

Question 1 (11 marks)

The Shinkansen, commonly known as a bullet train, is a network of high-speed magnetic levitation trains in Japan. The video below explores how the trains were redesigned to minimize the loud booms produced when the trains entered a tunnel.

Video

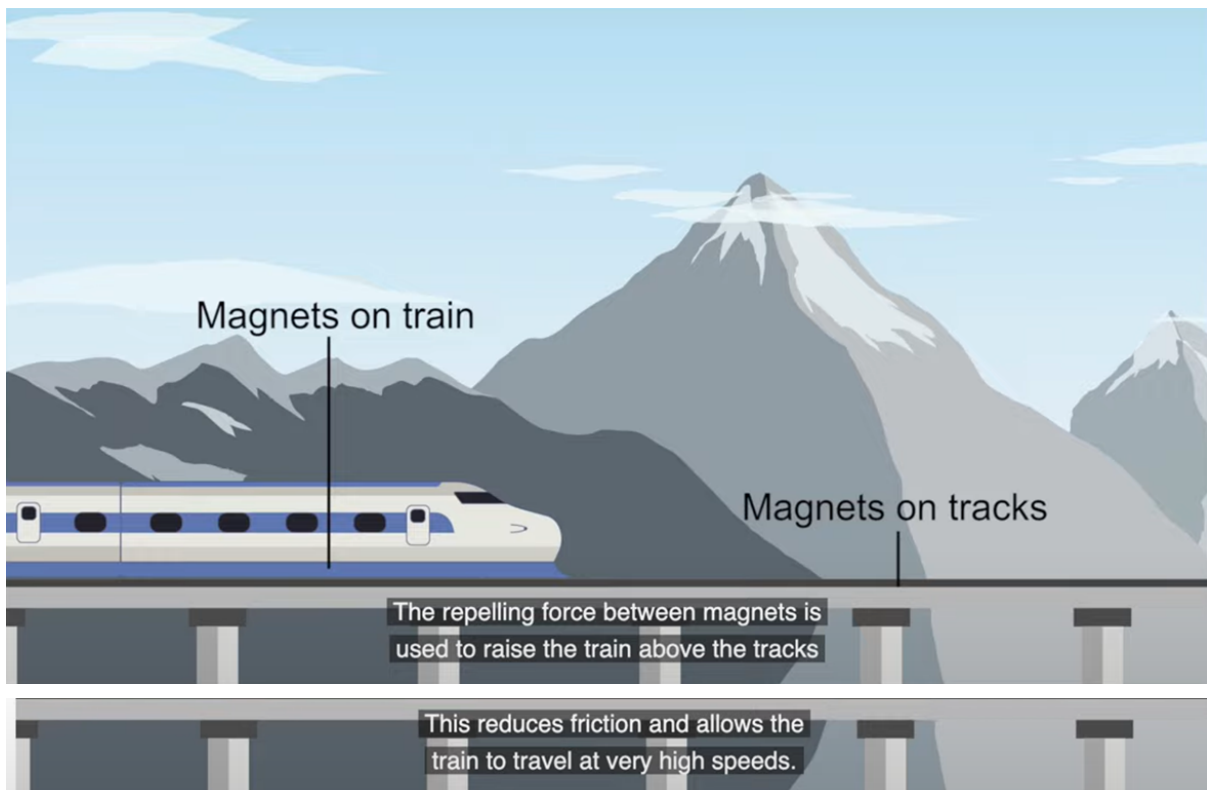
Script

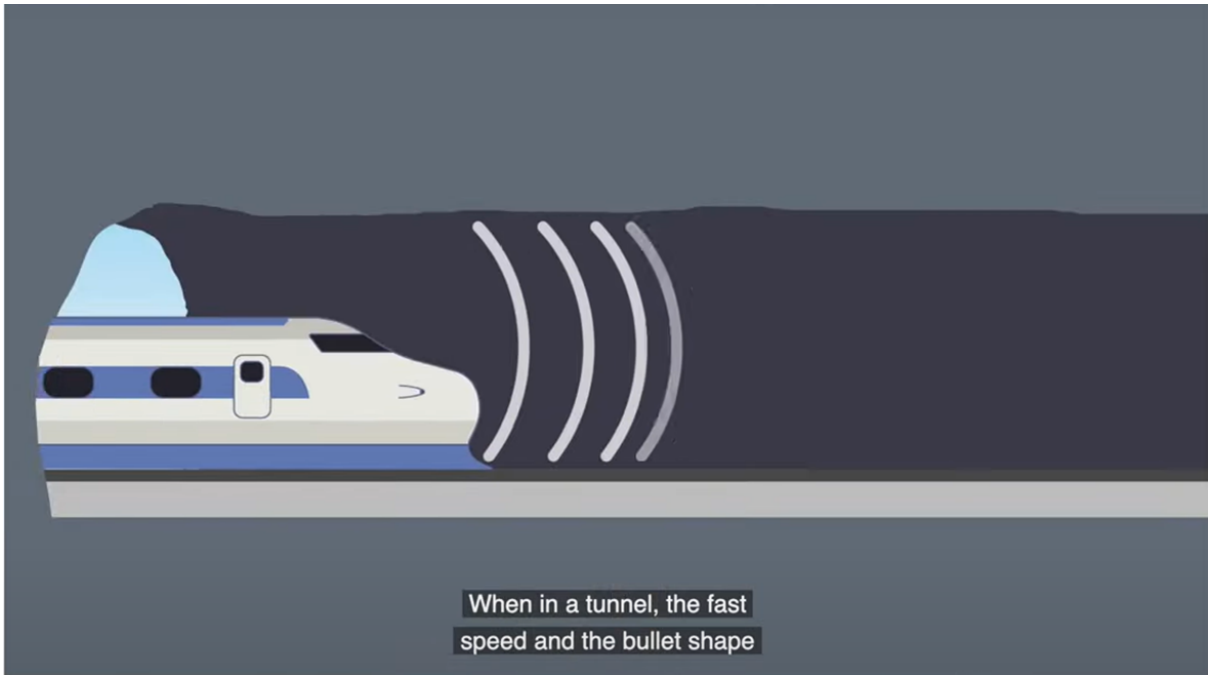
Japanese bullet trains were first designed in 1964. These trains use magnetic levitation. The repelling force between magnets is used to raise the train above the tracks. This reduces friction and allows the train to travel at very high speeds.

When in a tunnel, the fast speed and the bullet shape caused a layer of air to build up in front of a train. This caused a loud booming sound when the train exited the tunnel.

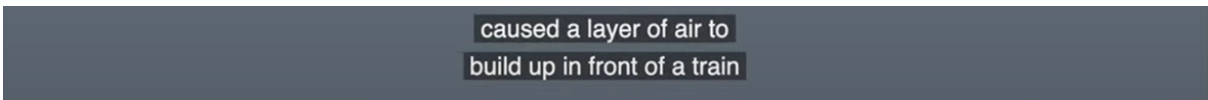
Scientists noticed that kingfisher birds did not disturb water when they dived into it due to the shape of their beaks. They redesigned the nose of the train by modelling it on a kingfisher's beak.

The redesigned train cut through the air and reduced the build-up of layers of air in tunnels. This reduced the loud booming sound and increased the train's efficiency.

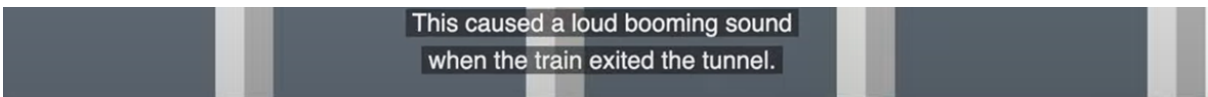




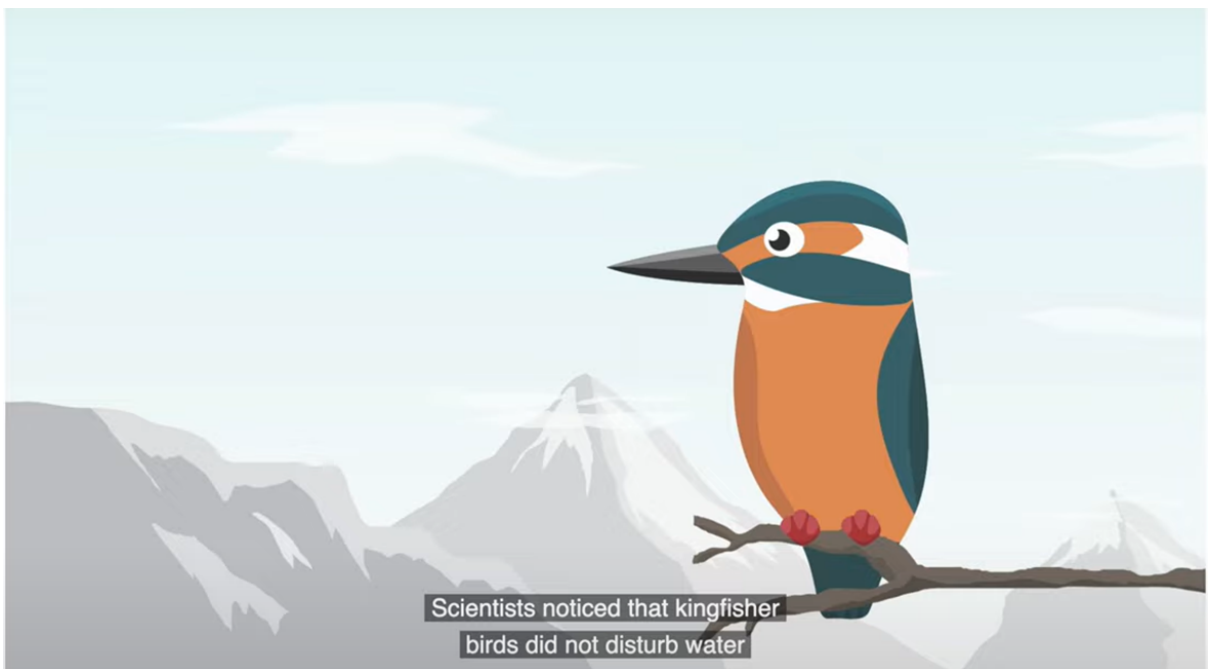
When in a tunnel, the fast speed and the bullet shape



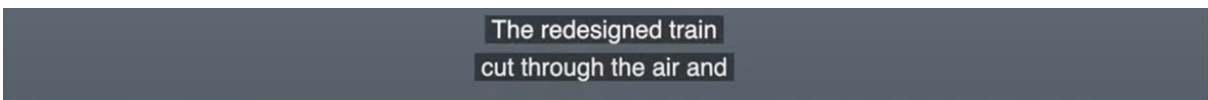
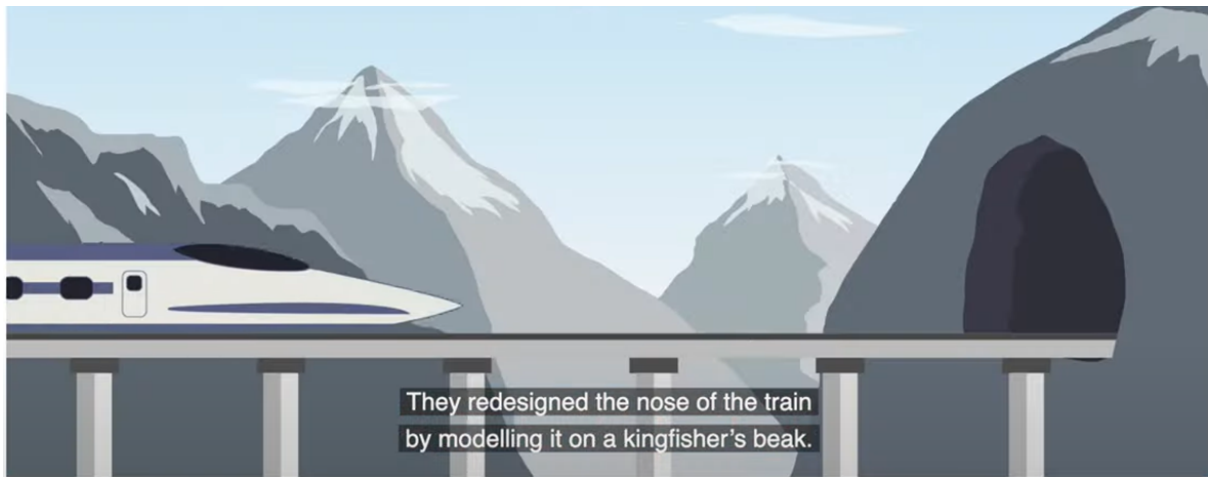
caused a layer of air to build up in front of a train

