



# Projectile Motion

Motion in Two Dimensions

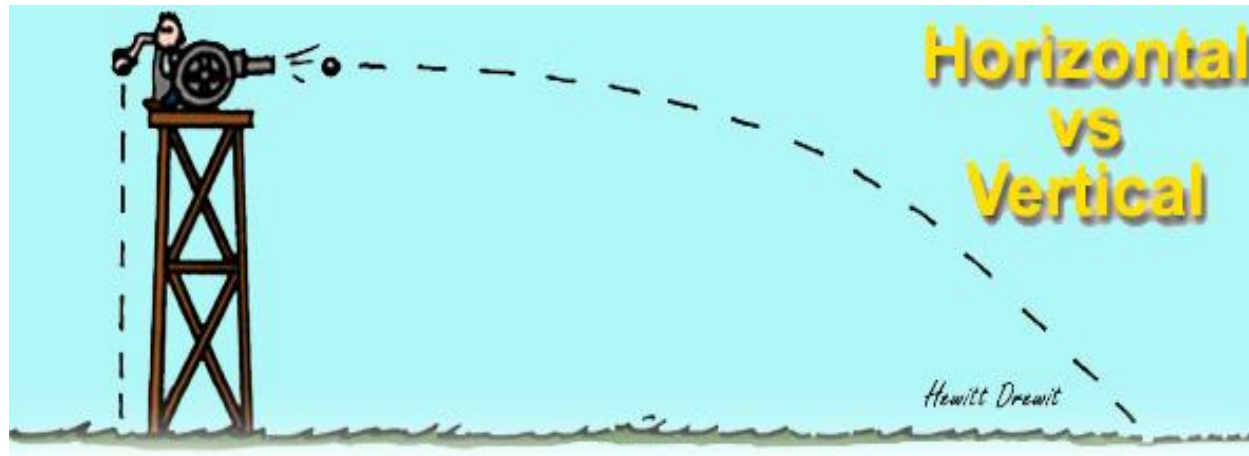
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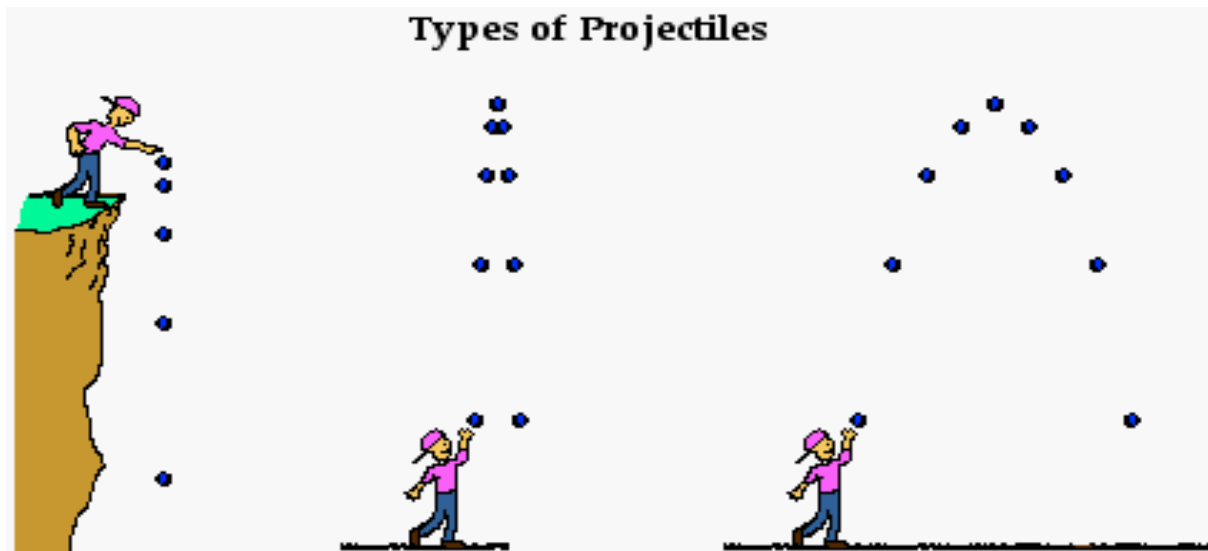
# A Question to Begin

- At the instant a horizontally pointed cannon ball is fired, a cannonball held at the cannon's side is released and drops to the ground. Which cannonball strikes the ground first, the one fired from the cannon or the one dropped?



