Suggested Equations and Constants for the Fall 2006 SP211 Final Exam

You may take one 8.5×11 inch sheet of paper to the final exam that contains any information you like (on both sides). You may use this equation sheet and write on it as you deem necessary **or** you may bring your own equation sheet.

$g = 9.80\ \text{m/s}^2$ $\qquad G = 6.67 \times 10^{-11}\ \text{N-m}^2/\text{kg}^2$ $\qquad 1\ \text{atm} = 1.013\times10^5\ \text{N/m}^2$

$$\bar{v}_x = \frac{\Delta x}{\Delta t} \qquad \bar{\vec{\mathbf{v}}} = \frac{\Delta\vec{\mathbf{r}}}{\Delta t} \qquad \vec{\mathbf{r}} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}} + z\hat{\mathbf{k}}$$

$$v_x = \lim_{\Delta t\to 0}\frac{\Delta x}{\Delta t} = \frac{dx}{dt} \qquad \vec{\mathbf{v}} = \lim_{\Delta t\to 0}\frac{\Delta\vec{\mathbf{r}}}{\Delta t} = \frac{d\vec{\mathbf{r}}}{dt} \qquad \vec{\mathbf{v}} = v_x\hat{\mathbf{i}} + v_y\hat{\mathbf{j}} + v_z\hat{\mathbf{k}}$$

$$\bar{a}_x = \frac{\Delta v_x}{\Delta t} \qquad \bar{\vec{\mathbf{a}}} = \frac{\Delta\vec{\mathbf{v}}}{\Delta t}$$

$$a_x = \lim_{\Delta t\to 0}\frac{\Delta v_x}{\Delta t} = \frac{dv_x}{dt} \qquad \vec{\mathbf{a}} = \lim_{\Delta t\to 0}\frac{\Delta\vec{\mathbf{v}}}{\Delta t} = \frac{d\vec{\mathbf{v}}}{dt} \qquad \vec{\mathbf{a}} = a_x\hat{\mathbf{i}} + a_y\hat{\mathbf{j}} + a_z\hat{\mathbf{k}}$$

$$v_{xf} = v_{xi} + a_x t \qquad \vec{\mathbf{v}}_f = \vec{\mathbf{v}}_i + \vec{\mathbf{a}}t$$

$$x_f = x_i + v_{xi}t + \tfrac{1}{2}a_x t^2 \qquad \vec{\mathbf{r}}_f = \vec{\mathbf{r}}_i + \vec{\mathbf{v}}_i t + \tfrac{1}{2}\vec{\mathbf{a}}t^2$$

$$v_{xf}^{\ 2} = v_{xi}^{\ 2} + 2a_x(x_f - x_i) \qquad \text{For vector } \vec{\mathbf{r}},\ r = \sqrt{x^2 + y^2 + z^2},\ \tan\theta = \frac{y}{x}$$

$$a_c = \frac{v^2}{r} \qquad a_t = \frac{d|\vec{\mathbf{v}}|}{dt} \qquad \sum\vec{\mathbf{F}} = m\vec{\mathbf{a}} \qquad \vec{\mathbf{F}}_g = m\vec{\mathbf{g}} \qquad \sum F_c = ma_c = m\frac{v^2}{r}$$

$$f_k = \mu_k n \qquad f_s \le \mu_s n \qquad \vec{\mathbf{R}} = -b\vec{\mathbf{v}} \qquad R = \frac{1}{2}D\rho A v^2 \qquad F_s = -kx$$

$$W = F\Delta r\cos\theta = \vec{\mathbf{F}}\bullet\Delta\vec{\mathbf{r}} \qquad W = \int_i^f F_x dx \qquad W = \int_i^f \vec{\mathbf{F}}\bullet d\vec{\mathbf{r}} = \int_i^f F\cos\theta dr$$

$$\sum W = \Delta K = K_f - K_i \qquad K = \frac{1}{2}mv^2 \qquad \Delta K = -f_k d + \sum W_{\text{other forces}}$$

$$U_g = mgy \qquad U_s = \frac{1}{2}kx^2 \qquad \Delta U = -\int_{x_i}^{x_f} F_x dx \qquad F_x = -\frac{\partial U}{\partial x} \qquad \Delta U = U_f - U_i = -\int_i^f \vec{\mathbf{F}}\bullet d\vec{\mathbf{r}}$$

$$E_{\text{mech}} = K + U = \text{constant} \qquad \sum W = \Delta K + \Delta U + \Delta E_{\text{int}} \qquad \Delta E_{\text{int}} = f_k d$$

$$\bar{P} = \frac{W}{\Delta t} \qquad P = \frac{dW}{dt} = \frac{dE}{dt} = \vec{\mathbf{F}}\bullet\vec{\mathbf{v}} \qquad \vec{\mathbf{p}} = m\vec{\mathbf{v}} \qquad \sum\vec{\mathbf{F}} = \frac{d\vec{\mathbf{p}}}{dt}$$

$$\vec{\mathbf{I}} = \int_{t_i}^{t_f}\vec{\mathbf{F}}dt = \vec{\mathbf{p}}_f - \vec{\mathbf{p}}_i \qquad \vec{\mathbf{I}} = \bar{\vec{\mathbf{F}}}\Delta t \qquad \vec{\mathbf{p}}_{\text{tot}} = \vec{\mathbf{p}}_1 + \vec{\mathbf{p}}_2 = m_1\vec{\mathbf{v}}_1 + m_2\vec{\mathbf{v}}_2 = \text{constant}$$

