Mini Projectile Launcher

94-1970

INSTRUCTIONAL GUIDE

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Mini Projectile Launcher

1. Release Mechanism
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Recommended for Activity:

- **BeeSpi Holder (94-1970-01)**
- **Meter stick (P1-7072)**
- **C-Clamp (PX-1209)**
- **Beespi (P4-1490)**

Background

This simple precise launcher projects 16 mm (5/8”) steel balls at ranges suitable for use on a bench top or from a bench to the floor. A protractor and plumb line make it easy to set any required launch angle from -45° to 90° from horizontal. Three different spring tensions give three repeatable initial velocities and a magnetic piston ensures that the ball does not touch the side of the barrel (to ensure the ball launches straight every time). A cable release provides for a smooth launch to prevent jerking. The unit can stand on its own or be fixed to a bench with a clamp.

Set-Up

Connect the launcher to the support stand using the set screw on the opposite side of the protractor. Once you have the desired angle, tighten the screw to hold it in place. Be sure the surface that you are attaching the launcher to is flat. If the bench or table has an incline there will be error in your results. For added stability and better repeatability, clamp the base of the launcher to the table or bench. A C-clamp works great for this. Steel ball diameter: 16 mm (5/8”)

If using the BeeSpi Holder accessory (sold separately or in a bundle), attach the holder by first removing the wingnut and washer from the bolt on the bottom of the launcher body. Slide the holder over the bolt. Make sure to seat the raised bump in the slot in the launcher body and fit the grove in the holder over the raised edge of the launcher’s end cap. Then replace the washer and wingnut.

Activity

The projectile's motion at any given moment can be described with a vector since at every point in its path, the projectile has speed and direction. Whenever an object is in motion in two dimensions, it can be broken down into two component vectors: V_x and V_y. V_0 is the initial velocity of the projectile the moment after it has been fired. Even objects moving parallel to the ground or straight up in the air have two components. One just happens to be zero.

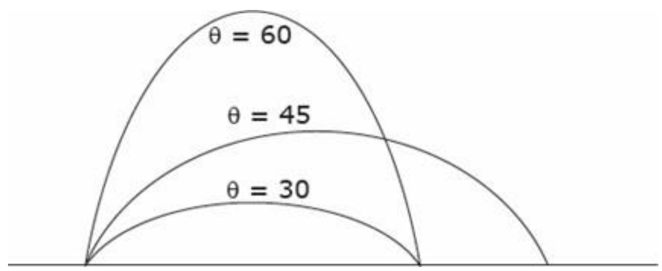
When analyzing the vertical component, V_y, we always need to consider gravity. At the top of the flight of the object the value for V_y will be zero. Since gravity only acts in the vertical direction, the horizontal velocity, V_x, will remain unchanged. (unless you consider any air resistance). The relationship between these values are rooted in trigonometry:

$$\sin\theta = \frac{V_y}{V_0} \qquad \cos\theta = \frac{V_x}{V_0}$$

Range versus height:

The maximum distance the projectile rises vertically is referred to as the height. The maximum distance a projectile travels horizontally is referred to as the range.

As the angle of the projectile increases the range and time of flight increases, until it hits 45˚. Afterwards the range starts to decrease as more of the velocity is directed in the vertical direction.



Determining the launch velocity:

I order to determine the launch velocity (V_0), you can use the two equations below:

$$\cos\theta = \frac{V_x}{V_0} \qquad V_x = \frac{range}{time}$$

You will need to measure the range the projectile travels and the time of flight. The angle can be measured from the protractor on the side of the apparatus.

Rearranging the two equations the value for the launch velocity is:

$$V_0 = \frac{\frac{range}{time}}{\cos\theta} = \frac{range}{time \cdot \cos\theta}$$

When determining the launch velocity, it is important to note that the launching point of the ball and the landing point should be on the same plane.

Figure **1** shows the proper set up determining the launch velocity. Figure **2** represents a complex projectile system, as the landing point is below the plane of the launcher. It is still a good exercise to investigate, but much more demanding mathematically.

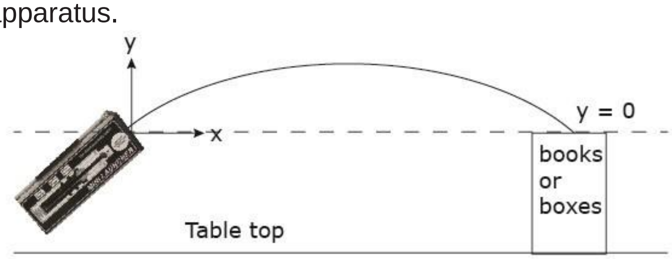


Figure 1

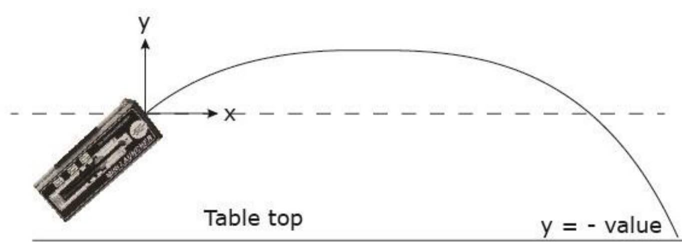


Figure 2

You can measure the launch velocity directly using the **BeeSpi Holder (94-1970-01)** and **BeeSpi (P4-1490)**. This serves to confirm the launch velocity calculated in the first part of this section and offers a means of error analysis. It also removes a variable when performing more advanced investigations of projectile motion.

NGSS Standards

Elementary School	Middle School	High School
3-PS2 Motion and Stability: Forces and Interactions • 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. 4-PS3 Energy • 4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.	MS-PS2 Motion and Stability: Forces and Interactions • MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. • MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.	HS-PS2 Motion and Stability: Forces and Interactions • HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Related Products

Vertical Acceleration Demonstrator (P3-3520) The Vertical Acceleration Demonstrator illustrates a concept that is crucial for understanding projectile motion: that the acceleration due to gravity only affects an object's vertical motion.

Horizontal Projectile Ramp with Ball (P2-8490) The Marble Projectile Ramp is used to launch a marble horizontally from a table or desk. The included screws can be moved to provide up to four different starting points and velocities.

Horizontal Projectile Lab (P4-1406) Horizontal Projectile Lab for the Physics workshop. Challenge students to predict the range of a projectile launched from the ramp!