PHYS-201 Equation Sheet for Final Exam
(6 December 2010, DISQUE 108, 1:00-3:00 pm)

Chapter 1: Units, Physical Quantities, and Vectors

$$1 \text{ kilometer} = 1 \text{ km} = 10^3 \text{ m} \qquad 1 \text{ decimeter} = 1 \text{ dm} = 10^{-1} \text{ m}$$

$$1 \text{ centimeter} = 1 \text{ cm} = 10^{-2} \text{ m} \qquad 1 \text{ millimeter} = 1 \text{ mm} = 10^{-3} \text{ m}$$

$$1 \text{ micrometer} = 1\ \mu\text{m} = 10^{-6} \text{ m} \qquad 1 \text{ nanometer} = 1 \text{ nm} = 10^{-9} \text{ m}$$

$$1 \text{ gram} = 1 \text{ g} = 10^{-3} \text{ kg} \qquad 1 \text{ milligram} = 1 \text{ mg} = 10^{-3} \text{ g}$$

$$1 \text{ microgram} = 1\ \mu\text{g} = 10^{-6} \text{ g} \qquad 1 \text{ millisecond} = 1 \text{ ms} = 10^{-3} \text{ s}$$

$$1 \text{ microsecond} = 1\ \mu\text{s} = 10^{-6} \text{ s} \qquad 1 \text{ nanosecond} = 1 \text{ ns} = 10^{-9} \text{ s}$$

$$\vec{\mathbf{A}} + \vec{\mathbf{B}} = \vec{\mathbf{B}} + \vec{\mathbf{A}} \qquad (\vec{\mathbf{A}} + \vec{\mathbf{B}}) + \vec{\mathbf{C}} = \vec{\mathbf{A}} + (\vec{\mathbf{B}} + \vec{\mathbf{C}})$$

$$\vec{\mathbf{A}} - \vec{\mathbf{B}} = \vec{\mathbf{A}} + (-\vec{\mathbf{B}}) \qquad \vec{\mathbf{A}} = \vec{\mathbf{A}}_{\mathbf{x}} + \vec{\mathbf{A}}_{\mathbf{y}}$$

$$A_x = A\cos\theta \qquad A_y = A\sin\theta$$

$$A = \sqrt{A_x^2 + A_y^2} \qquad \theta = arctan\frac{A_y}{A_x}$$

$$\vec{\mathbf{B}} = c\vec{\mathbf{A}} \qquad \vec{\mathbf{B}} = (B_x, B_y) = (cA_x, cA_y)$$

$$\vec{\mathbf{R}} = \vec{\mathbf{A}} + \vec{\mathbf{B}} = (A_x + B_x, A_y + B_y) \qquad R = \sqrt{(A_x + B_x)^2 + (A_y + B_y)^2}$$

$$\vec{\mathbf{A}} = A_x\hat{\mathbf{i}} + A_y\hat{\mathbf{j}} + A_z\hat{\mathbf{k}} \qquad \vec{\mathbf{B}} = B_x\hat{\mathbf{i}} + B_y\hat{\mathbf{j}} + B_z\hat{\mathbf{k}}$$

$$\vec{\mathbf{R}} = \vec{\mathbf{A}} + \vec{\mathbf{B}} = R_x\hat{\mathbf{i}} + R_y\hat{\mathbf{j}} + R_z\hat{\mathbf{k}} \qquad R_x = A_x + B_x$$

$$R_y = A_y + B_y \qquad R_z = A_z + B_z$$

Chapter 2: Motion Along a Straight Line

$$v_{av-x} == \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t} \qquad v_x = \lim_{\Delta t \to 0}\frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

$$a_{av-x} == \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t} \qquad a_x = \lim_{\Delta t \to 0}\frac{\Delta v_x}{\Delta t} = \frac{dv_x}{dt}$$

$$v_x = v_{0x} + a_x t \ (a_x = \text{const.}) \qquad x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2 \ (a_x = \text{const.})$$

$$v_x^2 = v_{0x}^2 + 2a_x(x - x_0) \ (a_x = \text{const.}) \qquad x - x_0 = \left(\frac{v_{0x} + v_x}{2}\right) t \ (a_x = \text{const.})$$

