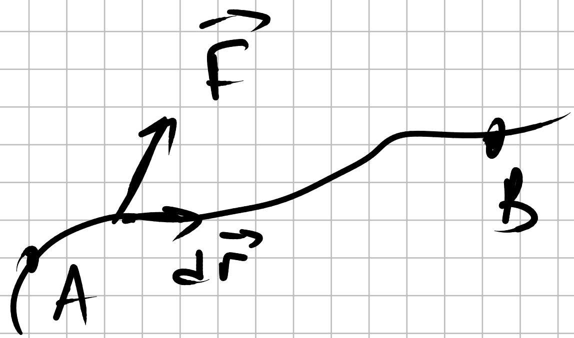


$$W = \int_A^B F(\vec{r})\, d\vec{r}$$

Work

→ units $[N \cdot m] = [J]$

Joule

Work energy theorem

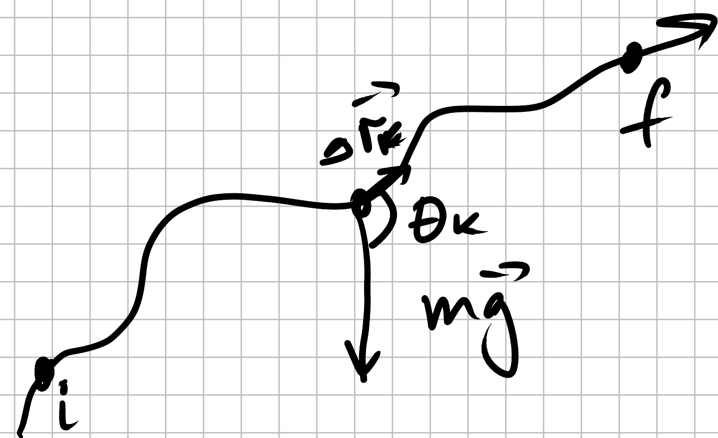
$$W_{\substack{net\\force}} = \Delta K$$

$$\boxed{K = \frac{m\vec{v}^2}{2}}$$ kinetic energy

$$\boxed{W_{\substack{net\\force}} = \frac{m v_f^2}{2} - \frac{m v_i^2}{2}}$$

Conservative force

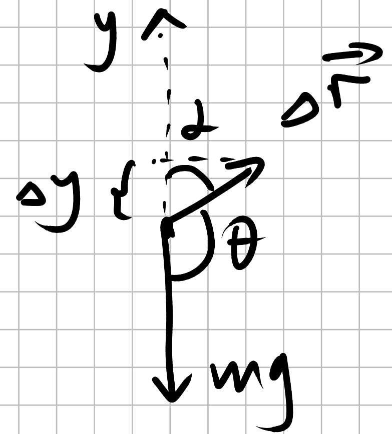
Gravity



W_g ?

$$W_g = \int_i^f \vec{F}_g \cdot d\vec{r} = \sum_k \vec{F}_{g_k} \cdot \Delta\vec{r}_k$$

$$= \sum_k |\vec{F}_g| \cdot |\Delta\vec{r}| \cdot \cos\theta_k$$



$$\Delta r \cdot \cos\alpha = \Delta y$$

$$\cos(\theta) = -\cos(\alpha)$$

$$\cos(\alpha) = \cos(180-\theta)$$
$$= -\cos(\theta)$$

$$W_g = \sum_k |\vec{F}_g| \cdot |\Delta \vec{r}_k| \cdot \cos(\theta_k) = \sum_k |F_g| (-\Delta y)_k = -|F_g| (y_f - y_i)$$
$$= -m\cdot g\,(y_f - y_i)$$

