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Mechanics Cheat Sheet

1. Kinematics

Linear Motion (a constant):

$$v = v_0 + at$$

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

Projectiles:

$$x(t) = (v_0 \cos \theta)t$$

$$y(t) = (v_0 \sin \theta)t - \frac{1}{2}gt^2$$

2. Newton's Laws

• **1st Law:** $\sum \mathbf{F} = 0 \implies \mathbf{a} = 0$

• **2nd Law:** $\mathbf{F} = \frac{d\mathbf{p}}{dt} = m\mathbf{a}$

• **3rd Law:** $\mathbf{A}_{12} = -\mathbf{A}_{21}$

Friction: $f_s \leq \mu_s N$, $f_k = \mu_k N$

3. Work, Energy, Power

Work: $W = \int \mathbf{F} \cdot d\mathbf{r}$

Kinetic Energy: $K = \frac{1}{2}mv^2$

Potential Energy: $F_x = -\frac{dU}{dx}$

Work-Energy Theorem: $W_{\text{net}} = \Delta K$

Power: $P = \mathbf{F} \cdot \mathbf{v} = \frac{dW}{dt}$

4. Momentum Collisions

Linear Momentum: $\mathbf{p} = m\mathbf{v}$

Impulse: $\mathbf{J} = \int \mathbf{F} dt = \Delta \mathbf{p}$

Conservation: If $\sum \mathbf{F}_{\text{ext}} = 0$, then $\sum \mathbf{p} = \text{constant}$.

Elastic Collision (1D):

$$v_1' = \frac{m_1 - m_2}{m_1 + m_2}v_1 + \frac{2m_2}{m_1 + m_2}v_2$$

5. Rotational Dynamics

Linear	Rotational
x	θ
v	ω
a	α
m	I
F	τ
p	L

Torque: $\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F} = I\boldsymbol{\alpha}$

Rotational KE: $K_{\text{rot}} = \frac{1}{2}I\omega^2$

Angular Momentum: $\mathbf{L} = I\boldsymbol{\omega} = \mathbf{r} \times \mathbf{p}$

6. Gravitation

Newton's Law of Gravitation:

$$F = G \frac{m_1 m_2}{r^2}$$

Gravitational Potential Energy:

$$U = -G \frac{m_1 m_2}{r}$$

Kepler's Third Law:

$$T^2 = \left(\frac{4\pi^2}{GM} \right) r^3$$