Barbara is on top of a 15m cliff. She shoots a cannon towards a pirate ship in the bay. The initial velocity of the cannon ball is 25m/s at an angle of 30° above the horizontal. If the ship is 100m away from her, will she hit the ship?

Given

- $v_i = 25\text{m/s}$
- $a = -9.8\text{m/s}^2$
- Initial height = 15m
- $v_f$ going up = 0

Want

- Horizontal distance traveled.

In order to do this, we need to know the time the cannon ball is in the air AND the horizontal velocity.

**Step 1:** Draw picture.
Step 2: Calculate the velocity in the horizontal direction ($v_x$) and the vertical direction ($v_y$)

$v_x = 25\text{m/s} \cdot \cos 30^\circ$  \hspace{1cm}  $v_y = 25\text{m/s} \cdot \sin 30^\circ$

$v_x = 21.7 \text{m/s}$  \hspace{1cm}  $v_y = 12.5 \text{m/s}$

(For significant digits, carry extra digit until the final calculations)

Step 3: Calculate the time the ball is rising, the max height, then the time the ball is falling.

Time ball is rising

\[
a = \frac{v_f - v_i}{t}
\]

\[
t = \frac{v_f - v_i}{a}
\]

\[
t = \frac{0 - 12.5 \text{m/s}}{-9.8 \text{m/s}^2}
\]

\[
t = 1.28 \text{s}
\]

Max Height

\[
s = v_i t + \frac{1}{2} at^2
\]

\[
s = 12.5 \text{m/s} \cdot (1.28 \text{s}) + \frac{1}{2} (-9.8 \text{m/s}^2)(1.28 \text{s})^2
\]

\[
s = 7.97 \text{m}
\]

Max Height = 15m + 7.97m
= 22.97m

Time ball is Falling

\[ s = \nu t + \frac{1}{2} at^2 \]

\[-22.97m = 0 + \frac{1}{2}(-9.8m/s^2) t^2 \]

\[ t = \sqrt{\frac{-22.97m}{-4.9m/s^2}} \]

\[ t = 4.69 \text{ s} \]

Total Time in the Air: 1.28s + 4.69s = 5.97s

**Step 4:** Calculate the distance the cannon ball will travel horizontally.

\[ s = \nu_x t \]

\[ s = 21.7m/s (5.97s) \]

\[ s = 129.5m \text{ or } 130m \]

Since the ship is only 100m away, the cannon ball sails over the ship. Therefore, Barbara misses the ship 😞