



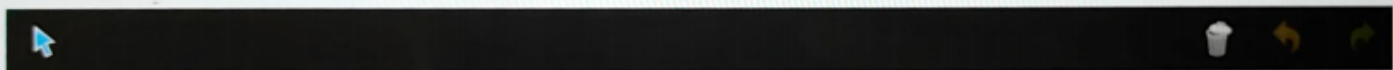
Question 1 (12 marks)



Question 1a (1 mark)

Coal-fired power stations are systems that change chemical potential energy into electricity, beginning with the burning of coal to heat water.

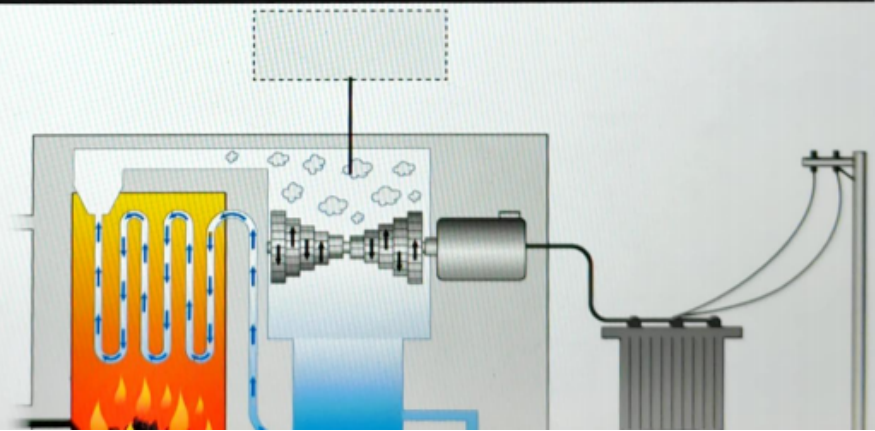
A coal-fired power station involves three states of matter. **Identify** the location of each of the substances below:



Draggable items:

Water

Steam



Scroll down to continue

A coal-fired power station involves three states of matter. **Identify** the location of each of the substances below:

Draggable items:

- Water
- Steam
- Coal

The diagram illustrates the Rankine cycle of a coal-fired power station. On the left, a boiler contains a coil of pipes through which water circulates. Below the boiler, a reservoir of coal is shown with a dashed box for identification. The boiler is heated by the coal, producing steam. The steam is directed to a turbine, which is connected to a generator. A dashed box is positioned above the turbine for identification. The turbine exhausts steam into a condenser, which is a large cooling coil. A dashed box is located to the right of the condenser for identification. The condenser is cooled by water from a cooling tower, which is shown as a blue reservoir at the bottom. A dashed box is placed to the right of the cooling tower for identification. The water from the cooling tower is pumped back to the boiler, completing the cycle. The generator is connected to a power line.



Question 1b (1 mark)

Absorbing heat can affect the kinetic energy of water molecules. **State** how water molecules are affected by this increase in kinetic energy.

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



Question 1c (2 marks)

As water boils into steam, the heat energy absorbed does not affect the kinetic energy of the molecules. **Outline** what happens to this heat energy referring to the movement and arrangement of particles.

B *I* | ← → U x_2 x^2 ;= := Ω Σ Styles ↕



Question 1d (2 marks)

One kilogram of coal contains approximately 2.5×10^7 J of chemical potential energy. For a coal-fired power station that burns 4.5×10^5 kg of coal per hour, **calculate** the energy released in one hour. You should give your answer to two significant figures.

B *I* | ← → | U \times \div x^2 | \int \sum | Ω Σ | Styles |



Question 1e (2 marks)

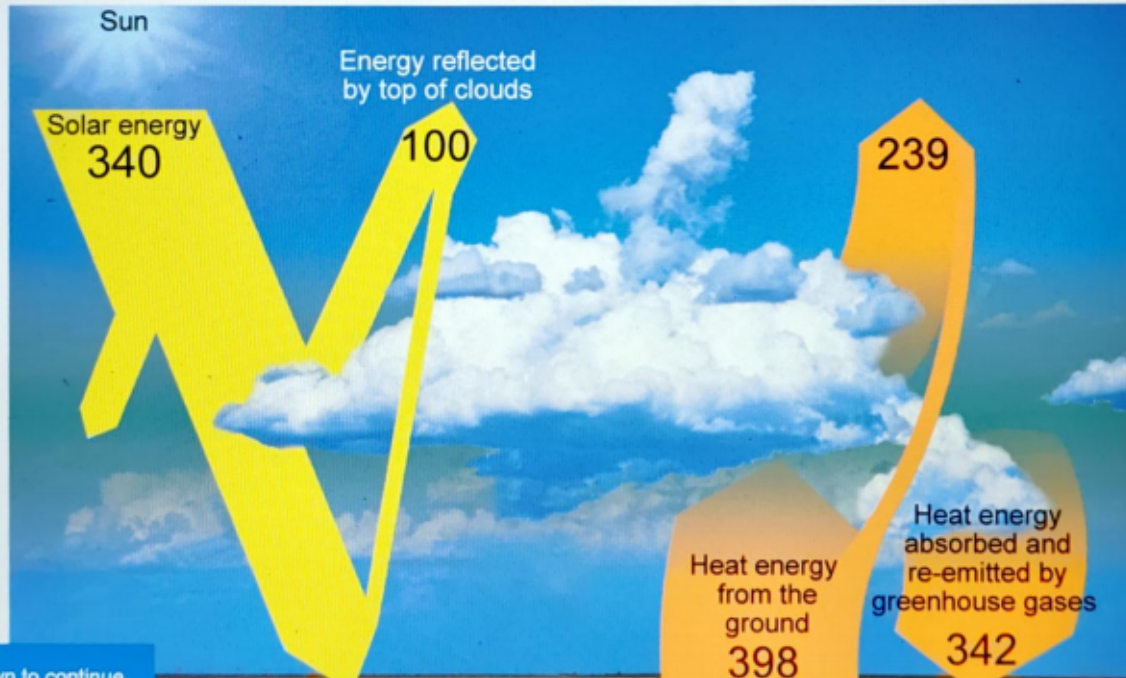
Another coal-fired power station burns enough coal per hour to generate a power of 26 700 MW. If the efficiency of this power station is 28 %, **determine** the useful power output.

B *I* | ← → | x₂ xⁿ | \int \sum | Ω Σ | Styles |



Question 1f (1 mark)

Burning coal contributes to climate change by altering the composition of Earth's atmosphere, increasing the quantity of greenhouse gases. The diagram below shows the flow of energy through the Earth's atmosphere.



Scroll down to continue



Select the arrow on the diagram which would be most affected by burning coal.

- Select
- Select
 - Solar energy
 - Energy reflected by top of clouds
 - Heat energy from the ground
 - Heat energy absorbed and re-emitted by greenhouse gases

Greenhouse gases trap heat energy in Earth's atmosphere. This trapped heat is associated with more extreme weather events like storms, droughts, floods and changes to Earth's climate. Using scientific knowledge, **explain** why trapping heat energy in Earth's atmosphere would cause more extreme weather events and changes to Earth's climate.

B I ← → x₂ x² ∑ Ω Σ Styles ↕



Question 1g (3 marks)

Greenhouse gases trap heat energy in Earth's atmosphere. This trapped heat is associated with more extreme weather events like storms, droughts, floods and changes to Earth's climate. Using scientific knowledge, **explain** why trapping heat energy in Earth's atmosphere would cause more extreme weather events and changes to Earth's climate.

B *I* | ← → | x_o x² | := :: | Ω Σ | Styles |



Question 2a (2 marks)

Using the periodic table, **state** the number of protons and the number of neutrons present in the nucleus of one atom of uranium-235.




Number of protons:

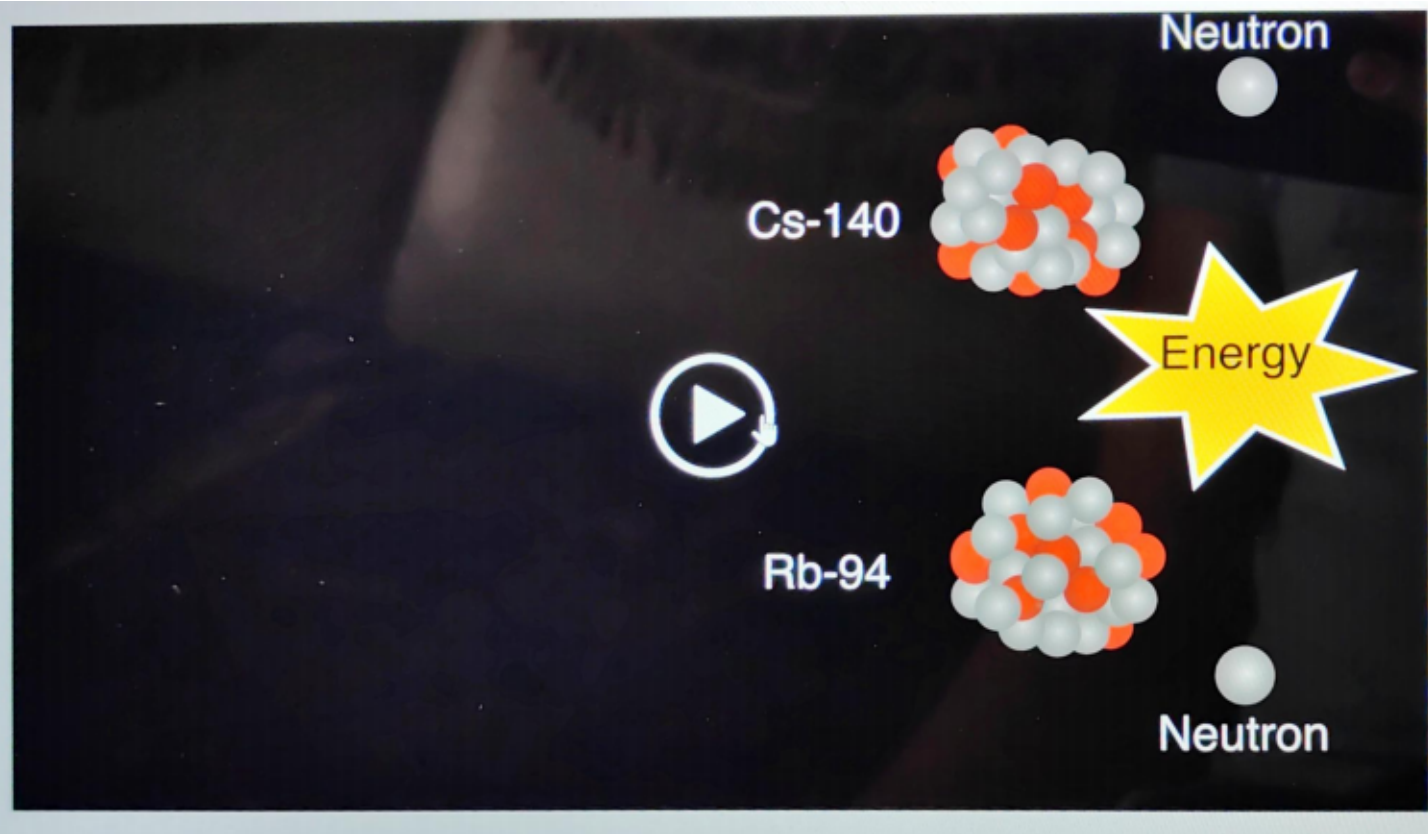
B **I** | ← → **U** x_2 x^2 \int $\frac{\text{d}}$ $\frac{\text{d}}$ Ω Σ
Styles -

