Air-Powered Projectile

P4-2200

INSTRUCTIONAL GUIDE

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Background

Experiments originating on the football field of Glenbard South High School in Glen Ellyn, Illinois, the Air-Powered Projectile has become a standard device for investigating projectile motion. Field data will conform to a high degree of accuracy with theoretical data of physics formulas. Your students will be amazed when they see proof that these formulas really work.

Introduction

The Air-Powered Projectile is a safe, chemical-free tool for exploring projectile motion. It is free of the numerous variables that plague solid-fuel and water rockets, and it flies straight and true with minimum wind effect, so your experiments have precise, consistent results. When combined with the adjustable Launch Pad (P4-2210) and Angled Wedges (P4-2215), the projectile can be launched consistently at different trajectories.

The Air-Powered Projectile uses compressed air as fuel to power its launch. One of three thrust washers (Low, Medium, or High) is pressed onto the top of the launch tube. **The red projectile slides over the launching tube and pressed onto the thrust washer. The top of the thrust washer should protrude slightly through the hole at the top of the red projectile.** Air is pumped into the launch tube with the air pump. When it reaches the pressure needed to launch the projectile, the thrust washer is forced off the launching tube, sending the projectile into the air.

Safety

Goggles should be worn and care taken in the launching of the Air-Powered Projectile as it launches at a high velocity! Do not lean over the launch pad when pumping the air pump.

Limit outside launches to days above 50^o F to reduce the possibility of the projectile body cracking.

Please launch projectiles to land in large grassy areas, such as a football field. Repeated landings on hard surfaces such as concrete or asphalt may damage the red projectile body.

Investigation

An example used in many classrooms is to have students launch the projectile vertically and time how long it takes for the projectile to complete the trip up and down. This time is then divided in half to get a pretty good approximation for the time of the upward portion of the trip. Your students, knowing that the Air-Powered Projectile slows at the rate of 10 m/s^2, can now calculate the initial speed. (We have found using 10 m/s^2 instead of 9.8 m/s^2 allows the students to do the calculations in their heads.) A projectile took 6 seconds to land after being launched vertically. The time spent on its upward trip would be 3 seconds, so to find initial velocity, v_0, multiply the time to reach maximum height by the acceleration due to gravity—the projectile's initial speed would be 30 m/s. Air resistance is not formally calculated but taken into consideration when calculating the initial velocity.

With this bit of information, your students can calculate the distance the projectile will travel at any angle the launch pad is placed! For example, if an angle of 60 degrees was assigned, a little trigonometry would yield both the vertical (y) and horizontal (x) components of velocity. Since all the energy of the launch is not going into upward thrust, your students should expect a lower velocity for the y direction.

The initial velocity stays the same at 30 m/s. The equations would be:

$$v_y = 30\ m/s \sin 60° = 26\ m/s \text{ and } v_x = 30\ m/s \cos 60° = 15\ m/s$$

If the projectile starts out at 26 m/s in the y direction and gravity slows velocity by 10 m/s each second, it will take 2.6 seconds to reach the top and 2.6 seconds to fall to the ground, totaling 5.2 seconds in the air. Since the projectile travels in the air for 5.2 seconds at 15 m/s in the horizontal direction, it will go 78 meters before hitting the ground (5.2 seconds x 15 m/s = 78 m). Your students will be stunned by how accurate their calculations will be.

Set-Up

1. Select a launching site clear of obstructions and preferably about 50 meters in diameter. Attach the Arbor Scientific air pump to the launch tube.

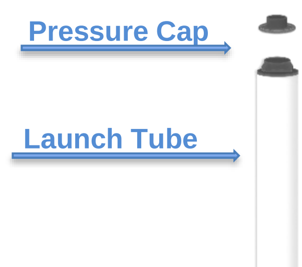
   a. <u>If you are using the launching pad (sold separately).</u> Attach the launch tube to the launching pad using two screws to secure it in place. Select the desired angle wedge and place it in the slot securing it in place by rotating the round knob setting the launch tube in its launching position.



2. Select the high, medium or low thrust washer according to desired altitudes. Snap the thrust washer onto the launch tube **(be sure it snaps)**.

3. Push the rocket completely onto the launch tube. Make sure that the top of the cap seats into the hole at the top of the projectile. Failure to do this will cause reduced performance and inconsistent results.





4. Attach the nose cone onto the red body. Push the cone on all the way; it will only slide approximately ½" onto the rocket body.

5. Attach a bicycle pump to the base of the rocket. Make sure the pump is located behind the rocket if it is pointing at an angle. Pump until the rocket launches automatically.



6. Have a student retrieve the projectile.
7. Push the thrust washer out of the end of the rocket with a pen and repeat the above steps for the next launch. The thrust washers fit tightly when new and are easier to push out if a small amount of lubricant is applied to the tapered plug on top of the cap.

Teachers Notes

A number of things can happen to generate error in the calculations of your students. The largest of these is in their ability to pace off the distance when estimating the expected range of the Air-Powered Projectile. To avoid this, have the experiment take place on the football field or measure the distances with a meter tape prior to the experiment.

Additionally, when doing the calculations, the majority of your students will actually use the wrong angle of launch. For example, if the angled wedge used in the launch pad was the 55-degree wedge, the actual launch angle was its complementary angle or 35 degrees. A way to show why the correct range was calculated in spite of the error would be to introduce them to the projectile range equation:

$$R = \left({v_0^2}/{g} \right) sin2\theta$$

The fact that the sine of twice an angle and twice the complement of an angle yields the same result demonstrates the mathematical reason why your students still got the right answer. Be sure to measure the angle of the launch pad and not the wedge, because the wedge can move.

Related Products

Replacement Washers (P4-2225) and the **Spare Projectile Body and Nose Cone (P4-2205)** allow your experiments to continue even if you lose your original components.

Use the **Altitude Finder (P4-2250)** with the Air-Powered Projectile or with the **Bottle Rocket Launcher (P4-2050)** to find the altitude that the projectile achieved.

Monkey and Hunter Demo (P4-1965) Analysis of the projectile path of the bullet and the monkey's freefall shows that the bullet will hit the target. But are your students still unconvinced? Show them!

Mini Projectile Launcher (94-1970) This simple but precise launcher is versatile and great for indoor classroom use with projectile motion studies! The Mini Projectile Launcher projects 16 mm steel balls at ranges suitable for use on the benchtop or from the bench to the floor. Three launch speeds give ranges of 1m, 1.5m, and 2m.