

Chapter Assessment

Projectile Motion



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Concept Summary

Vector quantities have both magnitude and direction.

A vector is represented by an arrow whose length represents the magnitude of the vector quantity and whose direction represents the direction of the vector quantity.

The resultant of two velocities can be determined from a vector diagram drawn to scale.

Any single vector can be replaced by two components that add by vector rules to form the original vector.

When gravity is the only force acting on a projectile near Earth, the horizontal component of its velocity does not change.

A satellite is continually falling around Earth.

Key Terms

component (3.3)	satellite (3.6)
projectile (3.4)	scalar quantity (3.1)
resolution (3.3)	vector (3.2)
resultant (3.2)	vector quantity (3.1)

Review Questions Check Concepts

- How does a vector quantity differ from a scalar quantity? (3.1)
- Why is speed classified as a scalar quantity and velocity classified as a vector quantity? (3.1)
- If a vector that is 1 cm long represents a velocity of 10 km/h, what velocity does a vector 2 cm long drawn to the same scale represent? (3.2)
- When a rectangle is constructed in order to add velocities, what represents the resultant of the velocities? (3.2)
- Why do we say a rectangle is a special case of a parallelogram? (3.2)
- Will a vector at 45° to the horizontal be larger or smaller than its horizontal and vertical components? By how much? (3.3)
- Why does a bowling ball move without acceleration when it rolls along a bowling alley? (3.4)
- In the absence of air resistance, why does the horizontal component of velocity for a projectile remain constant while the vertical component changes? (3.4)
- How does the downward component of the motion of a projectile compare with the motion of free fall? (3.4)
- At the instant a ball is thrown horizontally over a level range, a ball held at the side of the first is released and drops to the ground. If air resistance is neglected, which ball strikes the ground first? (3.4)
- How far below an initial straight-line path will a projectile fall in one second? (3.5)
 - Does your answer depend on the angle of launch or on the initial speed of the projectile? Defend your answer. (3.5)
- At what angle should a slingshot be oriented for maximum altitude? For maximum horizontal range? (3.5)
- Neglecting air resistance, if you throw a ball straight up with a speed of 20 m/s, how fast will it be moving when you catch it? (3.5)
- Neglecting air resistance, if you throw a baseball at 20 m/s to your friend who is on first base, will the catching speed be greater than, equal to, or less than 20 m/s?
 - Does the speed change if air resistance is a factor? (3.5)

15. What do we call a projectile that continually "falls" around Earth? (3.6)
16. How fast must a projectile moving horizontally travel so that the curve it follows matches the curve of Earth? (3.6)
17. Why is it important that such a satellite be above Earth's atmosphere? (3.6)
18. What force acts on a satellite that is above Earth's atmosphere? (3.6)

Plug and Chug *Use Equations*



19. Calculate the resultant velocity of an airplane that normally flies at 200 km/h if it encounters a 50-km/h tailwind. If it encounters a 50-km/h headwind.
20. Calculate the resultant of the pair of velocities 100 km/h north and 75 km/h south. Calculate the resultant if both of the velocities are directed north.
21. Calculate the magnitude of the resultant of a pair of 100-km/h velocity vectors that are at right angles to each other.
22. Calculate the magnitude of the horizontal and vertical components of a vector that is 100 units long and is oriented at 45° .
23. Calculate the resultant of a horizontal vector with a magnitude of 4 units and a vertical vector with a magnitude of 3 units. How does the resultant compare with the hypotenuse of a right triangle having sides of 3 and 4 units?
24. A right triangle with sides of 3, 4, and 5 units has angles that are 37° , 53° , and 90° , respectively. Which of its sides is the hypotenuse? Which side is opposite the 37° angle? Which side is opposite the 53° angle?
25. What are the horizontal and vertical components of a 10-unit vector that is oriented 37° above the horizontal?
26. What are the horizontal and vertical components of a 10-unit vector that is oriented 53° above the horizontal?

27. The launching velocity of a projectile is 20 m/s at 53° above the horizontal. What is the vertical component of its velocity at launch? Its horizontal component of velocity? Neglecting air friction, which of these components remains constant throughout the flight path? Which of these components determines the projectile's time in the air?
28. Satellites in a circular, low Earth-orbit move at 8 km/s. Convert this speed to miles per hour. (There are about 1.6 km in 1 mile and 3600 s in 1 h.)

