Question 1 (11 marks)

Horses can perform work for farming activities. In the past, they were used to loosen the soil before planting. Physics can be used to explore the ways in which horses complete these tasks.

Question 1a (2 marks)

A horse covers a distance of 3 km in 45 minutes. **Calculate** its speed in km per hour ($km\ h^{-1}$).

B I U x_2 x^2 Ω Σ Styles

Question 1b (1 mark)

Power is the rate of transforming energy or the rate of doing work. **Select** the formula for energy transformed.

- A. energy transformed = power × distance
- B. energy transformed = power ÷ distance
- C. energy transformed = power × time
- D. energy transformed = power ÷ time

Question 1c (2 marks)

The table below gives some data about two horses A and B. **Calculate** the missing values and complete the table. You should assume the value of g = 10 N kg^{-1}.

Horse	Mass of horse / kg	Weight / N
A	350	
B		5100

Reset

B I U x_2 x^2 Ω Σ Styles

Question 1d (1 mark)

Select the correct terms to complete the energy transformation diagram for a horse that starts from rest at the bottom of a hill, runs up the hill and then stops at the top of the hill.

Draggable items:

- Chemical potential energy
- Gravitational potential energy
- Elastic potential energy
- Electrical energy

→ **Kinetic energy** →

....

Question 1e (3 marks)

The hill in part (d) is 12 m high. Horse B reaches the top of the hill in 5.50 s. Use information from part (c) and the formula sheet to **calculate** the minimum power required for horse B to reach this height. You should give your answer in kW.

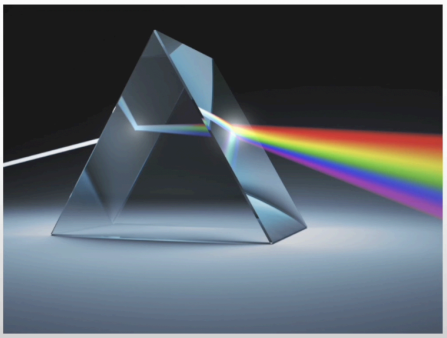
Question 1f (2 marks)

The power of some modern devices is given in horsepower (hp), where 1.0 hp is equivalent to 746 W. An example of such a device is an electric water pump. **Calculate** the current that would be needed by a water pump with a power of 2.0 hp operating at a voltage of 230 V.

Question 2 (7 marks)

Newton carried out experiments on light. Working in his darkened room, he directed white light through a glass prism, which separated the light into the seven colours we now know as the colour spectrum (red, orange, yellow, green, blue, indigo and violet). Before Newton's experiments, scientists believed that the prism itself transformed white light into these colours.

Question 2a (1 mark)



The image shows white light being separated into different colours. **Select** the term for this process.

- A. Absorption
- B. Deflection
- C. Reflection
- D. Dispersion

Question 2b (3 marks)

Explain why red light is at the top of the image in part (a). You should use scientific terminology in your answer.

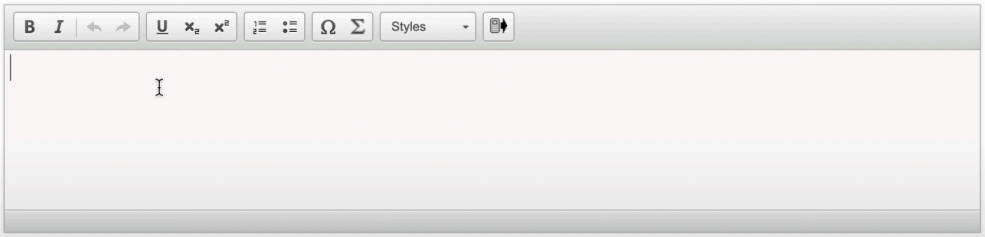
Styles

Beac

Words: 1

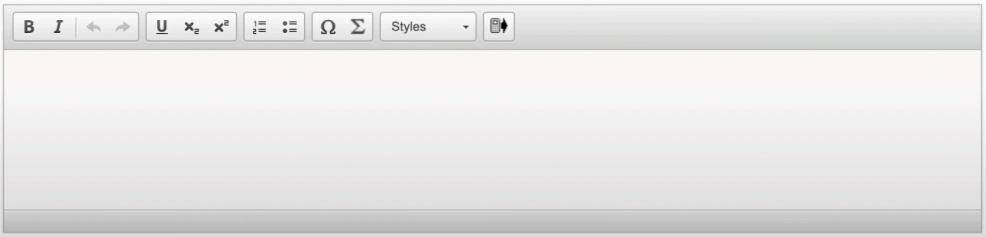
Question 2c (1 mark)

Another scientist called Herschel detected infrared waves beyond the visible spectrum. Unlike red light, infrared waves are not visible to the human eye. **State** one other difference between infrared waves and red light.



