Constants and units: \( g = 9.8 \text{ m/s}^2 \), \( 1 \text{ mm} = 10^{-3} \text{ m} \), \( 1 \text{ cm} = 10^{-2} \text{ m} \), \( 1 \text{ km} = 10^3 \text{ m} \), \( 1 \text{ in} = 2.54 \text{ cm} \), \( 1 \text{ N (newton)} = \text{ kg} \cdot \text{ m/s}^2 \), \( 1 \text{ J (joule)} = \text{ N} \cdot \text{ m} = \text{ kg} \cdot \text{ m}^2/\text{s}^2 \), \( 1 \text{ W (watt)} = \text{ J/s} \).

Volumes. Cylinder: \( \pi R^2 h \), sphere: \( \frac{4}{3} \pi R^3 \), cone: \( \frac{1}{3} \pi R^2 h \)

Quadratic equation. \( ax^2 + bx + c = 0 \), \( x = \left( -b \pm \sqrt{b^2 - 4ac} \right) / (2a) \)

Derivatives/integrals. \( \frac{d}{dt} t^n = nt^{n-1} \), \( \int r^n \, dr = \frac{1}{n+1} r^{n+1} \)

Vectors. If \( \vec{c} = \vec{a} + \vec{b} \), then \( c_x = a_x + b_x \), \( c_y = a_y + b_y \), \( c_z = a_z + b_z \) and \( c = \sqrt{c_x^2 + c_y^2 + c_z^2} \). Dot product: \( \vec{a} \cdot \vec{b} = a_x b_x + a_y b_y + a_z b_z = ab \cos \alpha \). Cross product: \( \vec{i} \times \vec{j} = \vec{k} \), \( \vec{j} \times \vec{k} = \vec{i} \), \( \vec{k} \times \vec{i} = \vec{j} \).

Kinematics: \( v = dx/dt, a = dv/dt = d^2 x / dt^2 \). Constant \( a \): \( v - v_0 = at \), \( x - x_0 = \frac{v_0 + v}{2} t = v_0 t + \frac{1}{2} a t^2 \). Projectile: \( v_x = \text{ const} \), \( x - x_0 = v_x t \), \( v_y = v_{0y} - gt \), \( y - y_0 = v_{0y} t - \frac{1}{2} gt^2 = (v_{0y}^2 - v_y^2) / (2g) \). Range: \( (v_0^2 / g) \sin(2\theta) \)

Circular motion with constant speed: \( \omega = v/R \), \( a_c = v^2 / R = \omega^2 R \), towards center.

The three laws of motion: (1) If \( \vec{F}_{\text{net}} = 0 \) then \( \vec{v} = \text{ const} \); (2) \( \vec{F}_{\text{net}} = m \vec{a} \); (3) \( \vec{F}_{21} = -\vec{F}_{12} \)

Specific forces. Gravity: \( mg \) (down). Normal \( \vec{N} \) - perpendicular to surface; tension \( T \) - constant along the string. Spring force: \( F = -kx \) (\( k \) is spring constant). Friction - parallel to surface; kinetic: \( f_k = \mu_k N \); static: \( f_s \leq \mu_s N \) with \( N = mg \) (horizontal plane) or \( N = mg \cos \theta \) (inclined plane).

Inclined plane. Components of gravity: \( mg \sin \theta \) (parallel to plane, downhill) and \( mg \cos \theta \) (perpendicular to plane). Kinetic friction: \( \mu_k mg \cos \theta \) (parallel to plane, opposite to direction of motion).

Centripetal motion: \( F_{\text{net}} = mv^2 / R \); direction of \( \vec{F}_{\text{net}} \) - towards center of revolution.

Work and power. Constant force \( W = \vec{F} \cdot (\vec{r}_2 - \vec{r}_1) = F_x \Delta x + F_y \Delta y + F_z \Delta z \) (or, \( W = F \Delta r \cos \alpha \)); general: \( W_{AB} = \int_A^B \vec{F} \cdot d\vec{r} \). Power: \( P = W / \Delta t = \vec{F} \cdot \vec{v} \). Work by specific forces: gravity: \( W_g = -mg \Delta y \) (and \( \Delta x \) does not matter); normal: \( W_N = 0 \); kinetic friction: \( W_f = -fL \); spring \( W_s = \frac{1}{2} k \left( x_1^2 - x_2^2 \right) \)

Kinetic energy and work-energy theorem: \( K = \frac{1}{2} mv^2 \), \( \Delta K = W \) where \( W \) is the net work (i.e., work by all forces).

Potential energy. For conservative forces (with path-independent work) introduce \( U (\vec{r}) \) so that \( W_{AB} = U_A - U_B = -\Delta U \). For specific forces: gravity: \( U_g = mgh \); spring: \( U_s = \frac{1}{2} kx^2 \). If only conservative forces, then energy conservation: \( K + U = \text{ const} \). If also non-conservative forces (e.g., friction) with work \( W_{\text{non-cons}} \), then \( \Delta (K + U) = W_{\text{non-cons}} \)