

## FORMULA SHEET

- Constants:

$$g = 9.8\text{m/s}^2$$

- Vectors:

$$\begin{aligned}\vec{A} \cdot \vec{B} &= AB \cos \theta \\ &= A_x B_x + A_y B_y + A_z B_z\end{aligned}$$

$$|\vec{A} \times \vec{B}| = AB \sin \theta$$

- Kinematics:

$$\Delta x = v_0 t + \frac{1}{2} a t^2$$

$$v = v_0 + a t$$

$$v^2 = v_0^2 + 2a\Delta x$$

- Forces:

$$\sum \vec{F} = m\vec{a}$$

$$W = mg$$

$$f_{s,max} = \mu_s N$$

$$f_k = \mu_k N$$

- Work & Energy:

$$W = \vec{F} \cdot \Delta \vec{x} \quad \text{or} \quad W = \int \vec{F} \cdot d\vec{x}$$

$$W_{tot} = \Delta K$$

$$W_{cons} = -\Delta U$$

$$K = \frac{1}{2} m v^2$$

$$U_g = mgy$$

$$K_i + U_i + W_{nc} = K_f + U_f$$

$$\vec{F} = -\vec{\nabla} U$$

$$\vec{\nabla} f = \frac{\partial f}{\partial x} \hat{i} + \frac{\partial f}{\partial y} \hat{j} + \frac{\partial f}{\partial z} \hat{k}$$

- Momentum & Collisions:

$$\vec{p} = m\vec{v}$$

$$\sum \vec{F} = \frac{d\vec{p}}{dt}$$

$$m_1 \vec{v}_{1i} + m_2 \vec{v}_{2i} = m_1 \vec{v}_{1f} + m_2 \vec{v}_{2f}$$

$$\vec{v}_{1i} - \vec{v}_{2i} = \vec{v}_{2f} - \vec{v}_{1f}$$

- Rotational Mechanics

$$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega = \omega_0 + \alpha t$$

$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$$

$$s = r\theta$$

$$v = r\omega$$

$$a = r\alpha$$

$$\tau = rF \sin \theta$$

$$\sum \tau = I\alpha \quad \text{or} \quad \sum \tau = \frac{dL}{dt}$$

$$K_{rot} = \frac{1}{2}I\omega^2$$

$$L = I\omega \quad \text{or} \quad L = rp$$

$$I = \int r^2 dm$$

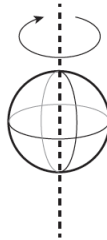
$$I_{new} = I_{cm} + md^2$$

**Solid sphere**



$$I = \frac{2}{5}MR^2$$

**Hollow sphere**



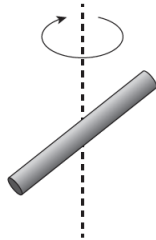
$$I = \frac{2}{3}MR^2$$

**Solid cylinder**



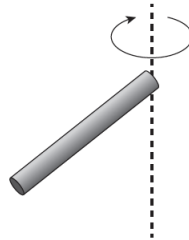
$$I = \frac{1}{2}MR^2$$

**Thin rod  
(axis in center)**



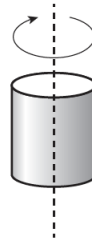
$$I = \frac{1}{12}ML^2$$

**Thin rod  
(axis at end)**



$$I = \frac{1}{3}ML^2$$

**Hoop**



$$I = MR^2$$

- Gravity:

$$G = 6.67 \times 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2}$$

$$F_G = G \frac{mM}{r^2}$$

$$a_G = G \frac{M}{r^2}$$

$$U_G = -G \frac{mM}{r}$$

$$v_{esc} = \sqrt{\frac{2GM}{R}}$$

$$v_{orb} = r\omega_{orb} = \frac{2\pi r}{T_{orb}}$$

- Oscillations:

$$F_{sp} = kx$$

$$U_{sp} = \frac{1}{2}kx^2$$

$$\omega_{sp} = \sqrt{\frac{k}{m}}$$

$$\omega_{pend} = \sqrt{\frac{g}{l}}$$

$$f = 1/T$$

$$\omega = 2\pi f$$

- Waves:

$$v = \lambda f$$

$$f_{beat} = |f_1 - f_2|$$