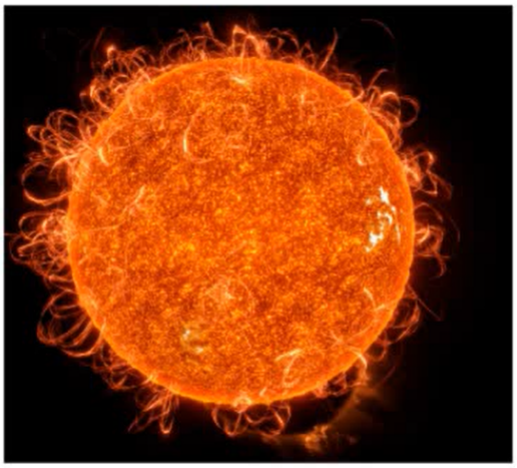
Question 1 (4 marks)

The colours of visible light emitted from a star are related to the star's temperature.
It is known that stars appear more red when they cool down and approach the end of their life.
Young, hot stars appear more blue.



Question 1a (2 marks)

Select the correct statements to complete the comparisons between red and blue light.

The speed of red light is Select ▾ the speed of blue light.

The wavelength of red light is Select ▾ the wavelength of blue light.

The frequency of red light is Select ▾ the frequency of blue light.

Question 1a (2 marks)

Select the correct statements to complete the comparisons between red and blue light.

The speed of red light is Select the speed of blue light.

Select
greater than
less than
equal to

The wavelength of red lig ▾ the wavelength of blue light.

The frequency of red light is Select ▾ the frequency of blue light.

The table below shows the surface temperature of stars and the colour that they appear.

Surface temperature / °C	Colour of star
< 3200	red
3200 – 4700	orange-yellow
4700 – 6000	yellow
6000 – 7500	yellow-white
7500 – 10 000	white
10 000 – 30 000	white-blue
30 000 – 60 000	blue

Pause (Ctrl+P)

Use data from the table to answer the following questions.

Question 1b (1 mark)

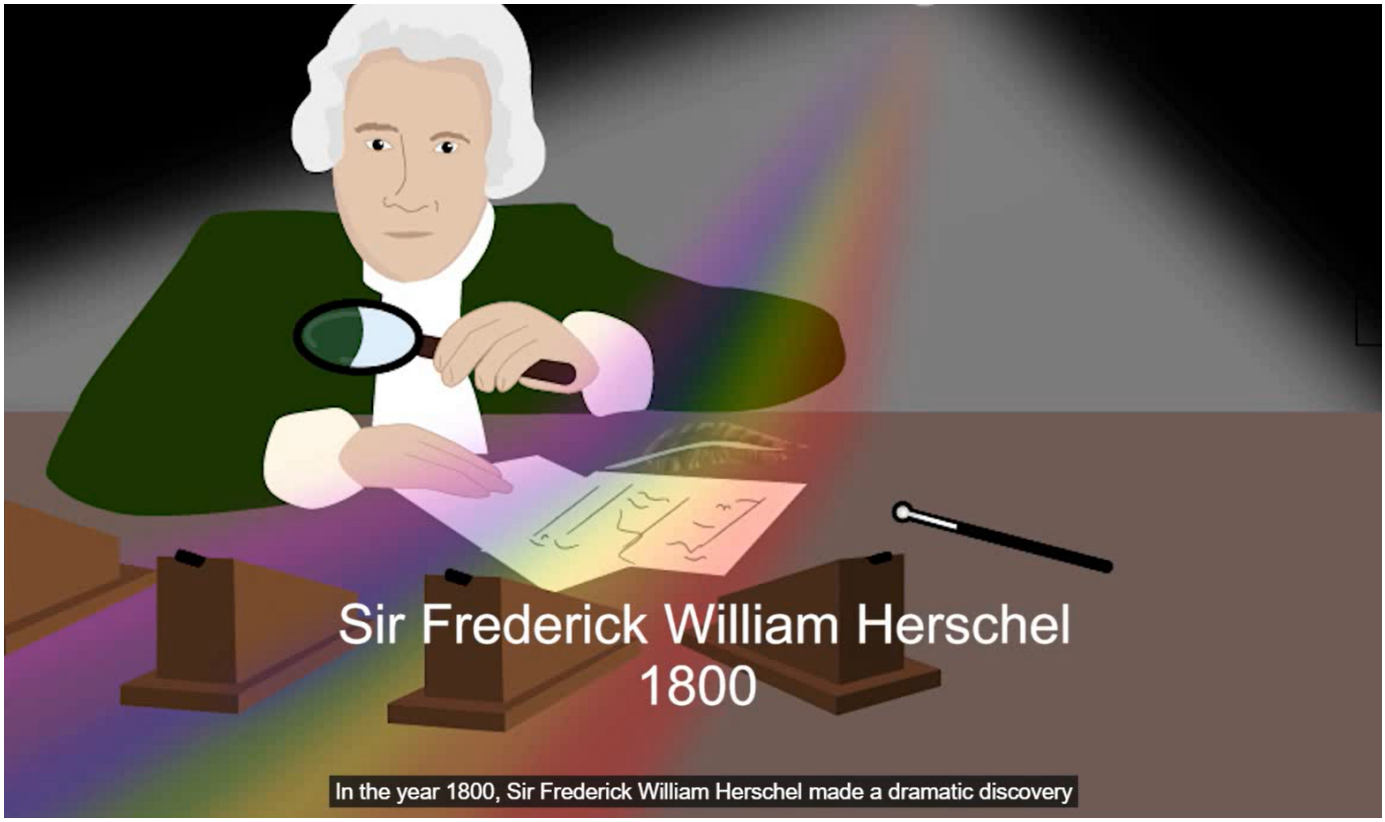
State the expected surface temperature for the red supergiant star Betelgeuse.

Styles

Question 1c (1 mark)

State the expected colour for a star with a surface temperature of 8500 °C.

Styles



Question 2a (2 marks)

Describe how a prism splits white light into a spectrum of colours.

B I U x_2 x^2 Ω Σ Styles

Question 2b (2 marks)

Explain what Herschel had discovered with this experiment and why this was significant.

B I U x_2 x^2 Ω Σ Styles

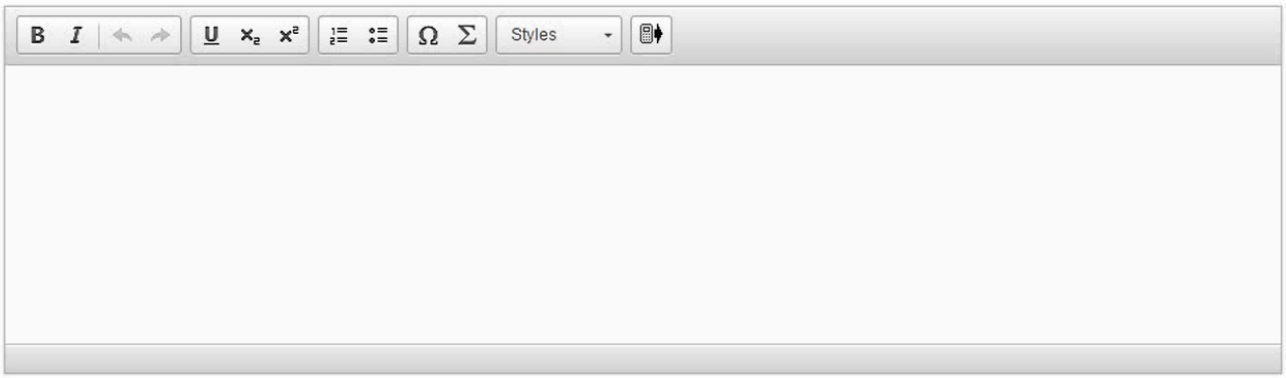
A student repeats Herschel's experiment and investigates the effect that changing the colour and surface of the thermometer has upon the results.

The student takes four identical thermometers and colours the bulb with different paints, placing each thermometer beyond the visible spectrum. The room temperature is 20 °C. The results are displayed below.

Thermometer colour	Thermometer surface	Temperature after five minutes / °C
White	Shiny	24
White	Matt	26
Black	Shiny	28
Black	Matt	30

Question 2c (3 marks)

Interpret this data and **explain** the results using scientific reasoning.



Question 3 (13 marks)

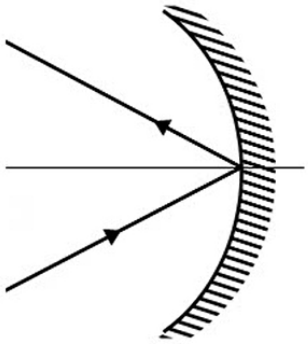
Question 3a (1 mark)

Many telescopes, such as the Hubble space telescope, make use of large reflecting surfaces. These surfaces obey the law of reflection.

