**Example 1:** Bob throws a ball straight up at 20 m/s, releasing the ball 1.5 m above the ground. What is the maximum height of the ball? What is the ball’s impact speed as it hits the ground?

**Example 2:** A ball is released at a height of 1.0 m on a frictionless 30° slope. At the bottom, it turns smoothly onto a 60° slope going back up. What maximum height does it reach on the right side?

![Diagram](image)

**Example 3:** A sprinter accelerates at 2.5 m/s² until reaching his top speed of 15 m/s. He then continues to run at top speed. How long does it take him to run the 100-m dash?

**Example 4:** Ball A rolls along a frictionless, horizontal surface at a speed of 1.0 m/s. Ball B is released from rest at the top of a 2.0-m-long, 10° ramp at the exact instant ball A passes by. Will B overtake A before reaching the bottom of the ramp? If so, at what position?

![Diagram](image)
Example 1

- at the top, \( v_y = 0 \)

Use \( v_{yf}^2 - v_{yi}^2 = 2a_y (y_f - y_i) \)

with \( v_{yf} = 0 \), \( v_{yi} = 20 \text{ m/s} \)
\( a_y = -9.8 \text{ m/s}^2 \)
\( y_f = ? \), \( y_i = 1.5 \text{ m} \)

\[
0^2 - 20^2 = 2(-9.8)(y_f - 1.5)
\]

\[
y_f = 21.9 \text{ m} \quad (\text{maximum height above ground})
\]

- Use again \( v_{yf}^2 - v_{yi}^2 = 2a_y (y_f - y_i) \)

with \( v_{yf} = ? \), \( v_{yi} = 20 \text{ m/s} \)
\( a_y = -9.8 \text{ m/s}^2 \)
\( y_f = 0 \text{ m} \), \( y_i = 1.5 \text{ m} \)

\[
v_{yf}^2 - 20^2 = 2(-9.8)(0 - 1.5)
\]

\[
v_{yf}^2 = 429.4 \text{ m}^2/\text{s}^2
\]

On impact, obviously \( v_{yf} < 0 \)

So \( v_{yf} = -20.7 \text{ m/s} \)
Example 2

- Ball rolling down:

\[
V_{f_1}^2 = V_{i_1}^2 + 2a_1(s_{f_1} - s_{i_1})
\]
with \( V_{i_1} = 0 \text{ m/s} \)
\( V_{f_1} = ? \)
\( a_1 = 9.8 \sin 30^\circ \cdot \)
\( s_{i_1} = 0 \cdot \)
\( s_{f_1} = \frac{1 \text{ m}}{\sin 30^\circ} = 2 \text{ m} \)

\[
V_{f_1}^2 = 0^2 + 2 \cdot 9.8 \cdot \sin 30^\circ \cdot (2 - 0) \\
V_{f_1}^2 = 19.6 \text{ m}^2/\text{s}^2 \\
V_{f_1} = 4.43 \text{ m/s}
\]

- Ball rolling up

at the top, \( V_{f_2} = 0 \)

\[
V_{f_2}^2 - V_{i_2}^2 = 2a_2(s_{f_2} - s_{i_2})
\]
\( V_{i_2} = 4.43 \text{ m/s} \cdot \)
\( a_2 = -9.8 \sin 60^\circ \cdot \)
\( s_{i_2} = 0 \text{ m} \)
\( s_{f_2} = \frac{h_2}{\sin 60^\circ} \cdot \)
\( 0^2 - 19.6 = -2 \cdot 9.8 \sin 60^\circ \left( \frac{h_2}{\sin 60^\circ} - 0 \right) \\
\begin{align*}
0^2 & = 19.6 & -2 \cdot 9.8 \cdot \sin 60^\circ \left( \frac{h_2}{\sin 60^\circ} - 0 \right) \\
h_2 & = 1 \text{ m}
\end{align*}
\]
comes back to the same height.
Example 3

To get to 15 m/s, it takes a time \( t_1 \), such that:

\[
2.5 \times t_1 = 15 \quad \Rightarrow \quad t_1 = 6 \text{ s}
\]

Graph \( v \) versus time:

\[\text{15 m/s} \]

\[\text{6 s} \quad \text{t_2} \quad \text{time to reach 100 m.}\]

The distance covered by the sprinter is the area under the \( v(t) \) curve.

\[
100 \text{ m} = \frac{15 \times 6}{2} + \frac{15 \times (t_2 - 6)}{\text{area of}}
\]

\[\text{area of triangle} \]

\[\text{area of rectangle} \]

\[
t_2 = \frac{145}{15} \quad \Rightarrow \quad t_2 = 9.67 \text{ s}
\]
Example 4.

Need to compare \( x_A \) and \( x_B \)

- \( x_A = v_A t = t \)
  - \( 1 \text{ m/s} \)

- Motion of B:
  - \( s_B = \frac{1}{2} g \sin(10^\circ) t^2 \)

But
  - \( s_B \cos 10^\circ = x_B \)

So
  - \( x_B = \frac{1}{2} g \sin 10^\circ \cos 10^\circ \cdot t^2 \)
  - \( x_B = 0.838 \text{ t}^2 \)

Graph \( x_A(t) \) and \( x_B(t) \).

\[ \begin{align*}
  x_A & : \text{Linear}
  \end{align*} \]

B passes A at \( t = 1.19 \text{ s} \) when A and B have an \( x = 1.19 \text{ m} \).