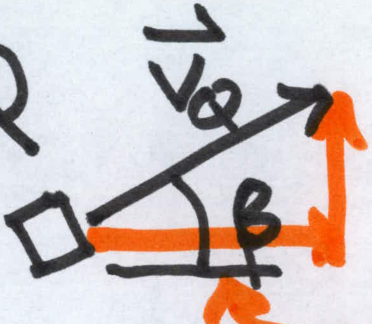
\# $P: E_P = mgh + 0$

$Q: E_Q = 0 + \frac{1}{2}mV_Q^2 \Rightarrow V_Q = \sqrt{2gh}$

$R: E_R = mgh_R + \frac{1}{2}mV_R^2 \quad V_R = V_Q \cos\beta$

@Q



@R:

gravity only acts vertically!

$\underbrace{E_P}_{} = E_R$

$mgh = mgh_R + \frac{1}{2}mV_R^2$

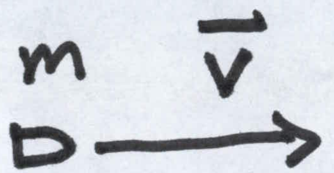
$\underbrace{\frac{1}{2}mV_Q^2}_{mgh!!}(\cos^2\beta)$

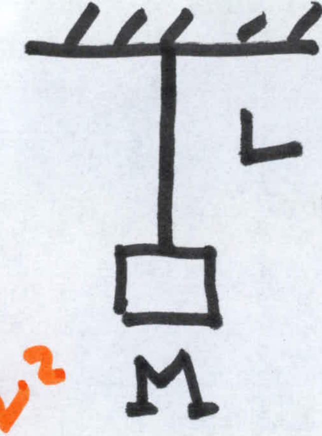
$mgh = mgh_R + mgh\cos^2\beta$

$$\cancel{m}\cancel{g}h_R = \cancel{m}\cancel{g}h - \cancel{m}\cancel{g}h \cos^2\beta$$

$$h_R = h(1 - \cos^2\beta) \qquad h_R < h$$

$$h_R = h \sin^2\beta \qquad (\text{if } \beta < 90^\circ)$$





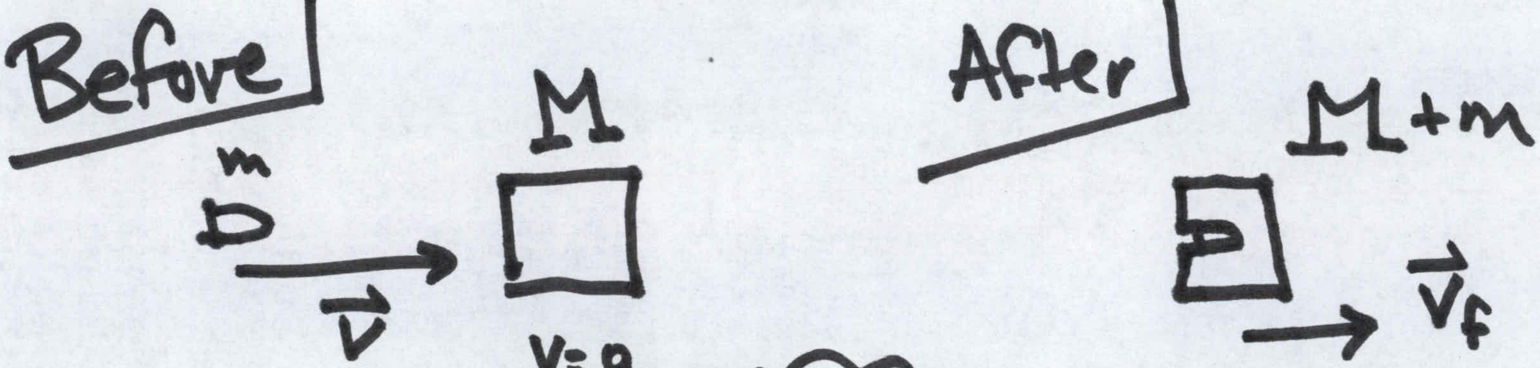
bullet lodges in the block.

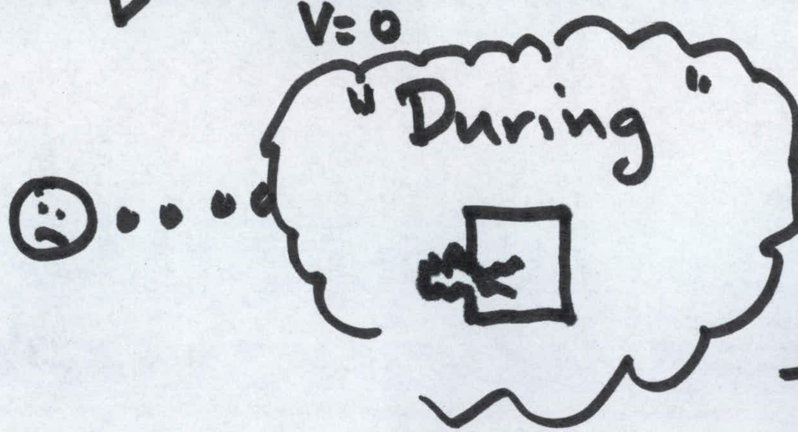
Kinetic Energy - Scalar $\frac{1}{2}mv^2$

momentum — vector $m\vec{v}$

① momentum is conserved
② energy is conserved
} always true (but)

$\frac{dE_s}{dt}$ = flow of energy into $\mathcal{S}$





conservation laws mean: only need to think about before + after.

