Physics 207-05S Final Exam Formula Sheet

Kinematics

$\mathbf{v} = \mathbf{v}_0 + \mathbf{a}t$

$\mathbf{r} = \mathbf{r}_0 + \mathbf{v}_0 t + \mathbf{a}t^2/2$

$v^2 = v_0^2 + 2a(x - x_0)$

$x - x_0 = (v_0 + v)t/2$

$x - x_0 = vt + at^2/2$

$g = 9.81 \text{ m/s}^2 = GM_R/R_E^2$

2D Motion

$h_{max} = v_i^2 \sin^2 q / 2g$

$Range = v_i^2 \sin 2q / g$

Uniform Circular Motion

$a = v^2/r = \omega^2 r$

$v = \omega r$

$\omega = 2\pi/T = 2\pi f$

Galilean Transformations

$\vec{r}' = \vec{r} - \vec{v}_0 t$

$\vec{v}' = \vec{v} - \vec{v}_0$

Dynamics

$\mathbf{F}_{NET} = m\mathbf{a} = d\mathbf{p}/dt$

$\mathbf{F}_{A,B} = -\mathbf{F}_{B,A}$

$F = mg$ (gravity near earth's surface)

$F_{12} = -G m_1 m_2 / r^2$; $G = 6.67\times10^{-11} \text{ N}\bullet\text{m}^2/\text{kg}^2$

$F_{spring} = -k(\Delta x)$

Friction

$f = \mu_K N$ (kinetic friction)

$f \le \mu_S N$ (static friction)

$\vec{f}_{drag} = -b\vec{v}$ (low speed)

$|f_{drag}| = \frac{1}{2} D r A v^2$ (high speed)

Work & Kinetic energy

$W = \int \vec{F} \bullet d\vec{r}$

$W = \vec{F} \bullet \vec{r} = Fr\cos q$ (constant force)

$W_{grav} = -mg\Delta y$ (near earth surface)

$W_{grav} = GmM(1/r_2 - 1/r_1)$ (in general)

$W_{spring} = -k(x_2^2 - x_1^2)/2$

$KE = mv^2/2 = p^2/2m$

$W_{NET} = \Delta KE$

Potential Energy

$U_{grav} = mgy$ **(near earth surface)**

$U_{grav} = -GMm/r$ **(in general)**

$U_{spring} = kx^2/2$

$\Delta E = \Delta K + \Delta U = W_{NC}$

$\Delta U = -W$

$F(x) = -dU(x)/dx$

Power

$P = dW/dt = \vec{F} \bullet \vec{v}$ **(for constant force)**

System of Particles and Momentum

$\mathbf{R}_{CM} = \sum m_i \mathbf{r}_i / \sum m_i$

$\mathbf{V}_{CM} = \sum m_i \mathbf{v}_i / \sum m_i$

$\mathbf{A}_{CM} = \sum m_i \mathbf{a}_i / \sum m_i$

$\mathbf{P} = \sum m_i \mathbf{v}_i$

$\sum \mathbf{F}_{EXT} = M\mathbf{A}_{CM} = d\mathbf{P}/dt$

Collisions

If $\sum \mathbf{F}_{EXT} = 0$ in some direction, then

$\mathbf{P}_{before} = \mathbf{P}_{after}$ **in this direction**

$\sum m_i \mathbf{v}_i(before) = \sum m_i \mathbf{v}_i(after)$

In addition, if collision is elastic

$*KE_{\text{before}} = KE_{\text{after}}$

Rotation Kinematics

$s = Rq,\ v = Rw,\ a = Ra$

$q = q_0 + w_0 t + \frac{1}{2} a t^2$

$w = w_0 + at$

$w^2 = w_0^2 + 2a\Delta q$

(for constant α)

Rotational Dynamics

$I = \sum m_i r_i^2,\quad I_{parallel} = I_{CM} + MD^2$

$I_{disk} = I_{cylinder} = \frac{1}{2}MR^2,\quad I_{hoop} = MR^2$

$I_{solid-sphere} = \frac{2}{5}MR^2,\quad I_{hollow-sphere} = \frac{2}{3}MR^2$

$I_{rod-cm} = \frac{1}{12}ML^2,\quad I_{rod-end} = \frac{1}{3}ML^2$

$t = Ia$ **(rotation about a fixed axis)**

$\mathbf{t} = \mathbf{r}\times\mathbf{F},\quad |t| = rF\sin f$ **(definition of torque)**

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Work & Energy

$K_{rotation} = \frac{1}{2} I w^2 = L^2/2I$

$K_{translation} = \frac{1}{2} M V_{CM}^2$

$K_{total} = K_{rotation} + K_{translation}$

$W = tq$

Angular Momentum

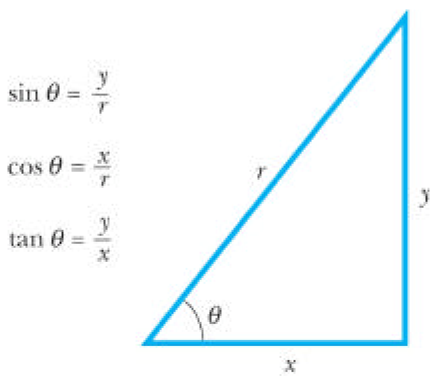
$\mathbf{L} = \mathbf{r} \times \mathbf{p}$

$L_z = I\omega_z$

$\mathbf{t}_{EXT} = d\mathbf{L}/dt$

Statics

$\sum \mathbf{F} = 0, \quad \sum \mathbf{t} = 0$ (about any axis)



$x^2 + y^2 = r^2$

$\sin 2q = 2 \sin q \cos q$

$\sin 30^\circ = 0.50; \quad \cos 30^\circ = 0.866$

$\sin 60^\circ = 0.866; \quad \cos 60^\circ = 0.50$

if $ax^2 + bx + c = 0$ then

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$