Energy & Power

Question Paper

Level	A Level
Subject	Physics
Exam Board	Edexcel
Topic	Mechanics
Sub Topic	Energy & Power
Booklet	Question Paper
Paper Type	Open-Response 2

Time Allowed: **68 minutes**

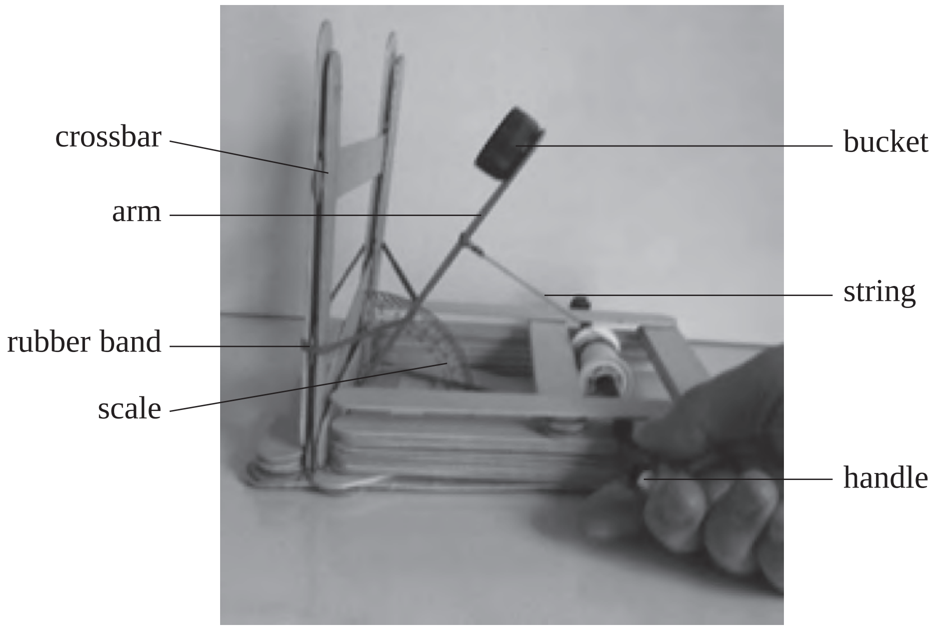
Score: **/56**

Percentage: **/100**

Grade Boundaries:

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

1 A Mangonel is a type of catapult used to launch projectiles such as rocks. A student made a working model of a Mangonel.



As the handle is turned, the arm is pulled back by the string. This increases the tension in the rubber band. When the string is released, the rubber band causes the arm to move upwards, launching a projectile from the bucket when the arm hits the crossbar.

(a) (i) Suggest why a rubber band is used to support the arm.

(1)

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(ii) State the energy transfers that occur when the string is released.

(1)

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(b) The student varied the angle to the vertical at which the arm was released.
The range of the projectile was measured for each angle.

Release angle to the vertical / °	15	30	45	60
Mean range / m	0.14	0.58	0.95	1.70

*(i) Explain why the range increases as the angle increases.

(4)

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(ii) The student replaces the projectile with one of a smaller mass.

State why this increases the range of the projectile.

(1)

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(iii) Suggest one modification to the model that would also increase the range of the projectile. Give a reason for your answer.

(2)

Modification ....

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Reason ....

(c) The student wishes to place a target in the path of the projectile. The height of the target is 5.0 cm. The projectile is released horizontally from a height of 13.0 cm.

(i) Show that the time taken for the projectile to fall to a height of 5.0 cm is about 0.1 s.

(2)

(ii) When the arm was pulled back through an angle of 60°, the time taken for the projectile to travel 1.7 m horizontally was 0.16 s.

Calculate the minimum horizontal distance that the target should be placed from the model for the projectile to hit it.

(3)

Minimum horizontal distance = ...

(Total for Question = 14 marks)

2 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.