Number of neutrons:

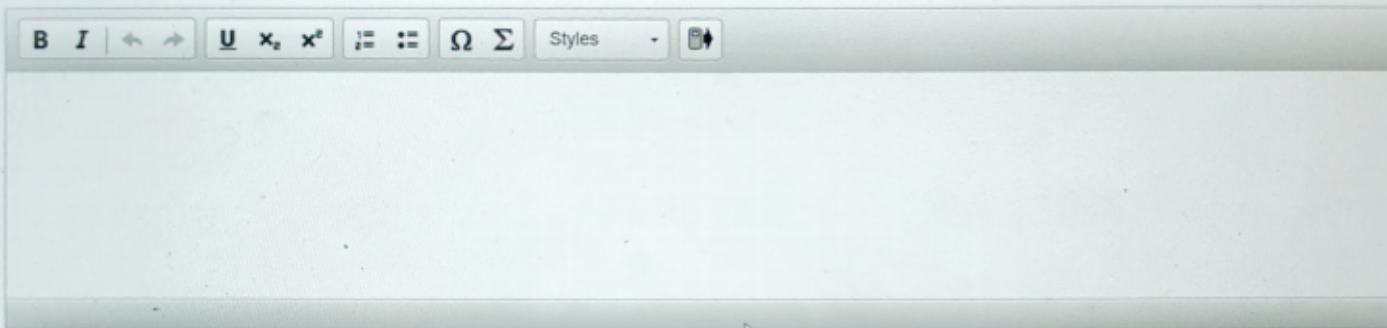
B **I** | ← → **U** x_2 x^2 \int $\frac{\text{d}}$ $\frac{\text{d}}$ Ω Σ
Styles -

A glowing blue sphere with a bright white center, set against a dark background. The word "Fission" is written in a dark blue, serif font in the center of the sphere.

Fission



Outline how the protons and neutrons are affected by the fission of uranium-235.



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 (x^e), Bulleted List (≡), Numbered List (:=), Link (Ω), Unlink (Σ), a dropdown menu labeled "Styles", and a mobile device icon.





Question 2c (2 marks)

A neutron is needed to start this fission reaction. Neutrons are also produced during the reaction. This means that a chain reaction can occur with the fission of uranium-235.

Suggest the meaning of the term *chain reaction*.

B *I* | ← → | x₂ x² | := :: | Ω Σ | Styles - | 📄

I



Question 2d (3 marks)

In nuclear power plants, fission reactions are used to supply energy but these chain reactions have to be carefully controlled. **Describe** a possible danger of an uncontrolled chain reaction in a nuclear power plant.

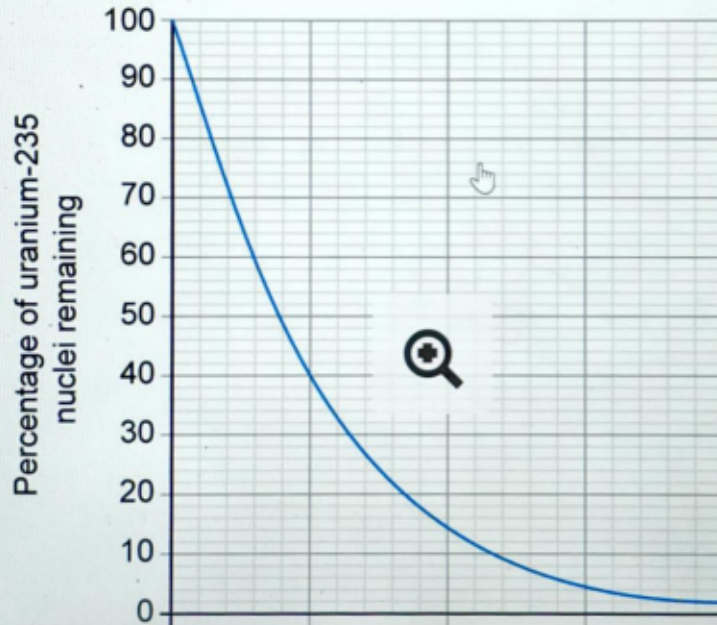
B *I* | ← → U x_2 x^2 \int \sum Ω Σ Styles -

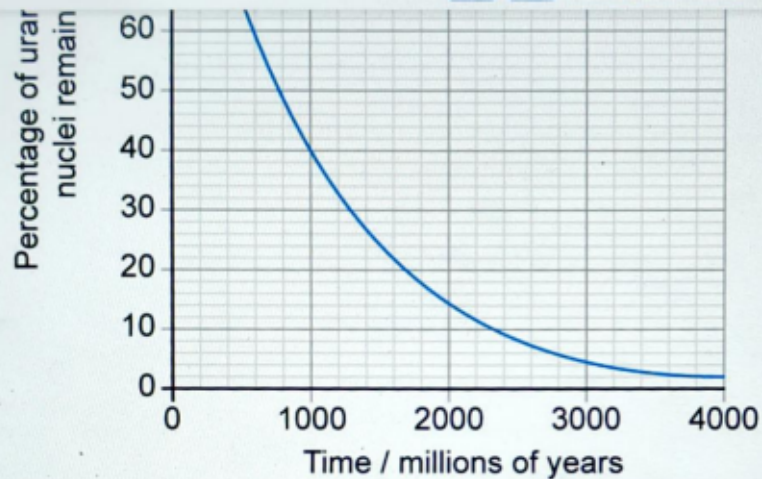
I



Question 2e (1 mark)

Nuclear power plants use uranium in the form of fuel rods. These rods are no longer useable when the level of uranium-235 remaining is low. However, used fuel rods still contain a small amount of remaining uranium-235 which decays over time, emitting radiation as shown in the graph below.





Use the graph to **predict** how many years it would take for 75% of the remaining uranium to decay.

B *I* | ← → | U x_2 x^e | \int $\frac{d}{dx}$ | Ω Σ | Styles - | 📄



Question 2f (2 marks)

Suggest why the long decay time of uranium-235 poses a significant challenge for the safe disposal of fuel rods.

B *I* | ← → | U x_2 x^2 | \int $\frac{1}{x}$ $\frac{1}{x^2}$ | Ω Σ | Styles |

I





Question 3a (1 mark)

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

B *I* ← → U x_2 x^2 ;= := Ω Σ Styles -



Question 3b (3 marks)

Formulate a hypothesis for this investigation using scientific reasoning.

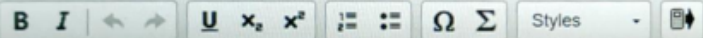
If:

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

Then:

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

Because:





Question 3c (3 marks)

Select the wires the student should use to collect sufficient data to determine the relationship between the resistance and the length of the wire.

	Length / cm	Material	Cross-sectional area / mm ²
<input type="checkbox"/>	40	Silver	2.5
<input type="checkbox"/>	60	Silver	2.5
<input type="checkbox"/>	80	Silver	2.5
<input type="checkbox"/>	100	Copper	1.0
<input type="checkbox"/>	100	Silver	1.5
<input type="checkbox"/>	100	Copper	2.0
<input type="checkbox"/>	100	Aluminium	2.5
<input type="checkbox"/>	100	Copper	2.5
<input type="checkbox"/>	100	Gold	2.5
<input type="checkbox"/>	100	Nichrome	2.5
<input type="checkbox"/>	100	Silver	2.5
<input type="checkbox"/>	100	Copper	3.0
<input type="checkbox"/>	120	Silver	2.5



Question 3d (2 marks)

Justify the selection you made in part (c).

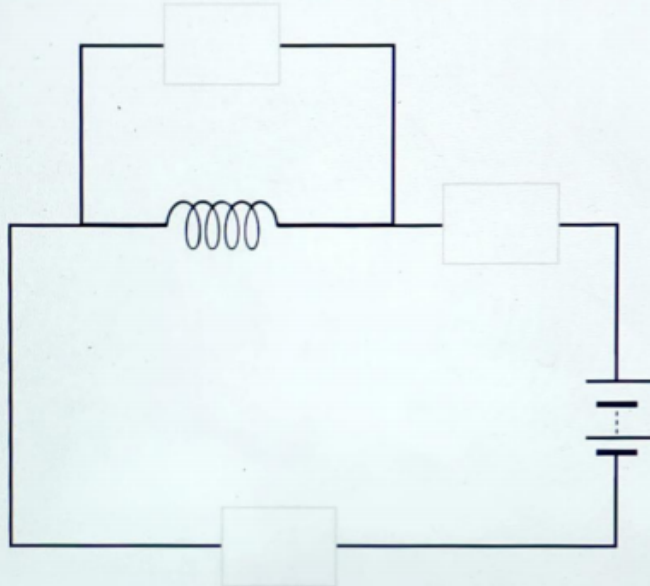
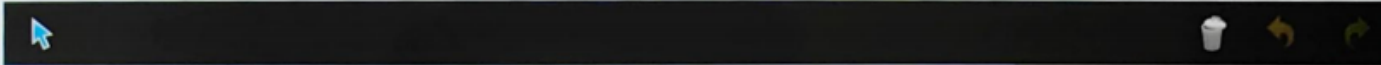
Rich text editor toolbar with buttons for Bold (B), Italic (I), Undo, Redo, Underline (U), Text color (x), Background color (x), Bulleted list, Numbered list, Link (Ω), and Unlink (Σ). Below the toolbar is a text input area with a "Styles" dropdown and a "Copy" icon.



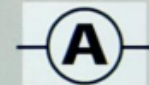
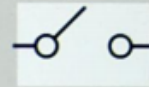


Question 3e (1 mark)

Select the location in the circuit below for each piece of equipment required to take measurements to calculate the resistance of a wire.



