Pearson Edexcel

Additional Assessment Materials

Summer 2021

Pearson Edexcel GCE in Mathematics

9MA0 (Applied) (Public release version)

Resource Set 1: Topic 7

Kinematics (Test 3)

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Additional Assessment Materials, Summer 2021

General guidance to Additional Assessment Materials for use in 2021

Context

- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an optional part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional Assessment Materials have been drawn from previous examination materials, namely past papers.
- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.

Purpose

- The purpose of this resource to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the mapping guidance which will map content and/or skills covered within each set of questions.
- These materials are only intended to support the summer 2021 series.

1. [*In this question the unit vectors* **i** *and* **j** *are in a vertical plane,* **i** *being horizontal and* **j** *being vertically upward.*]

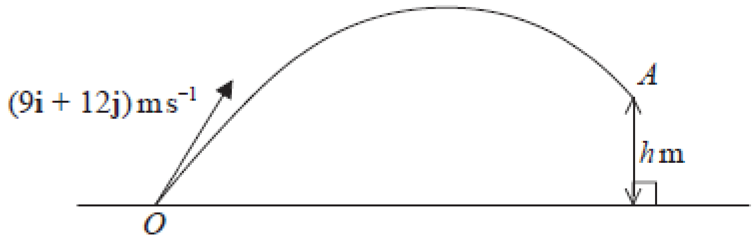

Figure 2

A small ball is projected from the fixed point O on horizontal ground with velocity (9**i** + 12**j**) m s^{-1}. The ball passes through the point A which is h metres vertically above the level of O, as shown in Figure 2. The velocity of the ball at the instant it passes through the point A is λ(**i** − **j**) m s^{-1}, where λ is a positive constant. The ball is modelled as a particle moving freely under gravity.

(a) Find the value of h.

(4)

(b) State the minimum speed of the ball as it moves from O to A.

(1)

(c) Find the length of time for which the speed of the ball is less than 12 m s^{-1}.

(4)

The model could be refined by considering air resistance.

(d) Suggest one other refinement to the model that would make it more realistic.

(1)

(Total for Question 1 is 10 marks)

2. A small ball is projected with speed u from a point O on horizontal ground. The angle of projection is θ to the horizontal, where $0 < \theta < 90°$. The ball hits the ground at the point A.

The ball is modelled as a particle moving freely under gravity.

(a) Show that, according to the model, $OA = \dfrac{u^2 \sin 2\theta}{g}$.

(5)

A golfer hits a golf ball with speed 25 m s^{-1} from a point X on horizontal ground.

The golf ball hits the ground at the point Y. The angle of projection is θ to the horizontal, where $0 < \theta < 90°$. The golfer requires the distance XY to be at least 40 m.

The golf ball is modelled as a particle moving freely under gravity.

(b) Find, according to the model, the size of the largest possible angle θ.

(2)

Given that $\theta = 30°$ and that the golf ball is more than 3 m above the ground for T seconds,

(c) find the value of T.

(4)

(Total for Question 2 is 11 marks)

3.

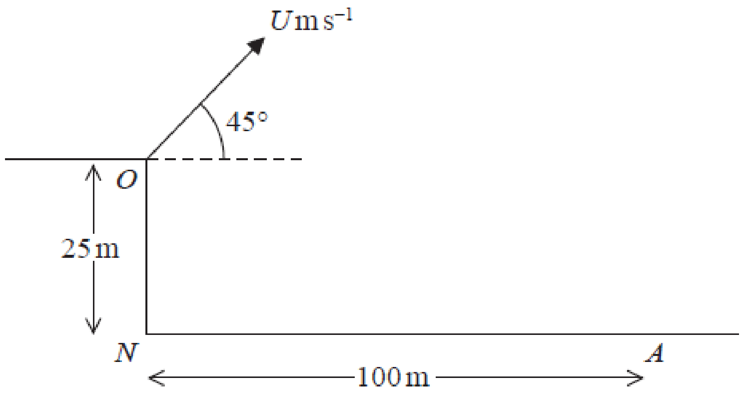

Figure 2

A small ball is projected with speed U m s^{-1} from a point O at the top of a vertical cliff.

The point O is 25 m vertically above the point N which is on horizontal ground.

The ball is projected at an angle of 45° above the horizontal.

The ball hits the ground at a point A, where $AN = 100$ m, as shown in Figure 2.

The motion of the ball is modelled as that of a particle moving freely under gravity.

Using this initial model,

(*a*) show that $U = 28$

(6)

(*b*) find the greatest height of the ball above the horizontal ground NA.

(3)

In a refinement to the model of the motion of the ball from O to A, the effect of air resistance is included.

This refined model is used to find a new value of U.

(*c*) How would this new value of U compare with 28, the value given in part (a)?

(1)

(*d*) State one further refinement to the model that would make the model more realistic.

(1)

(Total for Question 3 is 11 marks)

4. [In this question use $g = 10 \text{ m s}^{-2}$.]

