NYA Formula Sheet

Linear Kinematics

$$\vec{\boldsymbol{v}}_{\text{av}} = \frac{\Delta \vec{\boldsymbol{r}}}{\Delta t} \quad \text{and} \quad \vec{\boldsymbol{v}} = \frac{d\vec{\boldsymbol{r}}}{dt}$$

$$\vec{\boldsymbol{a}}_{\text{av}} = \frac{\Delta \vec{\boldsymbol{v}}}{\Delta t} \quad \text{and} \quad \vec{\boldsymbol{a}} = \frac{d\vec{\boldsymbol{v}}}{dt}$$

Constant acceleration (x-dir)

$$v_x = v_{0x} + a_x t$$

$$x = x_0 + v_{0x} t + \tfrac{1}{2} a_x t^2$$

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

$$x - x_0 = \tfrac{1}{2}(v_{0x} + v_x) t$$

Dynamics & Forces

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

$$f_{\text{s}} \le \mu_{\text{s}} n$$

$$f_{\text{k}} = \mu_{\text{k}} n$$

$$F_{\text{spring-}x} = -kx$$

Work, Energy & Power

$$W = \vec{\boldsymbol{F}} \cdot \vec{\boldsymbol{s}} \quad (\text{for constant } F)$$

$$W_{\text{grav}} = -\Delta U_{\text{grav}}$$

$$W_{\text{el}} = -\Delta U_{\text{el}}$$

$$W_{\text{total}} = \Delta K$$

$$K = \tfrac{1}{2} m v^2$$

$$W_{\text{el}} = \tfrac{1}{2} k x_1{}^2 - \tfrac{1}{2} k x_2{}^2$$

$$P_{\text{av}} = \frac{\Delta W}{\Delta t} \quad ; \quad P = \frac{dW}{dt}$$

and $\quad P_{\text{inst.}} = \vec{\boldsymbol{F}} \cdot \vec{\boldsymbol{v}}$

$$E_{\text{Mechanical}} = K_{\text{total}} + U_{\text{total}}$$

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

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

$$U_{\text{el}} = \tfrac{1}{2} k x^2$$

$$F_x = -\frac{dU}{dx}$$

Rotational motion

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

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

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

$$v_{\text{tan}} = \omega r$$

$$v = \frac{2\pi r}{T}$$

Rotational kinematics

$$\omega_{\text{av-}z} = \frac{\Delta\theta}{\Delta t} \quad ; \quad \omega_z = \frac{d\theta}{dt}$$

$$\alpha_{\text{av-}z} = \frac{\Delta\omega_z}{\Delta t} \quad ; \quad \alpha_z = \frac{d\omega_z}{dt}$$

$$\omega_z = \omega_{0z} + \alpha_z t$$

$$\theta = \theta_0 + \omega_{0z} t + \tfrac{1}{2}\alpha_z t^2$$

$$\omega_z{}^2 = \omega_{0z}{}^2 + 2\alpha_z (\theta - \theta_0)$$

Torque

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

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

Angular momentum

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

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

Rotational energy

$$K_{\text{rot}} = \tfrac{1}{2} I \omega^2$$

Linear Momentum

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

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

$$\sum \vec{\boldsymbol{F}}_{\text{ext}} = \frac{d\vec{\boldsymbol{P}}}{dt}$$

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

$$M\vec{\boldsymbol{v}}_{\text{cm}} = m_1\vec{\boldsymbol{v}}_1 + m_2\vec{\boldsymbol{v}}_2 + m_3\vec{\boldsymbol{v}}_3 + \cdots = \vec{\boldsymbol{P}}$$

Math

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

$$\vec{\boldsymbol{A}} \cdot \vec{\boldsymbol{B}} = AB\cos\phi = A_x B_x + A_y B_y + A_z B_z$$

$$\left|\vec{\boldsymbol{A}} \times \vec{\boldsymbol{B}}\right| = AB\sin\phi \quad ; \quad \vec{\boldsymbol{A}} \times \vec{\boldsymbol{B}} = (A_y B_z - A_z B_y)\hat{\boldsymbol{i}} + (A_z B_x - A_x B_z)\hat{\boldsymbol{j}} + (A_x B_y - A_y B_x)\hat{\boldsymbol{k}}$$

$$\text{if } u = ct^n \text{, then } \frac{du}{dt} = nct^{n-1} \quad \text{and} \quad \frac{d}{dt}(u + w) = \frac{du}{dt} + \frac{dw}{dt}$$