

*{Final Project}*  
*Universal Gravitation &*  
*Kepler's Third Law*  
*Computer. Information*  
*Technology (CIT)*  
*Aital Ghafoor*  
*Piston College*  
*Timing , 2:00 ,4:00*  
*Instructor Name*  
*Abdur Rehman Khan*

# **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*

*m<sub>1</sub>, m<sub>2</sub> = 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 N.m<sup>2</sup>/kg<sup>2</sup>.***

***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:  $G Mm/r^2=mv^2/r$*

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

*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.*

ATAL GHOSH