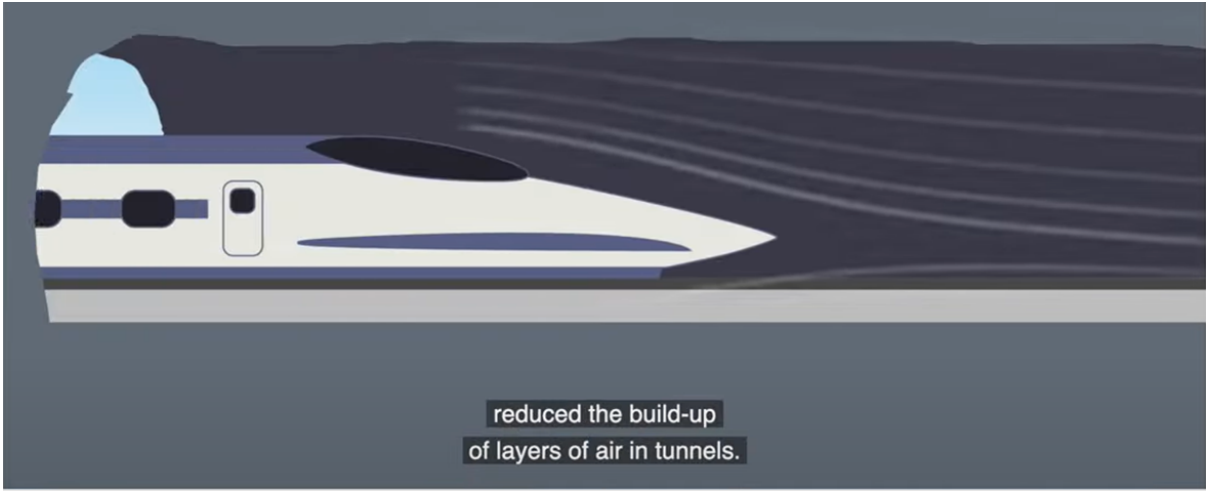


This caused a loud booming sound when the train exited the tunnel.



Scientists noticed that kingfisher birds did not disturb water





This reduced the loud booming sound

and increased the
train's efficiency.

Question 1a (1 mark)

Select the unit for measuring force.

- ✓ Select
- joule
- kilogram
- newton
- watt

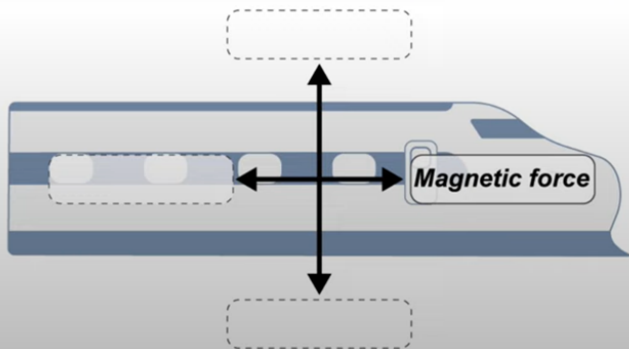
Question 1b (2 marks)

Question 1b (2 marks)

The diagram below shows the forces acting on the 1964 train traveling at a constant maximum speed of 220 km h^{-1} .

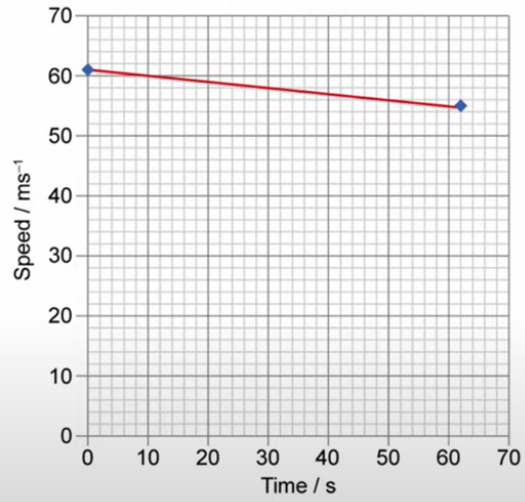
Label the forces in the diagram.

Draggable items: Weight Normal force Magnetic force Drag force



Question 1d (3 marks)

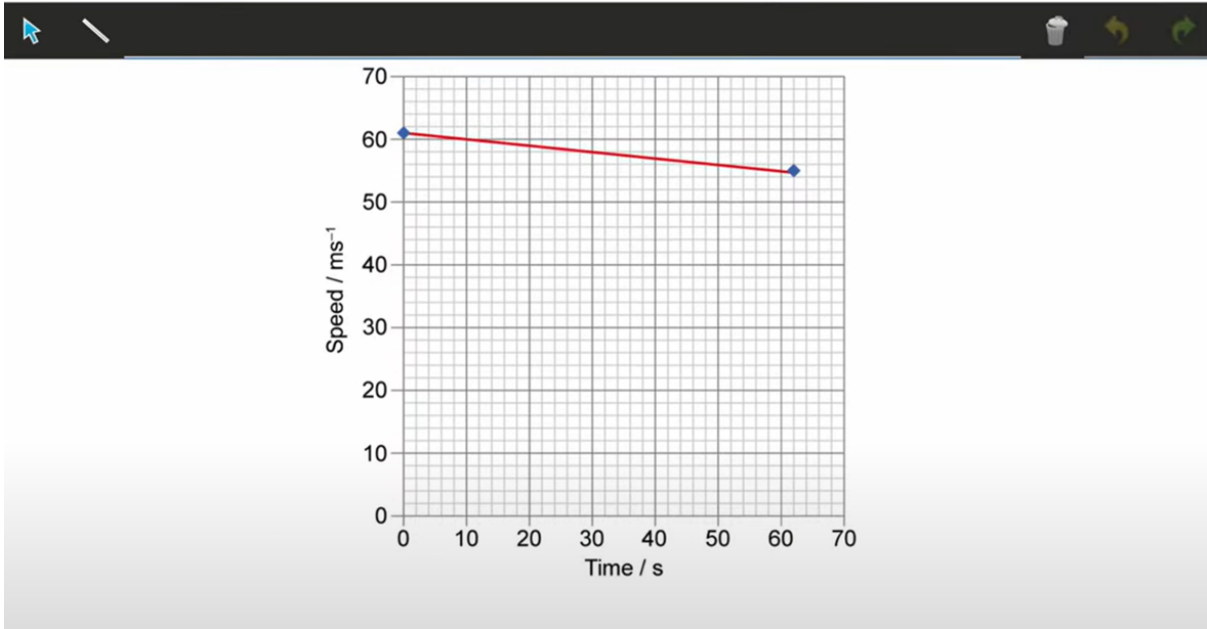
The speed–time graph shows the motion of the 1964 train on its journey through a tunnel. Use the graph to **calculate** the length of the tunnel.



Rich text editor toolbar with icons for Bold (B), Italic (I), Undo, Redo, Underline (U), subscript (x₂), superscript (x²), Bulleted list, Numbered list, Omega (Ω), Sigma (Σ), Styles dropdown, and a document icon.

Question 1e (2 marks)

Draw a line on the graph to represent the journey of the redesigned train through the tunnel at the same initial speed.



Question 2 (7 marks)

Question 2a (1 mark)

Transformers are electrical devices that are used for reducing or increasing the voltage of an alternating current.

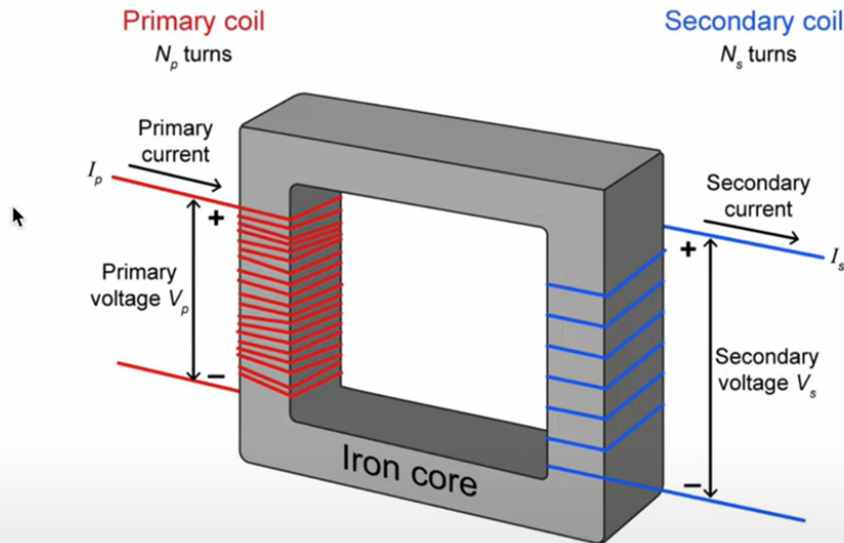
Select the correct terms to complete the sentence.

In a transformer that is 100% efficient, the input must be the output power.

	<input checked="" type="checkbox"/> Select power current voltage	<input checked="" type="checkbox"/> Select less than equal to greater than
--	---	---

Question 2b (2 marks)

Transformers are composed of primary and secondary coils wrapped around an iron core.



©

Transformers are commonly used to reduce the voltage from supply lines to the voltage required for homes.

	Voltage / V	Current / A
Primary coil		1.2
Secondary coil	240	60

Reset

Use information from the formula sheet to **calculate** the primary supply voltage. You should assume this transformer is 100% efficient.

Rich text editor toolbar with icons for bold, italic, undo, redo, underline, strikethrough, square, list, link, unlink, link icon, and a styles dropdown menu.

Question 2c (2 marks)

In reality, transformers are only 98% efficient. **Calculate** the actual power supplied by the secondary coil.

Rich text editor toolbar with icons for bold, italic, undo, redo, underline, strikethrough, square, list, link, unlink, link icon, and a styles dropdown menu.

Question 2d (2 marks)

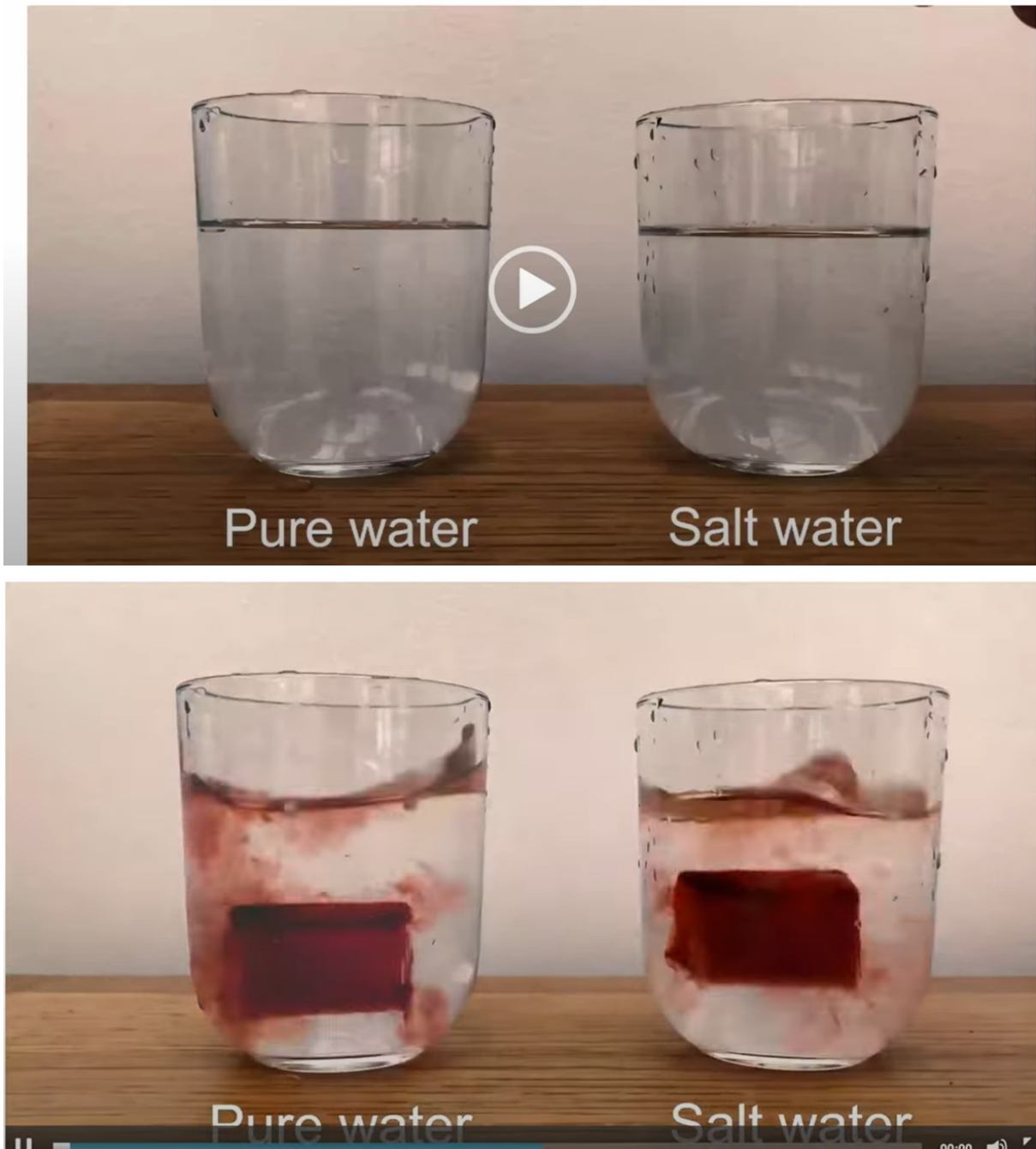
The relationship between power and current can be expressed as $P = I^2 R$ where P = power, I = current and R = resistance. Use this relationship to **describe** why electricity is transmitted over long distances at high voltage.

