Equation Sheet

$$\vec{v}_P = \dot{x}\hat{i} + \dot{y}\hat{j} + \dot{z}\hat{k} = v_P\hat{e}_t = \dot{r}\hat{e}_r + r\dot{\theta}\hat{e}_\theta + \dot{z}\hat{k}$$

$$\vec{a}_P = \ddot{x}\hat{i} + \ddot{y}\hat{j} + \ddot{z}\hat{k} = \dot{v}_P\hat{e}_t + \frac{v_P^2}{\rho}\hat{e}_n + 0\ \hat{e}_b = (\ddot{r} - r\dot{\theta}^2)\hat{e}_r + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\hat{e}_\theta + \ddot{z}\hat{k}$$

$$\vec{v}_B = \vec{v}_A + \vec{\omega} \times \vec{r}_{B/A}$$

$$\vec{a}_B = \vec{a}_A + \vec{\alpha} \times \vec{r}_{B/A} + \vec{\omega} \times \left(\vec{\omega} \times \vec{r}_{B/A}\right)$$

$$\vec{v}_B = \vec{v}_A + (\vec{v}_{B/A})_{rel} + \vec{\omega} \times \vec{r}_{B/A}$$

$$\vec{a}_B = \vec{a}_A + (\vec{a}_{B/A})_{rel} + \vec{\alpha} \times \vec{r}_{B/A} + 2\vec{\omega} \times (\vec{v}_{B/A})_{rel} + \vec{\omega} \times \left(\vec{\omega} \times \vec{r}_{B/A}\right)$$

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

$$T_1 + V_1 + U_{1\to2}^{nc} = T_2 + V_2$$

where:

$T = \sum_i^N \frac{1}{2}m_i v_i^2$ is the kinetic energy of each particle and N is the number of particles,

$V = V_g + V_{sp}$ where $V_g = mgh,\ h$ is the signed distance above or below the datum,

$V_{sp} = \frac{1}{2}k(l - l_o)^2,$ and l, l_o are the deformed and original length of the spring, respectively, and

$U_{1\to2}^{nc}$ is the work done by nonconservative forces.

$$m\vec{v}_{P_1} + \int_{t_1}^{t_2} \sum \vec{F} dt = m\vec{v}_{P_2} \qquad e = -\frac{v_{Bn2} - v_{An2}}{v_{Bn1} - v_{An1}}$$

$$\vec{H}_{O_1} + \int_{t_1}^{t_2} \sum \vec{M}_O dt = \vec{H}_{O_2} \qquad \vec{H}_O = \vec{r}_{P/O} \times m\vec{v}_P$$

$$\sum \vec{F} = m\vec{a}_G \qquad \sum \vec{M}_A = I_A\vec{\alpha} + \vec{r}_{G/A} \times m\vec{a}_A$$

$$T_1 + V_1 + U_{1\to2}^{nc} = T_2 + V_2 \qquad T = \frac{1}{2}mv_A^2 + \frac{1}{2}I_A\omega^2 + m\vec{v}_A \bullet (\vec{\omega} \times \vec{r}_{G/A})$$

$$m\vec{v}_{G_1} + \int_{t_1}^{t_2} \sum \vec{F} dt = m\vec{v}_{G_2}$$

$$\vec{H}_{A_1} + \int_{t_1}^{t_2} \sum \vec{M}_A dt = \vec{H}_{A_2}$$

$\vec{H}_A = I_A\ \vec{\omega},$ for special cases of point A.

$$I_{G,disk} = \frac{1}{2}mr^2 \qquad I_{G,bar} = \frac{1}{12}mL^2 \qquad I_{G,plate} = \frac{1}{12}m\left(a^2 + b^2\right) \qquad I_{G,sphere} = \frac{2}{5}mr^2 \qquad I_{G,ring} = mr^2$$

$$M\ddot{x} + C\dot{x} + Kx = F(t) \qquad \omega_n = \sqrt{\frac{K}{M}} \qquad 2\zeta\omega_n = \frac{C}{M} \qquad \omega_d = \sqrt{1-\zeta^2}\,\omega_n$$

$$x_P(t) = A_p \cos\omega t + B_p \sin\omega t \qquad x_C(t) = e^{-\zeta\omega_n t}\left[A_c \cos\omega_d t + B_c \sin\omega_d t\right]$$