Draggable items:





Question 3f (2 marks)

For one of the trials when the wire was 100 cm long, the voltage across the wire was 1.5 V and the current through the wire was measured as 0.24 A. **Determine** the resistance of the wire.

B

I



U

\times_2

\times^2

$\frac{1}{=}$

$:=$

Ω

Σ

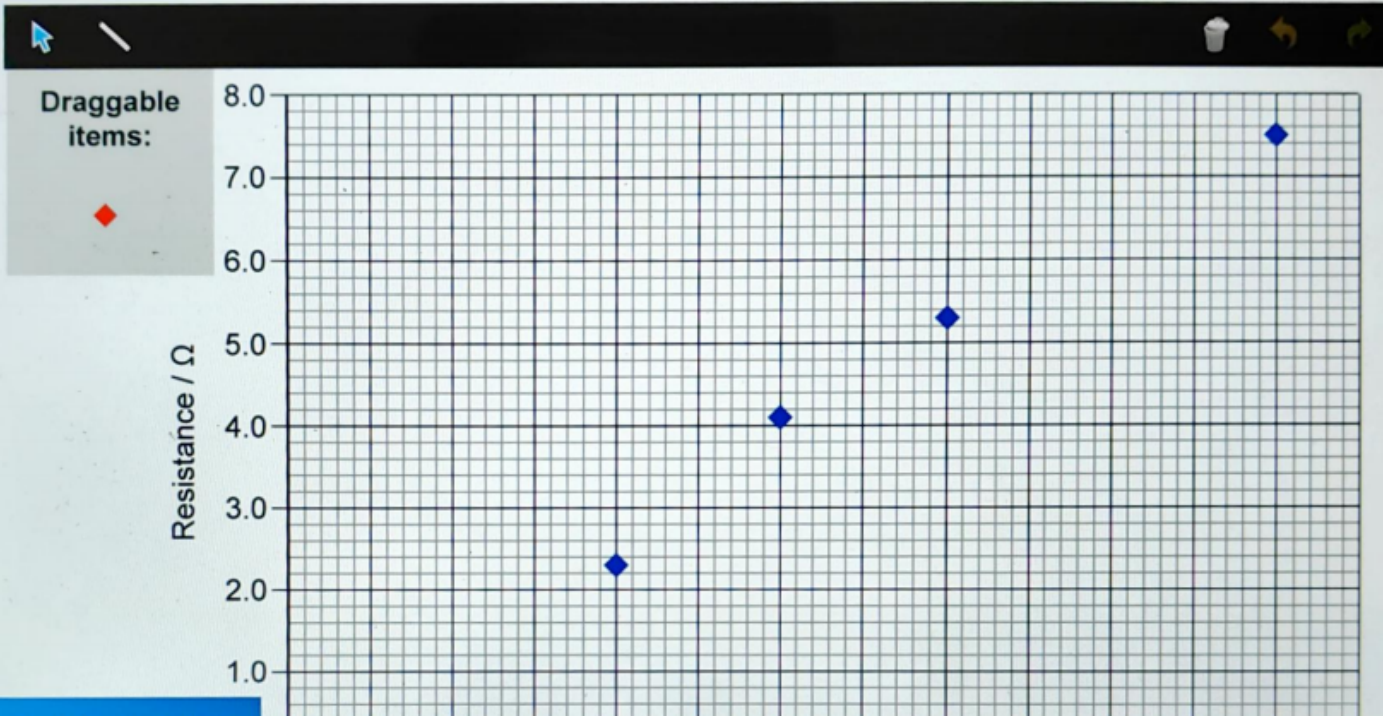
Styles

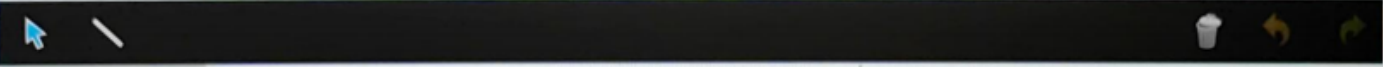




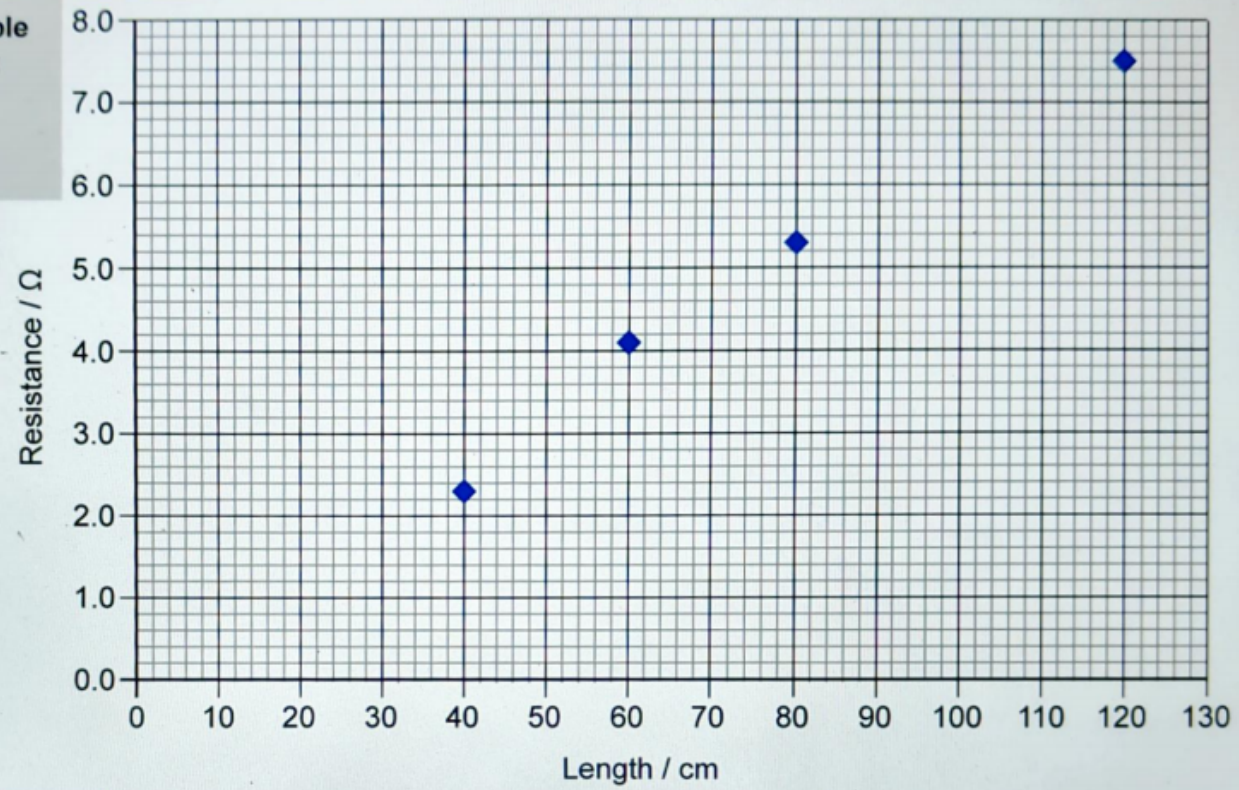
Question 3g (2 marks)

The graph below shows the processed data from the experiment. **Plot** the value you determined in part (f) and **draw** the line of best fit on the graph.





Draggable items:





Question 3h (2 marks)

According to theory, the relationship between resistance and length should be proportional, however, the student's results do not fit perfectly on the line of best fit. **Suggest** one source of error in this investigation and how this would affect the calculated value of resistance.

B

I



U

\times_2

\times^2

$\cdot =$

$: =$

Ω

Σ

Styles

-

-

-





Question 4a (1 mark)

State the conservation law that explains why the ball reaches the same height for both angles.

