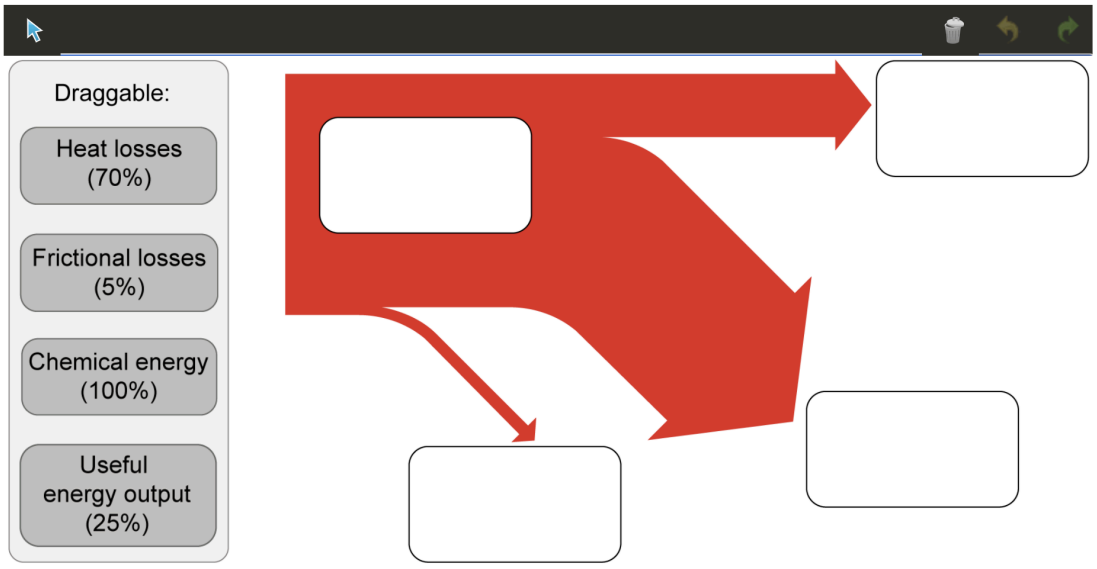
Question 2 (9 marks)

Hill climbing is a motor sport where drivers compete against each other to drive up a hill in the fastest time. A major event in the sport is the Pikes Peak event, held in the USA.



Question 2a (2 marks)

The Sankey diagram below represents the energy changes associated with a car engine. **Label** the energy forms on the diagram.



Question 2b (4 marks)

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The event starts at an altitude of 2860 m and ends at an altitude of 4300 m. A car competing in the 1988 race had a mass of 880 kg. **Calculate** the gain in gravitational potential energy. You should assume that the gravitational field strength is 10 N kg^{-1}.

Question 2c (3 marks)

©

A lighter car travelling the same route gained 8.8 MJ in 546 s. **Calculate** the power of this car.

B I U Styles Ω Σ

Question 3 (9 marks)

This question is about light waves and space.

When we look up at the night sky, many bright objects are visible.

Question 3a (2 marks)

Select whether each object emits its own light or reflects light.

Object	Emits or reflects light
Star	Select
Moon	Select
Planet	Select
Satellite	Select

Reset

Question 3b (1 mark)

Some satellites are always at the same point above the surface of the earth. These are known as geostationary satellites. **State** why these satellites appear to be stationary.

B I U x_2 x^2 Ω Σ Styles

Question 3c (1 mark)

Satellite phones allow people to communicate in remote areas.

©

State one additional application of geostationary satellites.

Question 3d (3 marks)

Geostationary orbit is approximately 36 000 km above the surface of the earth. Light travels at 3×10^8 m s^{-1}. For someone using a satellite phone to communicate with a friend, **calculate** the minimum time delay between sending a message and it being received back on Earth.

B I U x_2 x^2 Ω Σ Styles

Question 3e (2 marks)

The Hubble Space Telescope is a satellite currently orbiting the Earth.