Check $\Delta\vec{r}$ ↑ points up

$$\Delta W = -mg \cdot \Delta y$$

Conservative force work

$$W_{cons} = -\left(U(\vec{r}_f) - U(\vec{r}_i)\right)$$

For gravity $\boxed{\begin{array}{c} U(\vec{r}) = m \cdot g \cdot y \\ \text{Potential energy} \end{array}}$

$$W_{net} = \Delta K$$

$$W_{\substack{non \\ conservative}} + W_{conservative} = \Delta K$$

$$W_{n.c.} + (-)\left(\underbrace{U(\vec{r}_f) - U(\vec{r}_i)}_{\Delta U}\right) = \Delta K$$

$$\boxed{W_{n.c} = \Delta U + \Delta K}$$

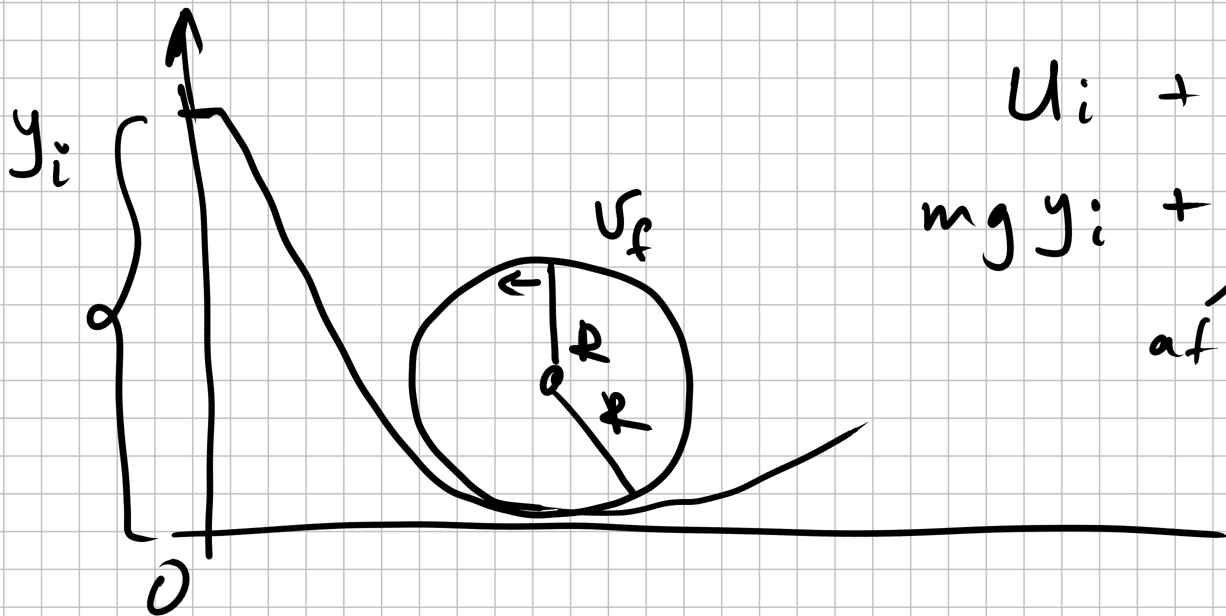
iff there no non-conservative forces

$$\boxed{0 = \Delta U + \Delta K}$$

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

$$\boxed{U_i + K_i = U_f + K_f}$$

Energy conservation



$$U_i + K_i = U_f + K_f$$

$$mg y_i + 0 = mg \cdot \underbrace{2R}_{y_f} + \frac{m v_f^2}{2}$$

at rest

$$v_f^2 = 2g(y_i - y_f)$$

Top point

$\vec{N}$ m $m\vec{g}$

$$\underset{\substack{\parallel \\ 0}}{\vec{N}} + m\vec{g} = m\vec{a} \sim m\frac{v^2}{R}$$

$$y: \quad -mg = -ma = -m\frac{v^2}{R}$$

$$\frac{v^2}{R} = g$$

$$v_f^2 = R\cancel{g} = 2\cancel{g}(\overset{\overset{2R}{\parallel}}{y_f} - y_i)$$

$$R = 2(-2R + y_i)$$

$$\boxed{y_i = 2R + \frac{R}{2} = \frac{5}{2}R}$$

$$2\,000 \ k\underbrace{\text{cal}}_{4.2\,J} = 8.4 \cdot 10^{6}\,J = 8.4\,MJ$$

$$E_{in} = \Delta U = m \cdot g \cdot \Delta h$$

$$h = \frac{E_{in}}{m \cdot g} = \frac{8.4 \cdot 10^{6}\,J}{100\,kg \cdot 10\,\frac{m}{s^2}} = 8.4 \cdot 10^{3}\,m$$

$$= 8.4\,km$$

$$\approx 5\,mi$$