Question 2d (2 marks)

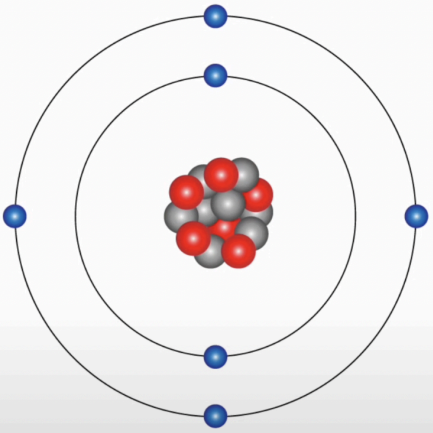
In air, all the colours of light in the spectrum travel at a speed of $3.00 \times 10^{8}\,ms^{-1}$. Use the formula sheet to **calculate** the frequency of red light with a wavelength of 750 nm. You should use scientific notation in your answer.



Question 3 (9 marks)

Question 3a (2 marks)

The diagram below shows an atom of carbon-14 which has 6 protons and 8 neutrons.



Key:

- Protons
- Neutrons
- Electrons

State the atomic number and mass number for this atom.

Atomic number	Mass number

Question 3b (2 marks)

State one similarity and one difference between a nucleus of carbon-12 and a nucleus of carbon-14.

Similarity:

B I U x_2 x^2 Ω Σ Styles

Difference:

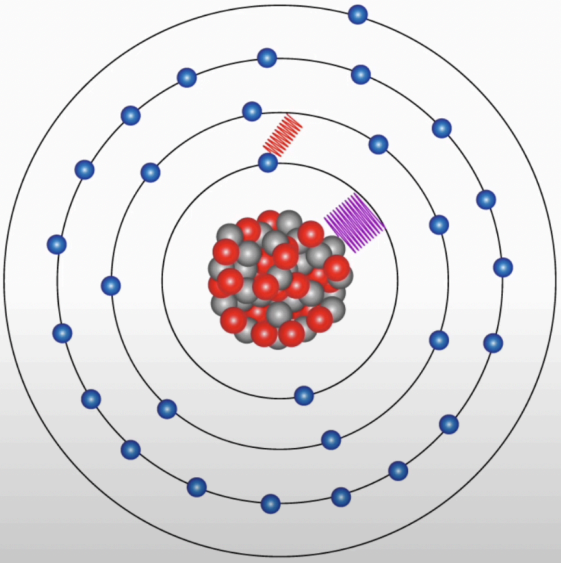
B I U x_2 x^2 Ω Σ Styles

Scroll down to continue

Question 3c (2 marks)

The diagram below shows two electromagnetic rays being emitted from a radioactive isotope.

Select the terms to complete the key.



Draggable items:

- Cosmic ray
- X-ray
- Ultrasound wave
- Gamma ray

Key:

.....	Produced from the nucleus of an atom
.....	Produced from inner orbit of electrons

Scroll down to continue

Question 3d (2 marks)

The composition of a nucleus can change during nuclear reactions. **Select** items and drag them into place to balance the equations for the nuclear reactions below.

Draggable items: $^{0}_{-1}\beta$ $^{4}_{2}\alpha$ $^{0}_{1}\beta$ $^{1}_{1}p$

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + \square$$

$$^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + \square$$

Question 3e (1 mark)

Suggest what is happening in the reaction shown below that results in the formation of a Uranium-239 nucleus.

