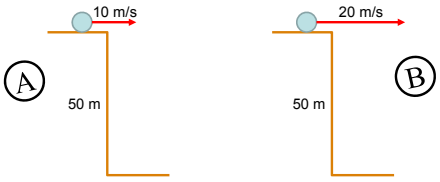
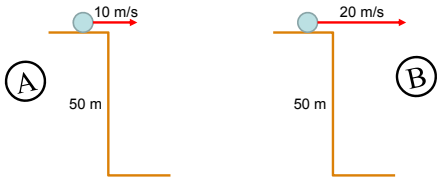
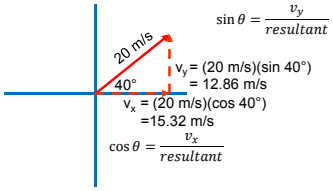
Let's say we have two identical objects going off two identical cliffs as shown below.



- Which one goes further before hitting the ground?
- Why?
- The answer is *intuitive* in that one is traveling faster so it should go farther.



- Which one is in the air longer?
- Why?



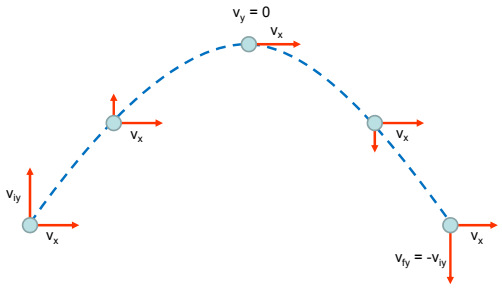
$$\sin\theta = \frac{v_y}{resultant}$$

v_y = (20 m/s)(sin 40°)
= 12.86 m/s

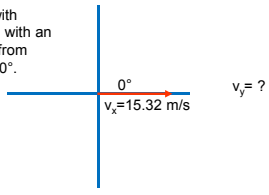
v_x = (20 m/s)(cos 40°)
=15.32 m/s

$$\cos\theta = \frac{v_x}{resultant}$$

- We learned how to resolve vectors earlier.
- v_y = 12.86 m/s
  this is the initial velocity in the y direction: v_i in the y column
- v_x = 15.32 m/s
  this is the *ONLY* velocity in the x direction: v_x in the x column



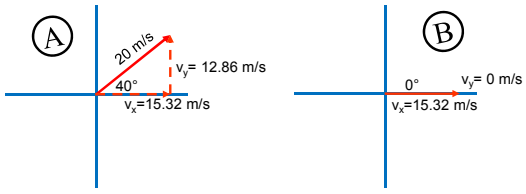
Let's look at a new set up with something fired horizontally with an initial velocity of 15.32 m/s from *ground level* at an angle of 0°.



v_y= ?

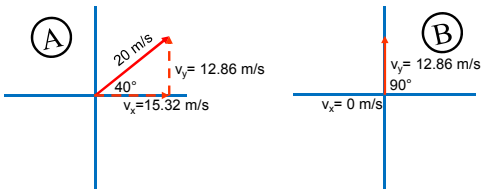
- How long is the object in the air for?
- Why?
  the initial velocity in the y direction is 0

Consider the following:

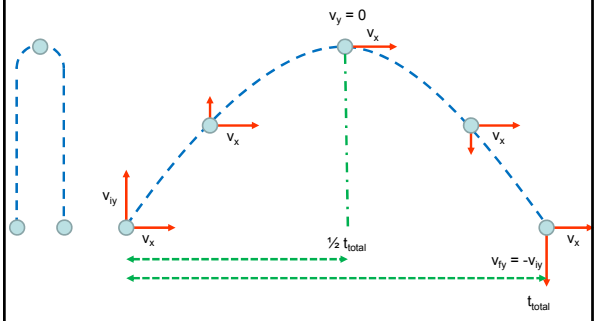


- Which one is in the air longer?
- The time an object projected from the ground spends in the air depends on the initial y velocity.

Consider the following:



- Which one is in the air longer?



GAZELLES OUT OF CANNONS

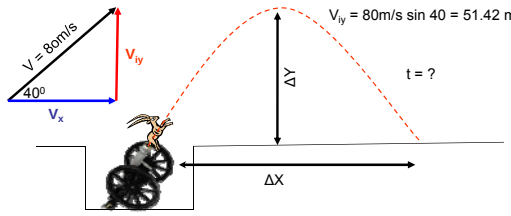
Sample Problem

A gazelle is fired at 80 m / s from a cannon inclined at an angle of 40 degrees above horizontal. How long does the gazelle spend in the air? How far away does the gazelle land? What is the maximum height that the gazelle reached?

