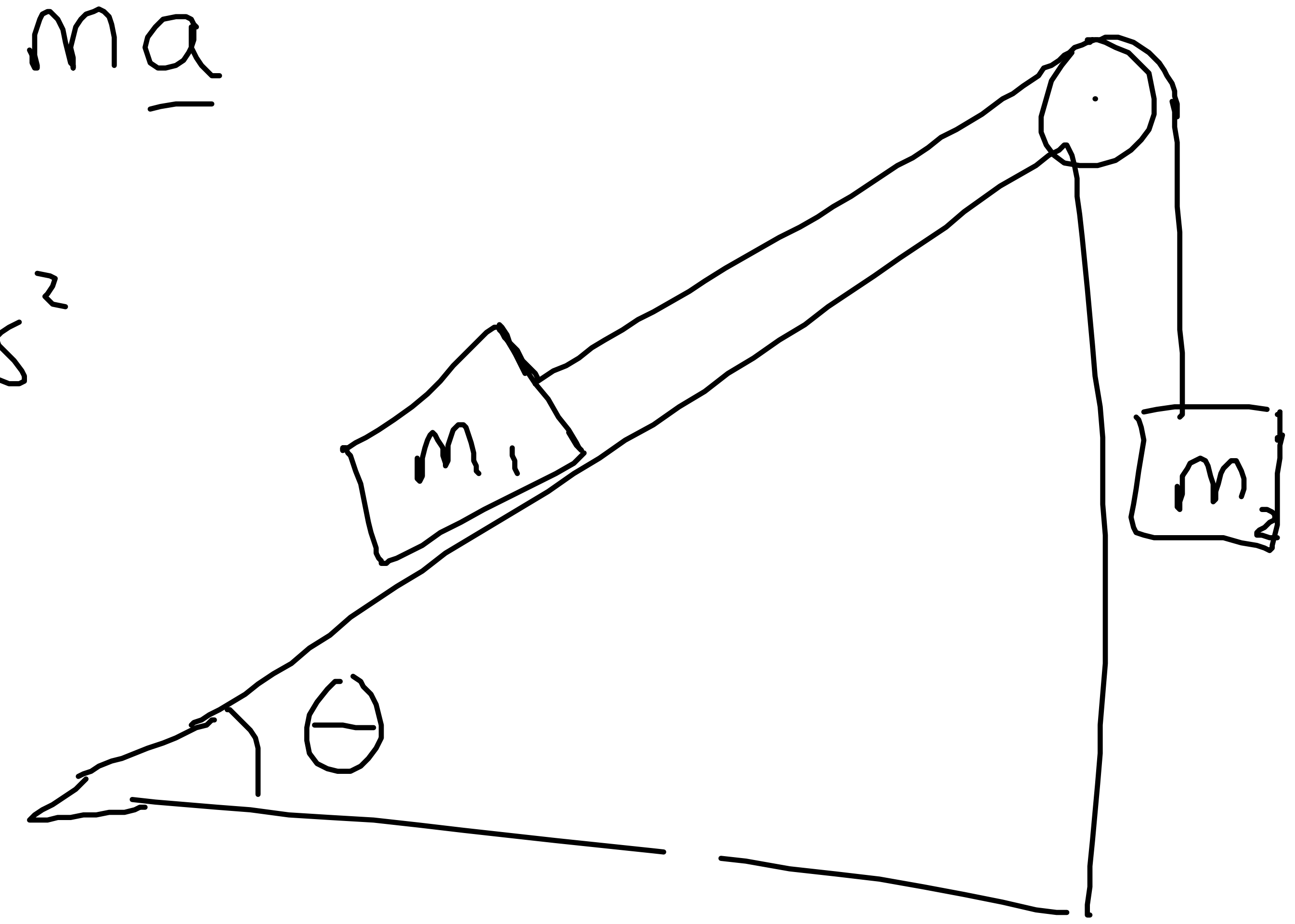
