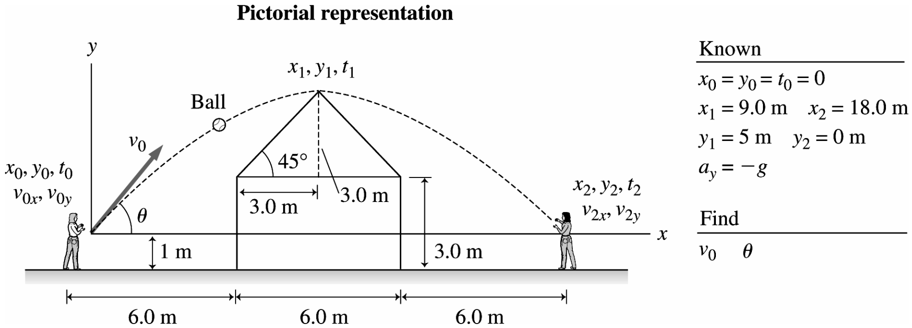
4.49. Model: Use the particle model for the ball and the constant-acceleration kinematic equations.
Visualize:



Solve: (a) The distance from the ground to the peak of the house is 6.0 m. From the throw position this distance is 5.0 m. Using the kinematic equation $v_{1y}^2 = v_{0y}^2 + 2a_y(y_1 - y_0)$,

$$0 \text{ m}^2/\text{s}^2 = v_{0y}^2 + 2(-9.8 \text{ m/s}^2)(5.0 \text{ m} - 0 \text{ m}) \Rightarrow v_{0y} = 9.899 \text{ m/s}$$

The time for up and down motion is calculated as follows:

$$y_2 = y_0 + v_{0y}(t_2 - t_0) + \tfrac{1}{2}a_y(t_2 - t_0)^2 \Rightarrow 0 \text{ m} = 0 \text{ m} + (9.899 \text{ m/s})t_2 - \tfrac{1}{2}(9.8 \text{ m/s}^2)t_2^2 \Rightarrow t_2 = 0 \text{ s and } 2.02 \text{ s}$$

The zero solution is not of interest. Having found the time $t_2 = 2.02$ s, we can now find the horizontal velocity needed to cover a displacement of 18.0 m:

$$x_2 = x_0 + v_{0x}(t_2 - t_0) \Rightarrow 18.0 \text{ m} = 0 \text{ m} + v_{0x}(2.02 \text{ s} - 0 \text{ s}) \Rightarrow v_{0x} = 8.911 \text{ m/s}$$

$$\Rightarrow v_0 = \sqrt{(8.911 \text{ m/s})^2 + (9.899 \text{ m/s})^2} = 13.3 \text{ m/s}$$

(b) The direction of $\vec{v}_0$ is given by

$$\theta = \tan^{-1}\frac{v_{0y}}{v_{0x}} = \tan^{-1}\frac{9.899}{8.911} = 48°$$

Assess: Since the maximum range corresponds to an angle of 45°, the value of 48° corresponding to a range of 18 m and at a modest speed of 13.3 m/s is reasonable.