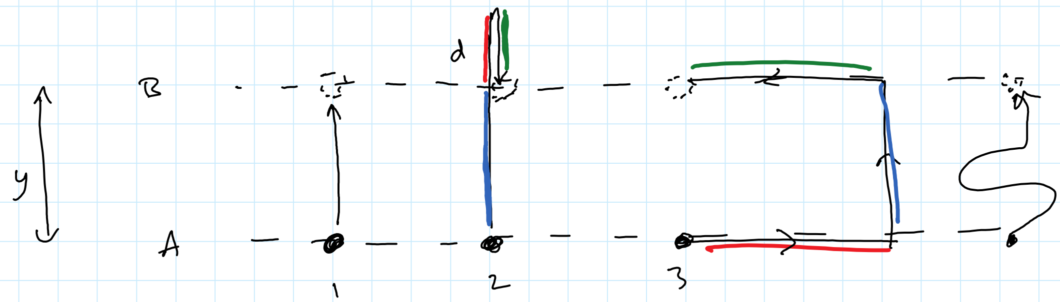
Conservative and non-conservative forces

gravity is a conservative force → the work done by gravity is the same for every path between points A and B



$$W_1 = -mgy$$

$$W_2 = W_1 + W_1 + W_1$$

$$= -mgy + \cancel{(-mgd)} + \cancel{mgd}$$

$$= -mgy$$

$$W_3 = W_1 + W_1 + W_1$$

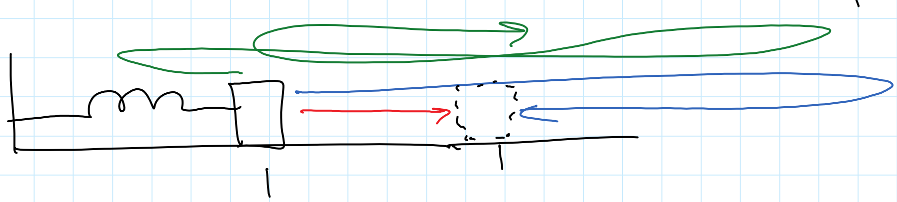
$$= 0 - mgy + 0$$

$$= -mgy$$

$$W_{A \to B} = mgy_B - mgy_A$$

$$= U_g$$

For every conservative force we encounter we come up with a potential energy



← The spring force is also a conservative force

$$W = \frac{1}{2}kx_f^2 - \frac{1}{2}kx_i^2$$

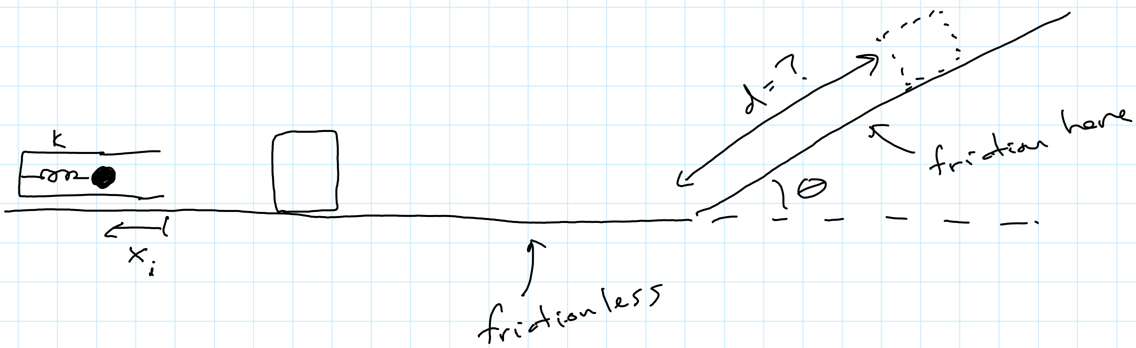
$$= U_{sp}$$

$\approx U_{sp}$

Friction is a Non-conservative force

Example Problem

A rubber ball is launched from a spring gun. It hits a block and bounces back with half of its incoming speed. How far up the incline does the block slide before coming to rest? The horizontal surface is frictionless, but there is friction on the incline surface.



given: $k = 400 \ \frac{N}{m}$

$x_i = 0.3 \ m$

$m_{RB} = 0.2 \ kg$ (rubber ball)

