Question 1 (5 marks)

The following table contains information that can be used to describe mass or weight.

Question 1a (2 marks)

Select the correct option to complete the table.

Draggable:

newton | size only | independent of gravitational field strength

kilogram | size and direction | dependent on gravitational field strength

	Mass	Weight
Units		
Type of quantity		
Effect of gravitational field strength		

Question 1b (2 marks)

The table below contains information about four planets in the solar system. Using this information, **select** the **three** unnamed planets and complete the table.

Draggable:

- Jupiter
- Venus
- Neptune

	Relative mass compared to Earth	Orbital period/ Year	Number of moons	Main gases in atmosphere	Are there any rings present?
Earth	1	1	1	N_2, O_2, Ar	No
	0.82	0.62	0	CO_2, N_2	No
	17.2	164.8	14	H_2, He	Yes
	317.8	11.86	67	H_2, He	Yes

Question 1c (1 mark)

State why the outer planets tend to be colder than the inner planets.

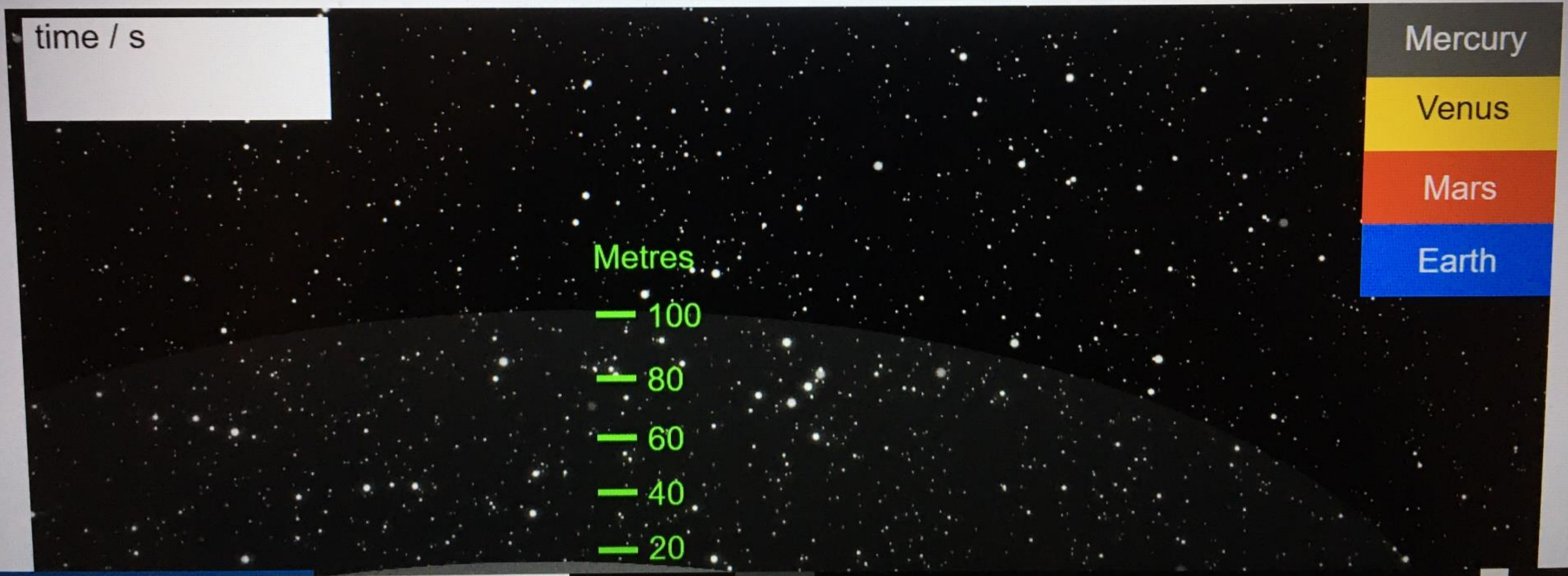
B I U x_2 x^2 Ω Σ Styles

Question 2 (11 marks)

A robotic probe is sent into space to collect data from three of the four inner planets: Mercury, Mars and Venus.

While passing close by each planet the probe drops a test object from a height of 100.0 m, the shape of the object ensures that any frictional forces are negligible over a fall of this distance.

Fly with the probe to collect the data. Click on the name of each planet to measure the time taken for the test object to fall.



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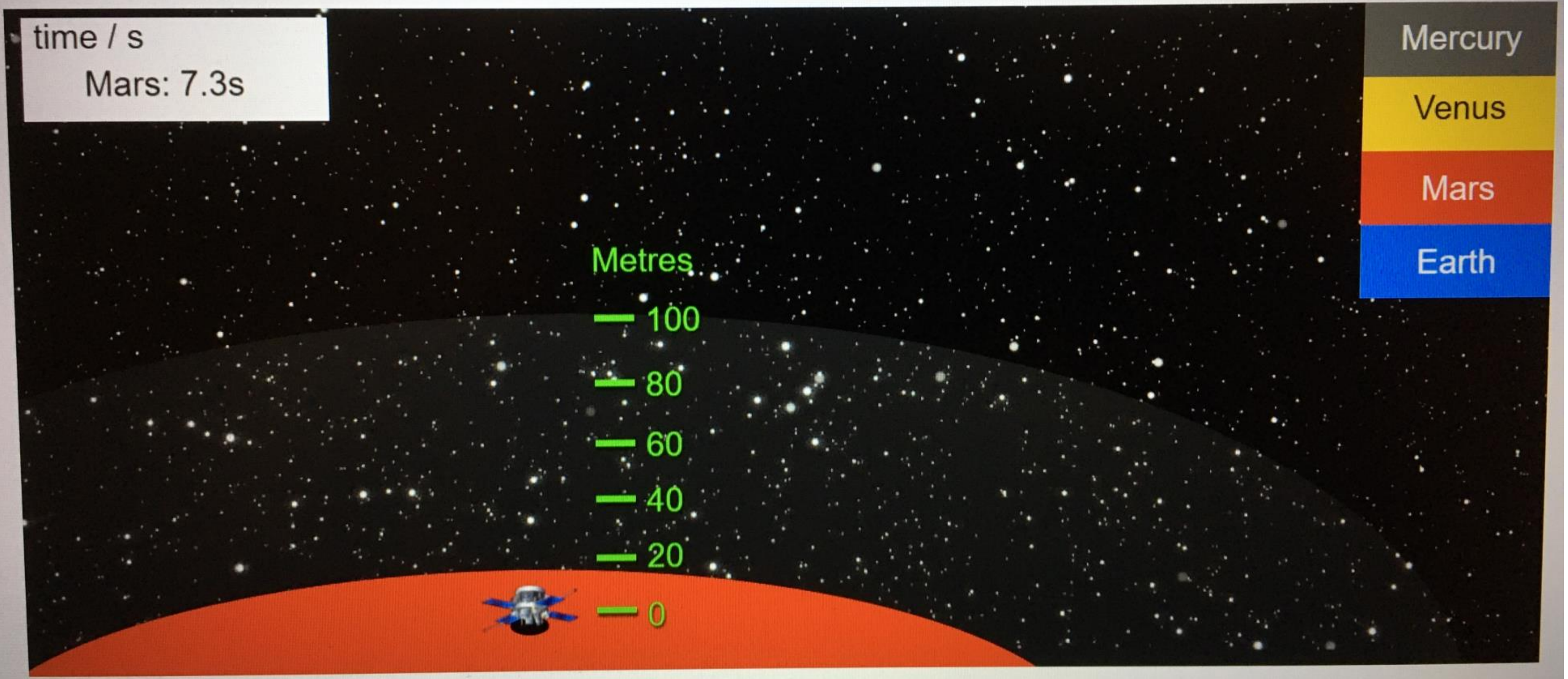
Fly with the probe to collect the data. Click on the name of each planet to measure the time taken for the test object to fall.



While passing close by each planet the probe drops a test object from a height of 100.0 m, the shape of the object ensures that any frictional forces are negligible over a fall of this distance.

