**Projectile Motion Demonstration**

Why does a baseball that is thrown follow a parabolic path? This question is central to the study of projectile motion.

Galileo was one of the first to study projectile motion. He correctly deduced that part of the motion of a projectile (such as the baseball) was accelerated and part of its motion was uniform.

Suppose that a bullet is loaded into the barrel of a gun. Another identical bullet is held at the same height as the bullet in the barrel of the gun. At the moment that the bullet is fired from the gun, the held bullet is dropped. Which hits the ground first? The correct answer? They both hit the ground at the same time!

According to Newton's first law of motion (the law of inertia), the bullet fired from the gun will continue in motion at the same speed unless acted upon by an outside force. *The horizontal motion of the fired bullet is constant*. The downward motion of both bullets is the same as a body in free-fall. *Vertically, both bullets are uniformly accelerated by gravity*. Both bullets are identical and are dropped from the same height. The only thing that makes the bullets hit the ground is gravity, and it acts on both the same. The result - both bullets hit the ground at the same time.

The curved path of the baseball, or any projected object, is the result of both of these two motions occurring simultaneously. The projectile's horizontal motion is constant and its vertical motion is accelerated by gravity.

**Demonstration**

* Horizontal Motion of a Projectile   
  Imagine that a ball is launched horizontally at 2 m/s. Calculate its position at 0.05 sec intervals.

|  |  |
| --- | --- |
| time in seconds | position in centimeters |
| 0.05 sec | 10 cm |
| 0.10 sec | 20 cm |
| 0.15 sec | 30 cm |
| 0.20 sec | 40 cm |
| 0.25 sec | 50 cm |
| 0.30 sec | 60 cm |
| 0.35 sec | 70 cm |
| 0.40 sec | 80 cm |
| 0.45 sec | 90 cm |
| 0.50 sec | 100 cm |

* Vertical Motion of a Projectile   
  Hang strings with washers on the ends on a meter stick representing the vertical motion of a ball in free fall at 0.05 sec intervals. The length of the string is equivalent to the vertical displacement of the ball at that elapsed time.

|  |  |
| --- | --- |
| time | displacement |
| 0.05 sec | 1.2 cm |
| 0.10 sec | 4.9 cm |
| 0.15 sec | 11.0 cm |
| 0.20 sec | 19.6 cm |
| 0.25 sec | 30.6 cm |
| 0.30 sec | 44.1 cm |
| 0.35 sec | 60.0 cm |
| 0.40 sec | 78.4 cm |
| 0.45 sec | 99.2 cm |
| 0.50 sec | 122.5 cm |

If there were no gravity, the position of the strings on the meter stick every ten centimeters would represent the position of the ball. If the ball were not launched with an initial horizontal speed of 2 m/s, the lengths of the string would represent the position of the ball in free fall.

Hang the meter stick on the black board so that it is horizontal. The washers represent the sum of the vertical and horizontal motions of the ball. Throw a tennis ball from the zero centimeter mark using a speed of 2 m/s. Notice how the ball follows the path of the washers.

Conclusion - the horizontal and vertical motions of a projectile occur simultaneously and do not affect one another. The horizontal motion is constant. The vertical motion is determined by the downward acceleration due to gravity.

**Demonstration**

What happens if the projectile is projected at an angle? When is its range the greatest?

Hold the meter stick with strings and washers at an angle in front of a table or anther horizontal object. Again, the washers represent the path of the projectile. It is easy to determine at what point the projectile "hits" the ground.

What happens when the angle is increased? At what angle is the range the greatest?

Conclusion - an object projected from the ground at a 45 has the greatest range.