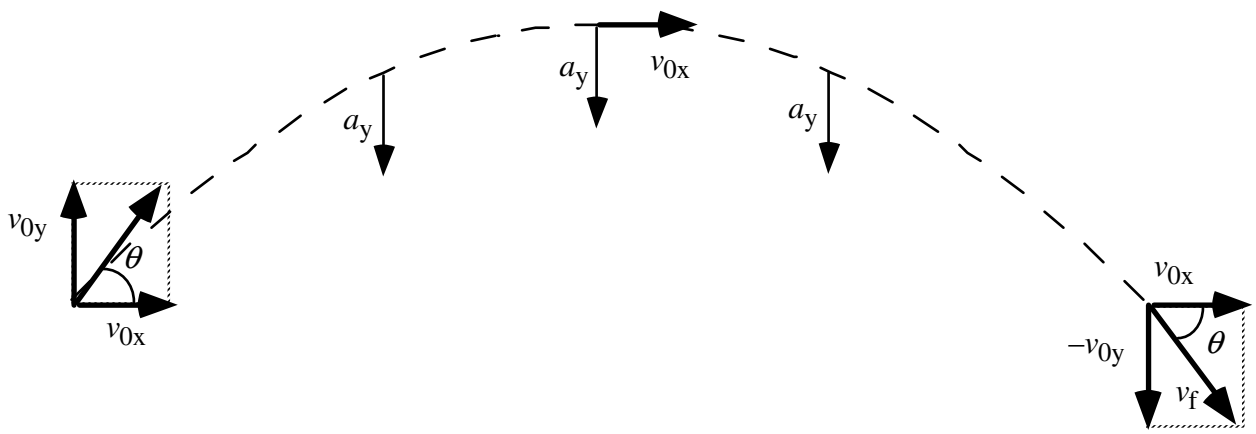
2. ***REASONING AND SOLUTION*** An object thrown upward at an angle θ will follow the trajectory shown below. Its acceleration is that due to gravity, and, therefore, always points downward. The acceleration is denoted by a_y in the figure. In general, the velocity of the object has two components, v_x and v_y. Since $a_x = 0$, v_x always equals its initial value. The y component of the velocity, v_y, decreases as the object rises, drops to zero when the object is at its highest point, and then increases in magnitude as the object falls downward.

a. Since $v_y = 0$ when the object is at its highest point, the velocity of the object points only in the x direction. As suggested in the figure below, the acceleration will be perpendicular to the velocity when the object is at its highest point and $v_y = 0$.



b. In order for the velocity and acceleration to be parallel, the x component of the velocity would have to drop to zero. However, v_x always remains equal to its initial value; therefore, the velocity and the acceleration can never be parallel.

4. ***REASONING AND SOLUTION*** If a baseball were pitched on the moon, it would still fall downwards as it travels toward the batter. However the acceleration due to gravity on the moon is roughly 6 times less than that on earth. Thus, in the time it takes to reach the batter, the ball will not fall as far vertically on the moon as it does on earth. Therefore, the pitcher's mound on the moon would be at a lower height than it is on earth.

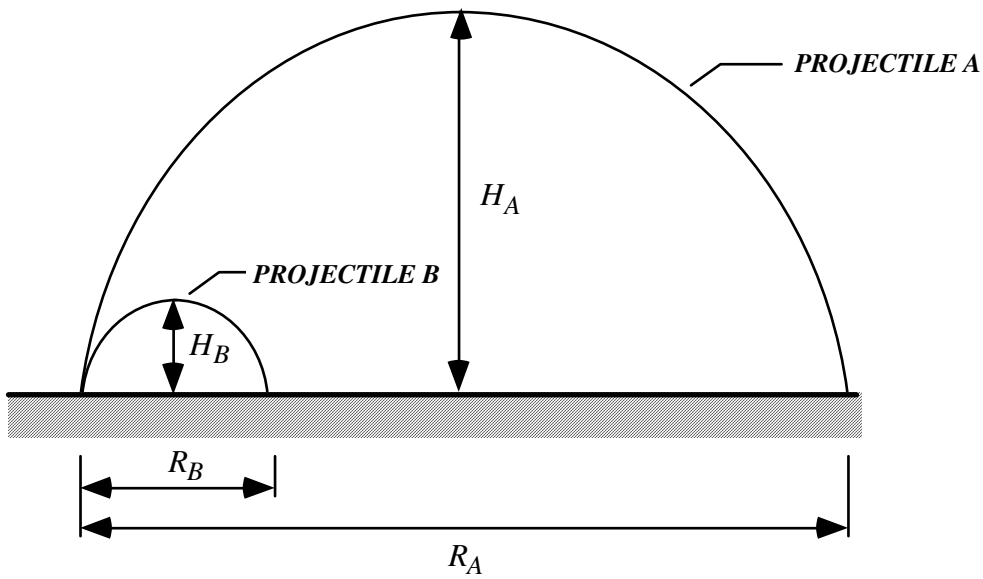
8. ***REASONING AND SOLUTION*** The two bullets differ only in their horizontal motion. One bullet has $v_x = 0$, while the other bullet has $v_x = v_{0x}$. The time of flight, however, is determined only by the vertical motion, and both bullets have the same initial vertical velocity component ($v_{0y} = 0$). Both bullets, therefore, reach the ground at the same time.