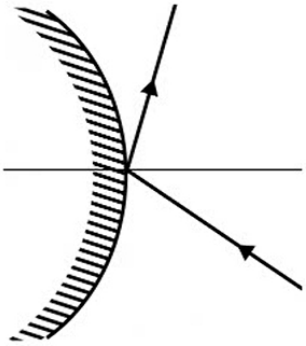
Select the diagram which is consistent with the law of reflection.

Select ▾

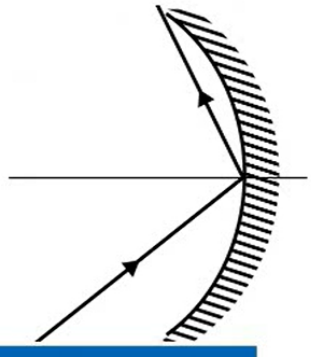
A



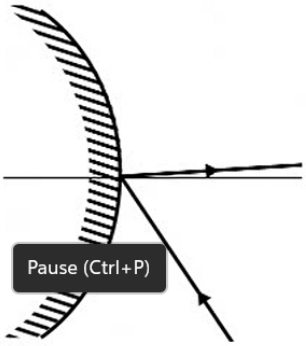
B



C



D



Pause (Ctrl+P)

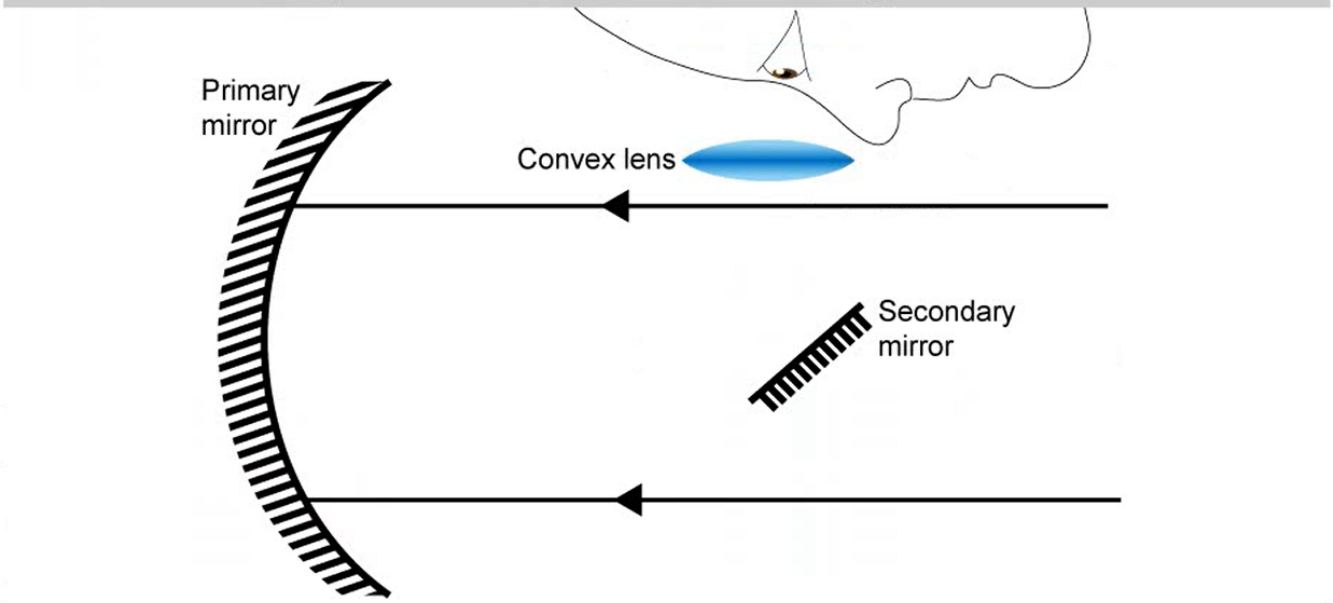
Question 3b (3 marks)

Reflecting telescopes use curved mirrors. The diagram below shows how a reflecting telescope works.

Apply the law of reflection to complete the ray diagram.

You can drag, resize and rotate the lines and add arrow markers as necessary.

Draggable items:



Trash area:

The appearance of the night sky changes over time.

A photograph taken over several hours shows the stars as curved lines of light rather than points. These lines are called “star trails”.

Question 3d (1 mark)

A similar image is shown in the image below. This image was captured in the northern hemisphere.

The point marked P is approximately where the star Polaris is located. This star has been used for thousands of years by travellers for navigation. Polaris appears to remain stationary in the night sky.

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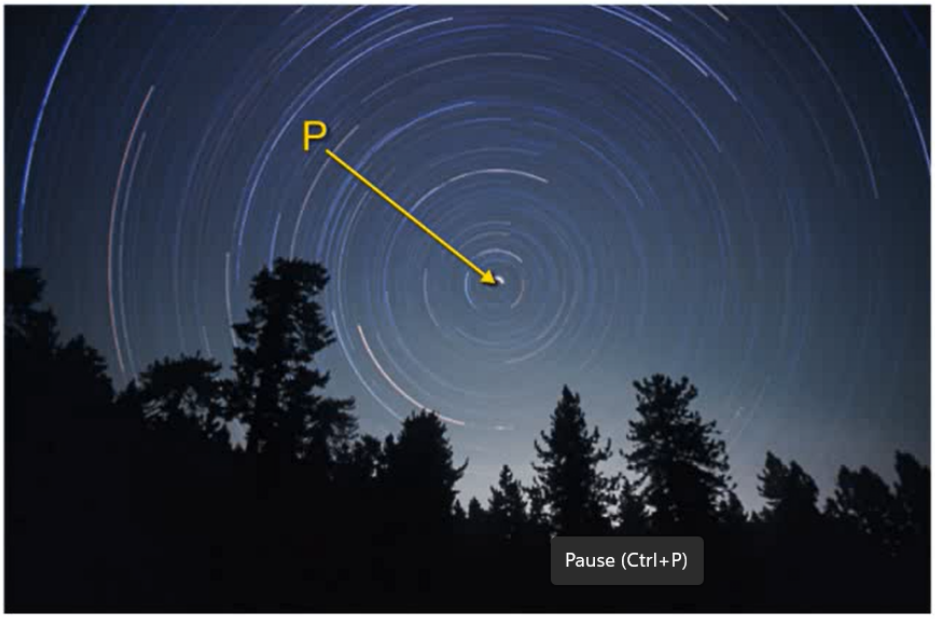

Outline why Polaris appears to remain stationary.

Scientists studying Polaris A have estimated it to be a distance of 323 light years from Earth. A light year is a unit of distance commonly used by astronomers. Light travels at a speed of 3.0×10^8 m s^{-1} in a vacuum. Assume that a year has 365 days.

Question 3f (3 marks)

Calculate how far in metres light travels in 1 year. Give your answer in scientific notation to an appropriate number of significant figures.

Question 3e (2 marks)

For thousands of years, it was thought that Polaris was a single star. Modern astronomers now classify Polaris as a multiple star. The largest star in the group is called Polaris A and the two closest stars to this are named Polaris Ab and Polaris B.

Suggest why Polaris was first thought to be a single star but is now known to be a group of stars.