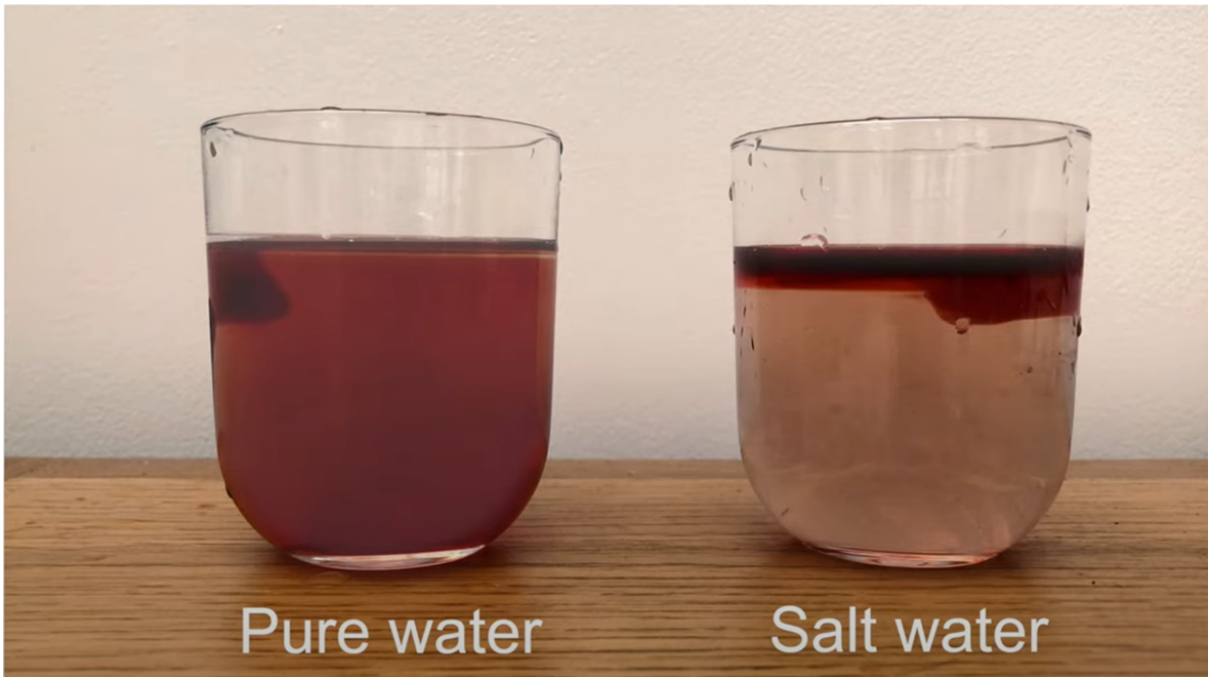
B *I* ← → U ×_o ×^o $\frac{1}{2}$ $\frac{3}{4}$ Ω Σ Styles 

Question 3 (9 marks)

The video below shows ice cubes made from pure water melting in glasses of pure and salt water. The ice cubes have been coloured so they are more visible while melting. The ice cube in pure water melts faster than the ice cube in salt water.

This media contains no audio







Pure water

Salt water

00:25

Question 3a (1 mark)

There are three methods of heat transfer. **Select** the most appropriate description for each method.

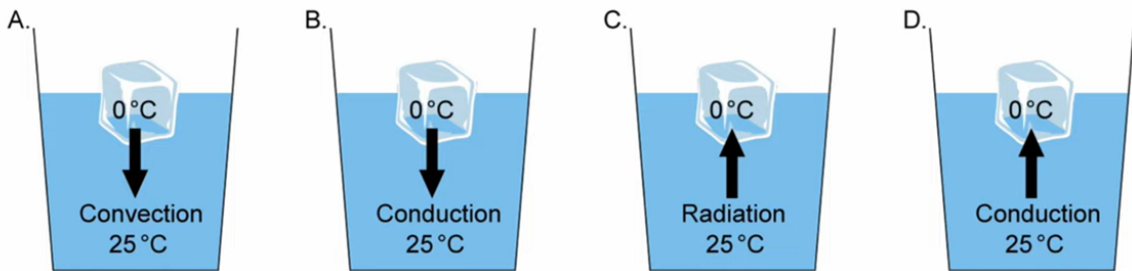
Draggable items:

- Transfer of heat by direct contact
- Transfer of heat by moving fluids
- Transfer of heat by electromagnetic radiation

Radiation	
Conduction	
Convection	

Question 3b (1 mark)

Select the diagram that best represents the process of heat energy transfer between the ice cube and the water.



- ✓ Select
- A
- B
- C
- D

Question 3c (1 mark)

Question 3d (1 mark)

Question 3c (1 mark)

In the video, tiny water droplets begin to form on the outside of each glass. **State** the physical change that is shown by the formation of these water droplets.

B **I** ← → U x_2 x^2 $\frac{1}{2}$ $\frac{3}{4}$ $\frac{5}{6}$ Ω Σ
Styles ▾

Question 3d (1 mark)

Tiny water droplets form around most of the outside of the glass containing pure water but only form at the top of the glass containing salt water. **Suggest** why the pattern of water droplets is different.

B **I** ← → U x_2 x^2 $\frac{1}{2}$ $\frac{3}{4}$ $\frac{5}{6}$ Ω Σ
Styles ▾

Question 3e (3 marks)

Using your knowledge of heat transfer processes, **explain** why the ice cube melts more slowly in the salt water.

B **I** ← → U x_2 x^2 $\frac{1}{2}$ $\frac{3}{4}$ $\frac{5}{6}$ Ω Σ
Styles ▾

Question 3f (2 marks)

Predict how the results of the experiment would change if the water in both glasses was stirred continuously.

B **I** ← → U x_2 x^2 $\frac{1}{2}$ $\frac{3}{4}$ $\frac{5}{6}$ Ω Σ
Styles ▾

Question 4 (16 marks)

A pan flute is a musical instrument made from hollow tubes that are closed at one end. The tubes are commonly made from natural materials, such as bamboo. The tubes are cut to different lengths. When air is blown across a tube, the air vibrates and produces a sound.



Question 4a (1 mark)

An MYP student is interested in the relationship between the length of a tube and the frequency of the sound being produced.

State a research question that would be tested by this investigation.

Rich text editor toolbar with icons for Bold (B), Italic (I), Undo, Redo, Underline (U), subscript (x₂), superscript (x²), Bulleted list, Numbered list, Link (Ω), Unlink (Σ), Styles dropdown, and Insert/Link icon.

Question 4b (3 marks)

You are provided with a box of tubes. **Select** the tubes you would use in the investigation in part (a) to collect appropriate data. Drag your selected tubes from the top box of available tubes into the bottom box.

Draggable items:

- 0.2 m (Aluminium, 2.5 cm diameter)
- 0.2 m (Wood, 5.0 cm diameter)
- 1.0 m (Plastic, 5.0 cm diameter)
- 0.6 m (Wood, 5.0 cm diameter)
- 80 cm (Wood, 5.0 cm diameter)
- 0.4 m (Wood, 5.0 cm diameter)
- 0.6 m (Wood, 5.0 cm diameter)
- 0.4 m (Aluminium, 2.5 cm diameter)
- 1.0 m (Wood, 5.0 cm diameter)
- 60 cm (Aluminium, 2.5 cm diameter)
- 0.2 m (Wood, 5.0 cm diameter)
- 1.2 m (Plastic, 5.0 cm diameter)

Available tubes

Tubes to use

Key:

- Aluminium 2.5 cm
- Plastic 5.0 cm
- Wood 5.0 cm

Question 4c (2 marks)

Justify the selection you made in part (b).

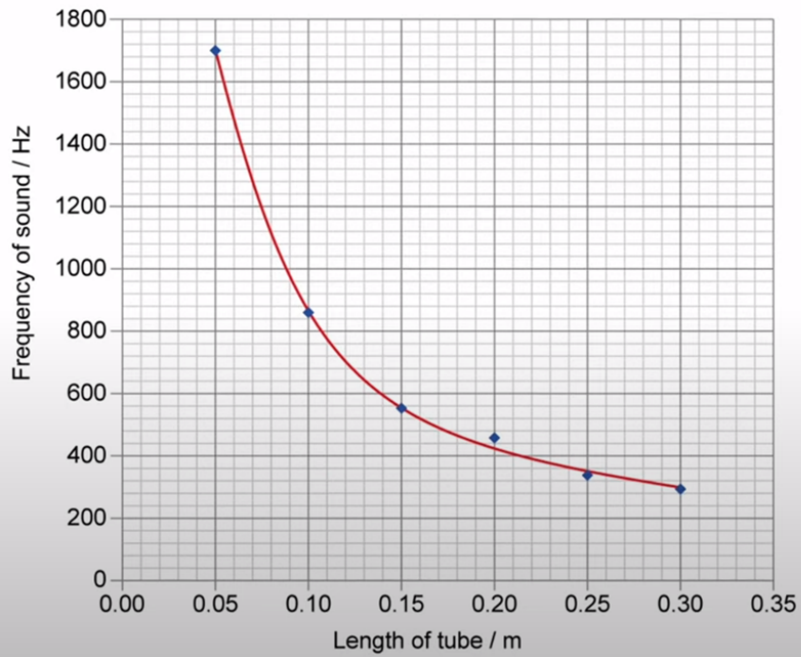
B *I* ← → U x_n x^a $\frac{1}{x}$ $\frac{1}{x^2}$ Ω Σ Styles

Question 4d (3 marks)

A student doing a similar investigation made the following prediction:

As the length of the tube increases, the frequency of the sound produced will decrease.
I predict that there will be an inversely proportional relationship between the variables.

The graph of her results is shown below:



Use data from the graph and a calculation to **explain** whether the student's prediction is supported.