# What is a Projectile?

- Any object that continues in motion by its own inertia and is influenced only by the downward force of gravity (and air resistance)
  - an object dropped from rest is a projectile
  - an object thrown straight upward is a projectile
  - an object thrown upward at an angle to the horizontal



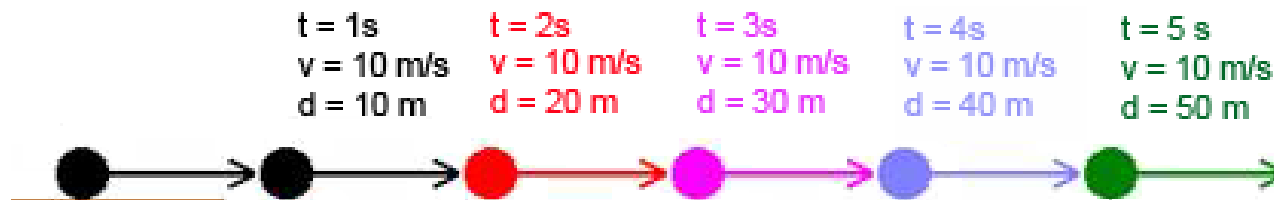
# The path that the projectile follows is a parabola...

- the path is called its trajectory



# Horizontal Motion

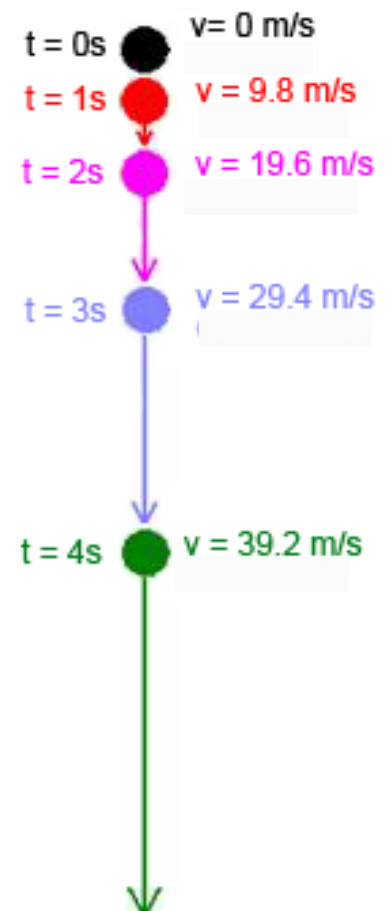
- If there is no force acting on an object, then it will continue moving at a constant speed in the same direction.
  - there will be no change in its velocity



- distance will increase the same amount with each second

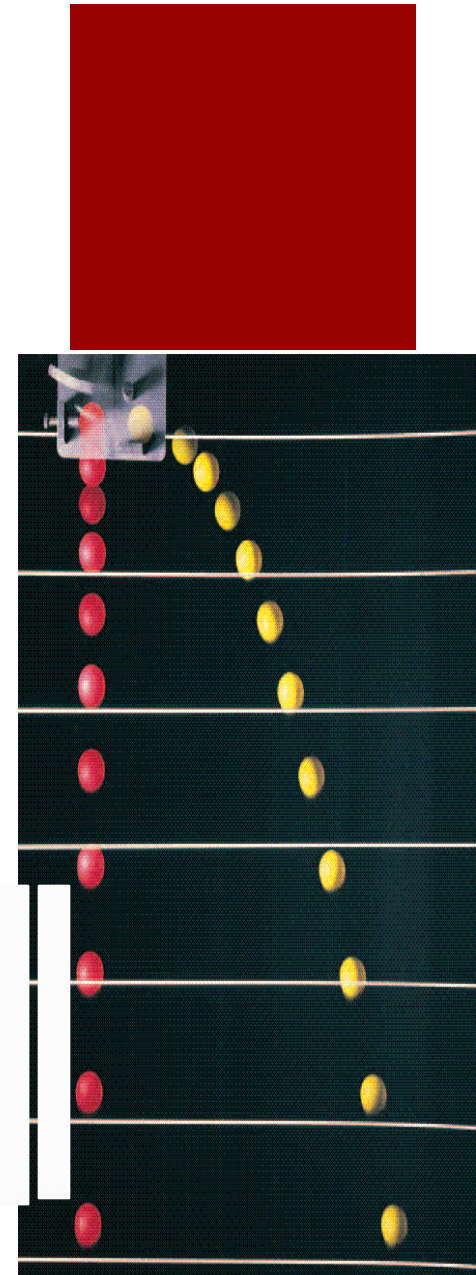
# Free Fall Revisited

- An object in free fall is only acted on by gravity
  - Acceleration due to gravity is  $9.8 \text{ m/s}^2$
  - distance covered increases with each second