B I U x_2 x^2 Ω Σ Styles

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B I U x_2 x^2 Ω Σ Styles

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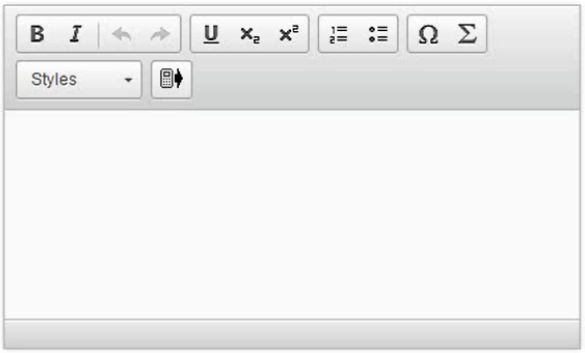
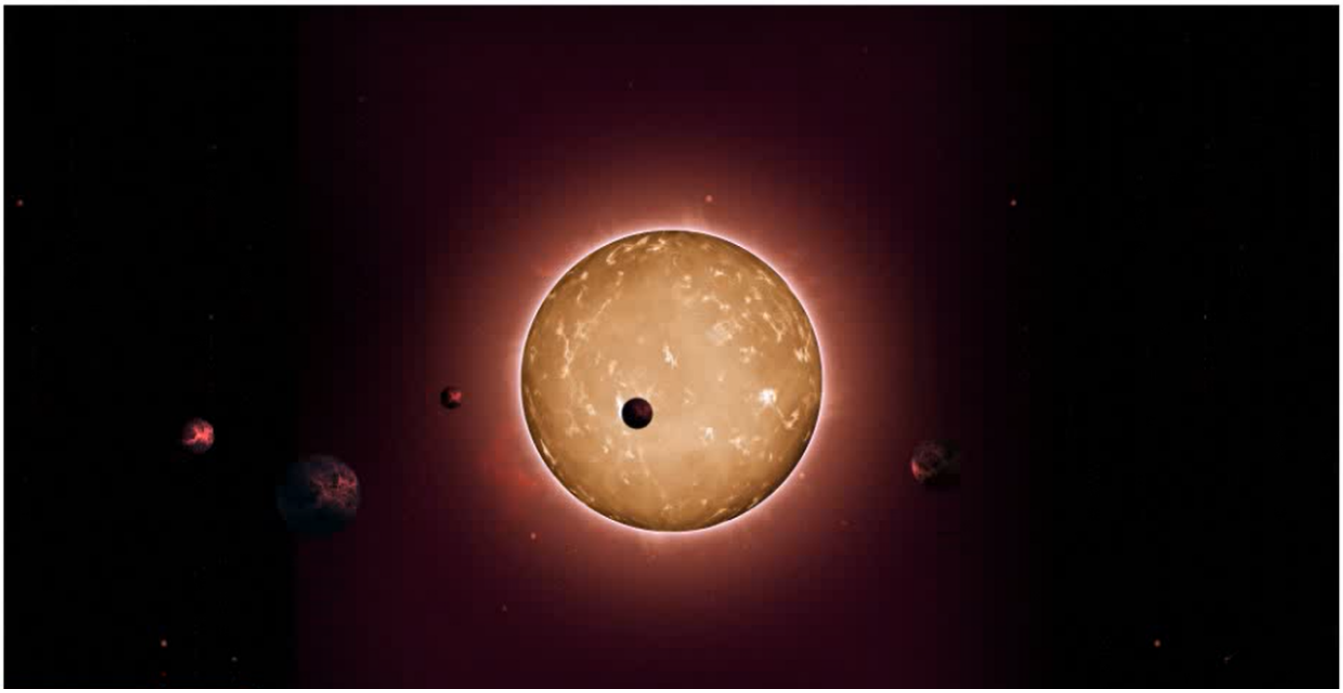
Question 3g (1 mark)

Use your answer from part (f) to **calculate** how far Polaris A is from the Earth in metres.



In 2009, the National Aeronautics and Space Administration (NASA) launched a space observatory called Kepler. The aim of this project was to discover “Earth-like” planets orbiting other stars. The equipment carried by Kepler was a simple photometer which is an instrument used to measure the brightness of stars. The idea behind this mission was that a planet orbiting a star could be detected when it moved between the star and the observatory.



Question 4a (2 marks)

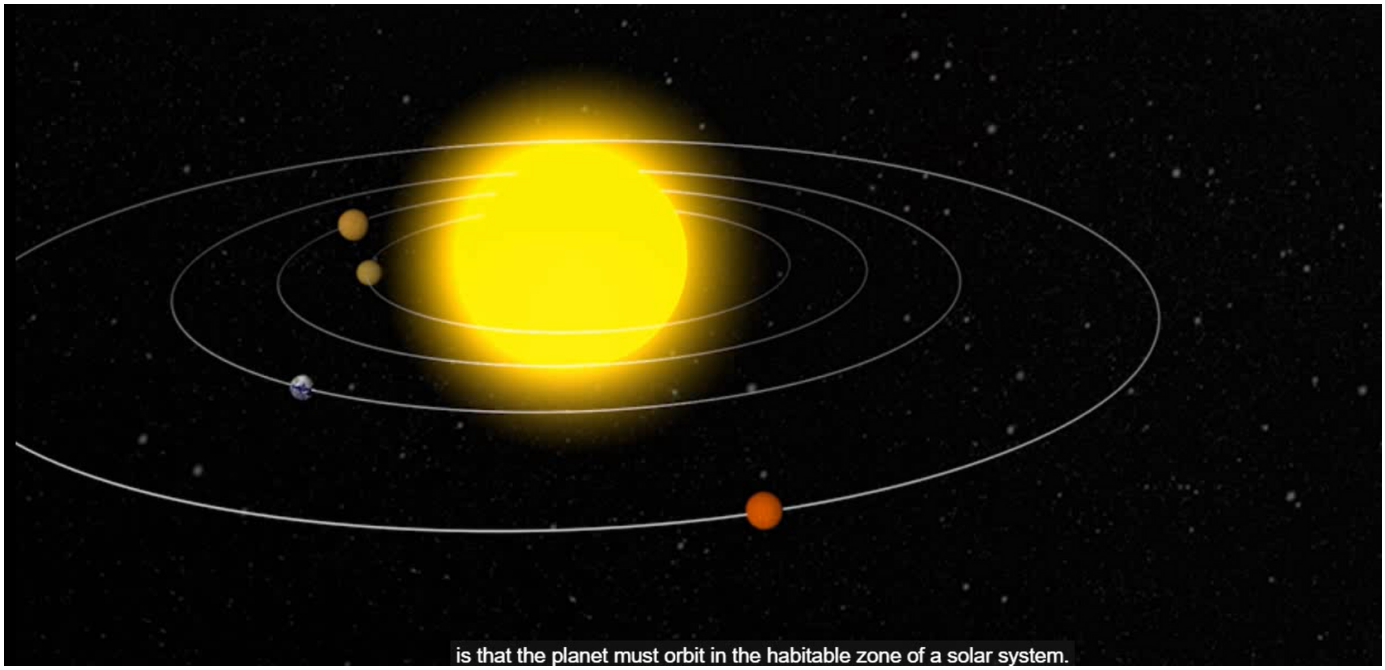
Describe how the brightness of a distant star measured by the observatory would be affected by a planet moving in front of it.

B I U x_2 x^2 Ω Σ Styles

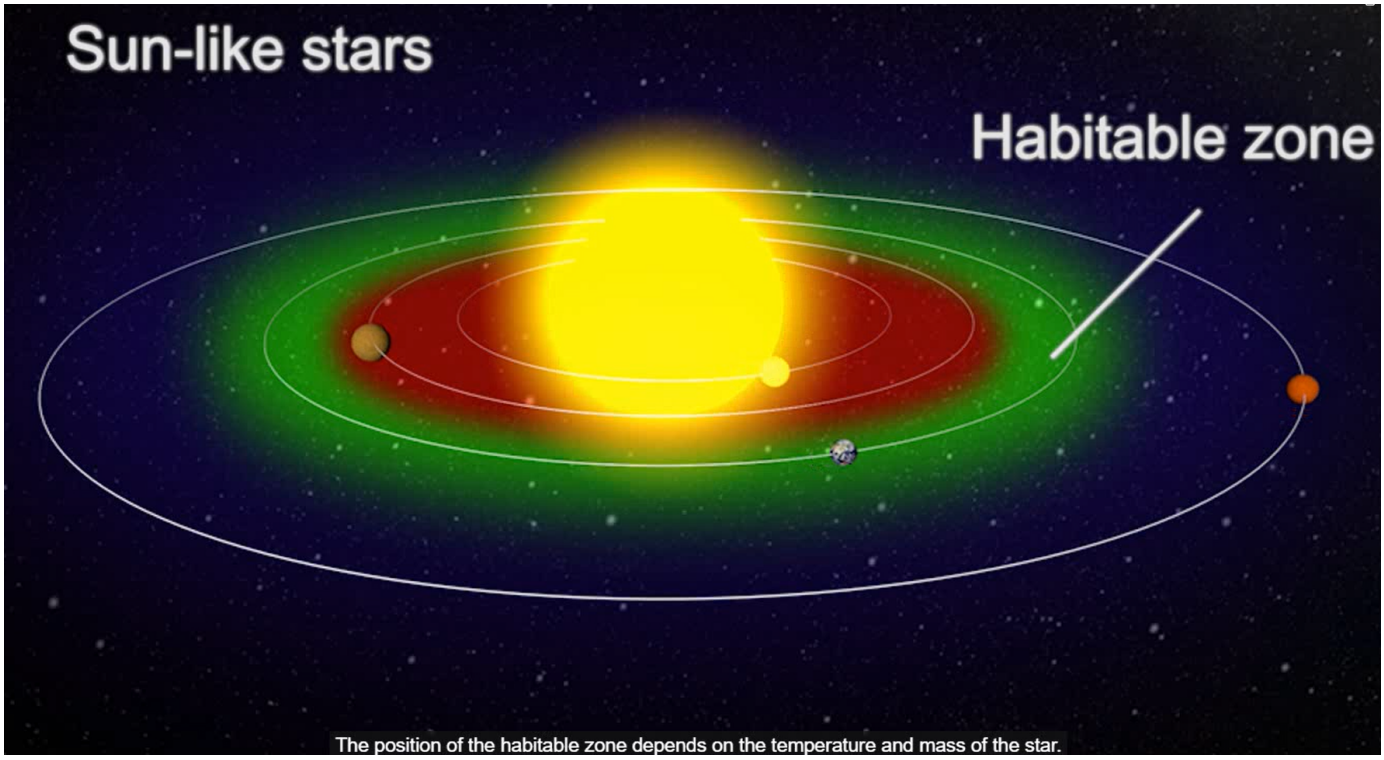
Question 4b (2 marks)

Suggest why NASA did not look for Earth-like planets directly with a telescope.

