Elementary Dynamics – Equation Sheet #4

Newton's Laws of Motion

$$\sum_i \underset{\sim}{F}_i = m\,\underset{\sim}{a}_G$$

$$\sum_i (\underset{\sim}{M}_G)_i = \sum_i (\underset{\sim}{r}_i \times \underset{\sim}{F}_i) = I_G\,\underset{\sim}{\alpha}$$

or

$$\sum_i (\underset{\sim}{M}_P)_i = \sum_i (\underset{\sim}{p}_i \times \underset{\sim}{F}_i) = I_G\underset{\sim}{\alpha} + (\underset{\sim}{r}_{G/P} \times m\underset{\sim}{a}_G)$$

Center of Mass

$$\underset{\sim}{r}_G = \frac{\sum_i m_i\,\underset{\sim}{r}_i}{\sum_i m_i}$$

Parallel Axis Theorem

$$I_O = I_G + M\,d^2$$

Newton's Laws of Motion: Fixed Axis Rotation

$$\sum_i \underset{\sim}{F}_i = m\,\underset{\sim}{a}_G = m\left(r\,\alpha\,\underset{\sim}{e}_\theta - r\,\omega^2\underset{\sim}{e}_r\right)$$

$$\sum_i (\underset{\sim}{M}_O)_i = \sum_i (\underset{\sim}{r}_i \times \underset{\sim}{F}_i) = I_O\,\underset{\sim}{\alpha}$$

Radius of Gyration

$$I_A = m\,k_A^2$$

Work and Energy Principle

$$KE_1 + U_{1\to 2} = KE_2$$

$$KE = \sum_{\text{bodies}} \left(\tfrac{1}{2} m v_G^2 + \tfrac{1}{2} I_G\,\omega^2\right)$$

$$KE = \tfrac{1}{2} I_O\,\omega^2 \quad \text{(fixed axis rotation)}$$

Work Done by a Force

$$U_F = \int_s F\cos(\theta)\,ds$$

Work Done by a Couple

$$U_M = \int_{\theta_1}^{\theta_2} M\,d\theta$$

Conservation of Energy

$$KE_1 + V_1 = KE_2 + V_2 = \text{constant}$$

$$U_{1\to 2} = V_1 - V_2$$

$$V_{\substack{\text{translational}\\ \text{spring}}} = \tfrac{1}{2} k\,e^2$$

$$V_{\substack{\text{rotational}\\ \text{spring}}} = \tfrac{1}{2} k\,\theta^2$$

$$V_{\text{gravity}} = m\,g\,h_G$$