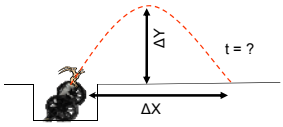
FIRST DRAW A PICTURE AND RESOLVE THE VELOCITY INTO X AND Y COMPONENTS:

V_x = 80m/s cos 40 = 61.28 m/s

V_{iy} = 80m/s sin 40 = 51.42 m/s



SPLIT INFORMATION INTO X AND Y:



X	Y
V_x = 61.28 m/s	V_i = 51.42 m/s
ΔX = ?	a = -9.8 m/s²
t = ____	V_f = -51.42 m/s
	t = **10.49 sec**

Because the gazelle returns to ground level you can say that the final y velocity is the same as the initial but negative

Solve:

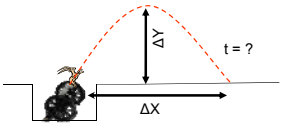
How Long ?

$$V_f = V_i + at$$
$$-51.42m/s = 51.42m/s + (-9.8m/s^2)t$$
$$-102.84 = -9.8t$$
$$t = 10.49\sec$$

How Far ?

$$V_x = \frac{\Delta x}{t}$$
$$61.28m/s = \frac{\Delta x}{10.49\sec}$$
$$\Delta x = 642.8m$$

How High?



X	Y
V_x = 61.28 m/s	V_i = 51.42 m/s
ΔX = 642.8 m	a = -9.8 m/s²
t = 10.49 sec	t = ?
	V_f = 0 m/s
	ΔY = ?

At maximum height the velocity in the y direction is 0 m/s

Solve:

$$V_f^2 = V_i^2 + 2a\Delta Y$$
$$(0m/s)^2 = (51.42m/s)^2 + 2(-9.8m/s^2)\Delta Y$$
$$-2644.02 = -19.6\Delta Y$$
$$\Delta Y = 134.9m$$

Please Note….there are MANY ways to solve these problems….

I have shown ONE acceptable solution.

Sample Problem

A gazelle is fired at 80 m / s from a cannon inclined at an angle of 40 degrees above horizontal. If there is a tall fence located 50 meters from the gazelle, how high on the fence will the gazelle hit?

Resolve the vector

V_x = 80m/s cos 40 = 61.28 m/s

V_{iy} = 80m/s sin 40 = 51.42 m/s

SPLIT INFORMATION INTO X AND Y:

X	Y
V_x = 61.28 m/s	V_i = 51.42 m/s
ΔX = 50 m	a = -9.8 m/s²
t = ?	ΔY = ?
	t = _____

X	Y
V_x = 61.28 m/s	V_i = 51.42 m/s
ΔX = 50 m	a = -9.8 m/s²
t = 0.816 sec	ΔY = ?
	t = _____

Use X information to solve for time

$$V_x = \frac{\Delta X}{t}$$

$$61.28m/s = \frac{50m}{t}$$

$$t = 0.816\text{sec}$$

Use time with Y information to solve for ΔY

$$\Delta Y = V_i t + \frac{1}{2}at^2$$

$$\Delta Y = (51.42m/s)(0.816s) + \frac{1}{2}(-9.8m/s^2)(0.816s)^2$$

$$\Delta Y = 38.7m$$

Practice Problem

A gazelle traveling 50 m/s is launched at a 48 degree angle with respect to the horizontal.

How long, how high, and how far?

X	Y
V_x = 33.46 m/s	V_i = 37.16 m/s
ΔX = ?	a = -9.8 m/s²
t = 7.58 sec	V_f = -37.16 m/s
	ΔY = ?
	t = ?

Use Y information to solve for time

$$V_f = V_i + at$$

$$-37.16m/s = 37.16m/s + (-9.8m/s^2)t$$

$$t = 7.58\text{sec}$$

Use ½ time with Y information to solve for ΔY (how high?)

$$\Delta Y = V_i t + \frac{1}{2}at^2$$

$$\Delta Y = (37.16m/s)(3.79s) + \frac{1}{2}(-9.8m/s^2)(3.79s)^2$$

$$\Delta Y = 70.45m$$

$$V_x = \frac{\Delta X}{t}$$

$$33.46m/s = \frac{\Delta x}{7.58s}$$

$$\Delta x = 253.63m$$

Practice Problem

A gazelle kicks a ball at an angle of 23 degrees at a velocity of 35 meters per second.

How long, how high, and how far?

X	Y
V_x = 32.22 m/s	V_i = 13.68 m/s
ΔX = ?	a = -9.8 m/s²
t = 2.79 sec	V_f = -13.68 m/s
	ΔY = ?
	t = ?

Use Y information to solve for time

$$V_f = V_i + at$$

$$-13.68m/s = 13.68m/s + (-9.8m/s^2)t$$

$$t = 2.79\text{sec}$$

Use ½ time with Y information to solve for ΔY (how high?)

$$\Delta Y = V_i t + \frac{1}{2}at^2$$

$$\Delta Y = (13.68m/s)(1.40s) + \frac{1}{2}(-9.8m/s^2)(1.40s)^2$$

$$\Delta Y = 9.55m$$

$$V_x = \frac{\Delta X}{t}$$

$$32.22m/s = \frac{\Delta x}{2.79s}$$

$$\Delta x = 89.89m$$