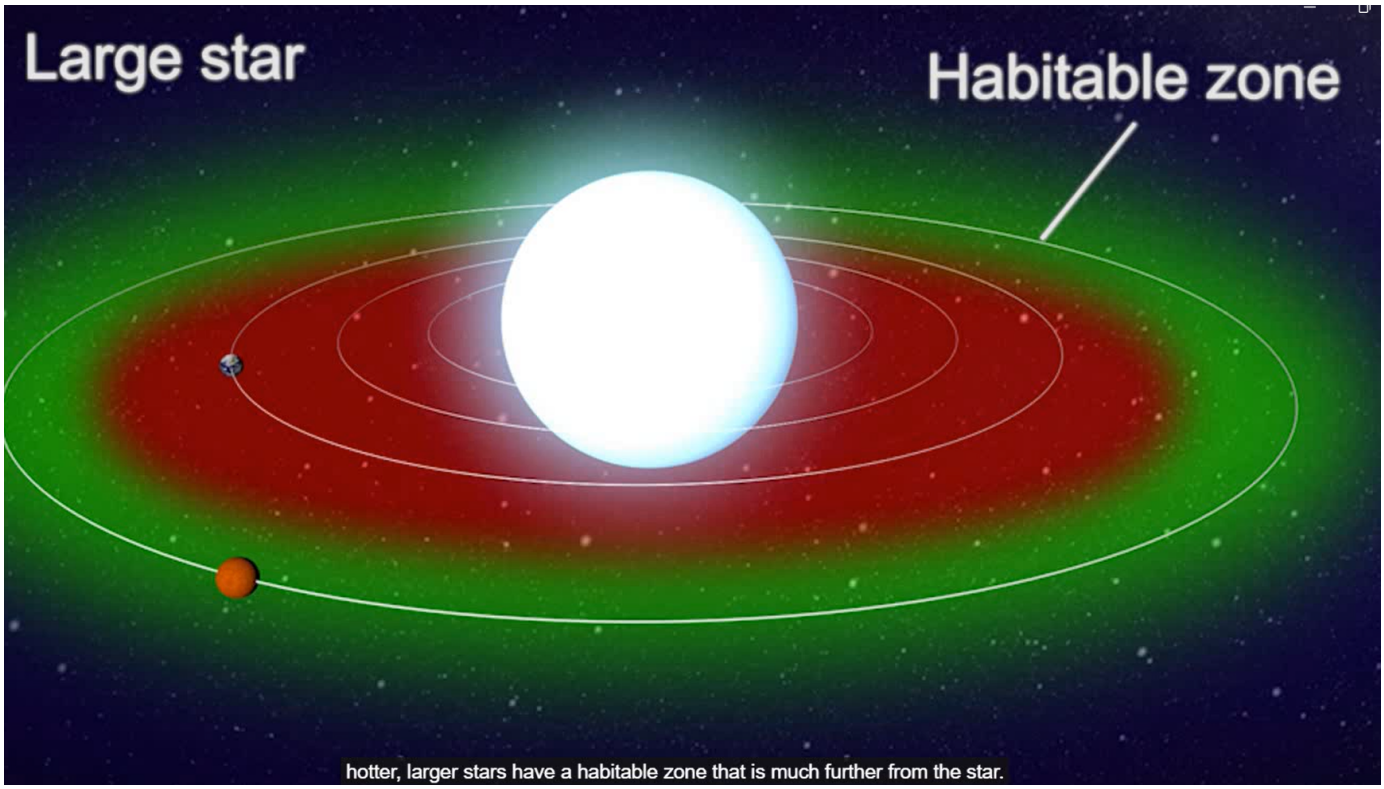
B I U x_2 x^2 Ω Σ Styles



is that the planet must orbit in the habitable zone of a solar system.



The position of the habitable zone depends on the temperature and mass of the star.



hotter, larger stars have a habitable zone that is much further from the star.

Question 4c (2 marks)

Outline why a planet located in the red zone would not be able to support liquid water at its surface.

B I U x_2 x^2 Ω Σ

Styles

Question 4d (2 marks)

Use the video to **formulate** a hypothesis relating the location of the habitable zone with the temperature of a star.

B I U x_2 x^2 Ω Σ

Styles

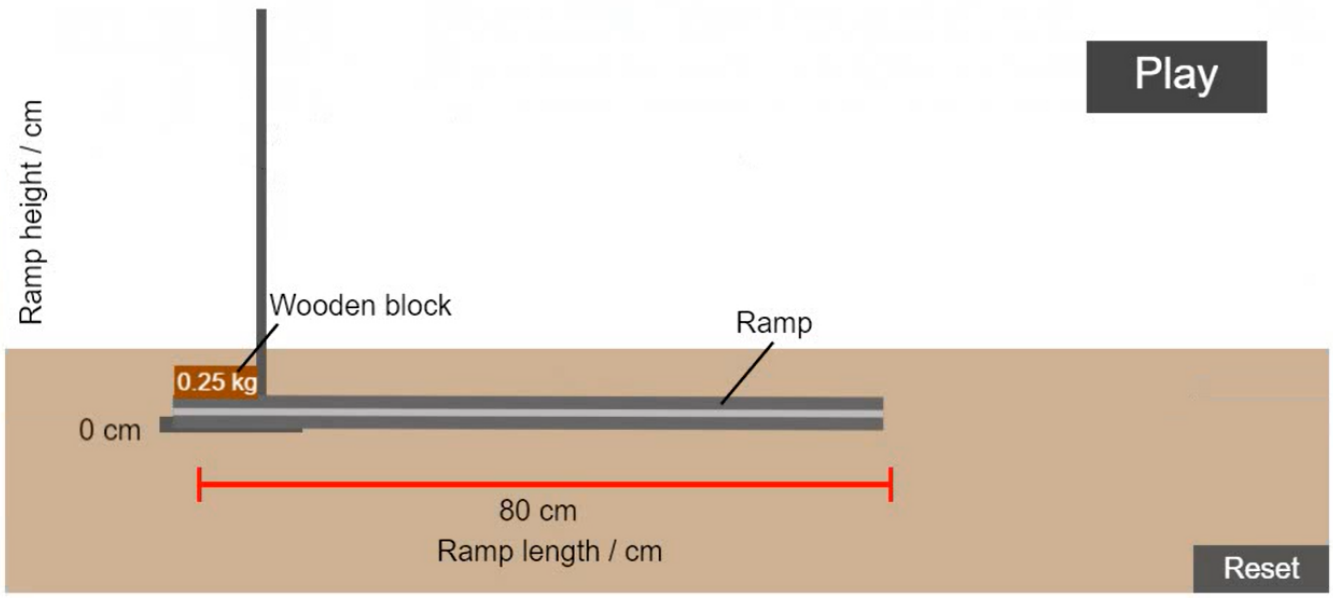
Question 5 (25 marks)

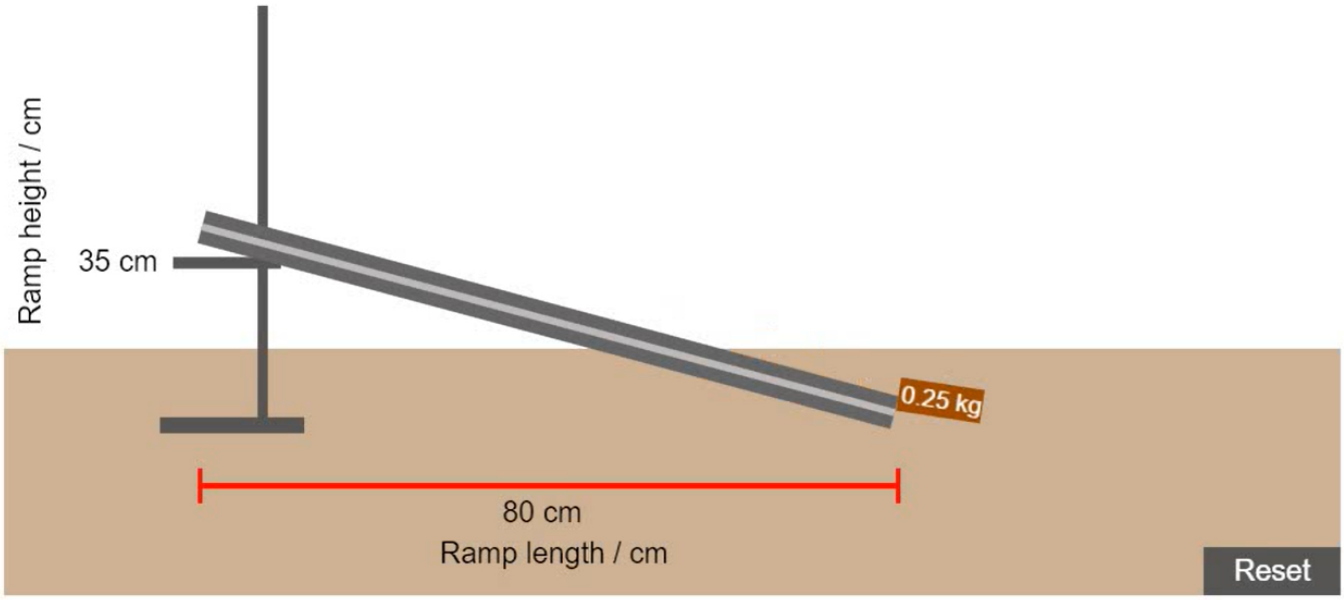
A class of MYP students has been asked to perform an experiment to investigate variables that affect the way moving objects behave.