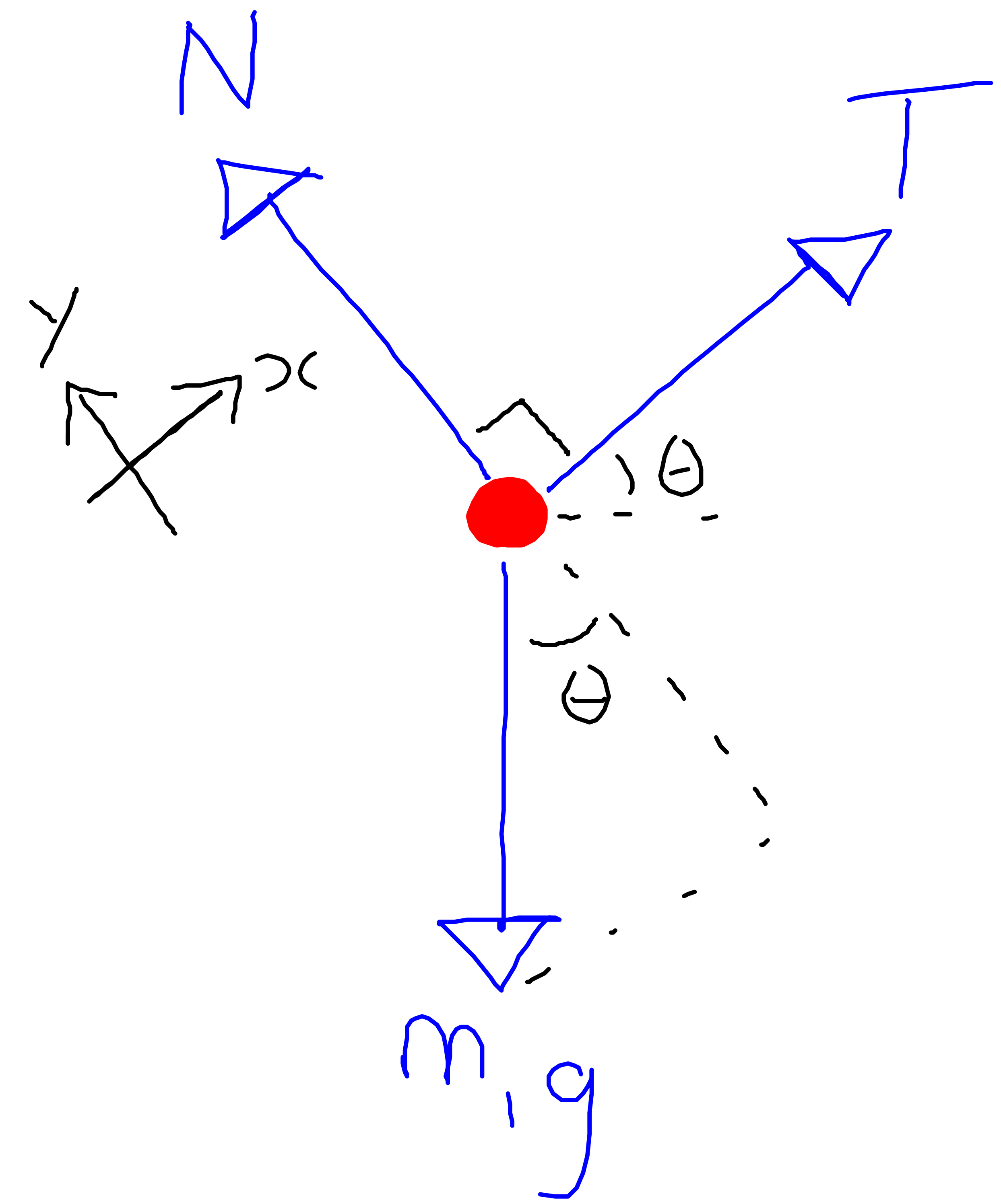
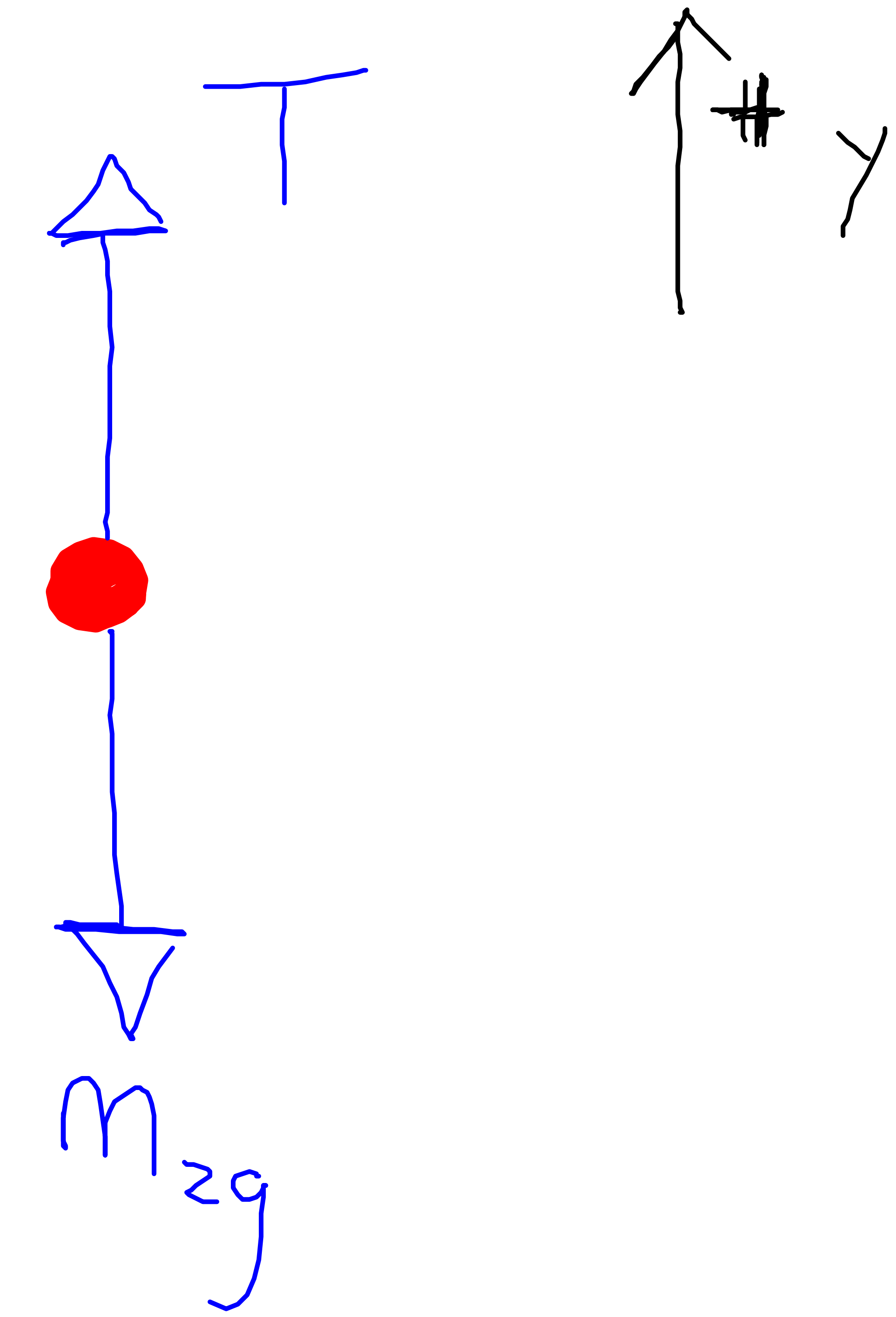
$\sum \underline{F} = m\underline{a}$

