Newtonian Mechanics is not general. Fails:

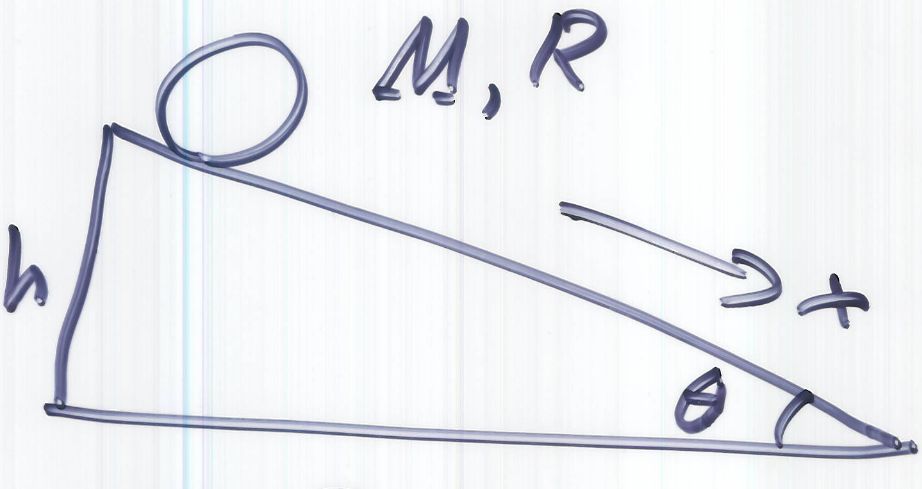
1) small dimensions
   → Quantum Mechanics

2) Speeds close to c
   → Special Relativity

3) strong gravity
   → General Relativity

Quantum Field Theory

? T.O.E.



solid cylinder

$a = ?$

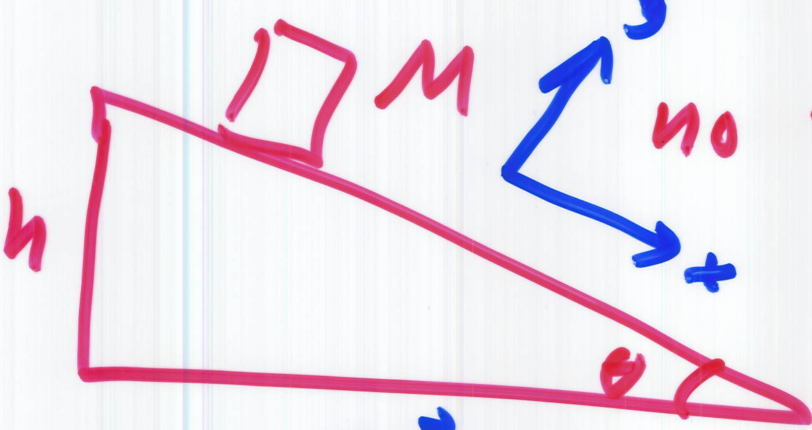
$v = ?$

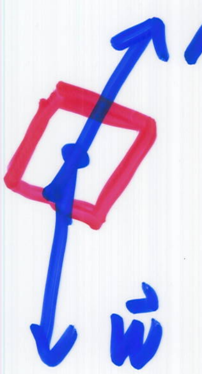
$x = ?$

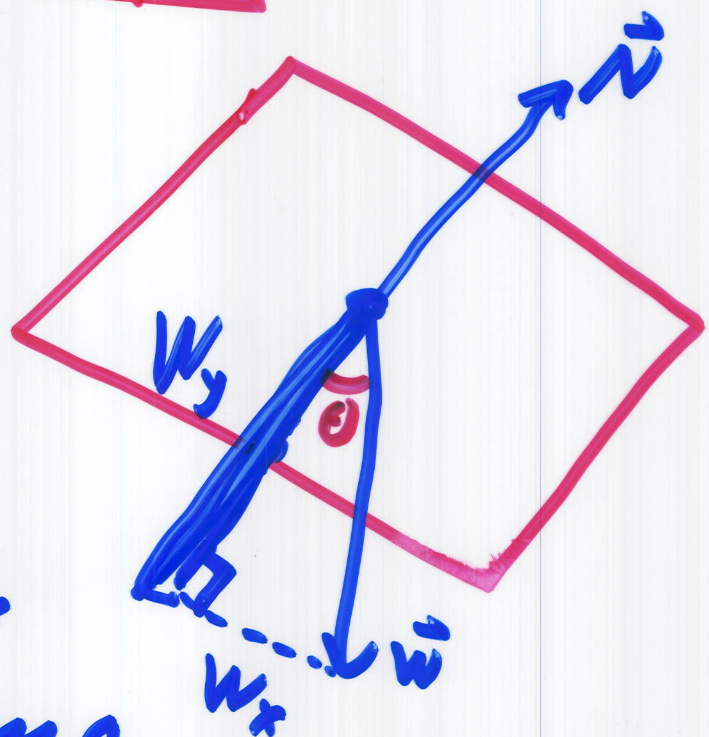
$$I_{cm} = \frac{1}{2} M R^2$$

$\Sigma \vec{F} = m\vec{a}$

no friction







$$\Sigma F_x = m a_x$$

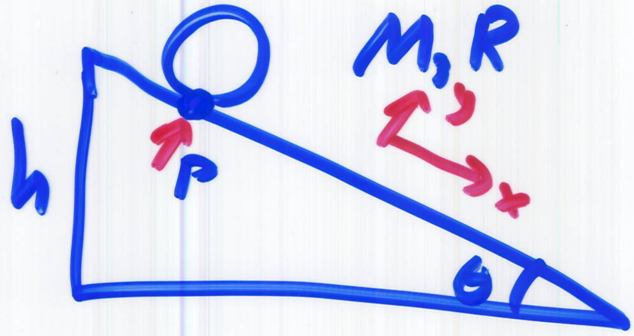
$$0 + W\sin\theta = m a_x$$

$$\cancel{m} g \sin\theta = \cancel{m} a_x \rightarrow \boxed{a_x = g\sin\theta}$$