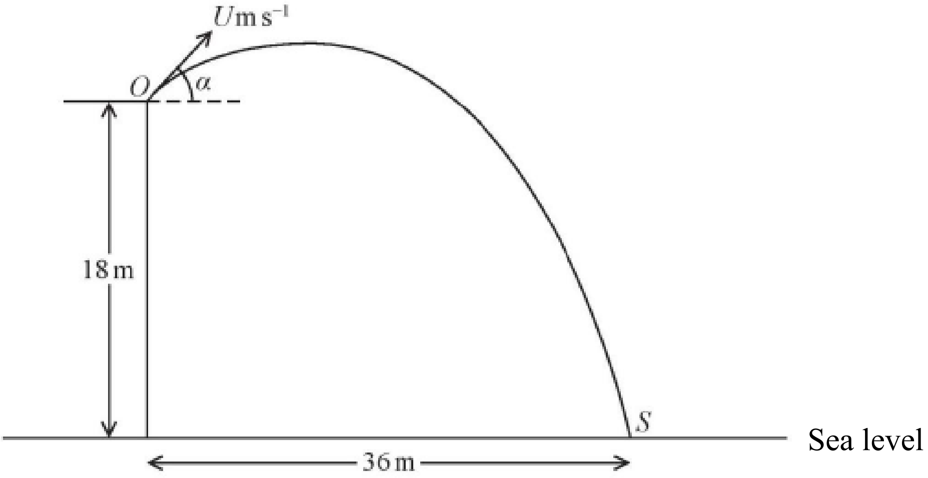

Figure 2

A boy throws a stone with speed U m s^{-1} from a point O at the top of a vertical cliff. The point O is 18 m above sea level.

The stone is thrown at an angle α above the horizontal, where $\tan \alpha = \frac{3}{4}$.

The stone hits the sea at the point S which is at a horizontal distance of 36 m from the foot of the cliff, as shown in Figure 2.
The stone is modelled as a particle moving freely under gravity with $g = 10 \text{ ms}^{-2}$

Find

(*a*) the value of U,

(6)

(*b*) the speed of the stone when it is 10.8 m above sea level, giving your answer to 2 significant figures.

(5)

(*c*) Suggest two improvements that could be made to the model.

(2)

(Total for Question 4 is 13 marks)

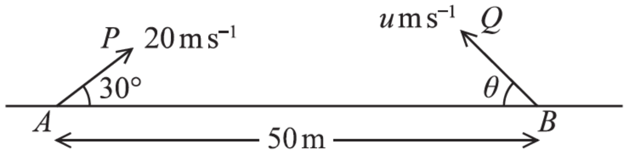

Figure 3

The points A and B lie 50 m apart on horizontal ground.

At time $t = 0$ two small balls, P and Q, are projected in the vertical plane containing AB.

Ball P is projected from A with speed 20 m s^{-1} at 30° to AB.

Ball Q is projected from B with speed u m s^{-1} at angle θ to BA, as shown in Figure 3.

At time $t = 2$ seconds, P and Q collide.

Until they collide, the balls are modelled as particles moving freely under gravity.

(a) Find the velocity of P at the instant before it collides with Q.

(6)

(b) Find

(i) the size of angle θ,

(ii) the value of u.

(6)

(c) State one limitation of the model, other than air resistance, that could affect the accuracy of your answers.

(1)

(Total for Question 5 is 13 marks)

6.

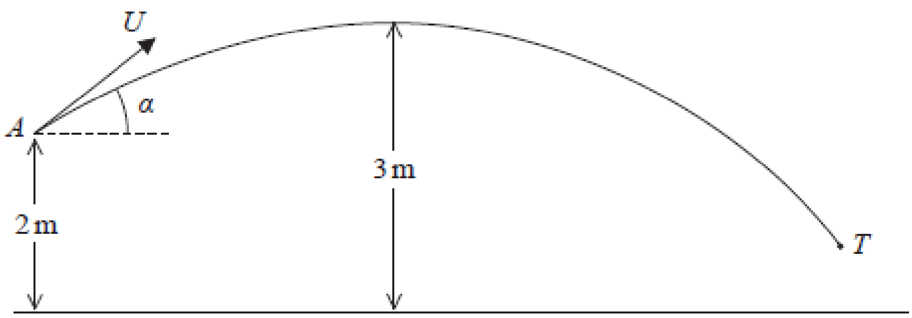

Figure 4

A boy throws a ball at a target. At the instant when the ball leaves the boy's hand at the point A, the ball is 2 m above horizontal ground and is moving with speed U at an angle α above the horizontal.

In the subsequent motion, the highest point reached by the ball is 3 m above the ground. The target is modelled as being the point T, as shown in Figure 4. The ball is modelled as a particle moving freely under gravity.

Using the model,

(a) show that $U^2 = \dfrac{2g}{\sin^2 \alpha}$.

(2)

The point T is at a horizontal distance of 20 m from A and is at a height of 0.75 m above the ground. The ball reaches T without hitting the ground.

(b) Find the size of the angle α.

(9)

(c) State one limitation of the model that could affect your answer to part (b).

(1)

(d) Find the time taken for the ball to travel from A to T.

(3)

(Total for Question 6 is 15 marks)