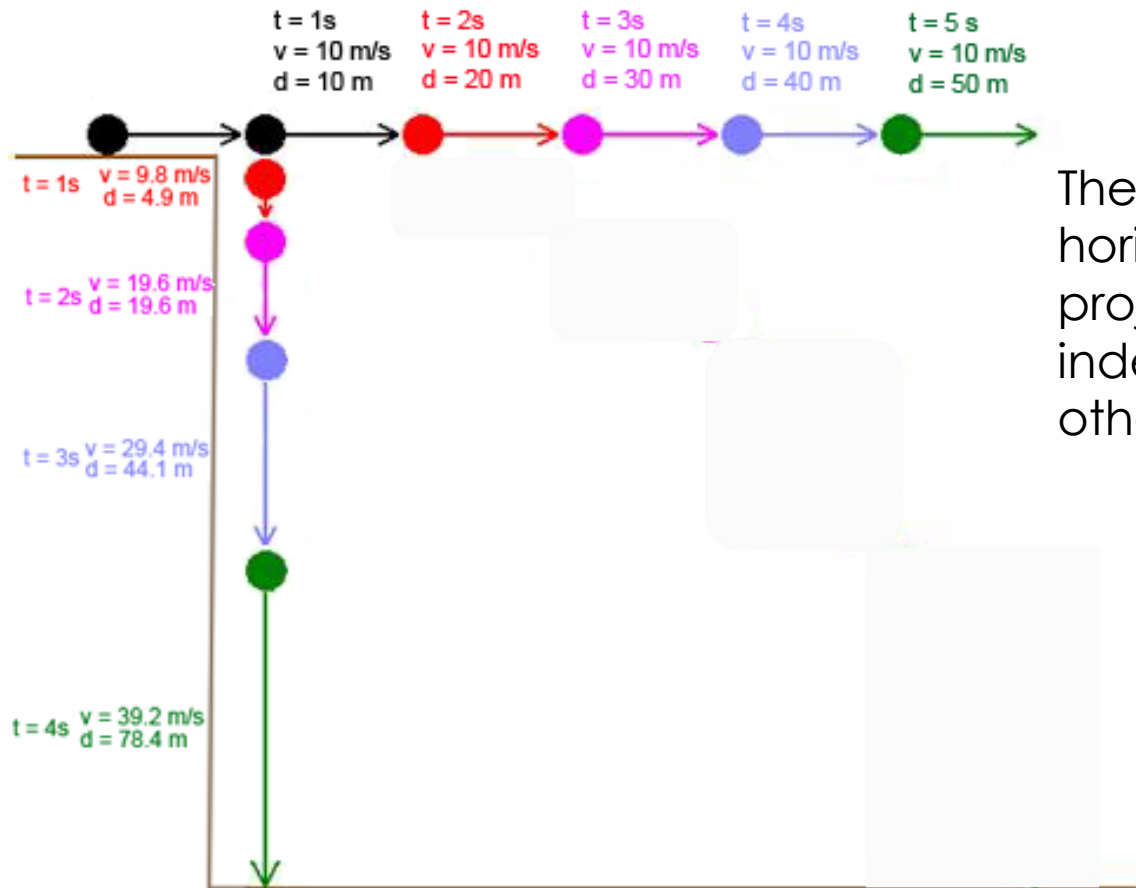


# Projectile Motion Combines Vertical Motion and Horizontal Motion

- The vertical motion of a projectile is not affected by its horizontal motion
  - meaning: The vertical motion of a projectile is identical to an object in free fall
- The horizontal motion of a projectile is not affected by its vertical motion
  - meaning the projectile will travel the same horizontal distance as it would if it were simply rolling on a flat surface in the absence of friction