$g = 9.8\ m/s^2$







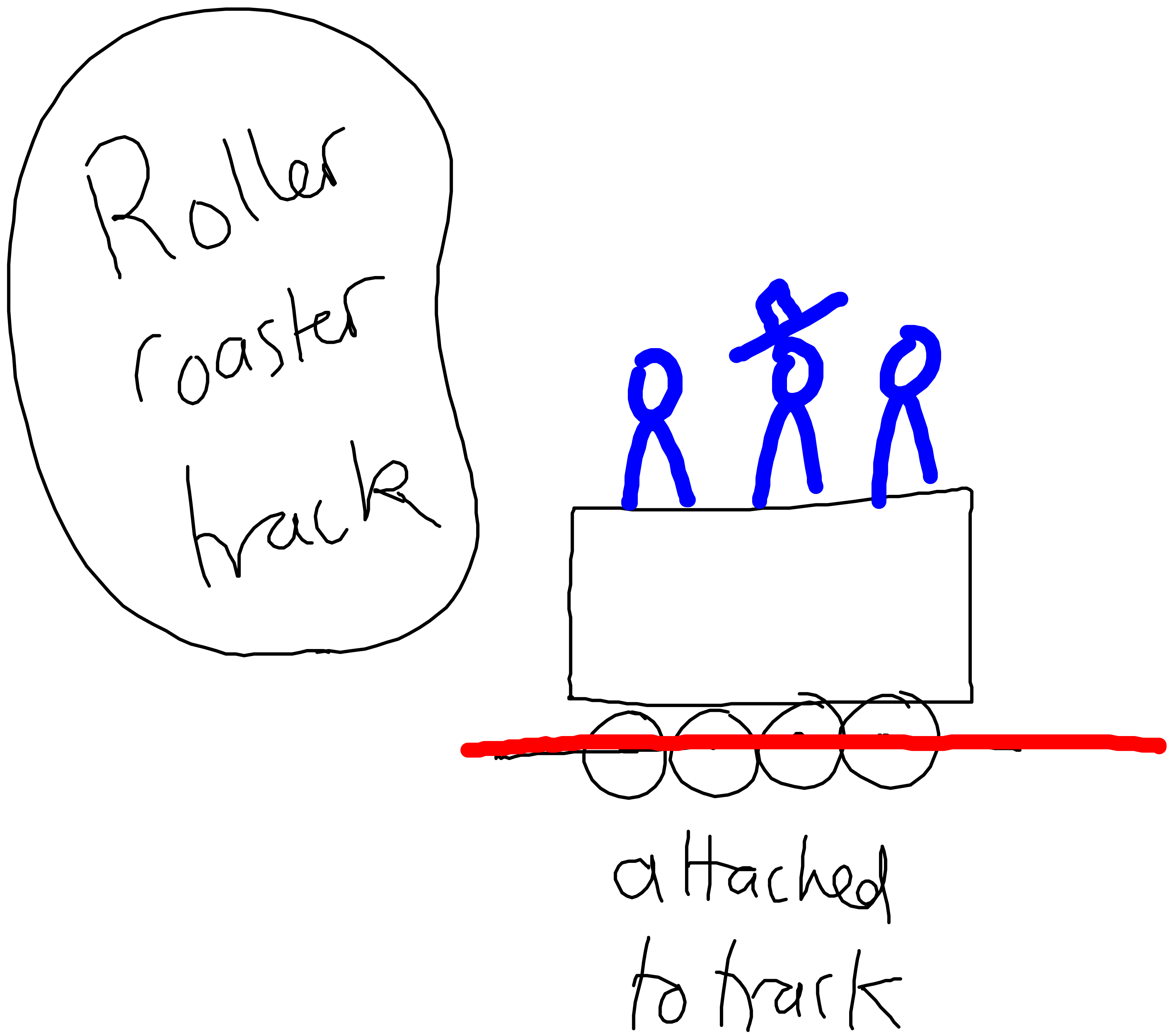
$$+T - m_1 g \sin\theta = m_1 a_{1x}$$

$$+N - m_1 g \cos\theta = m_1 a_{1y} = 0$$

$$+T - m_2 g = m_2 a_{2y}$$

$$\boxed{a_{2y} = -a_{1x}}$$

Ex know θ, M_1, M_2 find T and acceleration



Roller coaster track
attached to track

ENERGY

WORK, KINETIC, POTENTIAL

$f_K = \mu_K N$ (constant)

Kinetic energy

$$K_{object} = \frac{1}{2} m v^2 \quad \text{(scalar)}$$

$$K_{system} = \sum_{i=1}^{N} \frac{1}{2} m v_i^2 \quad (\div N \text{ gives you temperature})$$

