Mechanics Equation Sheet

Think about how to set up the problem first, then apply the needed principles and formulas.

Kinematics
\[ v_f = v_0 + at \]
\[ v_f^2 = v_0^2 + 2as \]
\[ s = v_0t + \frac{1}{2}at^2 \]
\[ s = \frac{1}{2}(v_f + v_0)t \]
\[ \bar{v} = \frac{\Delta s}{\Delta t} \]
\[ a_{avg} = \frac{\Delta v}{\Delta t} \]
\[ v_{inst} = \frac{ds}{dt} \]
\[ a_{inst} = \frac{dv}{dt} = \frac{d^2s}{d\tau^2} \]
\[ \bar{v} = v_x\hat{i} + v_y\hat{j} \]

Rotational Motion
\[ \theta = \frac{\bar{r}}{r} \]
\[ \omega = \frac{d\theta}{dt} = \frac{v}{r} \]
\[ \alpha = \frac{d\omega}{dt} = \frac{a_{tan}}{r} \]
\[ \omega = \omega_0 + \alpha t \]
\[ \omega^2 = \omega_0^2 + 2\alpha \Delta \theta \]
\[ \Delta \theta = \omega_0 t + \frac{1}{2} \alpha t^2 \]
\[ a_{rad} = \omega^2 r \]
\[ \tau = Fd \sin \theta \]
\[ \tau = I\alpha \]
\[ K_{total} = \frac{1}{2}m v_{com}^2 + \frac{1}{2}I_{com}\omega^2 \]
\[ W = \tau \Delta \theta = \int \tau \, d\theta \]
\[ \sum \tau = \frac{dI}{dt} \]
\[ L' = r \times \bar{p} = I\bar{\omega} \]
\[ L = rmv \sin \theta = I\omega \]

Uniform Circular Motion
\[ a_c = a_{rad} = \frac{v^2}{r} \]
\[ v = \frac{2\pi r}{T} \]
\[ a = \sqrt{a_{rad}^2 + a_{tan}^2} \]
\[ F_c = ma_c = \frac{m v^2}{r} \]

Energy and Work
\[ K = \frac{1}{2}mv^2 \]
\[ U_{grav} = mgh \]
\[ U_{spring} = \frac{1}{2}kx^2 \]
\[ \sum E_i = \sum E_f \] (conservative)
\[ W = \Delta E \]
\[ W = \bar{F} \cdot \bar{d} = Fd \cos \theta = \int \bar{F} \cdot d\bar{r} \]
\[ F = -\frac{dU}{dx} \]
\[ \bar{F} = -\nabla U \]
\[ P_{avg} = \frac{\Delta E}{\Delta t} = \frac{W}{\Delta t} \]
\[ P = \bar{F} \cdot \bar{v} = Fv \cos \theta \]
\[ P = \frac{dE}{dt} \]

Momentum and Impulse
\[ \bar{p} = mv \]
\[ \sum \bar{p}_i = \sum \bar{p}_f \]
\[ \bar{F}_{net} = \frac{\partial \bar{p}}{\partial t} \]
\[ J = \Delta \bar{p} = \bar{F}_{avg} \Delta t = \int \bar{F}_{net} \, dt \]

Periodic Motion
\[ f = \frac{1}{T} \]
\[ \omega = 2\pi f = \frac{2\pi}{T} \]
\[ a_x = -\frac{k}{m} \bar{x} \]
\[ \omega = \sqrt{\frac{k}{m}} \]
\[ x = A \cos(\omega t + \varphi) \]
\[ E_{SHM} = \frac{1}{2}kA^2 \]
\[ \Delta E_{SHM} = 0 \]
\[ \omega_{simp} = \sqrt{\frac{2}{L}} \]
\[ \omega_{phys} = \sqrt{\frac{mgd}{I}} \]

Constants
\[ g = 9.81 m/s^2 \]
\[ c = 2.998 \times 10^8 m/s \]
\[ G = 6.67 \times 10^{-11} \frac{N m^2}{kg^2} \]

Scientific Notation Prefixes

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