Example 2.6

Hot-air balloon rises with a constant speed \( V_b = 5.0 \text{ m/s} \). At a height of \( H = 21 \text{ m} \) a rock is dropped from the balloon.

(a) Find \( t \) for rock to hit the ground.

\[
\begin{align*}
\text{Rack:} & \quad Y_i = H = 21 \text{ m} \quad V_{iy} = +V_b = 5.0 \text{ m/s} \quad \alpha_y = -9.8 \text{ m/s}^2 \\
& \quad Y_f = 0 \quad V_{fy} = ? \\
& \quad t = ?
\end{align*}
\]

No \( V_{fy} \):

\[
Y_f = Y_i + V_{iy}t + \frac{1}{2} \alpha_y t^2
\]

\[
(\frac{1}{2} \alpha_y) t^2 + (V_{iy}) t + (Y_i) = 0 \quad \text{Quadratic in } t!
\]

Quadratic solution:

\[
t = -\frac{(V_{iy}) \pm \sqrt{(V_{iy})^2 - 4 \left( \frac{1}{2} \alpha_y \right)(Y_i)}}{2 \left( \frac{1}{2} \alpha_y \right)} = \left\{ \begin{array}{l}
-1.62 \text{ s using } (+) \\
2.64 \text{ s using } (-)
\end{array} \right.
\]

Since \( t > 0 \), we have

\[
\boxed{t = 2.64 \text{ s}}
\]

(b) Find final speed. Note: speed is always positive!

Find \( V_{fy} \):

\[
V_{fy} = V_{iy} + \alpha_y t = -20.9 \text{ m/s} \quad \text{\( \alpha_y \)-component of velocity.}
\]

The final speed is then

\[
20.9 \text{ m/s} = V_f
\]