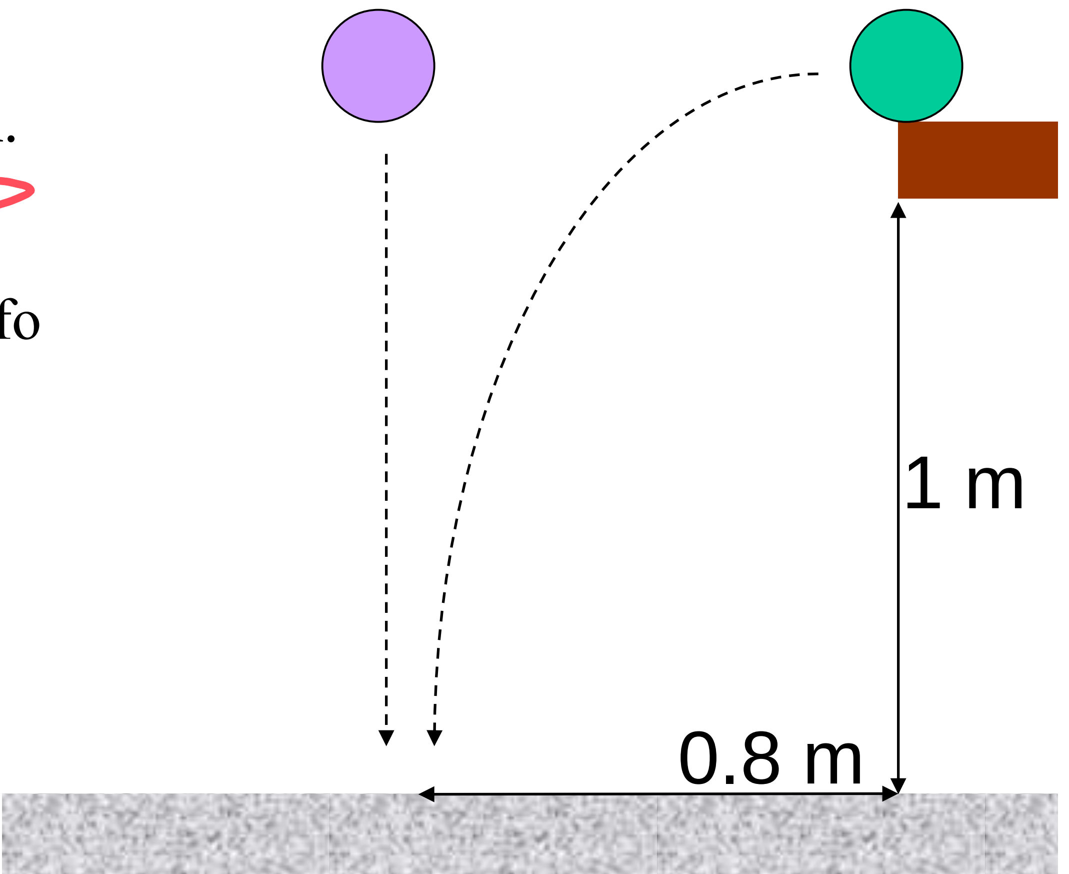
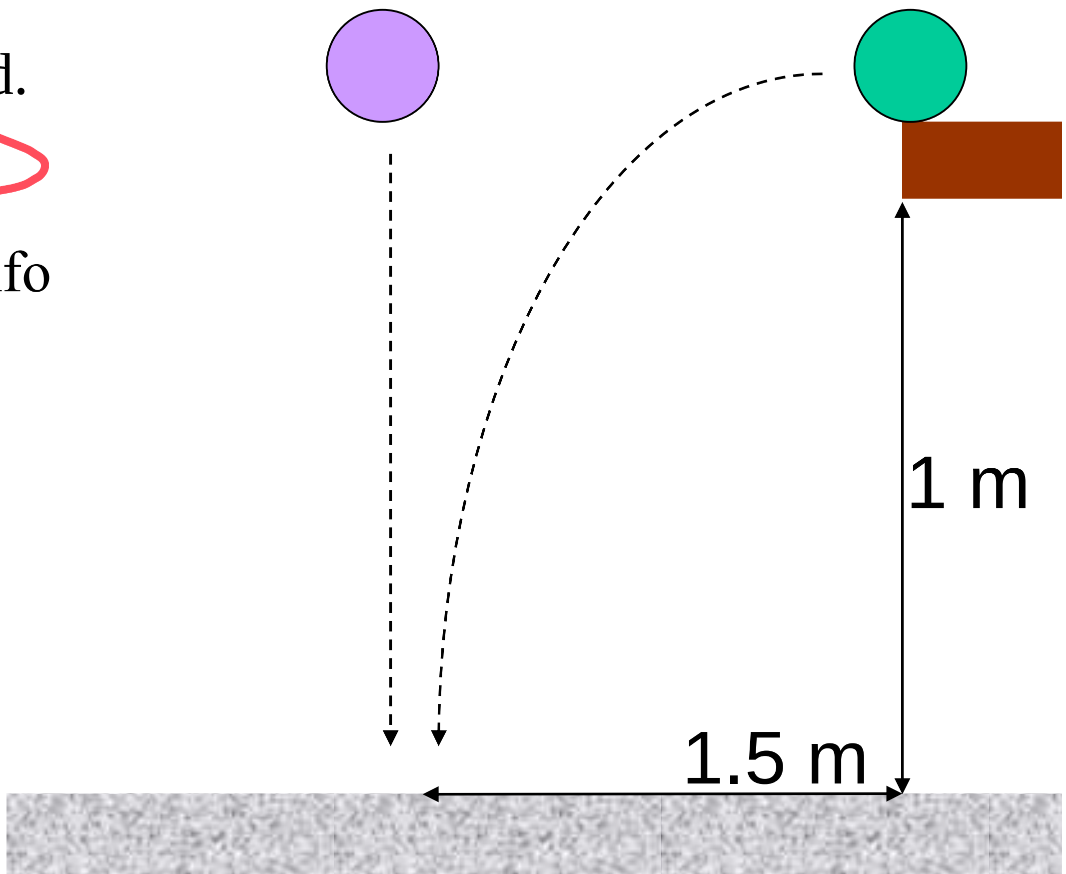
A ball is rolled off the edge of a table that is 1 meter high. It lands on the floor 0.8 meters away from the edge of the table. At the exact moment another ball rolls off the edge of the table, ball X is **released from rest** at a height of 1.0 meters from the floor. Which ball will hit the floor first?