This media contains no audio

©

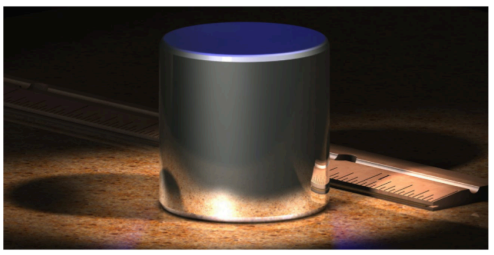
Astronomers can use the light gathered by the telescope to observe that distant galaxies are moving away from each other. **Outline** how this observation provides evidence for the origin of the universe.

B I U x_2 x^2 Ω Σ Styles

Scroll down to continue

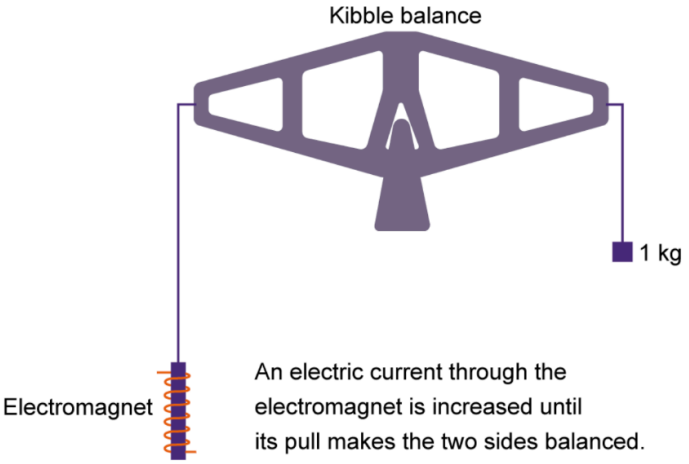
Question 4 (12 marks)

Between 1889 and 2019, the kilogram was defined as the mass of a block of metal known as the International Prototype of the Kilogram.



In 2019, scientists decided that a new way to define the mass of a kilogram was needed. The Kibble balance uses the force of an electromagnetic field produced by a current in a wire to balance the weight of an object and therefore calculate its mass.

It is possible to investigate the same effect in your school classroom.



Your teacher has asked you to investigate the strength of an electromagnet that you can build in your school laboratory. This consists of a circuit with a coil of wire wrapped around an iron rod. When a current flows through the wire, a magnetic field is generated. Your teacher tells you that there are three factors that affect the strength of the magnetic field:

- the current flowing through the wire
- the number of turns in the coil of wire
- the distance between the turns.

You first decide to investigate how the current flowing through the electromagnet affects the strength of the electromagnet using the method described in the video.

Question 4a (1 mark)

State the research question this experiment could investigate.

B I U x_2 x^2 Ω Σ Styles

Question 4b (4 marks)

Below is a list of variables that are important in this experiment. **Select** the description that best describes each.

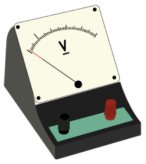
Quantity	Independent	Dependent	Control
Current	☐	☐	☐
Diameter of the iron rod	☐	☐	☐
Number of turns	☐	☐	☐
Total length taken up by the turns	☐	☐	☐
Total weight of paper clips supported by the electromagnet	☐	☐	☐
Size of the paper clips	☐	☐	☐

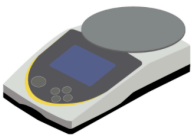
Question 4c (3 marks)

Using the information contained in the video and your knowledge of electromagnets, **formulate** a testable hypothesis that could test your research question from part (a).

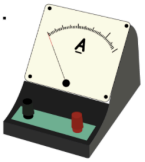
Question 4d (2 marks)

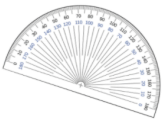
In the laboratory, you have a range of equipment available. **Select** one piece of equipment that you would need and **state** how it would be used in the investigation.

A. 

B. 

C. 

D. 

E. 