Chapter 4: Newton's Laws of Motion

$$\vec{\mathbf{R}} = \vec{\mathbf{F}}_1 + \vec{\mathbf{F}}_2 + ... = \sum \vec{\mathbf{F}} \qquad R_x = \sum F_x \quad \& \quad R_y = \sum F_y$$

$$\sum \vec{\mathbf{F}} = 0 \qquad \sum F_x = 0 \quad \& \quad \sum F_y = 0$$

$$\sum \vec{\mathbf{F}} = m\vec{\mathbf{a}} \qquad \sum F_x = ma_x \quad \& \quad \sum F_y = ma_y$$

$$\vec{\mathbf{F}}_{A\,on\,B} = -\vec{\mathbf{F}}_{B\,on\,A} \qquad \vec{\mathbf{w}} = m\vec{\mathbf{g}} \quad \& \quad g = 9.8\ \text{m/s}^2$$

Chapter 5: Applying Newton's Laws

$$\sum \vec{\mathbf{F}} = 0 \qquad \sum F_x = 0 \qquad \sum F_y = 0$$

$$\sum \vec{\mathbf{F}} = m\vec{\mathbf{a}} \qquad \sum F_x = ma_x \qquad \sum F_y = ma_y$$

$$f_k = \mu_k n \qquad f_s \leq \mu_s n$$

$$f = kv \qquad v_t = \frac{mg}{k}$$

$$f = Dv^2 \qquad v_t = \sqrt{\frac{mg}{D}}$$

$$a_{rad} = \frac{v^2}{R} \qquad T = \frac{2\pi R}{v}$$

$$a_{rad} = \frac{4\pi^2 R}{T^2} \qquad F = m\frac{v^2}{R}$$

Chapter 6: Work and Kinetic Energy

$$W = Fs\cos\Phi\ [1\text{ J} = 1\text{ Nm}] \qquad W = \vec{\mathbf{F}} \cdot \vec{\mathbf{s}}$$

$$K = \frac{1}{2}mv^2 \qquad W_{tot} = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2 = \Delta K$$

$$W = \int_{x_1}^{x_2} F_x\,dx \qquad W = F_x\,(x_2 - x_1)\ (F_x = \text{const.})$$

$$F_x = kx \qquad W = \int_{x_1}^{x_2} F_x\,dx = \frac{1}{2}kx_2^2 - \frac{1}{2}kx_1^2$$

$$W = \int_{P_1}^{P_2} F\cos\Phi\,dl \quad \Rightarrow \quad W = \int_{P_1}^{P_2} \vec{\mathbf{F}} \cdot d\vec{\mathbf{l}}$$

$$P_{av} = \frac{\Delta W}{\Delta t}\ [1\text{ W} = 1\text{ J/s}] \qquad P = \frac{dW}{dt} = \vec{\mathbf{F}} \cdot \vec{\mathbf{v}}$$

Chapter 7: Potential Energy and Energy Conservation

$$W_{grav} = Fs = mgy_1 - mgy_2$$
$$U_{grav} = mgy$$
$$W_{grav} = -\Delta U_{grav}$$
$$K_1 + U_{grav,1} = K_2 + U_{grav,2} \text{ (only gravity)}$$
$$K_1 + U_{grav,1} + W_{other} = K_2 + U_{grav,2} \text{ (other forces)}$$
$$\frac{1}{2}mv_1^2 + mgy_1 + W_{other} = \frac{1}{2}mv_2^2 + mgy_2 \text{ (other forces)}$$
$$U_{el} = \frac{1}{2}kx^2 \text{ (elastic potential energy)}$$
$$W_{el} = -\Delta U_{el}$$
$$K_1 + U_{el,1} = K_2 + U_{el,2} \text{ (only elastic forces)}$$
$$U = U_{grav} + U_{el} = mgy + \frac{1}{2}kx^2$$
$$K_1 + U_1 + W_{other} = K_2 + U_2 \text{ (valid in general)}$$
$$\Delta K + \Delta U + \Delta U_{int} = 0 \text{ (conservation energy law)}$$
$$F_x(x) = -\frac{dU(x)}{dx} \text{ (one dimension)}$$
$$\vec{\mathbf{F}} = -\left(\frac{\partial U}{\partial x}\hat{\mathbf{i}} + \frac{\partial U}{\partial y}\hat{\mathbf{j}} + \frac{\partial U}{\partial z}\hat{\mathbf{k}}\right) = -\vec{\nabla}U \text{ (three dimensions)}$$