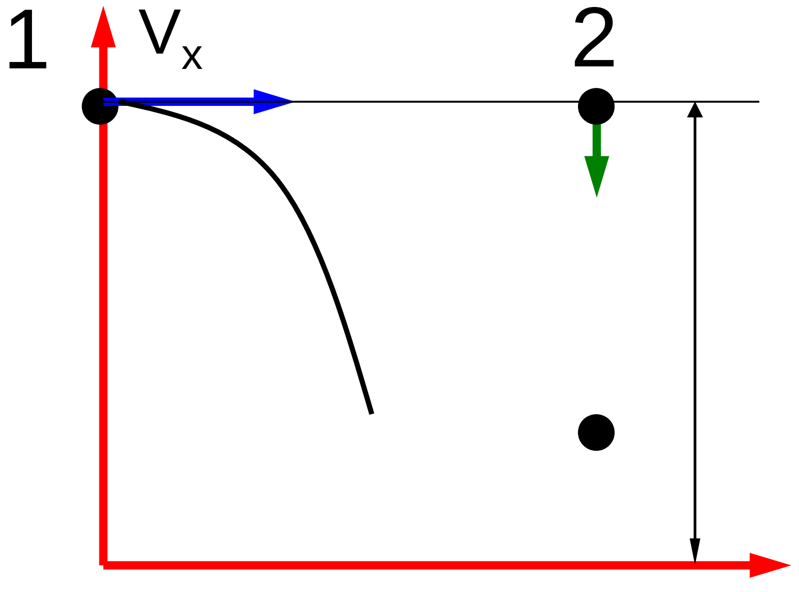
1. The ball that rolled off.
2. The ball that was dropped.
3. They will both hit at the same time
4. You can’t tell from the info given.



The same ball is rolled off the edge of the 1 meter high table again. This time it is rolling faster so it lands on the floor farther away from the table at 1.5 meters away from the edge of the table. If another ball is again **released from rest** at a height of 1.0 meters the instant the first ball rolls off the table, which ball will hit the floor first?

1. The ball that rolled off.
2. The ball that was dropped.
3. They will both hit at the same time
4. You can't tell from the info given.



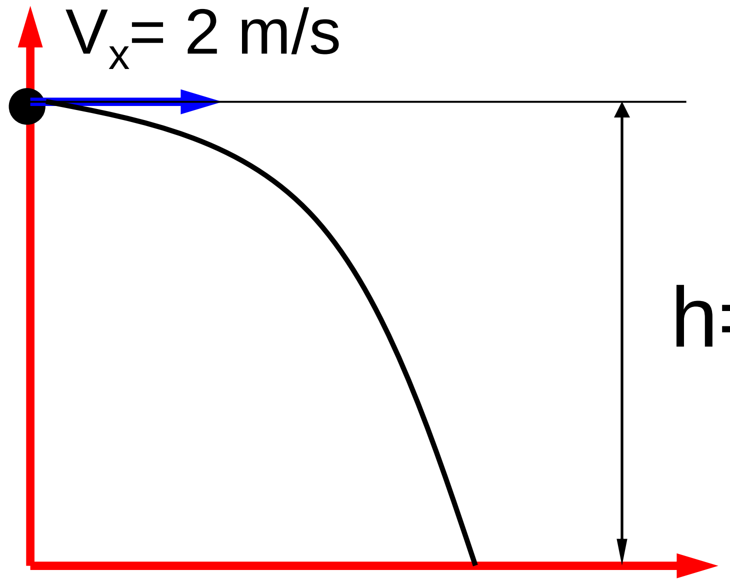


Motion in x direction Different

Motion in y direction Same

1

$V_x = 2$ m/s



h=1.25m

L=?

$1.25 = \frac{1}{2} 9.8 t^2$

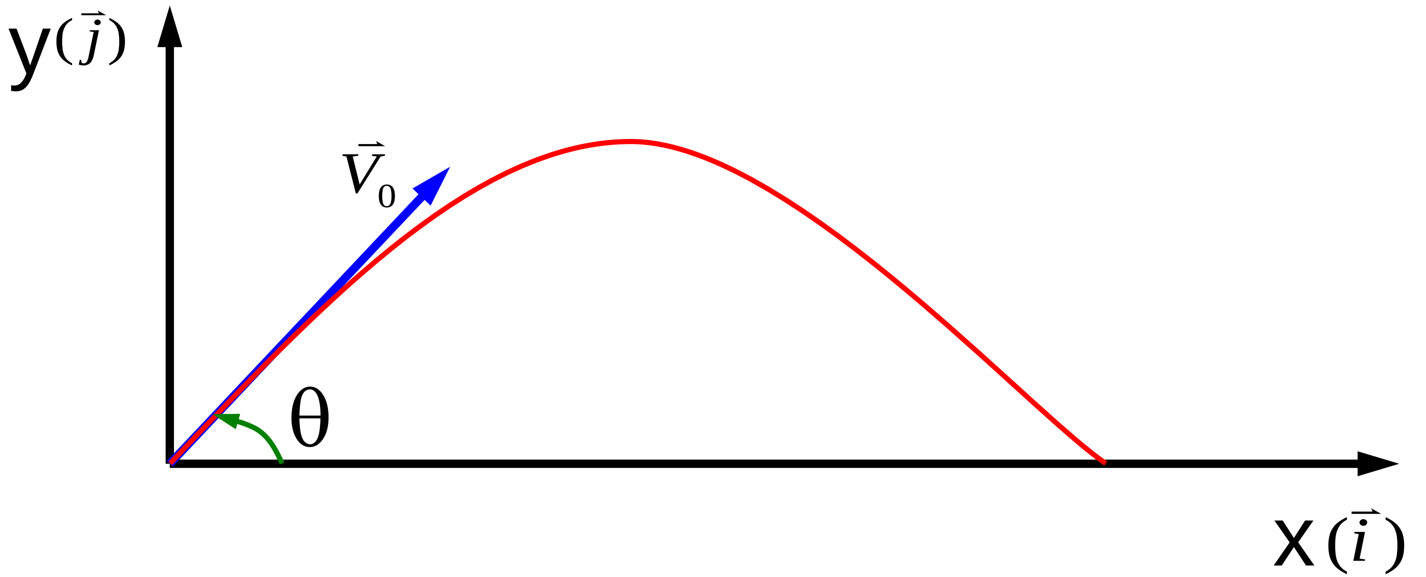
$\sqrt{\frac{1.25}{4.9}} = \boxed{t = 0.505}$