# Projectile Motion Combines Horizontal Motion and Vertical Motion

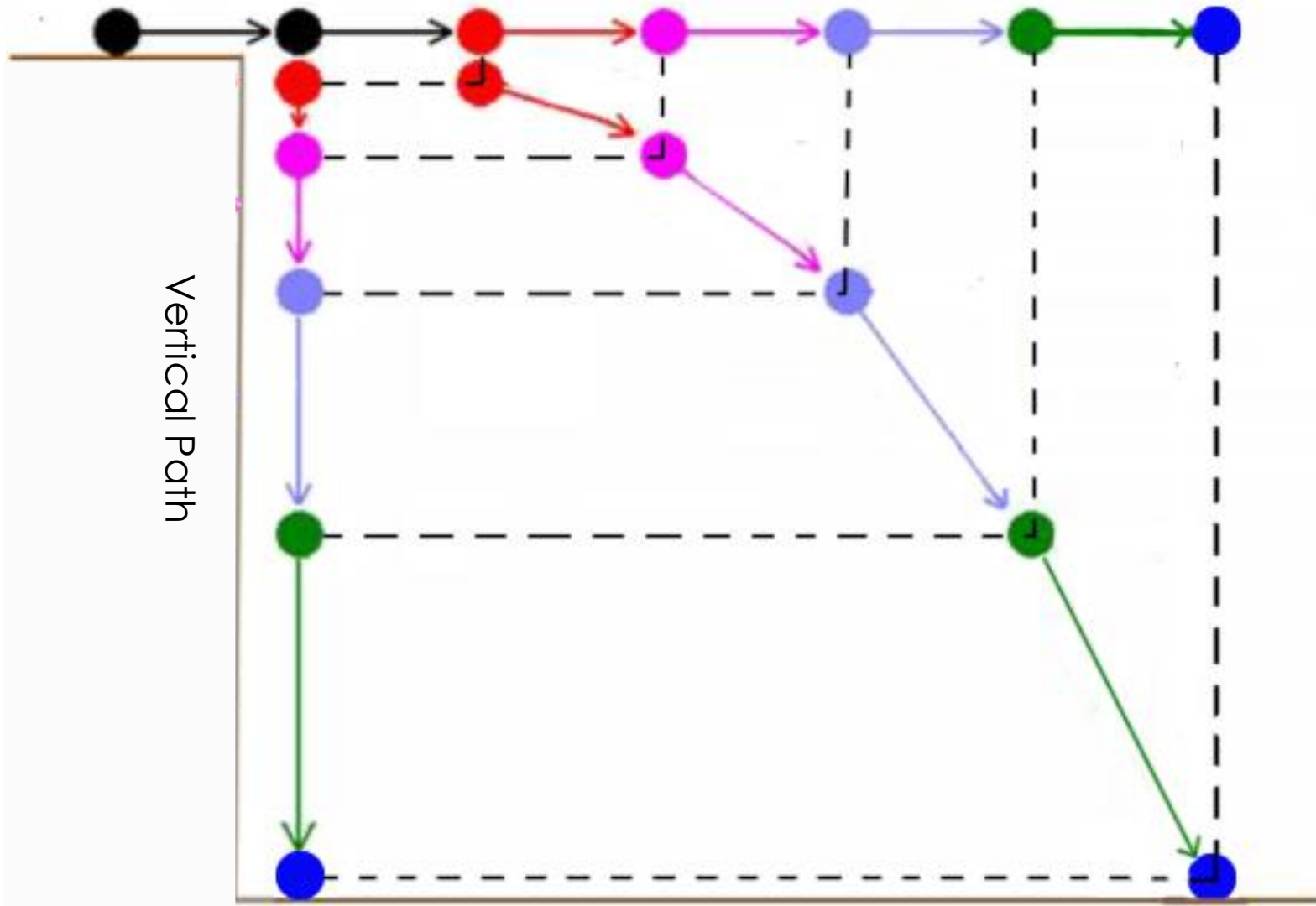


