Uniform Acceleration/ SUVAT Equations

Question Paper 2

Level	International A Level
Subject	Physics
Exam Board	Edexcel
Topic	Mechanics
Sub Topic	Uniform Acceleration / SUVAT Equations
Booklet	Question Paper 2

Time Allowed: **51 minutes**

Score: **/42**

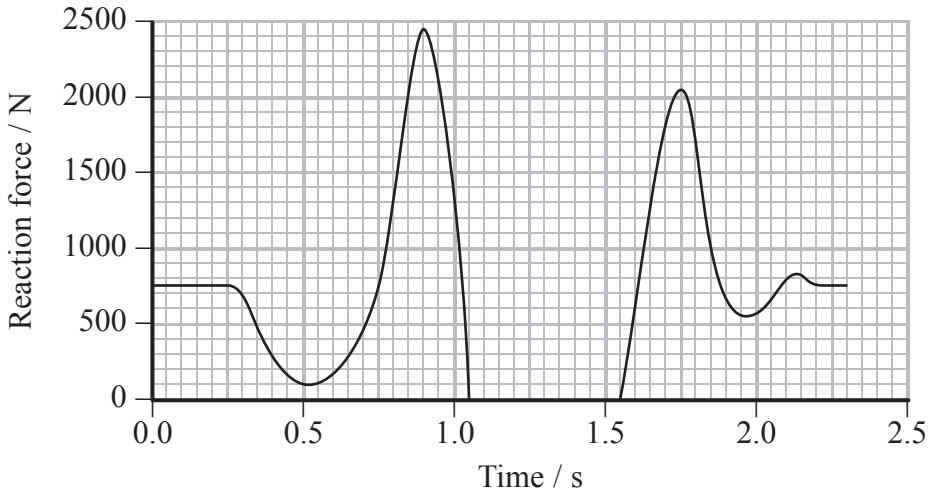
Percentage: **/100**

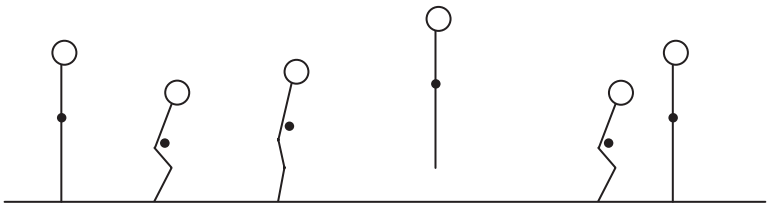
Grade Boundaries:

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

1 An athlete bends his knees and then springs up into a vertical jump. The graph below shows how the reaction force from the ground on the athlete varies with time.

The diagram below the graph shows the position of the athlete at the corresponding times as he completes his jump.





(a) Show that the mass of the athlete is about 80 kg.

(2)

(b) The small dot on each diagram of the athlete represents his centre of gravity.

(i) State what is meant by centre of gravity.

(1)

(ii) Between 0.25 s and 0.75 s the athlete bends his knees. As a result of this, his centre of gravity moves lower.

Explain how the graph shows that an acceleration is produced as the athlete bends his knees.

(2)

*(c) In order to jump, the athlete pushes down on the ground between 0.75 s and 1.05 s.

With reference to Newton's laws, explain why the athlete must push down on the ground.

(3)

(d) The maximum reaction force was reached at $t = 0.9$ s. Calculate the acceleration of the athlete at this point.

(3)

Acceleration = ...

(e) The athlete was in the air for 0.50 s.

(i) Calculate the height jumped by the athlete.

(2)

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Height = ...

(ii) Calculate the speed of the athlete on leaving the ground.