Chapter 8: Momentum, Impulse, and Collisions

$$\vec{\mathbf{p}} = m\vec{\mathbf{v}} \qquad \sum \vec{\mathbf{F}} = \frac{d\vec{\mathbf{p}}}{dt}$$

$$\vec{\mathbf{J}} = \int_{t_1}^{t_2} \sum \vec{\mathbf{F}} dt \qquad \vec{\mathbf{J}} = \vec{\mathbf{p}}_2 - \vec{\mathbf{p}}_1$$

$$\vec{\mathbf{P}} = \vec{\mathbf{p}}_A + \vec{\mathbf{p}}_B + \ldots = m\vec{\mathbf{v}}_A + m\vec{\mathbf{v}}_B + \ldots \qquad \frac{d\vec{\mathbf{P}}}{dt} = 0$$

$$\vec{\mathbf{r}}_{cm} = \frac{\sum_i m_i \vec{\mathbf{r}}_i}{\sum_i m_i} \qquad M = \sum_i m_i$$

$$M\vec{\mathbf{v}}_{cm} = \sum_i m_i \vec{\mathbf{v}}_i \qquad M\vec{\mathbf{v}}_{cm} = \vec{\mathbf{P}}$$

$$\sum \vec{\mathbf{F}}_{ext} = M\vec{\mathbf{a}}_{cm} = \frac{d\vec{\mathbf{P}}}{dt}$$

Chapter 9: Rotation of Rigid Bodies

$$\theta = \frac{s}{r} \qquad 1 \text{ rad} = \frac{360^\circ}{2\pi} = 57.3^\circ$$

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

$$1 \text{ rev/s} = 2\pi \text{ rad/s} \qquad 1 \text{ rev/min} = 1 \text{ rpm} = \frac{2\pi}{60} \text{ rad/s}$$

$$\alpha_{av-z} = \frac{\Delta\omega_z}{\Delta t} \qquad \alpha_z = \frac{d\omega_z}{dt} = \frac{d^2\alpha_z}{dt^2}$$

$$\omega_z = \omega_{0z} + \alpha_z t \qquad \theta - \theta_0 = \frac{1}{2}(\omega_{0z} + \omega_z)t \;\; (\alpha_z = \text{const.})$$

$$\theta = \theta_0 + \omega_{0z}t + \frac{1}{2}\alpha_z t^2 \qquad \omega_z^2 = \omega_{0z}^2 + 2\alpha_z\,(\theta - \theta_0)$$

$$s = r\theta \qquad v = r\omega$$

$$a_{tan} = r\alpha \qquad a_{rad} = \omega^2 r$$

$$I = \sum_i m_i r_i^2 \qquad K = \frac{1}{2}I\omega^2$$

$$I_P = I_{cm} + Md^2$$

Chapter 10: Dynamics of Rotational Motion

$$\tau = Fl = rF\sin\Phi = F_{tan}r \qquad \vec{\boldsymbol{\tau}} = \vec{\mathbf{r}} \times \vec{\mathbf{F}}$$

$$\sum \tau_z = I\alpha_z$$

$$K = \frac{1}{2}Mv_{cm}^2 + \frac{1}{2}I\omega_z^2 \qquad v_{cm} = R\omega \text{ (no slipping)}$$

$$\sum \vec{\mathbf{F}}_{ext} = M\vec{\mathbf{a}}_{cm} \qquad \sum \tau_z = I_{cm}\alpha_z$$

$$W = \int_{\theta_1}^{\theta_2} \tau_z \, d\theta \qquad W = \tau_z \Delta\theta \text{ } (\tau_z = \text{const.})$$

$$W_{tot} = \frac{1}{2}I\omega_2^2 - \frac{1}{2}I\omega_1^2 \qquad P = \frac{dW}{dt} = \tau_z\omega_z$$

$$\vec{\mathbf{L}} = \vec{\mathbf{r}} \times \vec{\mathbf{p}} = \vec{\mathbf{r}} \times m\vec{\mathbf{v}} \qquad \frac{d\vec{\mathbf{L}}}{dt} = \vec{\boldsymbol{\tau}}$$

$$\vec{\mathbf{L}} = I\vec{\boldsymbol{\omega}} \qquad \sum \vec{\boldsymbol{\tau}} = \frac{d\vec{\mathbf{L}}}{dt}$$

$$\vec{\mathbf{L}}_A + \vec{\mathbf{L}}_B = \text{const. isolated system} \qquad \frac{d\vec{\mathbf{L}}}{dt} = 0$$