Physics 1501: Things to know for Midterm II

Work, Energy, Power

$$W = \int \vec{\mathbf{F}} \cdot d\vec{\mathbf{r}}$$

Kinetic Energy

$$K = \frac{1}{2}mv^2 \quad - \text{translation}, \qquad K = \frac{1}{2}I\omega^2 \quad - \text{rotation}$$

Potential Energy

$$U = mgh \quad - \text{gravity}, \qquad U = \frac{1}{2}kx^2 \quad - \text{linear spring}$$

Conservation of energy

$$E = U + K = const$$

Linear Momentum and Collisions

Center of Mass

$$\vec{\mathbf{R}}_{CM} = \frac{1}{M}\sum_i m_i \vec{\mathbf{r}}_i, \qquad M = \sum_i m_i$$

Linear momentum

$$\vec{\mathbf{p}} = m\vec{\mathbf{v}}, \quad \text{with} \quad \vec{\mathbf{F}} = \frac{d\vec{\mathbf{p}}}{dt}$$

Linear momentum is conserved if

$$\vec{\mathbf{F}}_{ext} = 0$$

Elastic collisions: $K = \text{const}$. Inelastic collisions: $K \neq \text{const}$

Rotational Kinematics

$$\omega = \frac{d\theta}{dt}, \qquad \alpha = \frac{d\omega}{dr}$$

$$f = 2\pi\omega$$

Angular and linear motion

$$s = R\theta, \qquad v = R\omega, \qquad a = R\alpha$$

Constant angular acceleration

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2, \qquad \omega = \omega_0 + \alpha t, \qquad \omega^2 - \omega_0^2 = 2(\theta - \theta_0)\alpha$$

Moment of Inertia

$$I = \sum_i m_i r_i^2$$

$$I_{CM} = Mr^2 \text{ (ring)}, \quad I_{CM} = \frac{1}{2}Mr^2 \text{ (disk)},$$

$$I_{CM} = \frac{2}{5}Mr^2 \text{ (sphere)}, \quad I_{CM} = \frac{1}{12}Ml^2 \text{ (rod)}$$

Parallel axis theorem

$$I = I_{CM} + Md^2$$

Roling Motion

Total kinetic energy

$$K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Rolling without sliping

$$v = R\omega$$

Torque and Static Equilibrium

Torque

$$\vec{\tau} = \vec{\mathbf{r}} \times \vec{\mathbf{F}}, \qquad \tau = Fr\sin\theta = I\alpha$$

Static equilibrium

$$\sum_i \vec{\mathbf{F}}_i = 0, \qquad \sum_i \vec{\tau}_i = 0$$