

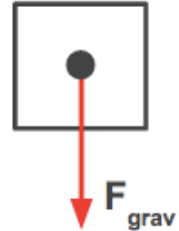
Free Fall and Newton's Second Law

Lesson Notes

Free Fall

We define **free fall** as a motion of an object that is under the sole influence of the force of gravity.

Given this definition, the free-body diagram for a free-falling object displays a single force. This type of motion is an *idealized* motion that occurs when the influence of air resistance is minimized to the point that its influence upon the object is negligible.



The BIG Idea

The acceleration of a free-falling object is independent of the mass of the object. A more massive object accelerates at the same rate as a less massive object.

Numerous demonstrations of this idea were provided in the video. These include ...

- The falling motion of four markers vs. one marker
- The falling motion of the hammer and the feather on the moon
- The falling motion of the bowling ball and the feather in a vacuum chamber
- Student lab where objects of varying mass are dropped and the acceleration value is determined.

Sources:

NASA: https://nssdc.gsfc.nasa.gov/planetary/lunar/apollo_15_feather_drop.html

BBC: <https://www.youtube.com/watch?v=E43-CfukEqs>

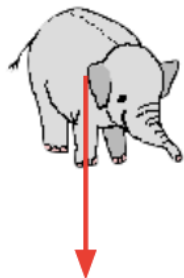
Acceleration of Gravity

The acceleration of gravity is the acceleration value that results when the force of gravity is the only force of influence. On Earth, this value is **9.8 m/s/s**. It is identical in value to the gravitational field strength of our planet (9.8 N/kg).

So Why is the Acceleration of Gravity Independent of Mass?

Newton's Second Law $a = F_{\text{net}} / m$

Elephant



$$a = \frac{\cancel{M} \cdot g}{\cancel{M}} = g$$

Feather



$$a = \frac{\cancel{m} \cdot g}{\cancel{m}} = g$$

The F_{net} -to-mass ratio is the same value for the elephant and for the feather. The ratio equals g ... sometimes referred to as the **acceleration of gravity**.

Logical Argument for the Above Claim:

For a free-falling object ...

- The only force is gravity.
- The force of gravity is calculated as $m \cdot g$ ($g = 9.8 \text{ N/kg}$).
- The F_{net} is $m \cdot g$.
- The a is F_{net}/m which turns out to be $m \cdot g/m$.
- Since the mass (m) cancels, acceleration is g , regardless of what the mass value is.

Check Your Understanding

Identify the following statements as being True or False:

1. The elephant and the feather each have the same force of gravity.
2. The elephant has more mass, yet both elephant and feather experience the same force of gravity.
3. On earth, all objects have the same force of gravity (whether an elephant or a feather).
4. The elephant weighs more than the feather, yet they each have the same mass.
5. The elephant clearly has more mass than the feather, yet they each weigh the same.
6. The elephant clearly has more mass than the feather, yet the amount of gravity (force) is the same for each.

Disclaimer

The fact that the acceleration of a falling object is independent of mass is restricted to free-fall situations in which air resistance is negligible. As air resistance begins to have a more significant effect upon an object's motion, this fact is no longer observable.