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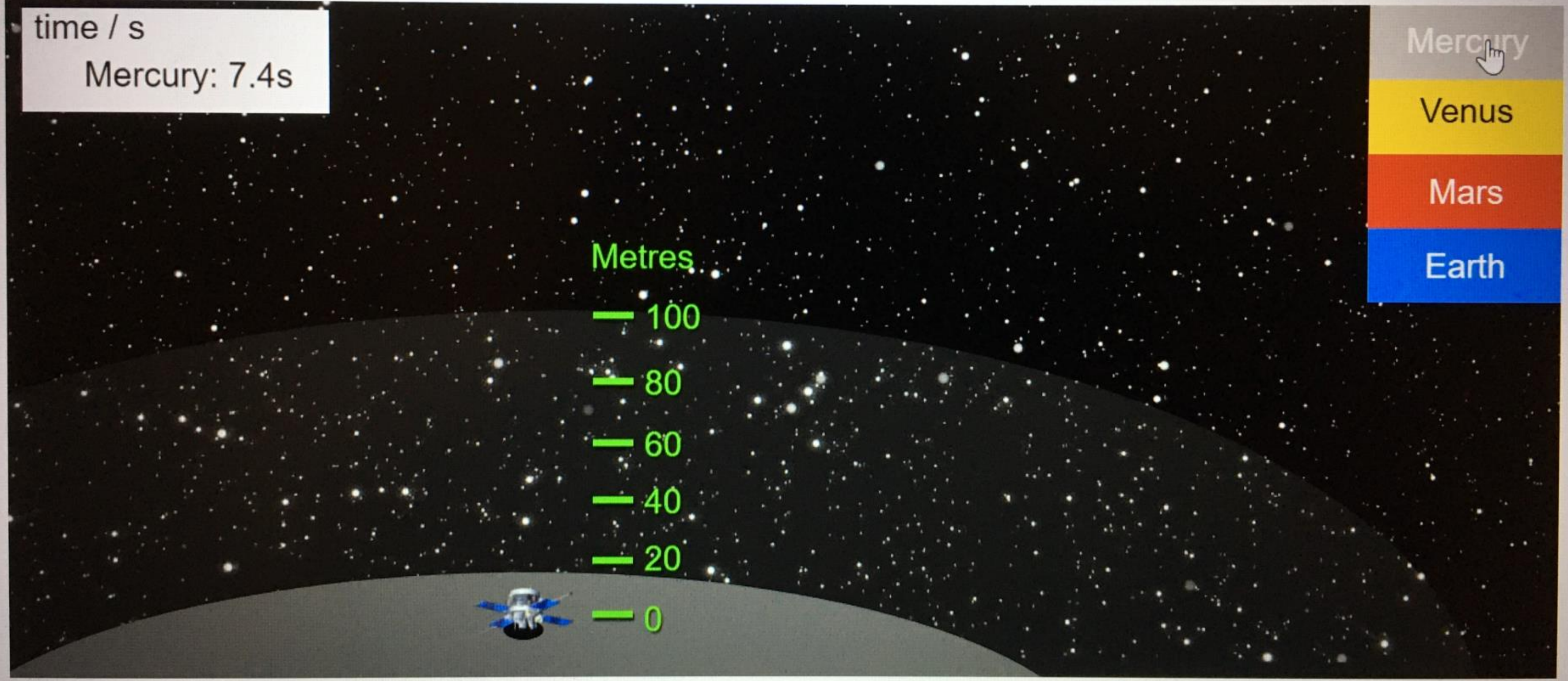

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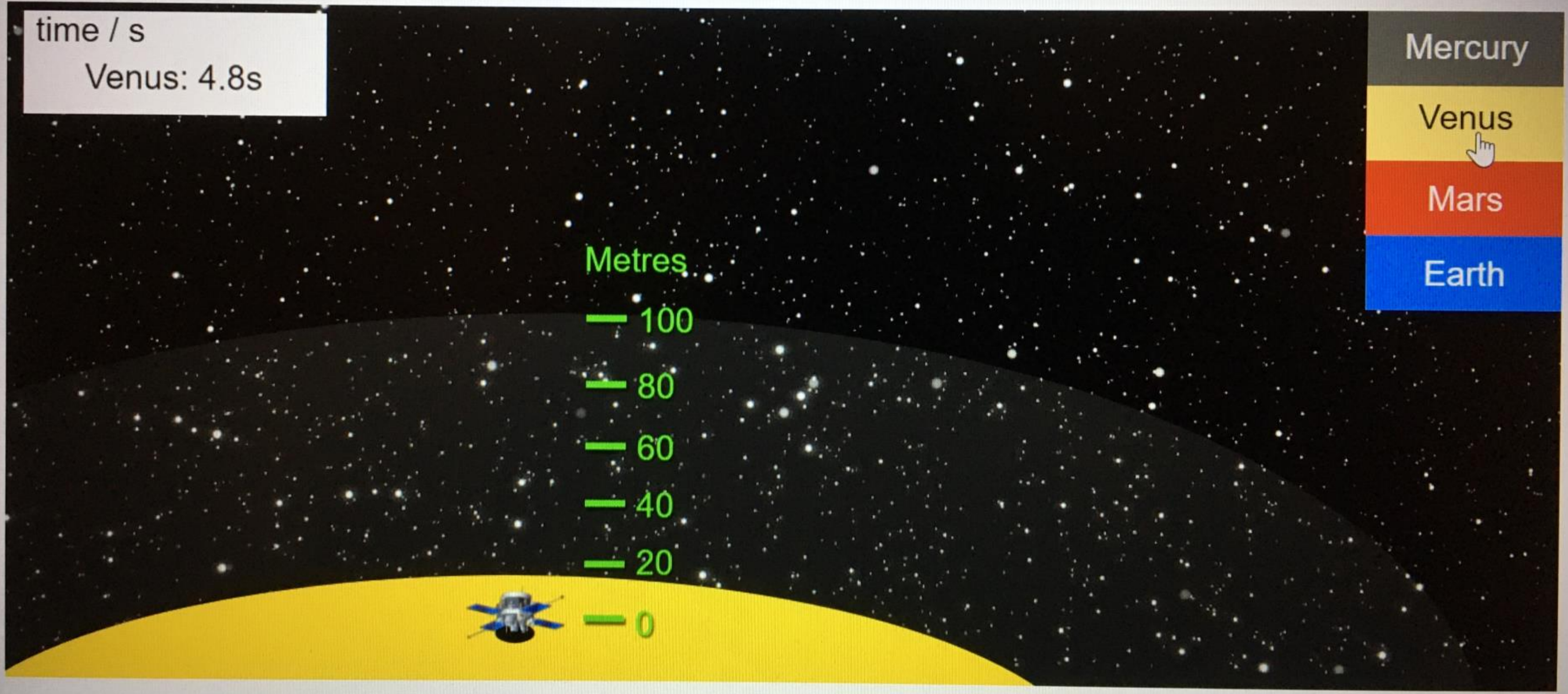

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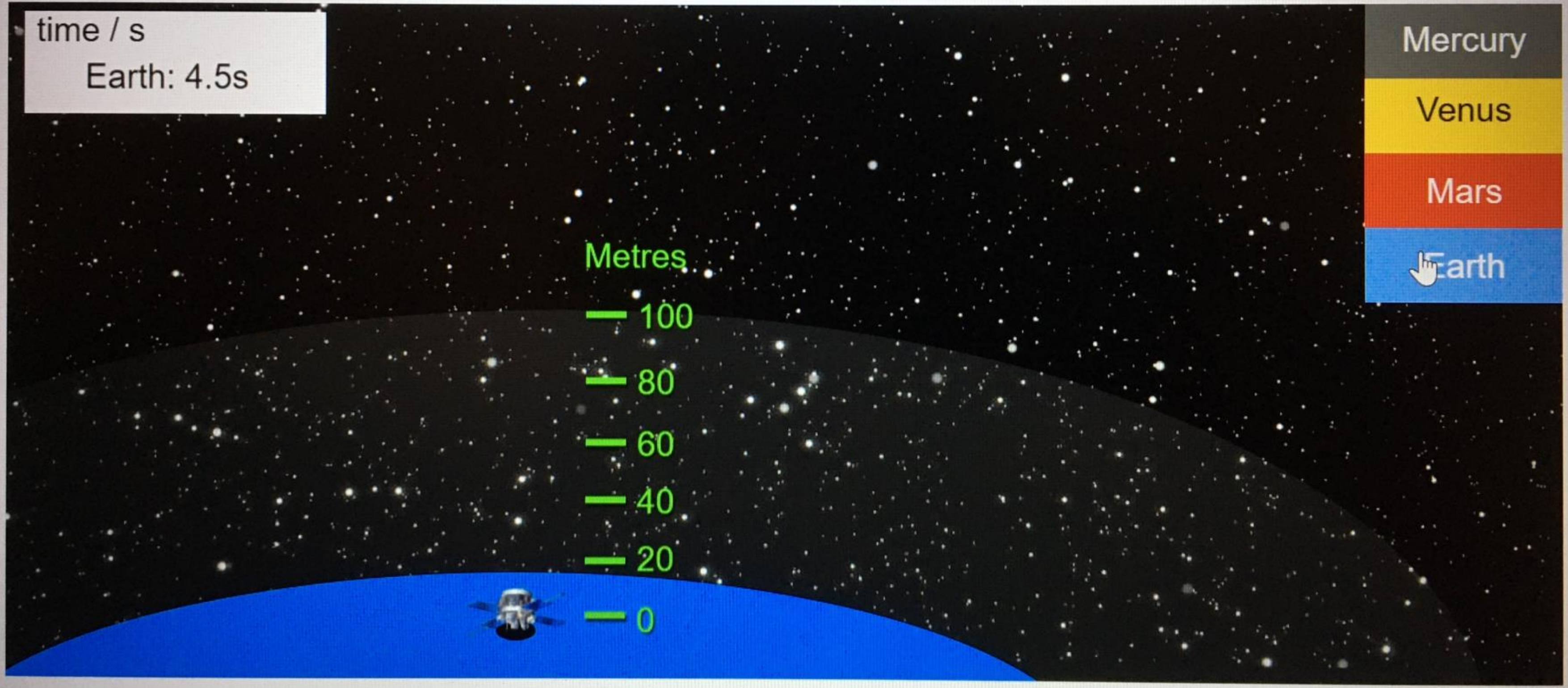
Fly with the probe to collect the data. Click on the name of each planet to measure the time taken for the test object to fall.



Question 2a (3 marks)

Using the data you collected above, **calculate** the acceleration due to gravity on Mercury and Mars. You may wish to use the formula sheet.

