6.34. **Model:** Use the particle model for the ball and the constant-acceleration kinematic equations.

**Visualize:**

**Known**
- \( x_0 = x_f = t_0 = 0 \)
- \( x_1 = 9.0 \text{ m} \)  \( x_2 = 18.0 \text{ m} \)
- \( y_1 = 5 \text{ m} \)  \( y_2 = 0 \text{ m} \)
- \( a_y = -g \)

**Find**
- \( v_0 \)  \( \theta \)

**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

\[
0 \text{ m}^2/\text{s}^2 = v_{y_0}^2 + 2(-9.8 \text{ m/s}^2)(5.0 \text{ m} - 0 \text{ m}) \Rightarrow v_{y_0} = 9.899 \text{ m/s}
\]

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

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

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

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

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

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

\[
\theta = \tan^{-1} \frac{v_{y_0}}{v_{x_0}} = \tan^{-1} \frac{9.899}{8.911} = 48.0^\circ
\]

**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.