Energy & Power

Question Paper 2

Level	International A Level
Subject	Physics
Exam Board	Edexcel
Topic	Mechanics
Sub Topic	Energy & Power
Booklet	Question Paper 2

Time Allowed: **81 minutes**

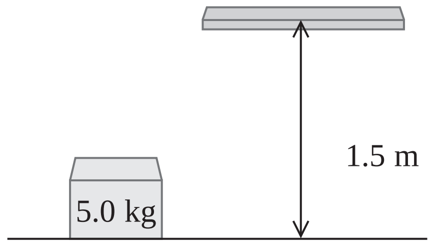
Score: **/67**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 A box of mass 5.0 kg is moved from the ground to a shelf at a height of 1.5 m.



A student is asked to calculate the energy transfer as the height is increased.

The student could use either of the following formulae.

$$\Delta W = F\Delta s \qquad \text{or} \qquad \Delta E_{grav} = mg\Delta h$$

(a) Explain how the two formulae are equivalent.

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(b) Calculate the increase in gravitational potential energy of the box.

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Increase in gravitational potential energy = ...

(Total for Question 1 = 4 marks)

2 One side of a mountain slopes at 35° to the horizontal and the other side at 25°.

A geologist needs to climb to the top to collect rock samples.

By discussing the work done and forces involved, explain which would be the easier side to use to climb to the top.

vertical height of mountain = 365 m

mass of geologist = 85 kg

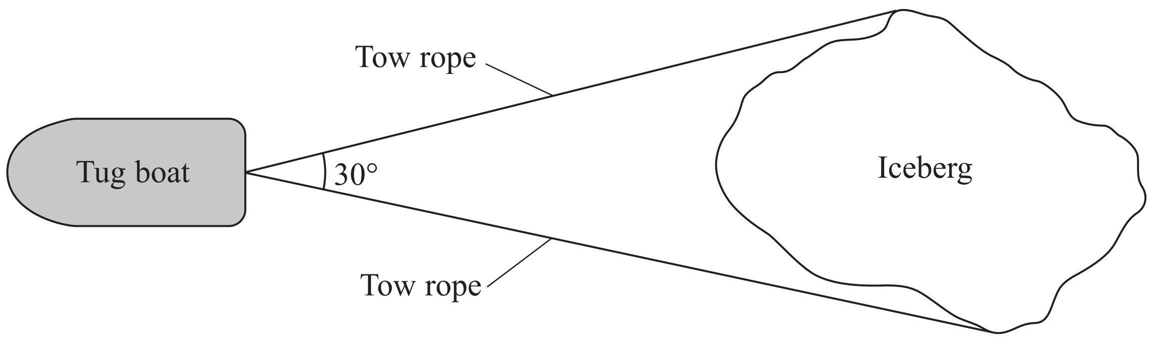
(3)

(Total for Question 2 = 3 marks)

3 An iceberg is a large piece of freshwater ice that has broken off a glacier or an ice shelf.

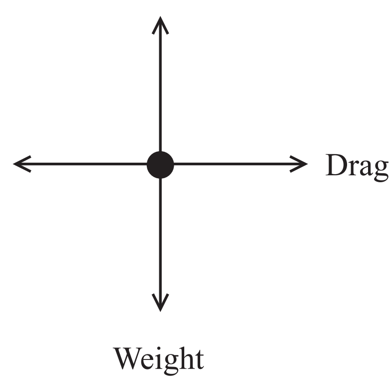
Some scientists believe that icebergs could be used to supply freshwater. It has been estimated that an iceberg of mass 3.0×10^9 kg could provide water for half a million people for up to a year.

Computer models have calculated that just one tug boat would be needed to move such an iceberg half way around the world.



(a) (i) Label the free-body force diagram below, for the iceberg.

(2)



(ii) The iceberg is moving at a constant speed and the tensions in the two tow ropes are equal. Show that the tension in each rope is about 2×10^5 N.

drag force from the water = 3.3×10^5 N

(3)

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(iii) Calculate the work done by the tug boat on the iceberg when the iceberg is pulled through 50 km.

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Work done = ...

(iv) State and explain the effect on the motion of the iceberg if the tow ropes were longer. Assume that the tug boat's power output remains the same.

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(b) The tug boat is moving through the water due west at 2.6 km hour^{-1}.

There is a water current of 0.9 km hour^{-1} due south.

On the grid below draw a vector diagram to scale, to determine the magnitude and direction of the resultant velocity of the tug boat.

(3)

North

Resultant velocity = ...

(c) Not all of the iceberg is visible above the surface of the water.