Mercury:

B I U x_2 x^2 Ω Σ Styles

Mars:

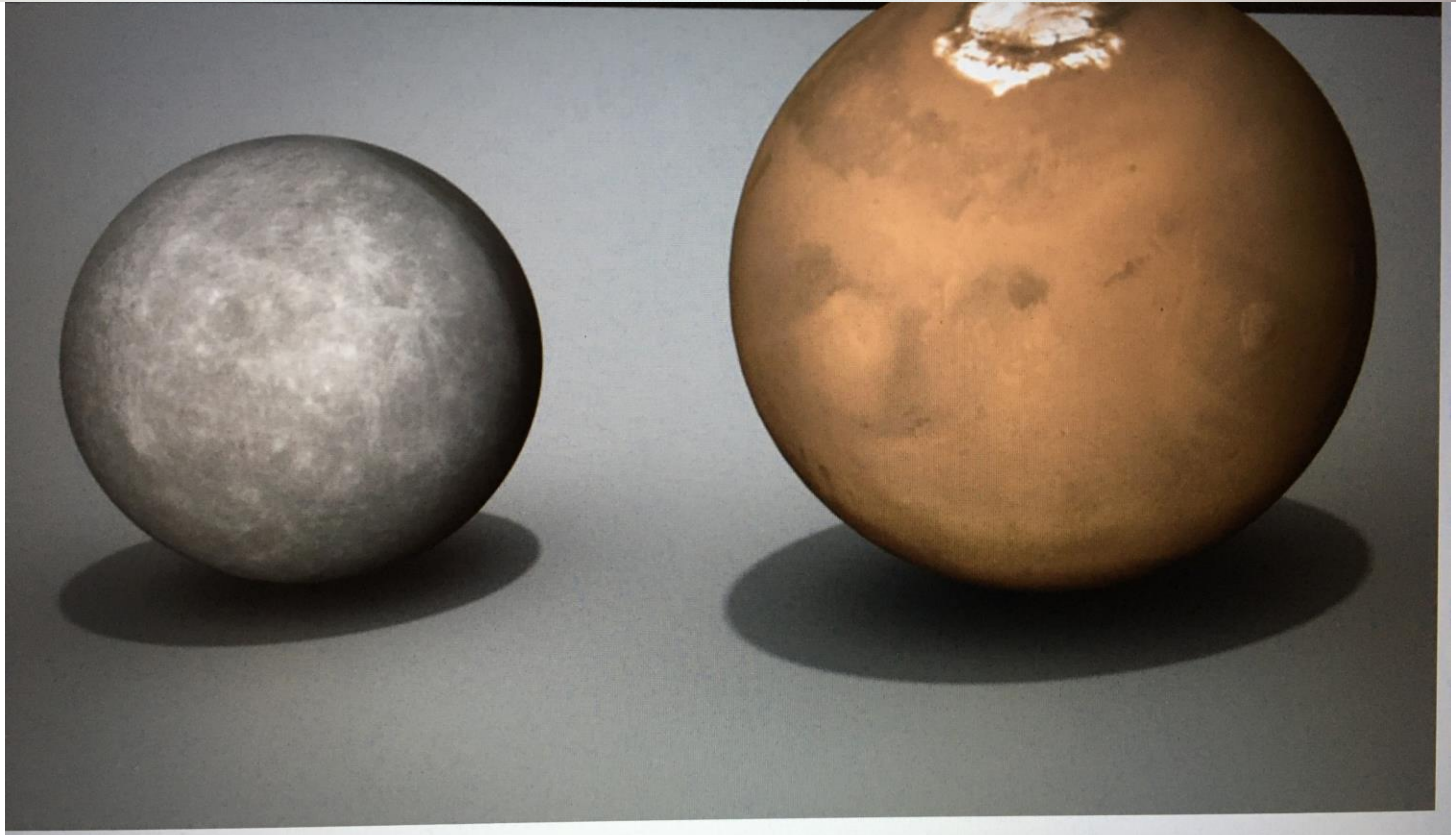
B I U x_2 x^2 Ω Σ Styles

The scientists receiving the data on Earth know that gravitational field strength (g) is proportional to a planet's density (ρ) and its radius (r).

$$\textit{gravitational field strength} \sim \textit{density} \times \textit{radius}$$

$$g \sim \rho \times r$$

The radius of Mercury is about two thirds of the radius of Mars.



Mercury Mars

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Explain why Mars and Mercury can have almost the same value of *g*, if Mars has a much larger radius.

Styles

Next, the space probe visits two of Jupiter's moons: Io and Ganymede.

The experiment is repeated and again a test object is dropped from a height of 100.0 m.

The gravitational field strength of Io = 1.8 N kg^{-1}.

The gravitational field strength of Ganymede = 1.4 N kg^{-1}.

The test object has a mass of 20 kg.

Question 2c (3 marks)

Use information from the formula sheet to **calculate** the gravitational potential energy (E_p) of the test object before it is dropped over Io.

All of the test object's gravitational potential energy (E_p) transforms to kinetic energy before hitting the surface of the moons.

Question 2d (3 marks)

The test object travels faster before hitting the surface of Io than it does before hitting the surface of Ganymede. **Explain** this observation.

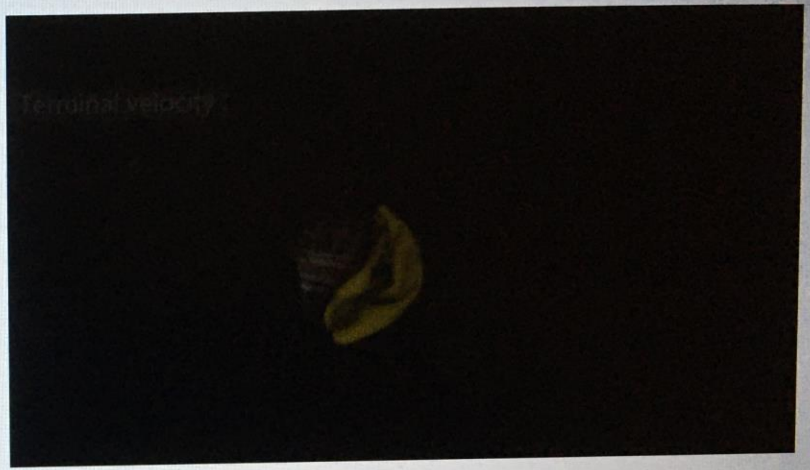
Styles

Question 3 (11 marks)

When the space probe in Question 2 is investigating acceleration, air resistance is negligible.

On Earth, a parachute can be used to increase air resistance.

The maximum speed a falling object reaches is known as the terminal velocity.



Question 3a (2 marks)

Some students perform an investigation into the terminal velocity of a simple parachute. One of the students wants to investigate how the area of the parachute affects its terminal velocity.

Some students perform an investigation into the terminal velocity of a simple parachute. One of the students wants to investigate how the area of the parachute affects its terminal velocity.

Suggest one piece of equipment that the student will need to perform this experiment.

Equipment:

Reason:

Question 3b (3 marks)

Suggest and **explain** a hypothesis for this experiment.

B I U Styles

Question 3c (3 marks)

State one variable that the student will need to control. **Describe** how this variable should be controlled and why it should be controlled.

Variable

How the variable should be controlled

Why the variable should be controlled

Question 3d (3 marks)

Explain what results the student will need to collect to ensure that they have sufficient relevant data.

Question 4 (3 marks)

The first animation shows the Moon orbiting the Earth.

©

This video contains no audio

The second animation shows how the Moon looks each day, when viewed from the Earth over a complete month.

©

This video contains no audio

Question 4a (2 marks)

Using the information from both animations, **describe** why the appearance of the Moon changes over a month.

Question 4b (1 mark)

The Moon affects the tides on Earth. **Identify** the force that produces this effect.

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Question 5 (2 marks)

In the 1950s, cosmologists proposed the "steady-state" theory to explain certain aspects of the universe after it was observed to be expanding. This theory states that:

- the universe has no beginning or end
- the temperature of the universe has always been constant and will not change in the future
- as the universe expands, new matter is created and the density of the universe remains constant.

Outline two ways in which this theory is different to the "big-bang" theory.

B I U Styles

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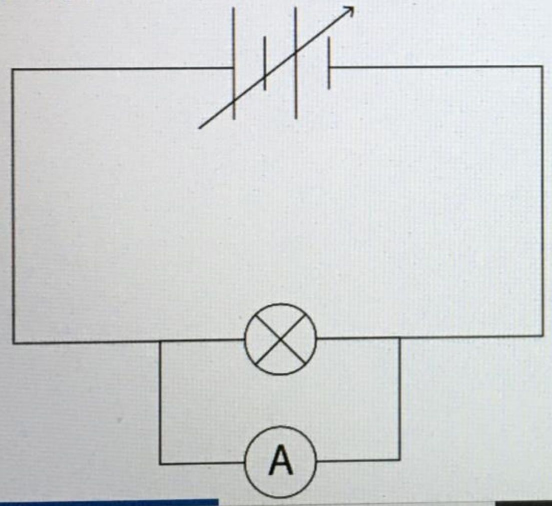
Question 6 (7 marks)

A student investigates an electrical circuit containing a variable power supply, an ammeter and a filament lamp (bulb) in which the current through the bulb can be changed.

One of the circuit diagrams below is incorrect, the other circuit diagram is correct.