©

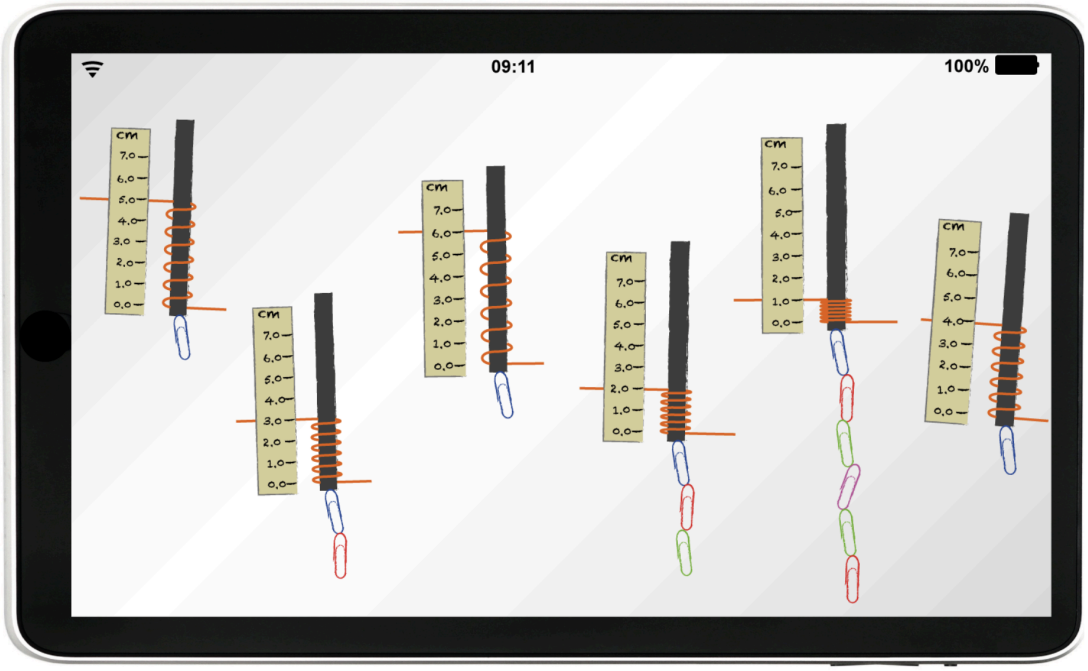
Select

Question 5 (15 marks)

Two different groups of students in your class choose to investigate a different variable. They both investigate whether the strength of the electromagnet is affected by the spacing of the turns wrapped around the iron rod. They decide to keep the current in the coil constant at 2 A. Your teacher tells the class that:

magnetic force ~ current × number of turns per centimetre

The first group of students uses large paper clips, each with a weight of 0.2 N, to determine the weight supported by the electromagnet. The data from their first set of trials are collected into a tablet.



Question 5a (3 marks)

Present the data from the tablet in a table.

Create New Table

Reset

Question 5b (4 marks)

Calculate the number of turns per centimetre and the total paper clip weight for each measurement. **Present** this processed data in a second table.

Create New Table

Reset

Question 5c (2 marks)

The first group used large paper clips in their experiment. The second group uses small pins, each with a weight of 0.01 N.

Justify why the second group of students will produce a better set of data.

B I U x_2 x^2 Ω Σ Styles

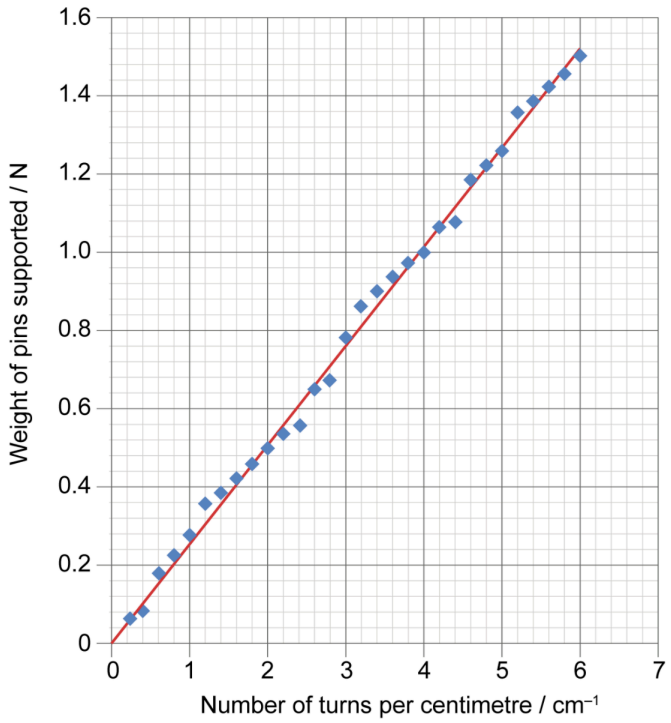
Question 5d (4 marks)