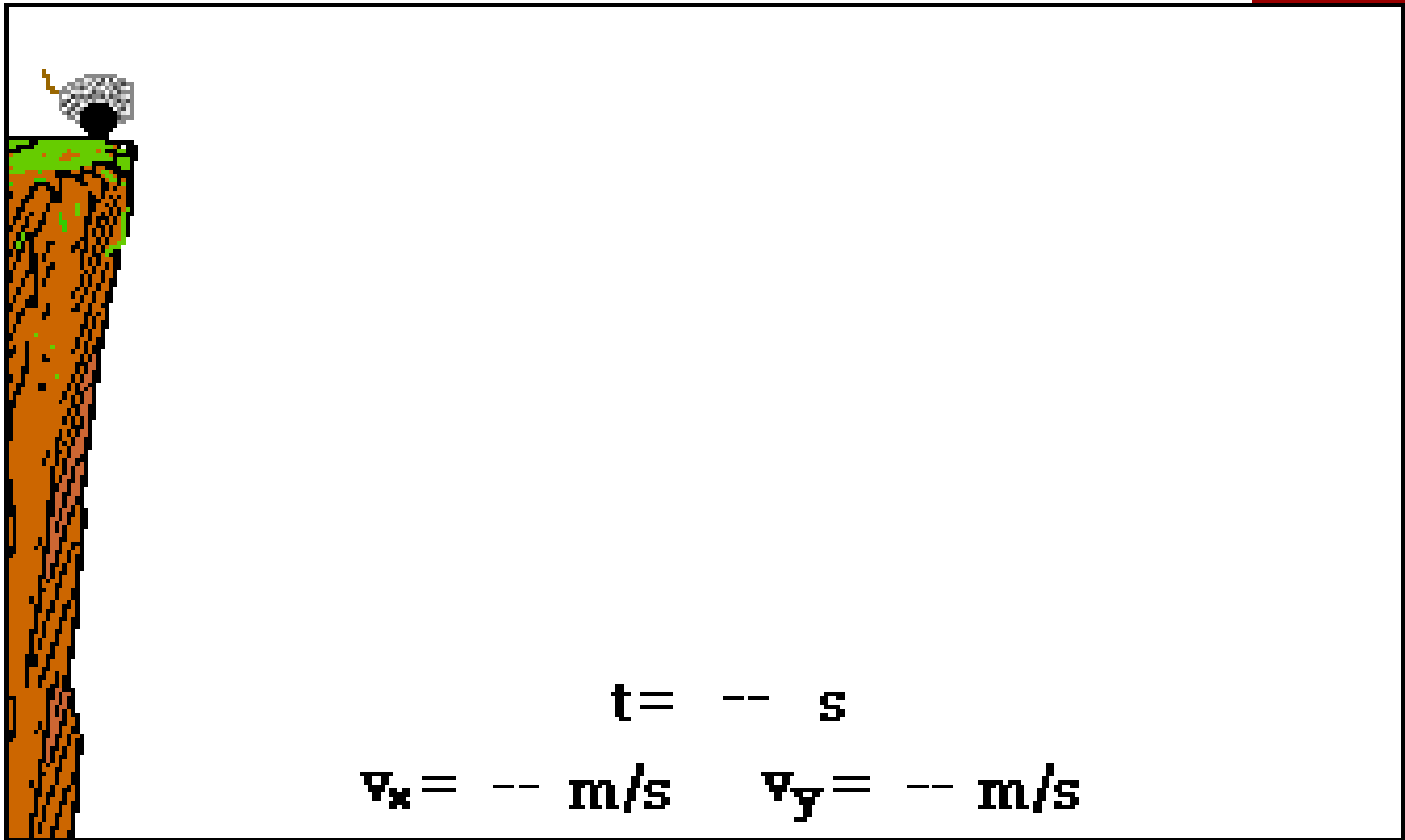
The vertical and horizontal motion of a projectile are independent of each other



