2D Kinematics

Projectile Motion and Relative Motion

1. A volleyball is spiked so that it has an initial velocity of 15 m/s directed downward at an angle of 55° below the horizontal. What is the horizontal component of the ball's velocity when the opposing player fields the ball?

2. A tennis ball is hit horizontally with a speed of 28.0 m/s. The ball hits the court at a horizontal distance of 19.6 m from the racket. How far above the court is the tennis ball when it leaves the racket?

3. A horizontal rifle is fired at a bull's-eye. The speed of the bullet is 670 m/s. The gun is pointed directly at the center of the bull's-eye, but the bullet strikes the target 0.025 m below the center. What is the horizontal distance between the end of the rifle and the bull's-eye?

4. A golfer this a ball with a speed of 30.3 m/s at an angle of 45° above the ground. How far does the ball travel? Assume the tee and the green are at the same elevation.

5. When chasing a hare along a flat stretch of ground, a greyhound leaps into the air at a speed of 10.0 m/s, at an angle of 31.0° above the horizontal. How long is the dog in the air?

6. A skateboarder shoots off a ramp with a velocity of 6.6 m/s, directed at an angle of 58° above the horizontal. The end of the ramp is 1.2 m above the ground.
   (a) How high above the ground is the highest point that the skateboarder reaches?
   (b) When the skateboarder reaches the highest point, how far is this point horizontally from the end of the ramp?

7. A spider, crawling across a table, leaps onto a magazine blocking its path. The initial velocity of the spider is 0.870 m/s at an angle of 35.0° above the table, and it lands on the magazine 0.0770 s after leaving the table. How thick, in millimeters, is the magazine?

8. A criminal runs off a roof horizontally at a speed of 5.3 m/s, hoping to land on the roof of an adjacent building. The horizontal distance between the two buildings is D, and the roof of the adjacent building is 2.0 m below the jumping-off point. Find the maximum value for D.

9. A major-league pitcher can throw a baseball more than 41.0 m/s. If a ball is thrown horizontally at this speed, how much will it drop by the time it reaches a catcher who is 17.0 m away from the point of release?

10. A quarterback claims that he can throw the football a horizontal distance of 183 m (200 yd). Furthermore, he claims that he can do this by launching the ball at the relatively low angle of 30.0° above the horizontal. To evaluate this claim, calculate the speed with which this quarterback must throw the ball. Assume that the ball is launched and caught at the same vertical level and that air resistance can be ignored.

11. A projectile is fired at a speed of 75.0 m/s from ground level, at an angle of 60.0° above the horizontal. The projectile is fired toward an 11.0 m high wall, which is located 27.0 m away. By how much does the projectile clear the top of the wall?

12. An airplane with a speed of 97.5 m/s is climbing upward at an angle of 50.0° with respect to the horizontal. When the plane's altitude is 732 m, the pilot releases a package. Calculate the distance along the ground, measured from a point directly beneath the point of release, to where the package hits the ground.

13. You are traveling in a convertible with the top down. The car is moving at a constant velocity of 25 m/s, due east along flat ground. You throw a tomato straight upward at a speed of 11 m/s. How far has the car moved when you get a chance to catch the tomato?

14. A child operating a radio-controlled model car on a dock accidentally steers it off the edge. The car's displacement 1.1 s after leaving the dock has a magnitude of 7.0 m. What is the car's speed at the instant it drives off the edge of the dock?

15. When kicking a field goal, the ball must be at least 3.0 m above the ground when it reaches the goal post. The average kicker kicks the ball with a speed of 31 m/s at an angle of 33° above the ground. Calculate the maximum length of an average field goal.

16. An airplane has an air speed of 200 m/s due North and is in a wind of 50.0 m/s to the West. Calculate the airplane's speed relative to the ground.

17. The driver of a motorboat that can move at 10 m/s in still water wishes to travel directly across a river 1.6 km wide in which the current flows at 5.0 m/s. How long will it take to cross the river?

18. Your motorboat can move at 30 km/h in still water. How much time will it take you to move 12 km downstream, in a river flowing at 6.0 km/h?

19. A swimmer, capable of swimming at a speed of 1.4 m/s in still water starts to swim directly across a 2.8 km wide river. The current is 0.91 m/s, and it carries the swimmer downstream. How far downstream will the swimmer be upon reaching the other side of the river?

20. The captain of a plane wishes to fly due west. The cruising speed of the plane is 245 m/s relative to the air. A weather report indicates that a 38.0 m/s wind is blowing from the south to the north. In what direction should the pilot head the plane?