**2-D Motion Practice Problems**

1. You throw two identical balls simultaneously at the same initial speed: one downward and the other horizontally. Describe and compare their motion in as much detail as you can.
2. Your friend says the vertical force exerted on a projectile when at the top of its flight is zero. Why would he say this? Do you agree or disagree? If you disagree, how would you convince your friend that your opinion is correct?
3. There are competitions in which pilots fly small planes low over the ground and drop weights, trying to hit a target. A pilot flying low and slow drops a weight; it takes 2.0 s to hit the ground, during which it travels a horizontal distance of 100 m. Now the pilot does a run at the same height but twice the speed. How much time does it take the weight to hit the ground? How far does it travel before it lands?
4. A projectile is shot horizontally at 23.4 m/s from the roof of a building 55 m tall and experiences negligible air resistance.
   1. Determine the time necessary for the projectile to reach the ground below. ***3.4 s***
   2. Determine the distance from the base of the building that the projectile lands. ***78 m***
   3. Determine the horizontal and vertical components of the velocity just before the projectile reaches the ground. ***vx = 23.4 m/s; vy = 33 m/s;***
5. A celebrating student throws a water balloon horizontally from a dormitory window that is 50 m above the ground. It hits the ground at a point 60 m from the building without appreciable air resistance.
   1. What will be the horizontal component of the velocity of the balloon just before it hits the ground? ***19 m/s***
   2. What will be the magnitude of the vertical velocity of the balloon just before it hits the ground? ***31 m/s***
6. A girl throws a rock horizontally with a speed of 12 m/s from a bridge. It falls 2.28 s before hitting the water below. Neglect air resistance.
   1. How high is the bridge from the water below? ***25 m***
   2. How far horizontally does the rock travel before striking the water? ***27 m***
7. A hunter points a rifle horizontally and holds it 3.30 m above the ground. The bullet leaves the barrel at 325 m/s and experiences no significant air resistance. The acceleration due to gravity at this location is 9.80 m/s2.
   1. How long does it take for the bullet to strike the ground? ***0.821 s***
   2. How far horizontally does it travel? ***267 m***
8. A person throws a ball horizontally from the top of a building that is 24.0 m above the ground level. The ball lands 100 m down range from the base of the building. What was the initial velocity of the ball? ***45.2 m/s***
9. A plane flying horizontally at a speed of 50 m/s and at an elevation of 160 m drops a package, and 2.0 s later it drops a second package. How far apart will the two packages land on the ground if air resistance is negligible? ***100 m***
10. A hockey puck slides off the edge of a platform with an initial velocity of 20 m/s horizontally. The height of the platform above the ground is 2.0 m. What is the magnitude of the velocity of the puck just before it touches the ground? ***21 m/s***

*Extension*

1. A projectile leaves the ground at 150 m/s and reaches a maximum height of 0.57 km. If there was no air resistance, at what angle above the horizontal did it leave the ground? ***45°***
2. A boy throws a ball with an initial velocity of 25 m/s at an angle of 30° above the horizontal. If air resistance is negligible, how high above the projection point is the ball after 2.0 s? ***5.4 m***
3. A boy kicks a football from ground level with an initial velocity of 20 m/s at an angle of 30° above the horizontal. What is the horizontal distance to the point where the football hits the ground if we neglect air resistance? ***35 m***
4. A child is trying to throw a ball over a fence. She gives the ball an initial speed of 8.0 m/s at an angle of 40° above the horizontal. The ball leaves her hand 1.0 m above the ground and the fence is 2.0 m high. The ball just clears the fence while still traveling upwards and experiences no significant air resistance. How far is the child from the fence? ***1.6 m***