Projectile Motion Worksheet

Module 5: Advanced Mechanics

Instructions

Complete all questions. Show all working for calculation questions. Use $g = 9.8$ m/s^2 unless otherwise specified.

Equipment needed: Scientific calculator, ruler

Part A: Fundamental Calculations (15 marks)

Question 1 (3 marks)

A ball is thrown horizontally at 12 m/s from a cliff 80 m high.

(a) Calculate the time for the ball to hit the ground. (1 mark)

> **Working Space**
>
> $y = \frac{1}{2}gt^2$ (since $u_y = 0$)

(b) Calculate the horizontal distance from the base of the cliff. (1 mark)

(c) Calculate the speed of the ball just before it hits the ground. (1 mark)

Question 2 (4 marks)

A projectile is launched at 40 m/s at an angle of 30° above the horizontal.

(a) Calculate the initial horizontal velocity component. (1 mark)

(b) Calculate the initial vertical velocity component. (1 mark)

(c) Calculate the maximum height reached. (2 marks)

Question 3 (4 marks)

A stone is thrown upward at 25 m/s at 53° to the horizontal from ground level.

(a) Calculate the time of flight. (2 marks)

(b) Calculate the horizontal range. (2 marks)

Question 4 (4 marks)

A ball is kicked at 20 m/s at 45° above the horizontal from a cliff 50 m above the sea.

(a) Calculate the time for the ball to hit the water. (3 marks)

(b) How far from the base of the cliff does the ball land? (1 mark)

Part B: Analysis Questions (15 marks)

Question 5 (3 marks)

Explain why the horizontal and vertical components of projectile motion can be analysed independently.

Question 6 (4 marks)

Two projectiles are launched simultaneously from the same point. Projectile A is launched at 30° and Projectile B at 60°, both with the same initial speed.

(a) Which projectile has the greater range? Explain. (2 marks)

(b) Which projectile reaches a greater maximum height? Justify your answer. (2 marks)

Question 7 (4 marks)

A football is kicked at 25 m/s at an angle of 40° above the horizontal.

(a) At what time(s) is the football at a height of 10 m? (3 marks)

(b) What is the horizontal displacement at each of these times? (1 mark)

Question 8 (4 marks)

A rescue package is dropped from a helicopter flying horizontally at 30 m/s at a height of 150 m.

(a) Where should the helicopter be (relative to the target) when the package is released? (2 marks)

(b) What is the velocity of the package (magnitude and direction) when it reaches the ground? (2 marks)

Part C: Extended Response (10 marks)

Question 9 (5 marks)

A golf ball is hit with an initial speed of 50 m/s at 35° above the horizontal. A tree 80 m away has a height of 15 m.

(a) Calculate the time for the ball to travel 80 m horizontally. (2 marks)

(b) Determine the height of the ball when it reaches the tree. (2 marks)

(c) Will the ball clear the tree? Justify your answer. (1 mark)

Question 10 (5 marks)

A basketball player shoots from 6.0 m horizontally from the basket. The ball is released at a height of 2.0 m and must enter the basket at a height of 3.0 m.

If the ball is thrown at an angle of 50° above the horizontal:

(a) Calculate the initial speed required. (4 marks)

(b) Calculate the time of flight. (1 mark)

Hint

Set up simultaneous equations using the horizontal and vertical displacement equations.

Answers

Part A Answers

Q1: (a) $t = 4.04$ s (b) $x = 48.5$ m (c) $v = 42.4$ m/s at 73° below horizontal
Q2: (a) $u_x = 34.6$ m/s (b) $u_y = 20$ m/s (c) $H = 20.4$ m
Q3: (a) $T = 4.08$ s (b) $R = 61.3$ m
Q4: (a) $t = 4.6$ s (b) $x = 65$ m

Part B Answers

Q5: Gravity only acts vertically, so horizontal motion is unaffected. Horizontal velocity remains constant while vertical motion undergoes constant acceleration.
Q6: (a) Same range - complementary angles give equal range with same initial speed (b) 60° gives greater height - larger vertical component ($u_y = u\sin 60° > u\sin 30°$)
Q7: (a) $t = 0.70$ s and $t = 2.58$ s (b) $x = 13.4$ m and $x = 49.4$ m
Q8: (a) 166 m before target (b) $v = 61.8$ m/s at 61° below horizontal

Part C Answers

Q9: (a) $t = 1.95$ s (b) $y = 37.1$ m (c) Yes, 37.1 m $>$ 15 m
Q10: (a) $v = 9.5$ m/s (b) $t = 0.98$ s