The relationship given for this experiment was:

weight supported ~ current × number of turns per centimetre

The second group produce the following graph of their results:

Graph showing the weight of pins held by a magnet against turn spacing



©

Use the graph in part (d) to **explain** if the data supports the relationship.

Question 5e (2 marks)

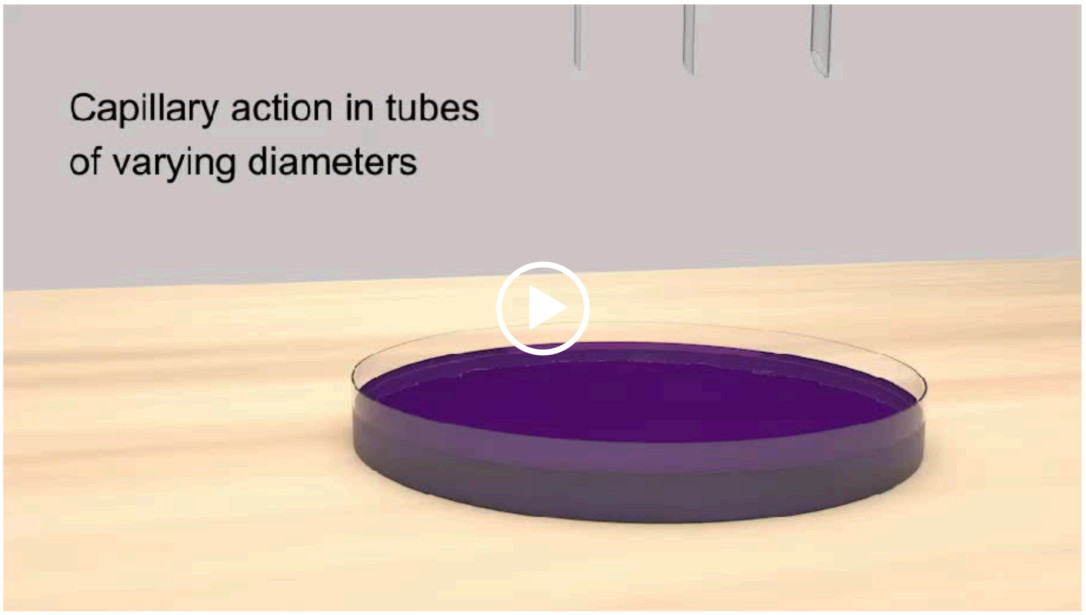
The independent variable in this experiment was number of turns per centimetre. If the independent variable was changed to current, **predict** the shape and the gradient of a graph drawn from the new data.

B I U x_a x^a Ω Σ Styles

Question 6 (11 marks)

We normally expect liquids to flow downwards through a tube. However, if the diameter of the tube is small enough the liquid will rise up through the tube. This process is known as capillary action. This is one of the mechanisms by which liquids flow up through plant stems and tree trunks.

This media contains no audio



©

A student decides to perform an experiment to investigate capillary action. After some research, they discover that the height to which the water level has risen above the liquid surface is determined by the following equation:

$$\text{height above the liquid surface} = \text{capillary constant} \times \frac{1}{\text{diameter}}$$

