



# Mechanics Equation Sheet

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

## Kinematics

$$\begin{aligned} v_f &= v_0 + at \\ v_f^2 &= v_0^2 + 2a\Delta s \\ \Delta s &= v_0 t + \frac{1}{2}at^2 \\ \Delta s &= \frac{1}{2}(v_f + v_0)t \\ v_{avg} &= \frac{\Delta s}{\Delta t} \\ a_{avg} &= \frac{\Delta v}{\Delta t} \\ v_{inst} &= \frac{ds}{dt} \\ a_{inst} &= \frac{dv}{dt} = \frac{d^2s}{dt^2} \\ \vec{v} &= v_x \hat{i} + v_y \hat{j} \end{aligned}$$

## Forces

$$\begin{aligned} \vec{F} &= F_x \hat{i} + F_y \hat{j} \\ F &= \sqrt{F_x^2 + F_y^2} \\ \vec{F}_{net} &= m\vec{a} = \sum \vec{F} \\ f_s &\leq \mu_s N \\ f_k &= \mu_k N \\ \vec{F}_{spring} &= -k\vec{x} \end{aligned}$$

## Uniform Circular Motion

$$\begin{aligned} a_c &= a_{rad} = \frac{v^2}{r} \\ v &= \frac{2\pi r}{T} \\ a &= \sqrt{a_{rad}^2 + a_{tan}^2} \\ F_c &= ma_c = m\frac{v^2}{r} \end{aligned}$$

## Energy and Work

$$\begin{aligned} K &= \frac{1}{2}mv^2 \\ U_{grav} &= mgh \\ U_{spring} &= \frac{1}{2}kx^2 \\ \sum E_i &= \sum E_f \text{ (conservative)} \\ W &= \Delta E \\ W &= \vec{F} \cdot \vec{d} = Fd \cos \theta = \int \vec{F} \cdot d\vec{r} \\ F &= -\frac{dU}{dx} \\ \vec{F} &= -\vec{\nabla}U \\ P_{avg} &= \frac{\Delta E}{\Delta t} = \frac{W}{\Delta t} \\ P &= \vec{F} \cdot \vec{v} = Fv \cos \theta \\ P &= \frac{dE}{dt} \end{aligned}$$

## Momentum and Impulse

$$\begin{aligned} \vec{p} &= mv \\ \sum \vec{p}_i &= \sum \vec{p}_f \\ \vec{F}_{net} &= \frac{d\vec{p}}{dt} \\ \vec{J} &= \Delta \vec{p} = \vec{F}_{avg} \Delta t = \int \vec{F}_{net} dt \end{aligned}$$

## Constants

$$\begin{aligned} g &= 9.81 m/s^2 \\ c &= 2.998 \times 10^8 m/s \\ G &= 6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2} \end{aligned}$$

Scientific Notation Prefixes		
Factor	Prefix	Symbol
$10^{-12}$	pico-	p
$10^{-9}$	nano-	n
$10^{-6}$	micro-	$\mu$
$10^{-3}$	milli-	m
$10^{-2}$	centi-	c
$10^3$	kilo-	k
$10^6$	mega-	M
$10^9$	giga-	G

## Rotational Motion

$$\begin{aligned} \theta &= \frac{s}{r} \\ \omega &= \frac{d\theta}{dt} = \frac{v}{r} \\ \alpha &= \frac{d\omega}{dt} = \frac{a_{tan}}{r} \\ \omega &= \omega_0 + \alpha t \\ \omega^2 &= \omega_0^2 + 2\alpha\Delta\theta \\ \Delta\theta &= \omega_0 t + \frac{1}{2}\alpha t^2 \\ a_{rad} &= \omega^2 r \\ I &= \sum_i m_i r_i^2 \\ K_{rot} &= \frac{1}{2}I\omega^2 \\ I &= I_{com} + md^2 \\ \vec{\tau} &= \vec{d} \times \vec{F} \\ \tau &= Fd \sin \theta \\ \tau &= I\alpha \end{aligned}$$

$$\begin{aligned} K_{total} &= \frac{1}{2}mv_{com}^2 + \frac{1}{2}I_{com}\omega^2 \\ W &= \tau\Delta\theta = \int \tau d\theta \\ \sum \tau &= \frac{dL}{dt} \\ \vec{L} &= \vec{r} \times \vec{p} = I\vec{\omega} \\ L &= rmv \sin \theta = I\omega \end{aligned}$$

## Periodic Motion

$$\begin{aligned} f &= \frac{1}{T} \\ \omega &= 2\pi f = \frac{2\pi}{T} \\ \vec{a}_x &= -\frac{k}{m} \vec{x} \\ \omega &= \sqrt{\frac{k}{m}} \\ x &= A \cos(\omega t + \varphi) \\ E_{SHM} &= \frac{1}{2}kA^2 \\ \Delta E_{SHM} &= 0 \\ \omega_{simp} &= \sqrt{\frac{g}{L}} \\ \omega_{phys} &= \sqrt{\frac{mgd}{I}} \end{aligned}$$