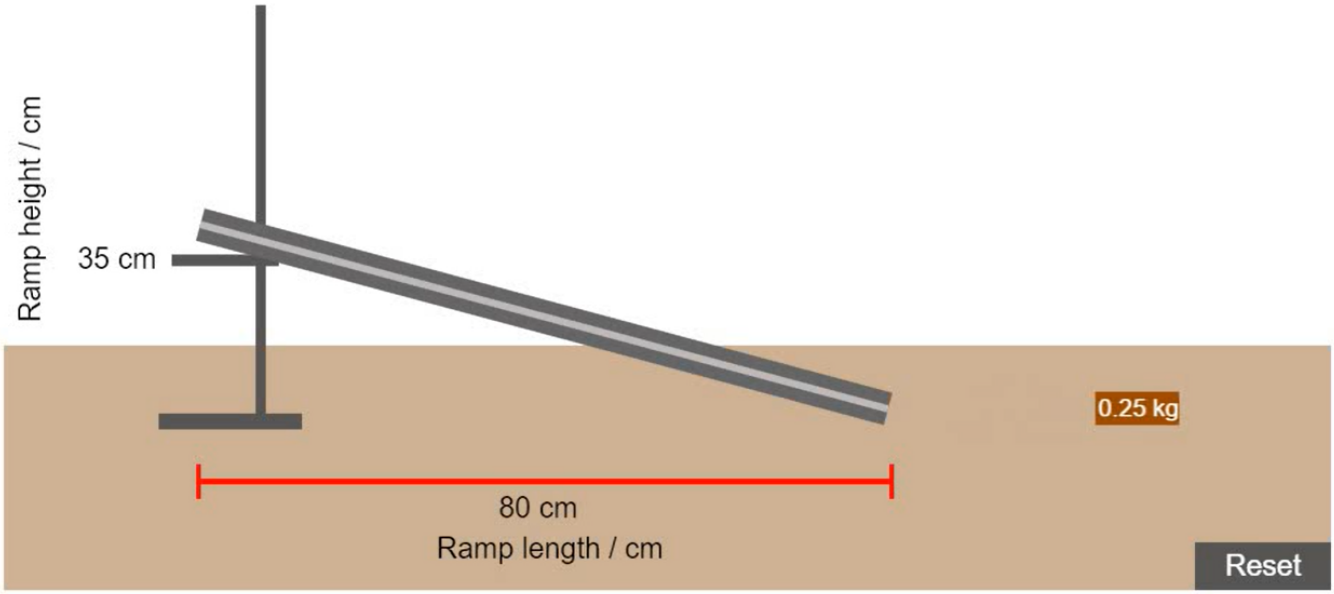
One student knows that energy changes take place as objects slide down ramps. She decides to investigate the motion of a sliding wooden block using a ramp and the effect the height of the ramp has on the distance travelled by the wooden block after it reaches the bottom of the ramp.

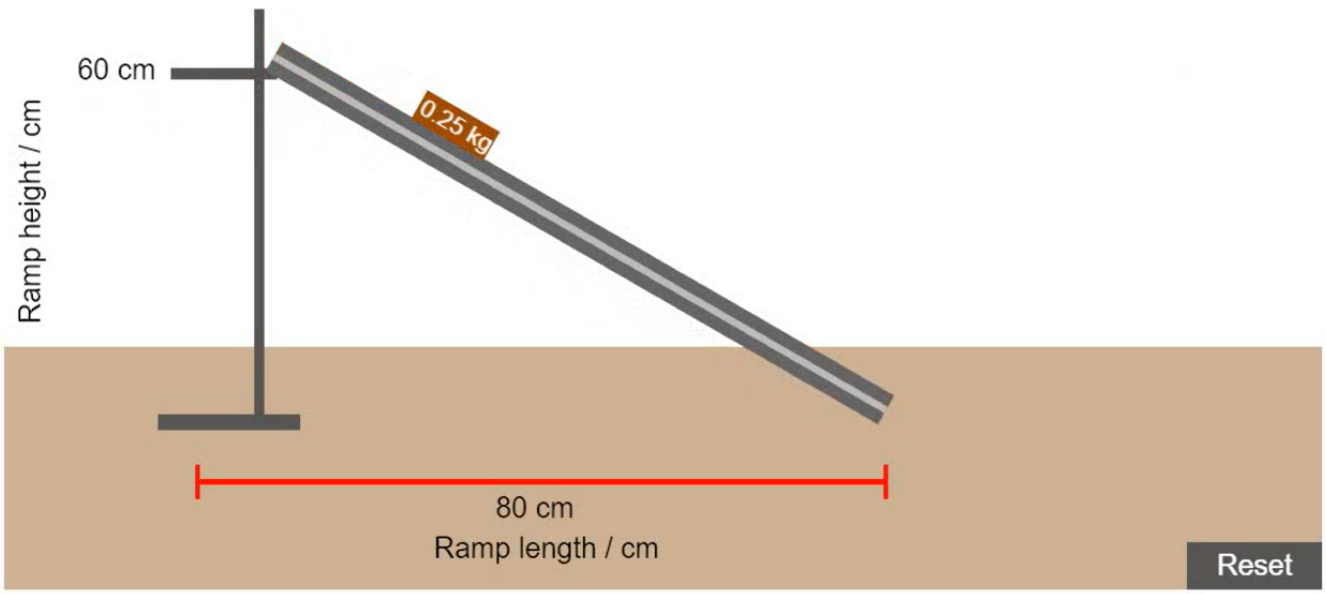
The ramp being used is 80 cm long and it can be set to any height between 35 cm – 60 cm. The block has a mass of 0.25 kg.

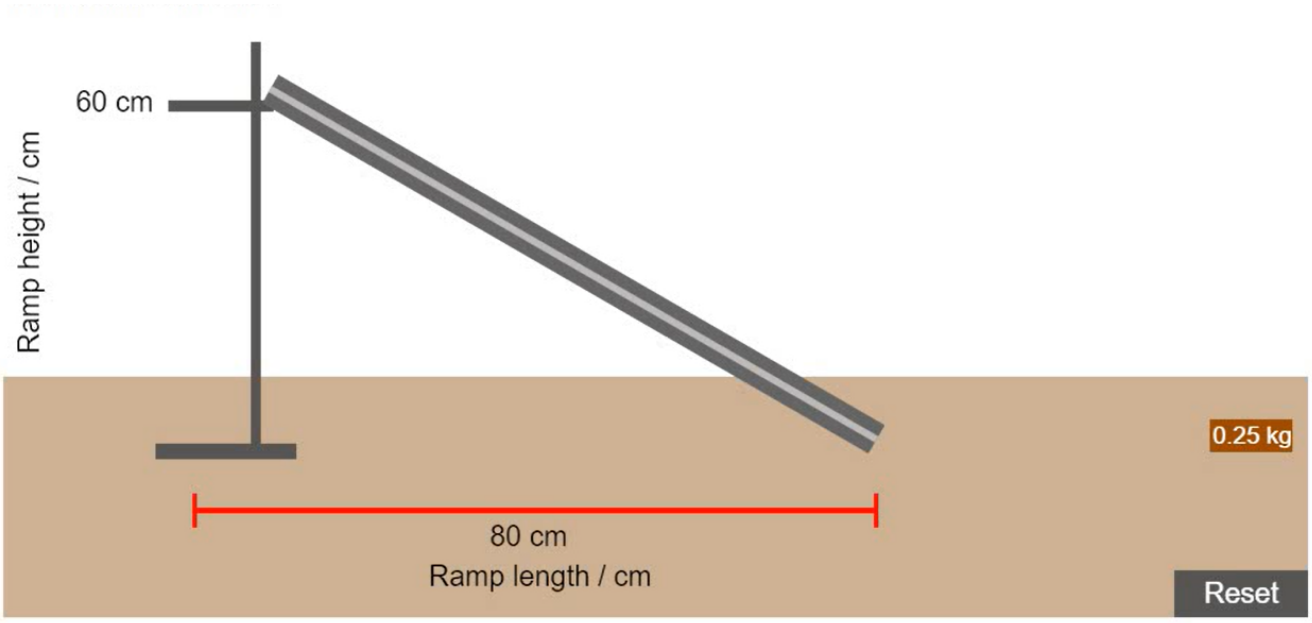
This media is interactive


Play
Ramp height / cm
Wooden block
Ramp
0.25 kg
0 cm
80 cm
Ramp length / cm
Reset


Ramp height / cm
35 cm
0.25 kg
80 cm
Ramp length / cm
Reset


Ramp height / cm
35 cm
0.25 kg
80 cm
Ramp length / cm
Reset


60 cm
Ramp height / cm
0.25 kg
80 cm
Ramp length / cm
Reset



Question 5a (1 mark)

Select the statement below that best describes the main energy transfer that takes place as the block slides down the ramp.