Show that the proportion of the volume of the iceberg that is beneath the surface of the water is about 0.9.

density of sea water = 1030 kg m^{-3}

density of freshwater ice = 920 kg m^{-3}

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(d) As the iceberg nears its destination, the climate would become warmer.

State the effect this would have on the following physical quantities.

(2)

Physical Quantity	Effect
Sea temperature	
Viscosity of sea water	
Density of sea water	
Position of the iceberg in the water	

(Total for Question 3 = 17 marks)

4 A bungee jump consists of three main stages:

- free fall jump until the rope is straight
- deceleration as the bungee rope stretches
- upwards motion as the bungee rope contracts.

(a) Complete the table to describe the energy transfers of the bungee jumper. Ignore any changes that could be due to air resistance.

(2)

Stage of jump	**Energy transfer**
free fall jump	gravitational potential energy → kinetic energy
deceleration as the bungee rope stretches	
upwards motion as the bungee rope contracts	

(b) A bungee jumper, of mass 54 kg, is going to jump from a platform that is 65 m above the ground. For the jump to be safe, his height above the ground must never be less than 10 m.

(i) Show that the maximum transfer of gravitational potential energy during a safe jump is about 30 kJ.

(2)

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(ii) Hence calculate the tension in the rope when the bungee jumper is 10 m above the ground.

initial length of rope = 23 m

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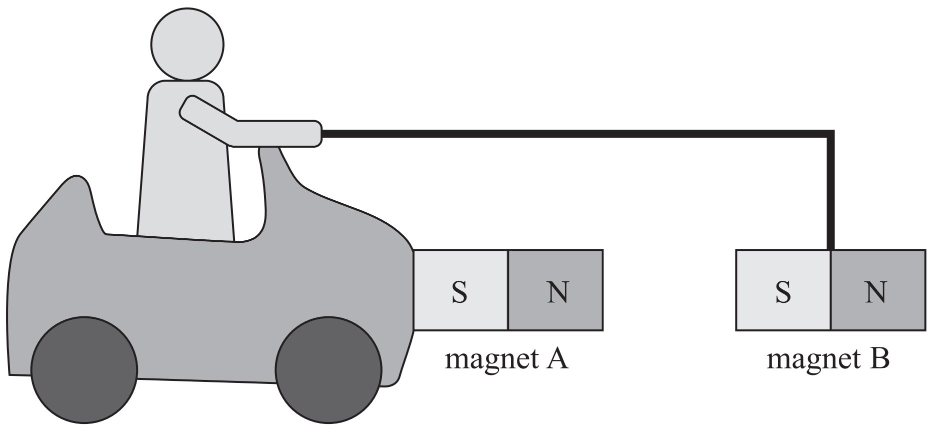
Tension = ...

(Total for Question 4 = 7 marks)

5 Opposite poles of a magnet attract one another. Using this principle, a student tried to design a toy car that could be self-propelled using a magnetic force. His design is shown below.



Magnet A is attached to the body of the toy car and magnet B is suspended from the driver's hand by a rigid rod. Magnet A is identical to magnet B.

The student stated that as long as the opposite poles of the magnets are facing one another, the attractive force created should cause the toy car to start moving forward.

Explain why in practice this could never work.

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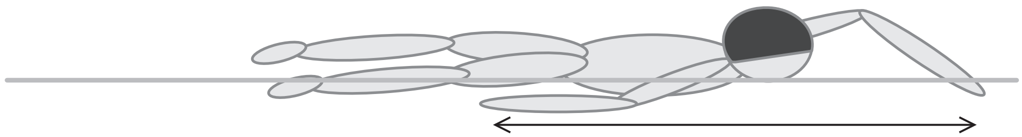
(Total for Question 5 = 3 marks)

6 The diagram shows a swimmer.



(a) The swimmer exerts an average horizontal backward force of 65 N on the water during each stroke. The length of each stroke is 1.4 m.

(i) Show that the work done by the swimmer on the water during each stroke is about 90 J.

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(ii) The stroke rate of the swimmer is 55 strokes per minute. Calculate the power developed by the swimmer's arms.

