Formula Sheet for Physics 215

$$\vec{v}_{avg} = \frac{\Delta\vec{x}}{\Delta t},\ \vec{v} = \frac{d\vec{x}}{dt}; \quad \vec{a}_{avg} = \frac{\Delta\vec{v}}{\Delta t},\ \vec{a} = \frac{d\vec{v}}{dt}$$

$$\Delta x = x(t_2) - x(t_1) \ = \text{ signed area under the v(t) curve from t1 to t2} = \int_{t_1}^{t_2} v(t)dt$$

$$\Delta v = v(t_2) - v(t_1) \ = \text{ signed area under the a(t) curve from t1 to t2} = \int_{t_1}^{t_2} a(t)dt$$

$$v_x = v_{0x} + a_x t; \quad x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2; \quad v_x^2 = v_{0x}^2 + 2a_x\Delta x$$

$$\vec{v} = v_x\hat{i} + v_y\hat{j}; \quad v_x = |v|\cos(\theta); \quad v_y = |v|\sin(\theta)$$

$$v = |\vec{v}| = \sqrt{v_x^2 + v_y^2}; \quad \theta = \tan^{-1}(v_y/v_x)$$

$$\vec{v}_{CB} = \vec{v}_{CA} + \vec{v}_{AB}$$

$$g = 9.8\ m/s^2; \quad G = 6.67\times10^{-11} Nm^2kg^{-2};\ M_E = 5.98\times10^{24}kg;\ R_E = 6.37\times10^6 m$$

$$ax^2 + bx + c = 0 \rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\theta = \frac{s}{r} : \theta \text{ in radians}; \quad \omega = \frac{d\theta}{dt} \quad \alpha = \frac{d\omega}{dt}$$

$$a_c = a_{rad} = \frac{v^2}{r}; \quad T = \frac{2\pi r}{v}$$

$$v = \omega r : \omega \text{ in radians per unit time}; \quad a_{tan} = \alpha r : \alpha \text{ in radians per unit time squared}$$

$$\omega = \omega_0 + \alpha t; \quad \theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2; \quad \omega^2 = \omega_0^2 + 2\alpha\Delta\theta$$

$$\vec{F}_{net} = \sum_i \vec{F}_i = m\vec{a}; \quad \vec{F}_{AB} = -\vec{F}_{BA}$$

$$|\vec{F}_{fk}| = \mu_k N; \quad |\vec{F}_{fs}| \leq \mu_s N$$

$$\vec{I}_{net} = \vec{F}_{net}\Delta t = \ \text{ area under the F(t) curve from t1 to t2 } = \int_{t1}^{t2} F(t)dt$$

$$|F_{net,radial}| = \frac{mv^2}{R}$$

$$\vec{p} = m\vec{v}; \quad \vec{I} = \Delta\vec{p} = \vec{p}_f - \vec{p}_i$$

$$\vec{p}_f = \vec{p}_i \ \text{ (for an isolated system with no external forces)}$$

$$K_{linear} = \frac{1}{2}mv^2$$

$$U_g = mgh \text{ (flat earth approximation)}; \quad U_{spring} = \frac{1}{2}k(x - x_0)^2$$

$$W = \vec{F} \cdot \vec{d} = Fd\cos\theta = \text{area under F(x) curve from x1 to x2} = \int_{x_1}^{x_2} F_x dx$$

$$F = -dU/dx; \quad \Delta W = -\Delta U \text{ (for a conservative system)}$$

$$E_{sys} = U + K = \text{constant, if there are only conservative forces}$$

$$\Delta K = W_{net}; \quad \Delta E_{sys} = \Delta K + \Delta U_g + \Delta U_s = W_{noncons}$$

$$P = \Delta W/\Delta t = \frac{dW}{dt} = \vec{F} \cdot \vec{v}$$

$$\vec{r}_{CM} = \frac{\sum_i m_i \vec{r}_i}{\sum_i m_i}$$

$$\vec{\tau} = \vec{r} \times \vec{F} \quad |\vec{\tau}| = rF\sin\theta$$

$$\tau_{net} = I\alpha, \alpha \text{ in radians per unit time squared}$$

$$I = \sum_i m_i r_i^2 = \int r^2 dm; \quad \vec{L} = I\vec{\omega} \text{ rigid body about fixed axis}$$

$$K_{rot} = \frac{1}{2} I\omega^2; \quad v_{cm} = R\omega; \quad a_{cm} = R\alpha : \text{rolling without slipping, angles in radians}$$

$$\vec{F}_{net} = 0 \text{ and } \vec{\tau}_{net} = 0 \text{ in rigid-body equilibrium}$$

$$F_g = \frac{GMm}{r^2}, \quad U_g = -\frac{GMm}{r}, \quad V_{sphere} = \frac{4}{3}\pi R^3$$

$$E_{sys} = K + U_g; \quad E_{sys} = 0 \text{ for a projectile that can just barely escape the earth's gravity}$$

$$F_g = F_{net,radial} \text{ for an orbiting satellite}$$

$$F_{net,spring} = -k(x - x_0); \quad T = 2\pi\sqrt{\frac{m}{k}};$$

$$\omega_{SHO} = \sqrt{\frac{k}{m}}, \omega \text{ must be in radians}; \quad f = \frac{1}{T} = \frac{\omega}{2\pi}, \omega \text{ must be in radians}$$

$$x(t) = A\cos(\omega t + \phi_0); \quad a(x) = \frac{d^2x(t)}{dt^2} = -\omega^2 x(t)$$

$$E_{spring} = K + U_{spring} = \frac{1}{2}m(v_{max})^2 = \frac{1}{2}kA^2$$

$$v_{wave} = \sqrt{\frac{T_s}{\mu}} = \lambda f = \frac{\omega}{k}; \quad k = \frac{2\pi}{\lambda}; \quad \omega = \frac{2\pi}{T}$$

$$y(x,t) = A\sin(kx - \omega t + \phi_0); \quad v_y = \frac{dy}{dt} = -\omega A\cos(kx - \omega t + \phi_0)$$

$$f_+ = \frac{f_0}{1 - v_s/v}; \quad f_- = \frac{f_0}{1 + v_s/v}$$

$$\Delta t = \frac{\Delta\tau}{\sqrt{1 - \frac{v^2}{c^2}}}; \quad L = L_0\sqrt{1 - \frac{v^2}{c^2}}$$