- Kinetic energy is transferred to gravitational potential energy.
- Elastic energy is transferred to kinetic energy.
- Gravitational potential energy is transferred to kinetic energy.
- Gravitational potential energy is transferred to elastic energy.

Question 5b (3 marks)

Calculate the energy of the block when it is at a height of 60 cm.

You should assume gravitational field strength = 10 N kg^{-1}.

Question 5c (1 mark)

State the question that could be answered in the experiment.

Question 5d (3 marks)

Formulate and **explain** the hypothesis that this question would test.

Question 5e (4 marks)

Identify the variables in this experiment.

Independent variable:

Question 5f (1 mark)

Select one piece of equipment you would need to perform this experiment.

- Ruler/measuring tape
- Stopwatch
- Thermometer
- Force meter

Question 5g (2 marks)

The lowest height that the ramp can be set to is 35 cm. **Outline** why there is a lower limit to the height of the ramp.

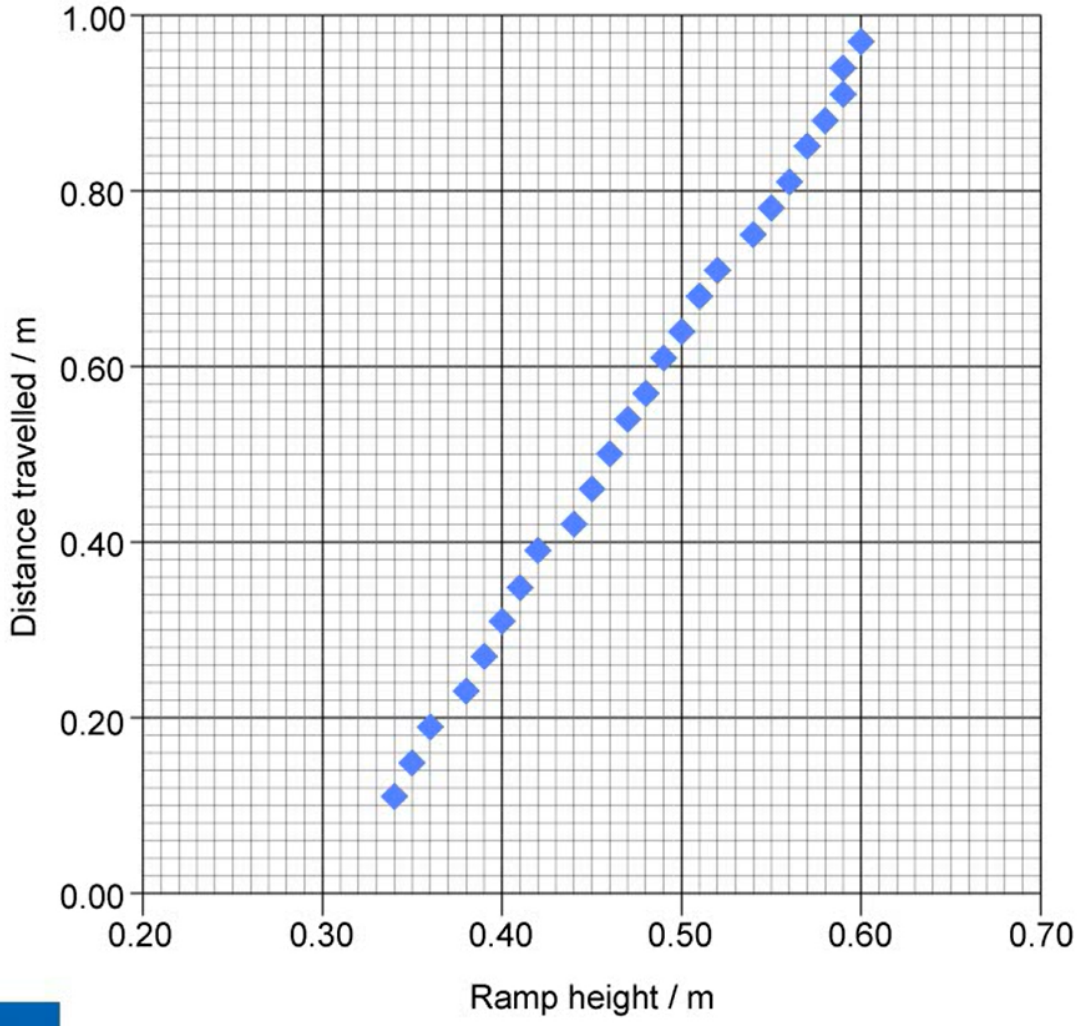
Question 5h (4 marks)

Describe the data you will collect.

The whole class collected their data and presented it in the following graph.

This media is interactive

"Click" and "drag" to add the line of best fit.



Question 5k (2 marks)

Outline the significance of the value in part (j) in terms of the movement of the block.

B I U x_2 x^2 Ω Σ Styles

Question 5l (1 mark)

Outline the validity of the method followed to determine this relationship.

B I U x_2 x^2 Ω Σ Styles

Question 6 (9 marks)

After completing this first experiment to investigate the independent variable of height, the student decides to extend the investigation. She decides to examine how a different independent variable affects the distance travelled.

Question 6a (1 mark)

State a question that could be asked in this new investigation.

B I U x_2 x^2 Ω Σ Styles

Question 6b (3 marks)

Formulate and **explain** the hypothesis that the question in part (a) would test.

Styles

Question 6c (3 marks)

Identify the variables in this experiment. The dependent variable has been completed for you.

Independent variable:

Question 6d (2 marks)

Outline the data you will collect.

B I U x_2 x^2 Ω Σ Styles

Question 7 (22 marks)

A second student in the class carries out an investigation using a trolley. He investigates how a trolley's stopping distance is affected by the drag force created by a sail, on a horizontal surface. The friction between the wheels and the track is negligible. The variables in the investigation are:

Independent variable:

Area of the sail

Dependent variable:

Stopping distance

Control variable 1:

Initial speed of the trolley

Pause (Ctrl+P)

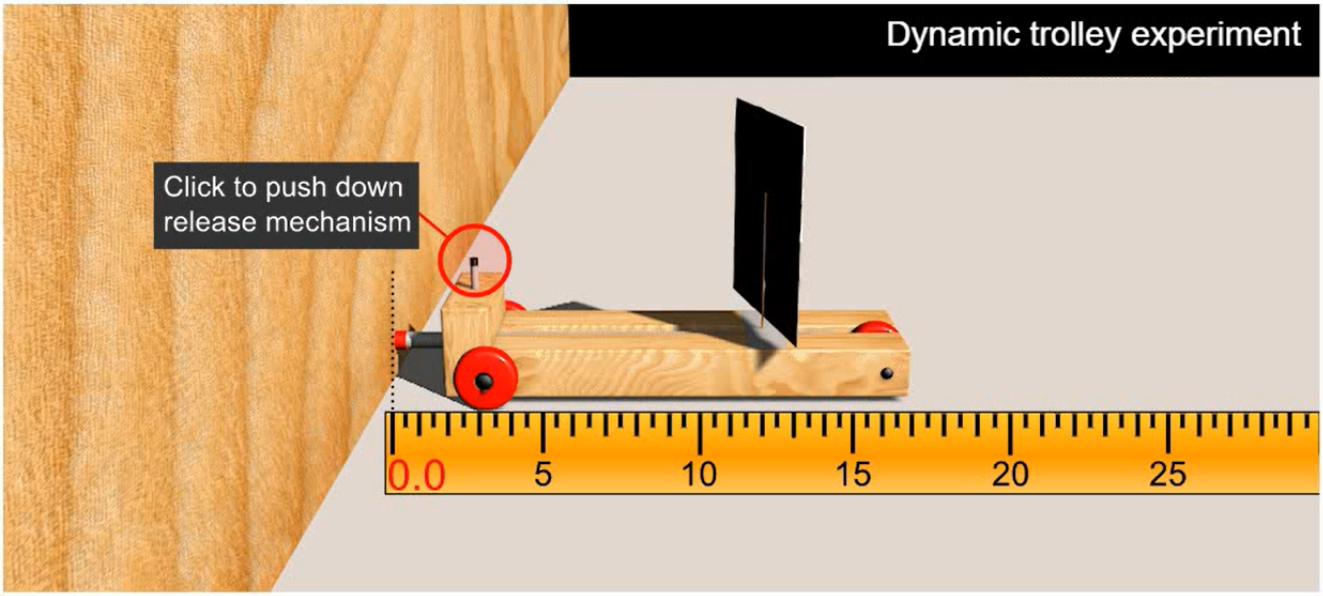
Question 7a (3 marks)

Take appropriate measurements and use your measurements to **determine** the stopping distance of the trolley.

