**PHYS 1311 Spring 2017 Final**

## Test 1 equations

$$\Delta\vec{r} = \vec{r}_f - \vec{r}_i \qquad \vec{v}_{\text{avg}} = \frac{\Delta\vec{r}}{\Delta t} \qquad \vec{a}_{\text{avg}} = \frac{\Delta\vec{v}}{\Delta t} \tag{1}$$

$$\Delta t = t_f - t_i \qquad \vec{v} = \frac{d\vec{r}}{dt} \qquad \vec{a} = \frac{d\vec{v}}{dt} \qquad \vec{v}_{\text{avg}} = \frac{1}{2}(\vec{v}_i + \vec{v}_f) \tag{2}$$

$$x_f = x_i + \frac{1}{2}(v_{xi} + v_{xf})(t_f - t_i) \qquad y_f = y_i + \frac{1}{2}(v_{yi} + v_{yf})(t_f - t_i) \tag{3}$$

$$x_f = x_i + v_{xi}(t_f - t_i) + \frac{1}{2}a_x(t_f - t_i)^2 \quad y_f = y_i + v_{yi}(t_f - t_i) + \frac{1}{2}a_y(t_f - t_i)^2 \tag{4}$$

$$v_{xf} = v_{xi} + a_x(t_f - t_i) \qquad v_{yf} = v_{yi} + a_y(t_f - t_i) \tag{5}$$

$$v_{xf}^2 = v_{xi}^2 + 2a_x(x_f - x_i) \qquad v_{yf}^2 = v_{yi}^2 + 2a_y(y_f - y_i) \tag{6}$$

$$\vec{p}_f = \vec{p}_i + \vec{F}_{\text{net}}\Delta t \qquad \vec{p} \approx m\vec{v} \qquad \vec{p} = \gamma m\vec{v} \tag{7}$$

$$\gamma = \frac{1}{\sqrt{1 - (|\vec{v}|/c)^2}} \qquad \vec{r}\,' = \vec{r} - \vec{v}_0 t \qquad \vec{v}\,' = \vec{v} - \vec{v}_0 \tag{8}$$

$$\sum_j \vec{F}_j = \vec{F}_{\text{net}} = m\vec{a} \qquad \vec{J} = \vec{F}_{\text{net}}\Delta t \qquad |\vec{F}_{\text{grav}}| = mg \tag{9}$$

$$|\vec{F}_{\text{spring}}| = k_s|s| \qquad s = |\vec{L}| - L_0 \qquad \vec{F}_{\text{grav}} = -G\frac{m_1 m_2}{|\vec{r}|^2}\hat{r} \tag{10}$$

## Test 2 equations

$$\vec{F}_e = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{|\vec{r}|^2}\hat{r} \qquad |\vec{f}_s^{\,\text{max}}| = \mu_s|\vec{F}_N| \qquad |\vec{f}_k| = \mu_k|\vec{F}_N| \tag{11}$$

$$\vec{r}_{\text{cm}} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2} \qquad \vec{v}_{\text{cm}} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1 + m_2} \tag{12}$$

$$x(t) = A\cos(\omega t + \phi) \qquad v(t) = -A\omega\sin(\omega t + \phi) \tag{13}$$

$$a(t) = -A\omega^2\cos(\omega t + \phi) \qquad \frac{d^2x(t)}{dt^2} + \omega^2 x(t) = 0 \tag{14}$$

$$\omega = 2\pi/T = 2\pi f \qquad \omega = \sqrt{k/m} \qquad \omega = \sqrt{g/L} \qquad s = r\theta \tag{15}$$

$$T = \frac{2\pi r}{v} \quad a_r = \frac{v_t^2}{r} \quad T = \frac{2\pi r^{3/2}}{\sqrt{GM}} \quad v = \sqrt{\frac{GM}{r}} \tag{16}$$

$$\omega_{\text{avg}} = \frac{\Delta\theta}{\Delta t} \quad \alpha_{\text{avg}} = \frac{\Delta\omega}{\Delta t} \quad \omega = \frac{d\theta}{dt} \quad \alpha = \frac{d\omega}{dt} \tag{17}$$

$$\theta_f = \theta_i + \frac{1}{2}(\omega_i + \omega_f)(t_f - t_i) \quad \theta_f = \theta_i + \omega_i(t_f - t_i) + \frac{1}{2}\alpha(t_f - t_i)^2 \tag{18}$$

$$\omega_f = \omega_i + \alpha(t_f - t_i) \quad \omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i) \tag{19}$$

$$v_t = r\omega \quad a_t = r\alpha \quad \vec{F}_{\parallel} = (\vec{F} \cdot \hat{p})\hat{p} = Fp\cos\theta\hat{p} \tag{20}$$

$$\frac{d\vec{p}}{dt} = \frac{dp}{dt}\hat{p} + p\frac{d\hat{p}}{dt} = \vec{F}_{\text{net}\parallel} + \vec{F}_{\text{net}\perp} \tag{21}$$