$$\Sigma F_y = m \cancel{a_y}^{\,0}$$

$$N - W\cos\theta = 0$$

$$N = W\cos\theta = mg\cos\theta$$



$$\sum F_y = m\cancel{a_y}^{\to 0}$$

$$N - mg\cos\theta + 0 = 0$$

$$N = mg\cos\theta$$

$$\sum F_x = ma_x$$

$$0 + mg\sin\theta - f_s = ma_x$$

$$\sum \tau_? = I_? \alpha \leftarrow$$ angular acceleration

torque   moment of inertia

? axis: 1) any point that does not accelerate e.g. P

2) center of mass, even if it accelerates.

$\sum \tau_P \to$ knock out $\vec{N}, \vec{f}_s$

$\sum \tau_{cm} \to$ knock out $\vec{N}, \vec{W}$

$$\sum \tau_{cm} = I_{cm}\,\alpha \qquad \alpha = \frac{a}{R}$$

$$f_s\, R = \frac{1}{2} M R^2 \left(\frac{a_x}{R}\right)$$

$$f_s = \frac{1}{2} M a_x$$

Remember $Mg \sin\theta - f_s = M a_x$

$$\cancel{M} g \sin\theta - \frac{1}{2} \cancel{M} a_x = \cancel{M} a_x$$

$$g \sin\theta = \frac{3}{2} a_x$$

$$a_x = \frac{2}{3} g \sin\theta$$

$$v_x = \int a_x \, dt = \frac{2}{3} g \sin\theta \; t + \underset{\substack{\parallel \\ v_0}}{\text{constant}}$$

unknown

$$x = \int v_x(t)\, dt = \int \frac{2}{3} g \sin\theta \; t \; dt$$

$$= \frac{2}{6} g \sin\theta \, t^2 + v_0 t + \underbrace{\text{constant}'}_{x_0}$$

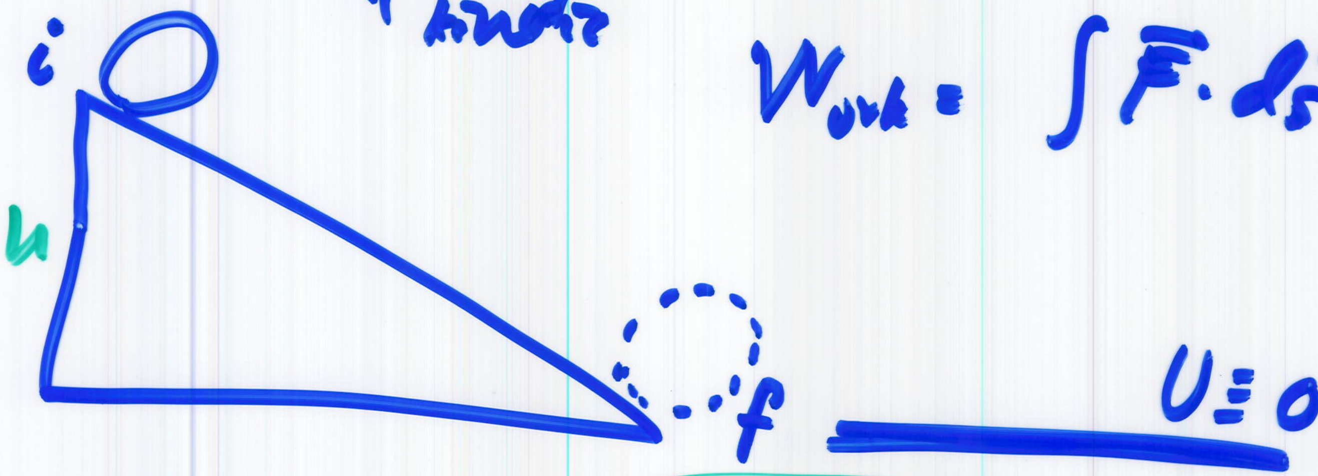
Again with Energy Conservation

total Mechanical Energy

$$E = K + U \leftarrow \text{potential}$$

$\uparrow$ kinetic

$$W_{ork} = \int \vec{F} \cdot d\vec{s}$$



$$E_i = E_f \Longrightarrow \boxed{K_i + U_i = K_f + U_f}$$

$$(K_f - K_i) + (U_f - U_i) = 0$$

$$\Delta K + \Delta U = 0$$

$$\Delta E = 0$$

$$\omega = \frac{v}{R}$$

$$0 + Mgh = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2 + 0$$

$$\cancel{M}gh = \frac{1}{2}\cancel{M}v^2 + \frac{1}{2}\left(\frac{1}{2}\cancel{M}R^2\right)\left(\frac{v}{R}\right)^2$$

$$= \frac{3}{4}\cancel{M}v^2$$

$$v = \sqrt{\frac{4gh}{3}}$$