5.1 Universal Gravitation

5.1

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The law of universal gravitation allows you to calculate the gravitational force between two objects from their masses and the distance between them. The law includes a value called the gravitational constant, or "G." This value is the same everywhere in the universe. Calculating the force between small objects like grapefruits or huge objects like planets, moons, and stars is possible using this law.

What is the law of universal gravitation?

The force between two masses m_1 and m_2 that are separated by a distance r is given by:

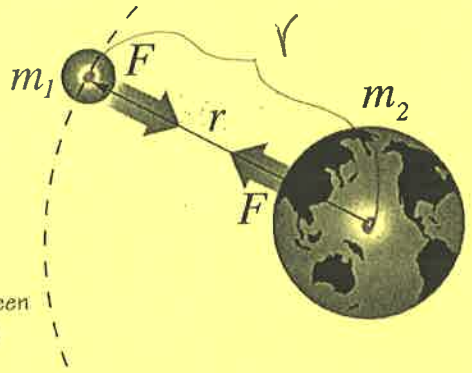
Law of universal gravitation

Force of gravity

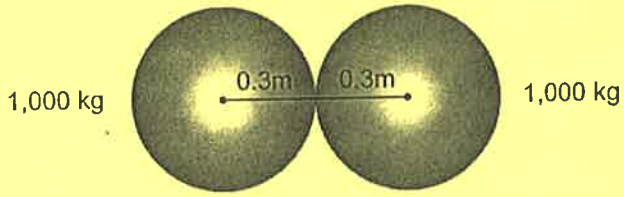
Force (N) $F_g = G \dfrac{m_1 m_2}{r^2}$ Mass 1, Mass 2 (kg)

Gravitational Constant (6.67×10^{-11} N.m^2/kg^2)

Distance between masses (m)



So, when the masses m_1 and m_2 are given in kilograms and the distance r is given in meters, the force has the unit of newtons. Remember that the distance r corresponds to the distance between the center of gravity of the two objects.



For example, the gravitational force between two spheres that are touching each other, each with a radius of 0.300 meter and a mass of 1,000. kilograms, is given by:

$$F = 6.67 \times 10^{-11}\,\text{N-m}^2/\text{kg}^2 \; \frac{1{,}000.\ \text{kg} \times 1{,}000.\ \text{kg}}{(0.300\ \text{m} + 0.300\ \text{m})^2} = 0.000185\ \text{N}$$

Any object of mass exerts a gravitational force on another object of mass.

Force of gravity is directly proportional to the objects' masses.

Force of gravity is inversely proportional to distance between the masses.