Chapter 1

$$\text{if } \vec{R} = \vec{A} + \vec{B}, \text{then } R_x = A_x + B_x, R_y = A_y + B_y$$

$$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$$

$$\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$$

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

(dot product/scalar product)

$$C = AB\sin\phi$$

(magnitude of the cross product/vector product)

$$\text{if } \vec{C} = \vec{A} \times \vec{B}$$

$$\text{then } C_x = A_yB_z - A_zB_y \;\; C_y = A_zB_x - A_xB_z$$

$$C_z = A_xB_y - A_yB_x$$

(components of the cross product)

Chapter 2

$$v_{\text{av}-x} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$

(average $x-$velocity, straight-line motion)

$$v_x = \frac{dx}{dt}$$

(instantaneous $x-$velocity, straight line motion)

$$a_{\text{av}-x} = \frac{v_{2x} - v_{1x}}{t_2 - t_1} = \frac{\Delta v_x}{\Delta t}$$

(average $x-$acceleration, straight-line motion)

$$a_x = \frac{dv_x}{dt}$$

(instantaneous $x-$acceleration, straight-line motion)

$$v_x = v_{0x} + a_xt$$

(assuming constant $x-$ acceleration)

$$x = x_0 + v_{0x}t + \frac{1}{2}a_xt^2$$

(assuming constant $x-$ acceleration)

$$v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$$

(assuming constant $x-$ acceleration)

$$x - x_0 = \left(\frac{v_{0x} + v_x}{2}\right)t$$

(assuming constant $x-$ acceleration)

$$v_x = v_0x + \int_0^t a_xdt$$

$$x = x_0 + \int_0^t v_xdt$$

Chapter 3

$$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$$

(position vector)

$$\vec{v}_av = \frac{\vec{r}_2 - \vec{r}_1}{t_2 - t_1} = \frac{\Delta\vec{r}}{\Delta t}$$

(average velocity)

$$\vec{v} = \frac{d\vec{r}}{dt}$$

(instantaneous velocity)

$$v_x = dx/dt, v_y = dy/dt, v_z = dz/dt$$

(components of instantaneous velocity)

$$\vec{a}_{\text{av}} = \frac{\vec{v}_2 - \vec{v}_1}{t_2 - t_1} = \frac{\Delta\vec{v}}{\Delta t}$$

(instantaneous acceleration)

$$a_x = dv_x/dt, a_y = dv_y/dt, a_z = dv_z/dt$$

(components of instantaneous acceleration)

$$x = (v_0\cos\alpha_0)t$$

(projectile motion)

$$y = (v_0\sin\alpha_0)t - \frac{1}{2}gt^2$$

(projectile motion)

$$v_x = v_0\cos\alpha_0$$

(projectile motion)

$$v_y = v_0\sin\alpha_0 - gt$$

(projectile motion)

$$a_{\text{rad}} = \frac{v^2}{R}$$

(uniform circular motion)

$$a_{\text{rad}} = \frac{4\pi^2 R}{T^2}$$

(uniform circular motion)

$$v_{P/A-x} = v_{P/B-x} + v_{B/A-x}$$

(relative velocity along a line)

Chapter 4

$$\vec{R} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots = \sum \vec{F}$$

$$\sum \vec{F} = 0$$

(body in equilibrium)

$$\sum \vec{F} = m\vec{a}$$

(Newton's second law of motion)

$$\sum F_x = ma_x, \sum F_y = ma_y, \sum F_z = ma_z$$

(Newton's second law of motion)

$$W = mg$$

(magnitude of the weight of a body of mass m)

$$\vec{F}_{A\ on\ B} = -\vec{F}_{B\ on\ A}$$

(Newton's third law of motion)

Chapter 5

$$\sum \vec{F} = 0$$

(particle in equilibrium, vector form)

$$\sum F_x = 0, \sum F_y = 0$$

(particle in equilibrium, component form)

$$\sum \vec{F} = m\vec{a}$$

(Newton's second law, vector form)

$$f_k = \mu_k n$$

(magnitude of kinetic friction force)

$$f_s \leq \mu_s n$$

(magnitude of static friction force)

$$a_{\text{rad}} = v^2/R$$

(uniform circular motion)

$$a_{\text{rad}} = \frac{4\pi^2 R}{T^2}$$

(uniform circular motion)

