Equation list

$$\vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t} \equiv \frac{\vec{r}_f - \vec{r}_i}{t_f - t_i} \qquad \vec{v} = \lim_{\Delta t \to 0} \frac{\Delta\vec{r}}{\Delta t} \equiv \frac{d\vec{r}}{dt} \qquad \vec{r}_f = \vec{r}_i + \vec{v}_{avg}\left(t_f - t_i\right)$$

$$r_f = r_i + \frac{v_i + v_f}{2}\left(t_f - t_i\right)$$

$$\vec{p} = \gamma m\vec{v} \qquad \gamma = \frac{1}{\sqrt{1 - \left(\frac{|\vec{v}|}{c}\right)^2}} \qquad \vec{v} = \frac{\vec{p}/m}{\sqrt{1 + \left(\frac{|\vec{p}|}{mc}\right)^2}}$$

$$\Delta\vec{p} \equiv \vec{p}_f - \vec{p}_i = \vec{F}_{net}\Delta t \qquad \frac{d\vec{p}}{dt} = \vec{F}_{net} \qquad \Delta\vec{p}_{system} + \Delta\vec{p}_{surrounding} = \vec{0}$$

$$\frac{d\vec{p}}{dt} = \frac{d|\vec{p}|}{dt}\hat{p} + |\vec{p}|\frac{d\hat{p}}{dt} \qquad \left(\frac{d\vec{p}}{dt}\right)_{\perp} = p\frac{v}{R} = F_{\perp} \qquad \left(\frac{d\vec{p}}{dt}\right)_{\parallel} = \frac{dp}{dt} = F_{\parallel}$$

$$\left|\vec{F}_{spring}\right| = k_S|s| \qquad \frac{F_T}{A} = Y\frac{\Delta L}{L} \qquad k_s = \frac{A}{L}Y \qquad k_{\text{int}eratomic} = Yd$$

$$\vec{F}_{grav\ \text{on 2 by 1}} = -G\frac{m_2 m_1}{\left|\vec{r}_{2-1}\right|^2}\hat{r}_{2-1} \qquad \vec{F}_{\text{elec on 2 by 1}} = \frac{1}{4\pi\varepsilon_0}\frac{q_2 q_1}{\left|\vec{r}_{2-1}\right|^2}\hat{r}_{2-1}$$

$$\Delta x \Delta p_x \geq h$$

$$\ddot{x}(t) = -\frac{k}{m}x(t) \qquad x = A\cos(\omega t) \quad \omega = \sqrt{\frac{k_s}{m}} \qquad T = \frac{2\pi}{\omega} \qquad f = \frac{1}{T}$$

Constants:

$G = 6.7\times10^{-11}\ \frac{\text{N}\times\text{m}^2}{\text{kg}^2}$ $\qquad \frac{1}{4\pi\varepsilon_0} = 9\times10^{9}\ \frac{\text{N}\times\text{m}^2}{\text{C}^2}$ $\qquad h = 6.6\times10^{-34}\ \text{kg}\cdot\text{m}^2/\text{s}$

$c = 3\times10^{8}$ m/s $\qquad g = 9.8$ N/kg $\qquad N_A = 6\times10^{23}\ \text{mol}^{-1}$

Geometry:

$\pi = 3.14$

Circle: *circumference* $= 2\pi r$, *area* $= \pi r^2$

Sphere: *area* $= 4\pi r^2$, *volume* $= (4/3)\pi r^3$