Question 1 (8 marks)

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At the end of the 19th Century physicists considered radio waves to be like an invisible form of light.

Question 1a (2 marks)

Select the correct option to complete the statements below.

Radio waves travel [Select / faster than / slower than / at the same speed as] light waves in a vacuum.

Radio waves have [ ] light waves.

Question 1a (2 marks)

Select the correct option to complete the statements below.

Radio waves travel [Select] light waves in a vacuum.

Radio waves have [Select / a longer wavelength than / a shorter wavelength than / the same wavelength as] light waves.

Question 1b (1 mark)

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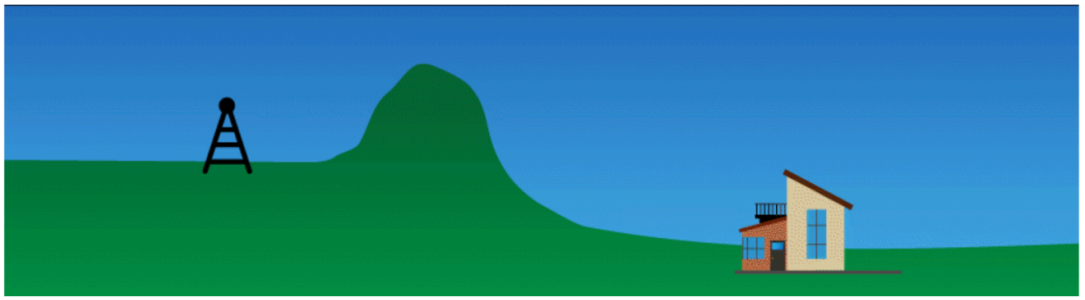
At this time messages could only be sent through connecting wires. Marconi, a famous physicist, was trying to find a way to send messages without the need for wires.

One advantage of sending messages using radio waves is that the waves can bend around obstacles as shown in the animation.



©

Select the phenomenon shown in the animation.

[Select]

Question 1c (3 marks)

In 1897, Marconi sent the first ever radio message across open sea. A message saying “are you ready” was sent over a distance of 6 km.

Calculate the time taken for Marconi’s message to travel 6 km. You should take the speed of radio waves in air to be 3.0×10^8 ms^{-1}. You should give your answer in scientific notation.

Question 1d (2 marks)

Suggest two reasons why communication using radio waves was such an important discovery.

Question 2a (2 marks)

Copper is a chemical element used as a conductor of heat and electricity. It has an atomic number of 29 and a mass number of 63.

Select the correct option to complete the following sentences about an atom of copper.

29 is the Select in the nucleus

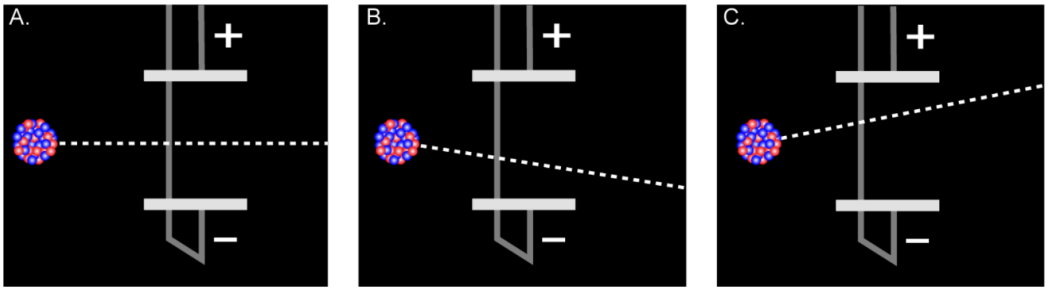
63 is the Select in the nucleus

Question 2b (3 marks)

Copper has many isotopes, some stable and some unstable. The unstable nucleus of copper-67 decays by emitting beta and gamma radiation.

The three images below show the radiation moving through an electric field.

Select the image that shows the path of beta radiation emitted by copper-67. **Justify** your answer.



