# PHYS 1410 6.0: PHYSICAL SCIENCE (Fall 2012)

**End-of-Term Exam** **Dec 11, 7 p.m. – 10 p.m. = 180 min**

FORMULAE

$$\frac{d}{dt}t^n = nt^{n-1}\ ;\ \frac{d}{dt}\sin t = \cos t\ ;\ \frac{d}{dt}\cos t = -\sin t\ ;\ \frac{d}{dt}\exp t = \exp t$$

$$\frac{d}{dt}\left(f(t)+g(t)\right) = \frac{df}{dt}+\frac{dg}{dt}\ ; \qquad \frac{d}{dt}(\alpha f(t)) = \alpha\frac{df}{dt} \quad \text{for any } \alpha \in \Re$$

$$\text{product rule}:\ \frac{d}{dt}(fg) = \frac{df}{dt}g + f\frac{dg}{dt}\ ; \qquad \text{chain rule}:\ \frac{d}{dt}[f(x(t))] = \frac{df}{dx}\frac{dx}{dt}$$

$\frac{d}{dt}\vec{r}(t) = \vec{v}(t)$; $\frac{d}{dt}\vec{v}(t) = \vec{a}(t)$; $m\vec{a} = \vec{F}_{\text{net}}$

$F_{\text{grav}} = G\frac{m_1 m_2}{r^2}$; $g = \frac{GM_E}{R_E^2} = 9.8\ \text{m/s}^2$; $R_E = 6370$ km; $G = 6.67\times10^{-11}\frac{\text{Nm}^2}{\text{kg}^2}$; $M_E = 5.98\times10^{24}$ kg; close to Earth: $F_{\text{grav}} = mg$

1D motion with $a =$const: $v = v_0 + at, x = x_0 + v_0 t + \frac{a}{2}t^2, v^2 = v_0^2 + 2a(x - x_0)$

on inclined plane with tilt angle $\theta$: $F_{||} = mg\sin\theta, F_{\perp} = mg\cos\theta$

$F_k = \mu_k N$; $F_s \le \mu_s N$; $\mu_k < \mu_s$; $F_{\text{drag}} = \frac{1}{2}\rho A v^2$

circular motion: $\vec{r}(t) = R\cos\theta(t)\hat{\imath} + R\sin\theta(t)\hat{\jmath}$; $\vec{a}(t) = \vec{a}_c(t) + \vec{a}_t(t)$ with $\vec{a}_c\cdot\vec{a}_t = 0$; $a_c = \omega^2 R$; $a_t = \alpha R$; $\alpha = \dot{\omega} = \ddot{\theta}$; $v = \omega R$, $\omega = 2\pi/T$;

$KE = \frac{m}{2}v^2$, $W = \vec{F}\cdot\vec{r} = F\Delta r\cos\theta$ (for constant forces); $W = \int_{x_i}^{x_f} F(x)dx$ (for 1D problems); $W = \Delta KE$; conservative systems: $W = -\Delta PE$; in 1D: $PE \equiv V(x)$ characterized by: $F(x) = -\frac{dV}{dx}$

$\vec{p} = m\vec{v}$, $\Delta\vec{p} = \vec{J} = \int_{t_i}^{t_f}\vec{F}(t)dt = \vec{F}_{\text{ave}}\Delta t$; closed system: $\Delta\vec{p}_1 + \Delta\vec{p}_2 = 0$; elastic collision: $\Delta KE = 0$; $\vec{r}_{CM} = \frac{\sum_i m_i\vec{r}_i}{\sum_i m_i}$

$\vec{\tau} = \vec{r}\times\vec{F}$; $I\vec{\alpha} = \vec{\tau}$; $I = \sum_i m_i r_i^2$; $KE_{\text{rot}} = \frac{1}{2}I\omega^2$; $\vec{L} = \vec{r}\times\vec{p}$; $\vec{L}_{\text{tot}} = \sum_i \vec{L}_i$; $\vec{L}_{\text{tot}} = I\vec{\omega}$; $\frac{d}{dt}\vec{L}_{\text{tot}} = \vec{\tau}_{\text{tot}}$