(2)

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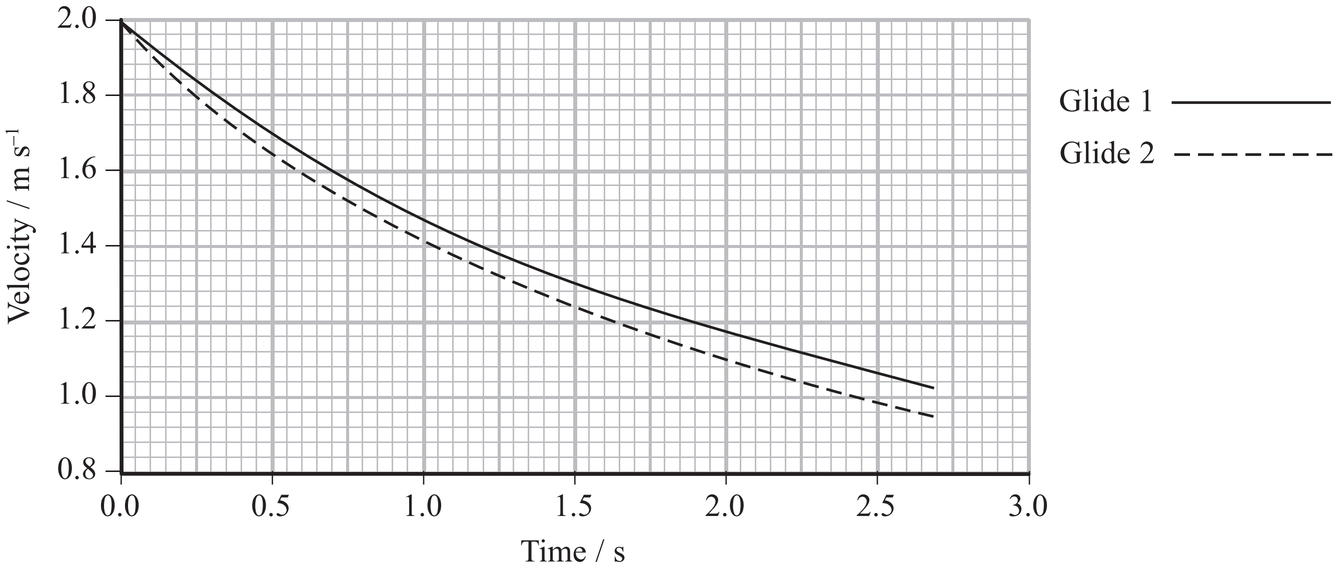
Power = ...

(b) An investigation was carried out on the drag forces acting on the swimmer. The swimmer pushed off from the side of the pool with his arms straight ahead of him and his velocity was measured as he glided through the water. This was repeated with the swimmer's arms at his sides.

Glide 1 Glide 2

A velocity-time graph was plotted for both glides.



*(i) Use the graph to describe and explain the motion of the swimmer when performing Glide 1 and Glide 2.

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(ii) The drag force can be calculated using

$$\text{Drag force} = \frac{1}{2}C\rho Av^2$$

where

C = drag coefficient

ρ = density of the water

A = cross-sectional area of the swimmer

v = velocity of the swimmer.

Demonstrate that the drag coefficient is a quantity with no units.

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(iii) Suggest and explain an additional measure that a swimmer could use to reduce the drag force acting on him.

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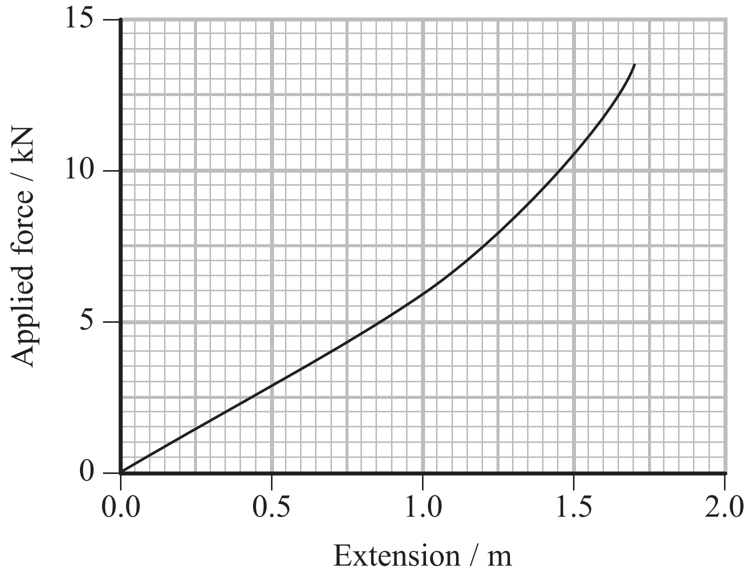
(Total for Question 6 = 12 marks)

7 (a) The force-extension graph obtained when stretching a nylon rope is shown below.



Use the graph to determine the work done in extending the rope by 1.5 m.

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Work done = ...

(b) Kinetic towing of cars is a method that can be used when it is difficult for a towing car to achieve sufficient grip, such as in snow or sand.

A nylon strap is connected, with a lot of slack, between the two cars. The towing car drives forward and the strap must become stretched before it is able to pull the trapped car free.