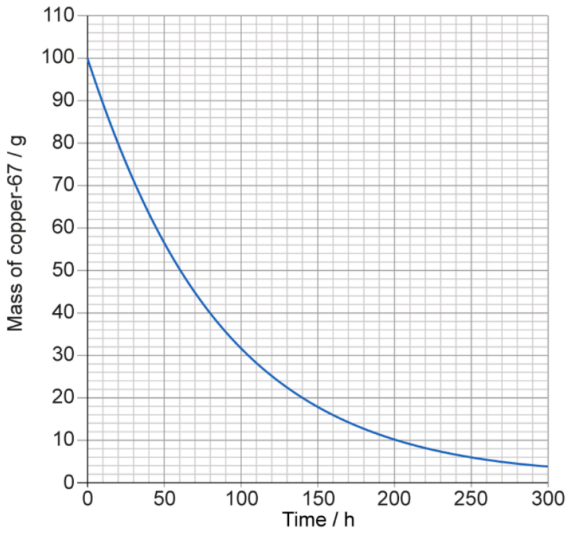
©

Select

Justification:

Question 2c (2 marks)

The graph below shows how the mass of copper-67 changes with time. Use the graph to **determine** the half-life of copper-67.



Question 2d (2 marks)

The copper-67 isotope is used in medicine either as a radioactive drug inside the body or as an external source of radiation. **Suggest** why the half-life and the combination of beta and gamma emissions of copper-67 make it useful to treat medical conditions such as cancer.

Question 3 (11 marks)

Energy transformations occur in moving cars. Hybrid cars use a combination of fuel and electrical power to provide their kinetic energy. These kinds of cars are designed to be more fuel efficient.

Question 3a (2 marks)

Calculate the kinetic energy of a 1500 kg car moving at 25 ms^{-1}.

Question 3b (4 marks)

When the driver of the car hits the brakes, the car slows down to a complete stop. The braking distance is 30 m.

Calculate the average deceleration of the car during the braking. Give your answer to 3 significant figures.

Question 3c (1 mark)

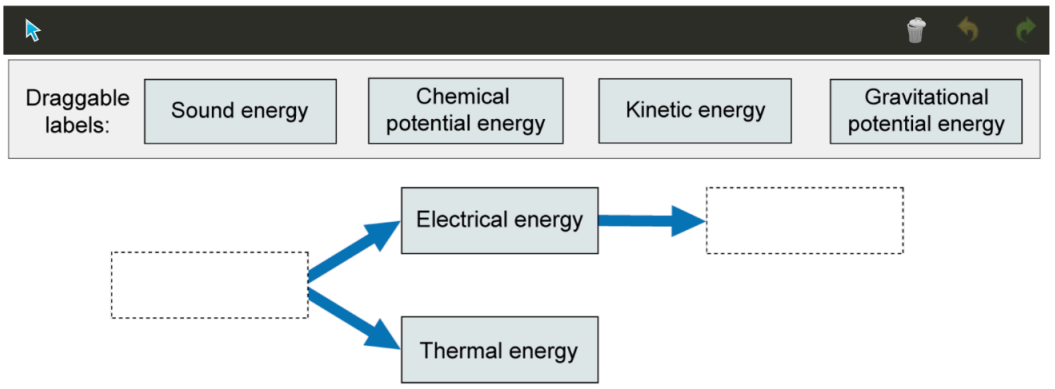
In petrol cars the brakes that slow down the car during braking would transform all of the kinetic energy of the car into heat energy.

State why the heat energy produced during braking is considered to be wasted energy.

Question 3d (1 mark)

Regenerative brakes are a feature of hybrid cars. During regenerative braking, some of the energy wasted as heat is used to recharge the car's battery instead.

The diagram below shows the energy transformations that would take place in a hybrid car during braking. **Select** the correct energy forms to complete the diagram.



Scroll down to continue

Question 3e (1 mark)

Suggest why regenerative braking helps the hybrid car to use less fuel than a petrol car.