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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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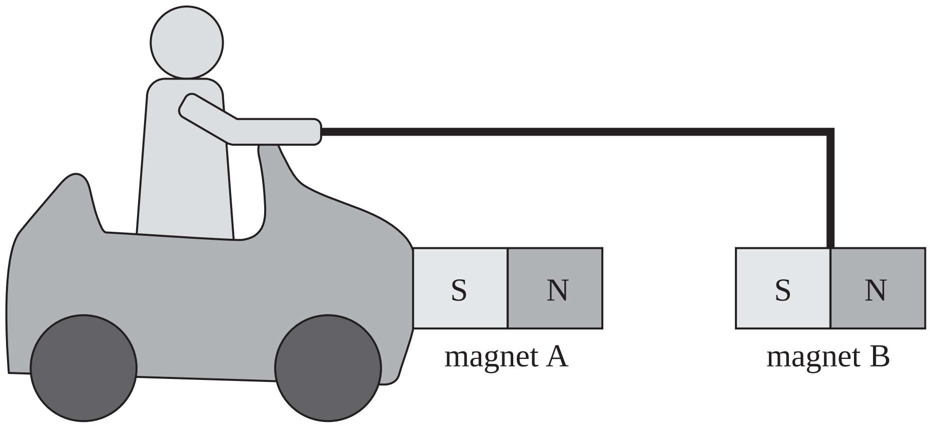
Tension = ...

(Total for Question = 7 marks)

3 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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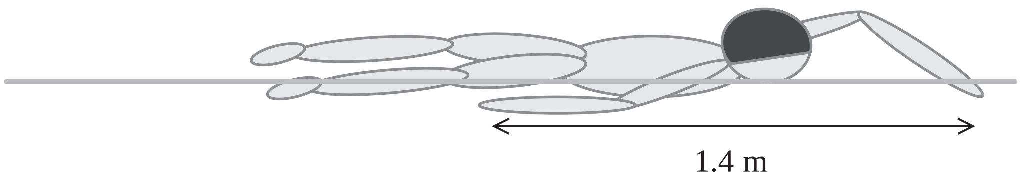
(Total for Question = 3 marks)

4 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.

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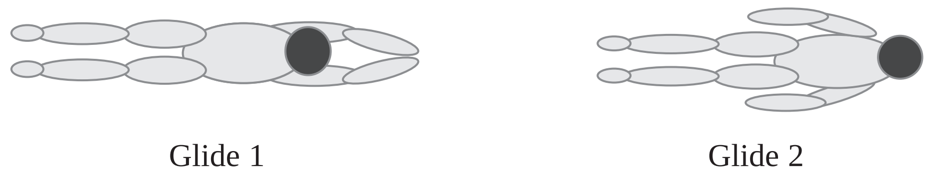
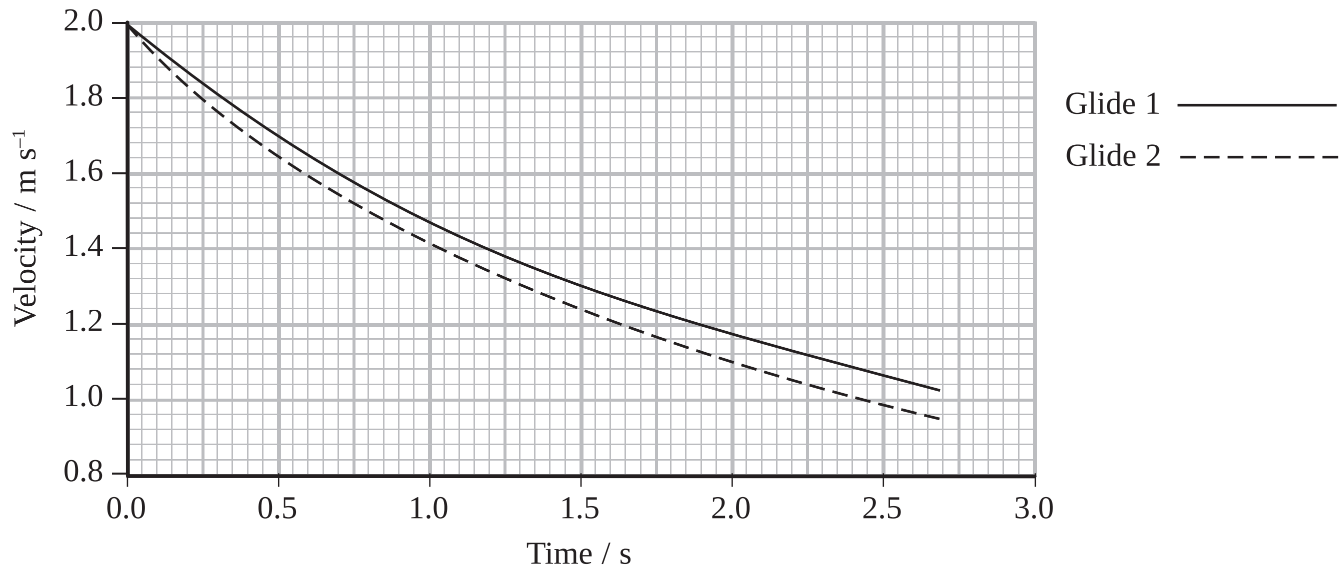
Power = ...