This media is interactive

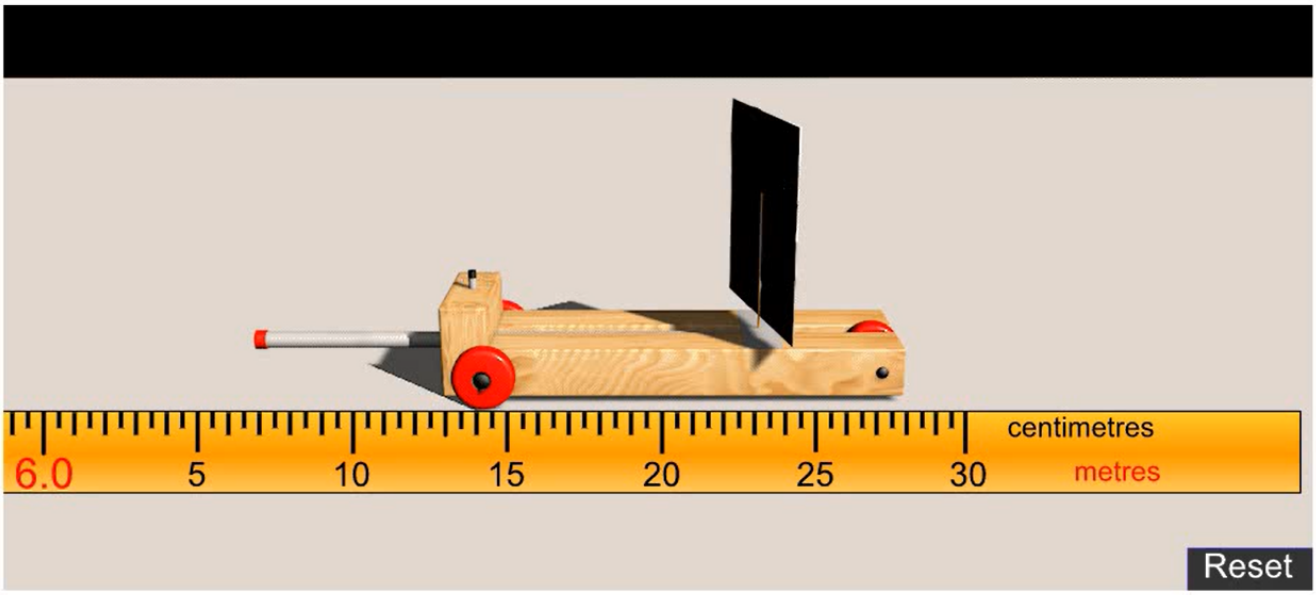
Take appropriate measurements and use your measurements to **determine** the stopping distance of the trolley.

This media is interactive



Take appropriate measurements and use your measurements to **determine** the stopping distance of the trolley.

This media is interactive



A student repeated the investigation with a circular sail. The student's data for stopping distance and sail radius is given below.

Question 7b (5 marks)

Organize and **present** the radius and stopping distance data in a suitable table.

Create New Table

Reset

Question 7c (2 marks)

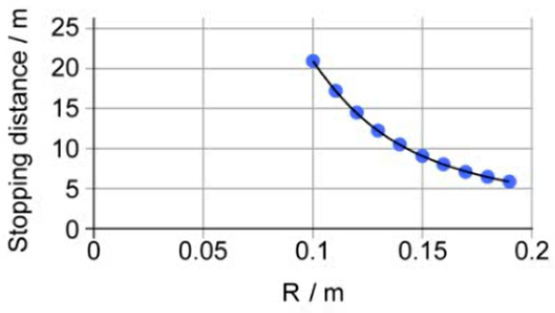
Explain why a scatter/line graph is the most appropriate choice to display and analyse these results.

Question 7d (2 marks)

Before recording his results, the student writes the following hypothesis:

"As the radius of the sail increases, the stopping distance will decrease. Stopping distance will be inversely proportional to radius."

Once the student has completed the experiment he produces the following graph.



Outline what this graph shows about the relationship between stopping distance and radius.

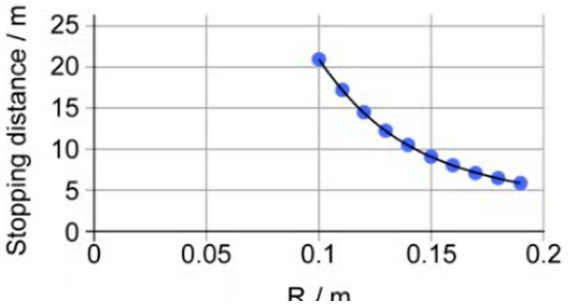
B I U x_2 x^2 Ω Σ

Styles

The student does some further processing and draws three more graphs to determine the relationship between the variables. Click on the four tabs to view all of the graphs.

Graph 1 | Graph 2 | Graph 3 | Graph 4

Sail experiment: graph showing stopping distance against sail radius



Question 7e (1 mark)

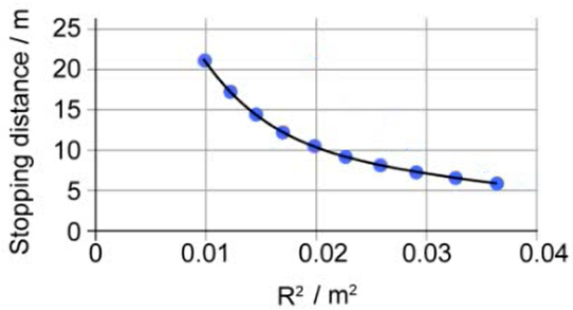
Deduce the relationship between the variables.

B I U x_2 x^2 Ω Σ Styles

The student does some further processing and draws three more graphs to determine the relationship between the variables. Click on the four tabs to view all of the graphs.

Graph 1 | Graph 2 | Graph 3 | Graph 4

Sail experiment: graph showing stopping distance against sail radius squared



Question 7e (1 mark)

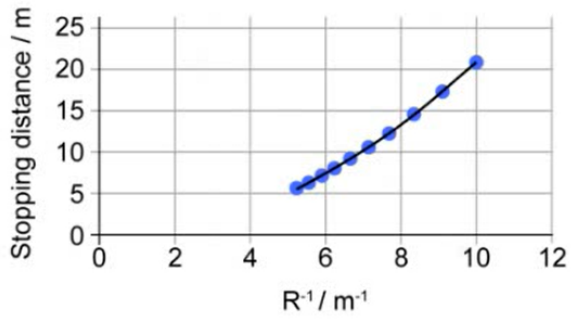
Deduce the relationship between the variables.

B I U x_2 x^2 Ω Σ Styles

The student does some further processing and draws three more graphs to determine the relationship between the variables. Click on the four tabs to view all of the graphs.

Graph 1 | Graph 2 | Graph 3 | Graph 4

Sail experiment: graph showing stopping distance against inverse of sail radius



Question 7e (1 mark)

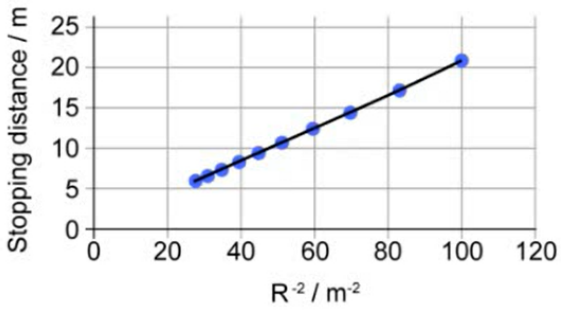
Deduce the relationship between the variables.

Styles

The student does some further processing and draws three more graphs to determine the relationship between the variables. Click on the four tabs to view all of the graphs.

