Vertical Motion - Why do things fall towards the ground?

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<http://science.howstuffworks.com/environmental/earth/geophysics/question2322.htm>

<http://www.physicsclassroom.com/Class/circles/U6L3a.cfm>

<http://www.physicsclassroom.com/Class/circles/U6L3c.cfm>

<http://www.physicsclassroom.com/Class/circles/U6L3e.cfm>

Nearly every child knows of the word **gravity**. Every time you jump, you experience gravity. It pulls you back down to the ground. Without gravity, you'd float off into the atmosphere -- along with all of the other matter on [Earth](http://science.howstuffworks.com/environmental/earth/geophysics/earth.htm). You see gravity at work any time you drop a book, step on a scale or toss a ball up into the air. It's such a constant presence in our lives, we seldom marvel at the mystery of it -- but even with several well-received theories out there attempting to explain why a book falls to the ground (and at the same rate as a pebble or a couch, at that), they're still just theories. The mystery of gravity's pull is pretty much intact.

So what do we know about gravity? We know that it causes any two objects in the universe to be drawn to one another. We know that gravity assisted in forming the universe, that it keeps the moon in orbit around the Earth, and that it can be harnessed for more mundane applications like [gravity-powered motors](http://www.fuellesspower.com/gravity2.html) or [gravity-powered lamps](http://science.howstuffworks.com/environmental/earth/geophysics/earth/green-technology/sustainable/home/gravity-powered-lamp.htm).

As for the science behind the action, we know that Isaac Newton defined gravity as a force -- one that attracts all objects to all other objects. In this article, we'll look at [Newton's](http://science.howstuffworks.com/dictionary/famous-scientists/physicists/isaac-newton.htm) theory of gravity. Although many people had already noted that gravity exists, Newton was the first to develop a cohesive explanation for gravity, so we'll start there.

**Newton's Gravity**

In the 1600s, an English physicist and mathematician named [Isaac Newton](http://science.howstuffworks.com/dictionary/famous-scientists/physicists/isaac-newton.htm) was sitting under an apple tree -- or so the legend tells us. Apparently, an apple fell on his head, and he started wondering why the apple was attracted to the ground in the first place.

Newton publicized his Theory of Universal Gravitation in the 1680s. It basically states that any two objects in this universe attract each other with a force, which is given by the following formula:

(Eq. 1),



where *m1* and *m2* are the masses of the two objects measured in kilograms (kg) and *d* is the distance between their centers measured in meters (m). *G* is a constant called gravitational constant and has a value of 6.67 x10-11Nm2/kg2. Eq. 1 states that the force between two objects is proportional to the product of their masses and inversely proportional to the square of the distance between them. The greater the masses, the greater the force; the greater the distance between the objects, the smaller the force!

A note on Units: Forces are measured in Newton denoted by symbol N. To get an idea of how much 1 Newton is, when you pick up 20 nickels or 1 AAA cell battery, you exert a force of 1N. To lift your school bag, you need to apply a force that is probably around 50N (maybe more or less but in that ballpark).

So, Newton’s Law of gravitation tells us that if two objects of mass 1 kg are placed 1 m apart, they each experience an attractive force of magnitude 6.67 x10-11N – that is 0.0000000000667 N - that’s a really small force!!! If we placed two 100kg (about 220 pounds) people 1 m apart, they will attract each other with a force of magnitude 0.000000667 N – still a miniscule force compared to forces we are accustomed to exerting or experiencing.

So why bother with Newton’s Law of Gravitation? What is the connection between the Law of Gravitation and the force of gravity?

We talk of the force of gravity on an object, say, a book, when one of the objects in Eq. 1 is the book and the other object is the Earth. When you deal with massive objects like the Earth, which has a mass of about 6 x 1024 kilograms, it adds up to a rather powerful gravitational force. That's why you're not floating around in space right now.

Lets calculate the force between the Earth and a 1 kg book placed on its surface. In this case d = radius of the Earth which has a value of 6.37 x 106 m. Lets put it all together using Eq. 1.



So the Earth is attracting the book with a force of 9.86 N - we say the force of gravity on the book is 9.86 N. To lift that book from the Earth’s surface, you need to exert a force of about 9.86 N. So what would be the force of gravity on a school bag that has a mass of 5kg? It is 5 times the force on a 1kg object or 5 x 9.86 N or 49.3 N!!

**QUESTION**: What is the force of gravity on a ninth grader whose mass is 65 kg? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What does this have to do with what we were learning so far?

Newton had also postulated his three Laws of Motion (you have learned those in middle school – find their statements using online resources):

Newton’s 1st Law: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Newton’s 2nd Law: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Newton’s 3rd Law: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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We will use Newton’s 2nd Law and apply it to the force of gravity: The 2nd Law tells us that if a force **F** acts on an object of mass m, it causes the object to accelerate with an acceleration **a** given by:

**F = m a** (Eq. 2)

