

## Lesson 2 Projectile Motion Simulation Software & Questions

WHAT IS A PROJECTILE? An object launched into the air and subject to gravity.

In medieval times it was believed that projectiles were pushed through the air until they reached their impetus. Once they reached that point, they fell straight to the ground, almost as if they had hit a wall. Galileo tested this theory and discovered that the path is actually the **shape of a parabola**. In fact he determined that the path is a combination of horizontal and vertical motion. Once launched, the horizontal force on a projectile is small (air resistance), so horizontal velocity is nearly constant, while the vertical velocity component is affected by gravity, decelerating the upward motion until it reaches the top of the path where the projectile begins to accelerate downward as the acceleration due to the force of gravity pulls it back toward Earth faster and faster.

SCENARIO: Submarines used deck guns to attack and defend when needed in defense of our country. A Mark 40 deck gun's projectile can travel 2155 Feet per Second (FPS) to reach a target up to about 14,500 yards. Attempt to use these numbers in the simulation below.

CHALLENGE: Use the following simulation and answer the questions listed on lesson 2 worksheet.

TIME ALLOWED FOR PREPARATION: two class blocks

GOING FURTHER: Review the Projectile Motion Tutorial Power Point, which is linked at the bottom of Unit Plan page 1.



Lawrence Chapman, Pre-Engineering Teacher, Old Saybrook High School, Saybrook CT (center), discusses STEM with fellowship teacher Stacy Haines and Representative Joe Courtney at the Submarine Force Library and Museum

## **Projectile Motion Simulation Lesson “Using Simulations”**

Open the phET projectile motion simulation:

**<http://phet.colorado.edu/en/simulation/projectile-motion>**

**Think about:**    1) the projectile itself,  
                         2) the launch conditions, and  
                         3) outcomes we can observe/measure.

### **The Projectile Itself**

- Mass
- Shape, features

### **The Launch Conditions**

- launch force
- launch angle
- Force of gravity
- Presence and density of air

### **Things to Observe/Measure**

- How long: time
- How fast: speed and velocity
- How far: distance and displacement: horizontal, vertical, and actual
- Shape of flight path
- Stability

### **In this simulation, what can we control?**

1. launch angle
2. initial speed
3. projectile mass
4. projectile size (diameter)
5. presence of air
6. projectile shape (drag coefficient)
7. air density (altitude)
8. Launch height. Note: Everything is in SI units (metric).

### **What questions can we investigate? (Answer on worksheet 2)**

- What effect(s) does the launch angle of a projectile have on its motion?
- What effect(s) does the initial speed of a projectile have on its motion?
- What effect(s) does the mass of a projectile have on its motion?
- What effect(s) does the size (diameter) of a projectile have on its motion?
- What effect(s) does the presence of air have on the motion of a projectile?
- What effect(s) does the shape of a projectile have on its motion?
- What effect(s) does the altitude of a projectile have on its motion?
- What effect(s) does the launch height of a projectile have on its motion?

### **Dependent Variables**

- In this simulation, what can we measure?

- Horizontal distance (range)
    - Total and at each second
  - Vertical position (height)
    - Final and at each second
  - Time of flight path
- These are the direct effects on motion we can quantitatively measure.
  - We can also observe the shape of the flight path (parabolic).

### **What else can we do?**

- Measurement tool
- Zoom
- Moveable target
- **Note:** The Erase button will remove the current flight paths, but to completely reset the simulation, use your browser's Refresh button (or F5).

### **Independent Variables**

Launch angle  
 Initial speed  
 Mass  
 Size (diameter)  
 Presence of air  
 Shape (drag coefficient)  
 Air density (altitude)  
 Launch height

## **Lesson 2 Projectile Simulation Software & Questions**

### **Worksheet 2**

- What effect(s) does the launch angle of a projectile have on its motion?

- What effect(s) does the initial speed of a projectile have on its motion?
- What effect(s) does the mass of a projectile have on its motion?
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