AP PHYSICS C: MECHANICS • EXERCISE SHEET

1.5 Motion in Two or Three Dimensions

Name: _____ Class: _____ Date: _____ **Total: 16 marks**

Objective

Build the skills to answer exam questions on **motion in two dimensions** —especially projectiles.

You must be able to:

- treat the horizontal and vertical motions as **independent** 独立
- use constant velocity horizontally and free-fall acceleration g vertically
- find the **time of flight** 飞行时间 from the vertical motion, then the range from the horizontal
- combine perpendicular velocity components into a resultant

1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

■ Independent axes

In projectile motion the two axes do not affect each other:

- horizontal: constant velocity, $x = v_x t$;
- vertical: free fall, $a_y = -g$.

They share only the **time** t.

■ Horizontal launch

A ball rolls off a table at $v_x = 5$ m s^{-1} from height $h = 1.25$ m. Vertical: $h = \frac{1}{2}gt^2$, so

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2(1.25)}{10}} = 0.5 \text{ s}.$$

Horizontal range: $x = v_x t = 5 \times 0.5 = 2.5$ m.

■ Combining velocity components

At any instant the speed is $\sqrt{v_x^2 + v_y^2}$. If $v_x = 5$ and $v_y = 5$, speed $= \sqrt{50} \approx 7.1$ m s^{-1}.

2 Practice

Now apply the methods above.

2.1 State what the horizontal and vertical motions of a projectile share in common. [1]

2.2 A ball is thrown horizontally at 8 m s^{-1}. State its horizontal acceleration (ignore air resistance). [1]

2.3 A stone falls from rest for 2 s. Find its vertical velocity (use $g = 10$ m s^{-2}). [2]

2.4 A projectile has $v_x = 6$ m s^{-1} and $v_y = 8$ m s^{-1} at some instant. Find its speed. [2]

3 Exam-style questions

3.1 For a projectile (no air resistance), the horizontal velocity [1]

- **A** increases
- **B** decreases
- **C** stays constant
- **D** becomes zero at the top

3.2 Two balls leave a table at the same instant; one is dropped and one is thrown horizontally. They [1]

- **A** land at the same time
- **B** the dropped one lands first
- **C** the thrown one lands first
- **D** never land

3.3 A ball is launched horizontally at 10 m s^{-1} from a height of 5 m ($g = 10$ m s^{-2}).

(a) Find the time to reach the ground. [2]

(b) Find the horizontal range. [2]

3.4 A projectile's velocity components are $v_x = 12$ m s^{-1} and $v_y = -5$ m s^{-1}.

(a) Find the speed. [2]

(b) Find the angle below the horizontal. [1]

4 Go further

You are ready for more on this subtopic:

- work through the interactive **1.5 Motion in Two or Three Dimensions** lesson on the **Learn** page;
- read the **Kinematics** section of the AP Physics C: Mechanics handout on the **Know** page for the full explanation and worked diagrams.

Solutions

2.1 The time of flight (both motions happen over the same time).

2.2 Zero —there is no horizontal force.

2.3 $v = gt = 10 \times 2 = 20$ m s^{-1}.

2.4 $\sqrt{6^2 + 8^2} = 10$ m s^{-1}.

3.1 C —with no horizontal force, the horizontal velocity is constant.

3.2 A —the vertical motions are identical, so they land together.

3.3 (a) $t = \sqrt{2h/g} = \sqrt{2(5)/10} = 1$ s. (b) $x = v_x t = 10 \times 1 = 10$ m.

3.4 (a) $\sqrt{12^2 + 5^2} = 13$ m s^{-1}. (b) $\tan^{-1}(5/12) = 23°$ below the horizontal.