Formula Sheet for LSU Physics 2101, Spring '08, Exam 2.

Units:

1 m = 39.4 in = 3.28 ft   1 mi = 5280 ft   1 min = 60 s   1 day = 24 h   1 h = 60 min

Constants:

g = 9.8 m/s^2

Quadratic formula: for $ax^2 + bx + c = 0$, $x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Dot Product: $\vec{a} \cdot \vec{b} = a_x b_x + a_y b_y + a_z b_z = |\vec{a}| \left|\vec{b}\right| \cos(\phi)$ (ϕ is smaller angle between $\vec{a}$ and $\vec{b}$)

Cross Product: $\vec{a} \times \vec{b} = (a_y b_z - a_z b_y)\hat{\imath} + (a_z b_x - a_x b_z)\hat{\jmath} + (a_x b_y - a_y b_x)\hat{k}$, $\left|\vec{a} \times \vec{b}\right| = |\vec{a}| \left|\vec{b}\right| \sin(\phi)$

Equations of Constant Acceleration (linear and rotational):

linear equation along x	missing
$v_x = v_{ox} + a_x t$	$x - x_o$
$x - x_o = v_{ox} t + \frac{1}{2} a_x t^2$	v_x
$v_x^2 = v_{ox}^2 + 2a_x (x - x_o)$	t
$x - x_o = \frac{1}{2}(v_{ox} + v_x) t$	a_x
$x - x_o = v_x t - \frac{1}{2} a_x t^2$	v_{ox}

Vector Equations of Motion for Constant Acceleration: $\vec{r} = \vec{r}_o + \vec{v}_o t + \frac{1}{2}\vec{a} t^2$, $\vec{v} = \vec{v}_o + \vec{a} t$

Projectile Motion:

$x = v_{ox} t$ $y = v_{oy} t - \frac{1}{2} g t^2$ $R = \frac{v_o^2 \sin(2\theta_o)}{g}$

$v_x = v_{ox} = \text{constant}$ $v_y = v_{oy} - g t$

Newton's Second Law: $\sum \vec{F} = m\vec{a}$

Centripetal Force: $F_c = \frac{mv^2}{r} = m a_c$ **Time per revolution:** $T = \frac{2\ \pi\ r}{v_{avg}}$

Force of Friction: Static: $f_s \leq f_{s,max} = \mu_s F_N$, Kinetic: $f_k = \mu_k F_N$

Elastic (Spring) Force: Hooke's Law $F = -kx$ (k = spring (force) constant)

Kinetic Energy (nonrelativistic): Translational: $K = \frac{1}{2} m v^2$

Work:

$W = \vec{F} \cdot \vec{d}$ (constant force), $W = \int_{x_i}^{x_f} F(x) dx$ (variable 1-D force), $W = \int_{r_i}^{r_f} \vec{F}(\vec{r}) \cdot d\vec{r}$ (variable 3-D force)

Work - Kinetic Energy Theorem: $W = \Delta K = K_f - K_i$

Work done by weight (gravity close to the Earth surface): $W = m\, \vec{g} \cdot \vec{d}$

Work done by spring force F = - k x: $W = -k \int_{x_i}^{x_f} x\ dx = -k \left(\frac{x_f^2}{2} - \frac{x_i^2}{2} \right)$

Power:

Average: $P_{avg} = \frac{W}{\Delta t}$, $P = \vec{F} \cdot \vec{v}_{avg}$ (const. force)   Instantaneous: $P = \frac{dW}{dt}$, $P = \vec{F} \cdot \vec{v}$ (const. force)

Potential Change: $\Delta U = -W$ (only conservative force) **Potential-Force Realation:** $F(x) = -\dfrac{dU(x)}{dx}$

Gravitational (near Earth) Potential Energy: $U(y) = mgy$ (at the height y)

Elastic (Spring) Potential Energy: $U = \frac{1}{2}kx^2$ (relative to the relaxed spring)

Mechanical Energy: $E_{mec} = K + U$

Energy Consideration: $W = \Delta K + \Delta U + \Delta E_{\text{th}} + \Delta E_{\text{int}}$, where W is the *external* work done on the system, and $\Delta E_{\text{th}} = -W_{f_k} = (f_k d$ for constant friction).

Center of mass: $M = \sum_{i=1}^{N} m_i,\ x_{\text{com}} = \frac{1}{M}\sum_{i=1}^{N} m_i x_i,\ y_{\text{com}} = \frac{1}{M}\sum_{i=1}^{N} m_i y_i,\ z_{\text{com}} = \frac{1}{M}\sum_{i=1}^{N} m_i z_i$

$$\vec{r}_{\text{com}} = \frac{1}{M}\sum_{i=1}^{N} m_i\vec{r}_i \qquad \vec{v}_{\text{com}} = \frac{1}{M}\sum_{i=1}^{N} m_i\vec{v}_i \qquad \vec{a}_{\text{com}} = \frac{1}{M}\sum_{i=1}^{N} m_i\vec{a}_i = \frac{1}{M}\sum_{i=1}^{N} \vec{F}_i$$

Definition of Linear Momentum: one particle: $\vec{p} = m\vec{v}$, system of particles: $\vec{P} = \sum_{i=1}^{N} \vec{p}_i = M\vec{v}_{\text{com}}$

Newton's 2nd Law for a System of Particles: $\vec{F}_{\text{net}} = M\vec{a}_{\text{com}} = \dfrac{d\vec{P}}{dt}$

Conservation of Linear Momentum of an Isolated System: $\sum \vec{p}_i = \sum \vec{p}_f$

Impulse - Linear Momentum Theorem: $\Delta\vec{p}_1 = \vec{J}_{12} = \int_{t_1}^{t_2} \vec{F}_{12}(t)dt = \vec{F}_{\text{avg},12}\Delta t$

Elastic Collision (1 Dim): $v_{1f} = \dfrac{m_1 - m_2}{m_1 + m_2}v_{1i} + \dfrac{2m_2}{m_1 + m_2}v_{2i} \quad v_{2f} = \dfrac{2m_1}{m_1 + m_2}v_{1i} + \dfrac{m_2 - m_1}{m_1 + m_2}v_{2i}$