$L = 2(.505) + \frac{1}{2}(9.8)(.505^2)$

$1.01 + 1.25$

$\boxed{L = 2.26\text{ m}}$

Projectile Motion



x-motion no acceleration

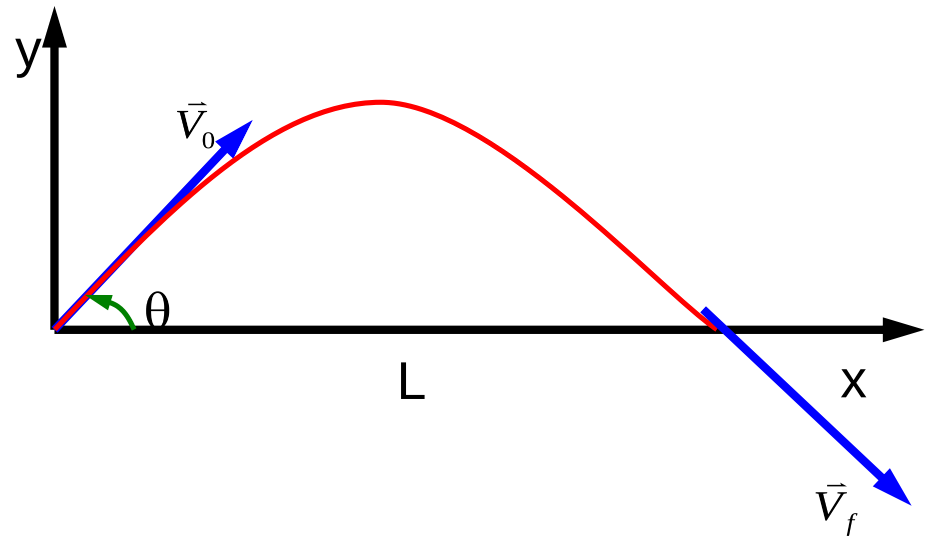
y-motion at constant acceleration

a_y=-10 m/s^2,
a_x=0

$$V_{0x} = V_0 \cos\theta, \quad V_{0y} = V_0 \sin\theta$$

$$\Delta V_x = V_{fx} - V_{0x} = a_x \Delta t = 0$$

$$\Delta V_y = V_{fy} - V_{0y} = a_y \Delta t = -g\Delta t$$



$$\Delta x = x(t) - x_0 = V_{0x}\Delta t = (V_0 \cos\theta)\,\Delta t$$

$$\Delta y = y(t) - y_0 = V_{0y}\Delta t + \frac{a_y}{2}\Delta t^2 = (V_0 \sin\theta)\Delta t - \frac{g}{2}\Delta t^2$$

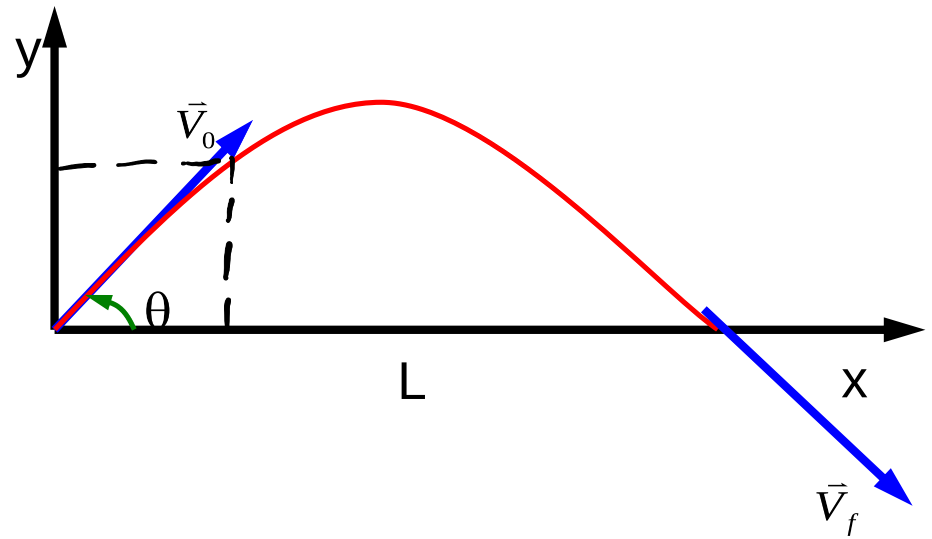
Longest Distance
when $\theta = 45°$

Example:

V_0=100 m/s,

θ=30° ,

g=10m/s^2



Finding L & t

$$\Delta y = 0 = V_{0y}\Delta t + \frac{a_y}{2}\Delta t^2 = (V_0 \sin\theta)\Delta t - \frac{g}{2}\Delta t^2$$

$$100 \cdot \sin(30°)\Delta t - \frac{10}{2}\Delta t^2 = 0, \quad \Rightarrow \Delta t = 10\ (s)$$

$$L = \Delta x = V_{0x}\Delta t = (V_0 \cos\theta)\,\Delta t = 100 \cdot \cos(30°) \cdot 10 = 866.03\ (m)$$

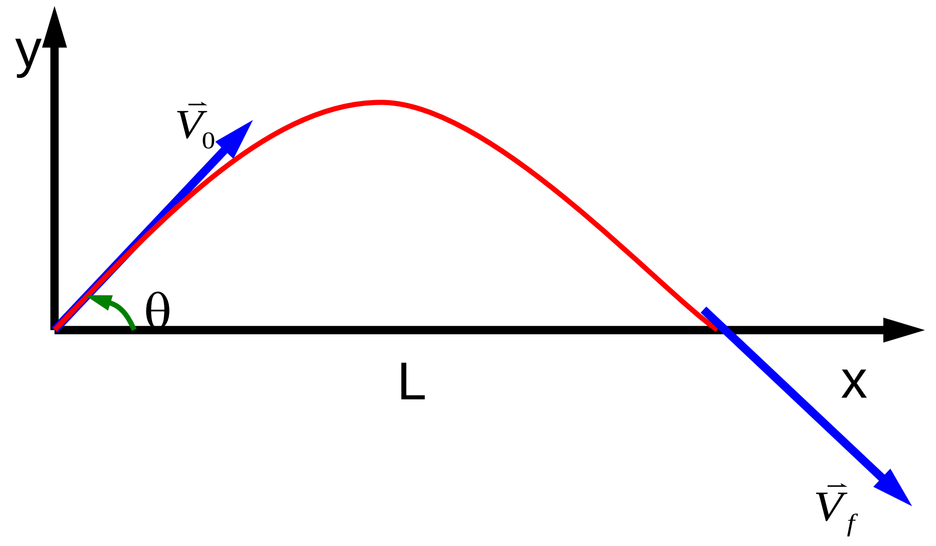
Example:

V_0=100 m/s,

θ=30° ,

g=10m/s^2

$$\vec{V}_f = ?$$



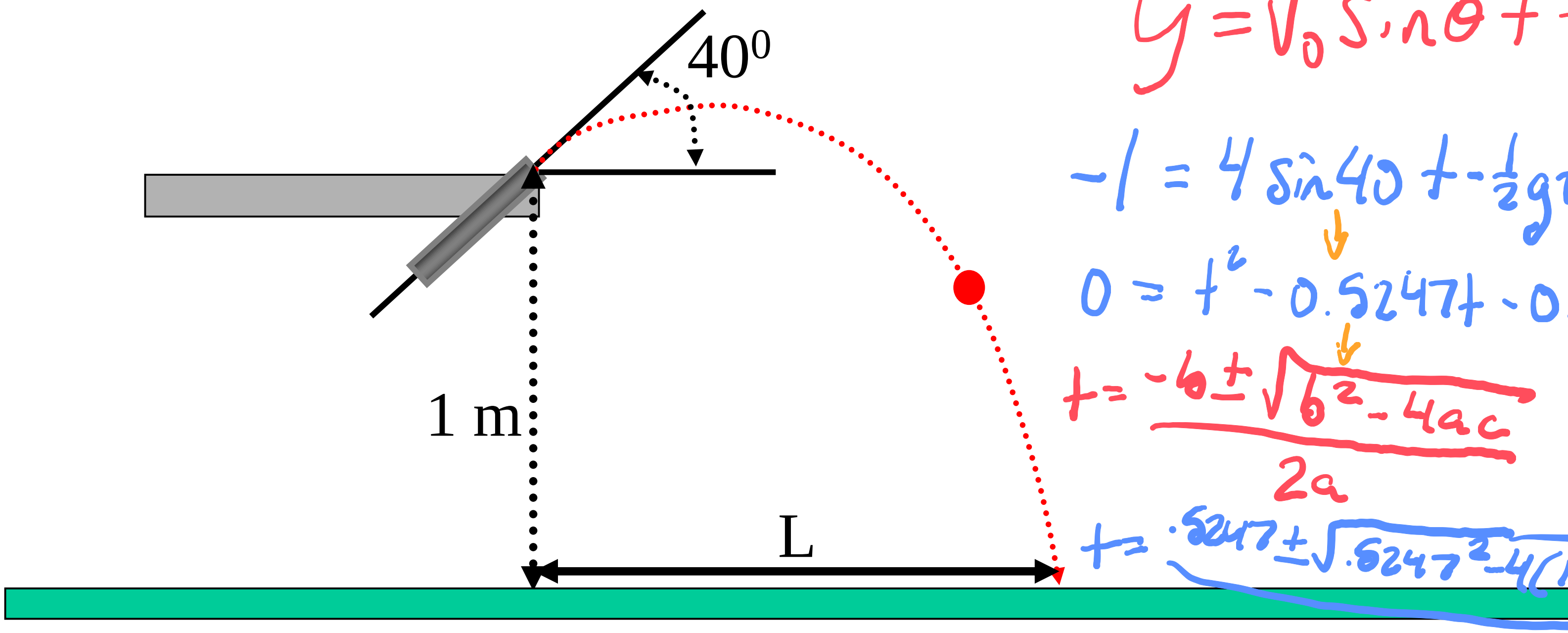
$$V_{fx} = V_{0x} = V_0 \cos\theta = 86.6\ (m/s)$$

$$V_{0y} = V_0 \sin\theta = 100\sin(30°) = 50\ (m/s)$$

$$V_{fy} = V_{0y} + a_y \Delta t = V_{0y} - \mathrm{g}\Delta t = 50 - 10 \cdot 10 = -50\ (m/s)$$

$$\vec{V}_f = (86.6\hat{i} - 50\hat{j})(m/s)$$

A ball's initial launch speed is 4.0 m/s. When projected off a table at an angle of 40^0 above horizontal, what is the horizontal distance L that the ball will travel before it lands on the floor? The floor is 1.0 meter below the ball's launch point.



$$y = V_0 \sin\theta\, t - \tfrac{1}{2} g t^2$$

$$-1 = 4 \sin 40\, t - \tfrac{1}{2} g t^2$$

$$0 = t^2 - 0.5247t - 0.2041$$

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$t = \frac{.5247 \pm \sqrt{.5247^2 - 4(1)(.2041)}}{2}$$

$$\boxed{t = 0.785\,s}$$

a_y=-10 m/s^2,

a_x=0

$$L = V_0 \cos\theta\, t \qquad L = 4 \times .766 \times .785$$

$$\boxed{L = 2.41\,m}$$

Solution to ball shooting problem

$$\Delta y = -h = \left[v_0 \sin(\theta)\right]t - \frac{1}{2}\mathrm{g}t^2$$

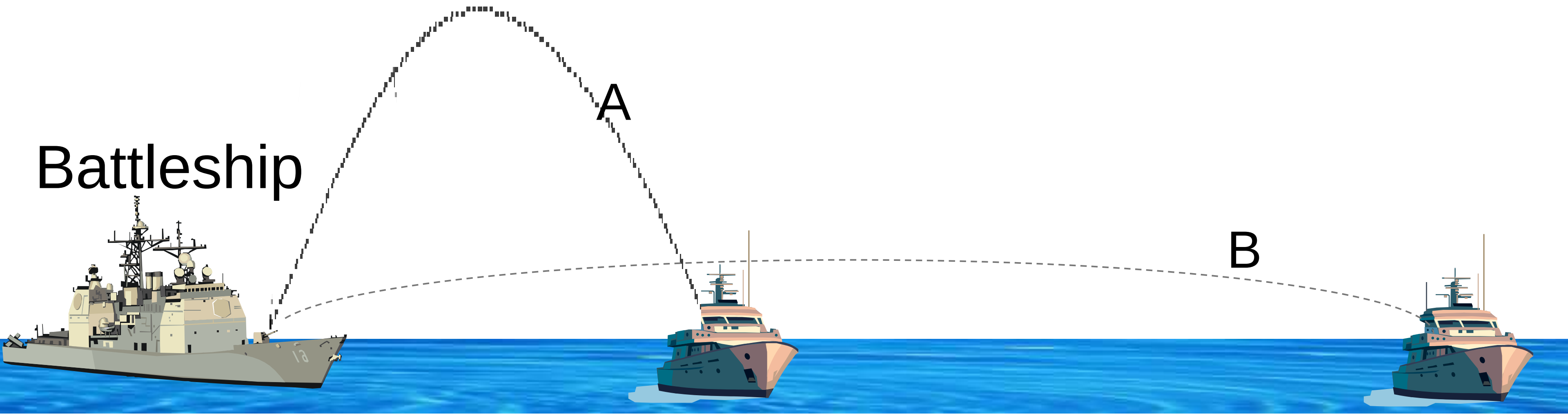
$$-1.0\,m = \left[(4m/s)\sin 40^0\right]t - \frac{1}{2}\left(9.8m/s^2\right)t^2$$

$$t^2 - (0.5247)t - (0.2041) = 0$$

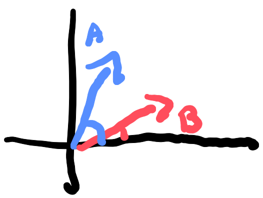
$$t = \frac{(0.5247) + \sqrt{(0.5247)^2 + 4(0.2041)}}{2} = 0.785\,s$$

$$L = \left[v_0 \cos(\theta)\right]t = (4m/s)\times 0.766 \times 0.785\,s = 2.41\,m$$

A battleship simultaneously fires two shells with the **same** initial speed at enemy ships. If the shells follow the parabolic trajectories shown, which trajectory corresponds to the shell fired with an initial velocity that has higher ***vertical*** component?



