Equation Sheet

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

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

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

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

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

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

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

$$T_1 + V_1 + U^{nc}_{1\to 2} = T_2 + V_2$$

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

$U^{nc}_{1\to 2}$ is the work done by nonconservative forces.