# Projectiles

1. A bullet is fired from a rifle that is held 1.6 m above the ground in a horizontal position. The initial speed of the bullet is 1100 m/s. Find
(a) the time it takes for the bullet to strike the ground and
(b) the horizontal distance traveled by the bullet.

2. A golf ball at John's MegaMini Golf rolls off a horizontal cliff with an initial speed of 11.4 m/s. The ball falls a vertical distance of 15.5 m into a water hazard below.
(a) How much time does the ball spend in the air?
(b) What is the velocity of the ball just before it strikes the water (magnitude and direction)?

3. A major league pitcher can throw a baseball in excess of 41 m/s. If a ball is thrown horizontally at this speed, how much can it be expected to drop due to gravity by the time it reaches a catcher who is 17 m away from the point of release? Pitcher's mounds are raised to compensate for this drop.

4. A car drives straight off the edge of a cliff that is 50 m high. The police at the scene of the accident note that the point of impact is 130 m from the base of the cliff. How fast was the car traveling when it went over the cliff?

5. A jet fighter is traveling horizontally with a speed of 111 m/s at an altitude of 300 m, when the pilot accidentally releases an outboard fuel tank.
(a) How much time elapses before the tank hits the ground.
(b) What is the velocity of the tank (magnitude and direction) just before it hits the ground?

6. Suppose the water at the top of Niagara Falls has a horizontal speed of 2.7 m/s before it cascades over the edge of the falls. The height of the falls is 59 m. What is the magnitude of the water's velocity just before the water strikes the bottom? Treat the water particles as if they are in free fall.

7. A horizontal rifle is fired at a bull's eye. The muzzle speed ofthe bullet is 670 m/s. The barrel is pointed directly at the center of the bull's eye, but the bullet strikes the target 2.5 cm below the center. What is the horizontal distance between the end of the rifle and the bull's eye?

8. A criminal is escaping across a rooftop and runs off the roof horizontally, landing on the roof of an adjacent building. The horizontal distance between the two buildings is 3.4 m, and the roof of the adjacent building is 2 m below the jumping off point. What would be the minimum speed needed by the criminal?

9. A ball is thrown horizontally from the top of a building 35 m high. The ball strikes the ground 80 m from the base of the building. Find
(a) the time the ball is in flight,
(b) its initial velocity,
(c) The horizontal and vertical components of the velocity just before the ball strikes the ground.

10. A quarterback throws a pass to a receiver, who catches it at the same height as the pass is thrown. The initial velocity of the ball is 15 m/s, at an angle of 25° above the horizontal. What is the horizontal component of the ball's velocity when the receiver catches it?

11. A rock climber throws a small first aid kit to another climber who is higher up on the mountain. The initial velocity of the kit is 11 m/s at an angle of 65° above the horizontal. At the instant the kit is caught, it is traveling horizontally. What is the vertical height between the two climbers?

12. With a particular club, the maximum speed that a golfer can impart to a ball is 30.3 m/s. Assume the tee and green are at the same elevation.
(a) What is the longest hole in one the golfer can make, if the ball does not roll when it hits the green?
(b) How much time does the ball spend in the air?

13. If a projectile has a launching angle of 52° above the horizontal and an initial speed of 18 m/s, what is the highest barrier that the projectile can clear?

14. A golfer drives the ball at an angle of 30° with the horizontal at a speed of 40 m/s.
    (a) How high does it rise?
    (b) If the green is 3 m above the initial position of the ball and 160 m away, does the ball land on the green?

15. If the maximum horizontal distance (θ=45°) that a ball can be thrown is 47 m, How high can it be thrown straight upward, assuming the same throwing speed in each case?

16. During a baseball game a fly ball is hit to center field and is caught 90 m from home plate. Just when the ball is caught, a runner on third base takes off for home, and the center fielder throws the ball to the catcher standing on home plate. The runner takes 3.5 seconds to reach home. It arrives at home plate at the exact same instant as the runner. Assume the ball is caught at the same height from which it was thrown.
    (a) What is the horizontal component of the throw home?
    (b) What is the vertical component of the throw home?
    (c) What is the initial velocity of the ball as it left the center fielder's hand (magnitude and direction)?

17. A motorcycle daredevil is attempting to jump across as many buses as possible. The takeoff ramp makes an angle of 18° above the horizontal, and the landing ramp is identical to the takeoff ramp. The buses are parked side-by-side, and each bus is 2.74 m wide. The cyclist leaves the ramp with a speed of 33.5 m/s. What is the maximum number of buses over which the cyclist can jump?
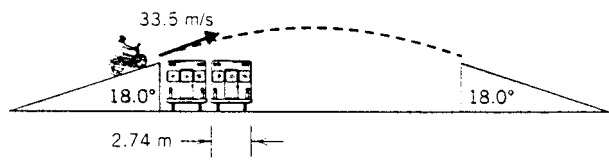
18. An airplane, with a speed of 97.5 m/s, is climbing upward at an angle of 50° with respect to the horizontal. When the plane's altitude is 732 m, the pilot releases a package.
    (a) Calculate the distance along the ground, measured from a point directly beneath the plane, to the point where the package hits the earth.
    (b) Relative to the ground, determine the angle of the velocity vector of the package just before impact.

19. An archer is standing inside a building whose ceiling is 11 m tall. An arrow is shot from ground level at an initial speed of 62 m/s. Calculate the angle of firing (above the horizontal) that gives the greatest possible range inside the building

20. An airplane is flying with a velocity of 240 m/s at an angle of 30° with the horizontal, as the drawing shows. When the altitude of the plane is 2.4 km, a flare is released from the plane. The flare hits the target of the ground. What is the angle θ?
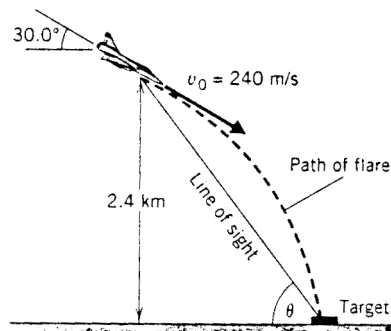
21. A footballer kicks a football at an angle of 30° with the horizontal and at an initial speed of 20 m/s. Where should another player position himself to catch the ball at the same height from which it was kicked?

22. A football kicked at an angle of 50° to the horizontal travels a horizontal distance of 20 m before hitting the ground. Find
    (a) the initial speed of the ball,
    (b) the time it is in the air,
    (c) the maximum height it reaches.

23. A home run is hit in such a way that the ball just clears a wall 21 m high located 130 m from home plate. The ball is hit an an angle of 35° to the horizontal, and air resistance is negligible. Assume the ball is hit from a height of 1 m off the ground. Find
    (a) the initial speed of the ball, and
    (b) the time it takes the ball to reach the wall.

24. The velocity of a spacecraft is 2650 m/s, directed at an angle of 30° above the x axis. Two engines fire for a time of 475 s. One gives the spacecraft an acceleration in the +x direction of 6.30 m/s^2. The other produces an acceleration in the +y direction of 2.85 m/s^2. What is the speed of the spacecraft when the engines shut off?

Answers (odd)
1. 629m   3. 0.84m   5. a) 7.82s b) 134.9m/s at 35° below horizontal   7. 47.9m   9. a) 2.67s b) 30.0m/s c) 30.0m/s 11.
50.55m   13. 10.3m   15. 47m   17. 24   19. 13.7°   21. 35.3m   23. a)34.5m/s b) 4.6s