ME 2580 Dynamics - Equation Sheet #2

Newton's Second Law

Cartesian Components

$$\sum_{i=1}^{N} F_{x_i} = ma_{G_x} \qquad \sum_{i=1}^{N} F_{y_i} = ma_{G_y} \qquad \sum_{i=1}^{N} F_{z_i} = ma_{G_z}$$

Normal, Tangential, and Binormal Components

$$\sum_{i=1}^{N} F_{n_i} = ma_{G_n} \qquad \sum_{i=1}^{N} F_{t_i} = ma_{G_t} \qquad \sum_{i=1}^{N} F_{b_i} = ma_{G_b} = 0$$

Cylindrical Components

$$\sum_{i=1}^{N} F_{r_i} = ma_{G_r} \qquad \sum_{i=1}^{N} F_{\theta_i} = ma_{G_\theta} \qquad \sum_{i=1}^{N} F_{z_i} = ma_{G_z}$$

Angle Between *X*-Axis and Tangent Line

$$\tan(\theta) = \frac{dy}{dx}$$

Angle between Radial Line and Tangent Line

$$tan(\psi) = v_\theta / v_r = r/(dr/d\theta)$$

Work and Energy

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

$$KE = \tfrac{1}{2} m v^2$$

$$U_{1\to 2} = \int_{t_1}^{t_2} (\underset{\sim}{F} \cdot \underset{\sim}{v})\, dt = \oint \underset{\sim}{F} \cdot d\underset{\sim}{r}$$

$$U_{1\to 2} = -\tfrac{1}{2} k \left(e_2^2 - e_1^2\right) \quad \text{(linear springs)}$$

$$U_{1\to 2} = -mg\left(y_2 - y_1\right) \quad \text{(weight forces)}$$

Conservation of Energy

$$\sum KE_1 + \sum V_1 = \sum KE_2 + \sum V_2$$

$$V = mgy \quad \text{(weight forces)}$$

$$V = \tfrac{1}{2} k e^2 \quad \text{(linear springs)}$$

Power/Efficiency

$$P = \underset{\sim}{F} \cdot \underset{\sim}{v} = dU/dt$$

$$\varepsilon = \frac{\text{power delivered}}{\text{power received}}$$

$$1 \text{ HP} = 550 \text{ (ft-lb/s)}$$

$$1 \text{ W} = 1 \text{ (J/s)} = 1 \text{ (N-m/s)}$$

Linear Impulse and Momentum (for Systems of Particles)

$$\sum m_i (\underset{\sim}{v}_i)_1 + \sum \int_{t_1}^{t_2} \underset{\sim}{F}_i\, dt = \sum m_i (\underset{\sim}{v}_i)_2$$

or

$$m(\underset{\sim}{v}_G)_1 + \sum \int_{t_1}^{t_2} \underset{\sim}{F}_i\, dt = m(\underset{\sim}{v}_G)_2$$

$$\underset{\sim}{F}_{avg} = \frac{1}{\Delta t} \sum \int_{t_1}^{t_2} \underset{\sim}{F}_i\, dt = \frac{1}{\Delta t} \underset{\sim}{I}_{1\to 2}$$