9. ***REASONING AND SOLUTION*** Since the launch speed of projectile A is twice that of B, it follows that

$$(v_{0x})_{\mathrm{A}} = 2(v_{0x})_{\mathrm{B}} \quad \text{and} \quad (v_{0y})_{\mathrm{A}} = 2(v_{0y})_{\mathrm{B}}$$

As seen from the result of Example 5, the maximum height attained by either projectile is directly proportional to the square of v_{0y}^2; therefore, the ratio of the maximum heights is $H_{\mathrm{A}} / H_{\mathrm{B}} = (2)^2 = 4$. Example 7 in the text shows that the range of either projectile is directly proportional to the product of v_{0x} and t. Example 6 shows that t is proportional to v_{0y}; thus,

$$\frac{R_{\mathrm{A}}}{R_{\mathrm{B}}} = \frac{(v_{0x})_{\mathrm{A}}\, t_{\mathrm{A}}}{(v_{0x})_{\mathrm{B}}\, t_{\mathrm{B}}} = \frac{(v_{0x})_{\mathrm{A}}\,(v_{0y})_{\mathrm{A}}}{(v_{0x})_{\mathrm{B}}\,(v_{0y})_{\mathrm{B}}} = \frac{\left[2(v_{0x})_{\mathrm{B}}\right]\left[2(v_{0y})_{\mathrm{B}}\right]}{(v_{0x})_{\mathrm{B}}\,(v_{0y})_{\mathrm{B}}} = 4$$



10. ***REASONING AND SOLUTION***

a. The displacement is greater for the stone that is thrown horizontally, because it has the same vertical component as the dropped stone and, in addition, has a horizontal component.

b. The impact speed is greater for the stone that is thrown horizontally. The reason is that it has the same vertical velocity component as the dropped stone but, in addition, also has a horizontal component that equals the throwing velocity.

c. The time of flight is the same in each case, because the vertical part of the motion for each stone is the same. That is, each stone has an initial vertical velocity component of zero and falls through the same height.

6. ***REASONING*** To determine the horizontal and vertical components of the launch velocity, we will use trigonometry. To do so, however, we need to know both the launch angle and the magnitude of the launch velocity. The launch angle is given. The magnitude of the launch velocity can be determined from the given acceleration and the definition of acceleration given in Equation 3.2.

SOLUTION According to Equation 3.2, we have

$$a = \frac{v - v_0}{t - t_0} \quad \text{or} \quad 340\ \text{m/s}^2 = \frac{v - 0\ \text{m/s}}{0.050\ \text{s}} \quad \text{or} \quad v = \left(340\ \text{m/s}^2\right)\left(0.050\ \text{s}\right)$$

Using trigonometry, we find the components to be

$$v_x = v\cos 51° = \left(340\ \text{m/s}^2\right)\left(0.050\ \text{s}\right)\cos 51° = \boxed{11\ \text{m/s}}$$

$$v_y = v\sin 51° = \left(340\ \text{m/s}^2\right)\left(0.050\ \text{s}\right)\sin 51° = \boxed{13\ \text{m/s}}$$

12. ***REASONING AND SOLUTION***

a. The x component of velocity is

$$v_x = v_{0x} + a_x t = 5480 \text{ m/s} + \left(1.20 \text{ m/s}^2\right)(842 \text{ s}) = \boxed{6490 \text{ m/s}}$$

b. For the y component

$$v_y = v_{0y} + a_y t = 0 \text{ m/s} + \left(8.40 \text{ m/s}^2\right)(842 \text{ s}) = \boxed{7070 \text{ m/s}}$$