Question 4e (1 mark)

This data can be used to find the speed of sound in air using the relationship:

$$f = \frac{v}{4L}$$

Where:

f – frequency

L – length of the tube

v – speed of sound in air

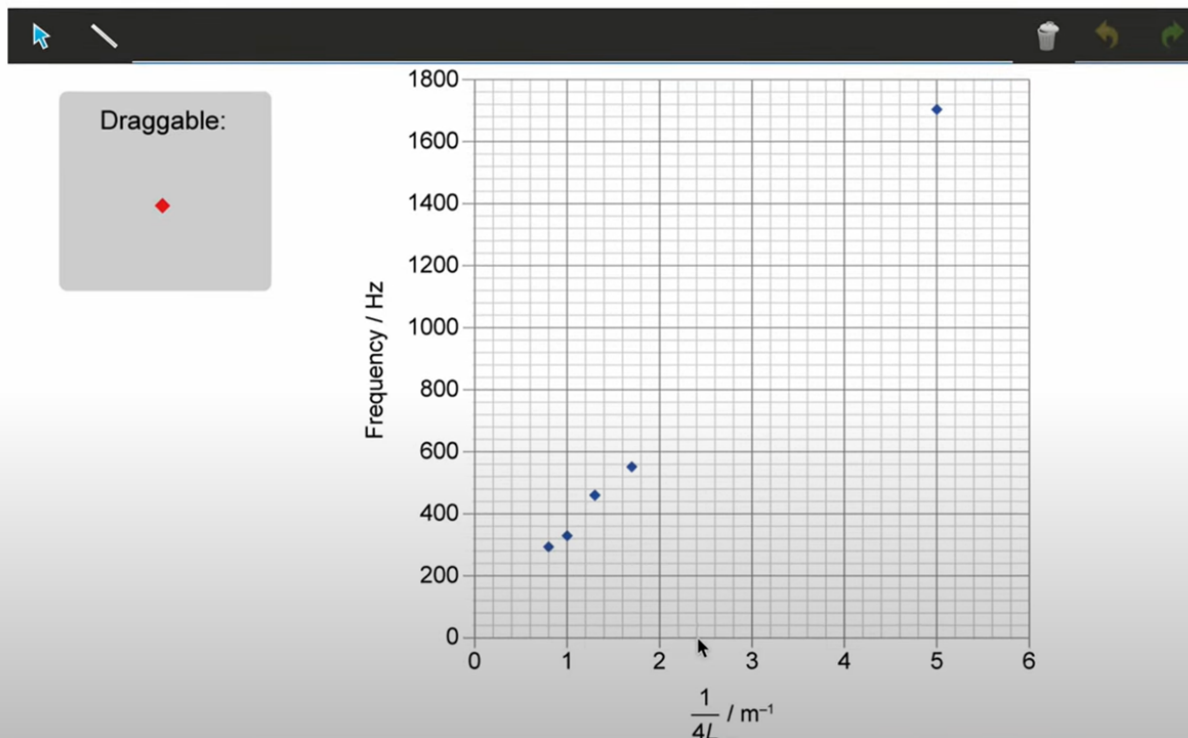
Determine the missing values and add them to the table of processed data below.

Length L / m	Frequency f / Hz	$4L$ / m	$\frac{1}{4L}$ / m^{-1}
0.05	1715	0.2	5.0
0.10	860		
0.15	572	0.6	1.7
0.20	450	0.8	1.3
0.25	343	1.0	1.0
0.30	290	1.2	0.8

Question 4f (2 marks)

The graph below shows the processed data from part (e).

Plot the data point you determined in part (e) and **draw** a line of best fit on the graph.



Question 4g (1 mark)

The student is investigating the relationship $f = \frac{v}{4L}$. **Identify** what quantity is shown by the gradient of the graph in part (f).

$\frac{1}{v}$

v

$\frac{1}{4L}$

$\frac{v}{4L}$

Question 4h (3 marks)

Calculate the gradient of your line of best fit. You should include your working and **state** the unit.

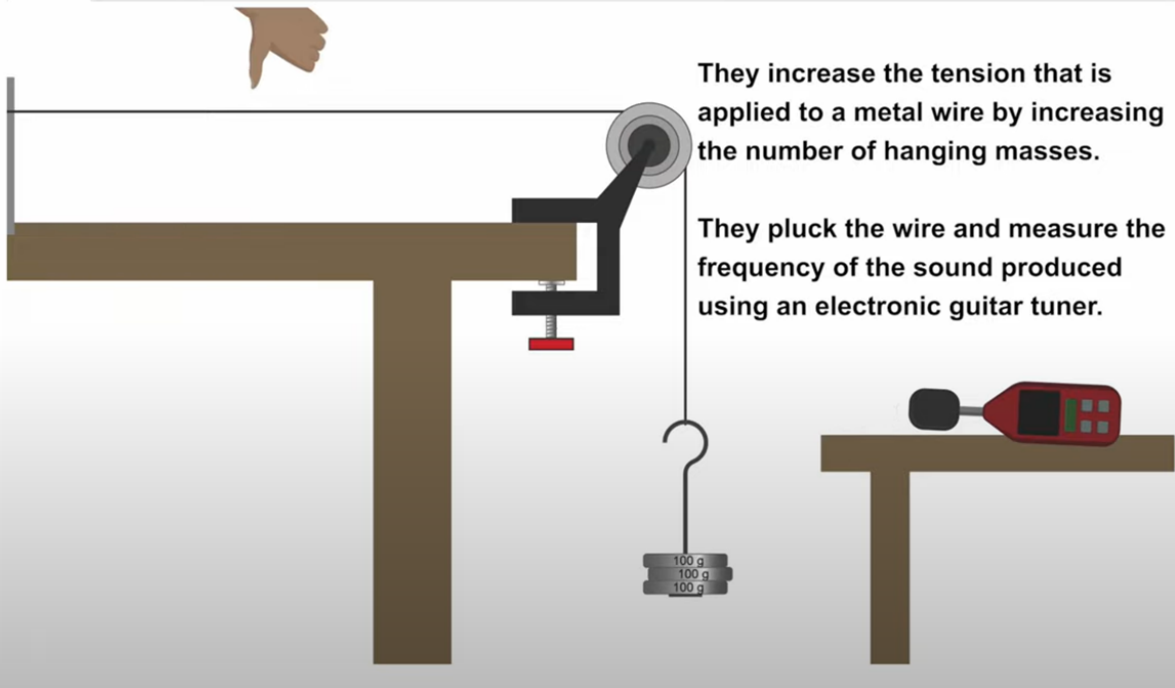
B *I* ← → U x_2 x^2 \int \sum Ω Σ Styles



Some musical instruments, such as the guitar, make sounds by vibrating strings.

Video

Script



Calculate the force of tension in the wire if the hanging mass is 300 g. You should assume that gravitational field strength is 10 N kg^{-1} .

Rich text editor toolbar with icons for Bold (B), Italic (I), Undo, Redo, Underline (U), Subscript (x₂), Superscript (x²), Bulleted list, Numbered list, Link (Ω), Unlink (Σ), Styles dropdown, and Insert image.

Question 5b (2 marks)

The student's research question is:

How does increasing the force of tension affect the frequency of vibration of a wire?

Suggest two variables the student should have controlled during this investigation.



Control variable 1:

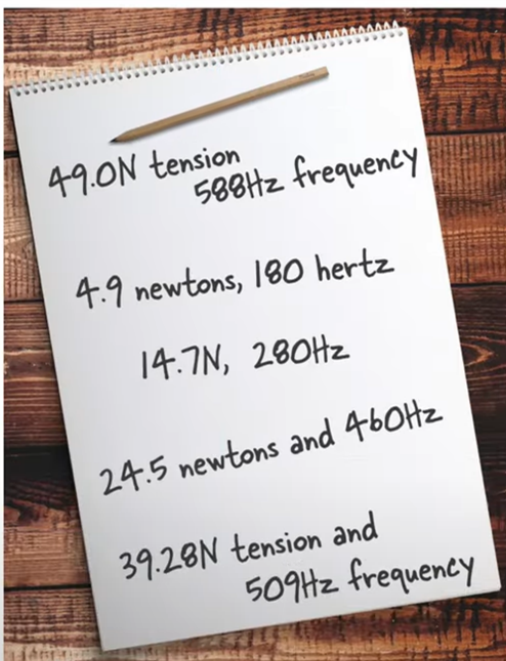
Rich text editor toolbar for Control variable 1 with buttons for Bold (B), Italic (I), Undo, Redo, Underline (U), Subscript (x₂), Superscript (x²), Bulleted List, Numbered List, Link (Ω), and Unlink (Σ). Includes a Styles dropdown and a document icon.

Control variable 2:

Rich text editor toolbar for Control variable 2 with buttons for Bold (B), Italic (I), Undo, Redo, Underline (U), Subscript (x₂), Superscript (x²), Bulleted List, Numbered List, Link (Ω), and Unlink (Σ). Includes a Styles dropdown and a document icon.

Question 5c (4 marks)

The student's notebook containing the results from this investigation is shown below:



Organize and **present** the data in a table.

Create New Table

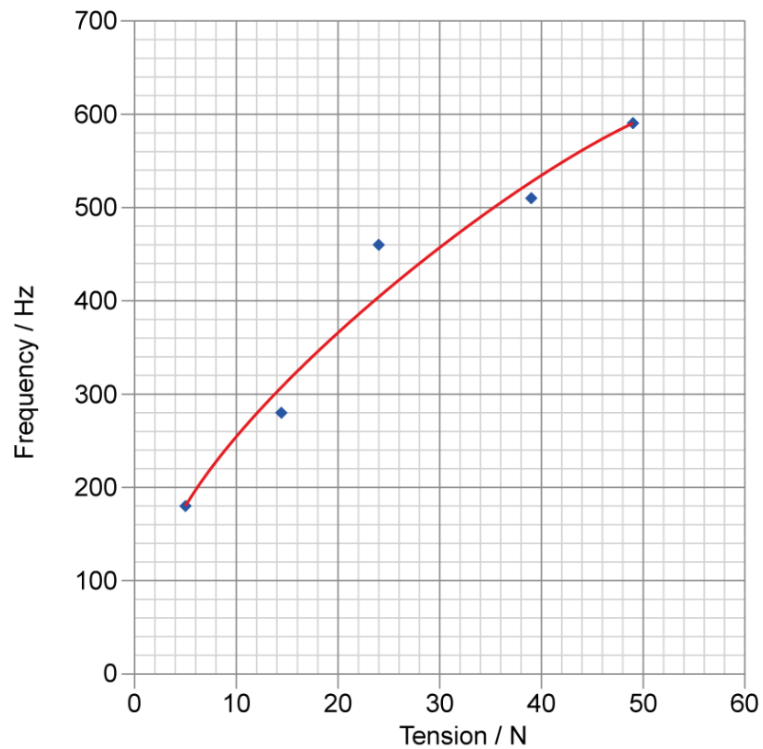
Reset





Question 5d (2 marks)

The student plots a graph of frequency against tension for their results.



Scroll down to continue

The student makes the following statement:

The line of best fit could be a curve, but I am not confident that the graph correctly shows the relationship between the two variables. I should take more measurements.

Suggest what additional measurements the student should make to verify the relationship shown by the graph. **Justify** your answer.

B I | ← → | x₂ x^e | ☰ ☷ | Ω Σ | Styles | 📱



Question 5e (3 marks)

Many different investigations can be carried out relating to the frequency of vibration of a wire. **Identify** the variables for a new investigation with frequency as the dependent variable.



Independent variable:

Dependent variable:

Frequency



Question 5f (2 marks)

Formulate a hypothesis for the new investigation in part (e).

If:

Then:



Question 6 (17 marks)

The loudness of a sound relates to its intensity level. The sound intensity level can be measured in decibels (dB) using an instrument known as a sound level meter.

A sound level meter was used to investigate the relationship between sound intensity level and distance from the sound source. The investigation was performed on a school field using a speaker and three trials were carried out at each distance.



Sound level meter



Question 6a (1 mark)

Suggest why three trials were carried out during data collection.