1 dimension, constant force F_x

$$\text{Work } W = F_x \Delta x = \frac{1}{2} m v_x^2 - \frac{1}{2} m v_{0x}^2$$

$$= K_{final} - K_{initial} = \Delta K$$

3 dimensions, constant force $\underline{F}$

force

$$\underline{F} = F_x \underline{i} + F_y \underline{j} + F_z \underline{k}$$

unit vector ⊥ to board

Displacement

$$\Delta \underline{r} = \Delta x \, \underline{i} + \Delta y \, \underline{j} + \Delta z \, \underline{k}$$

$$W = F_x \Delta x + F_y \Delta y + F_z \Delta z \quad \text{(scaler)}$$

$$= \underline{F} \cdot \Delta \underline{r} \quad \text{dot product}$$

$$= F \Delta r \cos\theta$$

θ angle between $\underline{F}$ & $\Delta \underline{r}$

1 ||
2 |||
3
4
5

$$\Delta \underline{r} = \underline{r}_{final} - \underline{r}_{initial}$$

$$= 2\underline{i} + \underline{j} - (\underline{i} - 2\underline{j})$$

$$= \underline{i} + 3\underline{j}$$

$$\underline{F} = 2\underline{i} + 3\underline{j}$$

$$W = \underline{F} \cdot \Delta \underline{r} = (2)(1) + (3)(3) + (0)(0)$$

$$= 11 \text{ J} \quad (\text{Scalar})$$

W	1D	3D
Constant force F_x = number	$F_x \Delta x$	$\underline{F} \cdot \Delta \underline{r}$
Variable force $F_x(x)$	$\int_{x_1}^{x_2} F_x \, dx$	$\int_{x_1}^{x_2} F_x \, dx + \int_{y_1}^{y_2} F_y \, dy + \int_{z_1}^{z_2} F_z \, dz$

ideal spring

$$F_{net} = -ky$$

force & displ. opposite

Spring constant (stiffness)

displacement from equilibrium

+y

Equlibrium — 0

$F_{net} = 0$

a
b
c IIII
d
e

$$F_x = -kx \quad \text{ideal spring for } x \text{ motion}$$

$$W = \int_{x_1}^{x_2} F_x \, dx = \int_{x_1}^{x_2} -kx \, dx$$

$$= -k \left[\frac{x^2}{2} \right]_{x_1}^{x_2}$$

$$= -k \left(\frac{x_2^2}{2} - \frac{x_1^2}{2} \right)$$

$$= \frac{kx_1^2}{2} - \frac{kx_2^2}{2}$$

Power = rate at which work is done

$$P_{av} = \frac{\Delta W}{\Delta t}$$

Units Work $\rightarrow$ Joules (J)

Power $\rightarrow$ J/s = Watts (W)

1 hp = 745 Watts

$$P_{av} = \frac{\Delta E}{\Delta t} = \frac{\Delta K}{\Delta t} = \frac{W}{\Delta t}$$

short way

long way

$$\Delta K = \frac{1}{2} m v_f^2 - \cancel{\frac{1}{2} m v_i^2}^{\,0}$$

$$P_{av} = \frac{\frac{1}{2} m v_f^2}{\Delta t}$$

$$= \frac{F_{AV}\,\Delta x}{\Delta t}$$

assume constant acceleration

$$= m a V_{AV}$$

$$= m \left(\frac{V_f - \cancel{V_i}^{\,0}}{\Delta t}\right)\left(\frac{V_f + \cancel{V_i}^{\,0}}{2}\right)$$