Question 6a (2 marks)

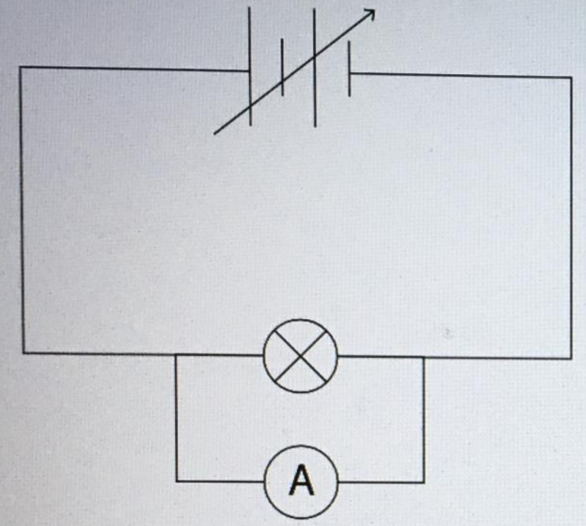
Incorrect



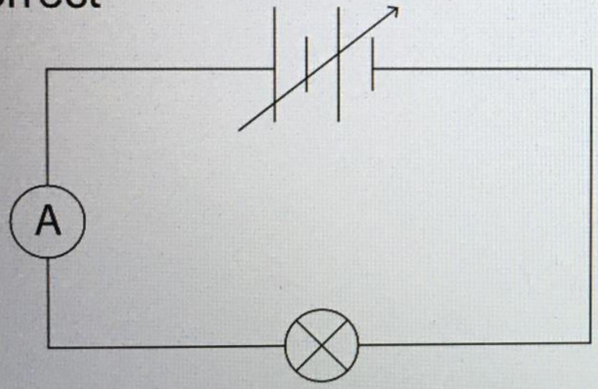
Explain why the current through the bulb could not be measured using the incorrect circuit.

Styles

Incorrect



Correct



Explain why the current through the bulb could not be measured using the incorrect circuit.

Styles

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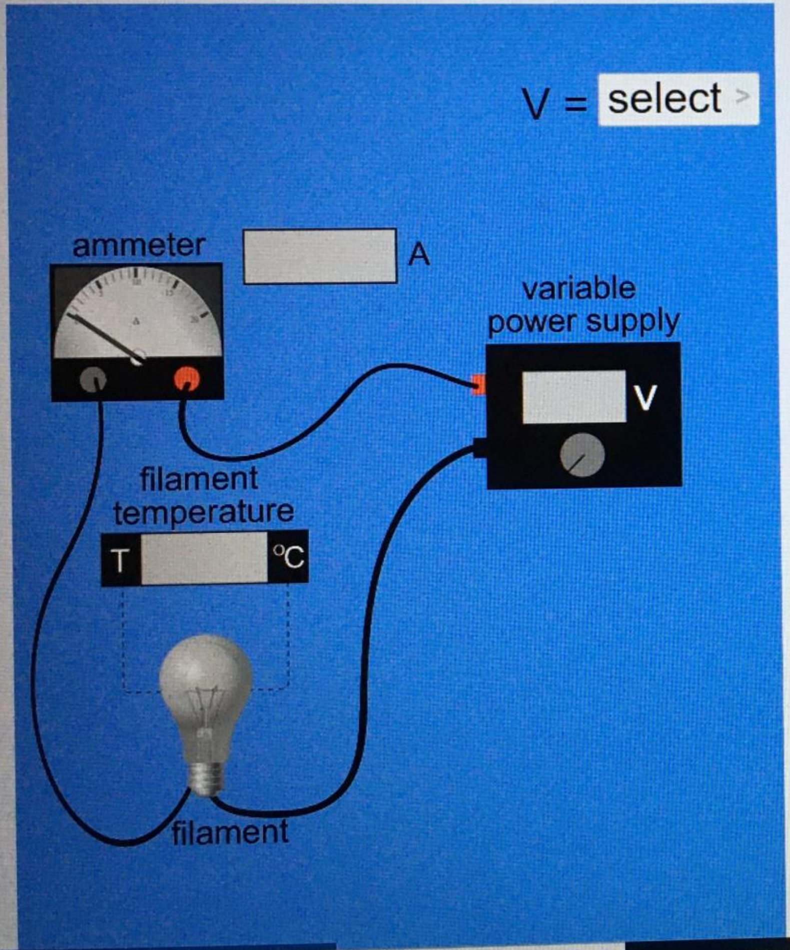
Question 6b (2 marks)

Student example | Circuit simulation



The student connects the components as shown and attaches a sensor to the filament. The sensor displays the temperature of the filament.

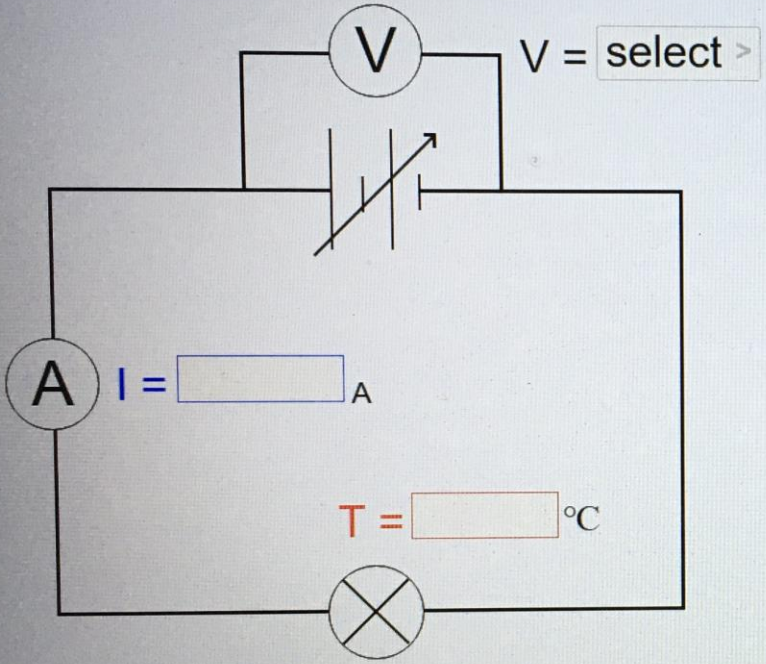
State the dependent and independent variables in this investigation.

Independent variable

Type here to search

Question 6b (2 marks)

Student example | Circuit simulation



The student connects the components as shown and attaches a sensor to the filament. The sensor displays the temperature of the filament.

State the dependent and independent variables in this investigation.

Independent variable

Question 6c (3 marks)

The student decides to measure the current at each of the following voltages.

Voltage / V
0.0
0.4
0.8
1.2
3.6
4.0
9.2
11.6
12.0

When asked about the reason for choosing these values the student says:

"I consider this to be a valid variation of voltage as it provides an appropriate number of measurements within the proposed range of voltage I am covering from 0 V to 12 V."

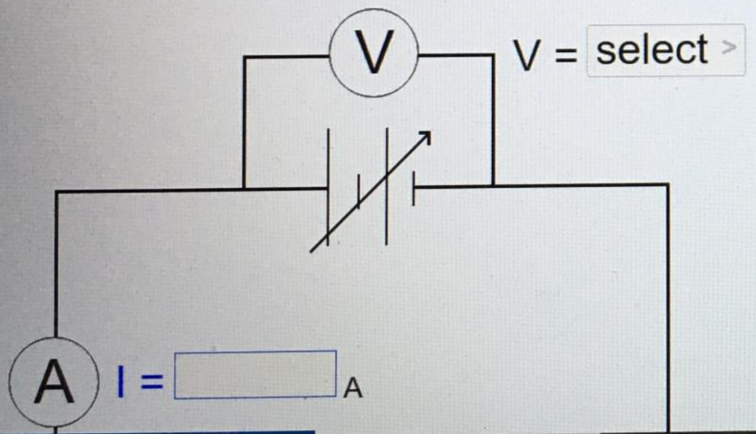
Evaluate the values of voltage the student has chosen.

Question 7 (13 marks)

Choose your own appropriate values of voltage and use the simulation to **measure** the current. Also collect data about filament temperature and state any changes you observe in the lamp. When you finish completing the table, double click on "**Plot data**" below to produce the graph for your data and proceed to the next question.

Question 7a (3 marks)

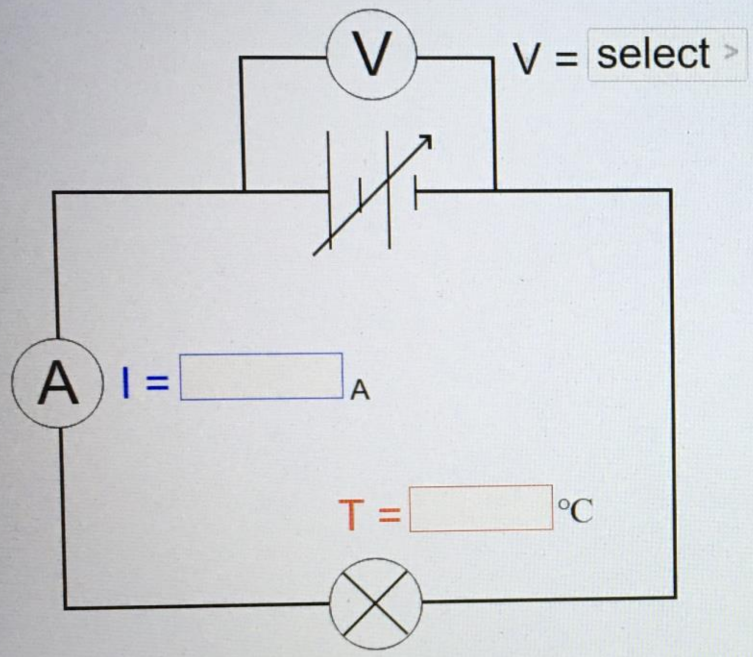
Circuit simulation | Student example



Voltage / V	Current / A	Filament temperature / °C	Lamp observations

Question 7a (3 marks)