B *I* ← → U x_2 x^e \int \sum Ω Σ Styles



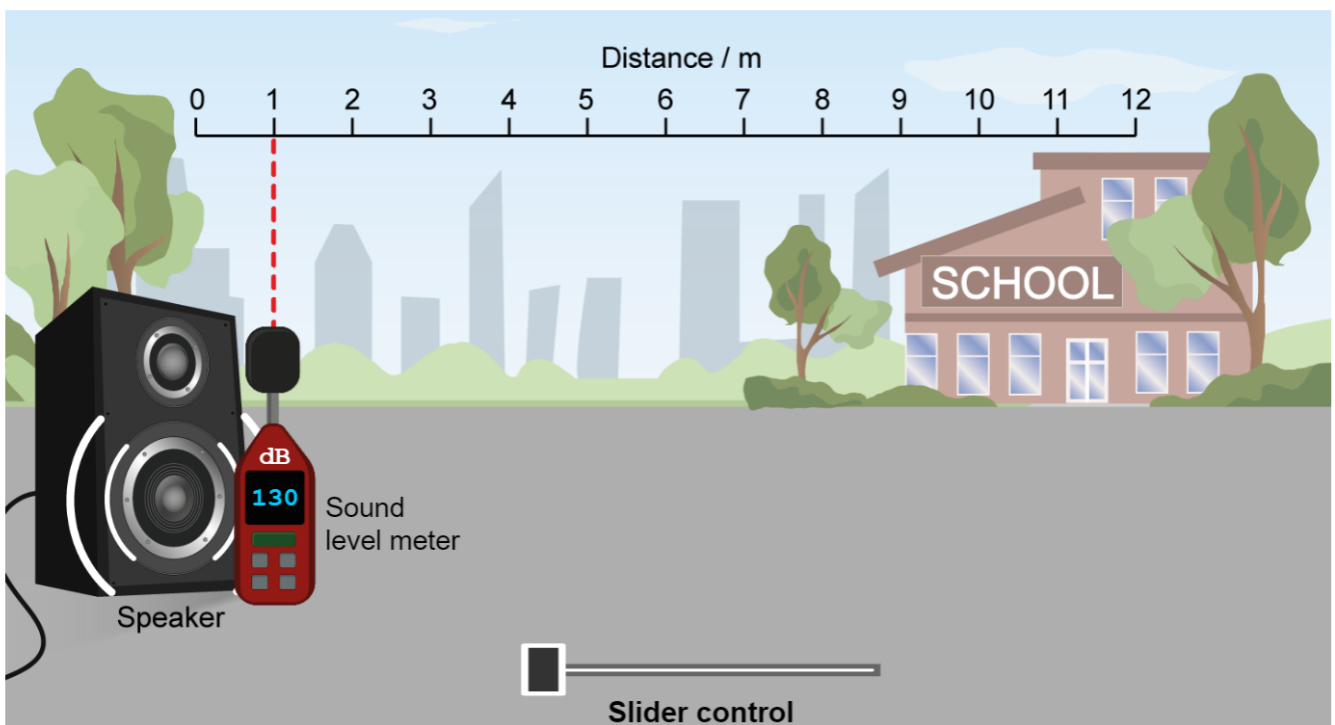


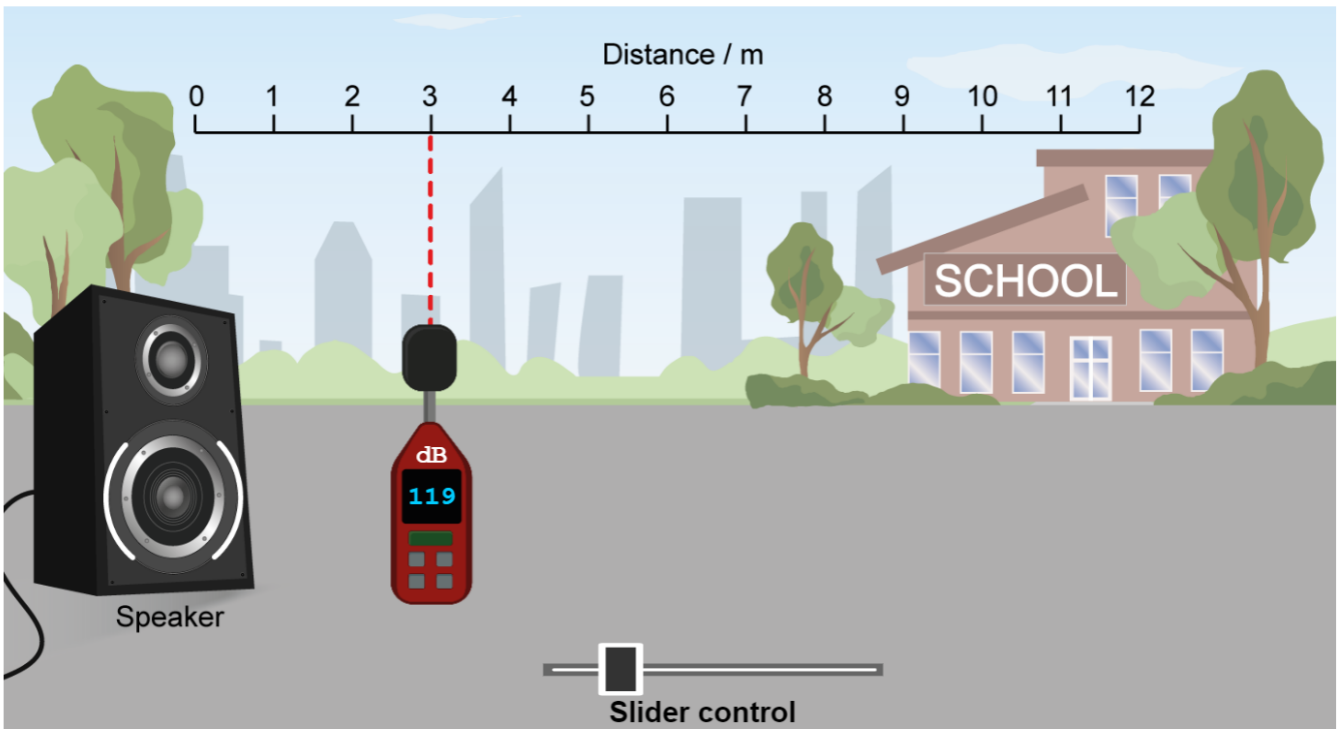
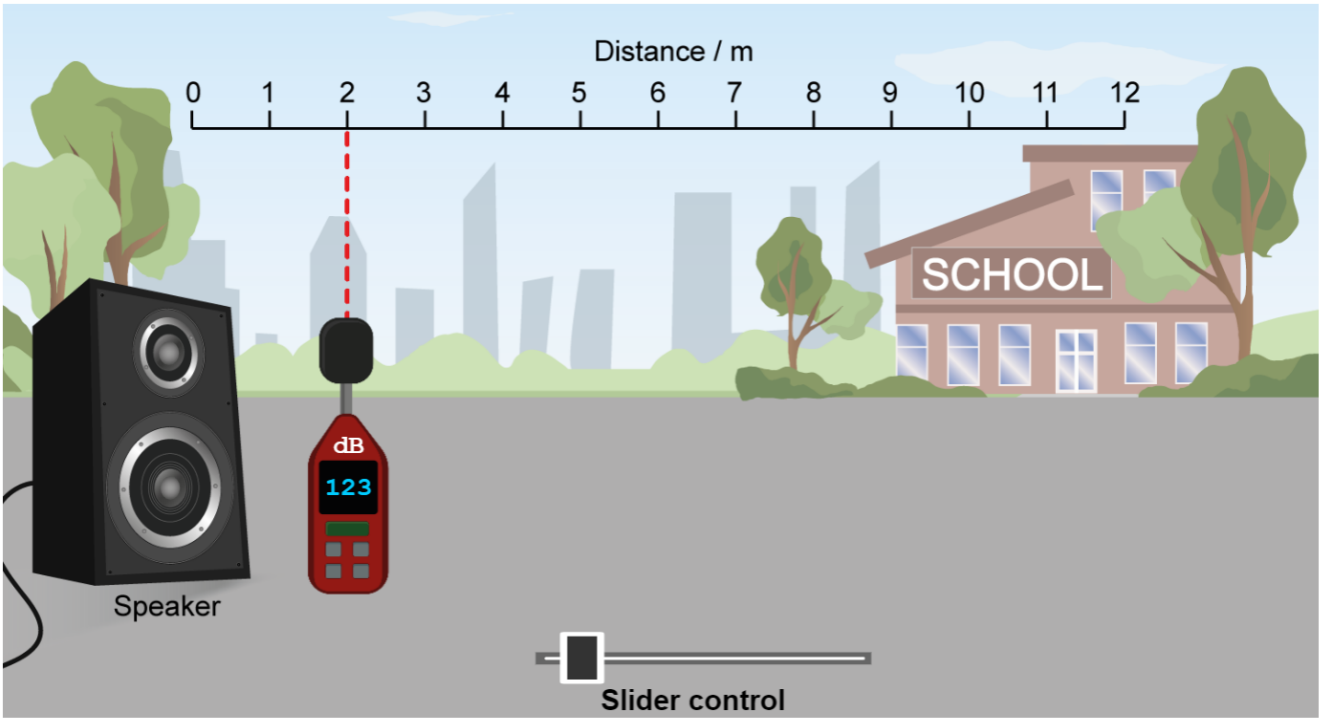
Question 6b (2 marks)

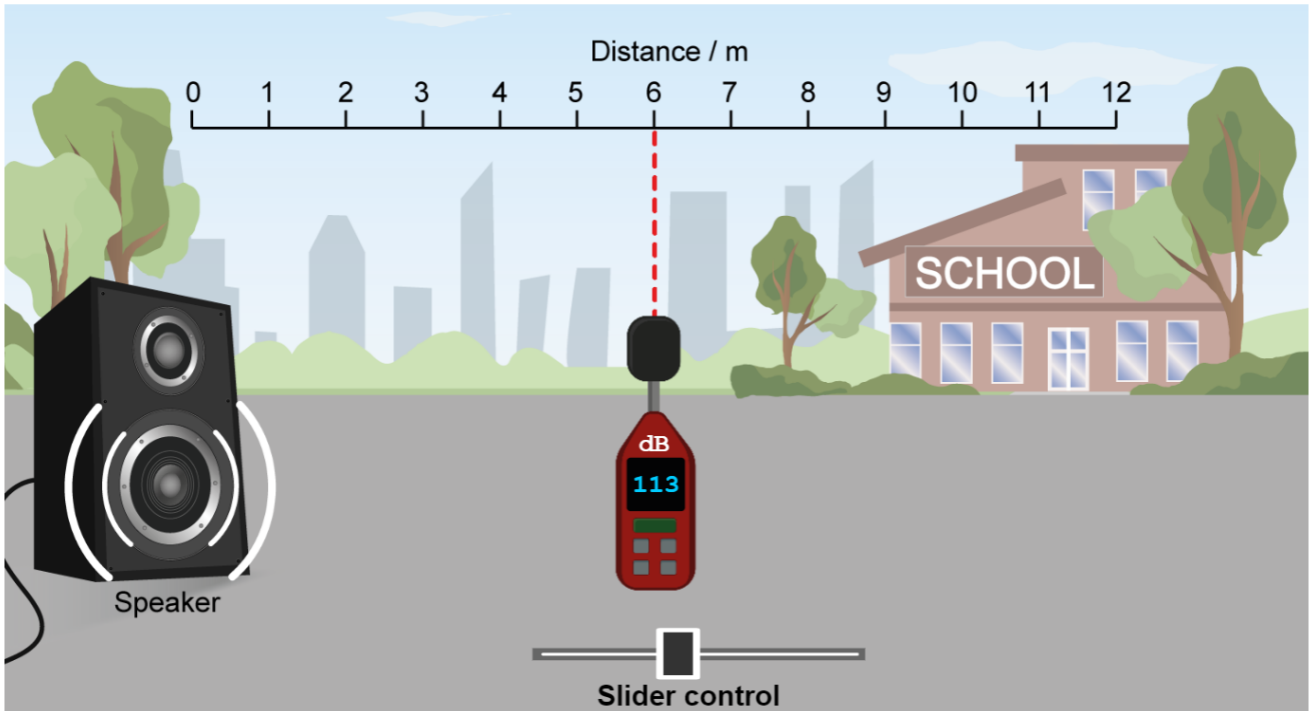
Use the equipment below to **measure** the sound intensity level at a distance of 6 m from the speaker. **Calculate** the average sound intensity level and add your value to the table.

Diagram not to scale

This media contains no audio







Question 6c (1 mark)

A simple pattern that can be seen in the data is that a doubling of the distance changes the sound intensity level by the same amount. Use this pattern to **predict** the sound intensity level at a distance of 16 m.