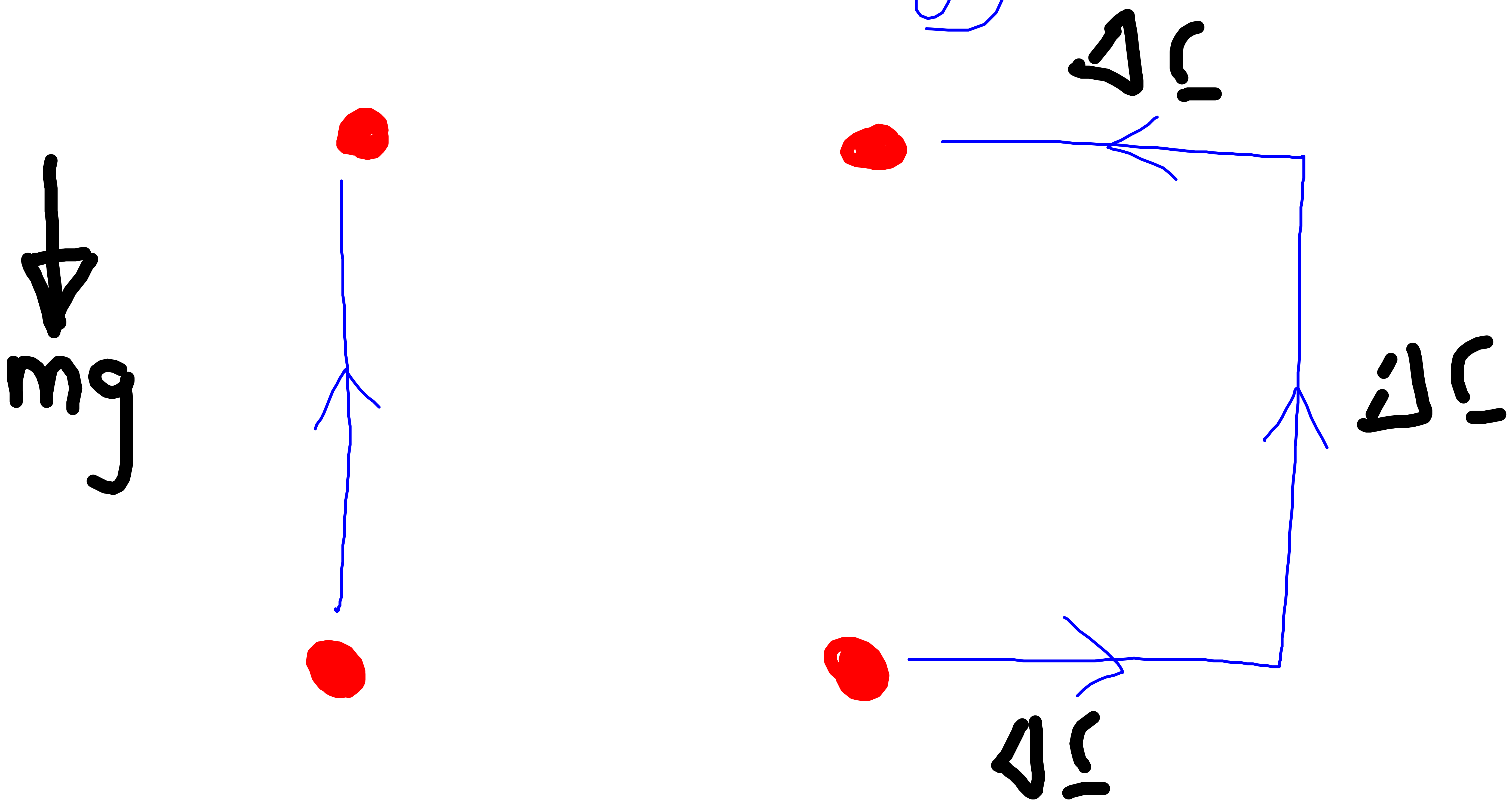
$$= \frac{1}{2} \frac{m V_f^2}{\Delta t}$$