B

I



U

x_2

x^2

$\dot{=}$

$::=$

Ω

Σ

Styles

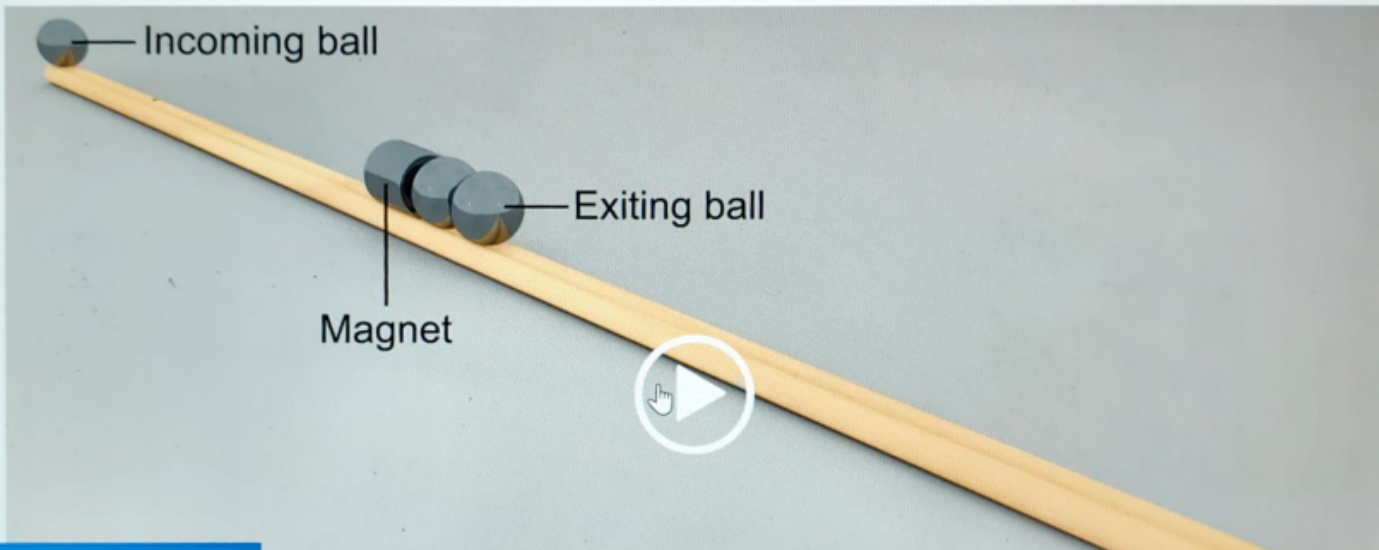


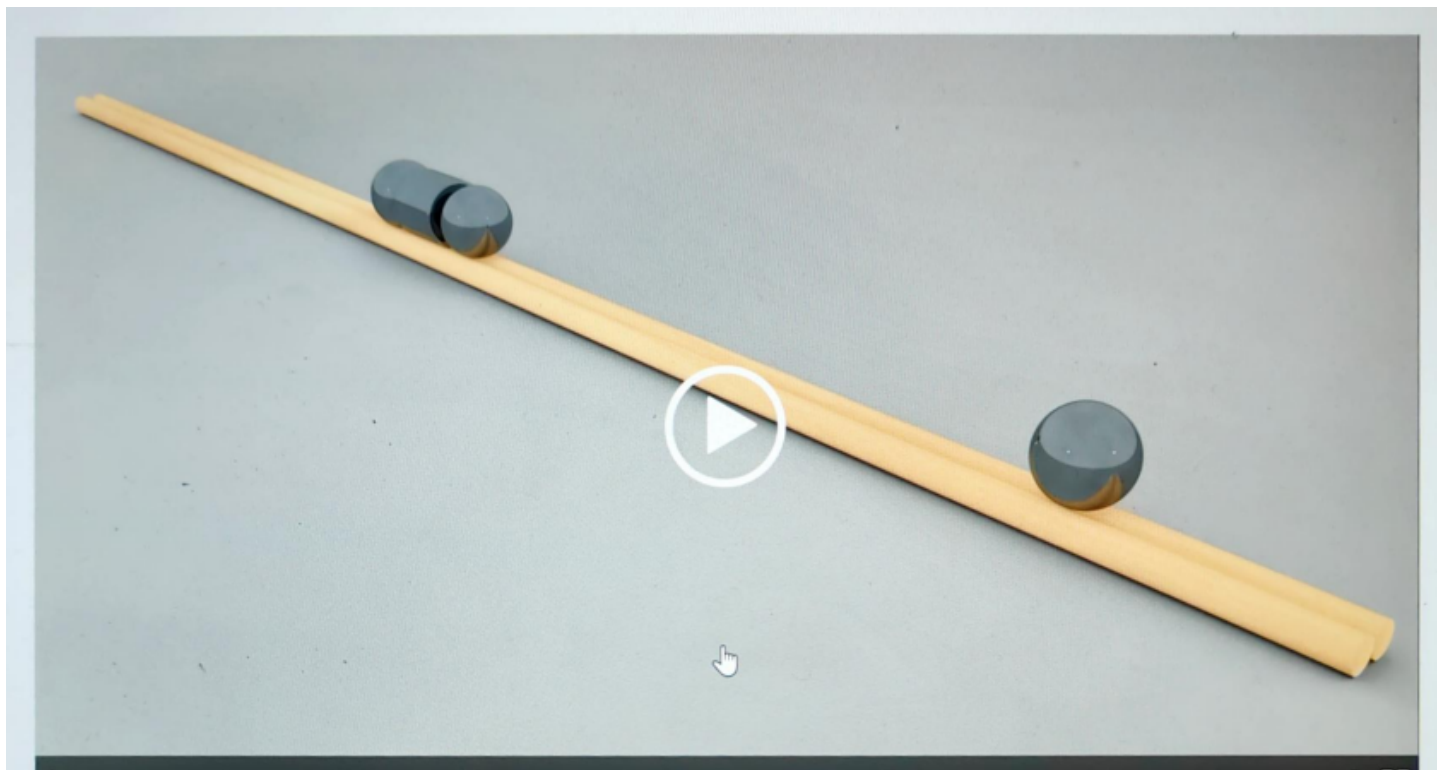


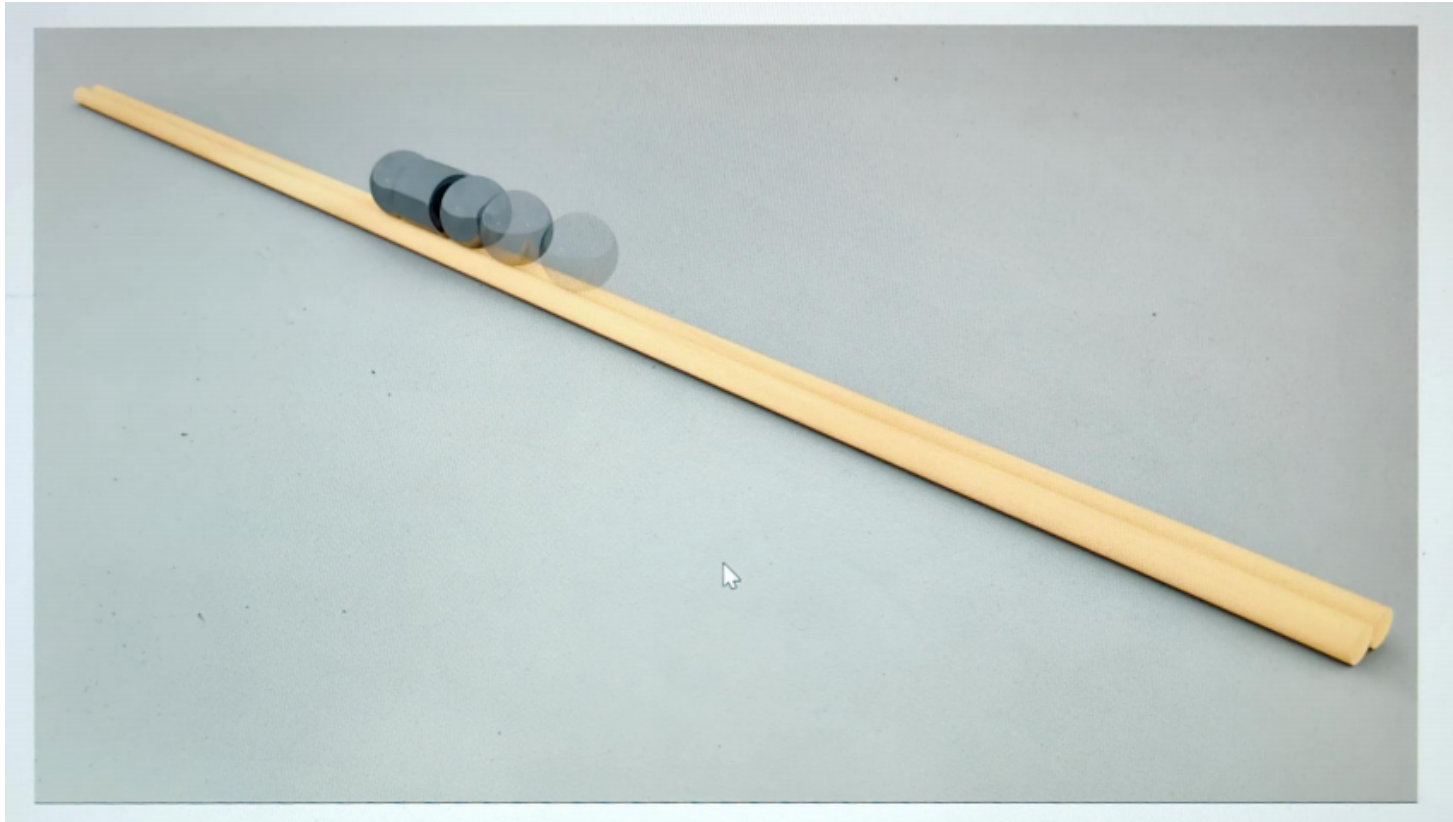
Question 4b (3 marks)

You are given a new piece of equipment with two steel balls held magnetically on one side of a very strong neodymium magnet placed on a wooden track. A single ball is rolled towards the other side of the magnet. As this ball collides with the magnet, the ball on the other side shoots out with a much faster velocity, as shown in the slow motion video below.

This media contains no audio







The slow-motion video shows the motion of the ball just before it collides with the magnet. Drag and drop to **draw** and **label** the forces acting on the ball while it is rolling **just before** it collides with the magnet.

Draggable items:

Electrostatic force	Magnetic force	Normal force	Tension force	Upthrust	Weight force
---------------------	----------------	--------------	---------------	----------	--------------

Draggable items:

Electrostatic force

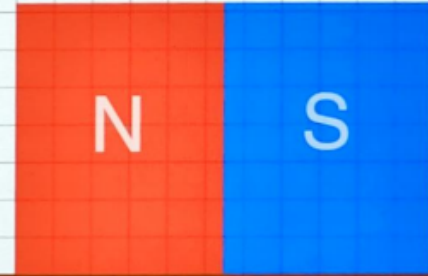
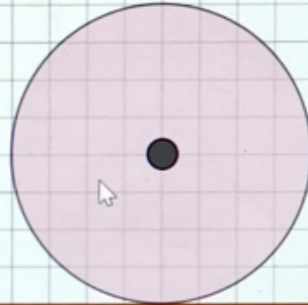
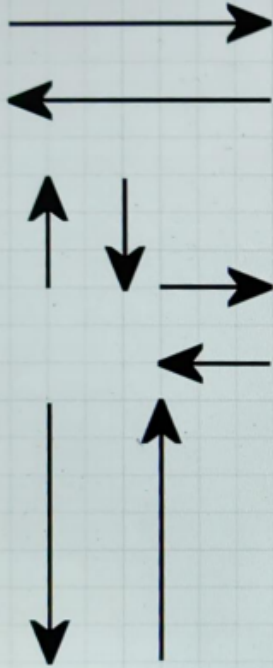
Magnetic force

Normal force

Tension force

Upthrust

Weight force





Question 4c (2 marks)

Suggest why the acceleration of the ball is not constant as it approaches the magnet. **Justify** your answer using scientific reasoning.

B *I* ← → U x_2 x^2 \int $\frac{d}{dt}$ Ω Σ Styles

I

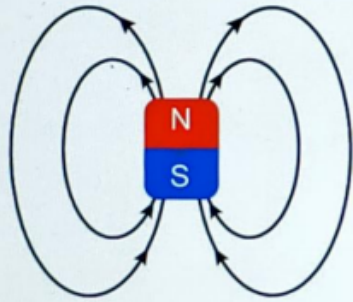


Question 4d (1 mark)

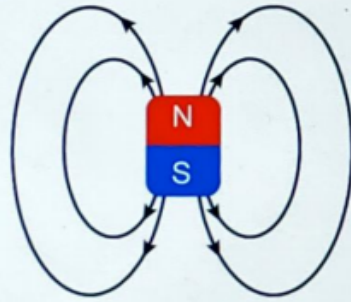
The magnet can be assumed to have a magnetic field similar to that of the Earth. **Select** the diagram that best represents the magnetic field lines around the magnet.

Select ▾

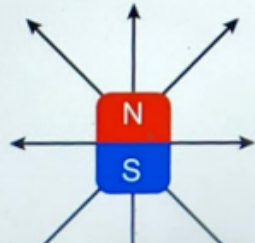
A.