B **I** | ← → | \times_2 \times^2 | $\frac{1}{x}$ $\frac{1}{x^2}$ | Ω Σ | Styles |

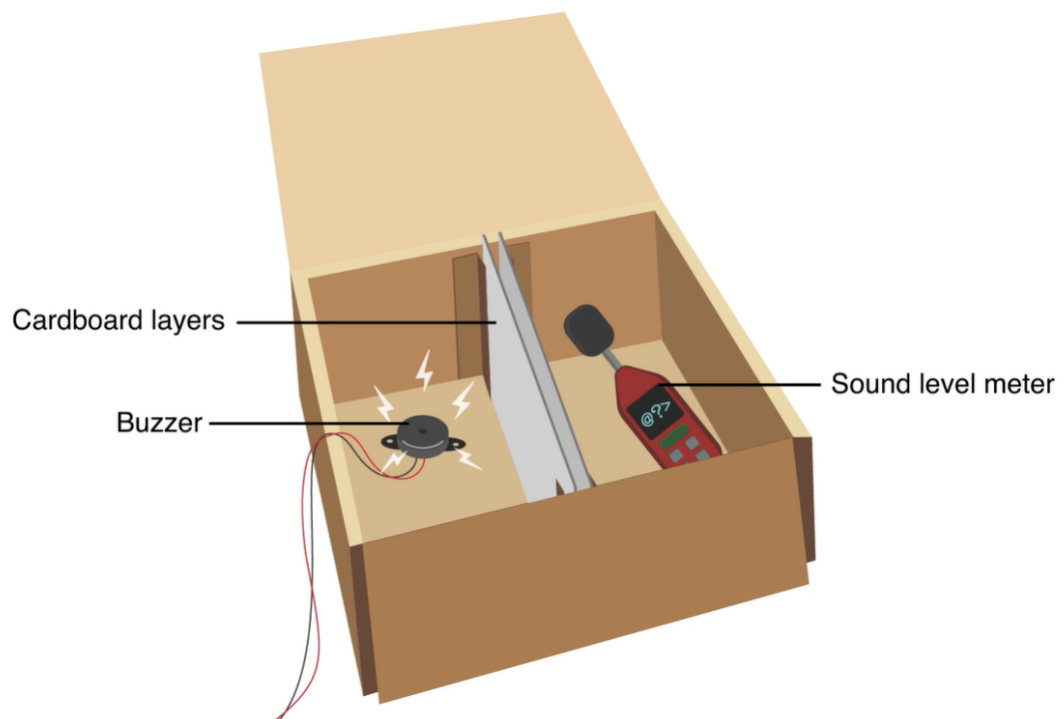




Question 6d (13 marks)

An MYP student is interested in how the thickness of a wall affects the sound intensity level that is measured on the other side of the wall.

They make the model that is shown below to use in their investigation.



On one side of the wall they will have a buzzer and on the other side of the wall they will have a sound level meter.

Design an investigation to find out how the number of layers of cardboard in the wall affects the sound intensity level. In your plan, you should include:

- your independent and dependent variables and the justification of two control variables
- a hypothesis which is explained using scientific reasoning
- a detailed method for how you will collect data
- an explanation of how you will collect sufficient data.

B *I* | ← → | x₂ x² | ☰ ☷ | Ω Σ | Styles ▾ | 📄 ↕



Question 7 (6 marks)

Many years ago, people believed that all the planets and the Sun orbited Earth. This is known as the geocentric model. As viewed from Earth, Mars takes the path shown in the animation.





Question 7a (2 marks)

Suggest why this observation is not consistent with the geocentric model of the solar system.

B *I* | ← → | x₂ x² | $\frac{1}{x}$ $\frac{1}{x^2}$ | Ω Σ | Styles - |



Question 7b (2 marks)

When Earth and Mars are 6×10^{10} m apart, a radio signal travelling at 3×10^8 ms⁻¹ will take 200 s to travel between the planets.

Calculate the time for the radio signal to travel from Earth to Mars when they are 4×10^{11} m apart. Give your answer to the nearest minute.

B *I* | ← → | x₂ x² | $\frac{1}{x}$ $\frac{1}{x^2}$ | Ω Σ | Styles - |

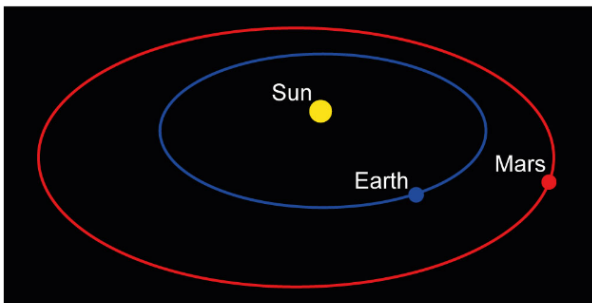


Question 7c (2 marks)

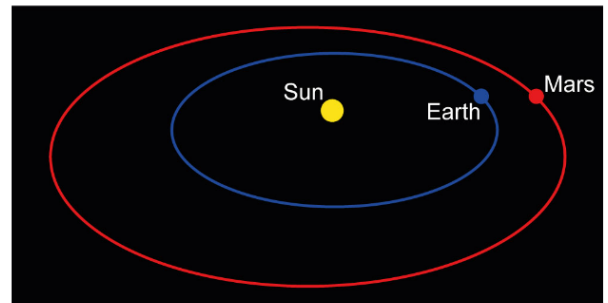
The UAE (United Arab Emirates) launched an un-crewed mission to Mars on 19 July 2020. Similar missions from China and the US (United States) were launched around the same date. The orientation of Earth and Mars on this date is shown below.

The planets were closest together on 6 October 2020.

19 July 2020



6 October 2020



Use the diagrams to **suggest** two reasons why it was an advantage to launch the missions to Mars in July rather than October.

Reason 1:

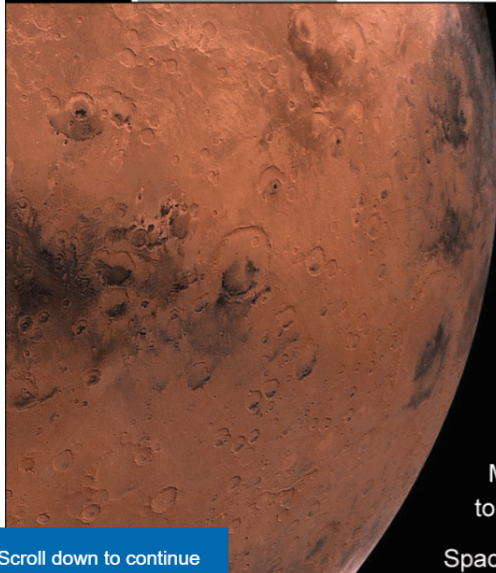
Reason 2:

Question 8 (13 marks)

Since 1960, there have been around 47 missions to Mars launched. Of these, only around half have been successful and have collected data to extend our knowledge of Mars. The interactive graphic below shows details of the missions.

Facts

Missions



Timeline missions to Mars

Click on the flag to reveal successful and unsuccessful missions to Mars



Facts

Crewed expeditions to Mars in the next decades have already been announced by the US and China.

Such project would cost up to \$100 billion over the course of 30 to 40 years. A typical journey to Mars takes around 6 to 8 months.

Private companies have also entered the race.

The main goal of the private companies is to make space accessible to people who are not trained astronauts.

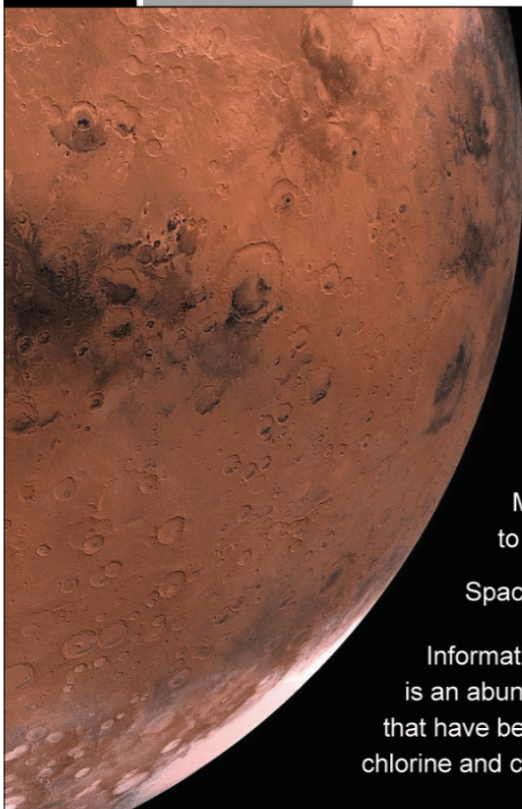
Mars One, a Dutch-Swiss organization plans to bring four people to Mars at a cost of \$6 billion.

SpaceX founder Elon Musk put the cost to about \$10 billion per person.

