Shoot the Monkey Demonstration

Introduction

A very clever monkey named Mittens has escaped from a zoo. Mittens climbs up a tree to escape the pursuing zookeeper. The only way the zookeeper can get her down now is by hitting her with a stun dart. However, Mittens is wise to the zookeeper's plan. Not wanting to be hit with the dart, Mittens believes that if she lets go of the tree branch at the same time the zookeeper shoots the dart, the dart will sail over her head as she falls safely to the ground to flee to another tree. The zookeeper knows that Mittens is a very clever monkey. He has a feeling that Mittens will let go of the tree branch as soon as the dart is fired. Where should the zookeeper aim the dart in order to hit the monkey as she falls? Luckily, the zookeeper knows something that Mittens doesn't—the zookeeper knows a little something about physics.

Science Concepts

- Acceleration due to gravity
- Projectile motion
- Falling objects

Materials (for each demonstration)

Backboard assembly with release mechanism and dart launcher
Monkey target*
C-clamp or heavy books

Safety Precautions

Wear safety glasses when performing this demonstration. The dart is tethered to the backboard so it will have limited range if it misses the backboard. However, the dart tip is dangerous. Do not aim the dart at anyone and make sure no one stands behind the backboard during the demonstration. Observers should be at least ten feet away from the demonstration apparatus when the dart is released.

Procedure

1. See Figure 1 for an image of the setup. For complete instructions, refer to Demonstration Kit AP6439.
2. Release the dart and observe the dart strike the target in midair.

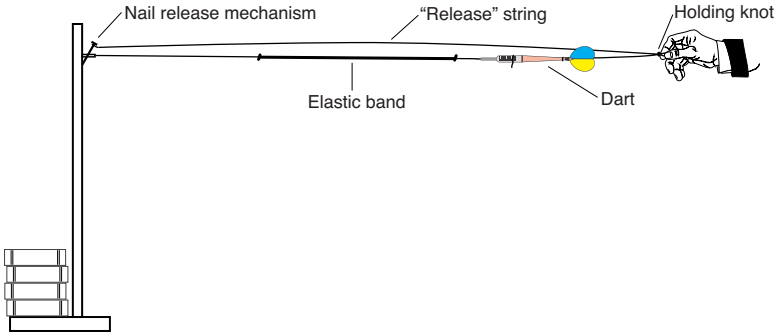

Figure 1.

Tip

- **Practice, Practice, Practice!** Practice launching the dart at the target several times before demonstrating in front of the class. Make sure you are comfortable with the dart launch and target drop procedure.

Discussion

What Galileo (1564–1642) proposed and Newton (1643–1727) essentially proved is that all objects fall toward the Earth at the same increasing rate (in a vacuum). That is, all objects will accelerate toward the Earth equally, regardless of their mass. In a vacuum, where there is no drag friction due to air, a heavy hammer will fall at exactly the same rate as a light feather. At the
surface of the Earth, the acceleration toward the center of the Earth experienced by all objects is measured to be (on average) 9.8 m/s^2 (32 ft/s^2).

Newton also demonstrated that forces can be separated into horizontal and vertical components that are independent of each other. Thus, for a force that pushes a ball up at an angle with respect to the ground, the force is said to have one force

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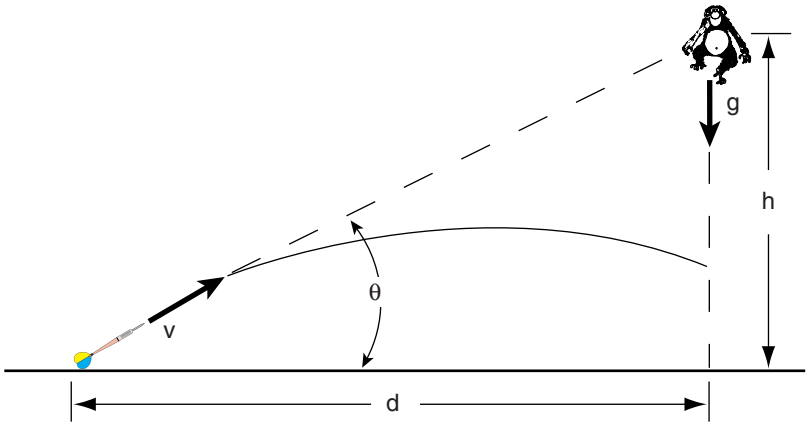
component that is vertical and one that is horizontal. Both force components depend on the total force and on the angle of the force with respect to the ground, but they are independent of each other. A vertical force will have no effect on the magnitude of the horizontal force component, and vice versa.

In the Shoot the Monkey demonstration, both the constant acceleration of gravity and the independence of component forces can be observed and studied. The two objects (the dart and monkey target) are released from the same height at the same time. Because they are both acted on by the force of gravity that pulls them toward the Earth with the same acceleration, the dart and target will fall the same distance in a given amount of time. This means that as long as they are released at the same time, they will always be at the same relative height in a given time.

Aiming the dart at the monkey from the ground will produce the same result because the dart and monkey will still be falling at the same rate. See Flinn Publication No. 6439 for a more advanced discussion on the motion of the dart and the monkey.



Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation
Content Standards: Grades 5–8
Content Standard B: Physical Science, understanding of motions and forces
Content Standards: Grades 9–12
Content Standard B: Physical Science, motions and forces

Shoot the Monkey is available as a demonstration kit from Flinn Scientific, Inc.

Catalog No.	Description
AP6439	Shoot the Monkey—Demonstration Kit

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.