B I U x_2 x^2 Ω Σ Styles

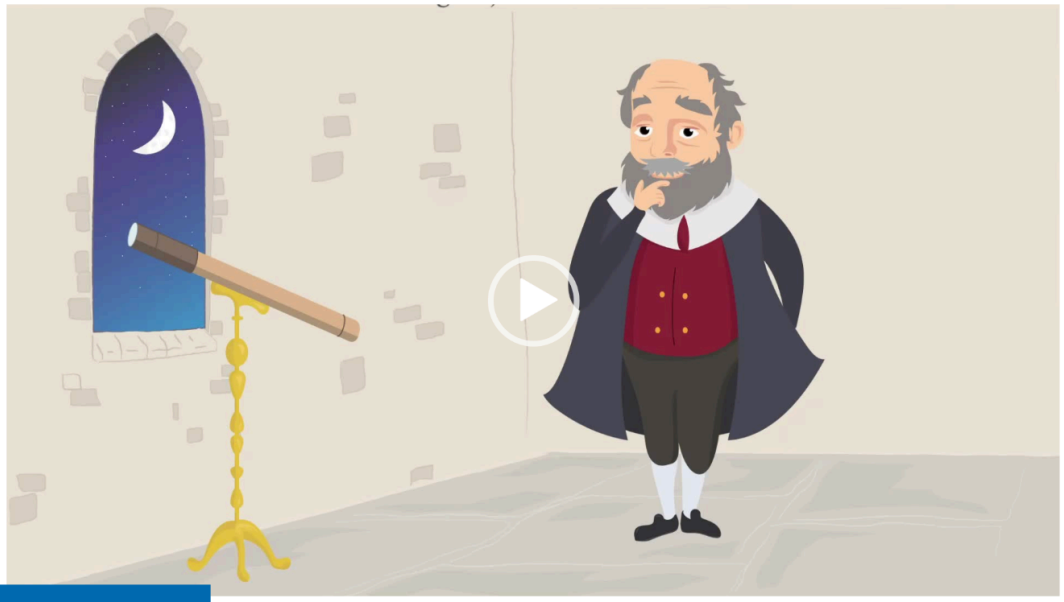
Question 3f (2 marks)

Outline why reducing the amount of fuel required by cars is an issue of global significance.

Question 4 (18 marks)

The famous scientist Galileo was fascinated by the motion of accelerating objects. He took an interest in objects that were falling. The falling motion happened so quickly he decided to start by studying the motion of a ball rolling down a ramp.

Video Script



Scroll down to continue

Question 4 (18 marks)

The famous scientist Galileo was fascinated by the motion of accelerating objects. He took an interest in objects that were falling. The falling motion happened so quickly he decided to start by studying the motion of a ball rolling down a ramp.

Video | Script

The famous scientist Galileo was interested in the motion of falling objects.

As this motion happened so quickly he decided to start by studying the motion of a ball rolling down a ramp. He was interested in the relationship between distance and time. By setting the ramp at a small angle, the motion would happen slowly enough for him to take measurements.

During the 17^{th} century there was no equipment for measuring short time periods, so Galileo developed his own measuring equipment. Galileo experimented with pendulums and a water clock to measure time.

Question 4a (1 mark)

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

Question 4b (3 marks)

Identify the variables for this investigation.

	Independent variable	Dependent variable	Control variable
Mass of the ball	☐	☐	☐
Time taken	☐	☐	☐
Size of the ball	☐	☐	☐
Distance travelled by the ball	☐	☐	☐
Angle of the slope	☐	☐	☐

Question 4c (2 marks)

The student starts to write the following hypothesis:

> As the distance the ball rolls increases, the time taken will also increase but the relationship will not be proportional.
> The ball will have a constant acceleration as it moves down the slope.
> This is because…

Outline why the ball accelerates at a constant rate as it moves down the slope by referring to relevant scientific principles.

Question 4d (3 marks)

For a ball moving with constant acceleration, the distance the ball moves and the time taken are related by the formula:

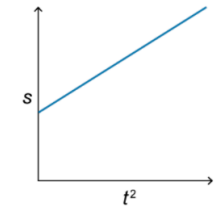
$$s = ut + \frac{1}{2}at^2$$

When the initial velocity is zero, this becomes:

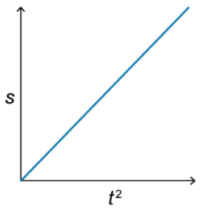
$$s = \frac{1}{2}at^2$$

Use the second formula to **select** the results that you would expect to be shown by this investigation. **Justify** your answer.