$$^{238}_{92}U + ^{1}_{0}n \longrightarrow ^{239}_{92}U$$

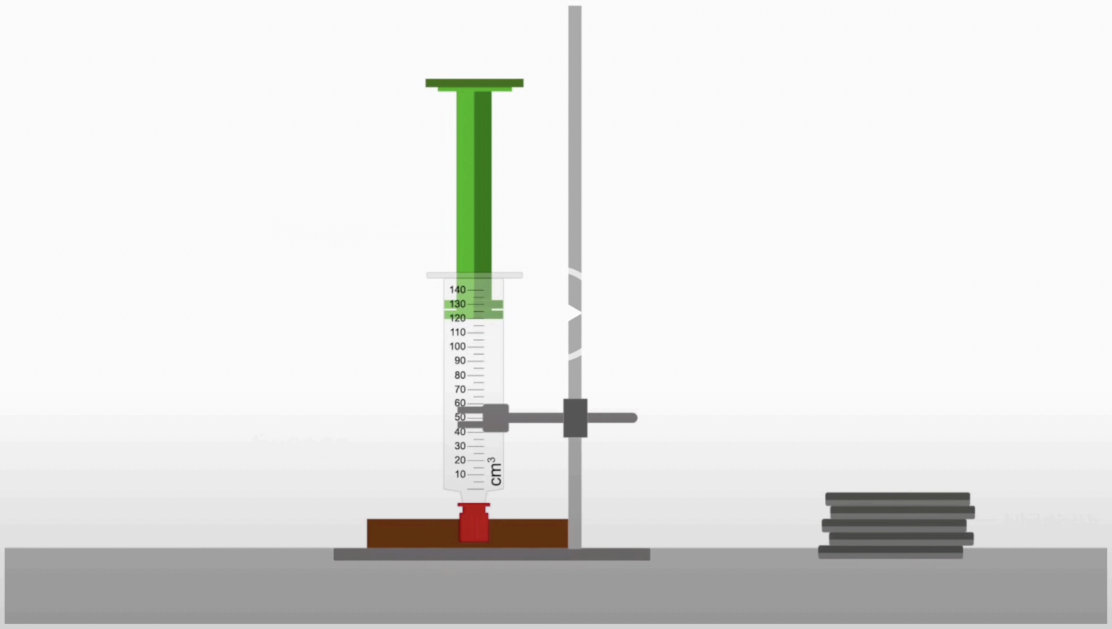
B I U x_2 x^2 Ω Σ Styles

Question 4 (13 marks)

The pressure, volume and temperature of a gas are related. The ideal gas law describes the relationship between them. Gas is all around us in the form of air.

A student decides to investigate the effect of adding masses on the volume of air in a syringe. The student adds the masses slowly so that the temperature of the air in the syringe remains constant, as shown in the animation below.

Animation Script



Animation | Script

The tip of the syringe is sealed so that the amount of air is constant.

Masses are added and the plunger is pushed downwards, compressing the air in the syringe.

Question 4a (1 mark)

State the research question that could be answered in this scientific investigation.

B I U x_2 x^2 Ω Σ Styles

Question 4b (2 marks)

Identify the variables for this investigation.

Variable	Independent	Dependent	Control
Amount of air in the syringe	☐	☐	☐
Mass added to plunger	☐	☐	☐
Size of syringe	☐	☐	☐
Temperature	☐	☐	☐
Volume of air	☐	☐	☐

Reset

Question 4c (1 mark)

Select the correct response to complete the sentence.

When masses are added to the plunger, the pressure will Select .

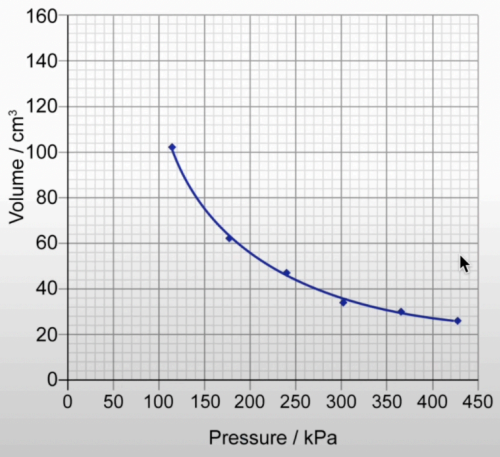
Question 4d (3 marks)

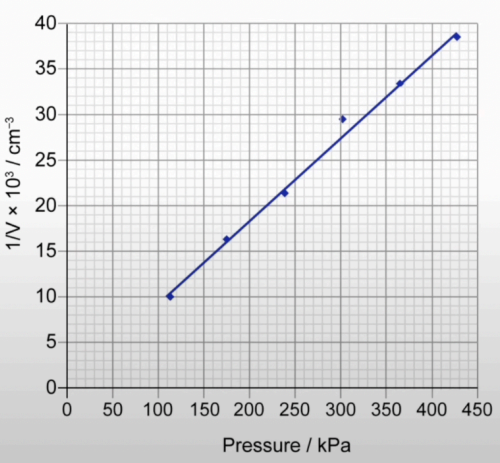
The plunger has an area of 7.9×10^{-5} m^2. Atmospheric pressure is 100 000 Pa. Use the formula sheet to **calculate** the total pressure on the air in the syringe if the mass applied is 1.2 kg. You should assume that the value of g = 10 N kg^{-1}.