*(i) Explain why, even if the towing car had then stopped, the trapped car would still begin to move.

(2)

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(ii) The nylon strap used for kinetic towing typically has a breaking strain of 25%. Steel cables, often used for towing cars along roads, typically have a breaking strain of 0.02%.

It can be assumed that the nylon strap and the steel cable both obey Hooke's law. Show that, for the same pulling force and just before breaking, a nylon strap can store over 1000 times more energy than a steel cable of identical initial length and cross sectional area.

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(iii) Suggest why steel cables are **not** suitable for kinetic towing of cars.

(1)

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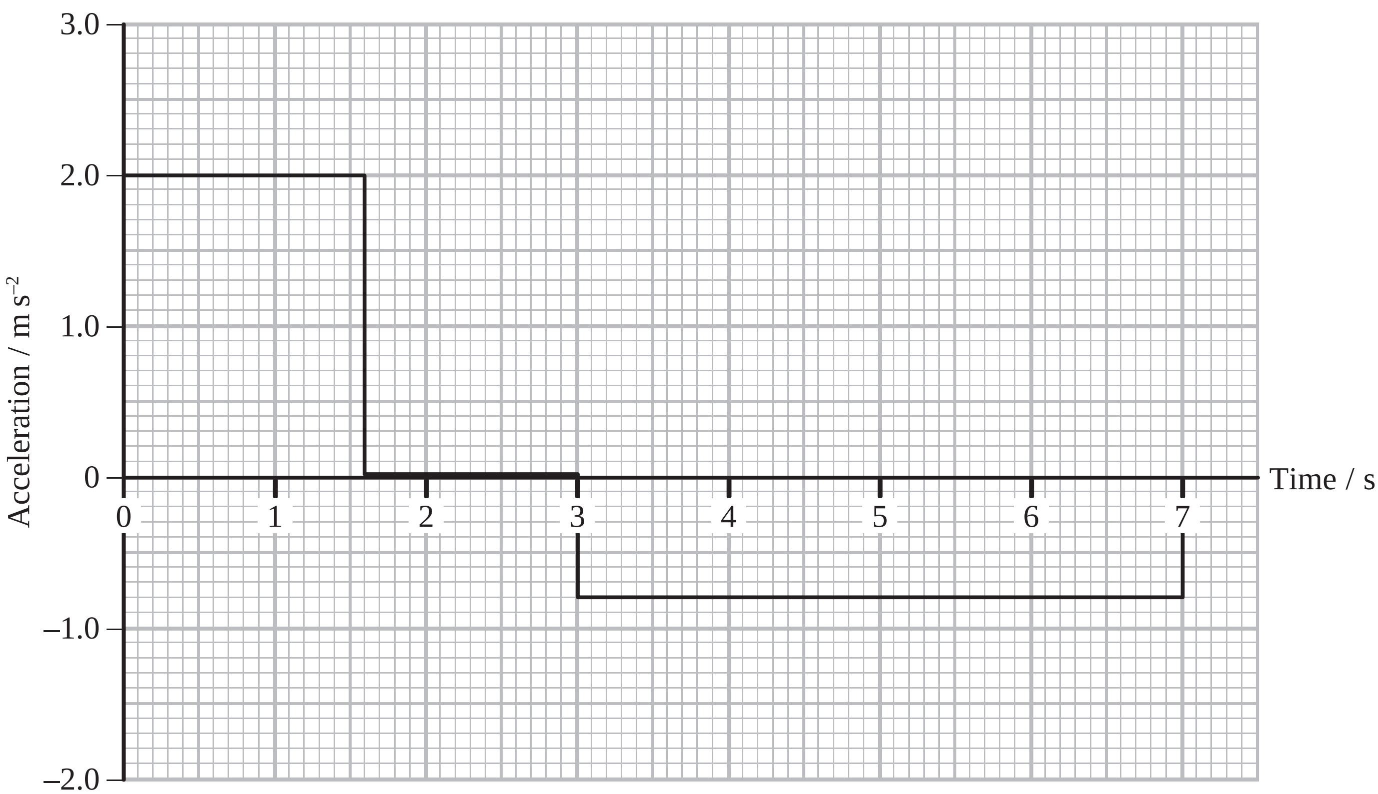
(Total for Question 7 = 9 marks)

8 The toy aeroplane in the photograph has a spring mechanism connected to the wheels. When the aeroplane is pulled backwards, the wheels rotate backwards and a spring is compressed. When the aeroplane is released, the force from the spring propels the aeroplane forwards.