17. **SSM** **WWW** ***REASONING*** Once the diver is airborne, he moves in the x direction with constant velocity while his motion in the y direction is accelerated (at the acceleration due to gravity). Therefore, the magnitude of the x component of his velocity remains constant at 1.20 m/s for all times t. The magnitude of the y component of the diver's velocity after he has fallen through a vertical displacement y can be determined from Equation 3.6b: $v_y^2 = v_{0y}^2 + 2a_y y$. Since the diver runs off the platform horizontally, $v_{0y} = 0$. Once the x and y components of the velocity are known for a particular vertical displacement y, the speed of the diver can be obtained from $v = \sqrt{v_x^2 + v_y^2}$.

SOLUTION For convenience, we will take downward as the positive y direction. After the diver has fallen 10.0 m, the y component of his velocity is, from Equation 3.6b,

$$v_y = \sqrt{v_{0y}^2 + 2a_y y} = \sqrt{0^2 + 2(9.80\ \text{m/s}^2)(10.0\ \text{m})} = 14.0\ \text{m/s}$$

Therefore,

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(1.20\ \text{m/s})^2 + (14.0\ \text{m/s})^2} = \boxed{14.1\ \text{m/s}}$$

18. ***REASONING***

a. The maximum possible distance that the ball can travel occurs when it is launched at an angle of 45.0°. When the ball lands on the green, it is at the same elevation as the tee, so the vertical component (or y component) of the ball's displacement is zero. The time of flight is given by the y variables, which are listed in the table below. We designate "up" as the $+y$ direction.

y-Direction Data

y	a_y	v_y	v_{0y}	t
0 m	$-9.80\ \text{m/s}^2$		+(30.3 m/s) sin 45.0° = +21.4 m/s	?

Since three of the five kinematic variables are known, we can employ one of the equations of kinematics to find the time t that the ball is in the air.

b. The longest hole in one that the golfer can make is equal to the range R of the ball. This distance is given by the x variables and the time of flight, as determined in part (a). Once again, three variables are known, so an equation of kinematics can be used to find the range of the ball. The $+x$ direction is taken to be from the tee to the green.

x-Direction Data

x	a_x	v_x	v_{0x}	t
R = ?	$0\ \text{m/s}^2$		+(30.3 m/s) cos 45.0° = +21.4 m/s	from part a

SOLUTION

a. We will use Equation 3.5b to find the time, since this equation involves the three known variables in the y direction:

$$y = v_{0y}t + \tfrac{1}{2}a_y t^2 = \left(v_{0y} + \tfrac{1}{2}a_y t\right)t$$

$$0\ \text{m} = \left[+21.4\ \text{m/s} + \tfrac{1}{2}\left(-9.80\ \text{m/s}^2\right)t\right]t$$

Solving this quadratic equation yields two solutions, $t = 0$ s and $t = 4.37$ s. The first solution represents the situation when the golf ball just begins its flight, so we discard this one. Therefore, $t = \boxed{4.37\ \text{s}}$.

b. With the knowledge that $t = 4.37$ s and the values for a_x and v_{0x} (see the x-direction data table above), we can use Equation 3.5a to obtain the range R of the golf ball.

$$\underbrace{x}_{=R} = v_{0x}t + \tfrac{1}{2}a_x t^2 = \left(+21.4\ \text{m/s}\right)\left(4.37\ \text{s}\right) + \tfrac{1}{2}\left(0\ \text{m/s}^2\right)\left(4.37\ \text{s}\right)^2 = \boxed{93.5\ \text{m}}$$

27. ***REASONING AND SOLUTION*** The time of flight of the motorcycle is given by

$$t = \frac{2v_0 \sin\theta_0}{g} = \frac{2(33.5\text{ m/s})\sin 18.0°}{9.80\text{ m/s}^2} = 2.11\text{ s}$$

The horizontal distance traveled by the motorcycle is then

$$x = v_0 \cos\theta_0\, t = (33.5\text{ m/s})(\cos 18.0°)(2.11\text{ s}) = 67.2\text{ m}$$

The daredevil can jump over (67.2 m)/(2.74 m/bus) = 24.5 buses. In even numbers, this means $\boxed{\text{24 buses}}$.