Graph 1 | Graph 2 | Graph 3 | Graph 4

Sail experiment: graph showing stopping distance against inverse of sail radius squared



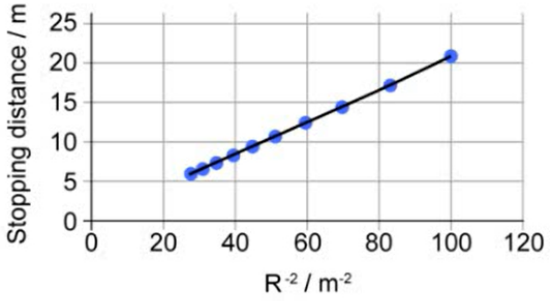
Question 7e (1 mark)

Deduce the relationship between the variables.

Styles

Graph 1 | Graph 2 | Graph 3 | Graph 4

Sail experiment: graph showing stopping distance against inverse of sail radius squared



Question 7f (3 marks)

Explain the results of the investigation using scientific reasoning.

Styles

Graph 1 | Graph 2 | Graph 3 | Graph 4

Sail experiment: graph showing stopping distance against inverse of sail radius squared

Stopping distance / m
25
20
15
10
5
0
0
20
40
60
80
100
120
R-2 / m-2

Question 7g (2 marks)

Evaluate the validity of the hypothesis.

Styles

Question 7h (1 mark)

Suggest an extension to this investigation.

B I U x_2 x^2 Ω Σ Styles

Question 7i (3 marks)

Formulate and **explain** a hypothesis that the extension in part (h) would test.

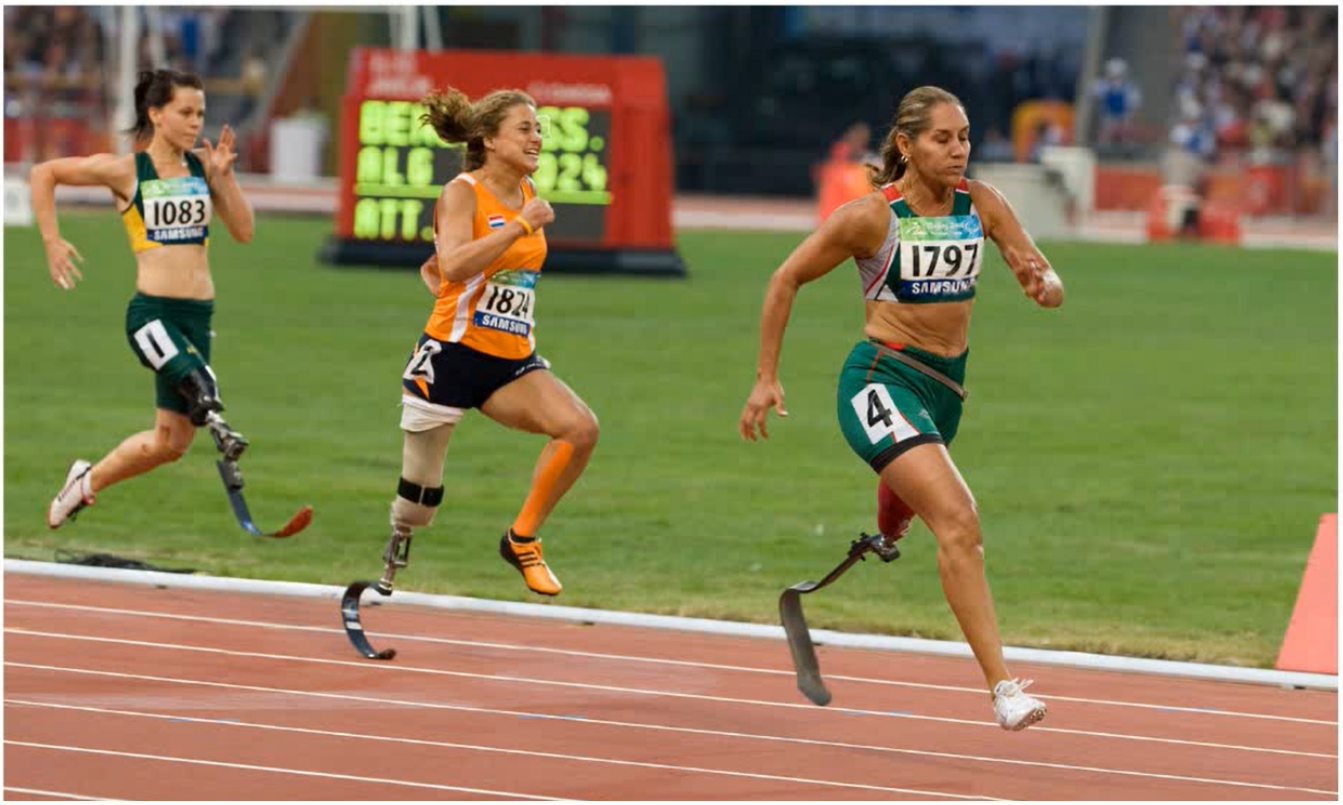
B I U x_2 x^2 Ω Σ Styles

Question 8 (7 marks)

Humans have used their understanding of physical principles to develop a variety of systems that help people without limbs adapt to their environment.

Prostheses (replacements for a missing body part) are widely used by athletes in competitions. The design of the prostheses needs to take into account physical differences to give good performance while keeping the competition fair.

The following image shows three athletes using different types of “below the knee” prostheses.



When a force is applied to a material it can cause a change in the length of that material. Young's modulus (E) is a measure of how much the material can be changed. Stiff or more rigid materials have a bigger value of E compared to softer materials.

The table below shows some data for bone as well as for some of the materials used in prostheses.

Material	E / GPa	Density / g cm^{-3}
Polypropylene	2	0.95
Bone	15	1.75
Material X	17	4.23
Carbon fibre	40	1.60
Aluminium	69	2.72
Steel	200	7.85

Scroll down to continue

Question 8a (1 mark)

State the name of the most rigid material in the table.

B I U x_2 x^2 Ω Σ Styles

8b (1 mark)

Pause (Ctrl+P)

When a force is applied to a material it can cause a change in the length of that material. Young's modulus (E) is a measure of how much the material can be changed. Stiff or more rigid materials have a bigger value of E compared to softer materials.

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Aluminium	69	2.72
Steel	200	7.85

Scroll down to continue

Question 8b (1 mark)

Suggest why the E value of polypropylene means it is not suitable for prostheses used by athletes.

B I U x_2 x^2 Ω Σ Styles

Pause (Ctrl+P)

ial it can
at

l can be
als have
ofter

for
aterials

nsity / cm^{-3}
).95
l.75
4.23

A scientist has developed material X which has a Young's modulus similar to human bone. Consider the two identical limbs designed for a particular athlete shown in the figure.

©

Material X Carbon fibre

Question 8c (5 marks)

Use information from the table to **discuss** how the properties of carbon fibre and material X could help people without limbs adapt to their environment.

B I U x_2 x^2 Ω Σ

Styles

Pause (Ctrl+P)

Question 9 (11 marks)

Some competitions involve regular and prosthesis-aided athletes.

Discuss and **evaluate** the implications of this type of technological advance in relation to the fairness of the competition and inclusive access to sport for all athletes. In your answer, you should consider:

- the ethical implications of improving performance with prostheses
- the social implications of including prosthesis-aided athletes in competitions
- a concluding appraisal.

Question 10 (14 marks)

Land mines around the world are responsible for thousands of injured people and animals. As advanced prosthetic limbs are not affordable to people on low incomes, solutions have been found for reducing costs to help amputees. Recycled aluminium was used to give an elephant that stepped on to a land mine the possibility of walking again. Human understanding of scientific principles was used to create the artificial leg.

Question 10a (2 marks)

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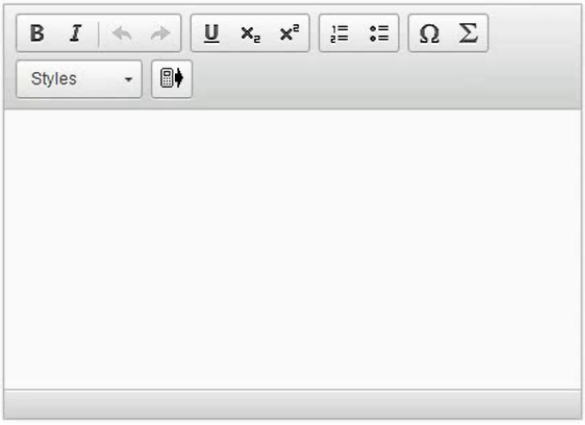
Calculate the pressure on the ground when an elephant weighing 30 000 N is standing on only three feet. Assume each foot has an area of 0.2 m^2.



Question 10b (5 marks)

Explain how the design of the prosthesis takes account of pressure when:

creating contact with the ground

providing comfort to the elephant when connecting the prosthesis to its upper leg.

Question 10c (7 marks)

Outline the advantages and disadvantages a prosthetic limb would have on an elephant when returned to its natural habitat. **Evaluate** whether or not you think elephants with prosthetic limbs should be returned to their natural habitat.