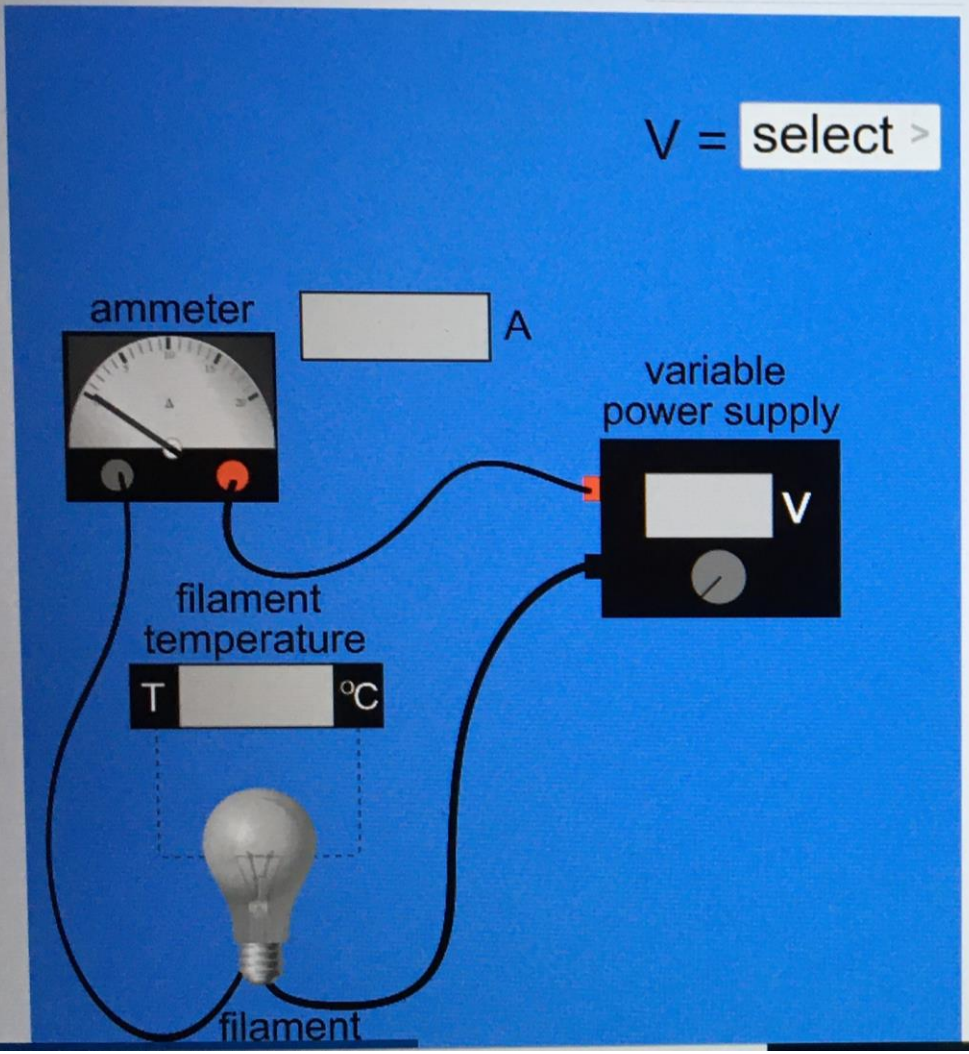
Circuit simulation | Student example



Voltage / V	Current / A	Filament temperature / °C	Lamp observations

Reset

Circuit simulation | Student example



Voltage / V	Current / A	Filament temperature / °C	Lamp observations

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Question 7b (3 marks)

Plot data

Using the graph, **describe** the relationship between voltage and current in the circuit.

Styles

Resistance (R) is defined as the ratio of

Type here to search

Plot data

Resistance (R) is defined as the ratio of voltage (V) across a material to the current (I) flowing through the material. The unit of resistance is the ohm and its symbol is Ω.

$$R = \frac{V}{I}$$

Question 7c (4 marks)

Describe how resistance changes in the filament across the range of the experiment. You should choose two points on the graph to calculate values of resistance to support your answer.

B I U x_2 x^2 Ω Σ

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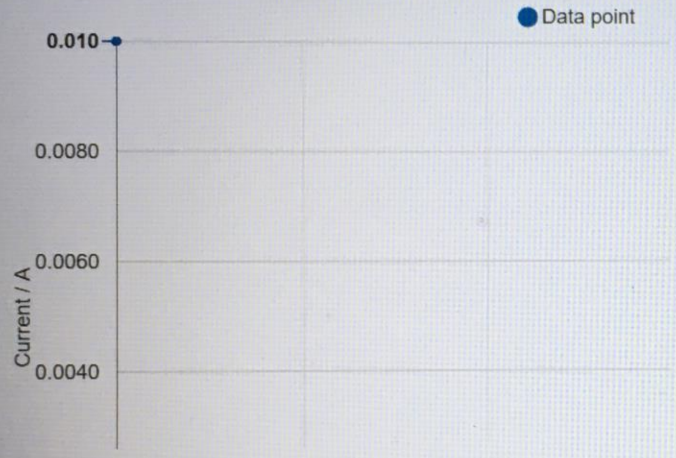
Plot data



Question 7d (3 marks)

Before starting the experiment, the following hypothesis was proposed:

"In all materials, the current is directly proportional to the voltage."

Discuss whether or not the results from this experiment support this hypothesis.

Styles

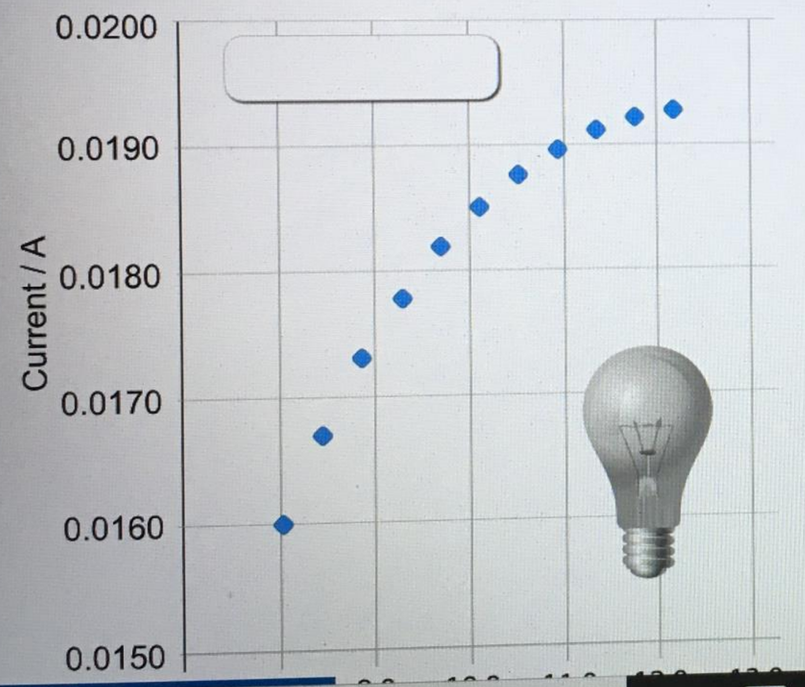
Type here to search

Question 8 (10 marks)

A second student carries out a similar experiment using a different light bulb.

He realizes that the lamp begins to glow above a certain temperature.

Hover over the points on the graph to show the data values.



Question 8a (1 mark)

For these results, **state** the voltage at which the light bulb begins to glow.

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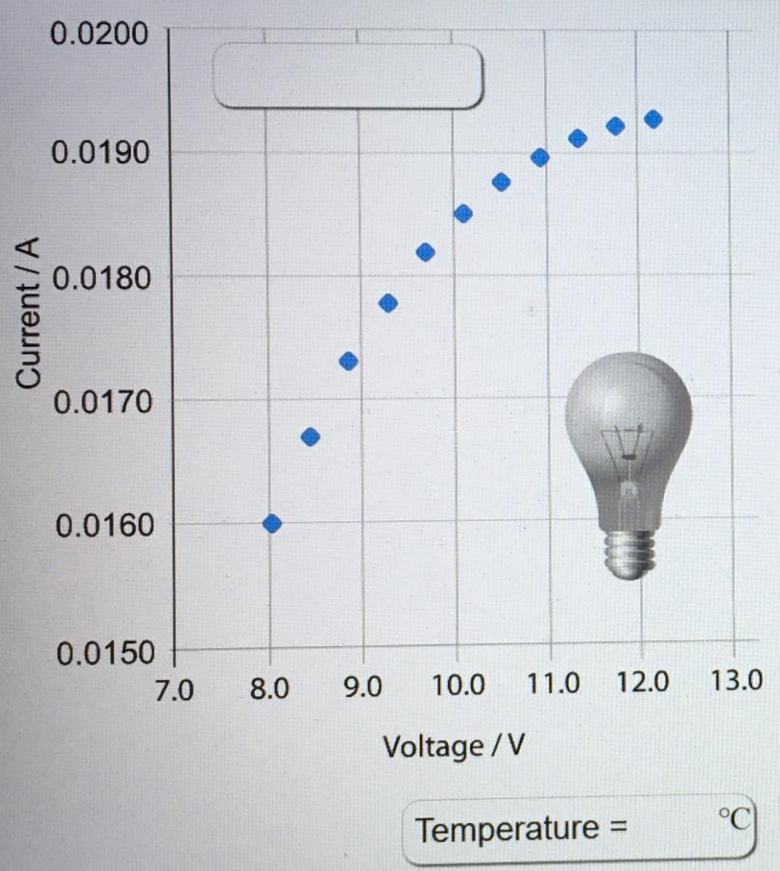


Question 8b (2 marks)

All materials radiate energy in the form of electromagnetic waves. The frequency of the waves increases with temperature.