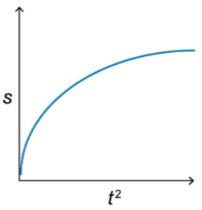
A.



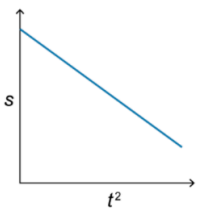
B.



C.



D.



Select

Justification:

Question 4e (3 marks)

Another student performs a similar investigation and obtains the results shown in the table below.

Distance / m	Time / s	$(\text{Time})^2$ /
0.25	1.02	1.04
0.50	1.39	1.93
0.75	1.75	3.06
1.00	1.98	3.92
1.25	2.19	

Reset

The table is incomplete. **Label** the missing unit for the column $(\text{Time})^2$ and **calculate** the missing value.

Question 4f (1 mark)

In Galileo's original investigation, the measuring equipment available was quite basic. One piece of equipment that Galileo used to measure time was a water clock. The water clock provided a relative measure of time based on the volume of water collected in a beaker as the ball rolled down the ramp.

Suggest why using a measurement device such as a water clock to measure time would have made it hard for Galileo to share his results with other scientists.

B I U x_2 x^2 Ω Σ Styles

Question 4g (1 mark)

In modern times we have much more advanced equipment available to us. **State** the name of the measuring equipment that you would use to measure time if you were repeating Galileo's investigation.

B I U x_2 x^2 Ω Σ Styles

Question 4h (4 marks)

State a follow-up investigation into another factor that can affect the motion of a ball on a ramp and a research question that this new investigation would test. The dependent variable is time.

Research question:

Question 5 (16 marks)

Video Script

Question 5 (16 marks)

Video Script

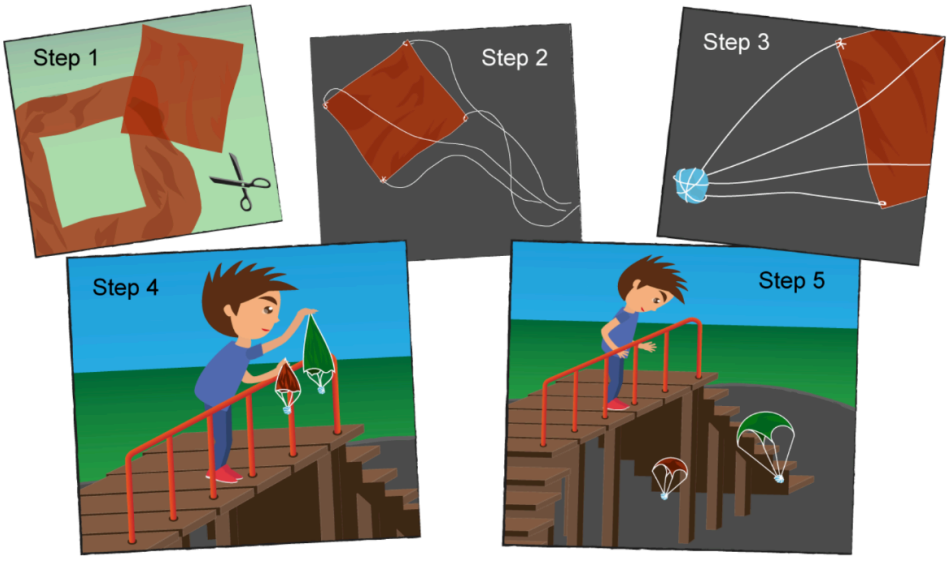
One of Galileo's most important discoveries was that objects would fall at the same rate if they were dropped from the same height.

This was famously expressed as a thought experiment where two different objects, one large and one small, were dropped from the leaning tower of Pisa and hit the ground at the same time.

Galileo stated that this was only true if air resistance was not significant.

In real life, air resistance has a significant effect on the rate at which objects fall to the ground. For example, we know from our everyday experience that a feather does not fall at the same rate as a stone.

An MYP student is interested in the effect that surface area has on the time taken for an object to fall to the ground. He decides to perform an investigation using model parachutes.



Question 5a (3 marks)

Formulate a hypothesis for the student's investigation. Your explanation should refer to forces and particle theory.