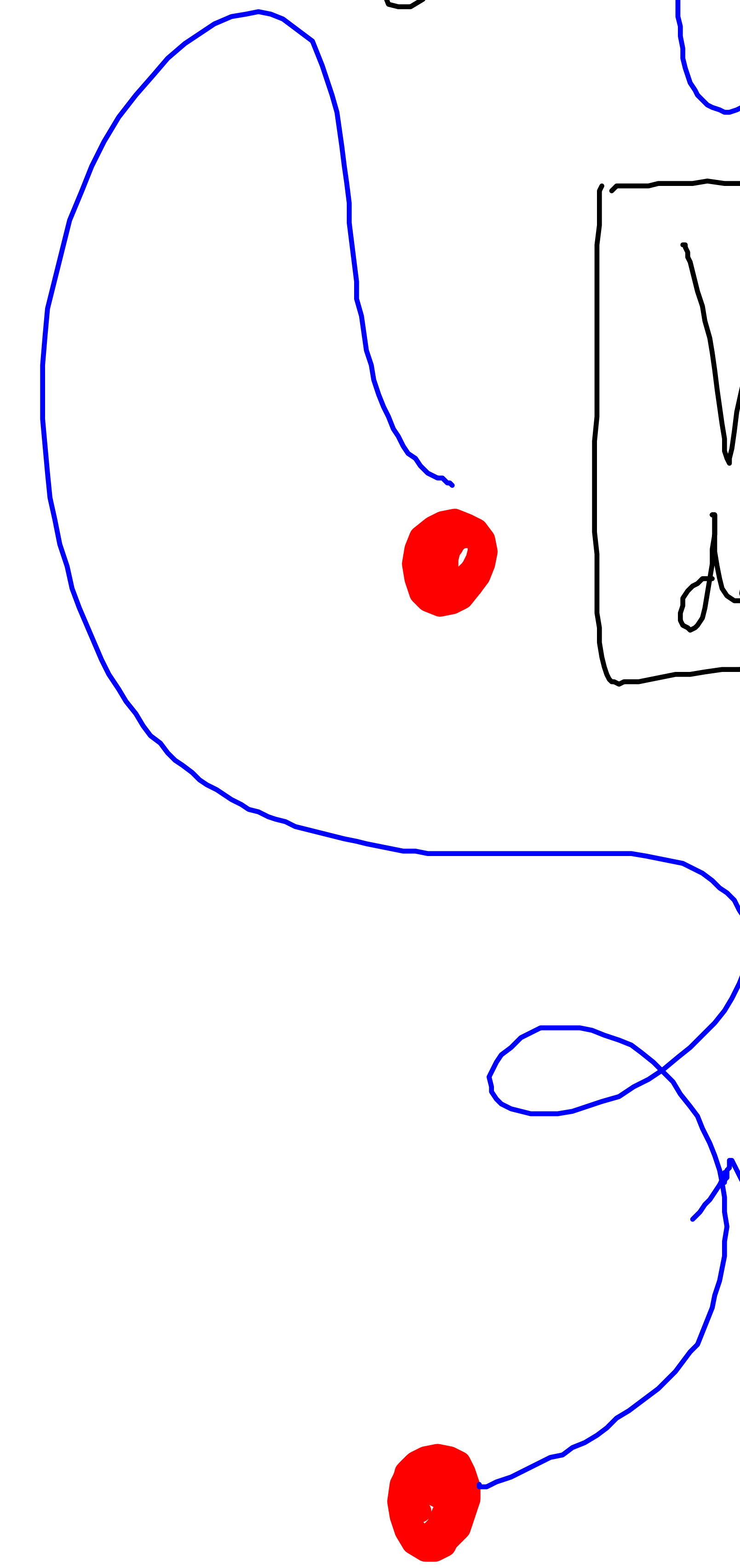
Potential Energy

$+y \uparrow$

gravity $U = mgy$

$$\boxed{\begin{array}{c} W = -\Delta U \\ \text{definition of } U \end{array}}$$





$$W = \underline{F} \cdot \Delta \underline{r}$$
$$= F \Delta r \cos\theta$$

Conservative force → work path independent
→ can define a U

Conservative forces

ideal spring

$$F = -kx$$

displacement from equilibrium

$$U = \frac{1}{2}kx^2$$

gravity

$$F = mg$$

$$U = mgy$$

$$E = \sum_i K_i + U_i$$

total mechanical energy

$$\Delta E = 0$$

"isolated"

"E conserved"

