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QUESTION WORKBOOK

Projectile motion

Mechanics · Year 12

AQA 3.4.1.4 · CIE 2.1.9 · OCR A 3.1.3(a), 3.1.3(b)

17 questions · 57 marks

NAVY SCREEN EDITION

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SECTION A · Warm-up

A1 A projectile is launched horizontally. Explain why its horizontal and vertical motions can be treated separately. [2]

A2 A ball rolls off a table 1.2 m high with a horizontal velocity of 3.0 m s^{-1}. Taking g = 9.81 m s^{-2}, calculate the time to reach the floor and the horizontal distance travelled. [3]

A3 State what happens to the horizontal and vertical components of a projectile's velocity during its flight (ignore air resistance). [2]

SECTION B · Standard

B1 A stone is thrown horizontally at 20 m s^{-1} from the top of a cliff 45 m high. Taking g = 9.81 m s^{-2}, calculate (a) the time of flight, (b) the horizontal distance travelled, and (c) the vertical component of velocity just before impact. [4]

B2 A ball is launched at 25 m s^{-1} at 30° above the horizontal over level ground. Taking g = 9.81 m s^{-2}, calculate (a) the horizontal and vertical components of the initial velocity, (b) the time of flight, and (c) the horizontal range. [5]

B3 For the launch in the previous question, calculate the maximum height reached above the launch point. [3]

SECTION C · Stretch

C1 A projectile is launched over level ground at 30 m s^{-1} at 40° to the horizontal. Using $R = u^2 \sin 2\theta / g$ with $g = 9.81$ m s^{-2}, calculate its range and state the launch angle that would give the maximum range. [4]

C2 A ball is launched at 15 m s^{-1} at 25° above the horizontal from a point 2.0 m above the ground. Taking $g = 9.81$ m s^{-2}, determine the time of flight until it lands and the horizontal distance travelled. [5]

C3 Describe how air resistance affects the trajectory, the maximum height and the range of a projectile, compared with the motion when air resistance is ignored. [3]

SECTION A · Warm-up

A4 Ignoring air resistance, state, for a projectile at the highest point of its path, (a) the magnitude of the vertical component of its velocity, and (b) the magnitude and direction of its acceleration. [2]

A5 Two identical coins rest at the edge of a bench. At the same instant, one is struck so it leaves the bench horizontally at high speed while the other is nudged off the edge and falls from rest. State and explain which coin lands first. Ignore air resistance. [2]

SECTION B · Standard

B4 In a film stunt, a cyclist rides horizontally off a flat roof 3.2 m above the ground and lands 7.2 m from the base of the building. Taking $g = 9.81\ \text{m s}^{-2}$, determine the cyclist's speed on leaving the roof. [3]

B5 A stunt diver runs off the top of a cliff with a horizontal velocity of 12 m s^{-1} and enters the sea 30 m below. Taking g = 9.81 m s^{-2}, calculate the magnitude of the diver's velocity on entering the water and the angle it makes with the horizontal. [4]

B6 A ball is thrown at 24 m s^{-1} at 55° above the horizontal. Taking g = 9.81 m s^{-2}, calculate the horizontal and vertical components of its velocity 1.5 s after launch, and state whether the ball is still rising. [3]

SECTION C · Stretch

C4 A javelin leaves the thrower's hand at 26 m s^{-1} at 40° above the horizontal. Calculate the javelin's speed at the highest point of its flight, and explain why the speed there is not zero. [3]

C5 A rugby conversion is kicked from a point 43 m from the posts. The ball leaves the ground at 22 m s^{-1} at 38° above the horizontal, travelling straight towards the posts. To score, the ball must pass above the crossbar, which is 3.0 m above the ground. Ignoring air resistance and taking g = 9.81 m s^{-2}, deduce whether the kick scores. [5]

C6 An aircraft on a flood-relief flight travels horizontally at 65 m s^{-1} at a height of 300 m, aiming to drop a supply package onto a marked target. Ignoring air resistance and taking g = 9.81 m s^{-2}, calculate the horizontal distance before the target at which the package must be released, and state where the aircraft is relative to the package at the moment it lands. [4]