Horizontal Path Without Gravity

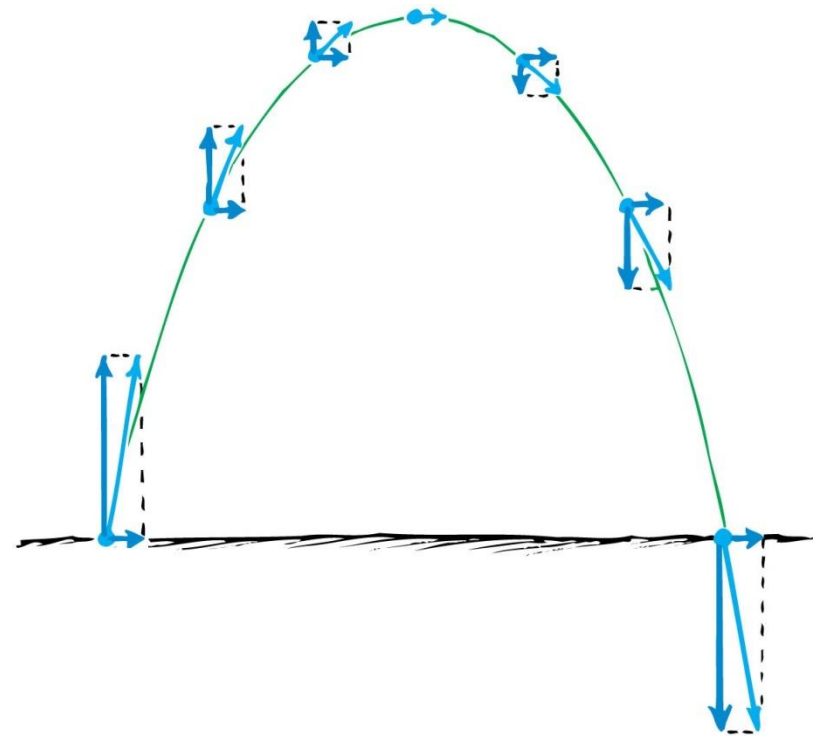
Vertical Path

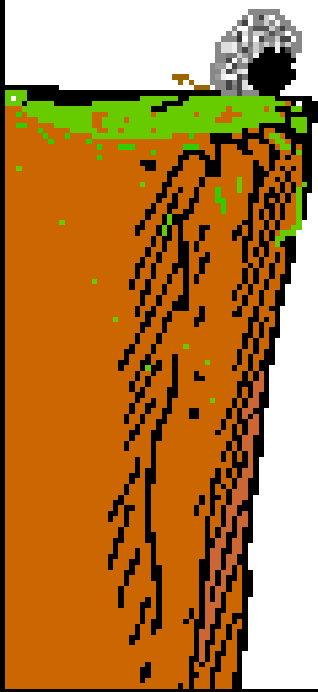




# Projectile Motion

- Projectiles follow a parabolic trajectory
- Horizontal component along trajectory remains unchanged.
- Acceleration only occurs in the vertical component



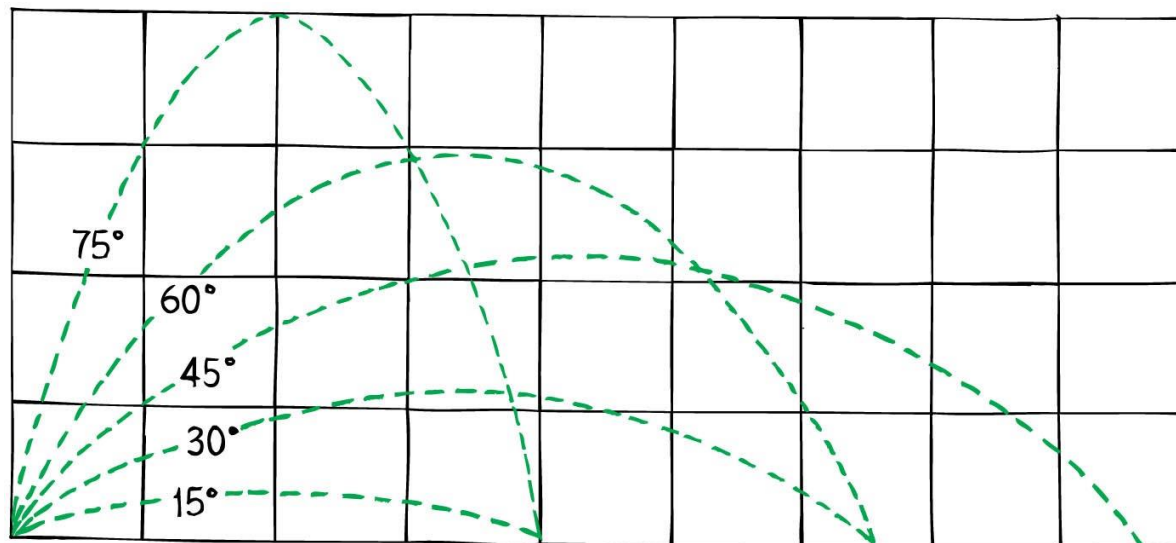


t= -- s

$v_x =$  -- m/s       $v_y =$  -- m/s

# Projectile Motion and Complementary Angles

- Different launch angles result in different horizontal distances traveled by the projectile
- Same range is obtained from two different launching angles when the angles add up to  $90^\circ$ .
  - Object launched at an angle of  $60^\circ$  has the same range as if it were thrown at an angle of  $30^\circ$ .
    - What launch angle would have the same range as a projectile launched at  $20^\circ$ ?



