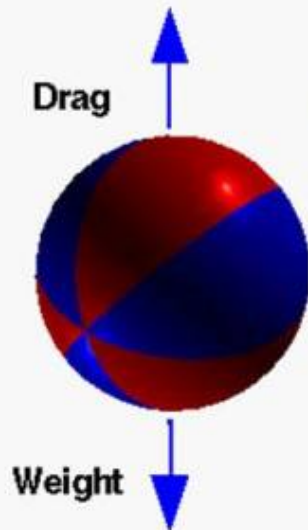




Forces on a Falling Object

(with air resistance)

**Glenn
Research
Center**

Weight is constant.

$$W = m g$$

**Resistance (Drag) depends on
square of velocity.**

$$D = C_d \rho \frac{V^2 A}{2}$$

Motion of object (Newton's second law).

$$F = m a$$

$$a = \frac{F}{m} = \frac{(W - D)}{m}$$

When Drag is equal to Weight, acceleration is zero.
Velocity becomes constant (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 **W** to be equal to the mass **m** of the object times the gravitational acceleration **g**:

$$W = m * g$$

the value of **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. But 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. But in the atmosphere, the motion of a falling object is opposed by the aerodynamic [drag](#). The [drag equation](#) tells us that drag **D** is equal to a [drag coefficient](#) **C_d** times one half the air [density](#) **ρ** times the [velocity](#) **V** squared times a reference [area](#) **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.

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

The motion of any moving object can be described by Newton's [second law](#) of motion, force **F** equals mass **m** times 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](#).

Activities:

11-12

[Guided Tours](#)

•



Falling Objects:



Navigation ..

[Aerodynamics Index](#)

[Model Rocket Index](#)

[Beginner's Guide Home Page](#)



- + Inspector General Hotline
- + Equal Employment Opportunity Data Posted Pursuant to the No Fear Act
- + Budgets, Strategic Plans and Accountability Reports
- + Freedom of Information Act
- + The President's Management Agenda
- + NASA Privacy Statement, Disclaimer, and Accessibility Certification



Editor: Nancy Hall
NASA Official: Nancy Hall
Last Updated: May 13 2021
+ Contact Glenn