$$\boxed{W_{ext} = \Delta E = \Delta K + \Delta U}$$

$\neq 0$

work by non-conservative forces

Ex. friction

$\uparrow +y$

$$U = mgy$$

$$W = \underline{F} \cdot \Delta \underline{r}$$

$$= F \Delta r \cos\theta$$

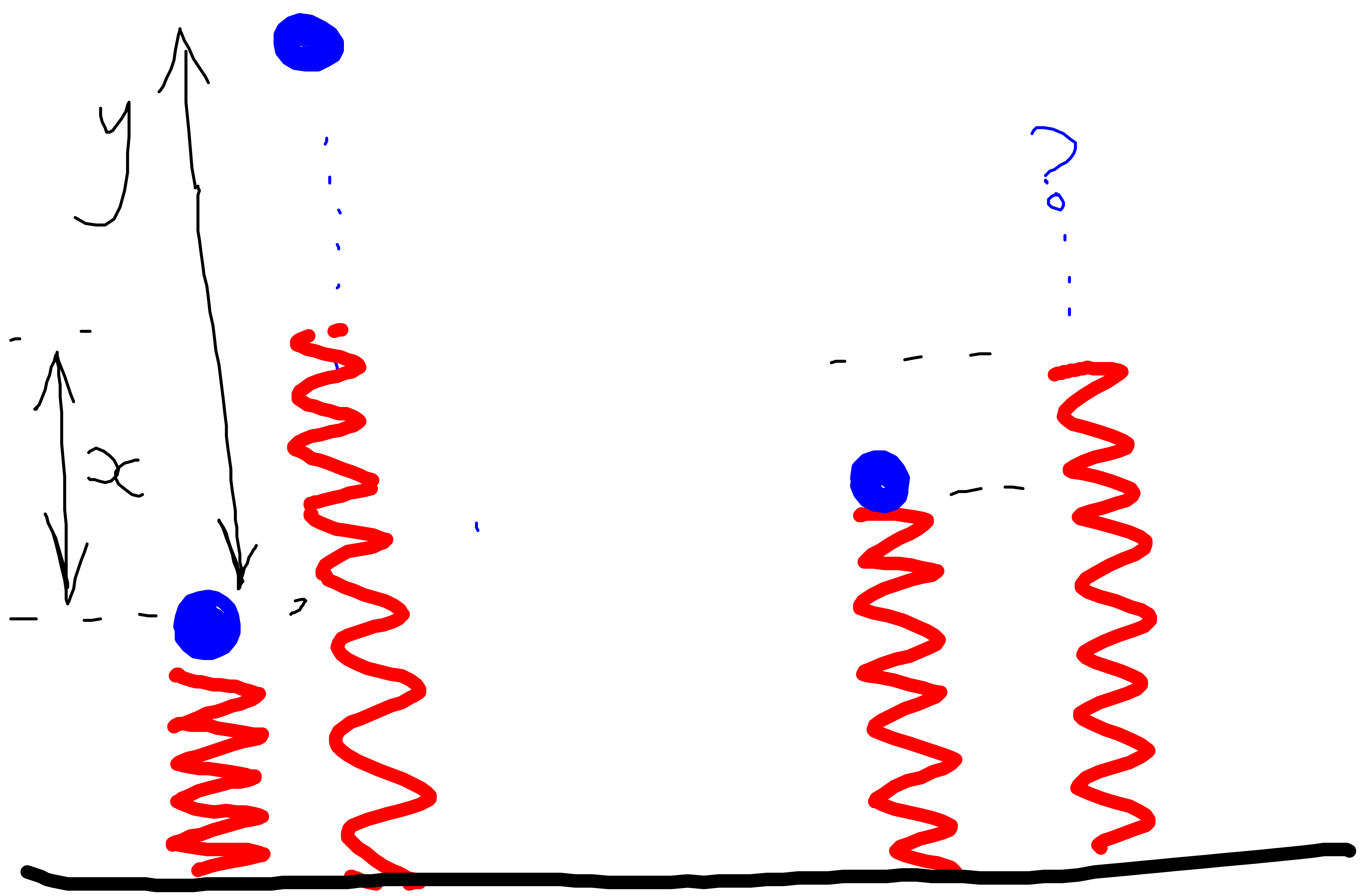
Assume $\Delta K = 0$

$$\Delta U = 5(10)(0.5 - 0) = 25$$

$$W = F \times 1 \times \cos 0 = F$$

Isolated system (dart)

$$E = \underbrace{\tfrac{1}{2}mv^2}_{\text{kinetic}} + \underbrace{\tfrac{1}{2}kx^2}_{\text{elastic } U} + \underbrace{mgy}_{\text{gravity } U}$$



$$E_{initial} = E_{final}$$

$$\tfrac{1}{2}kx^2 = mgy$$

Dark Energy

$$E_{univ} = \sum K_i + U_i + ?$$