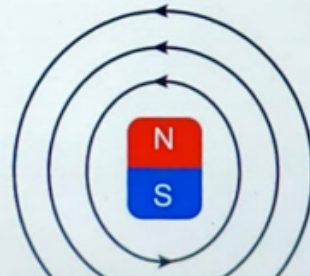
B.



C.

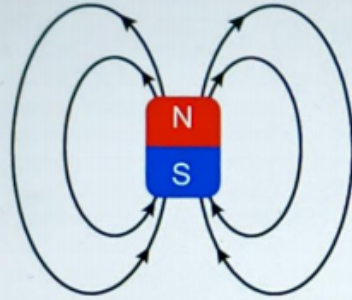


D.

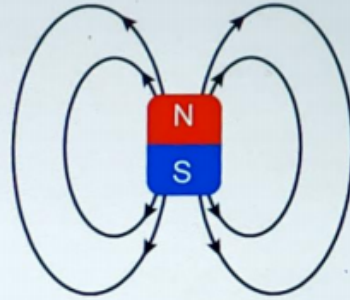


Scroll down to continue

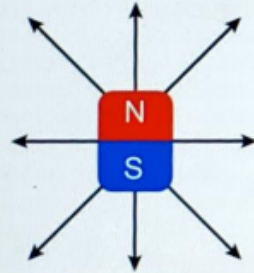
A.



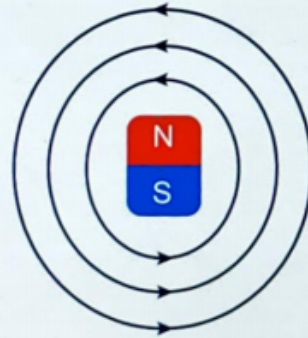
B.



C.



D.





Question 4e (1 mark)

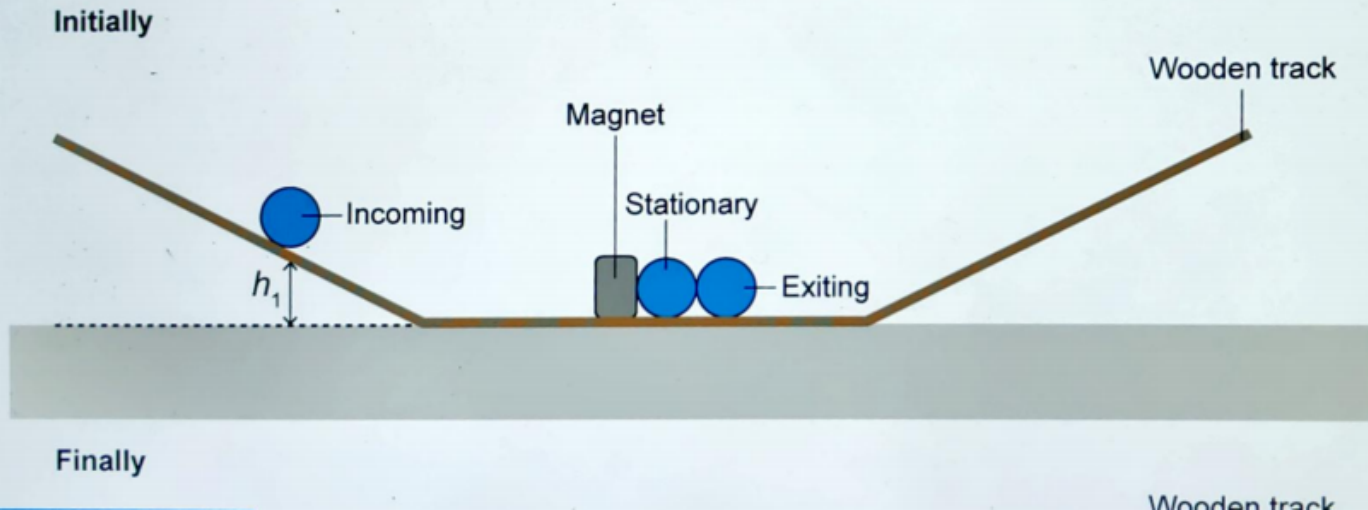
Once the incoming ball collides with the magnet, the exiting ball on the other side has a much greater kinetic energy than the incoming ball before the collision. Use your scientific knowledge to **suggest** a reason for this observation.

B *I* ← → u x_2 x^2 ;= := Ω Σ Styles - ↕

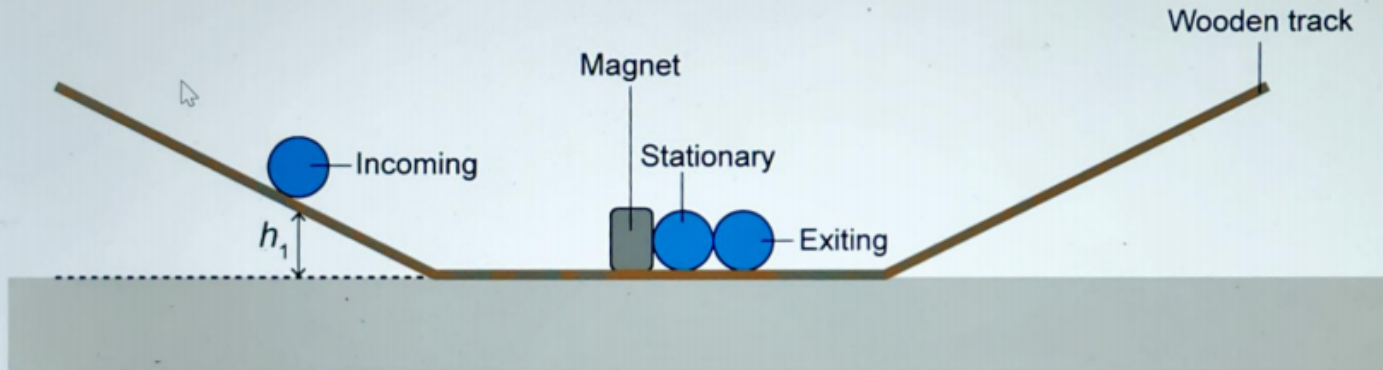


Question 4f (11 marks)

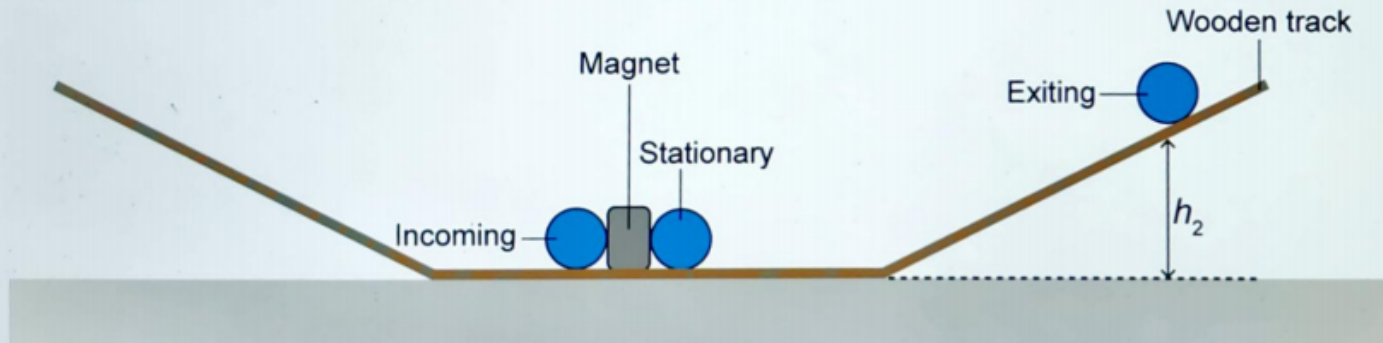
You plan to design an experiment using this equipment with a ball rolling down an inclined plane at a fixed angle and colliding with a magnet on a level surface. The exiting ball on the right moves along an upward inclined plane at the same angle, as shown below.



Initially



Finally



Design an investigation to find out the relationship between the maximum height (h_2) reached by the exiting ball and the initial height (h_1) of the incoming ball. In your plan, you should include:

- the independent variable, dependent variable and one control variable
- a hypothesis which is explained using scientific reasoning
- a detailed method for how you will collect data, including the equipment you will use
- details of how you will make sure your method is safe.

B *I* | ← → | x_o x^o | := :: | Ω Σ | Styles | ↕



Question 4g (4 marks)

Construct a data table that could be used to record data from the investigation in part (f).
The table must include:

- an appropriate number of rows and columns
- the values of the independent variable that will be used
- a column for processed data with an appropriate title.