Collision is Inelastic: "they don't bounce"

if $M \gg m$ $|\vec{v}_f| \approx 0$ | if $M \ll m$ $|\vec{v}_f| \approx |\vec{v}|$

$\vec{v}_f \approx \vec{v}$

"Kinetic energy is ~~lost~~ converted to other forms"

$\vec{P}_{before} = m\vec{v} + \vec{0} \qquad \vec{P}_{after} = (M+m)\vec{v}_f$

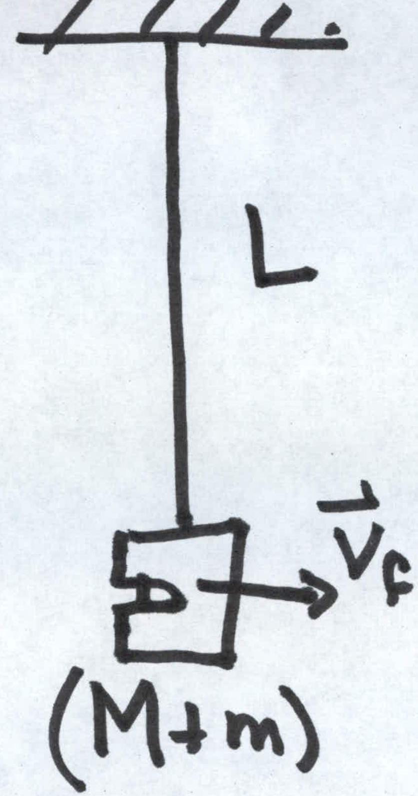
$$m\vec{v} = (M+m)\vec{v}_f$$

$$\vec{v}_f = \frac{m}{M+m}\vec{v}$$

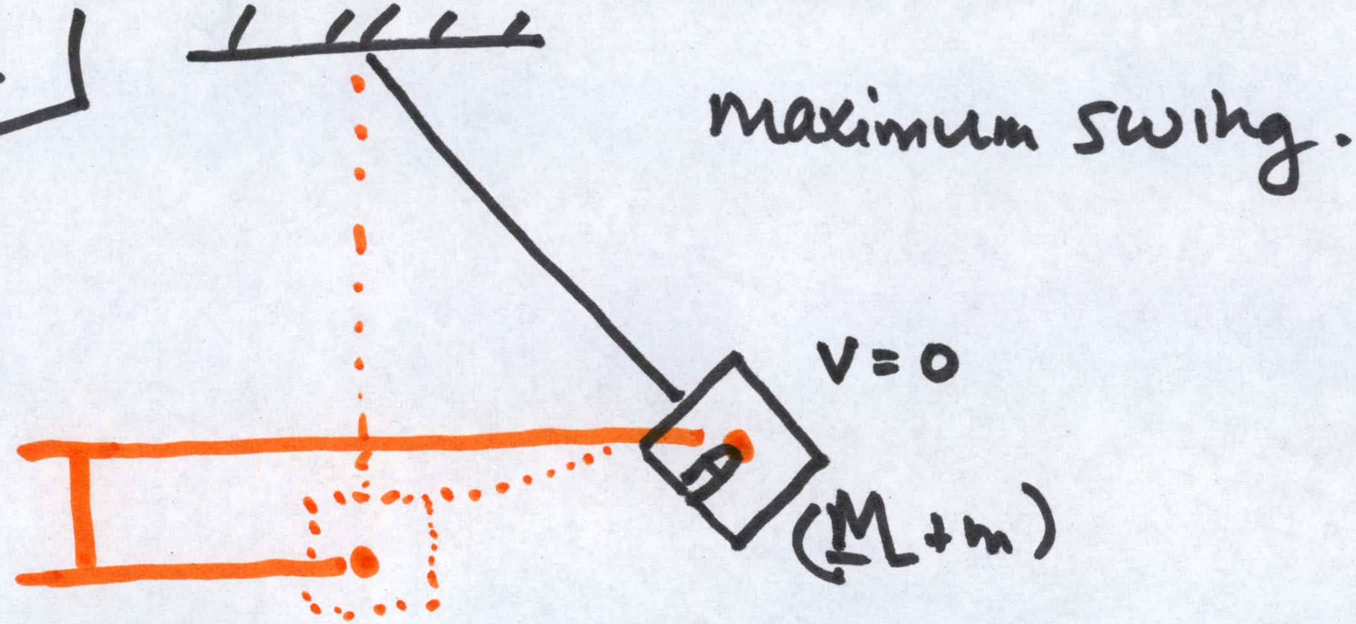
check @ $M \ll m$, $M \gg m$

Bullets lodge in blocks <u>fast</u>,
<u>Pendula</u> swing <u>slowly</u>.

momentum conservation is
useful for fast impacts



...Later



$$E_{max} = mg\Delta h = E_{bottom} = E_{after} = \frac{1}{2}(M+m)v_f^2$$

in 1860: measure Δh, compute v_f, infer/compute $\vec{v}$