Question 5b (13 marks)

Design an investigation that the student could use to test the hypothesis in part (a). In your plan you should include:

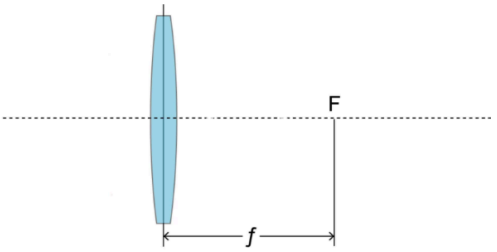
- your independent and dependent variables
- two control variables with justification
- a list of the equipment you will use
- a detailed method for the collection of data
- an explanation of how you will collect sufficient data
- details of how you will make sure your method is safe.

Question 6 (15 marks)

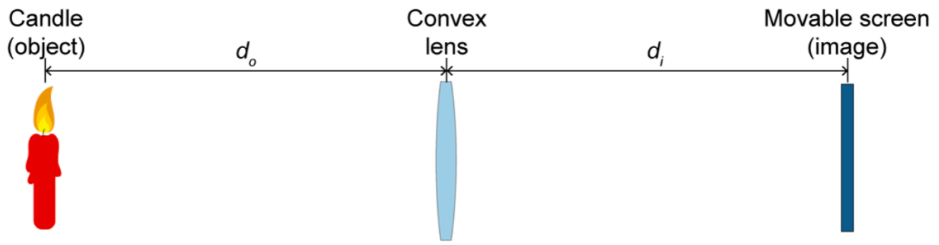
Galileo is also famous for his work on the development of the telescope. Galileo used a combination of lenses to allow an observer to see far away objects clearly.

Lenses work using the refraction of light. One type of lens is a convex lens. With this lens, light waves coming from an object meet at a point known as the focus (F). The focal length of a lens (f) is defined as the distance between the centre of the lens and its focus. It is a constant for a particular lens; different lenses have different focal lengths.

This media contains no audio



The focal length of this type of lens can be found experimentally by using a candle and a screen with the lens placed in between as shown in the diagram below.



When the image is in focus, the distance between the object and the lens (d_o), the distance between the lens and the image (d_i) and the focal length of the lens (f) are related by the formula:

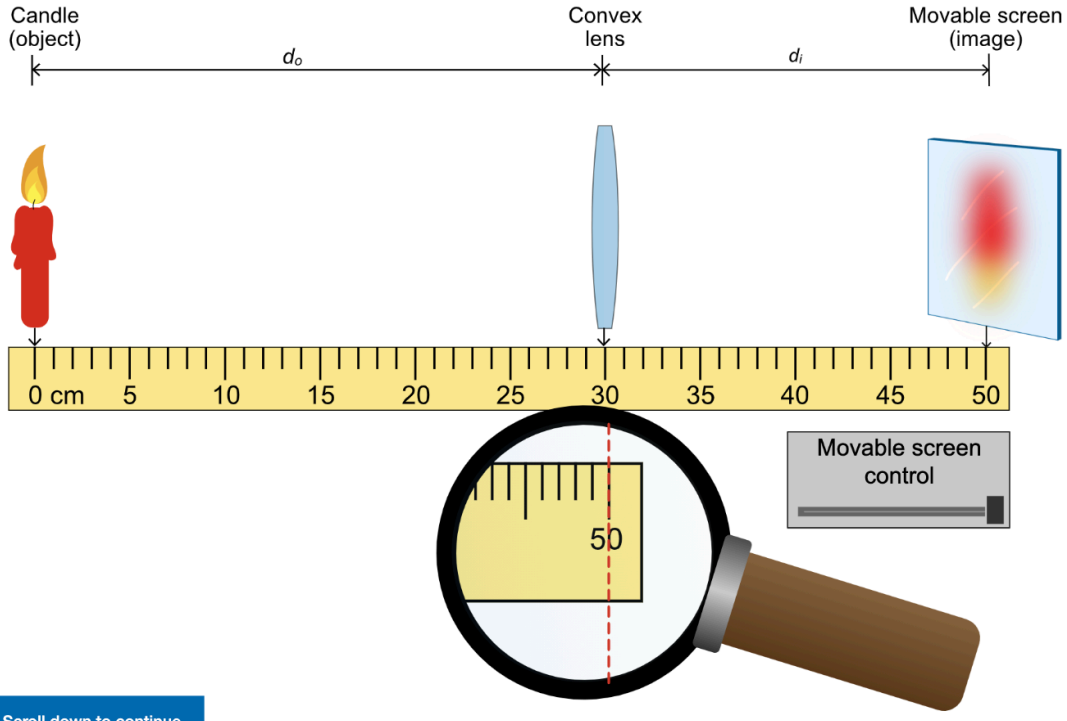
$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