B I U x_2 x^2 Ω Σ Styles

Question 4e (2 marks)

The student calculated the total pressure for each of the masses used. She presented the processed data in the graphs below.

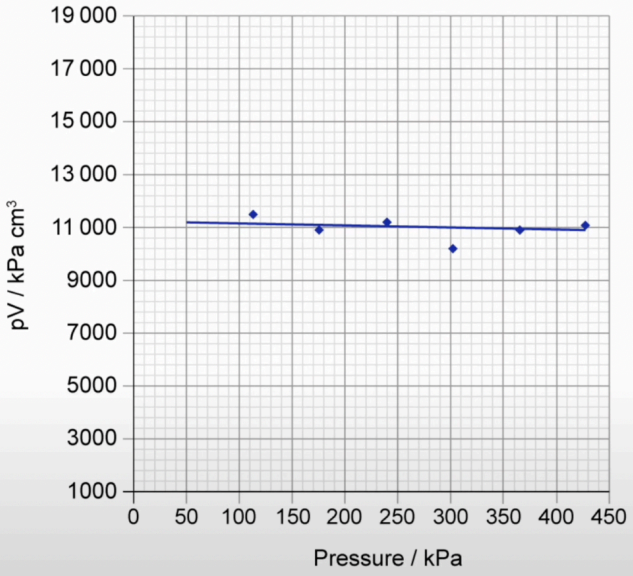




Use both graphs above to **describe** the relationship between pressure and volume of a gas.

Question 4f (2 marks)

Another student decided to multiply pressure by volume (pV) and presented this on the graph below.



Boyle's law states that pV is constant for a fixed amount of gas at constant temperature.
Suggest whether the graph supports Boyle's law. **Justify** your answer.

Scroll down to continue

Question 4g (2 marks)

Use the graph in part (f) to **calculate** the volume of gas when the pressure is 75 kPa. You should include a unit in your answer.

B I U x_2 x^2 Ω Σ Styles

Question 5 (17 marks)

Another group of students decides to use balloons to investigate the relationship between the volume of a gas and its temperature.

They make the following prediction:

> If the temperature of a fixed amount of gas inside a balloon increases, the volume of the balloon will increase.

Question 5a (3 marks)

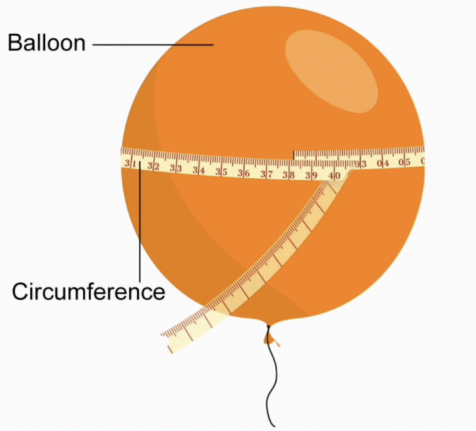
Use kinetic theory to **explain** the prediction.

B I U x_2 x^2 Ω Σ Styles

Scroll down to continue

Question 5b (14 marks)

Measuring the volume of a balloon directly is difficult. The students plan to measure the circumference of the balloon instead of measuring its volume.



The students are interested in how the temperature of the balloon affects its circumference. **Design** an experiment that the students could use to carry out this investigation. They are provided with standard laboratory equipment, including an oven to change the temperature. In your plan, you must include:

- a research question
- the independent, dependent and one control variable
- a list of the equipment they will need
- a detailed method for collecting data
- an explanation of how the students will collect sufficient data
- details of how they will make sure that the method is safe.

B I U x_2 x^2 Ω Σ Styles

Scroll down to continue

Question 6 (17 marks)

When the air inside an inflated balloon is released, the balloon accelerates forward.