$$K = \frac{1}{2}mv^2 = \frac{p^2}{2m} \quad W = \vec{F} \cdot \vec{s} \quad W = \Delta K \tag{22}$$

$$E_{\text{particle}} = \gamma mc^2 = E_{\text{rest}} + K \quad E_{\text{rest}} = mc^2 \quad K = (\gamma - 1)E_{\text{rest}} \tag{23}$$

$$E^2 - (pc)^2 = (mc^2)^2 \quad E_f = E_i + W_{\text{surr}} \tag{24}$$

## Test 3 equations

$$W = \int \vec{F} \cdot d\vec{r} \quad W_{\text{int}} = -\Delta U \tag{25}$$

$$F_r = -\frac{dU}{dr} \quad U_g = -\frac{Gm_1m_1}{r} \quad U_g = mgy \quad U_e = \frac{k_eq_1q_2}{r} \tag{26}$$

$$U_s = \frac{1}{2}k_sx^2 \quad U_M = \frac{1}{2}k_sx^2 - E_M \quad U_M = E_M\Big[1 - \exp[-\alpha(r - r_{eq})]\Big]^2 \tag{27}$$

$$\Delta E_{\text{thermal}} = Cm\Delta T \quad \Delta E_{\text{sys}} = Q + W \quad P = \frac{\vec{F} \cdot \Delta\vec{r}}{\Delta t} = \vec{F} \cdot \vec{v} = \frac{dW}{dt} \tag{28}$$

$$E_n = \frac{-13.6 \text{ eV}}{n^2} \quad E_n = n\hbar\omega_0 + E_0 \quad E_0 = \frac{1}{2}\hbar\omega_0 \tag{29}$$

$$E_n = \frac{h^2}{8mR^2}n^2 \quad \tau = rF\sin\phi \quad I = \Sigma_i m_i r_i^2 \quad \sum\tau = I\alpha \tag{30}$$

$$K_{\text{rot}} = \frac{1}{2}I\omega^2 \quad I_{cm}^{\text{rod}} = \frac{1}{12}ML^2 \quad I_{cm}^{\text{disk}} = \frac{1}{2}MR^2 \tag{31}$$

$$I_{cm}^{\text{ring}} = MR^2 \quad I_{cm}^{\text{sphere}} = \frac{2}{5}MR^2 \quad I_{cm}^{\text{hollowsphere}} = \frac{2}{3}MR^2 \tag{32}$$

$$I = I_{cm} + MD^2 \qquad W_{\rm rot} = \tau\theta \tag{33}$$

$$M = \int dm \qquad \vec{r}_{\rm cm} = \frac{1}{M}\int \vec{r} dm \qquad I = \int r^2 dm \tag{34}$$

$$\rho = M/V \qquad \sigma = M/A \qquad \lambda = M/L \tag{35}$$

## Post Test 3 equations

$$\vec{\tau} = \vec{r} \times \vec{F} \qquad \vec{L} = I\vec{\omega} = \vec{r} \times \vec{p} \tag{36}$$

## Math relations and constants

$$\cos\theta = x/h \qquad \sin\theta = y/h \qquad \tan\theta = y/x \tag{37}$$

$$\vec{r} = |\vec{r}|\hat{r} \qquad |\vec{r}| = \sqrt{x^2 + y^2 + z^2} \tag{38}$$

$$az^2 + bz + c = 0 \qquad z = \frac{-b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a} \tag{39}$$

$$\vec{A} \cdot \vec{B} = AB\cos\phi = A_x B_x + A_y B_y + A_z B_z \tag{40}$$

$$\vec{A} \times \vec{B} = AB\sin\phi = \Big\langle (A_y B_z - A_z B_y), -(A_x B_z - A_z B_x), (A_x B_y - A_y B_x) \Big\rangle \tag{41}$$

$$\frac{d}{dx}\Big[\frac{u}{v}\Big] = \frac{1}{v}\frac{du}{dx} - \frac{u}{v^2}\frac{dv}{dx} \qquad \text{Circumference} = 2\pi r \tag{42}$$

$$(1 \pm \epsilon)^{-n} = 1 \mp n\epsilon + \frac{n(n+1)\epsilon^2}{2!} \mp ..., \epsilon << 1 \tag{43}$$

$$A = \pi r^2 \qquad V = \frac{4}{3}\pi r^3 \qquad g = 9.8 \text{ m/s}^2 \qquad G = 6.673 \times 10^{-11} \text{ Nm}^2/\text{kg}^2 \tag{44}$$

$$c = 2.998 \times 10^8 \text{ m/s} \qquad m_e = 9.109 \times 10^{-31} \text{ kg} \qquad m_p = 6.726 \times 10^{-27} \text{ kg} \tag{45}$$

$$M_{\rm Earth} = 5.97 \times 10^{24} \text{ kg} \qquad 1e = 1.6 \times 10^{-19} \text{ C} \qquad \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2/\text{C}^2 \tag{46}$$

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J} \qquad h = 6.6 \times 10^{-34} \text{ Js} \qquad \hbar = \frac{h}{2\pi} \tag{47}$$