Think and Explain *Think Critically*

29. What is the maximum possible resultant of two vectors with magnitudes of 4 and 5 units? What is the minimum possible resultant?
30. If you swim in a direction directly across a river and you end up downstream due to the flow of water, do you move faster than you would if the water didn't flow? Explain.
31. The speed of falling rain is the same 10 m above ground as it is just before it hits the ground. What does this tell you about whether or not the rain encounters air resistance?
32. Rain falling vertically will make vertical streaks on a car's side window. However, if the car is moving, the streaks are slanted. If the streaks from a vertically falling rain make 45° streaks, how fast is the car moving compared with the speed of the falling rain?
33. You're driving behind a car and wish to pass, so you turn to the left and pull into the passing lane without changing speed. Why does the distance increase between you and the car you're following?
34. A projectile is launched straight up at 141 m/s. How fast is it moving at the top of its trajectory? Suppose it is launched upward at 45° above the horizontal plane. How fast is it moving at the top of its curved trajectory?

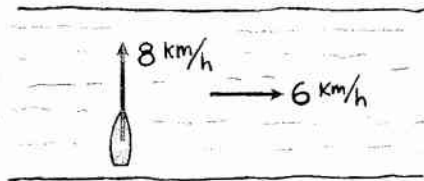
35. When you jump up, your hang time is the time your feet are off the ground. Does hang time depend on your vertical component of velocity when you jump, your horizontal component of velocity, or both? Defend your answer.
36. The hang time of a basketball player who jumps a vertical distance of 2 feet (0.6 m) is $\frac{2}{3}$ second. What will be the hang time if the player reaches the same height while jumping a horizontal distance of 4 feet (1.2 m)?
37. Assuming no air resistance, why does a projectile launched horizontally at 8 km/s not strike Earth's surface?
38. We think of something falling if it gets closer to the ground. Yet a satellite in circular orbit does not get closer to the ground, because Earth curves as much as the satellite's trajectory does. So how can we say it falls? (*Hint:* Compare the position of the satellite with the imaginary line it would follow if there were no gravity. Does it fall beneath this line?)

Think and Solve

Develop Problem-Solving Skills

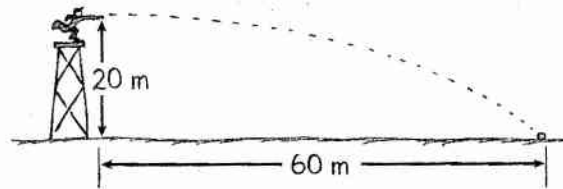


39. A boat is rowed at 8 km/h directly across a river that flows at 6 km/h, as shown in the figure.



- a. What is the resultant speed of the boat?
- b. How fast and in what direction can the boat be rowed to reach a destination directly across the river?
40. A girl is playing shuffleboard on an ocean liner that travels due north at 3 m/s. She makes a starboard shot (toward the east), relative to the deck, of 4 m/s. What is the velocity of the puck relative to the stationary stars?

41. Harry accidentally falls out of a helicopter that is traveling at 100 m/s. He plunges into a swimming pool 2 seconds later. Assuming no air resistance, what was the horizontal distance between Harry and the swimming pool when he fell from the helicopter?
42. Harry and Angela look from their balcony to a swimming pool below that is 15 m from the bottom of their building. They estimate the balcony is 45 m high and wonder how fast they would have to jump horizontally to succeed in reaching the pool. What is your answer?
43. A girl throws a slingshot pellet directly at a target that is far enough away to take one-half second to reach. How far below the target does the pellet hit? How high above the target should she aim?
44. The boy on the tower in the figure below throws a ball a distance of 60 m, as shown. At what speed, in m/s, is the ball thrown?



45. A shiny new sports car sits in the parking lot of a car dealership. Above is a cargo plane, flying horizontally at 50 m/s. At the exact moment the plane is 125 m directly above the car, a heavy crate accidentally falls from its cargo doors. Relative to the car, where will the crate hit?
46. A cannonball launched with an initial velocity of 141 m/s at an angle of 45° follows a parabolic path and hits a balloon at the top of its trajectory. Neglecting air resistance, how fast is it going when it hits the balloon? What is the acceleration of the cannonball just before it hits the balloon?



More Problem-Solving Practice
Appendix F