Explain, with reference to the electromagnetic spectrum, why the filament only glows above a certain temperature.

Styles

Type here to search

Question 8c (5 marks)

Kinetic theory describes how particles in materials are in constant motion. **Interpret** the results of the experiment and use kinetic theory to **explain** the results.

B I U x_2 x^2 Ω Σ Styles

Question 8d (2 marks)

Outline another experiment that the student could perform to extend this investigation.

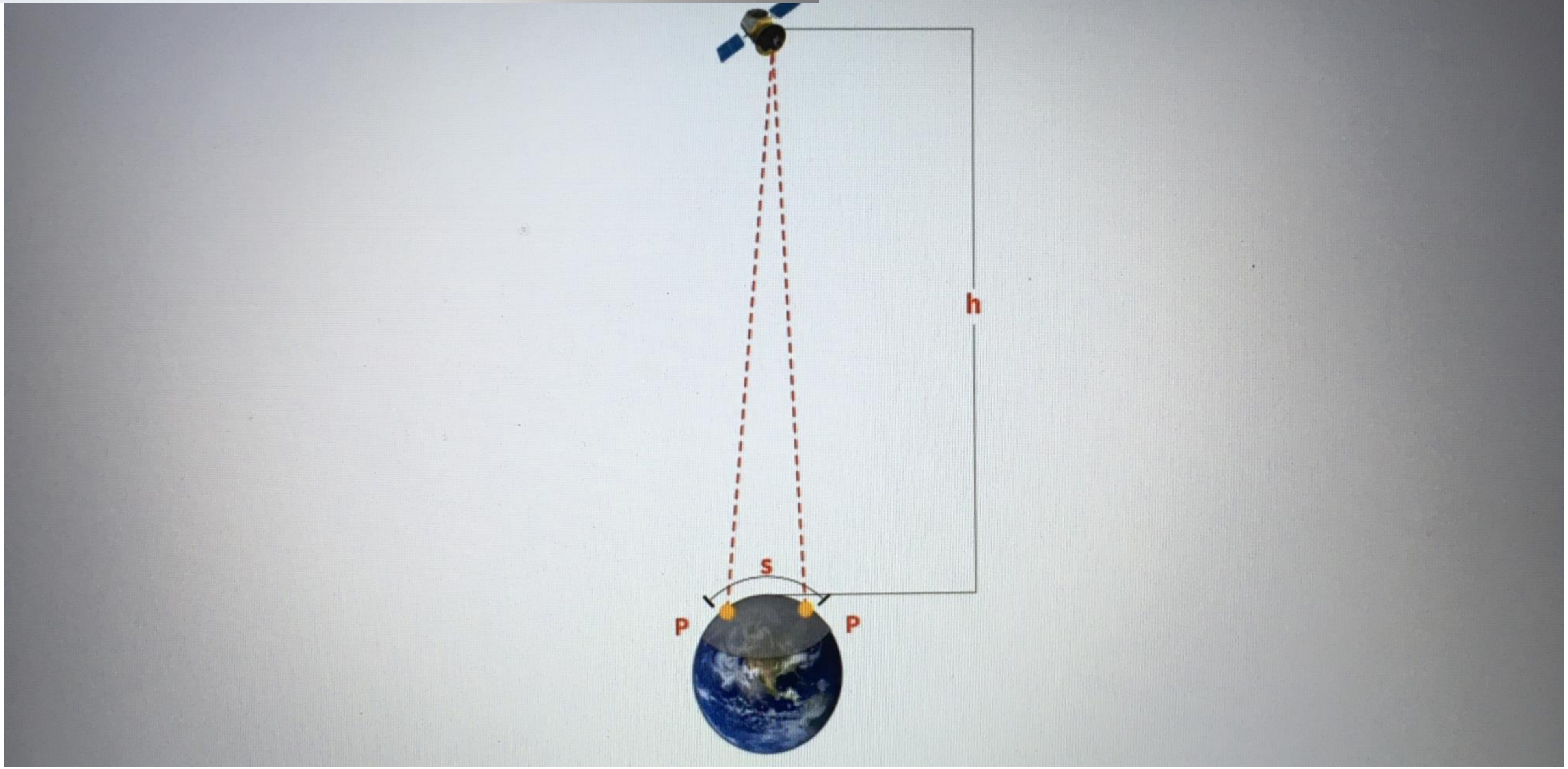
B I U Styles

Question 9 (16 marks)

Communication in the modern world relies on transmission using satellites. Pictures, documents, videos and songs are examples of information that can be converted into electromagnetic waves. The electromagnetic waves are sent from a ground station to a satellite and then retransmitted to a second station on Earth. Satellite transmission means that the electromagnetic waves can be sent over much larger distances than are possible with ground transmission.

The animation shows a simple model of a satellite transmission where *s* is the ground distance between the two stations, *h* is the height of the satellite above the surface of the Earth and the P marks show the limits of the satellite footprint. Signals travel at the speed of light from the ground station to the satellite and back.

A study is performed to determine if there is a relationship between ground distance (*s*) and transmission time (*t*).



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Question 9a (2 marks)

Identify the independent, dependent and control variables for this experiment.

transmission time *t*:

height *h*:

ground distance *s*:

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Question 9b (3 marks)

Formulate and **justify** a hypothesis about the relationship between the variables for this study.

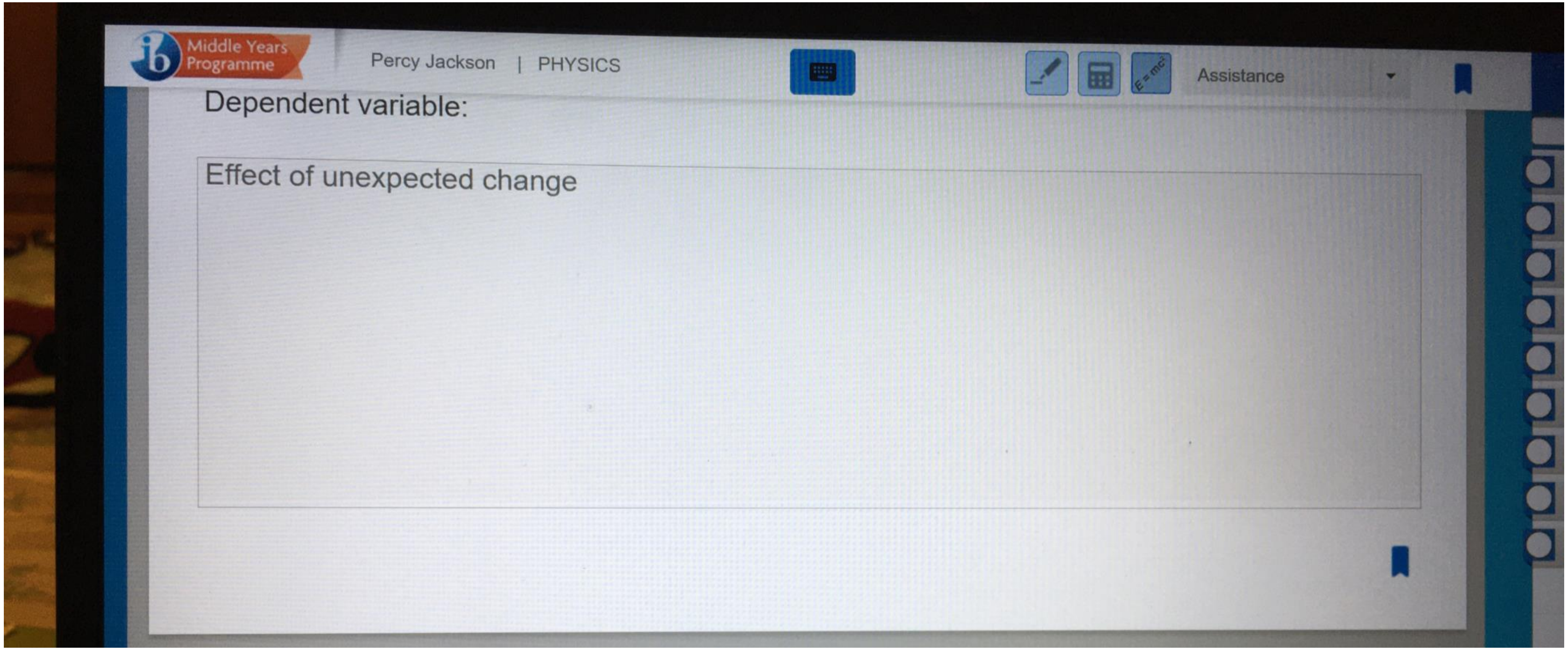
Styles

Question 9c (3 marks)

Describe the effect an unexpected change of the control variable would have on the **independent** and **dependent** variables.

Independent variable:

Effect of unexpected change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Dependent variable:
Effect of unexpected change

Question 9d (2 marks)

Use the animation to **outline** why there is a maximum possible ground distance between stations.