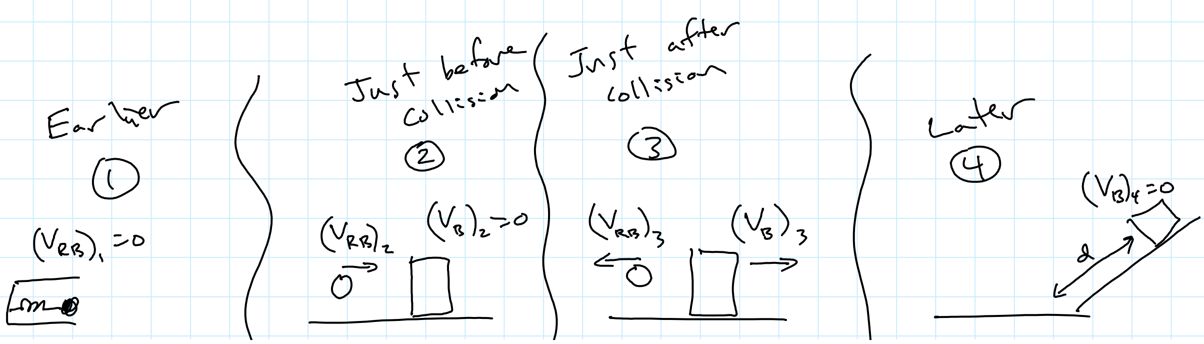
$m_B = 1.5 \ kg$ (block)

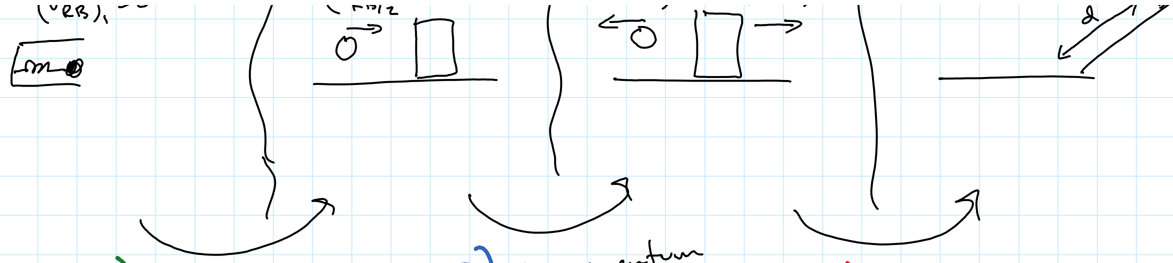
$\theta = 30^\circ$

$\mu_k = 0.15$

Make a timeline:

2 times you should always have on your timeline are the instant before the collision and the instant after the collision.





1) use energy
$E_1 = E_2$
to find
$(V_{RB})_2$

2) use momentum
$P_2 = P_3$
to find
$(V_B)_3$

3) use energy
$E_3 + W_{friction} = E_4$
to find
d

1) $E_1 = E_2$

$$(U_{sp})_1 = (K)_2$$

$$\frac{1}{2} K x_i^2 = \frac{1}{2} m_{RB} (V_{RB})_2^2$$

$$400 (0.3)^2 = (0.2)(V_{RB})_2^2$$

$$(V_{RB})_2 = 13.4 \ \frac{m}{s}$$

2) $\vec{P}_2 = \vec{P}_3 \quad \rightarrow +$

$$(\vec{P}_{RB})_2 + (\vec{P}_B)_2 = (\vec{P}_{RB})_3 + (\vec{P}_B)_3 \quad \rightarrow +$$

$$m_{RB} (\vec{V}_{RB})_2 + m_B \cancel{(\vec{V}_B)_2}^{\,0} = m_{RB} (\vec{V}_{RB})_3 + m_B (\vec{V}_B)_3 \quad \rightarrow +$$

$$(0.2)(13.4) + 0 = (0.2)\left(-\frac{13.4}{2}\right) + (1.5)(V_B)_3$$

bounces back

$$\frac{3}{2} (0.2)(13.4) = (1.5)(V_B)_3$$

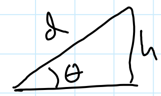
$$(V_B)_3 = 2.68 \ \frac{m}{s}$$

3) $E_3 + W_{friction} = E_4$

$$K_3 + W_{friction} = (U_g)_3$$

$$\frac{1}{2} m_B (V_B)_3^2 - \mu_k N d = m_B g h$$

$$\frac{1}{2} m_B (V_B)_3^2 - \mu_k N d = m_B g h$$



$$N = m_B g \cos\theta \qquad h = d \sin\theta$$

$$\frac{1}{2} \cancel{m_B} (V_B)_3^2 - \mu_k \cancel{m_B} g \cos\theta \; d = \cancel{m_B} g \, d \, \sin\theta$$

$$\frac{1}{2} (2.68)^2 - (0.15)(9.8)(\cos 30^\circ) d = (9.8)(\sin 30^\circ) d$$

$$3.59 = (4.9 + 1.27) d$$

$$3.59 = 6.17 d$$

$$d = 0.582 \text{ m}$$