Universal Gravitation, Kepler's Laws of Planetary Motion, and Satellite Motion

HS-PS2-4:

Use mathematical representations of Newton's Law of Gravitation to describe and predict the gravitational forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational fields.]

HS-ESS1-4:

Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.]

Learning Targets:

I CAN…

- **LT29 - Use proportional reasoning to predict changes in gravitational forces based on changes in masses and/or separation distance.**
- **LT30 - Make calculations using F=mg.**
- **LT31 - Make calculations using Newton's Law of Gravitation.**
- **LT33 - Recognize Kepler's 3 Laws of Planetary Motion.**
- **LT34 - Use Newton's form of Kepler's 3rd Law to determine orbital periods.**

LT29 examples:

Two objects exert a certain gravitational force on each other. If one of the object's mass triples, how does the gravitational force change?

Two objects exert a certain gravitational force on each other. If the separation of the objects is reduced to 1/3 the original distance, how does the gravitational force change?

LT30 examples

What does a 5.0 kg object weigh on Earth?

What does a 5.0 kg object weigh on the Moon where $g=1.6\ m/s^2$?

If a 5.0 kg object weighs 21 N on another planet. What is the gravitational acceleration on that planet?

LT31 examples

Two objects, mass 5.0 kg and 7.0 kg are separated by 0.25 m. Calculate the gravitational force the 5.0 kg mass exerts on the 7.0 kg mass and the gravitational force the 7.0 kg mass exerts on the 5.0 kg mass.

Two planets of equal mass 6×10^{24} kg exert a gravitational force equal to 2×10^{10} N on each other. How far apart are the planets?

LT33 examples

Kepler discovered that planets don't travel in circles, but instead _____ . Where is the Sun in relation to the planet's orbit?

Kepler's 2nd Law gave a geometric way of calculating the speed of a planet in its orbit. Where in an orbit does the planet travel the fastest?

Kepler's 3rd Law involves the ratio of what two properties of a planet's orbit? What is the ratio that remains constant for all the planets?

LT34 examples

A GPS satellite orbits the Earth (mass of Earth is 5.98E24 kg) in a circular orbit with an orbital radius of 6.65E6 m (low Earth orbit). How long does it take to orbit the Earth once?