B I U Styles

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Question 9e (2 marks)

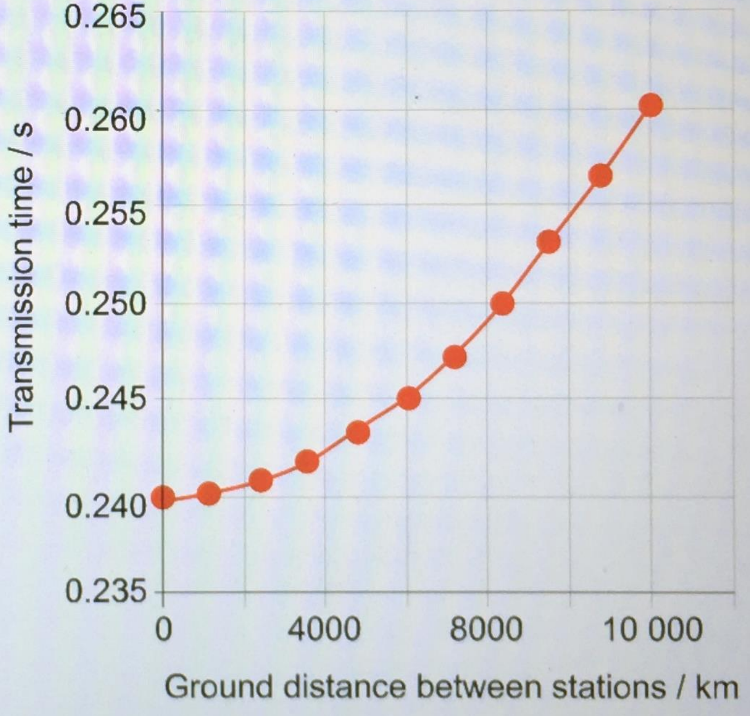
In the animation above, the value of *s* can be set to small values (even zero).

Explain why in a real situation, satellite transmission would not even be considered for small distances.

B I U x_2 x^2 Ω Σ Styles

Question 9f (2 marks)

The graph shows data collected from the satellite animation. **Comment** on the shape of the graph.



Question 9g (2 marks)

Use your answer to part (f) to **select** the correct option. **Justify** your answer.

- The results support the hypothesis.
- The results do not support the hypothesis.

Justification

B I U x_2 x^2 Ω Σ Styles

Question 10 (12 marks)

Satellites can be used to access the internet.

Discuss and **evaluate** the advantages and disadvantages of internet access using satellites compared to traditional cable-based internet access. In your answer you should include:

- an advantage of satellite internet access
- a disadvantage of satellite internet access
- technological considerations
- economic factors
- a concluding appraisal.

Styles

Question 11 (23 marks)

X-rays are a form of ionising radiation. Other forms of ionising radiation include alpha particles, beta particles and gamma rays.

Question 11a (3 marks)

Describe the process of ionisation by one of the forms of ionising radiation.

B I U Styles

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Question 11b (2 marks)

Outline the danger of ionising radiation for living cells.

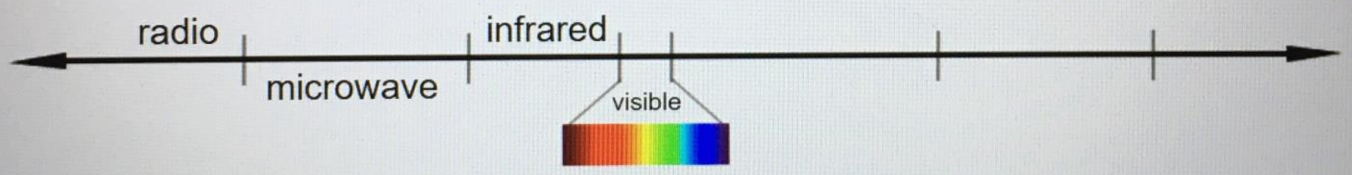
Question 11c (1 mark)

X-rays, gamma rays and ultraviolet light are all forms of electromagnetic radiation.

Label the diagram of the electromagnetic spectrum.

Draggable:

ultraviolet | X-ray | gamma ray



Question 11d (3 marks)

X-rays and gamma rays can both be used by doctors to produce images of the internal structure of the human body. The different properties of X-rays and gamma rays produce different types of image.

An X-ray image is formed by projecting X-rays, and then capturing the "shadow" on a surface that reacts to X-ray radiation.

Using information from the table, **discuss** why X-rays are used, rather than ultraviolet or gamma rays, when doctors wish to make images of a person's bones.

	ultraviolet	X-rays	gamma rays
absorption by skin	high	low	low
absorption by bones	high	high	low
absorption by soft tissue	high	medium	low

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Assistance

X-ray CT scan MRI Ultrasound

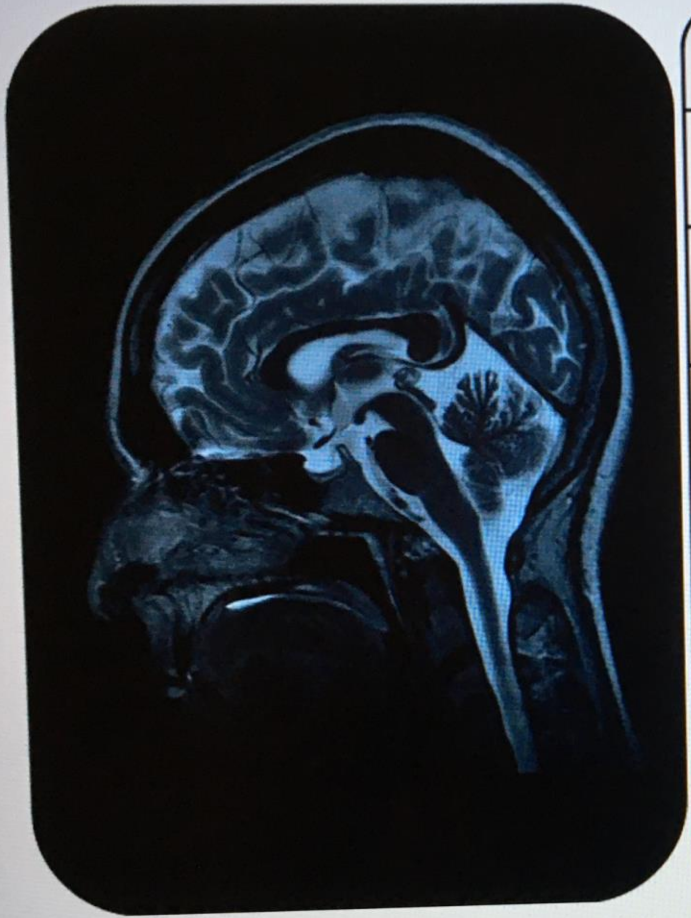
Details of bony structures	High detail
Details of soft structures	No image possible
Ionising radiation exposure	Equivalent to 1/10 annual radiation dose from natural sources
Cost to patient per image	$70
Time taken for scan	5 seconds
Is 3D imaging possible?	No
Other issues	None

Type here to search

X-ray | CT scan | MRI | Ultrasound

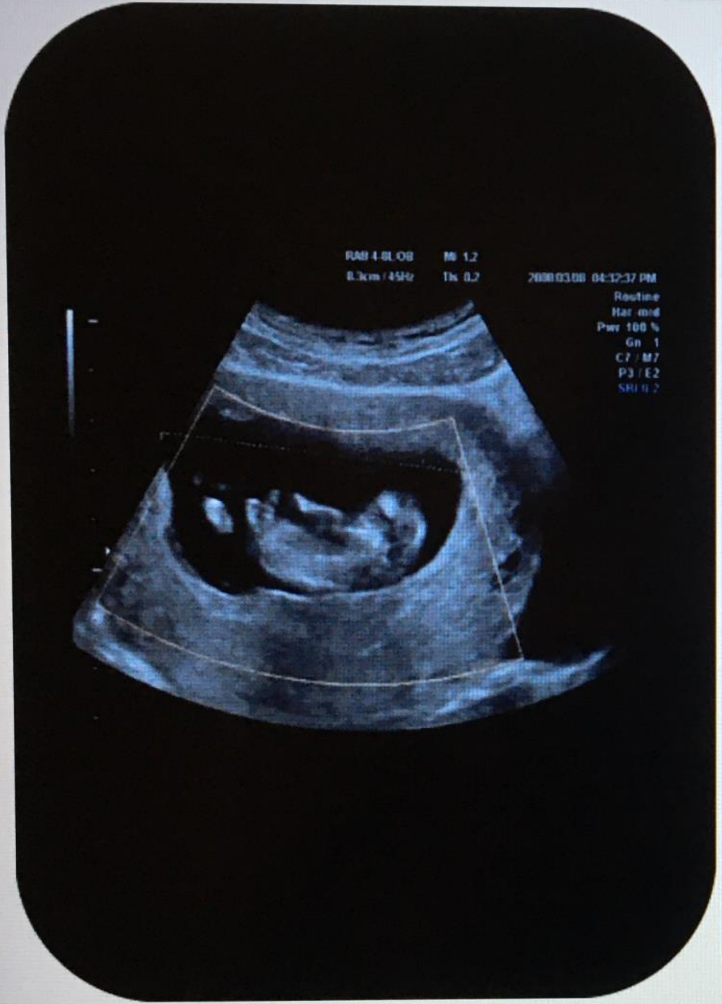
Details of bony structures	High detail
Details of soft structures	Good detail
Ionising radiation exposure	10 times annual radiation dose from natural sources
Cost to patient per image	$2000
Time taken for scan	30 seconds – 5 minutes
Is 3D imaging possible?	Yes
Other issues	• Very obese patients may not fit in the scanning machine or may be too heavy for the table • Can't scan image bone, soft tissue and blood vessels at the same time

X-ray CT scan MRI Ultrasound



Details of bony structures	Low detail
Details of soft structures	High detail
Ionising radiation exposure	None
Cost to patient per image	$4000
Time taken for scan	15 minutes – 2 hours
Is 3D imaging possible?	Yes
Other issues	• Potential claustrophobia • Can't be used by patients with pacemakers or other metal implants

X-ray | CT scan | MRI | Ultrasound



Details of bony structures	Not used for bones
Details of soft structures	Good detail
Ionising radiation exposure	None
Cost to patient per image	$500
Time taken for scan	10 – 15 minutes
Is 3D imaging possible?	Yes
Other issues	Requires highly trained operator

Question 11e (14 marks)

All hospitals have a limited amount of money to spend on medical equipment. Hospital managers have to balance the advantages and disadvantages of different types of equipment when they decide how to spend their money.