00:00

Question 6a (3 marks)

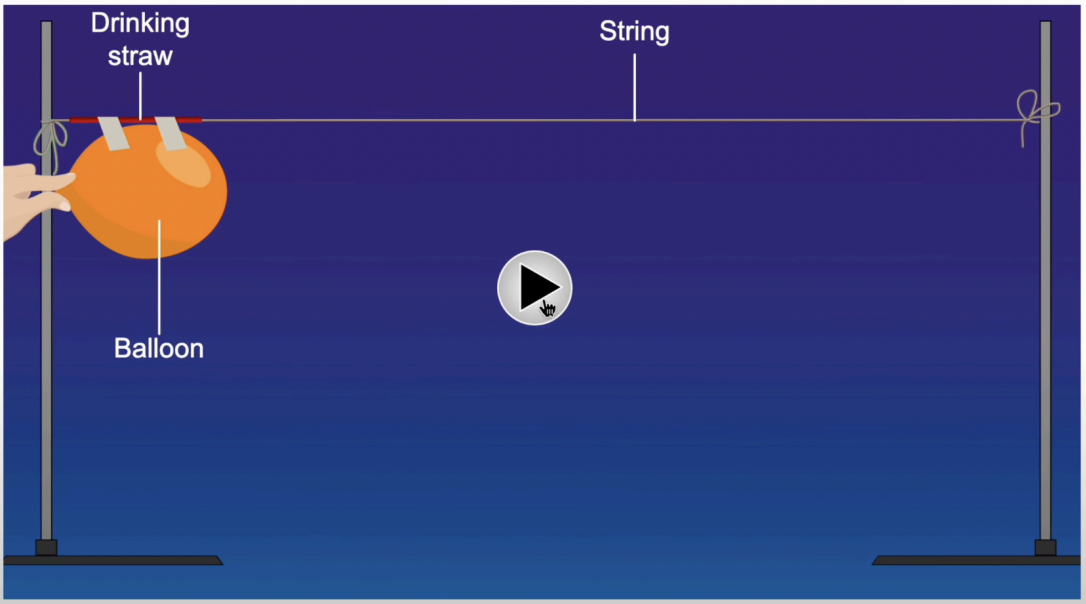
Use Newton's laws to **explain** the motion of the balloon.

Styles

Question 6b (1 mark)

A group of students decide to investigate the distance travelled by a balloon filled with different volumes of air. They use the following equipment.

Diagram not to scale

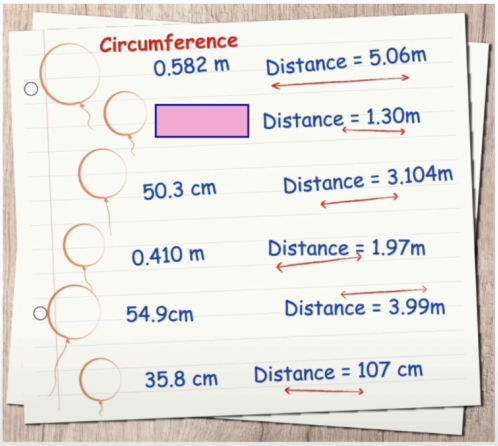


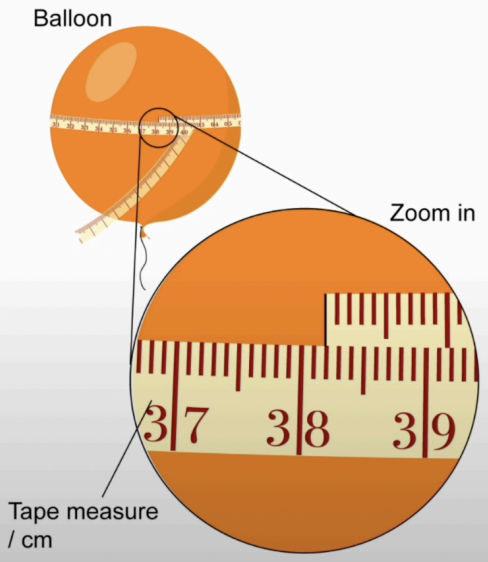
State the research question that the students are investigating.

Scroll down to continue

Question 6c (1 mark)

The students' data is shown below. The circumference of one of the balloons has not been recorded. **Measure** the circumference as shown in the picture.

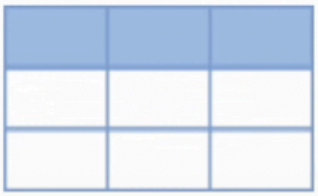




Question 6d (4 marks)

Organise and **present** the data from the experiment into a table, including the result from part (c).