Scroll down to continue

Facts

Missions



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Facts

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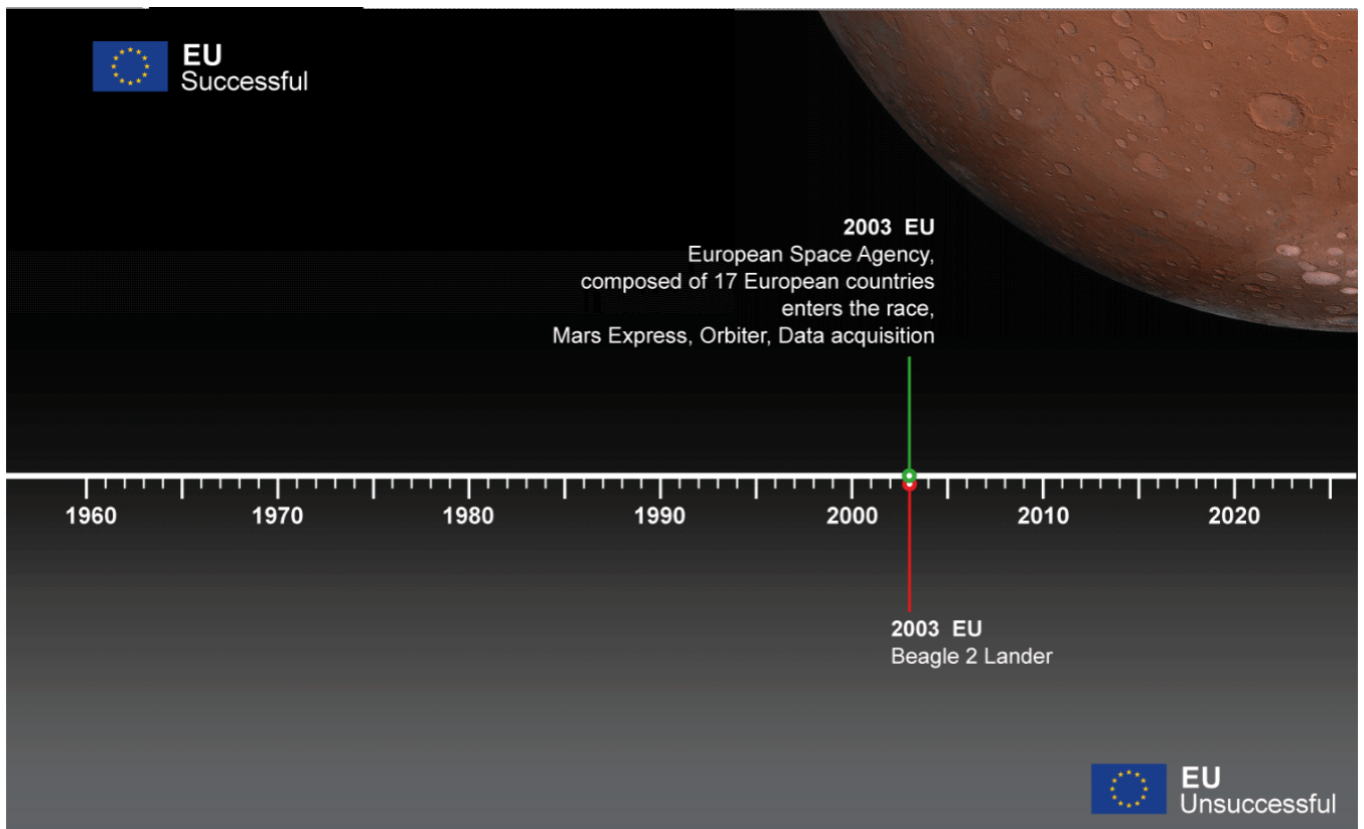
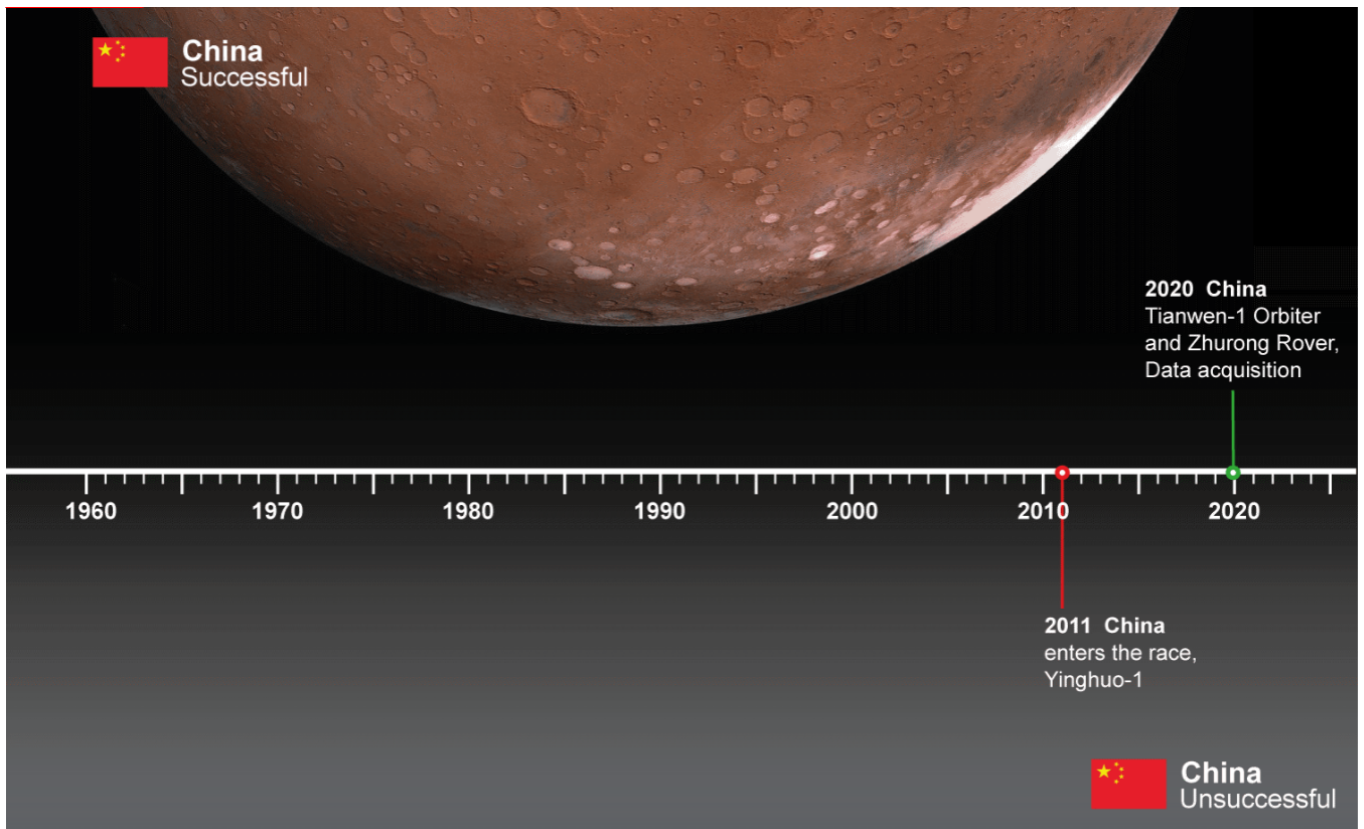
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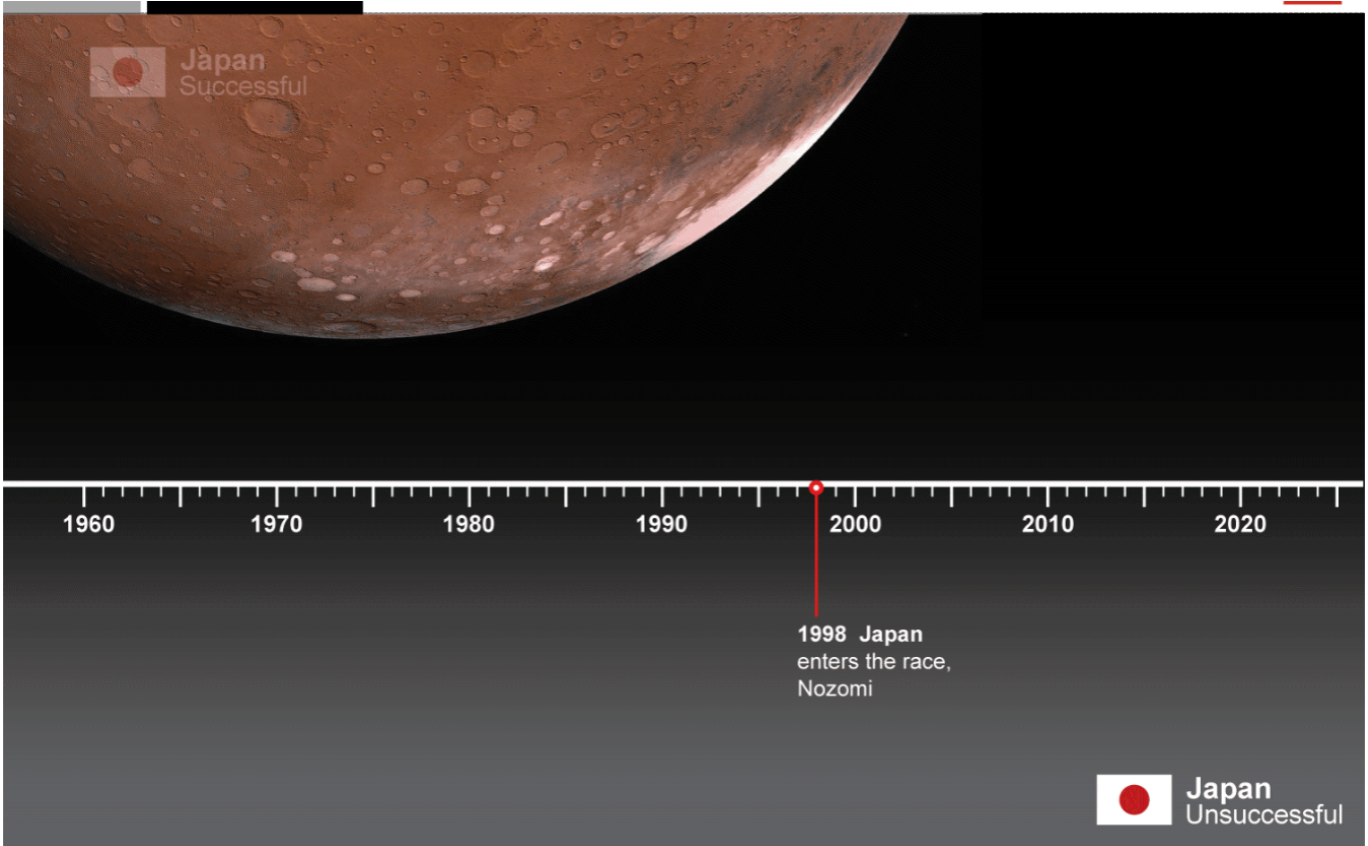
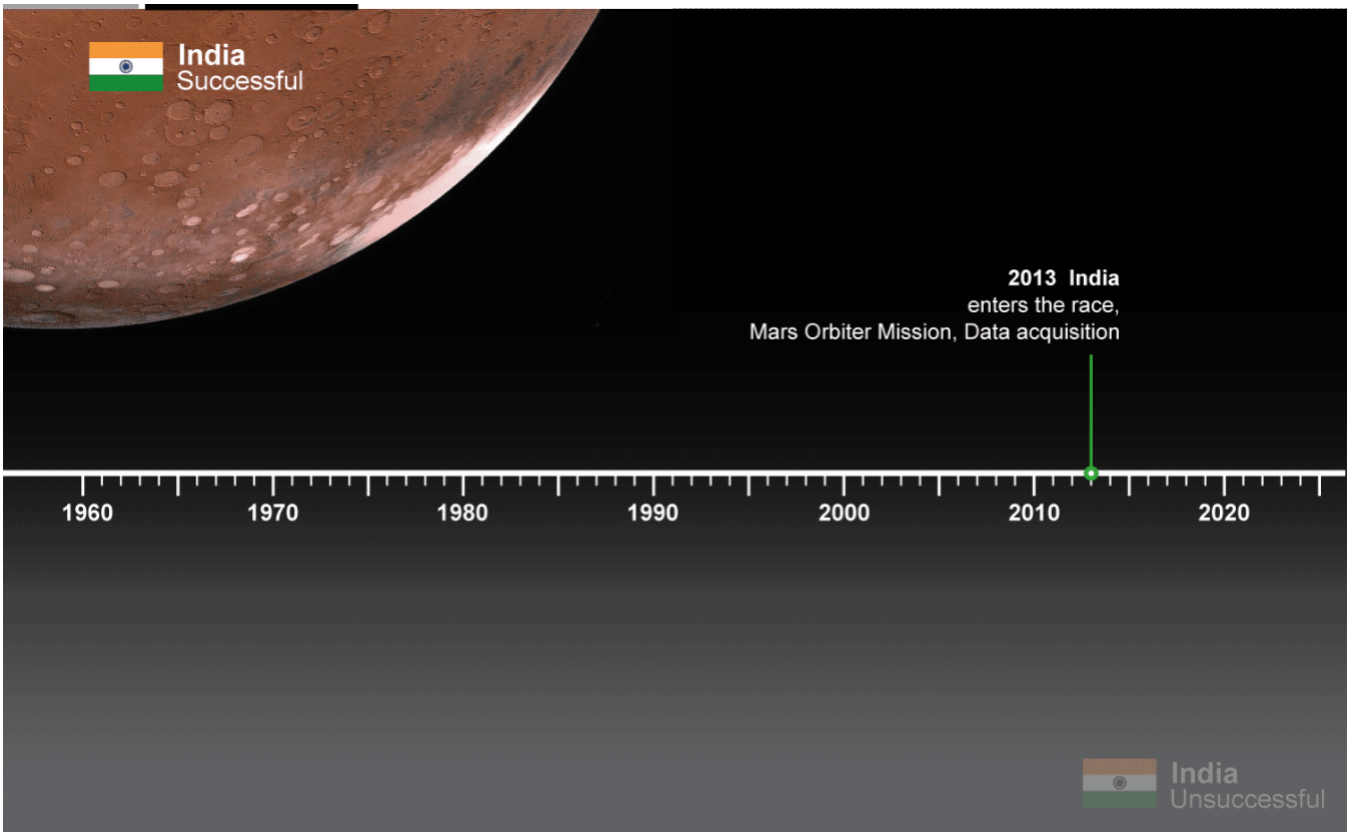
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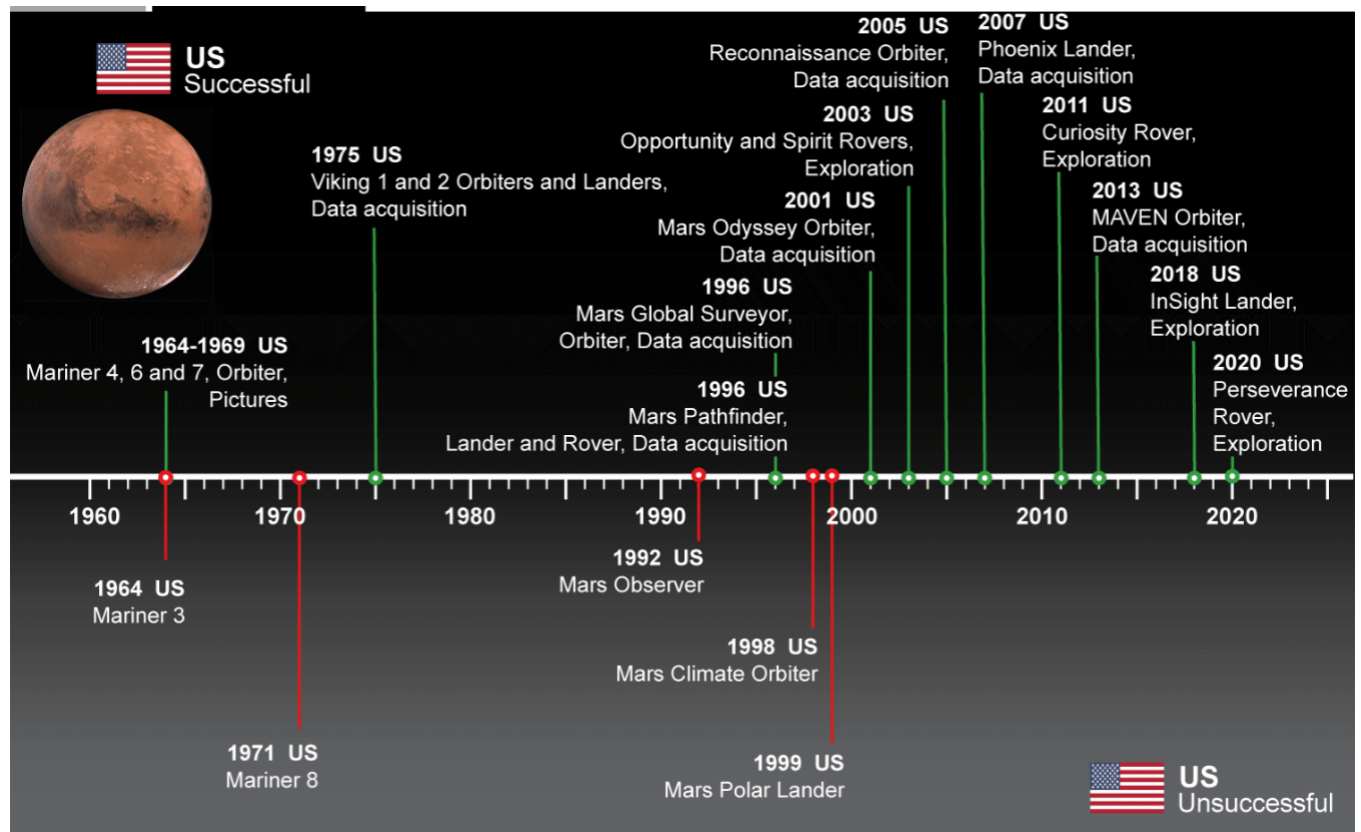
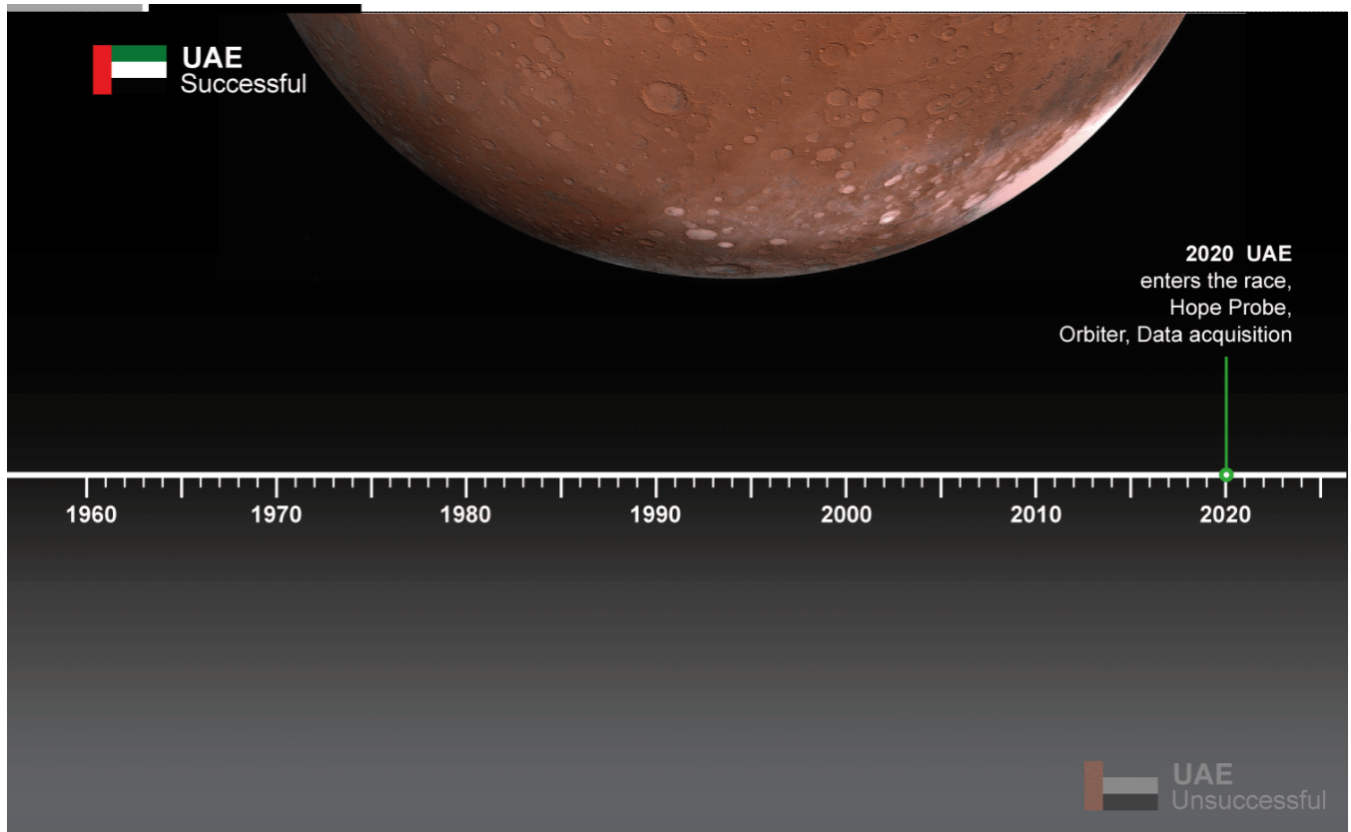
Mars One, a Dutch-Swiss organization plans to bring four people to Mars at a cost of \$6 billion.

