Laws, Principles, Useful Relationships, and Other Information

The Definition of Velocity: $\vec{v} \equiv \frac{d\vec{r}}{dt}$

The Definition of Acceleration: $\vec{a} \equiv \frac{d\vec{v}}{dt}$

The Kinematic Equations:
$v = v_o + at \qquad x = x_o + v_o t + \frac{1}{2}at^2 \qquad v^2 = v_o^2 + 2a(x - x_o) \qquad x - x_o = \frac{1}{2}(v + v_o)t$

Centripetal Acceleration: $a_c = \frac{v^2}{r}$

Newton's Second Law $\Sigma\vec{F}_{ext} = m\vec{a}_{cm}$

The Mass/weight Rule $F_g = mg$

Definition of Coefficient of Friction $\mu \equiv \frac{F_{fr}}{F_n}$

Definition of Work $W \equiv \int \vec{F} \bullet d\vec{s}$

Definition of Kinetic Energy $K \equiv \frac{1}{2}mv^2$

Work-Energy Theorem $W_{net} = \Delta K$

The Definition of Power $P \equiv \frac{dW}{dt}$

Law of Conservation of Energy $\Delta K + \Delta U = W_{nc}$

Definition of Potential Energy $\Delta U \equiv -W_c$

Gravitational Potential Energy $U_g = mgy$

Spring Potential Energy $U_s = \frac{1}{2}kx^2$

The Definition of Center of Mass $\vec{r}_{cm} \equiv \frac{\int \vec{r}\,dm}{M}$

The Definition of Linear Momentum $\vec{p} \equiv m\vec{v}$

The Original Second Law $\Sigma\vec{F} = \frac{d\vec{p}}{dt}$

The Definition of Impulse $\vec{J} \equiv \int_{t_o}^{t} \vec{F}dt$

The Impulse-Linear Momentum Theorem $\Delta\vec{p} = \vec{J}$

The Definition of Angular Velocity: $\omega \equiv \frac{d\theta}{dt}$

The Definition of Angular Acceleration: $\alpha \equiv \frac{d\omega}{dt}$

Linear/Angular Relationships $s = r\theta \qquad v_t = r\omega \qquad a_t = r\alpha \qquad a_c = \omega^2 r$

The Definition of Torque $\vec{\tau} \equiv \vec{r} \times \vec{F}$ $(\tau = F_\perp r = Fr_\perp)$

The Second Law for Rotation $\Sigma\tau = I\alpha$ or $\Sigma\vec{\tau} = \frac{d\vec{L}}{dt}$

The Definition of Rotational Inertia $I \equiv \int r^2 dm$

The Rotational Kinetic Energy $K = \frac{1}{2}I\omega^2$

The Angular Momentum of a Rigid Body $\vec{L} = I\vec{\omega}$

The Definition of Angular Momentum $\vec{L} \equiv \vec{r} \times \vec{p}$

Dot Product $\vec{A} \bullet \vec{B} \equiv AB\cos\theta = A_xB_x + A_yB_y + A_zB_z$

Cross Product $\vec{A} \times \vec{B} \equiv AB\sin\theta\hat{n} = (A_yB_z - A_zB_y)\hat{i} + (A_zB_x - A_xB_z)\hat{j} + (A_xB_y - A_yB_x)\hat{k}$

Moments of Inertia (about the cm unless noted):

hoop: mr^2 disk: $\frac{1}{2}mr^2$ solid sphere: $\frac{2}{5}mr^2$ hollow sphere: $\frac{2}{3}mr^2$

rod: $\frac{1}{12}m\ell^2$ rod (about one end): $\frac{1}{3}m\ell^2$ plate: $\frac{1}{12}m(a^2 + b^2)$

Acceleration due to gravity $g = 9.80\ m/s^2$

Earth - mass: 5.98×10^{24} kg radius: 6.38×10^6 m

Moon - mass: 7.36×10^{22} kg radius: 1.74×10^6 m Earth - moon distance: 3.82×10^8 m

Sun - mass: 1.99×10^{30} kg radius: 6.96×10^8 m Sun - Earth distance: 1.50×10^{11} m