

{Final Project}

Universal Gravitation &

Kepler's Third Law

Computer. Information

Technology (CIT)

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Timing , 2:00 ,4:00

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Section 1: Introduction

Gravitation is a fundamental force of nature that attracts any two objects having mass toward each other. This force is responsible for many natural phenomena, such as the falling of objects toward the Earth, the motion of planets around the Sun, and the movement of moons around planets. Without gravitation, the structure of the universe would not exist in its present form. The study of gravitation became more systematic after Sir Isaac Newton presented his Universal Law of Gravitation, which explained

how every object in the universe attracts every other object. Later, Johannes Kepler described the motion of planets through his three laws of planetary motion. Newton's law provided the physical explanation behind Kepler's laws, especially Kepler's Third Law. Together, these laws play a vital role in physics and astronomy

Section 2: Universal Law of Gravitation-

Statement of the Law According to Newton's Universal Law of

Gravitation, every particle in the universe attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers.

Mathematical Formula

$$F = G(m_1 m_2 / r^2)$$

Explanation of variables

F = Gravitational force between two objects

G = Universal gravitational constant

m₁, m₂ = Masses of the two objects

r = Distance between the centers of the two objects

Units and Dimensions

Unit of force F is Newton (N)

The unit of gravitational constant G is $\text{N.m}^2/\text{kg}^2$.

Dimensional formula of G :

$$[G] = M^{-1} L^3 T^{-2}$$

Real-Life Applications

Motion of planets around the Sun

Motion of the Moon around the Earth

Artificial satellites revolving around the Earth

Calculation of weight of objects

Section 3:Kepler's

Third Law

Statement of the Law

Kepler's Third Law states that the square of the orbital period of a planet is directly proportional to the cube of the radius of its orbit around the Sun.

Mathematical Expression

Explanation of Fractional

Exponents and Square Roots

If the cube of the radius increases, the square of the time period also increases. This shows that planets

farther from the Sun take more time to complete one revolution.

Fractional powers and square roots help in understanding the proportional relationship between distance and time.

Relationship Between Orbital Period and Radius

As the orbital radius increases, the time period of revolution increases.

Therefore, distant planets move more slowly in their orbits compared to nearer planets.

Importance in Astronomy

Kepler's Third Law helps astronomers calculate the distance of

planets from the Sun and study the motion of stars, planets, and satellites.

Section 4: Derivation of Kepler's Third Law

Consider a planet of mass m revolving around the Sun of mass M in a circular orbit of radius r .

According to Newton's Law

$F = GMm/r^2$ of Gravitation:

This gravitational force provides the necessary centripetal force: $F = mv^2/r$

Equating both forces: $GMm/r^2 = mv^2/r$

Canceling m from both sides:

$$GM/r^2 = v^2/r$$

Orbital velocity is: $v=2\pi r/T$

Substituting: $(2\pi r / T)^2 = GM / r$

This proves: $t^2=(4\pi^2 / GM) r^3$, T^2, r^3

Hence, Kepler's Third Law is derived from Newton's Law of Gravitation.

Section 5: Applications

Planetary Motion

Kepler's Third Law explains the motion of planets around the Sun and helps determine their orbital periods and distances.

Artificial Satellites

The law is used to calculate the orbital time and height of artificial satellites around the Earth.

Space Missions

Scientists use these laws to plan satellite launches, space probes, and interplanetary missions accurately.

Section 6: Conclusion

Newton's Universal Law of Gravitation and Kepler's Third Law are fundamental principles of classical physics. They explain the motion of celestial bodies and provide a deep understanding of the structure of the universe. These laws are

essential for astronomy, space science, and satellite technology. Their scientific significance lies in connecting mathematical laws with real physical phenomena, making them a cornerstone of modern physics.