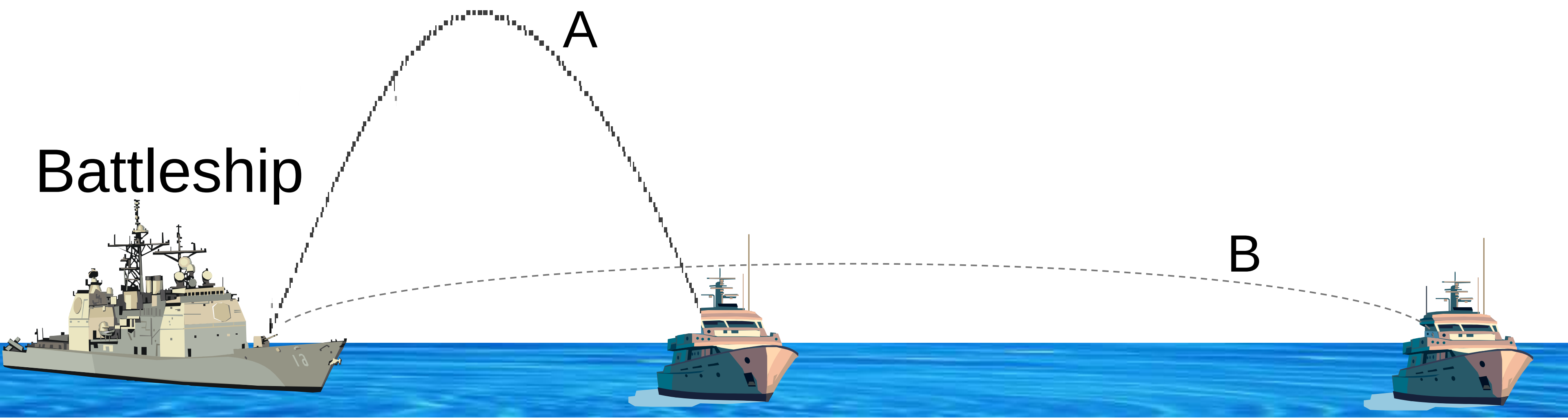
1. A
2. Both have the same initial vertical velocity.
3. B
4. Not enough info is given.



$0^2 - V_{0y}^2 = 2gh$

$V_{0y} = \sqrt{2gh}$

A battleship simultaneously fires two shells at enemy ships. If the shells follow the parabolic trajectories shown, which ship gets hit first?



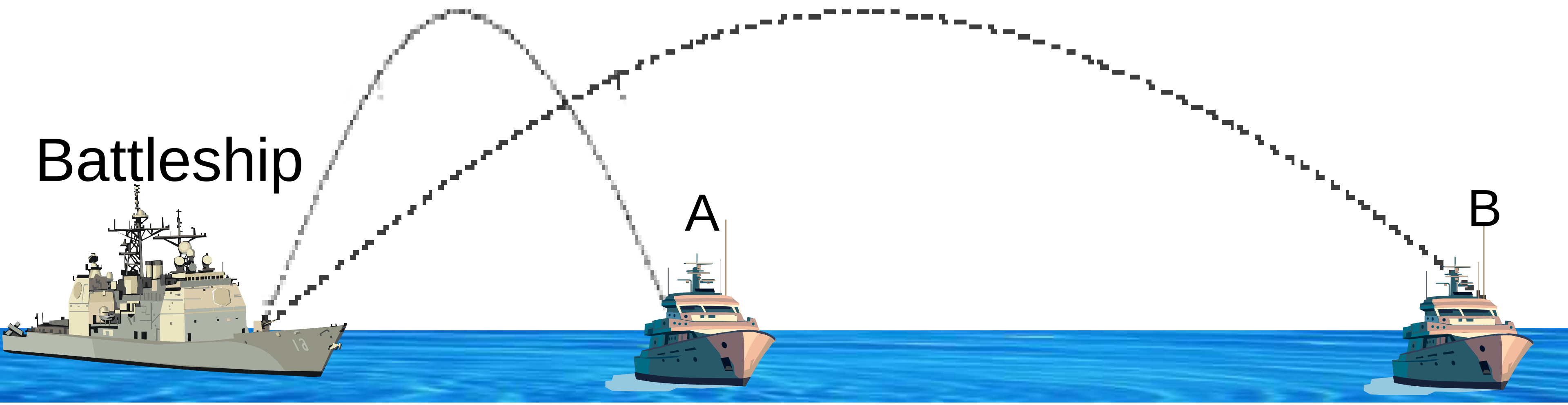
1. A
2. Both are hit simultaneously.
3. B
4. Not enough info is given.

4 is usually not the ans.

$$0 = V_{oy} - gt$$

$$t = \frac{V_{oy}}{g}$$

A battleship simultaneously fires two shells with **different** initial speeds at enemy ships. If the shells follow the parabolic trajectories with **same** maximum height as shown below, which ship gets hit first?



