San Jacinto College

Student Success Center

University Physics 1 - Formula Sheet

One Dimensional Kinematics

- $\Delta x \equiv x_f - x_i$
- Avg speed $\equiv \frac{total\ distance\ traveled}{total\ time}$
- $V_{avg} \equiv \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$
- $v \equiv \lim_{\Delta t \to 0} v_{avg} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$
- $a_{avg} \equiv \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$
- $a \equiv \lim_{\Delta t \to 0} a_{av} = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$
- Constant linear acceleration
  - $v = v_o + at$
  - $x = x_o + \frac{1}{2}(v_o + v)t$
  - $x = x_o + v_o t + \frac{1}{2}at^2$
  - $v^2 = v_0^2 + 2a(x - x_0)$

Newton's Laws of Motion

- $\sum F = ma$
- $W = mg$

Applications of Newton's Laws

- $f_s \leq \mu_s N$
- $f_k = \mu_k N$
- $|F| = kx$
- $a_c = \frac{v^2}{r}$

Work and Kinetic Energy

- $W \equiv Fd\cos\theta$
- $K \equiv \frac{1}{2}mv^2$
- $W_{net} = \Delta K$
- $W = \frac{1}{2}kx^2$
- $P = \frac{W}{t} = Fv$

Potential Energy and Conservation of Energy

- $W_c = -\Delta U$
- $U_{grav} \equiv mgy$
- $E \equiv K + U$
- $U_{spring} \equiv \frac{1}{2}kx^2$
- $W_{nc} = \Delta E$

Linear Momentum and Collisions

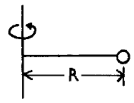
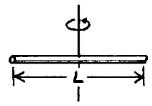
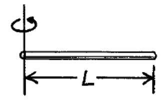
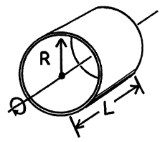
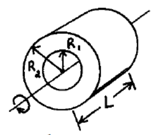
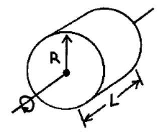
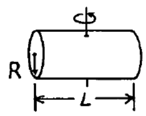
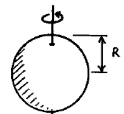
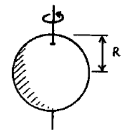
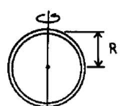
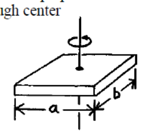
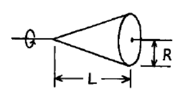
- $\vec{p} \equiv m\vec{v}$
- $\sum F = \lim_{\Delta t \to 0} \frac{\Delta \vec{p}}{\Delta t}$
- $\sum \vec{F}_{avg} = \frac{\Delta \vec{p}}{\Delta t}$
- $\vec{I} = \sum \vec{F}_{avg} \Delta t$
- $\vec{I} = \Delta \vec{p}$
- $X_{cm} = \frac{\sum m_i x_i}{\sum m_i} = \frac{m_1 x_1 + m_2 x_2 + \cdots}{m_1 + m_2 + \cdots}$
- $Y_{cm} = \frac{\sum m_i y_i}{\sum m_i} = \frac{m_1 v_1 + m_2 v + \cdots}{m_1 + m_2 + \cdots}$

Rotational Kinematics and Energy

- $\theta \equiv \frac{s}{r}$
- $\Delta\theta \equiv \theta_f - \theta_i$
- $\omega_{avg} \equiv \frac{\Delta\theta}{\Delta t} = \frac{\theta_f - \theta_i}{t_f - t_i}.$
- $\omega \equiv \lim_{\Delta t \to 0} \frac{\Delta\theta}{\Delta t}$
- $\alpha_{avg} \frac{\Delta\omega}{\Delta l} = \frac{\omega_t - \omega_i}{l_t - l_i}$
- $\alpha \equiv \lim_{\Delta t \to 0} \frac{\Delta\omega}{\Delta t}$
- $T = \frac{2\pi}{\omega}$
- $v_t = r\omega$
- $a_t = r\alpha$
- $a_{cp} = r\omega^2$
- Constant angular acceleration
  - $\omega = \omega_o + \alpha t$
  - $\theta = \theta_o + \frac{1}{2}(\omega_o + \omega)t$
  - $\theta = \theta_o + \omega_o l + \frac{1}{2}\alpha t^2$
  - $\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_a)$
- $I \equiv \sum_{i=1}^{N} m_i r_i^2 = m_1 r_1^2 + m_2 r_2^2 + \cdots m_N r_N^2$

  (N point masses)
- $K_{rot} \equiv \frac{1}{2} I\omega^2$
- $K_{total} = K_{trans} + K_{rot} = \frac{1}{2} M v_{cm}^2 + \frac{1}{2} I_{cm}\omega^2$

Moments of Inertia for Uniform, Rigid Objects of Various Shapes

Point mass at a radius R  $I = MR^2$	Thin rod about axis through center perpendicular to length  $I = \frac{1}{12}ML^2$	Thin rod about axis through end perpendicular to length  $I = \frac{1}{3}ML^2$
Thin-walled cylinder about central axis  $I = MR^2$	Thick-walled cylinder about central axis  $I = \frac{1}{2}M(R_1^2 + R_2^2)$	Solid cylinder about central axis  $I = \frac{1}{2}MR^2$
Solid cylinder about central diameter  $I = \frac{1}{4}MR^2 + \frac{1}{12}ML^2$	Solid sphere about center  $I = \frac{2}{5}MR^2$	Thin hollow sphere about center  $I = \frac{2}{3}MR^2$
Thin ring about diameter  $I = \frac{1}{2}MR^2$	Slab about perpendicular axis through center  $I = \frac{1}{12}M(a^2 + b^2)$	Cone about central axis  $I = \frac{3}{10}MR^2$

Note: All formulas shown assume objects of uniform mass density.

Rotational Dynamics and Static Equilibrium

- $\tau \equiv rF\sin\theta$
- $\sum \tau = I\alpha$
- $L \equiv I\omega$
- $L = rmv\sin\theta$
- $\sum \tau = \frac{\Delta L}{\Delta t}$
- $W = \tau\theta$

Gravity

- $F_{grav} = G\frac{m_1 m_2}{r^2}$

$$G = 6.67 \cdot 10^{-11}\frac{N \cdot m^2}{kg^2}$$

- $U_{grav} = -G\frac{m_1 m_2}{r}$
- $T^2 = \frac{4\pi^2}{GM}r^3$
- $v_t = \sqrt{\frac{2GM}{R}}$

A list of solar system data is located at the end of the formula sheet

Solar System Data

- Radius of Earth: $R_E=6.37x10^6$ m
- Radius of Moon: $R_M=1.74x10^6$ m
- Mass of Earth: $M_E=5.97x10^{24}$ kg
- Mass of Moon: $7.35x10^{22}$ kg
- Mass of Sun: $2.00x10^{30}$ kg
- Earth-Moon distance: $3.84x10^8$ m
- Earth-Sun distance: $1.50x10^{11}$ m