The aeroplane is pulled backwards, released and then moves forward in a straight line along a flat surface. The simplified acceleration-time graph for the forward motion of the aeroplane is shown.



(a) Show that the maximum velocity of the aeroplane is about 3 m s^{-1}.

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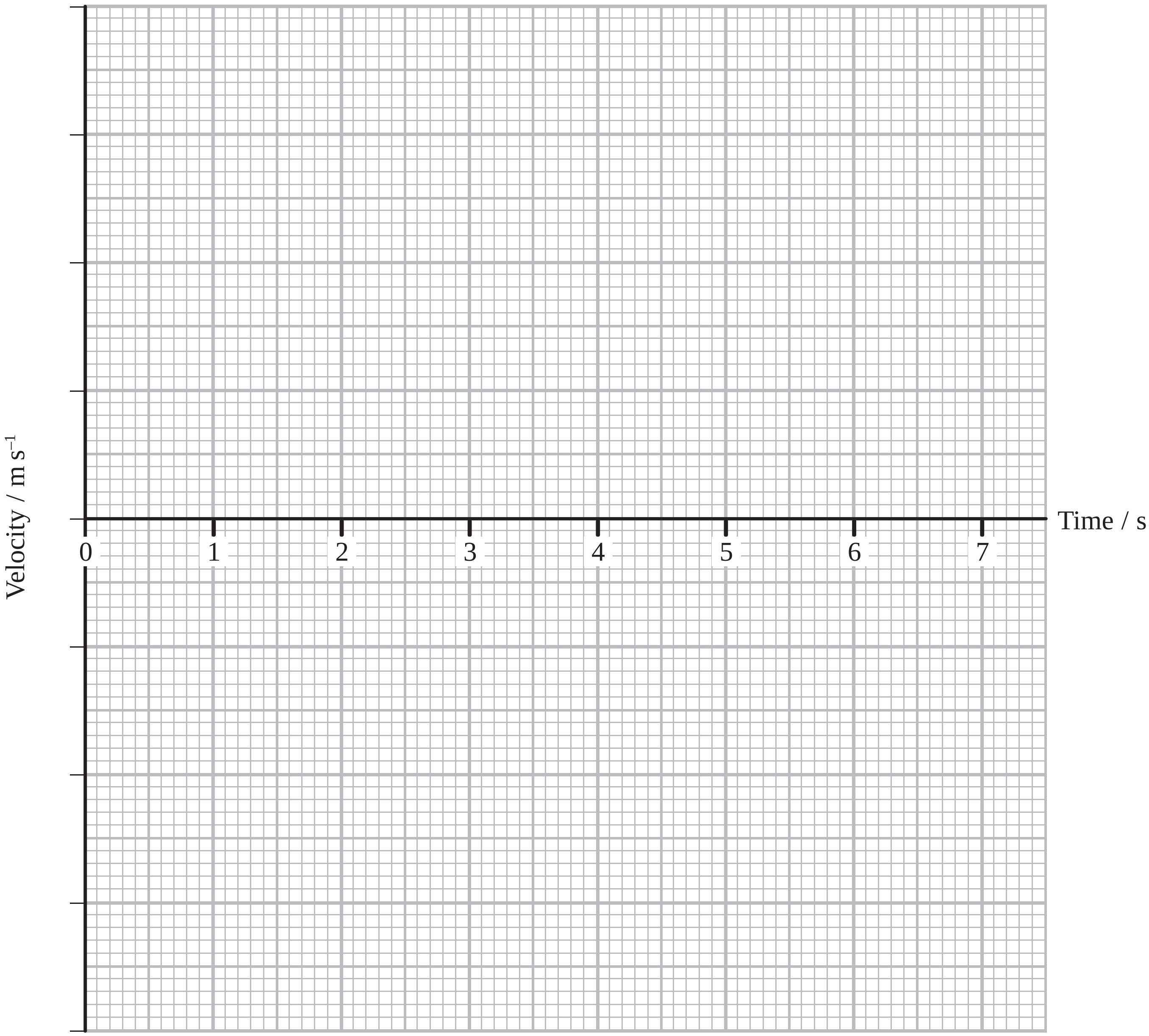
(b) On the axes below draw the corresponding velocity-time graph for the aeroplane.

(3)



(c) Calculate the total distance travelled by the aeroplane after release.

(3)

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Total distance travelled = ...

(d) (i) Calculate the maximum kinetic energy of the aeroplane.

mass of aeroplane = 0.12 kg

(2)

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Maximum kinetic energy = ...

(ii) Calculate the mean power developed by the spring mechanism during the period of acceleration.

(2)

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Mean power developed = ...

(Total for Question 8 = 12 marks)