$\vec{\mathbf{r}}_{\mathrm{CM}} = \dfrac{\sum m_i \vec{\mathbf{r}}_i}{M}$ $\vec{\mathbf{v}}_{\mathrm{CM}} = \dfrac{\sum m_i \vec{\mathbf{v}}_i}{M}$ $\vec{\mathbf{p}}_{\mathrm{tot}} = M\vec{\mathbf{v}}_{\mathrm{CM}}$ $\sum \vec{\mathbf{F}}_{\mathrm{ext}} = M\vec{\mathbf{a}}_{\mathrm{CM}} = \dfrac{d\vec{\mathbf{p}}_{\mathrm{tot}}}{dt}$

$s = r\theta$ $\omega = \dfrac{d\theta}{dt}$ $v = r\omega$ $\alpha = \dfrac{d\omega}{dt}$ $a_t = r\alpha$ $a_c = r\omega^2$

$\omega_f = \omega_i + \alpha t$ $\theta_f = \theta_i + \omega_i t + \tfrac{1}{2}\alpha t^2$ $\omega_f^{\,2} = \omega_i^{\,2} + 2\alpha(\theta_f - \theta_i)$

$\tau = rF\sin\phi = Fd$ $I = \sum m_i r_i^2$ $K_R = \dfrac{1}{2}I\omega^2$ $\sum \tau = I\alpha = \dfrac{dL}{dt}$ $L = I\omega$

$P = \dfrac{F}{A}$ $\rho = \dfrac{m}{V}$ $P = P_0 + \rho g h$ $B = \rho_{\mathrm{fluid}} g V$

$A_1 v_1 = A_2 v_2 = \text{constant}$ $P_1 + \tfrac{1}{2}\rho v_1^{\,2} + \rho g y_1 = P_2 + \tfrac{1}{2}\rho v_2^{\,2} + \rho g y_2 = \text{constant}$

$F_g = G\dfrac{m_1 m_2}{r^2}$ $T^2 = \left(\dfrac{4\pi^2}{GM}\right)a^3$ $U_g = -G\dfrac{m_1 m_2}{r}$ $E = \dfrac{1}{2}mv^2 - \dfrac{GMm}{r}$

$E = -\dfrac{GMm}{2a}$ $v_{\mathrm{esc}} = \sqrt{\dfrac{2GM}{R}}$

$\dfrac{d^2x}{dt^2} = -\dfrac{k}{m}x$ $x = A\cos(\omega t + \phi)$ $\omega = \sqrt{\dfrac{k}{m}}$ $T = \dfrac{2\pi}{\omega} = 2\pi\sqrt{\dfrac{m}{k}}$ $f = \dfrac{1}{T}$

$E = \dfrac{1}{2}mv^2 + \dfrac{1}{2}kx^2 = \dfrac{1}{2}kA^2$ $T = 2\pi\sqrt{\dfrac{L}{g}}$ $T = 2\pi\sqrt{\dfrac{I}{mgd}}$

$x = Ae^{-\frac{b}{2m}t}\cos(\omega t + \phi)$ $\omega = \sqrt{\dfrac{k}{m} - \left(\dfrac{b}{2m}\right)^2}$ $\omega_0 = \sqrt{\dfrac{k}{m}}$ $A = \dfrac{F_0/m}{\sqrt{\left(\omega^2 - \omega_0^{\,2}\right)^2 - \left(\dfrac{b\omega}{m}\right)^2}}$

$y(x,t) = f(x \mp vt)$ $y(x,t) = A\sin\left[\dfrac{2\pi}{\lambda}(x - vt)\right] = A\sin(kx - \omega t)$ $k = \dfrac{2\pi}{\lambda}$ $\omega = \dfrac{2\pi}{T}$

$v = \lambda f = \dfrac{\omega}{k}$ $v = \sqrt{\dfrac{T}{\mu}}$ $v = \sqrt{\dfrac{B}{\rho}}$ $\overline{P} = \dfrac{1}{2}\mu\omega^2 A^2 v$

$y = (2A\sin kx)\cos\omega t$ $f_n = n\dfrac{v}{2L},\ n = 1, 2, 3\ldots$ $f' = f\left(\dfrac{v \pm v_{\mathrm{O}}}{v \mp v_{\mathrm{S}}}\right)$ $\sin\theta = \dfrac{v}{v_s}$

$s(x,t) = s_{\max}\cos(kx - \omega t)$ $\Delta P = \Delta P_{\max}\sin(kx - \omega t)$ $f_n = n\dfrac{v}{4L},\ n = 1, 3, 5\ldots$