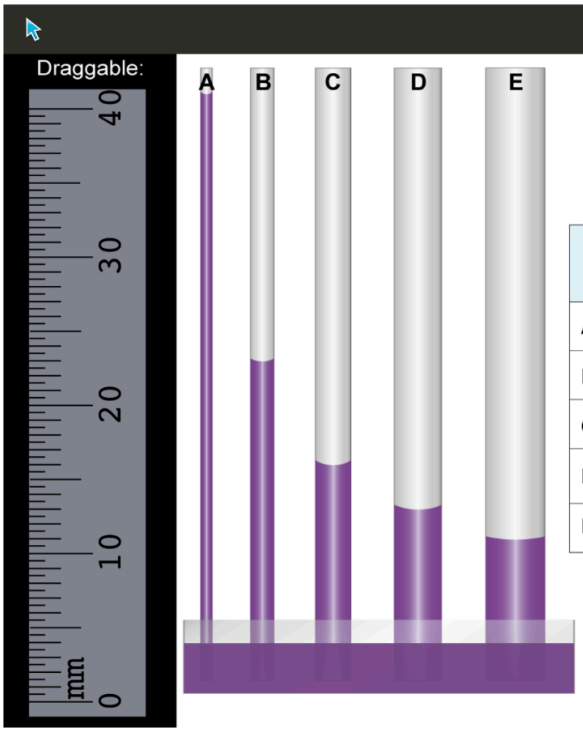
The capillary constant is the constant of proportionality for this relationship.

From this, the student makes the following prediction:

> As the diameter of the tube decreases, the height that the water travels up the tube will increase. If a graph of height against $\frac{1}{\text{diameter}}$ is plotted it will show the relationship is proportional.

Question 6a (2 marks)

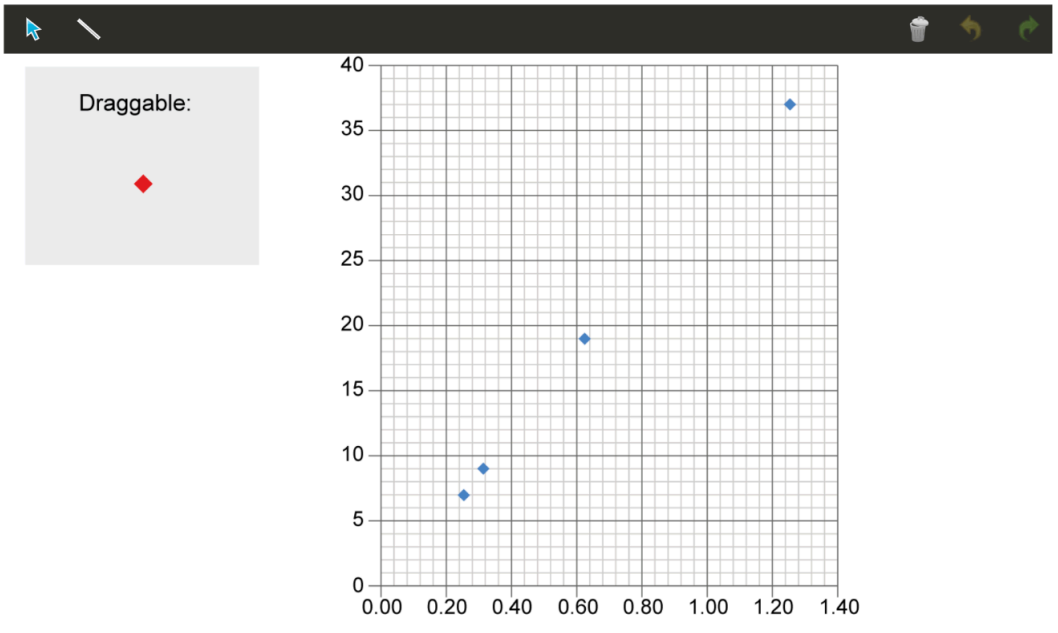
The results of the experiment are recorded in the table below. **Measure** the height of the water in the tube and complete the table.



