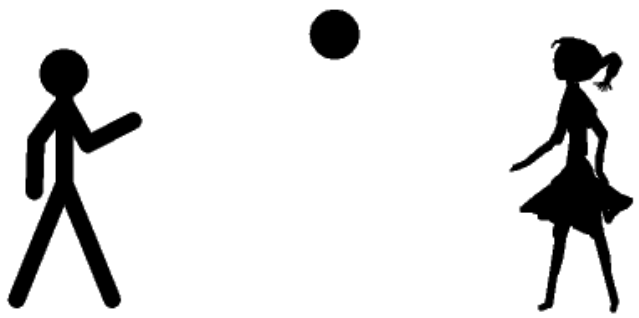
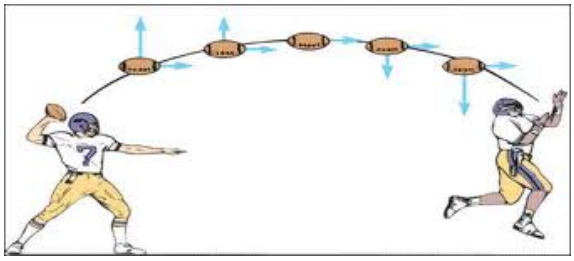
Projectile Motion

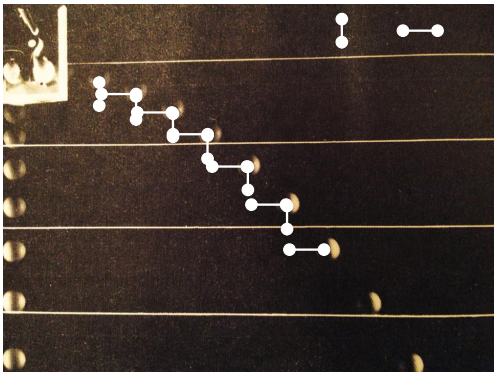


Objects that are launched are **projectiles**.
The path they follow is called a **trajectory**.



The motion of a projectile is described in terms of its position, velocity, and acceleration

If we could frame each motion of the trip of the golf balls they would resemble the following diagram.



This allows us to make comparisons between horizontal and the vertical components

<u>Horizontal Component</u>

If we call the horizontal displacement $\vec{x}$ and the initial horizontal velocity $\vec{v}_x$ then, at time t

$$\vec{x} = \vec{v}_x t$$

If we do not have the horizontal displacement then we can still find an equation for the horizontal velocity.

$$a_x = \frac{v_{xf} - v_{xi}}{t}$$

$$v_{xf} = v_{xi} + a_x t$$ *What is the horizontal acceleration?

$$v_{xf} = v_{xi}$$

Vertical Component

When the object falls, it does so with constant acceleration (gravity). If $\vec{y}$ is the vertical displacement, the initial vertical velocity is $\vec{v}_y$. At time t, the vertical displacement is,

$$\vec{y} = \vec{v}_y t + \frac{1}{2}\vec{g}t^2$$

Using the similar rearranging from the horizontal component we can calculate the final vertical velocity as

