

Elementary Dynamics - Equation Sheet #2

Newton's Second Law

Cartesian Components

$$\sum_{i=1}^N F_{x_i} = m a_{G_x} \quad \sum_{i=1}^N F_{y_i} = m a_{G_y} \quad \sum_{i=1}^N F_{z_i} = m a_{G_z}$$

Normal, Tangential, and Binormal Components

$$\sum_{i=1}^N F_{n_i} = m a_{G_n} \quad \sum_{i=1}^N F_{t_i} = m a_{G_t} \quad \sum_{i=1}^N F_{b_i} = m a_{G_b} = 0$$

Cylindrical Components

$$\sum_{i=1}^N F_{r_i} = m a_{G_r} \quad \sum_{i=1}^N F_{\theta_i} = m a_{G_\theta} \quad \sum_{i=1}^N F_{z_i} = m a_{G_z}$$

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

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

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

$$U_{1 \rightarrow 2} = \int_{t_1}^{t_2} (\vec{F} \cdot \vec{v}) dt = \oint \vec{F} \cdot d\vec{r}$$

$$U_{1 \rightarrow 2} = -\frac{1}{2} k (e_2^2 - e_1^2) \quad (\text{linear springs})$$

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

Power/Efficiency

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

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

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

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

Conservation of Energy

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

$$V = m g y \quad (\text{weight forces})$$

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

Linear Impulse and Momentum (for Systems of Particles)

$$\sum m_i (v_i)_1 + \sum \int_{t_1}^{t_2} \vec{F}_i dt = \sum m_i (v_i)_2$$

or

$$m(v_G)_1 + \sum \int_{t_1}^{t_2} \vec{F}_i dt = m(v_G)_2$$

$$\vec{F}_{avg} = \frac{1}{\Delta t} \sum \int_{t_1}^{t_2} \vec{F}_i dt = \frac{1}{\Delta t} I_{1 \rightarrow 2}$$