An MYP student changes the distance d_o and measures the distance d_i that produces a clear image on the screen.

Question 6a (3 marks)

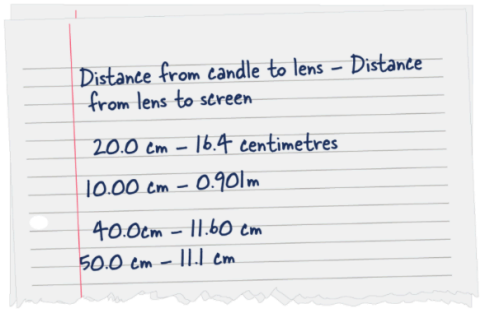
The simulation below has a distance d_o of 30 cm. Change the position of the movable screen to **determine** the distance d_i.

This media is interactive



Scroll down to continue

Question 6b (4 marks)



Organize and **present** the student's data in a table of results. You should include your result from part (a).

Create New Table

Reset

Question 6c (3 marks)

Another student in the same class is doing a similar investigation to find the focal length of a different convex lens. He uses the formula $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ to process his data. His table of processed data is shown below:

$\frac{1}{d_o} / m^{-1}$	$\frac{1}{d_i} / m^{-1}$	$\frac{1}{f} / m^{-1}$	$f /$
5.00	0.95	5.95	0.168
3.33	2.63	5.96	0.168
2.50	3.33	5.83	0.171
2.00	3.87		
1.67	3.67	5.34	0.187
1.43	4.35	5.78	0.173

Label the incomplete column header and **calculate** the missing processed data values and add these to the table.

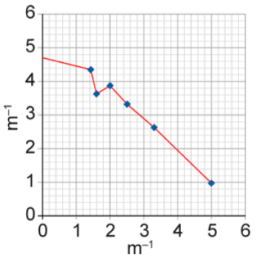
Question 6d (1 mark)

One of the calculated f values in the table appears to be anomalous. **Identify** this data point.

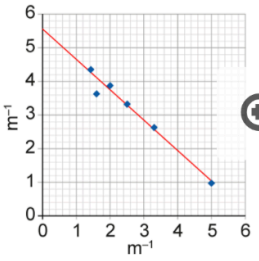
Question 6e (2 marks)

A graph of $\frac{1}{d_i}$ against $\frac{1}{d_o}$ can be used to find the focal length of the lens as the line of best fit will have a y intercept of $\frac{1}{f}$. The four graphs below show different lines of best fit for the data points. **Select** the most appropriate graph. **Justify** your answer.

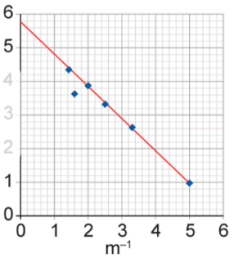
A.



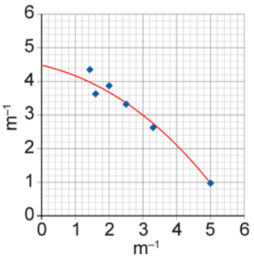
B.



C.



D.



Select

Question 6f (2 marks)

Use your answer to part (e) to **calculate** f.

B I U x_2 x^2 Ω Σ Styles

Question 7 (9 marks)

A drone is a vehicle that can fly without a pilot on board. A drone may be controlled by computers or someone on the ground who may be a long distance away. A quadcopter is a common type of drone.