# Projectile Calculations

For Projectiles Launched horizontally



Horizontal Distance

$$d = v(t)$$

Horizontal Velocity

$$v_f = v_i + at$$

Vertical Distance

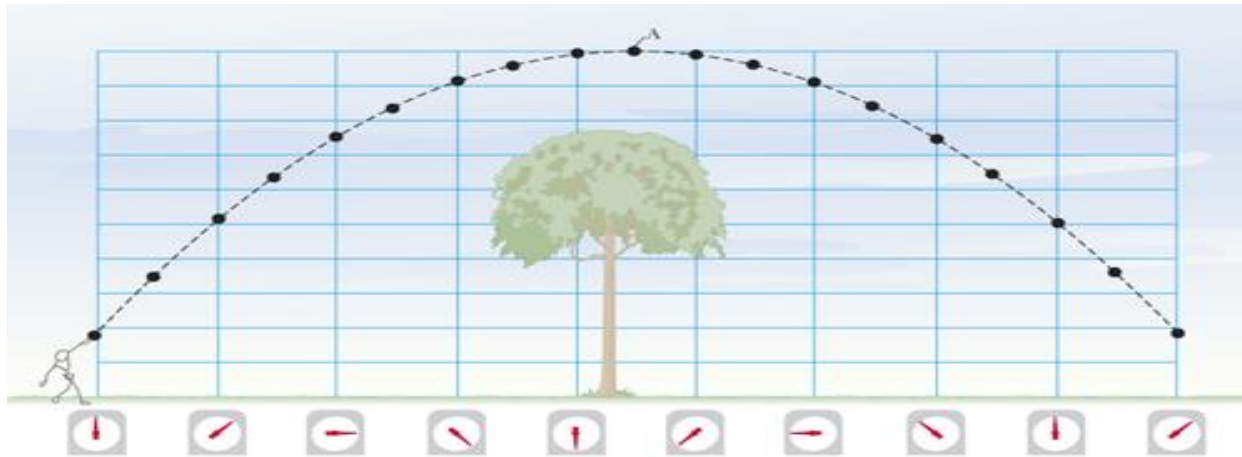
$$d = v_i t + \frac{1}{2} gt^2$$

Vertical Velocity

$$V_f = V_i + gt$$

# Review

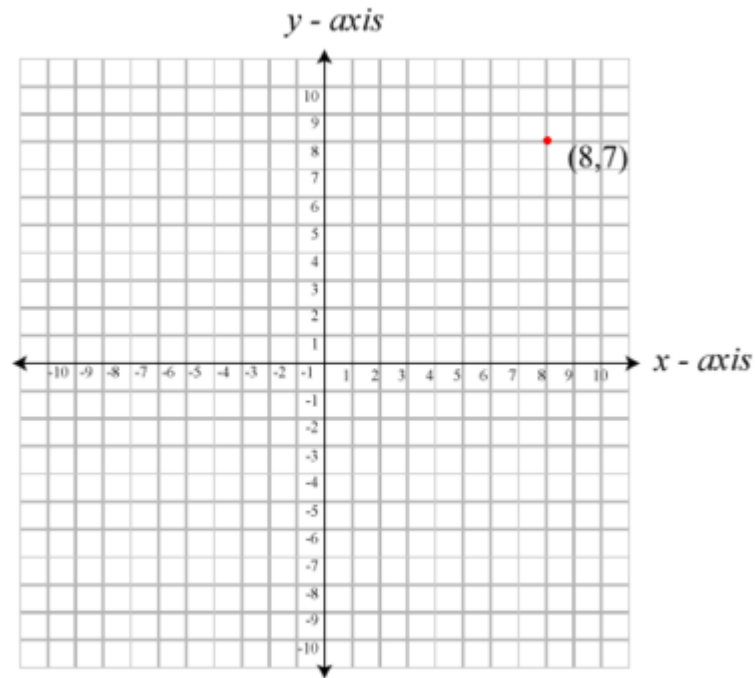
- What is the path of a projectile called?



- Trajectory

# Review

- Is projectile motion one dimensional?

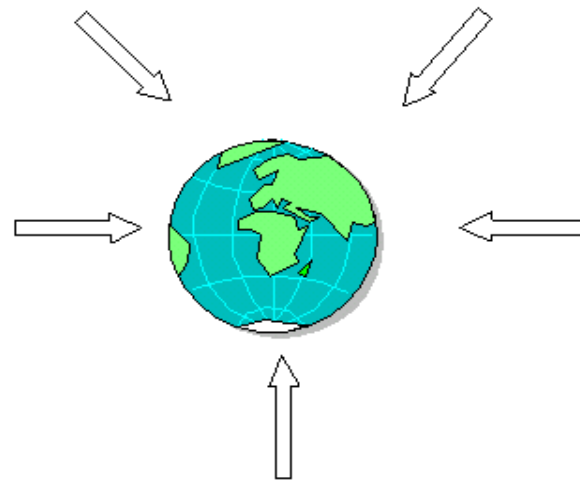




# Review

- What force (s) is acting on the projectile?

