Section II. The Tools of Astronomy.

Chapter 5. Isaac Newton and the Laws of Motion

Note. In this section we present Newton's contributions to classical mechanics.

Note. Isaac Newton (1643–1727) published *Principia* (1687) in which he established the science of mechanics and applied this to the motion of the moon and planets. He also developed his law of gravitation.

Note. Newtons' three laws of motion are:

First Law of Motion. A body at rest or in a state of uniform motion tends to stay at rest or in uniform motion unless an unbalanced force acts upon it.

Second Law of Motion. An unbalanced force produces an acceleration that is proportional to the force and inversely proportional to the mass of the object; that is, $a = F/m$ or $F = ma$.

Third Law of Motion. For every action there is an equal and opposite reaction.

Note. Newton's Law of Universal Gravitation states: Any two bodies in the universe are attracted to each other with a force that is proportional to the product of the masses and inversely proportional to the square of the distance between them. Quantitatively, $F = \dfrac{Gm_1m_2}{R^2}$.

Note. We can derive a result of Galileo: at the surface of the Earth, bodies fall at the same rate. Let $a = g$ and $m = m_1 =$ mass of the Earth. Then $F = m_2 g$ implies

$$g = \frac{F}{m_2} = \frac{Gm_1m_2/R^2}{m_2} = \frac{Gm_1}{R^2} = \text{ constant at the surface of the Earth.}$$

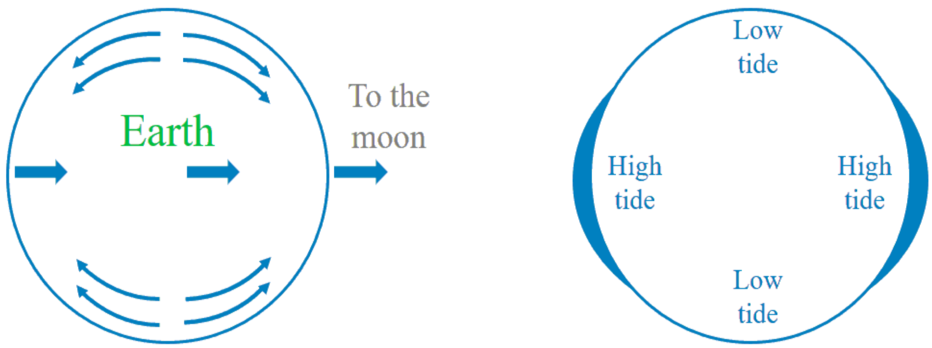
Since g is constant at the surface of the Earth (32 feet/sec $\approx$ 9.8 m/sec) and so objects with the same velocity will fall at the same rate.

Note. Newton derived Kepler's three laws of planetary motion from his universal law of gravitation.

Note. An object (not necessarily connected) that is rotating about a point hand *angular momentum* that is the product of its linear speed and mass. For Kepler's second law (equal area in equal time), this means that a planet must move faster when it is neat the Sun. We can restate this law: The angular momentum of a two body system is constant.

Note. Newton restated Kepler's third law as $(m_1 + m_2) = \dfrac{a^3}{p^2}$ where m_1 and m_2 are the masses of the objects involved. Notice, we can determine masses of objects if we can determine a and p.

Note. The moon exerts a force on the Earth that causes "bulges" in the oceans:



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