Create New Table



Reset

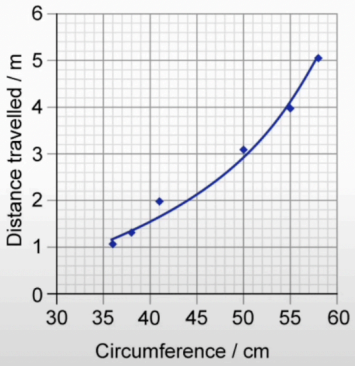
Question 6e (3 marks)

Before their investigation, the students suggested the following hypothesis:

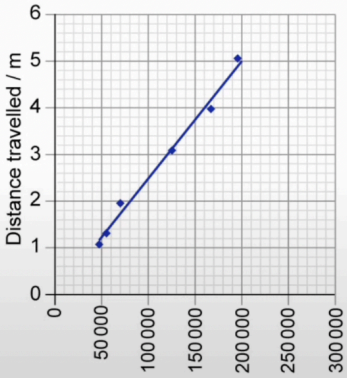
> If the circumference of the balloon increases, then the distance travelled will increase because the resultant or net force will be greater with an increased volume of air. The distance travelled will be directly proportional to the circumference.

The students plotted three different graphs of their data. Use the graphs of the students' data below to **evaluate** the validity of their hypothesis.

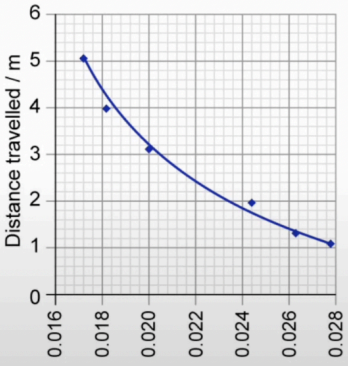
Graph A



Graph B



Graph C



Question 6f (3 marks)

The students wanted to extend their investigation. **Suggest** variables that the students could use to extend this investigation. The dependent variable has been completed for you.

Independent variable:

Control variable 1:

Dependent variable:

distance travelled

Control variable 2:

Scroll down to continue

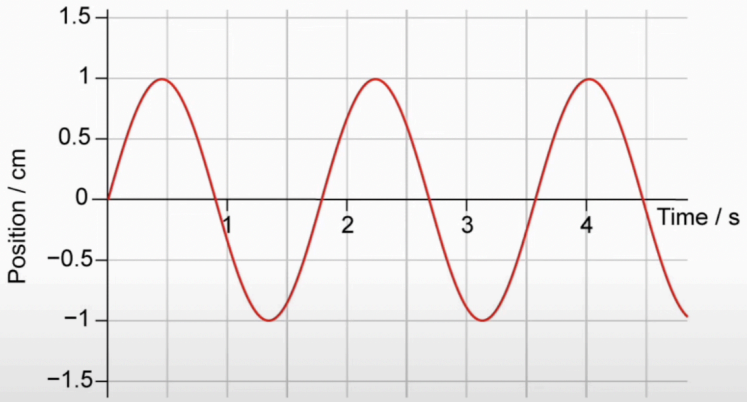
Question 6g (2 marks)

Formulate a hypothesis that your extension in part (f) would test.

Question 7 (18 marks)

Question 7a (3 marks)

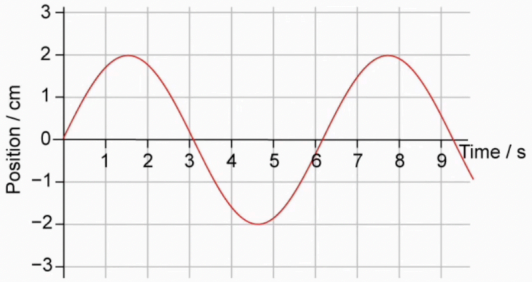
The frequency of any wave can be found from a graph of the wave position against time. Use the formula sheet to **calculate** the frequency of the waveform shown below. Give your answer to two significant figures and include a unit.



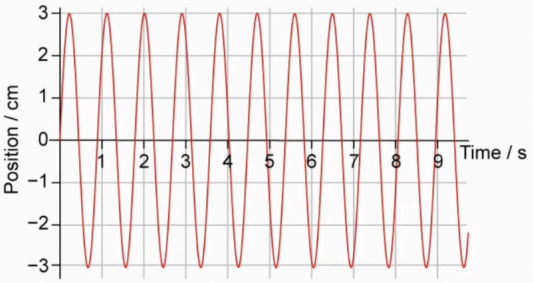
Question 7b (1 mark)

Select the waveform with the same frequency as the waveform in part (a).