$$\vec{v}_{yf} = \vec{v}_y + \vec{g}t$$

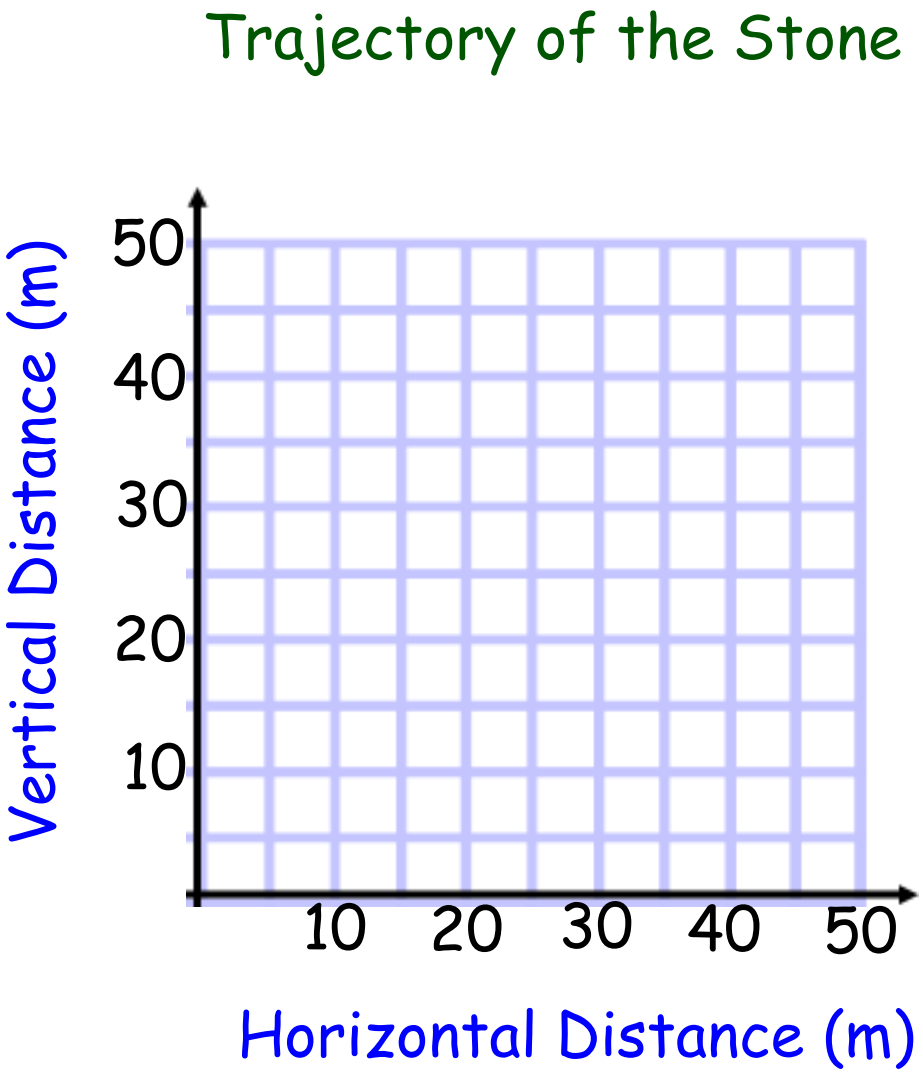
Example 1

A stone is thrown horizontally at +15 m/s from the top of a cliff 44 meters high.

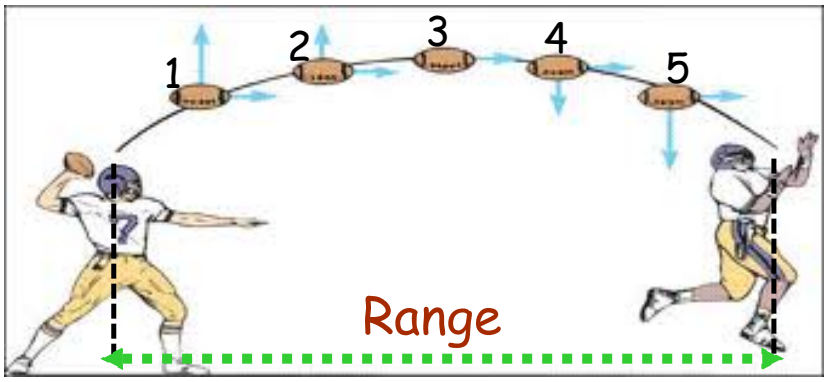
a) How long does the stone take to reach the bottom of the cliff?

b) How far from the base of the cliff does the stone strike the ground?

c) Sketch the trajectory of the stone.


Trajectory of the Stone
Vertical Distance (m)
50
40
30
20
10
10
20
30
40
50
Horizontal Distance (m)

Objects Launched at an Angle



What do you notice here about the vertical and horizontal components at each stage of the football?

Problem Solving Tips

- Determine the horizontal and vertical components of the initial velocity
- The symmetry of the trajectory can be used when launching and landing are at the same height.
- Rising and falling times are equal, and the parabola is symmetrical about the highest point

Example 2

The initial velocity of a thrown ball was 4.47 m/s at an angle of 66^0 above the horizontal. The ball landed at the same height it was originally thrown at.

a) Find how long it took the ball to land.

b) Find how high the ball flew.

c) What was the range of the ball?

Example 3

A golf ball is chipped onto the green at a 70.0^0 angle and travels 25.0 meters before landing at the same relative height at which it was struck.

a) What was the initial velocity of the ball?

b) What what maximum height did the ball reach?

In general, we can form an equation for the situation described in the previous problem.