**Vectors:** $\vec{A} = A_x\hat{x} + A_y\hat{y} + A_z\hat{z}$ $\quad A = |\vec{A}| = \left(A_x^2 + A_y^2 + A_z^2\right)^{1/2}$ $\quad \hat{a} = \frac{\vec{a}}{|\vec{a}|}$

$C_x = A_x + B_x$ $\quad C_y = A_y + B_y$ $\quad C_z = A_z + B_z$

$\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z = AB\cos\theta$

**Kinematics:** $\vec{r} = x\hat{x} + y\hat{y}$ $\quad \vec{v} = \frac{d\vec{r}}{dt} = v_x\hat{x} + v_y\hat{y}$ $\quad \vec{a} = \frac{d\vec{v}}{dt} = a_x\hat{x} + a_y\hat{y}$

$\Delta\vec{r} = \vec{r}_f - \vec{r}_i$ $\quad <\vec{v}> = \frac{\Delta\vec{r}}{\Delta t}$ $\quad <\vec{a}> = \frac{\Delta\vec{v}}{\Delta t}$

**Constant acceleration:** $x = x_o + v_{ox}t + \frac{1}{2}a_xt^2$

**Earth's gravity:** g = 9.8 m/sec$^2$

$v_x = v_{ox} + a_xt$

$v_x^2 = v_{ox}^2 + 2a_x\left(x - x_o\right)$

$<v_x> = \frac{v_f + v_i}{2}$ $\quad x - x_o = <v_x>\Delta t$

**Uniform circular motion:** $a_r = \frac{v^2}{r}$

**Quadratic formula** $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

**Newton's 2nd Law** $F_x = ma_x$ $\quad F_y = ma_y$ $\quad F_z = ma_z$

**Friction** $F_f = \mu N$

**Restoring Force (Hooke's Law)** $|F_s| = k|\ell - \ell_o|$

$F_x = -kx$

| | | | |
|---|---|---|---|
| **Work & Energy** | $W = F \cdot d \cdot \cos(\theta)$ | $W_{total} = \Delta K$; $W_{conservative} = -\Delta U$; $\Delta U_g = mg\Delta y$ or $U = mgh$ | $K = \frac{1}{2}mv^2$; $\Delta U_{spring} = \frac{1}{2}k(l - l_o)^2$; $\Delta U_{spring} = \frac{1}{2}kx^2$ |
| **Mechanical Energy** | $E = K + U$ | $\Delta E = W_{nonconservative} = \Delta I$ | |
| **Impulse & Momentum** | $\vec{J} = \vec{F} \cdot \Delta t = \Delta\vec{p}$ | $\vec{p} = m \cdot \vec{v}$ | **No external force** : $\vec{p}_{final} = \vec{p}_{initial}$ |
| **Rocket** | vector version $\vec{F}_{ext} = m\frac{d\vec{v}}{dt} + \vec{V}\frac{dm}{dt}$; $\frac{dm}{dt} > 0$ | one dimensional as in the text $v_e > 0$; $\frac{dm}{dt} < 0$ | $F_{ext,x} = m\frac{dv_x}{dt} + v_{e,x}\frac{dm}{dt}$ |
| **angular motion** | $\langle\omega\rangle = \frac{\Delta\theta}{\Delta t}$; $\theta = \frac{s}{r}$ $\omega = \frac{v_t}{r}$ $\alpha = \frac{a_t}{r}$ | $\langle\alpha\rangle = \frac{\Delta\omega}{\Delta t}$ | $K_r = \frac{1}{2} \cdot I\omega^2$; **Moment of Inertia for a particle about a point:** $I = mr^2$ |
| **constant angular acceleration** | $\omega = \omega_o + \alpha \cdot t$ | $\theta = \theta_o + \omega_o \cdot t + (1/2) \cdot \alpha \cdot t^2$ | $\omega^2 = \omega_o^2 + 2\alpha \cdot \Delta\theta$ |
| **angular momentum** | $\vec{L} = \vec{r} \times \vec{p}$ | **rigid body** | $\vec{L} = I\vec{\omega}$ |
| | **kinetic energy** $K = \frac{1}{2}I\omega^2$ | **static equilibrium** | $\sum\vec{F} = 0$ & $\sum\vec{\tau} = 0$ |
| **torque** | $\vec{\tau} = \vec{r} \times \vec{F}$ | $\vec{\tau} = \frac{d\vec{L}}{dt}$ | |
| **Universal Gravitation** | $F_g = \frac{G \cdot M \cdot m}{r^2}$; $G = 6.67 \times 10^{-11}\frac{N \cdot m^2}{kg^2}$ | $U_g = -\frac{G \cdot M \cdot m}{r}$ | $v_e = \sqrt{\frac{2GM}{R}}$ |
| **Simple Harmonic Motion** | $y = A\sin(\omega t + \delta)$; $\omega = 2\pi f$ | **spring:** $\omega = \sqrt{\frac{k}{m}}$ | **pendulum:** $\omega = \sqrt{\frac{g}{\ell}}$ |
| **Waves** | $y = A\cos(kx - \omega t)$ | $k = \frac{2\pi}{\lambda}$ $\omega = 2\pi f$ | **wave speed:** $c = \lambda f$ |