Chapter 6

$$W = \vec{F} \cdot \vec{s}$$

(definition of work, constant force, straight-line displacement)

$$W = Fs\cos\phi$$

(constant force, straight-line displacement)

$$K = \frac{1}{2}mv^2$$

(definition of kinetic energy)

$$W_{\text{tot}} = K_2 - K_1 = \Delta K$$

(work-energy theorem)

$$W = \int_{x_1}^{x_2} F_x dx$$

(varying $x-$ component of force, straight-line displacement)

$$P_{\text{av}} = \frac{\Delta W}{\Delta t}$$

(average power)

$$P = \frac{dW}{dt}$$

(instantaneous power)

$$P = \vec{F} \cdot \vec{v}$$

Chapter 7

$$W_{\text{grav}} = Fs = mgy_1 - mgy_2$$

$$U_{\text{grav}} = mgy$$

(gravitational potential energy)

$$W_{\text{grav}} = -(U_{\text{grav},2} - U_{\text{grav},1}) = -\Delta U_{\text{grav}}$$

$$K_1 + U_{\text{grav},1} = K_2 + U_{\text{grav},2}$$

(if only gravity does work)

$$\frac{1}{2}mv_1^2 + mgy_1 = \frac{1}{2}mv_2^2 + mgy_2$$

(if only gravity does work)

$$U_{\text{el}} = \frac{1}{2}kx^2$$

(elastic potential energy)

$$\frac{1}{2}mv_1^2 + \frac{1}{2}kx_1^2 = \frac{1}{2}mv_2^2 + \frac{1}{2}kx^2$$

(if only the elastic force does work)

$$K_1 + U_1 + W_{\text{other}} = K_2 + U_2$$

$$\Delta K + \Delta U + \Delta U_{\text{int}} = 0$$

$$F_x(x) = -\frac{dU(x)}{dx}$$

(force from potential energy, one dimension)

Chapter 8

$$\vec{p} = m\vec{v}$$

(definition of momentum)

$$\sum \vec{F} = \frac{d\vec{p}}{dt}$$

(Newton's second law in terms of momentum)

$$\vec{J} = \sum \vec{F}\Delta t = \vec{F}_{\text{av}}\Delta t$$

(assuming constant net force)

$$\vec{J} = \vec{p}_2 - \vec{p}_1$$

(impulse-momentum theorem)

$$\vec{J} = \int_{t_1}^{t_2} \sum \vec{F} dt$$

(general definition of impulse)

$$\vec{P} = \vec{p}_A + \vec{p}_B + \cdots = m_A\vec{v}_A + m_B\vec{v}_B + \cdots$$

(total momentum of a system of particles)

$$x_{CM} = \frac{m_1x_1 + m_2x_2 + m_3x_3 + \cdots}{m_1 + m_2 + m_3 + \cdots} = \frac{\sum_i m_i x_i}{\sum_i m_i}$$

(center of mass)

$$\sum \vec{F}_{\text{ext}} = M\vec{a}_{\text{cm}}$$

(body or collection of particles)

Chapter 9

$$\omega = \frac{d\theta}{dt}$$

(definition of angular velocity)

$$\alpha = \frac{d\omega}{dt}$$

(definition of angular acceleration)

$$\alpha = \frac{d^2\theta}{dt^2}$$

$$\omega = \omega_0 + \alpha t$$

(assuming constant angular acceleration)

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$$

(assuming constant angular acceleration)

$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

(assuming constant angular acceleration)

$$v = r\omega$$

(relationship between linear and angular speeds)

$$a_{\text{tan}} = r\alpha$$

(tangential acceleration of a point on a rotating body)

$$a_{\text{rad}} = v^2/r = \omega^2 r$$

(centripetal acceleration of a point on a rotating body)

$$I = m_1r_1^2 + m_2r_2^2 + \cdots = \sum_i m_i r_i^2$$

(definition of moment of inertia)

$$K = \frac{1}{2}I\omega^2$$

(rotational kinetic energy of a rigid body)

$$I_P = I_{\text{cm}} + Md^2$$

(parallel-axis theorem)

Chapter 10

$$\vec{\tau} = \vec{r} \times \vec{F}$$

(definition of torque vector)

$$\tau = rF\sin\phi = F_{\tan}r$$

(magnitude of torque vector)

$$\sum \tau_z = I\alpha_z$$

(rotational analog of Newton's second law for a rigid body)

$$K = \frac{1}{2}Mv_{\text{cm}}^2 + \frac{1}{2}I_{\text{cm}}\omega^2$$

(rigid body with both translation and rotation)

$$v_{\text{cm}} = R\omega$$

(condition for rolling without slipping)

$$W = \tau\Delta\theta$$

(work done by a constant torque)

$$W_{\text{tot}} = \frac{1}{2}I\omega_2^2 - \frac{1}{2}I\omega_1^2$$

$$\vec{L} = \vec{r} \times \vec{p} = \vec{r} \times m\vec{v}$$

(angular momentum of a particle)

$$\vec{L} = I\vec{\omega}$$

(angular momentum for a rigid body about a symmetry axis)

$$\sum \vec{\tau} = \frac{d\vec{L}}{dt}$$

(for any system of particles)

Chapter 11

$$\sum \vec{F} = 0$$

(first condition for equilibrium)

$$\sum \vec{\tau} = 0$$

(second condition for equilibrium)

$$\vec{r}_{\text{cm}} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + m_3\vec{r}_3 + \cdots}{m_1 + m_2 + m_3 + \cdots} = \frac{\sum_i m_i\vec{r}_i}{\sum_i m_i}$$

(position vector of the center of mass)