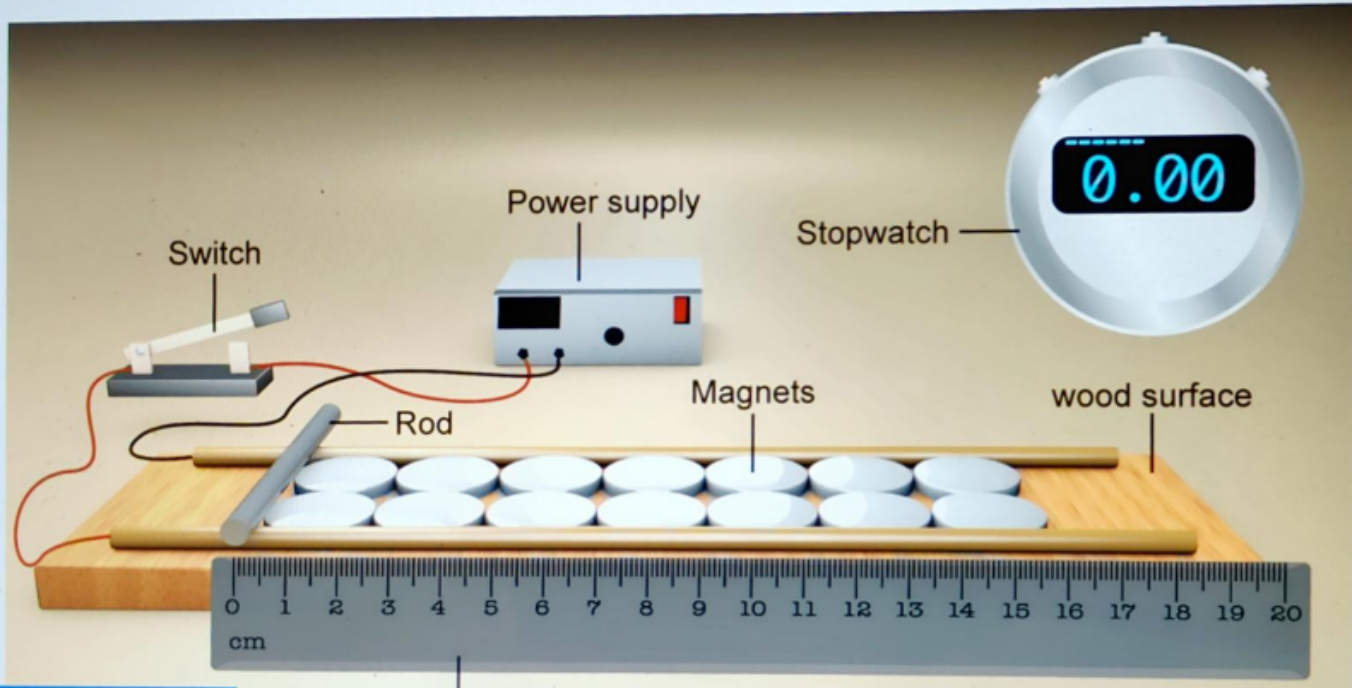
Create New Table

Reset



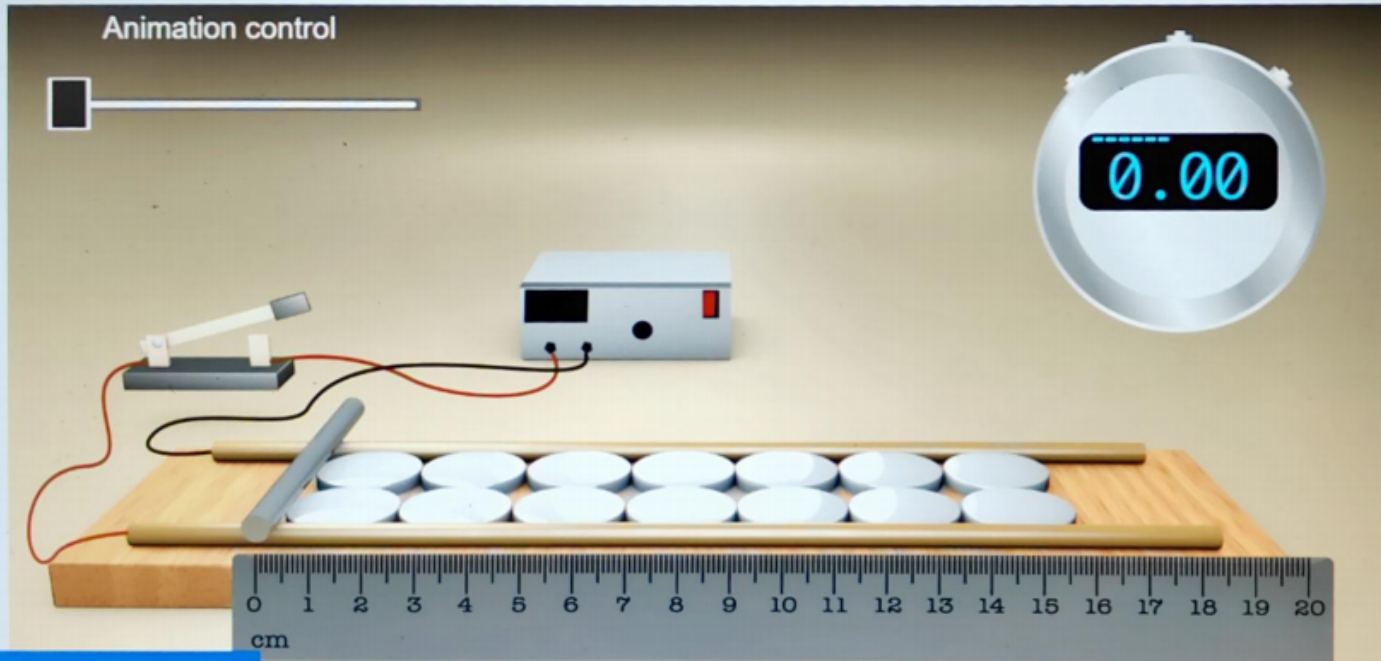
Question 5a (1 mark)

A student carried out an experiment using the equipment below.



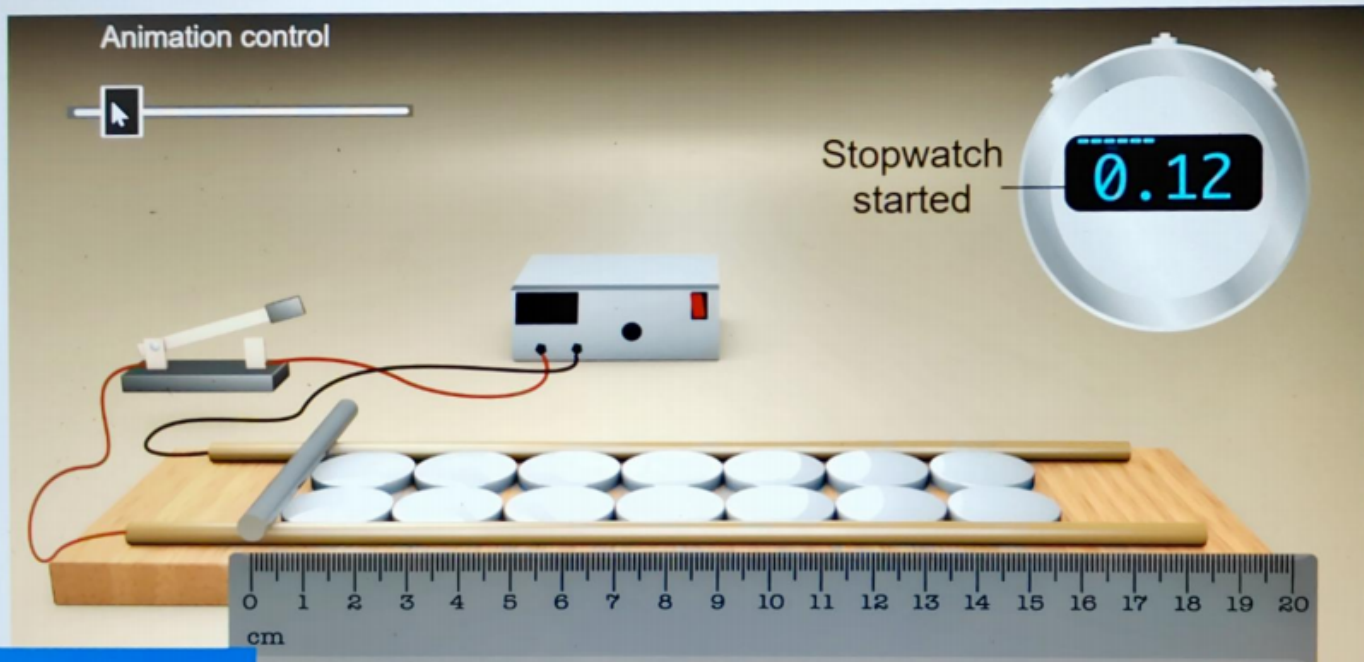
They adjust the current of the power supply. The rod is initially at rest, but when the switch is closed, it accelerates to the right. The student measures the time taken by the rod to move 16 cm.

This media is interactive



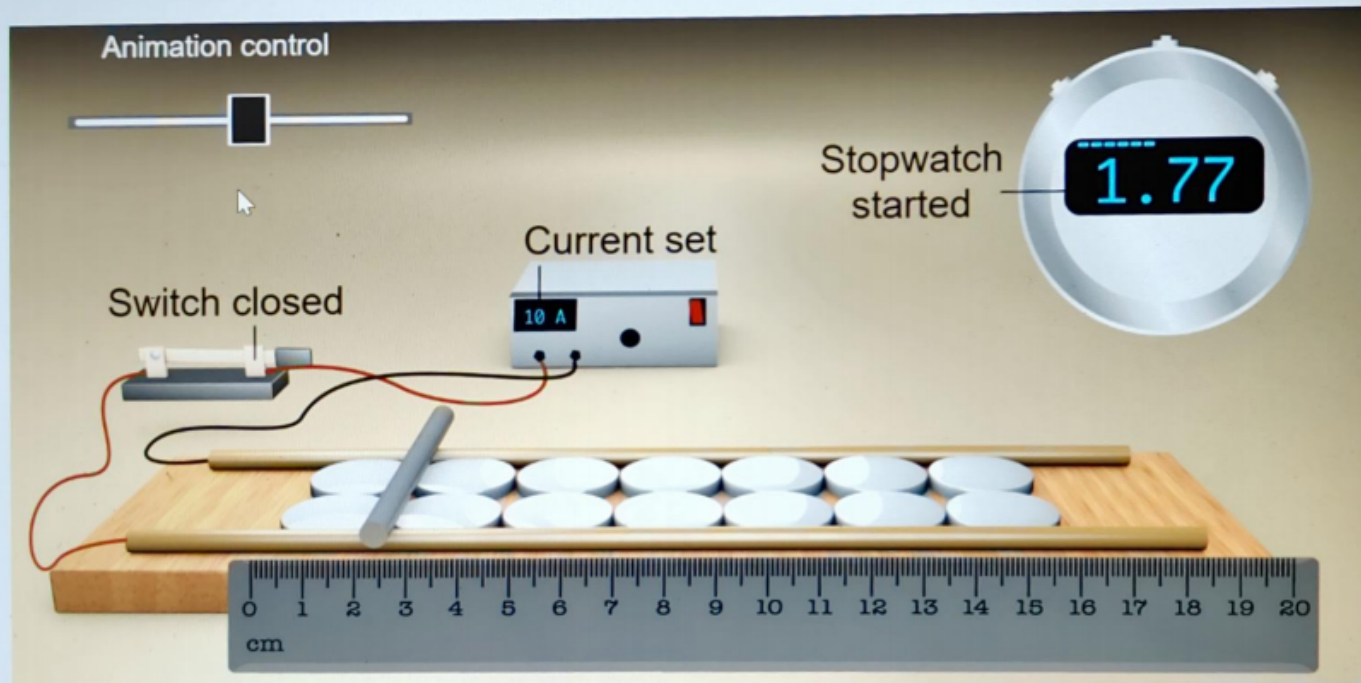
They adjust the current of the power supply. The rod is initially at rest, but when the switch is closed, it accelerates to the right. The student measures the time taken by the rod to move 16 cm.

