

4

Motion in Two Dimensions

CHAPTER OUTLINE

- 4.1 The Position, Velocity, and Acceleration Vectors
- 4.2 Two-Dimensional Motion with Constant Acceleration
- 4.3 Projectile Motion
- 4.4 Uniform Circular Motion
- 4.5 Tangential and Radial Acceleration
- 4.6 Relative Velocity and Relative Acceleration

ANSWERS TO QUESTIONS

- Q 4.1** Yes. An object moving in uniform circular motion moves at a constant speed, but changes its direction of motion. An object cannot accelerate if its velocity is constant.
- Q 4.2** No, you cannot determine the instantaneous velocity. Yes, you can determine the average velocity. The points could be widely separated. In this case, you can only determine the average velocity, which is

$$\bar{\mathbf{v}} = \frac{\Delta \mathbf{x}}{\Delta t}$$



Q 4.4 (a) $10\hat{i}$ m/s

(b) $-8.50\hat{j}$ m/s²

- Q 4.5** The easiest way to approach this problem is to determine acceleration first, velocity second and finally position.
- Vertical: In free flight, $a_y = -g$. At the top of a projectile's trajectory, $v_y = 0$. Using this, the maximum height can be found using $v_y^2 = v_{iy}^2 + 2a_y(y_f - y_i)$.
- Horizontal: $a_x = 0$, so v_x is always the same. To find the horizontal position at maximum height, one needs the flight time, t . Using the vertical information found previously, the flight time can be found using $v_{fy} = v_{iy} + a_y t$. The horizontal position is $x_f = v_{ix} t$.
- If air resistance is taken into account, then the acceleration in both the x and y -directions would have an additional term due to the drag.

Q 4.6 A parabola.

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