

Gravitation Terms and Definitions



Lecture Notes on Newton's Law of Universal Gravitation

1. Statement of Newton's Law of Universal Gravitation

Newton's Law of Universal Gravitation states that every particle of matter in the universe attracts every other particle with a force that is:

- Directly proportional to the product of their masses
- Inversely proportional to the square of the distance between their centers.

Mathematically, it can be expressed as:

"Every point mass attracts every other point mass by a force pointing along the line intersecting both points. The force is proportional to the product of the two masses and inversely proportional to the square of the distance between them."

2. Mathematical Expression

The gravitational force (F) between two masses m_1 and m_2 , separated by a distance r , is given by:

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

where:

- F = gravitational force between the two masses
 - G = gravitational constant
 - m_1 and m_2 = masses of the two objects
 - r = distance between the centers of the two masses
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3. Gravitational Constant (G)

- **Definition:** The gravitational constant G is a proportionality factor in Newton's law of gravitation. It quantifies the strength of the gravitational force between two objects.
 - **Value:** $G = 6.674 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$.
 - This constant ensures that the units of force are consistent with the units of mass and distance in the equation.
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4. Dimensional Formula and Units of G

- **Dimensional Formula:** The dimensional formula of G is derived based on Newton's second law (Force = mass \times acceleration) and the formula for gravitational force.

$$[G] = [F] \times [r^2]/[m_1 \cdot m_2]$$

Breaking this down:

$$[G] = \text{Nm}^2/\text{kg}^2 = M^{-1}L^3T^{-2}$$

- **Units:**
 - In SI Units: Nm^2/kg^2 (Newton meter squared per kilogram squared)
 - In CGS Units: $\text{dyn cm}^2/\text{g}^2$
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5. Importance of the Universal Law of Gravitation

- **Explains Planetary Motion:** The law provides the basis for understanding planetary orbits and the movement of celestial bodies within the solar system and the universe.
 - **Predicts Gravitational Attraction:** It helps in calculating gravitational forces between any two objects with mass, which is essential in fields like astrophysics, satellite technology, and space exploration.
 - **Foundation for Modern Physics:** This law laid the groundwork for more advanced theories of gravitation, including Einstein's theory of General Relativity.
 - **Explains Weight:** It provides an explanation for weight as the gravitational pull between Earth and objects on or near its surface.
 - **Relevance in Various Scientific Fields:** From meteorology to oceanography, the gravitational law plays a critical role in explaining tides, atmospheric phenomena, and other Earth-bound phenomena driven by gravitational interactions.
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