Newton's Law of Gravity

"Every particle of matter in the universe attracts every other particle with a force that is directly proportional to the product of the masses of the particles and inversely proportional to the square of the distance between them."

– Issac Newton

This translates to:

$$F = G\frac{m_1 m_2}{r^2}$$

Where,

- F is the force,
- m_1 and m_2 are masses of the objects interacting,
- r is the distance between the centre of the masses. (In some equations called distance d.)
- G is the gravitational constant ($6.674 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$).

Anything that has mass also has gravity. More massive objects have more gravity. All of an object's mass make a combined gravitational pull on all the mass of other objects. Gravity gets weaker with distance. The closer objects are to each other, the stronger their gravitational pull toward each other.

The gravitational force between two objects is created by the combined gravitational forces of both objects.The Earth pulls on us; we pull on the Earth. Because the Earth is so much more massive, the combined force does not have an obvious effect on the planet. Even the smallest particles of dust have a slight gravitational pull on each other. It is this small gravitational pull that causes the universe's vast expanse of star dust to slowly gather into stars, planets and galaxies.

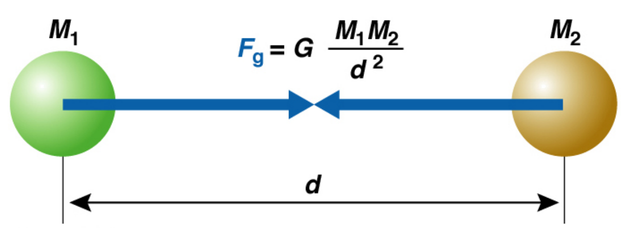

Figure 1: Force of Gravity Between Two Objects

Gravity Everywhere

Gravity creates stars and planets by pulling together the interstellar dust from which they are made.Gravity holds planets in orbit around stars, and keeps the moon in orbit around Earth. The gravitational pull of the moon pulls the Earth's oceans towards it, creating the tides. Gravity keeps the atmosphere close to the surface of the Earth, allowing us to breath. Gravity makes the rain fall, the rivers flow, dropped an apple on poor Newton's head, and—combined with humidity—is a known contributor to seriously "bad hair days".

The Universal Gravitational Constant (Big G)

The gravitational constant was first defined by Isaac Newton in his paper, *Law of Universal Gravitation*, formulated in 1680. It is thought to be one of the fundamental constants of nature.

The universal gravitational constant is a key to understanding our universe—including its size, mass, age, beginning, future, as well as the secrets of gravity, space-time, time travel, dark-matter, black holes, 42, and more or less everything else. It describes the intrinsic strength of gravity, and can be used to calculate the gravitational pull between any two objects, from individual particles of dust to massive galaxy clusters.

A Predictable Universe?

Most scientists today think the value of G is always the same everywhere in the universe. Although this fact can not yet be scientifically proven, all evidence on earth and from deep space research so far seems to confirm it. However, there are several interesting theories that challenge this view. If any of them could be proven closer to the truth, it would fundamentally alter our understanding of reality.

Acceleration of Gravity (Little g)

Galileo was the first to create equations for the behavior of falling objects. He discovered that a free-falling object near the earth's surface has an acceleration of about 9.8 m/s^2. This value is called the **Acceleration of Gravity**, and is given the symbol g. If the earth were heavier or lighter, g would be a different value.

Differences Between "Big G" and "Little g"

G and g are closely related ideas, but the relationship is not proportional. Although formulas can be created to relate G and g for a given location, there is no universal correlation between them. This is because the value of g is different for different locations due to many independent variables.

	Symbol	Definition	Nature of Value	Unit
Acceleration due to gravity	g	The acceleration experienced by a body under free fall due to the gravitational force of the massive body	Changes from place to place. Acceleration due to gravity of the earth is 9.8 m/s^2	m/s^2
Universal Gravitational Constant	G	The force of attraction between two objects with unit mass separated by a unit distance at any part of this universe.	Constant at any point in this universe. $G = 6.67 \times 10^{-11}\ Nm^2/kg^2$	Nm^2/kg^2

Table 1: Differences Between "Big G" and "Little g"

The Newton

The newton N is the unit of force in the International System of Units (SI). It is defined as $1kg\frac{m}{s^2}$, the force which gives a mass of 1 kilogram an acceleration of 1 meter per second per second. It is named after Isaac Newton in recognition of his work on classical mechanics, specifically Newton's second law of motion.

The units "meter per second squared" can be understood as measuring a rate of change in velocity per unit of time, i.e. an increase in velocity of 1 meter/second, every second.

As with every SI unit named for a person, its symbol starts with an upper case letter N, but when written in full it follows the rules for capitalization of common nouns; i.e., "newton" becomes capitalized at the beginning of a sentence and in titles, but is otherwise in lower case.

$$1\ \mathrm{N} = 1\ \frac{\mathrm{kg{\cdot}m}}{\mathrm{s}^2}$$

Examples

At average gravity on Earth ($g = 9.80665m/s^2$), a kilogram mass exerts a force of about 9.8 newtons.

1. How much force does an apple exert on the Earth's surface?

$$0.200kg \times 9.80665m/s^2 = 1.961N$$

The mass of an average-sized apple at 200 g, exerts about two newtons of force at Earth's surface, which we measure as the apple's weight on Earth.

2. How much force does the average adult human exert on the surface of the Earth?

$$62kg \times 9.80665m/s^2 = 608N$$

The average adult human exerts a force of about 608 N on the Earth's surface (where 62 kg is the average mass of an adult human).