(2)

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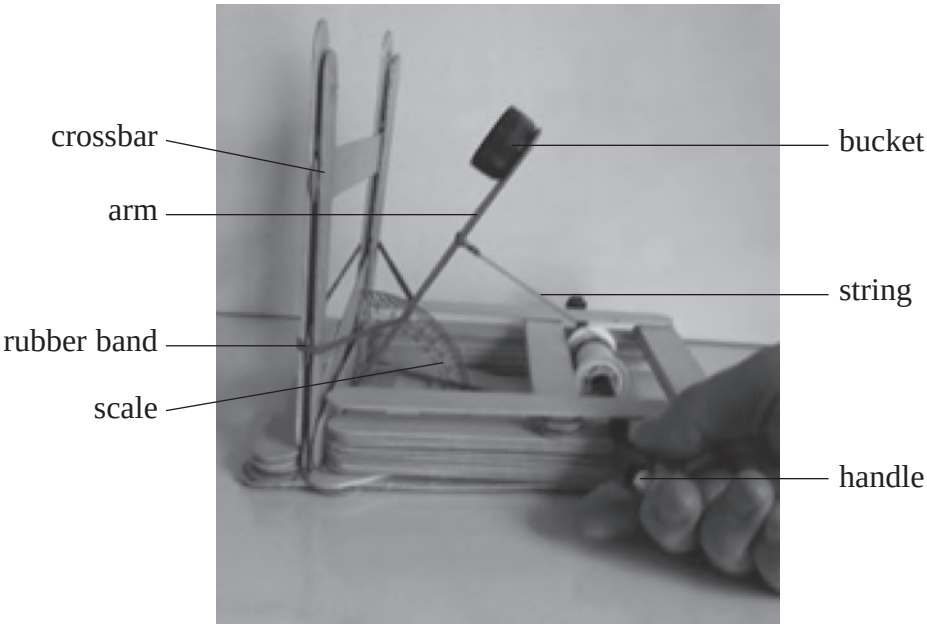
Speed = ...

(Total for Question 1 = 15 marks)

2 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 .....

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(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)

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(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)

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Minimum horizontal distance = ...

(Total for Question 2 = 14 marks)

3 The world's tallest building is the Burj Khalifa in Dubai, UAE.

The viewing gallery for the public is on the 124th floor. The lift that visitors use takes 56 seconds to reach this floor. The motion of the lift can be divided into three parts:

- acceleration
- constant velocity of 10 m s^{-1}
- deceleration.

(a) Draw a free-body force diagram for the forces acting on a passenger as the lift rises.

(2)

(b) A physics student of mass 60 kg decides to measure the initial acceleration of the lift. She places a set of scales on the floor of the lift and steps onto them. Whilst the lift is accelerating upwards the reading on the scales increases to 73 kg.

(i) Show that the initial acceleration of the lift is about 2 m s^{-2}.

(3)

(ii) Near the end of the ascent, the velocity of the lift decreases from 10 m s^{-1} to rest in 5.3 seconds.

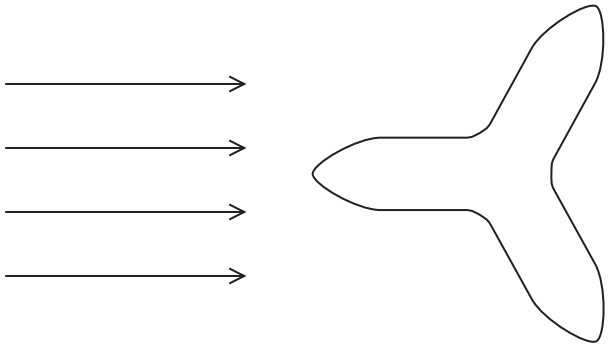
Calculate the deceleration.

(2)

Deceleration = ...

(c) The effects of the wind had to be considered in the position and design of the building, due to its height. It has been shaped, as in the diagram, so that the wind deflects around the building in a way which minimises turbulence.

Aerial view of the Burj Khalifa building



Add to the diagram above to show the air flow around the building, labelling regions of laminar and turbulent flow.

(2)

(Total for Question 3 = 9 marks)

4 A student carried out an experiment to obtain a value for the acceleration of free fall *g*.

A small ball was dropped from rest and the motion of the ball was captured using a digital camera. The student counted the frames from the recording to measure the time *t* for the ball to fall to the ground.

A ruler was visible on the recording to enable the student to measure the distance *s* fallen by the ball.

(a) Use Newton's second law of motion to show that the acceleration of the ball is independent of its mass.

(1)

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(b) (i) State the equation that the student should use to calculate the value of *g*.

(1)

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(ii) A value for *g* was obtained and was greater than expected.

Explain **one** possible source of error that would have produced a greater than expected value.

(2)

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(Total for Question 4 = 4 marks)