This media is interactive



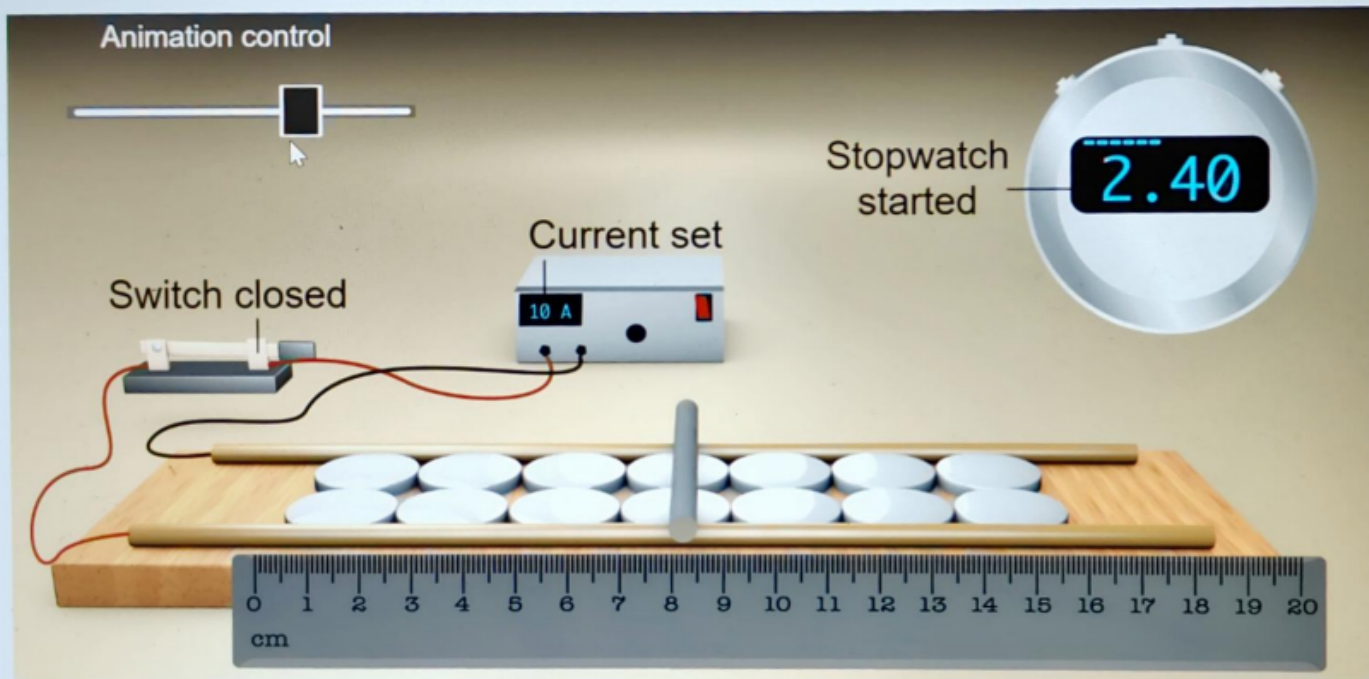
is closed, it accelerates to the right. The student measures the time taken by the rod to move 16 cm.

This media is interactive



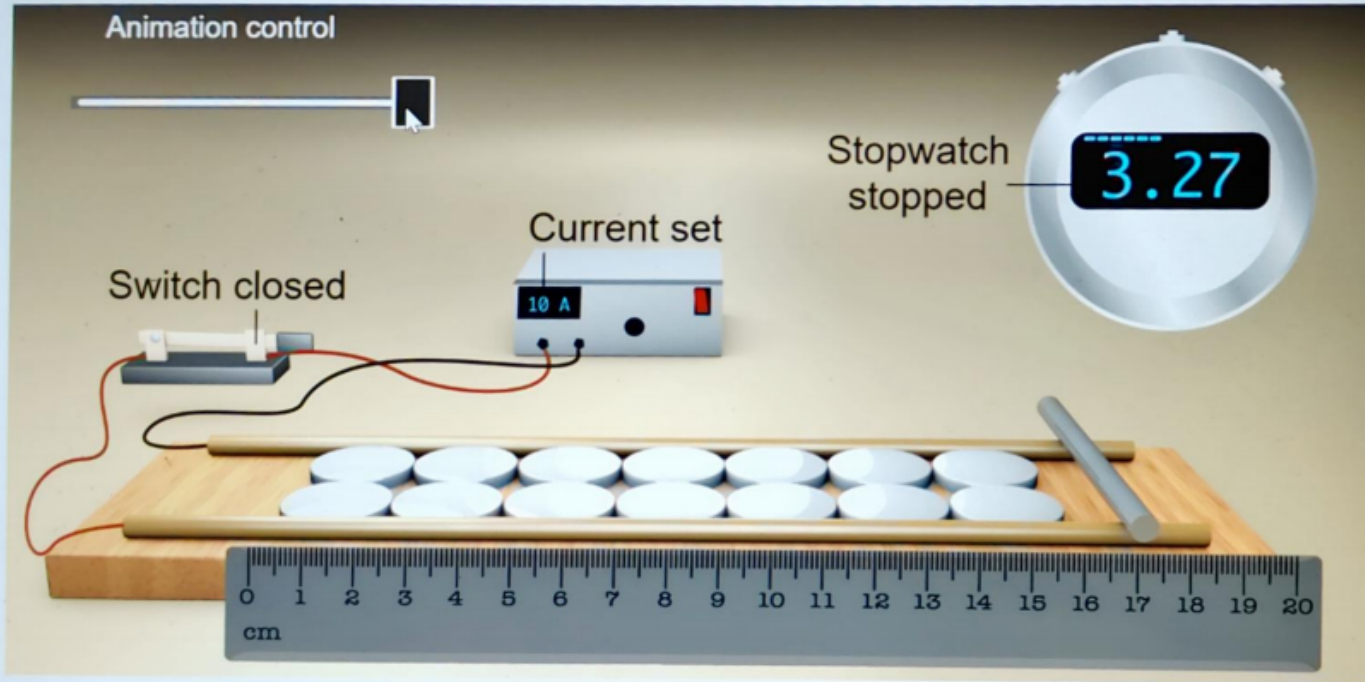
is closed, it accelerates to the right. The student measures the time taken by the rod to move 16 cm.

This media is interactive



is closed, it accelerates to the right. The student measures the time taken by the rod to move 16 cm.

This media is interactive



The time for a current of 10 A was not recorded by the student. Using the animation, **measure** the time it takes the rod to travel 16 cm from rest.

Current / A	Time / s
7	2.73
8	2.40
9	2.10
10	
11	1.83
12	1.70

Reset

B

I



U

x_0

x^0



Ω

Σ

Styles





Question 5b (3 marks)

The student assumes that the rod accelerates uniformly. For the last trial, at a current of 12 A, the student records a time of 1.70 s. Using the formula sheet, **calculate** the acceleration of the rod.

B *I* | ← → | U \times_2 \times^e | \int $\frac{d}{dt}$ | Ω Σ | Styles - |



Question 5c (1 mark)

After calculating its acceleration, the student wanted to calculate the net force acting on the rod.
State what additional quantity would be needed for this calculation.

Rich text editor toolbar with icons for Bold (B), Italic (I), Undo, Redo, Underline (U), Subscript (x₂), Superscript (x^a), Bulleted List (bulleted list icon), Numbered List (numbered list icon), Omega (Ω), Sigma (Σ), Styles, and a document icon. A tooltip "Insert/Remove Bulleted List" is visible over the bulleted list icon.



Question 5d (1 mark)

Before starting the experiment, the student makes the following prediction:

If the electric current passing through the rod doubles, the force on the rod will double. The relationship will be proportional.

If the results of the experiment support this hypothesis, **select** the graph that would represent the data.

Select ▾

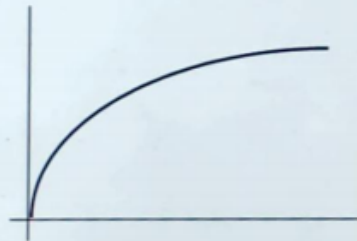
Select

- A
- B
- C
- D

A.



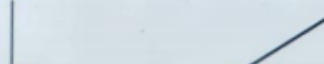
B.



C.

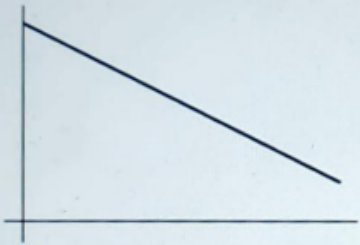


D.



Select ▾

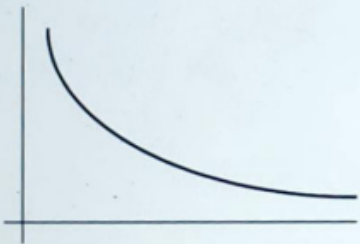
A.



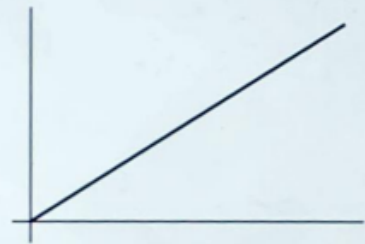
B.



C.



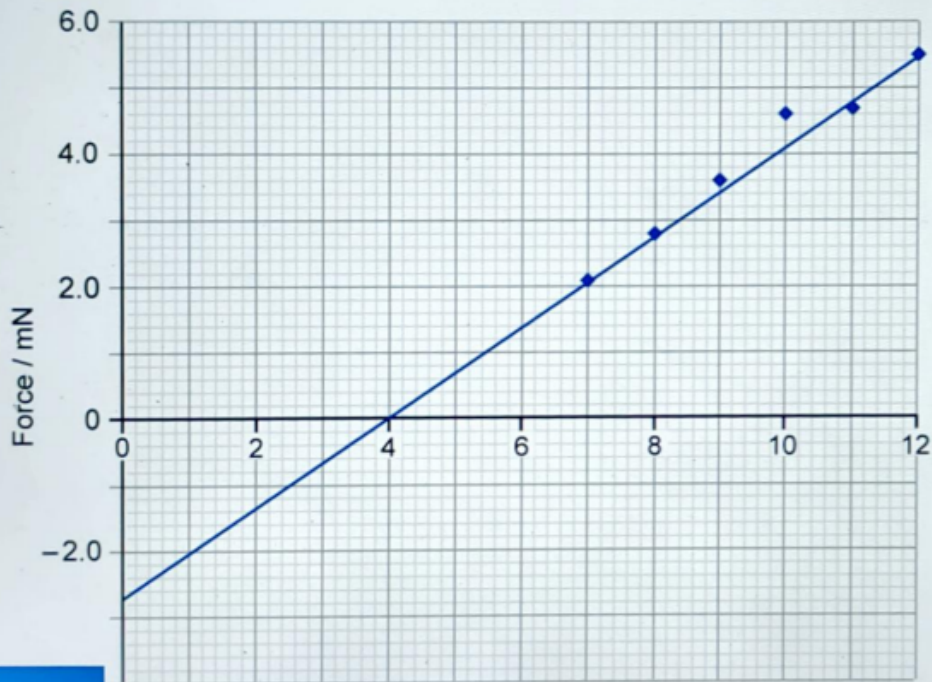
D.

