611-2350 (35-050) Free-Fall Tube

(Guinea and Feather Tube)

Description

This apparatus demonstrates the concepts of air resistance and uniformly accelerated motion. It duplicates a famous story which has caught the imagination of scientists over the centuries. Our version consists of a butyrate tube sealed at both ends, one with an exhaust tube assembly which fits ¼-⅜ diameter pressure tubing for evacuating the tube. Inside the tube are carbon or paper "feathers" and a solid mass ("guinea") to serve as representative weights. Actual feathers are not used due to static electric adherence to the tube which will alter the demonstration.

Additional Materials Needed:

- **¼-⅜ inch tubing (depending on pump outlet)**
- **Electric Vacuum Pump *or***
- **Hand Aspirator** (not recommended)

Aspirator will create vacuum of about 90%, probably insufficient for your experiment.

Warranty and Parts:

We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.

Visit us online at:
www.sciencefirst.com

History and Theory

Aristotle thought that heavy objects fall more rapidly than light objects. A two-pound stone should fall twice as fast as a one-pound stone, in his view. Galileo, disagreeing, devised a series of experiments which led to a compilation of the *laws of falling bodies.* Galileo experimented with an **Inclined Plane** and used it to resolve the force of gravity into two smaller components, one of which accelerates a ball down the plane at a rate of speed slow enough to measure. This was in contrast to a ball falling vertically under full force of gravity, which would have been two rapid to measure. Galileo rolled balls of differing weights down a plane inclined at a particular angle to demonstrate that the balls would roll at the same rate of speed. This held true for any angle at which the inclined plane was tipped.

If the plane was tipped more sharply, the balls rolled more rapidly. All the balls, however, despite their different weights, increased the rate at which they rolled by the same amount. The end result is that they all covered the same distance in the same time. In other words, the acceleration of the balls is *constant.*

The story that Galileo demonstrated this phenomenon by dropping two stones of different weights off the Leaning Tower of Pisa, where to an astounded audience they struck the ground at the same time with a simultaneous thump, is probably false. A similar experiment probably was performed during this time, and - combined with Galileo's Inclined Plane observations - gave rise to the birth of modern-day physics.

This type of experiment makes immediate sense to observers because the balls used, although of different weights, are nonetheless substantial. What about the rates of acceleration, however, for a soap bubble, ping pong ball, and solid wood ball the same size as the ping pong ball? In these instances *air resistance* must obviously be taken into account. A heavy body falling through air pushes the air aside with no discernible difference in time elapsed. A light body such as a ping pong ball would press down so softly that it would fall more slowly; the soap bubble would barely fall at all.

The difference in rates of acceleration caused by air resistance is even more exaggerated in the classic demonstration duplicated by the **Free-fall Tube.**

Here, a "guinea" (compact heavy coin) and light, airy "feather" (carbon or paper circle) are dropped in a vacuum where the effect of air resistance has been eliminated. In air, both fall at different speeds. Air resistance retards the fall of each, but the small mass of the feather is retarded more severely than the guinea.

For the ultimate proof, this experiment was performed on the moon by the Apollo 15 astronauts in 1970. The moon being an almost perfect vacuum, the experiment worked perfectly, thus proving Galileo's contention in a fashion inconceivable to his time.

Operation

1. Insert the tube with the hose fitting into fitting at the top of the tube.

2. Connect the hose connector of your vacuum pump to the fitting at the end of the inserted tube. *A motorized vacuum pump will provide the best results.*

3. Hold down the valve at the top of the tube and pump out all of air inside tube**.**

4. Release the valve once the air is removed to maintain vacuum.

Demonstration

To demonstrate, tip the evacuated Free-fall Tube upside down. Observe the rate at which the "guinea" and "feather" fall.

If you've achieved a good vacuum, both "guinea" and "feather" should fall at the same rate of speed and strike the end of the tube at the same visually discernible moment.

Other free-fall experiments

Acceleration during free fall is so rapid you can't observe it very well. However, you can listen and draw conclusions about acceleration by the sounds falling objects make.