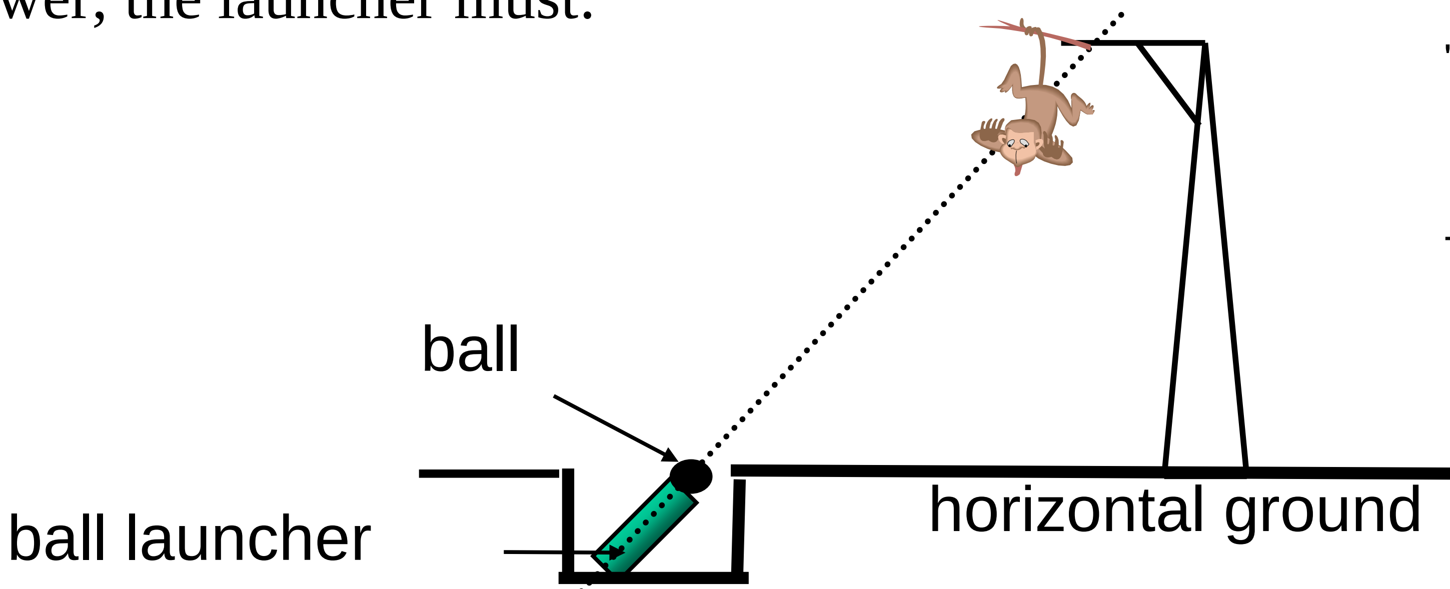
1. A
2. Both are hit simultaneously.
3. B
4. Not enough info is given.

Same height, same V_{0y}

different V_{0x}

only matters for distance, not time (in this case)

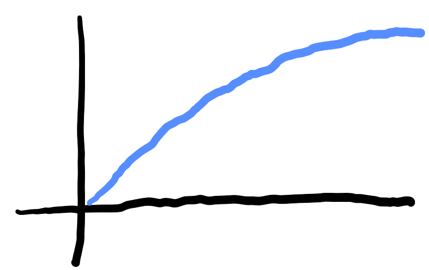
A steel ball is launched from ground level on a no-wind day. (Air drag can be neglected for this problem.) To hit a small toy monkey ***attached*** to scaffolding near the top of a neighboring tower, the launcher must:



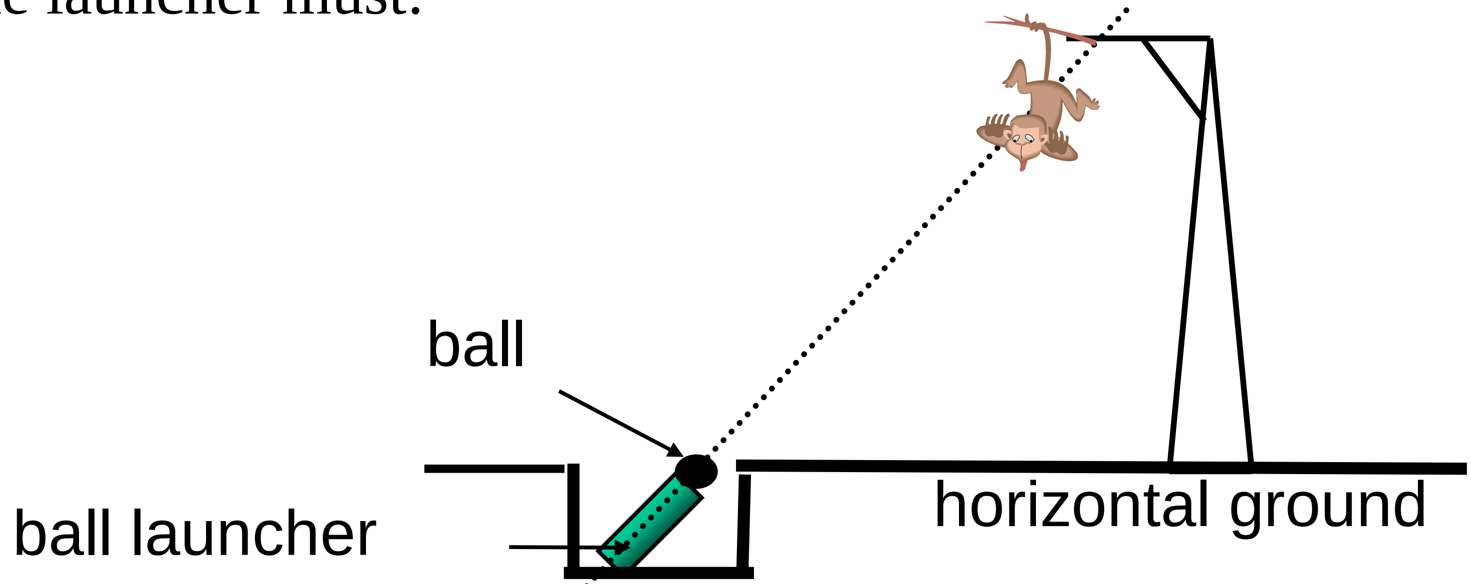
"Hit the monkey
Hit the monkey
Hit the monkey
Hit the monkey"

-Dr. Zhong

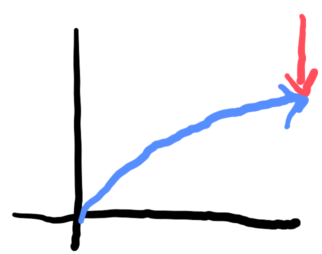
1. point at the monkey.
2. point above the monkey.
3. point below the monkey.
4. Not enough information is given.