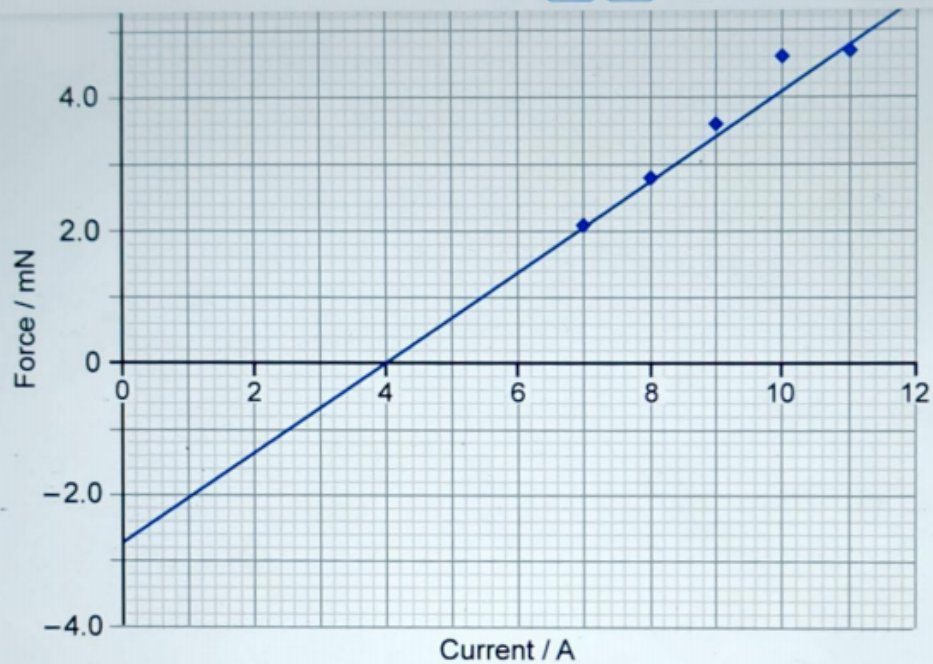




Question 5e (2 marks)

Another student processed the data and calculated the force on the rod for each current. The student plotted their data on the graph below.





Referring to the graph, **outline** why the student's hypothesis in part (d) is not supported by the data.

B I ← → $\underline{\quad}$ \times \cdot \times^2 \int $\frac{\quad}{\quad}$ Ω Σ Styles \rightarrow



Question 5f (2 marks)

The student adjusts the current to 4 A. Use the graph in part (e) to **suggest** what you think would happen to the rod. **Justify** your answer.

B **I** | ← → **U** x_2 x^2 $\frac{1}{2}$ $:=$ $:=$ Ω Σ Styles -

I



Question 5g (1 mark)

For the rod to move, it needs to overcome frictional forces. Use the graph to **suggest** the size of the frictional forces.

B

I



U

x_2

x^e

$\int =$

$:=$

Ω

Σ

Styles



I



Question 6a (2 marks)

Outline why a refracting telescope causes the different colours of light to separate.

B

I



U

x_2

x^2



Ω

Σ

Styles





Question 6b (1 mark)

Clearer images can be obtained by using mirrors to create a reflecting telescope. The first reflecting telescope was made by Isaac Newton in 1668. Parallel rays from a distant object are reflected by a curved primary mirror onto a plane secondary mirror. The rays are reflected again by the secondary mirror and come into focus at the eyepiece.

Label the primary mirror, secondary mirror and the position of the eyepiece in the diagram shown.

The diagram shows a reflecting telescope with a curved primary mirror at the back and a plane secondary mirror in front of it. Parallel red rays enter from the left, reflect off the primary mirror, then off the secondary mirror, and converge at an eyepiece on the right. The interface includes a toolbar with a mouse cursor, a trash can, and undo/redo arrows. A 'Draggable items:' panel on the left contains three dashed boxes: 'Primary mirror', 'Secondary mirror', and an empty one. A blue bar at the bottom left says 'Scroll down to continue'.

Label the primary mirror, secondary mirror and the position of the eyepiece in the diagram shown.

Draggable items:

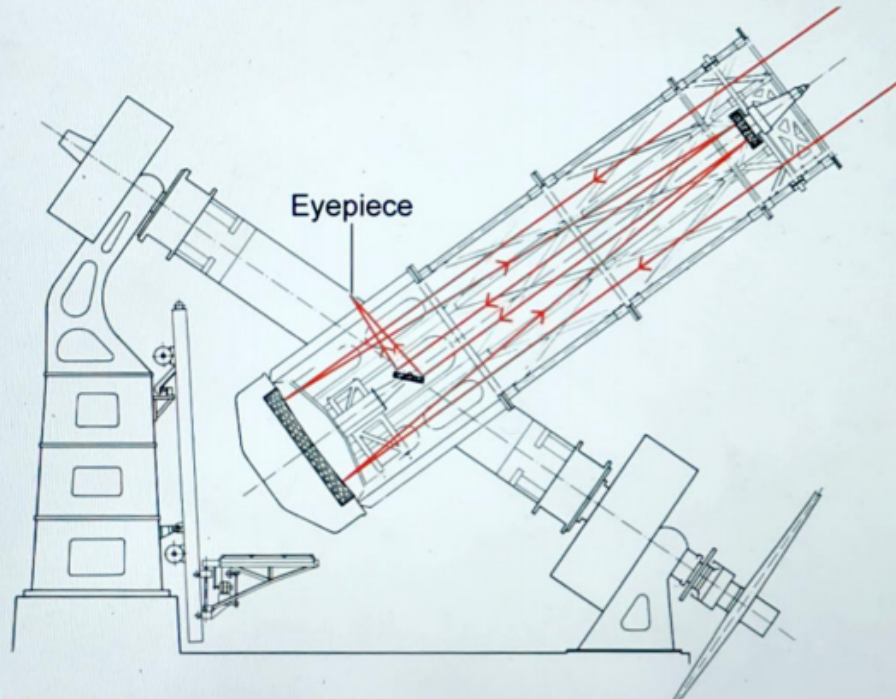
- Primary mirror
- Secondary mirror
- Eyepiece

The diagram shows a Cassegrain telescope. Light rays enter from the left, pass through an eyepiece, and are reflected by a primary mirror at the back. The light is then reflected by a secondary mirror and exits through a hole in the primary mirror. The diagram includes a 'Draggable items' panel on the left with three items: 'Primary mirror', 'Secondary mirror', and 'Eyepiece'. The primary mirror is a large blue concave mirror at the back. The secondary mirror is a smaller blue convex mirror in the middle. The eyepiece is a small blue lens at the front. Three red arrows show the light path: two entering from the left, reflecting off the primary mirror, then off the secondary mirror, and exiting through the hole in the primary mirror. A third arrow enters from the left and reflects off the primary mirror. There are three grey rectangular boxes for labeling: one at the top, one on the left side, and one on the right side.



Question 6c (1 mark)

One of the most famous telescopes of the 20th century was called the Hooker telescope. It was the world's largest telescope from 1917 to 1949 and included a 2.5 m reflecting mirror.





Question 6d (1 mark)

The Hooker telescope was used by Edwin Hubble to make observations that would change our view of the universe forever. He was able to prove that the universe extends far beyond the edge of the Milky Way galaxy. Hubble also proposed that the universe is expanding.

Suggest what phenomenon Hubble observed to show him that the universe is expanding.

B *I* ← → U x_2 x^2 \int \sum Ω Σ

Styles -





Question 6e (2 marks)

The idea of having a telescope in space, instead of on the surface of the Earth, was proposed early in the 20th century. This was an idea to improve the quality of the observations that could be made.

Suggest why a telescope in space can make clearer observations than a telescope on the Earth's surface.

B *I* | ← → | x₀ x² | \int \sum | Ω Σ | Styles |



Question 7 (19 marks)

Video

Script

The Hubble Space Telescope, named after Edwin Hubble, was built in the 1970s, but wasn't launched until 1990 due to technical delays and budget problems.

Soon after the telescope had been successfully launched into space, a problem with the main mirror of the telescope was discovered.

A mission in 1993 corrected the problem with the mirror and brought instrument upgrades to the telescope. The mission to correct the telescope took almost 11 days and the crew members made five spacewalks during the mission.

The Hubble Space Telescope changed our understanding of the universe forever. A famous image was taken in 1995 of the Eagle Nebula at a distance of around 7000 light years from Earth. The image showed dust and gas in the process of creating new stars.

This image has been replicated on everything from T-shirts to coffee mugs.

Plans for a new space telescope started in 1996. The new telescope would include a larger mirror and would have to travel further from Earth so that it could see deeper into space than ever before. This telescope, named the James Webb Space Telescope, was designed to look for waves in the infrared region of the electromagnetic spectrum.



Scroll down to continue

would be sent to a location that was so far from Earth that it couldn't be repaired

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The telescope would be sent to a location that was so far from Earth that it couldn't be repaired if there were problems.

The telescope is the most expensive piece of scientific equipment ever made. However, the 10-billion-dollar cost is much less than the over 750 billion dollars that the US has as its annual military budget.



Question 7a (13 marks)

Using the information in the video and your wider MYP studies, **discuss** and **evaluate** the development of the JWST and its role in extending our knowledge and understanding of the universe. In your answer, you should include:

- the scientific challenges of launching a telescope into space
- the social or cultural implications of the observations made with telescopes
- the economic implications of spending government funds on a space telescope
- a concluding appraisal giving your opinion on the impact of the JWST.

B *I* | ← → U x_n x^2 \int \sum Ω Σ Styles -



Question 7b (6 marks)

The JWST carries a mid-infrared instrument that some people believe could provide evidence of life on other planets.

Some facts about the JWST are given below.

- The instrument can detect substances such as water, oxygen, ozone, methane and carbon dioxide on planets outside our solar system. These planets are known as exoplanets.
- The exoplanet has to be orbiting a specific kind of star, known as a white dwarf, for the substances to be detected by the instrument.
- The nearest white dwarf star to Earth is over eight light-years away and there are only about 34 known white dwarf stars within 40 light-years of Earth.



34 known white dwarf stars within 40 light-years of Earth.



Use the information above to **evaluate** the benefits and limitations of using the mid-infrared instrument on the JWST to search for evidence of life on other planets.

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