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Coin & Feather 4-7801

Warning:

- Not a toy; use only in a laboratory or educational setting.
- California Proposition 65
 Warning: This product can expose you to chemicals including lead, nickel, and benzene, which are known to the State of California to cause cancer, birth defects, or other reproductive harm. For more

information go to www.P65Warnings.ca.gov.

Introduction

The Coin & Feather Apparatus is used to show that in a vacuum all objects fall at the same rate regardless of their mass. When the effect of air resistance is removed, both a light and a heavy object will fall at the same speed.

Look at the Coin & Feather in the tube. Ask them which will fall to the bottom of the tube first when you turn it on the end. Turn the tube on the other end and observe that the coin does fall faster than the feather.

Using a Hand Vacuum Pump, remove the air from inside the tube. Reduce the pressure to 1.25 Hg (30mmHg or less).

Next, repeat the demonstration by inverting the tube. The coin and feather fall as the same speed. You can also substitute a bit of cotton or foil for the feather. If you notice that the feather is sticking to the side of the tube, wipe it with a damp cloth to discharge the static buildup.

Facts

Weight is constant. W= mg

Resistance depends on square of velocity. R=CdpV²A/2

Motion of object, Newton's second law: F=ma, a = F/m = (W-D)/m

When drag is equal to weight, acceleration is zero and velocity becomes constant also known as terminal velocity.

An object that is falling through the atmosphere is subjected to two external forces. The first force is the gravitational force, expressed as the weight of the object, and the second force is the aerodynamic drag of the object. The weight equation defines the weight \mathbf{W} to be equal to the mass \mathbf{m} of the object times the gravitational acceleration $\mathbf{g}: \mathbf{W} = \mathbf{m}^*\mathbf{g}$

The value of \mathbf{g} is 9.8 meters per square second on the surface of the earth. The gravitational acceleration decreases with the square of the distance from the center of the earth. For most practical problems in the atmosphere, we can assume this factor is constant. If the object were falling in a vacuum, this would be the only force acting on the object. In the atmosphere, the motion of a falling object is opposed by the aerodynamic drag. The drag equation tells us that drag \mathbf{D} is equal to a drag coefficient \mathbf{Cd} times one half the air density \mathbf{r} times the velocity \mathbf{V} squared times a reference area \mathbf{A} on which the drag coefficient is based:



On the figure at the top, the density is expressed by the Greek symbol "rho". The symbol looks like a script "p". This is the standard symbol used by aeronautical engineers. We are using "r" in the text for ease of translation by interpretive software.

$$D = Cd * .5 * r * V^2 * A$$

The motion of any moving object can be described by Newton's second law of motion, force **F** equals mass **m** time's acceleration **a**:

$$F = m * a$$

We can do a little algebra and solve for the acceleration of the object in terms of the net external force and the mass of the object:

$$a = F / m$$

Weight and drag are **forces** which are vector quantities. The **net external force** is then equal to the difference of the weight and the drag forces:

$$F = W - D$$

The acceleration of the object then becomes:

$$a = (W-D) / m$$

The **drag force** depends on the square of the velocity. So as the body accelerates its velocity and the drag increase. It quickly reaches a point where the drag is exactly equal to the weight. When drag is equal to weight, there is **no net external force** on the object, and the acceleration becomes zero. The object then falls at a constant velocity as described by Newton's first law of motion. The constant velocity is called the terminal velocity.