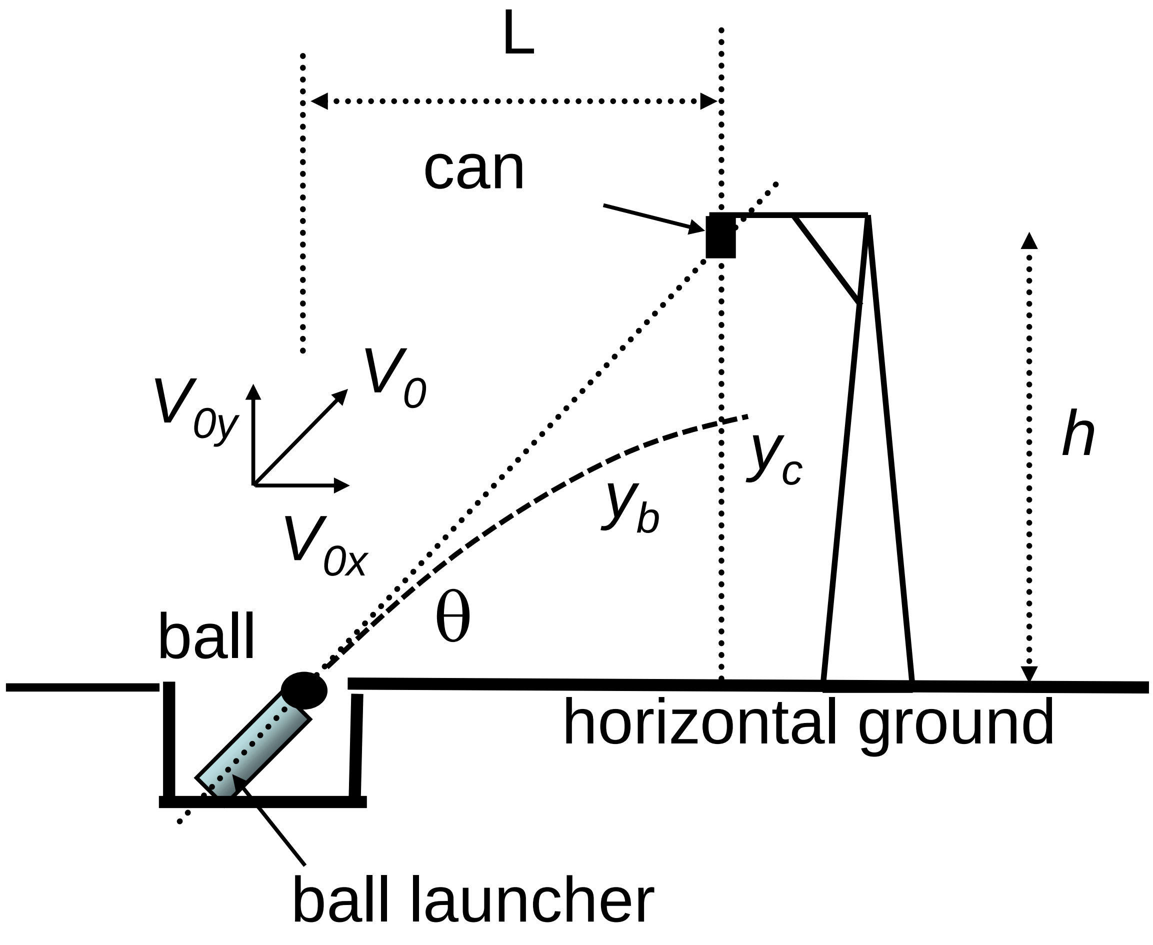
(Air drag can be neglected for this problem.) Again on a no-wind day, at ***the exact instant*** the steel ball is launched from ground level the small toy monkey ***is released***. In order to hit the monkey, the launcher must:



1. point at the monkey.
2. point above the monkey.
3. point below the monkey.
4. Not enough information is given.



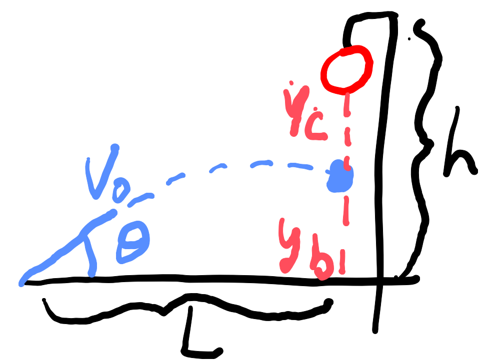
A steel ball is launched from ground level in a direction pointed directly at a small steel can attached to scaffolding near the top of a neighboring tower. The can is dropped precisely at the same time as the ball is launched. The ball will hit the can provided its horizontal velocity is large enough.



A steel ball is launched from ground level in a direction pointed directly at a small steel can attached to scaffolding near the top of a neighboring tower. The can is dropped precisely at the same time as the ball is launched. The ball will hit the can provided its horizontal velocity is large enough.

$$h = L\tan\theta \quad \text{(gun points at can)}$$

$$V_x t = (V_0\cos\theta)t = L \quad \Rightarrow \quad t = \underline{\frac{L}{V_0\cos\theta}}$$



$$y_B = y_0 + V_{0y}t - \frac{1}{2}gt^2 \quad (y\ of\ ball)$$

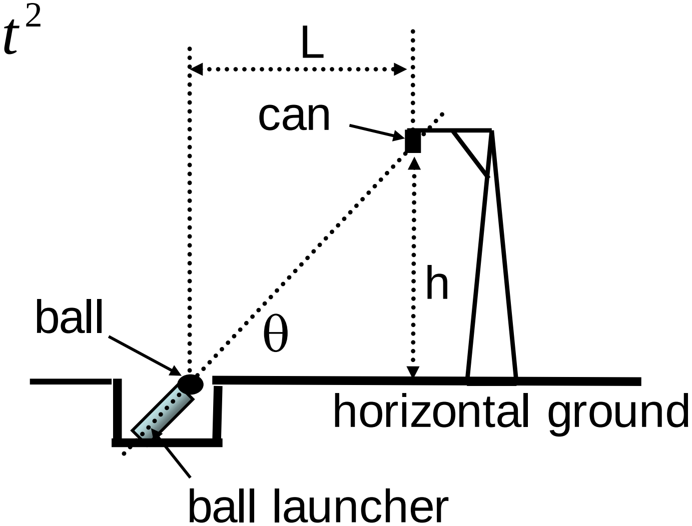
V_0 cancel out :)

$$y_B = 0 + \underline{(V_0\sin\theta)t} - \frac{1}{2}gt^2 = \boxed{\frac{L\sin\theta}{\cos\theta}} - \frac{1}{2}gt^2$$