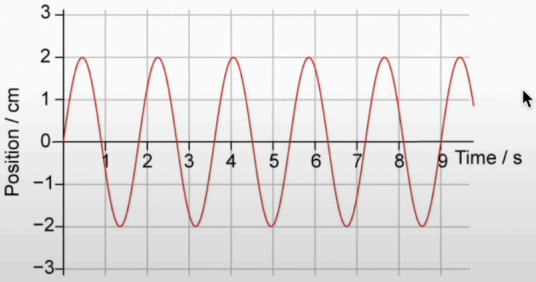
A



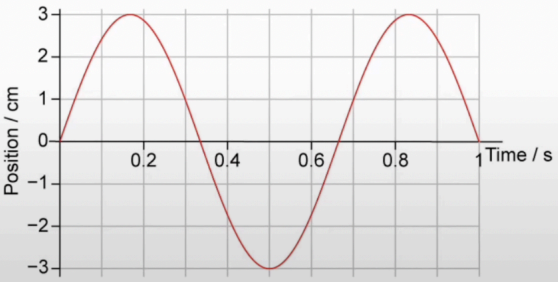
B



C



D



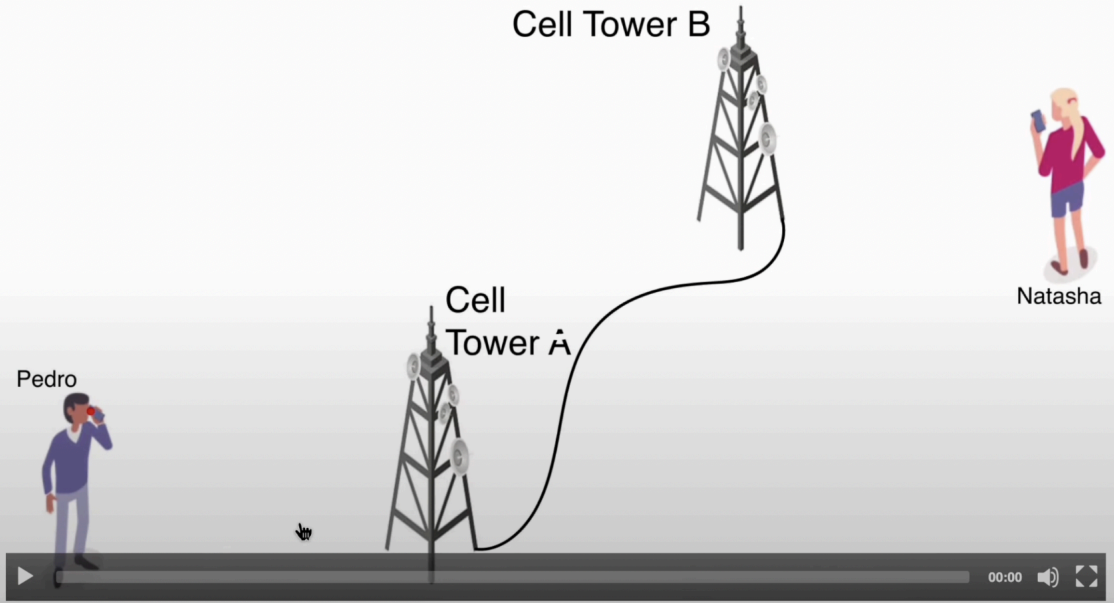
Select

Question 7c (1 mark)

Pedro and Natasha are communicating using mobile phones. The phones send and receive information in the form of radio waves. Different frequencies are used to transmit this information.

The animation below shows a simplified view of the mobile phone network that is used.

This media contains no audio



Put the following statements in order to **outline** the process taking place in the animation above.

Draggable items:

- Tower A receives the signal, then sends the signal out through a connection using wires or fibre-optic cables to Tower B, where the signal is converted again.
- Natasha's phone receives the radio wave signal and converts it back into a sound wave that she can hear.
- The radio wave signal is transmitted from the mobile phone to tower A.

1. Pedro's voice is converted into an electrical signal by the microphone in his mobile phone. The phone then converts that electrical signal into a radio wave.
2.
3.
4.

The use of radio waves enables high-speed communication, but the technology requires the location of the phone to be detectable. This has consequences for security and data protection.

Video | Script

Video | Script

There are networks of cell towers all over the world. Mobile phones work by sending signals to and receiving signals from the nearest cell tower. When the user moves from one area to another, the phone disconnects from one cell tower and connects to a new cell tower to maintain a strong signal.

A consequence of this technology is that the location of a phone, and therefore the user of that phone, can be detected at any time. Even a phone that is switched off but has its battery inserted can be located.