	Diameter / mm	$\frac{1}{\text{diameter}}$ / mm^{-1}	Height of water / mm
A	0.8	1.25	37.0
B	1.6	0.63	19.0
C			
D	3.2	0.31	9.0
E	4.0	0.25	7.0

Question 6b (4 marks)

Plot your measured value on the graph below, and **draw** a line of best fit. You should add labels to the axes.



x axis label:

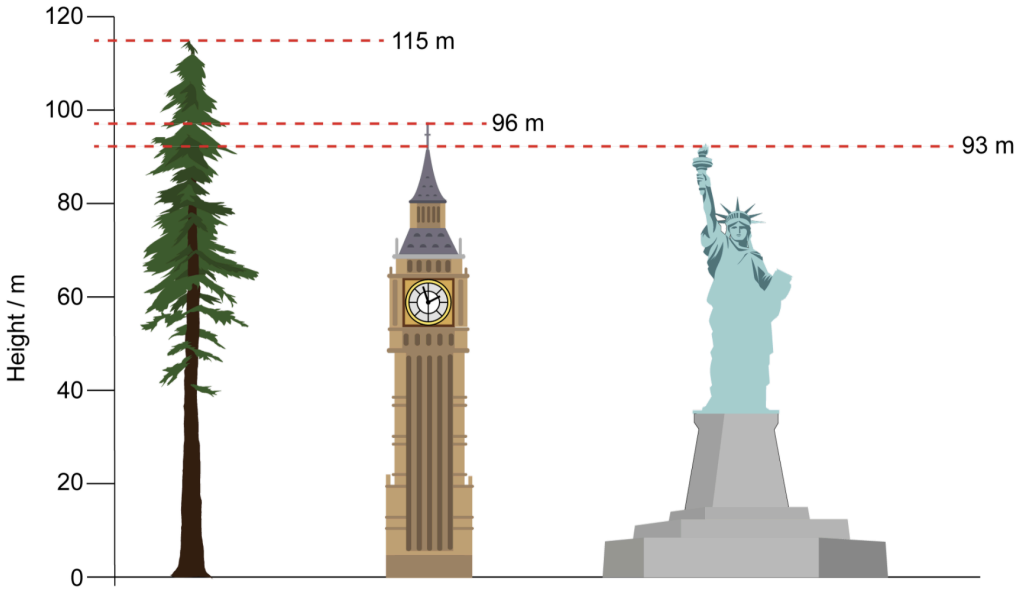
y axis label:

Question 6c (3 marks)

Calculate the capillary constant from the graph. You must show your working in your answer.

Question 6d (2 marks)

Giant redwood trees can grow to around 100 m in height. From this experiment, we can conclude that capillary action is not the only mechanism used to move water through tree trunks. Use data from the image below to **suggest** how this experiment supports this conclusion.



Question 7 (13 marks)

You decide to extend the experiment and investigate how the temperature of the water affects the height that the water rises up a tube.

Design an investigation that you could use to carry out this investigation. In your plan, you must include:

- a research question
- the independent, dependent and one control variable
- the equipment you need and how it will be used
- your method for manipulating the variables
- how you will collect sufficient data.

B I U Styles

Question 8 (8 marks)

One strategy used by infrastructure planners to transport people quickly in urban areas is the maglev (magnetic levitation) train. This type of train moves using powerful electromagnets instead of the conventional rail-and-wheels system.

Question 8a (1 mark)

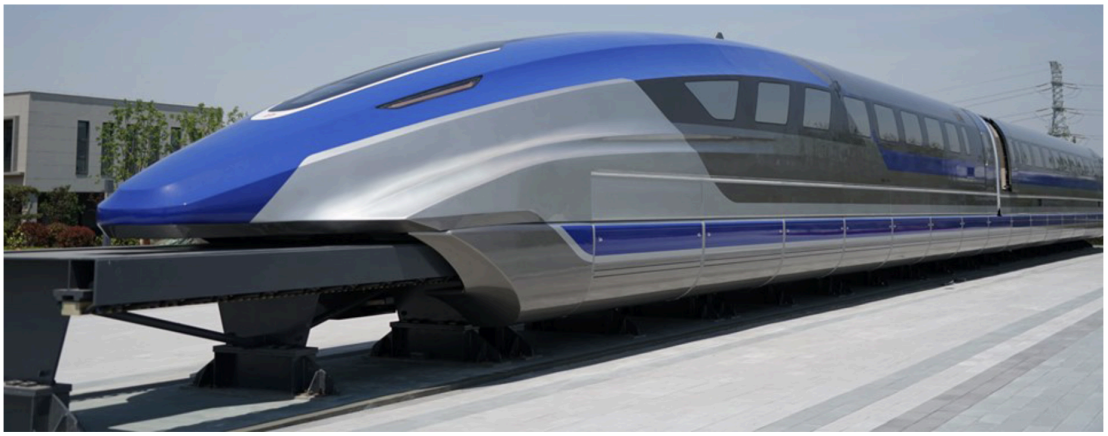
Some metals are attracted to magnets, some are not. **Select** the metal that is attracted to magnets.