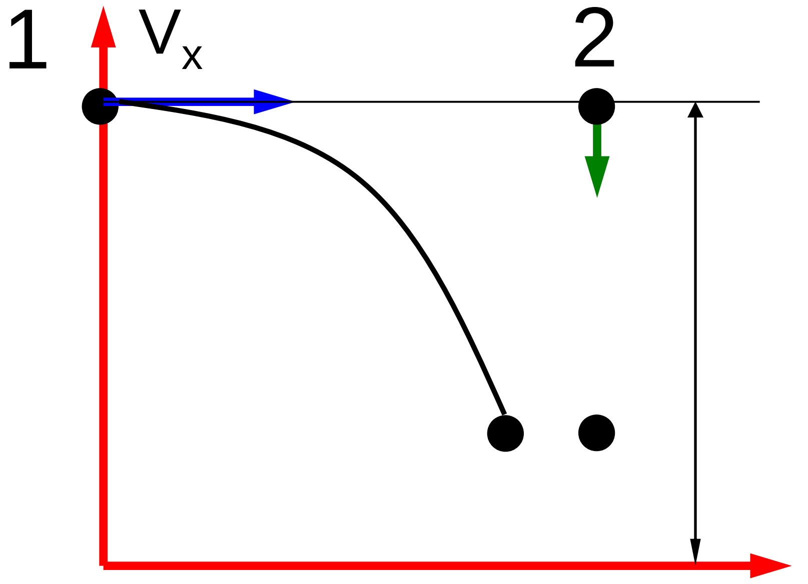
$$= \underline{L\tan\theta} - \frac{1}{2}gt^2 = h - \frac{1}{2}gt^2$$

trig identity

$$y_C = y_0 - \frac{1}{2}gt^2 = h - \frac{1}{2}gt^2 \quad (y\ of\ can)$$



$$y_B = y_C \Rightarrow ball\ will\ hit\ can!$$

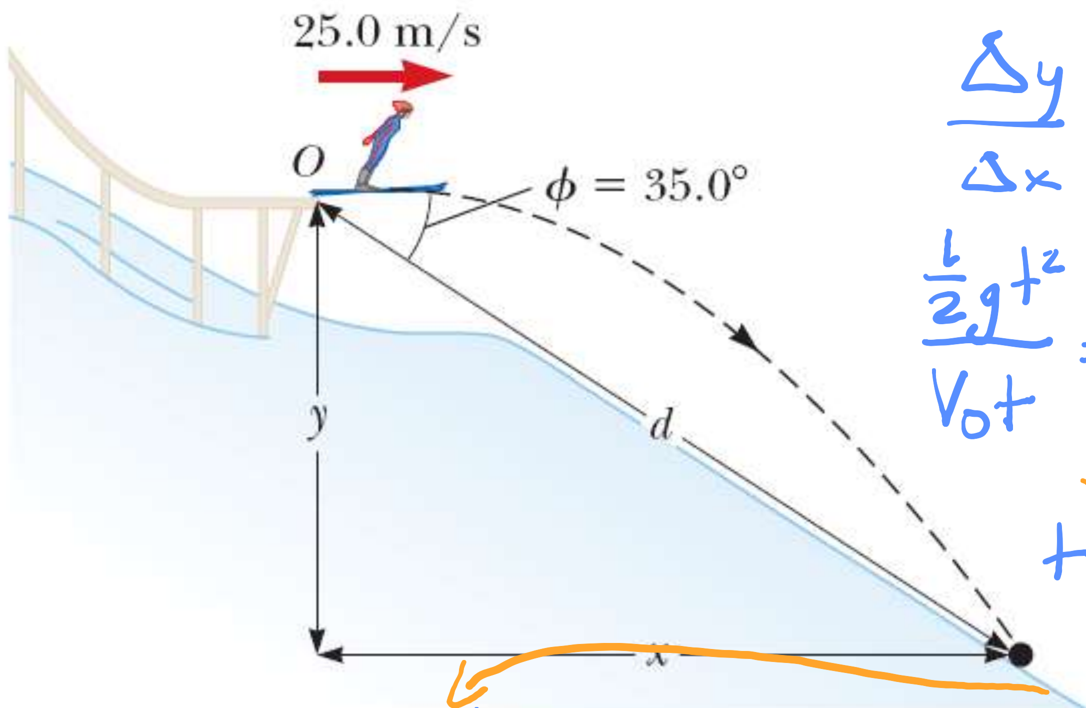


$t = \frac{L}{v_0}$

Motion in x direction

Motion in y direction

A ski jumper leaves the ski track moving in the horizontal direction with a speed of 25.0 m/s as shown in the Figure below. The landing incline below her falls off with a slope of 35.0°. Where does she land on the incline (d=?)? (Before doing it, outline a plan on how to solve it)



$$\frac{\Delta y}{\Delta x} = \tan 35^\circ$$

$$\frac{\frac{1}{2}gt^2}{V_0 t} = \tan 35^\circ$$

$$t = \frac{2V_0}{g} \times \tan 35$$

$$t = 3.5\,s$$

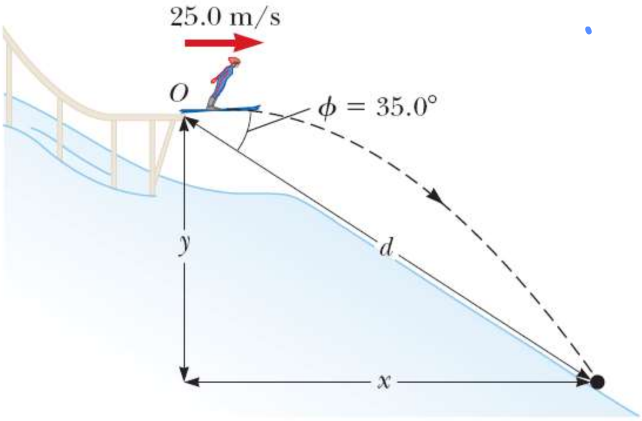
$$\Delta y = \frac{1}{2}gt^2 = -61.25\,m$$

$$\Delta x = 25 * 3.5 = 87.5\,m$$

$$d = \sqrt{61.25^2 + 87.5^2} = 106.8\,m$$

A ski jumper leaves the ski track moving in the horizontal direction with a speed of 25.0 m/s as shown in the figure below. The landing incline below her falls off with a slope of 35.0°. Where does she land on the incline (d)?

$$V_0 = 25.0\ m/s$$
$$g = 10\ m/s^2$$



$$\Delta y = -\frac{1}{2} g \Delta t^2$$

$$\Delta x = V_0 \Delta t$$

$$\frac{|\Delta y|}{|\Delta x|} = \tan 35° = \frac{\frac{1}{2} g \Delta t^2}{V_0 \Delta t} = \frac{g \Delta t}{2V_0}$$

$$\Delta t = \frac{2V_0}{g} \tan 35° = \frac{2 \times 25.0}{10} \times 0.700 = 3.5\ s$$

$$\Delta y = -\frac{1}{2} \times 10 \times 3.5^2 = 61.25\ m$$

$$\Delta x = 25.0 \times 3.5 = 87.5\ m$$

$$d = \sqrt{\Delta y^2 + \Delta x^2} = 106.8\ m$$