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Gravitation

1. **Law of Gravitation:**
   - **Statement of the Law:** Every point mass attracts every other point mass in the universe 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 Expression:** The gravitational force (F) between two point masses (m_1 and m_2) separated by a distance (r) is given by the formula:
     $F = \frac{G \cdot m_1 \cdot m_2}{r^2}$
     where G is the gravitational constant.
   - **Gravitational Constant (G):** G is a universal constant with an approximate value of $6.674 \times 10^{-11}\,\mathrm{Nm^2/kg^2}$.
   - **Variation of g with Altitude, Depth, and Latitude:** The acceleration due to gravity (g) decreases with altitude, increases with depth, and varies with latitude due to the Earth's rotation and shape.
2. **Gravitational Field:**
   - **Gravitational Field Intensity:** The gravitational field intensity (E) at a point is the force experienced by a unit mass placed at that point.
   - **Gravitational Field Due to Various Mass Distributions:**
     - Point mass: $E = \frac{G \cdot M}{r^2}$
     - Uniform ring: $E = \frac{G \cdot M \cdot z}{(z^2+R^2)^{3/2}}$
     - Uniform disc: $E = \frac{2 \cdot G \cdot M \cdot z}{(z^2+R^2)^{3/2}}$
     - Uniform solid sphere: $E = \frac{G \cdot M \cdot z}{R^3}$, where z is the distance from the center.
3. **Gravitational Potential Energy:**
   - **Definition:** Gravitational potential energy (U) is the work done in bringing a mass from infinity to a point in a gravitational field.
   - **Expression:** $U = -\frac{G \cdot m_1 \cdot m_2}{r}$
   - **Escape Velocity:** The minimum velocity required for an object to escape the gravitational field of a celestial body.
4. **Orbital Velocity:**
   - **Orbital Velocity of a Satellite:** $v = \sqrt{\frac{G \cdot M}{r}}$, where M is the mass of the celestial body and r is the radius of the orbit.
   - **Energy Consideration in Satellite Motion:** Total energy (E), kinetic energy (T), and potential energy (U) are related by $E = T + U$.

5. **Kepler's Laws of Planetary Motion:**
   - **Kepler's First Law (Law of Orbits):** Planets move in elliptical orbits with the sun at one of the foci.
   - **Kepler's Second Law (Law of Areas):** A line segment joining a planet and the sun sweeps out equal areas during equal intervals of time.
   - **Kepler's Third Law (Law of Periods):** The square of the orbital period (T) of a planet is directly proportional to the cube of the semi-major axis (a) of its orbit. $T^2 \propto a^3$.
6. **Satellites:**
   - **Artificial Satellites:** Human-made objects placed in orbit around celestial bodies.
   - **Geostationary and Polar Satellites:** Geostationary satellites orbit the Earth at the same rate as the Earth's rotation, appearing stationary. Polar satellites orbit over the Earth's poles.
   - **Satellite Communication:** Use of satellites for communication purposes, including TV broadcasting and internet services.
7. **Acceleration due to Gravity on the Earth's Surface:**
   - **Calculation of g at a Point Above the Earth's Surface:** $g' = \frac{G \cdot M}{(R+h)^2}$, where R is the Earth's radius and h is the height.
   - **Calculation of g at a Point Below the Earth's Surface:** $g'' = \frac{G \cdot M}{(R-h)^2}$, where R is the Earth's radius and h is the depth.
8. **Gravitational Potential:**
   - **Gravitational Potential Due to a Point Mass:** $V = -\frac{G \cdot M}{r}$
   - **Gravitational Potential Due to a Uniform Ring, Disc, and Solid Sphere:** Formulas depend on the specific geometry and can be derived using integration.
9. **Potential Energy of Two Mass System:**
   - **Potential Energy of a System of Two Point Masses:** $U = -\frac{G \cdot m_1 \cdot m_2}{r}$
10. **Escape Velocity:**
    - **Definition and Derivation of Escape Velocity:** $v_e = \sqrt{\frac{2 \cdot G \cdot M}{r}}$
    - **Relation between Escape Velocity and Orbital Velocity:** $v_e = \sqrt{2} \cdot v_{\text{orbital}}$
11. **Energy of an Orbiting Satellite:**
    - **Total Energy, Kinetic Energy, and Potential Energy of a Satellite in an Orbit:** $E = T + U$

12. **Variation of g with Altitude and Depth:**
    - **Derivation of g at Height h Above the Earth's Surface:** $g' = \frac{G \cdot M}{(R+h)^2}$
    - **Derivation of g Below the Earth's Surface:** $g'' = \frac{G \cdot M}{(R-h)^2}$

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