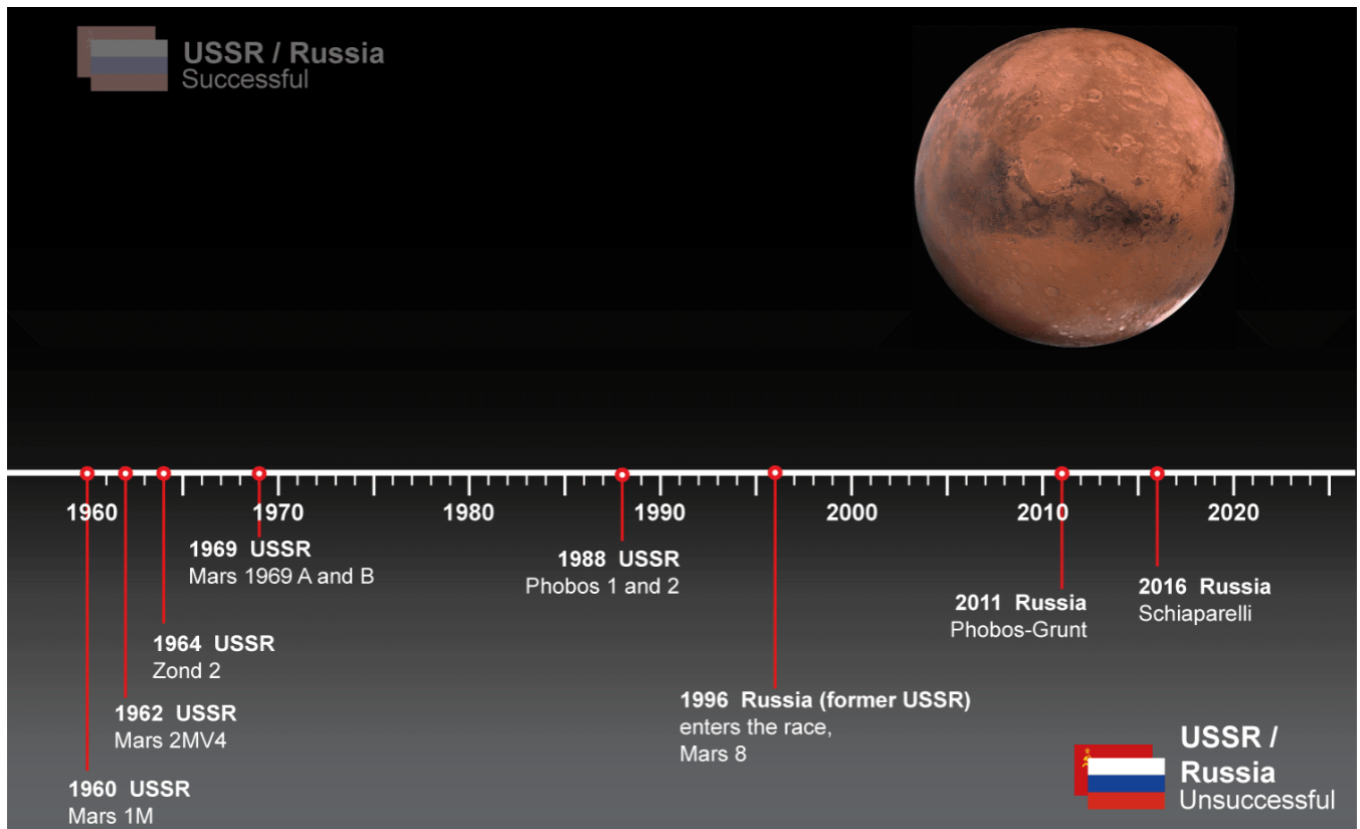
SpaceX founder Elon Musk put the cost to about \$10 billion per person.

Information collected from rover and orbiter missions suggests that there is an abundance of resources on Mars. Among the mineral resources that have been discovered are iron, titanium, nickel, aluminium, sulfur, chlorine and calcium.









Using all the information provided on Mars and your wider MYP studies, **discuss** and **evaluate** why a government might want to attempt to send humans to Mars. In your answer, you should include:

- the technical challenges of planning the journey to Mars
- a discussion of the economic advantages and disadvantages for the government
- a discussion of the political implications of attempting to put a human on Mars
- a concluding appraisal.

Rich text editor toolbar with icons for Bold (B), Italic (I), Undo, Redo, Underline (U), Text Color (x₂), Background Color (x²), Bulleted List, Numbered List, Link (Ω), Unlink (Σ), Styles dropdown, and a mobile device icon.



Question 9 (6 marks)

Mars will be an unwelcoming place for humans because of its atmosphere and environment.

Video

Script

Living on Mars will not be easy.

The planet is covered with sand and rocks that create powerful dust storms.

A year on Mars is almost twice as long as a year on Earth.

There are four seasons on Mars.

Mars is very cold. The average temperature is -62°C

ranging from -126°C in winter to 21°C in summer. Night-time temperatures can be 90°C lower than daytime temperatures.

Mars has an atmosphere of 95% CO_2 . The layer of gas is 100 times thinner than that of Earth and the atmospheric pressure is far lower. The gravitational field strength on the

Video

Script

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Mars is very cold. The average temperature is -62°C

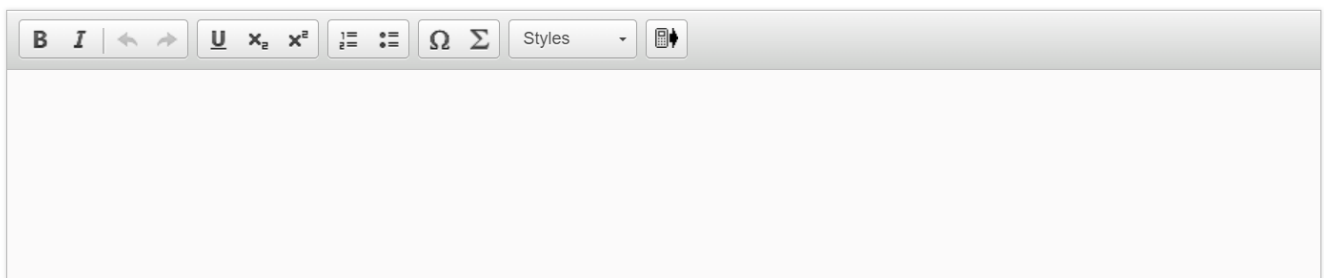
ranging from -126°C in winter to 21°C in summer. Night-time temperatures can be 90°C lower than daytime temperatures.

Mars has an atmosphere of 95% CO_2 . The layer of gas is 100 times thinner than that of Earth and the atmospheric pressure is far lower. The gravitational field strength on the surface of Mars is 0.38 times that of Earth.

There is no protection from the Sun's radiation on Mars. The amount of high energy UV radiation from the Sun is many times greater than on Earth.

Scientific principles would be applied when establishing a settlement on Mars. **Discuss** how scientific principles could be used to build appropriate living conditions for humans. In your answer, you should consider:

- the effect of temperature
- the effect of radiation
- the effect of low gravity
- a suggestion for how each of these effects can be overcome.



A rich text editor toolbar with the following icons from left to right: Bold (B), Italic (I), Undo (left arrow), Redo (right arrow), Underline (U), Subscript (x₂), Superscript (x²), Bulleted List (list with dots), Numbered List (list with numbers), Link (Ω), Unlink (Σ), Styles dropdown menu, and a document icon with a double-headed arrow.