(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.



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

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

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.

(2)

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

(2)

(Total for Question = 12 marks)

5 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

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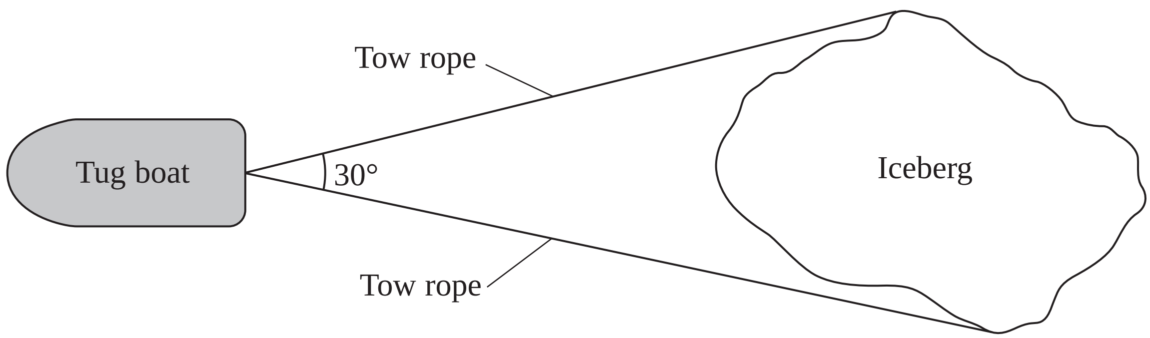
(Total for Question = 3 marks)

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

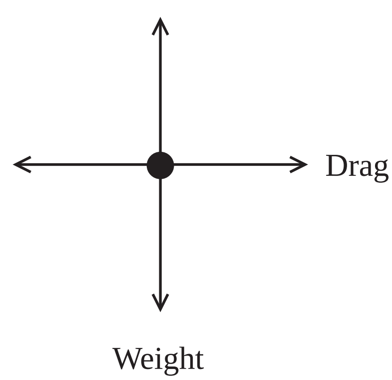
Some scientists believe that icebergs could be used to supply freshwater. It has been estimated that an iceberg of mass 3.0×10^9 kg could provide water for half a million people for up to a year.

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.

(2)

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.

(2)

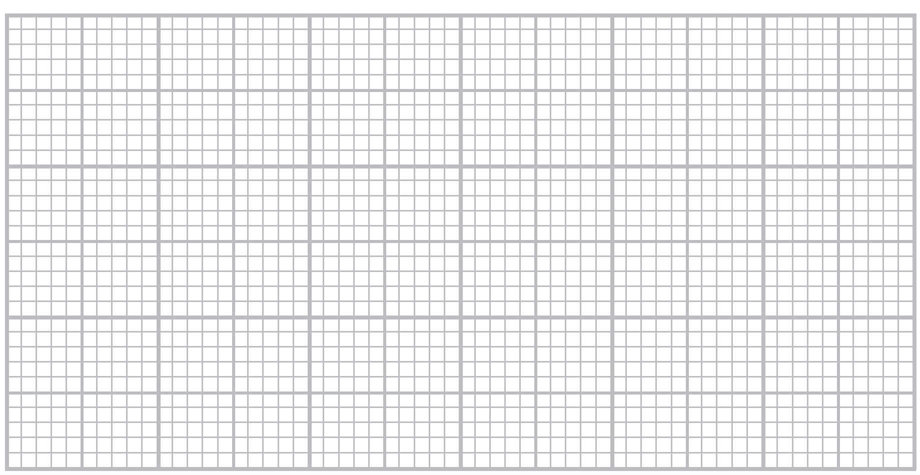
(b) The tug boat is moving through the water due west at 2.6 km $hour^{-1}$.

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



(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}

(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 = 17 marks)