- ✓ Select
- Aluminium
- Copper
- Iron
- Lead

(2 marks)

Question 8b (2 marks)

Maglev trains use repelling forces between strong electromagnets attached to the tracks and the underside of the train. These electromagnets lift the whole train to float at about 1 cm above the tracks. The train can travel at an average speed of 430 km h^{-1}.

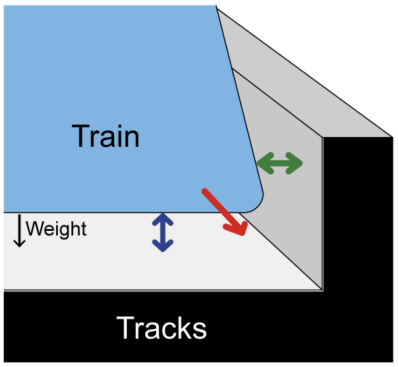


©

In order to function, the maglev train uses magnetic forces to control three systems:

- the levitation system allows the train to stay suspended about 1 cm above the tracks
- the guidance system keeps the train centred over the tracks
- the propulsion system drives the train forward.

Identify the force corresponding to each system in the diagram below.



Maglev

Draggable: Guidance Levitation Propulsion

Key:

Question 8c (2 marks)

Compared to a conventional train with wheels in contact with the track, the frictional forces in maglev trains are lower. **Suggest** two advantages of lower frictional forces.

Advantage one:

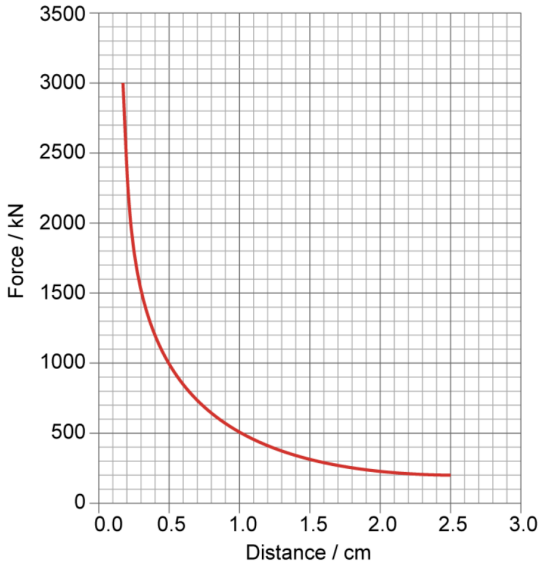
Advantage two:

Question 8d (3 marks)

The size of the repelling force depends on the distance between the magnets.

The graph below shows how the repelling force varies when the distance between the magnets increases.

A graph showing the magnetic repelling force against distance between the train and the track



Use the graph to **explain** the effect on the repelling force of an increase in the number of passengers.

B I U x_2 x^2 Ω Σ Styles

Question 9 (15 marks)

The increase in world population has created a need for a complex and varied transportation infrastructure. New technologies have given people the choice of several options for moving between cities. More people are able to travel long distances for work and leisure. People value comfort, reduced travel times and low cost. The infographic shows some information related to four transport options that could be taken when travelling between two cities.

Click on each transport option to reveal information.

Using information from the infographic above and your wider MYP studies, choose one of the alternative transportation methods. **Discuss** and **evaluate** your chosen method compared to driving a car. In your answer you should include:

- the economic advantages and disadvantages of your chosen method compared to driving
- the environmental advantages and disadvantages of your chosen method compared to driving
- the comfort of your chosen method compared to driving
- the safety of your chosen method compared to driving
- your final recommendation.

B I U x_2 x^2 Ω Σ Styles