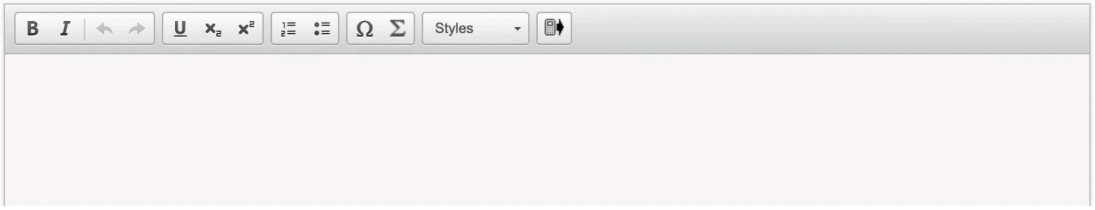
User location information can be used in navigation apps and fitness trackers. Even applications not directly used in navigation can track the location of the phone and map the movements of the user. It is not widely known that this personal movement data can be bought by companies who have an interest in it.

People in large gatherings can be tracked and this information can be used to identify where they live and other personal details.

Question 7d (13 marks)

Discuss and **evaluate** the implications of mobile phone technology being used to track the locations and movements of individuals. In your answer, you should discuss:

- the advantages and disadvantages of location-tracking technology for an individual
- the economic benefits of location-tracking technology for a company
- the positive and negative security implications of location-tracking technology for a country
- an overall appraisal in which you evaluate the points discussed.



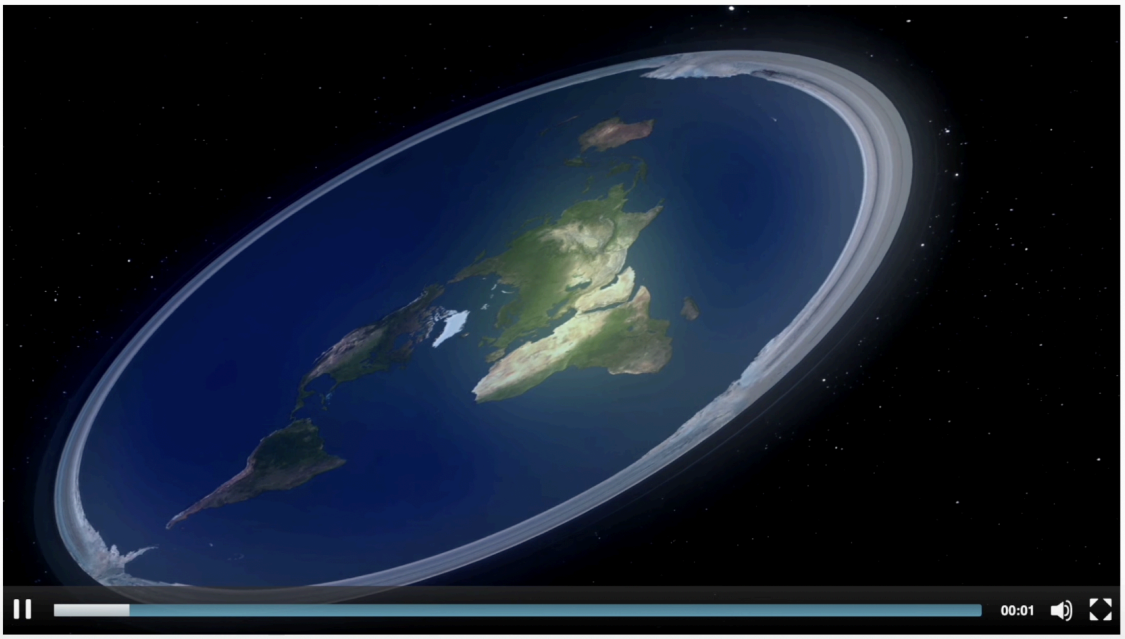
Question 8 (8 marks)

The ability of modern mobile phones to access the internet has influenced the way that people communicate. On the internet, people tend to communicate with other people that have the same ideas as they do, which can reinforce opinions that may not be logical or scientifically accurate.

Some people think that this kind of communication has led to an increase in the number of people believing in conspiracy theories. One such idea is the flat-Earth theory.

This media contains no audio

Scroll down to continue



Some people have suggested that any scientific information that is shared through the internet should be checked for accuracy. Information that is incorrect or misleading should be removed.

Discuss and **evaluate** the benefits and limitations of controlling scientific information that is shared through the internet.