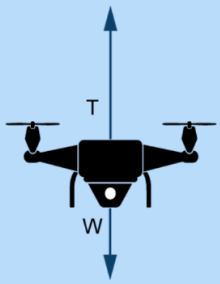
Video | Script

Scroll down to continue

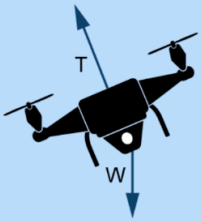
Question 7a (2 marks)

The diagrams below show the forces acting on a moving quadcopter. T is the total thrust generated by the propellers and W is the weight of the quadcopter. **Select** the diagram showing a quadcopter taking off. **Justify** your answer.

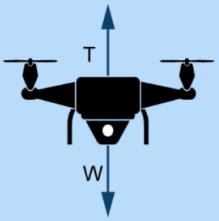
A.



B.



C.



Question 7b (7 marks)

Many cities have serious traffic problems which can increase the delivery time of urgent medical supplies. Scientists have suggested that quadcopters could be a good option for faster delivery of these supplies. Some quadcopters can carry up to 3 kg of material, can fly for 20 minutes and can cover a distance up to 20 km.

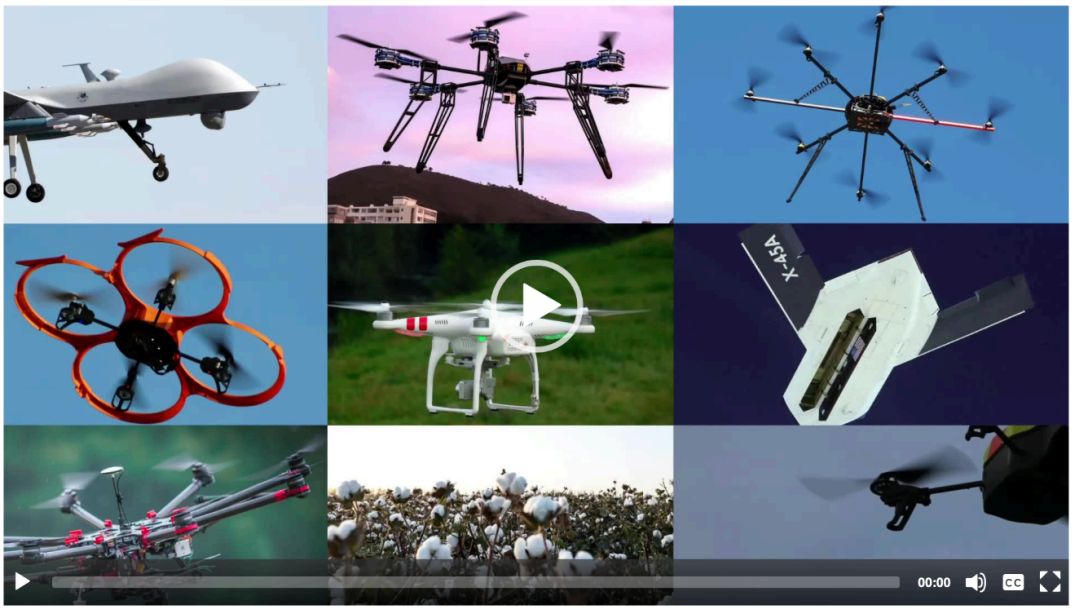
Discuss and **evaluate** the advantages and disadvantages of using quadcopters to deliver urgent medical supplies.

B I U Styles

Question 8 (14 marks)

The video below outlines some common uses of drones.

Video Script



Question 8 (14 marks)

The video below outlines some common uses of drones.

Video | Script

Drones have increased the possibility of making observations of places that have previously been inaccessible. This application of drone technology is known as surveillance.

Drones have been used for the surveillance of crops and animals in farming, tracking the movements of wildlife, observing environmental changes, monitoring landscape changes following natural disasters, locating people who are lost, military uses and even for following the activities of celebrities.

Some people are excited about the opportunities for future use of drones, but many others are concerned about how the technology could be misused.

Using information from the video above and your wider MYP studies, **discuss** and **evaluate** the use of drones in surveillance. In your answer you should include:

- a discussion of the benefits to science in the use of drones to monitor the environment
- the positive and negative social implications for an individual
- the positive and negative political implications for the security of a country
- a concluding appraisal giving your opinion on the use of drones.