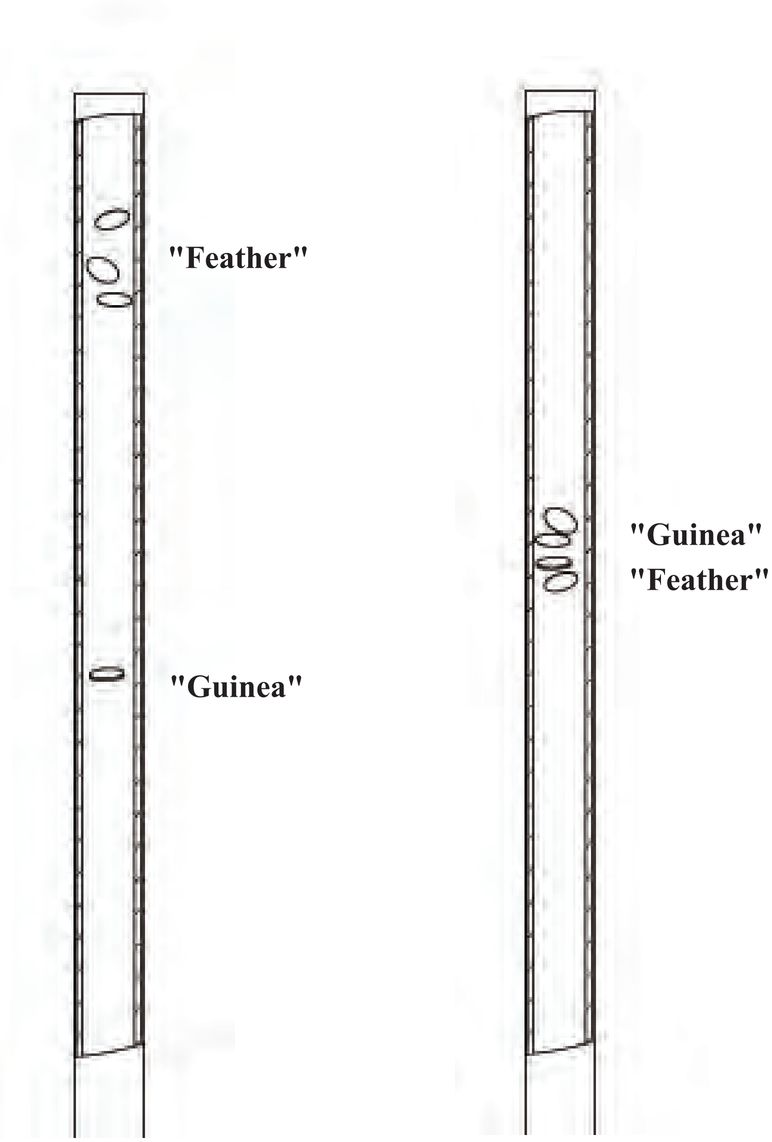
Tie heavy metal objects two feet apart along a piece of 12" or longer cord. Have a second person hold an end of the cord above a pan or box which are placed below a window or stairwell.

Signal your helper to drop the cord. Listen for the sounds of the metal objects as they hit the pan. Imitate the sound pattern by tapping your pencil. What conclusion can you draw about the speed of the objects as they land?

Objects that are streamlined or nearly so are not greatly affected by air resistance until they are going rapidly. A ball accelerates almost as much during the first 50 feet of its fall as it would if it were in free fall.

Air friction slows down the lighter object..

In a vacuum, the coin and carbon circle fall at the same rate of speed.



Related Products

The following products may be ordered from your distributor, or, if unavailable, from manufacturer **Science First®.**

611-0035 Inclined Plane - for studies of acceleration, friction and gravity. All-aluminum, clamps up to 45°, removable protractor with scale, low-friction pulley. Folds for storage.

611-1215 Ring and Disc - Good economical lab. Metal ring and wood disc both with same mass and diameter. Roll down an incline. Which is faster?

611-0110 Second Law of Motion - Which of 2 balls will strike the ground first, the one dropped or the one shot outward? Contains spring plunger, 2 steel balls, instructions. No clamp needed.

611-1220 Variable Inertia - Two plastic discs with 8 steel balls that can fit a variety of compartments. Roll down an incline. Which is faster?

How to Teach with Free-Fall Tube

Concepts: Velocity and acceleration; uniformly accelerated motion; gravitational force and acceleration due to gravity. Equations of motion under gravity - time/distance/velocity/acceleration relations.

Curriculum Fit: Physics Sequence: Motion and Force. *Unit: Causes of Motion - Newton's First and Second Laws.*

P/N 24-35050