Using the information in the tables, **discuss** and **evaluate** the medical imaging equipment **you** would recommend to the hospital manager, clearly justifying your recommendation. In this extended piece of writing, you should consider the social and economic factors and include:

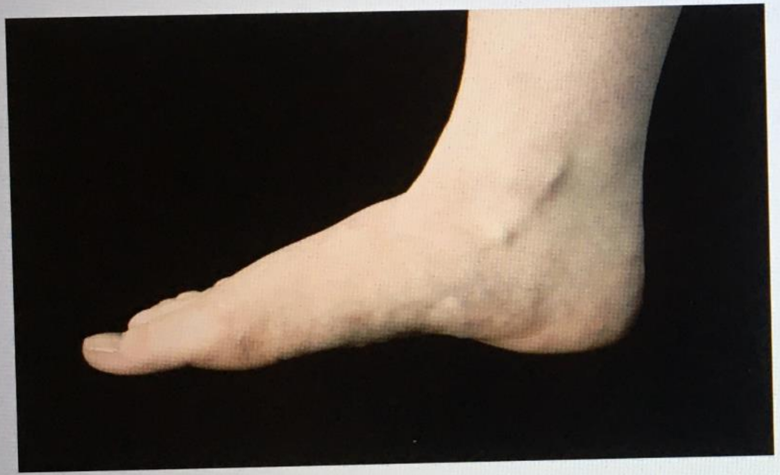
- the advantages of your chosen equipment
- the disadvantages of your chosen equipment
- the perspective of the hospital
- the perspective of the patients.

B I U Styles

Question 12 (3 marks)

Look at the two very different images of feet.

Image 1



©

Image 2

©

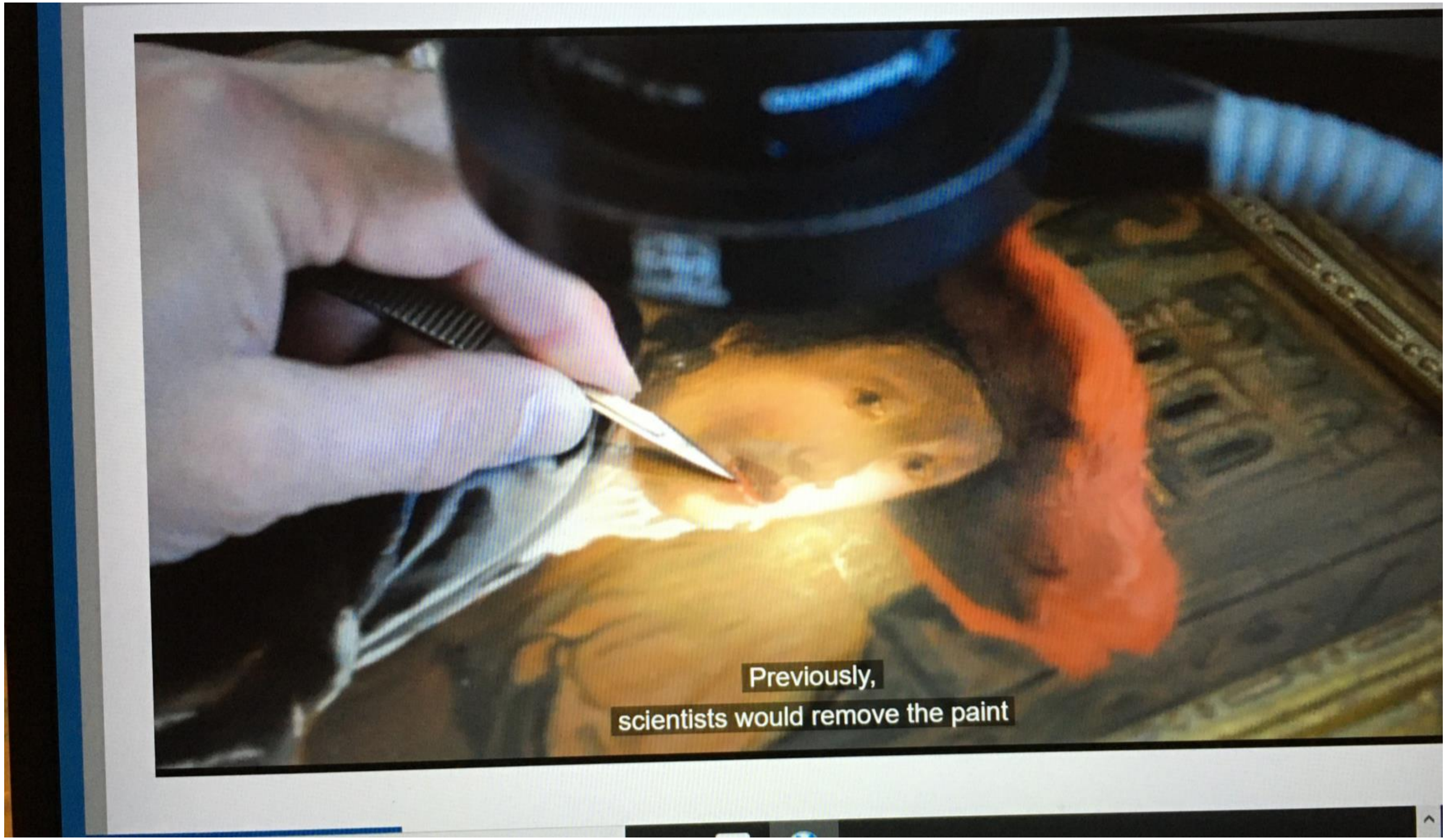
The second image is by the artist Hugh Turvey who uses X-rays in his work. This piece of art is called *Femme Fatale* and shows the foot of a woman wearing a high-heeled shoe. The artist has used an X-ray, normally used in science, medicine or industry to create this artistic image.

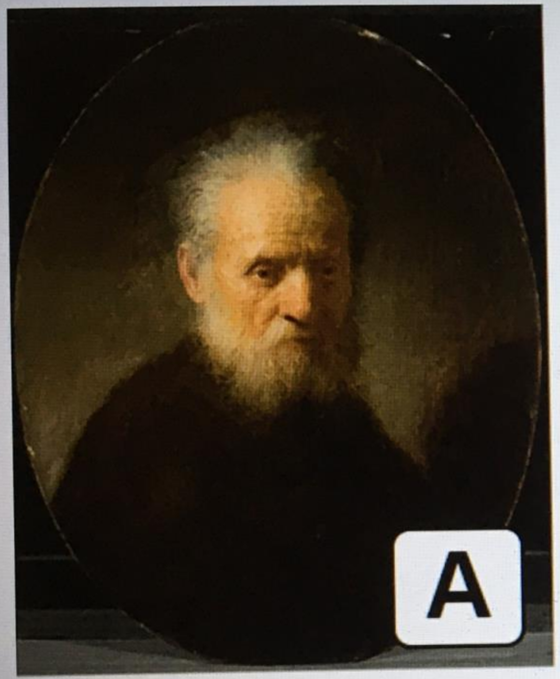
Outline what the use of science can reveal that a photograph does not. Refer to the image and apply the ideas that you have been introduced to in this task in your answer.

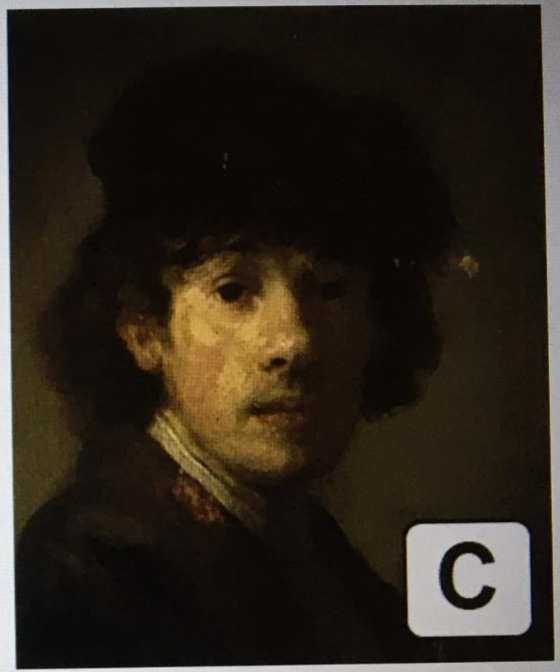
B I U Styles

The link below gives similar information about the use of XRFS & Rembrandt’s work

https://colourlex.com/project/x-ray-fluorescence/







Compare **image C** to **images A** and **B**.

Some art historians suggest that Rembrandt reused the canvas shown in **image B**.

Question 13a (2 marks)

Outline the evidence in these three images that supports the suggestion that the canvas was reused.

B I U x_2 x^2 Ω Σ Styles

Question 13b (2 marks)

Suggest two benefits of using XRFS to examine paintings rather than removing areas of paint.

B I U Styles