- Gravity only



# Review

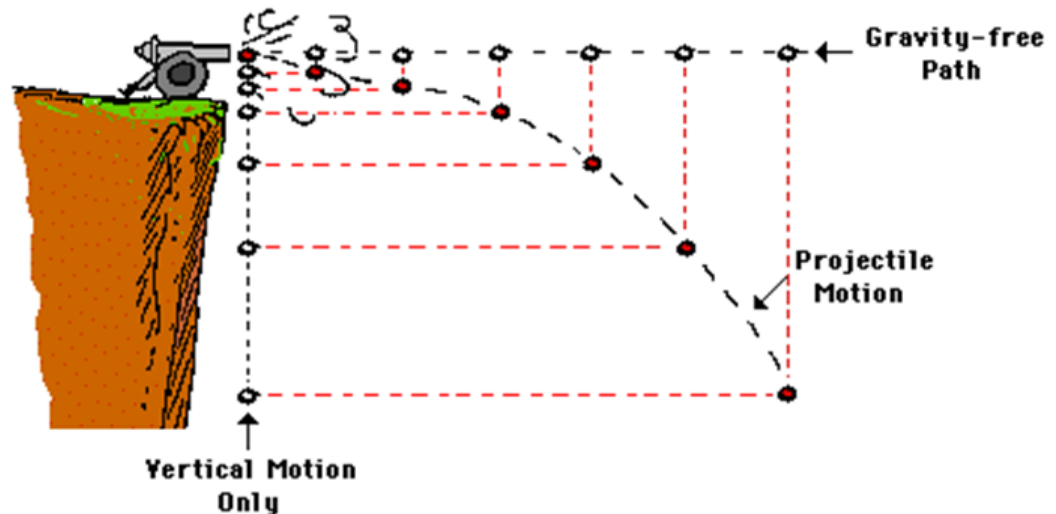
- Which direction, horizontal or vertical has acceleration?
- Vertical
- Which direction, horizontal or vertical has constant speed?
- Horizontal

# Review

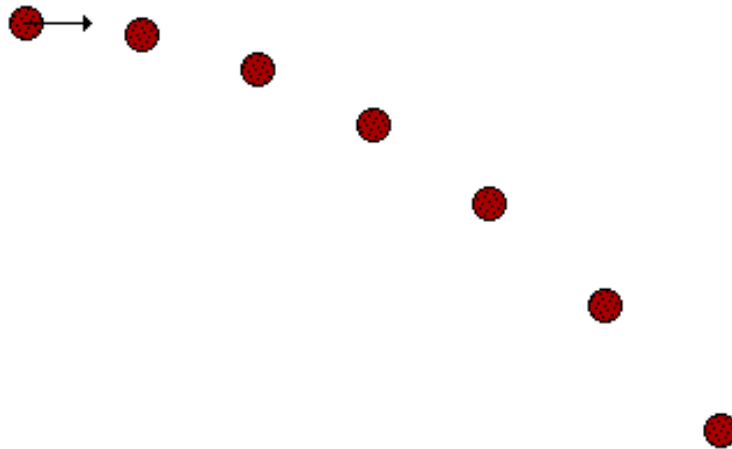
- Two identical balls roll off the edge of a table. One leaves the table travelling twice the speed of the other. Which ball hits the floor first?
- Both hit the ground at the same time. The difference in horizontal velocity does not affect the vertical time.

# Review

- At the instant a horizontally pointed cannon ball is fired, a cannonball held at the cannon's side is released and drops to the ground. Which cannonball strikes the ground first, the one fired from the cannon or the one dropped?
- They hit at the exact same time



Draw vector arrows representing the  $\mathbf{v}_x$  and  $\mathbf{v}_y$  velocity components during the course of the motion. The length of the arrows should represent the magnitude of the velocity components.



Draw vector arrows representing the  $\mathbf{v}_x$  and  $\mathbf{v}_y$  velocity components during the course of the motion.

