Example

- electric scooter battery: $120 W \cdot h$ of energy
- 60% loss (friction, etc.)
- total weight = 890 N
- what altitude change is possible?

Aside

$$(\$120/hr) \cdot hr = \$120$$

$$(120 W) \cdot hr = (120 \tfrac{J}{s}) \cdot (3600 s)$$

$$= 432{,}000 J$$

Total energy = 432,000 J

useable energy = (432,000 J)(0.4) = 172,800 J

↓

convert to PE_g

$$172{,}800 = (mg)h$$

$$172{,}800 = (890)h \Rightarrow \boxed{h = 194.16 m}$$

Example

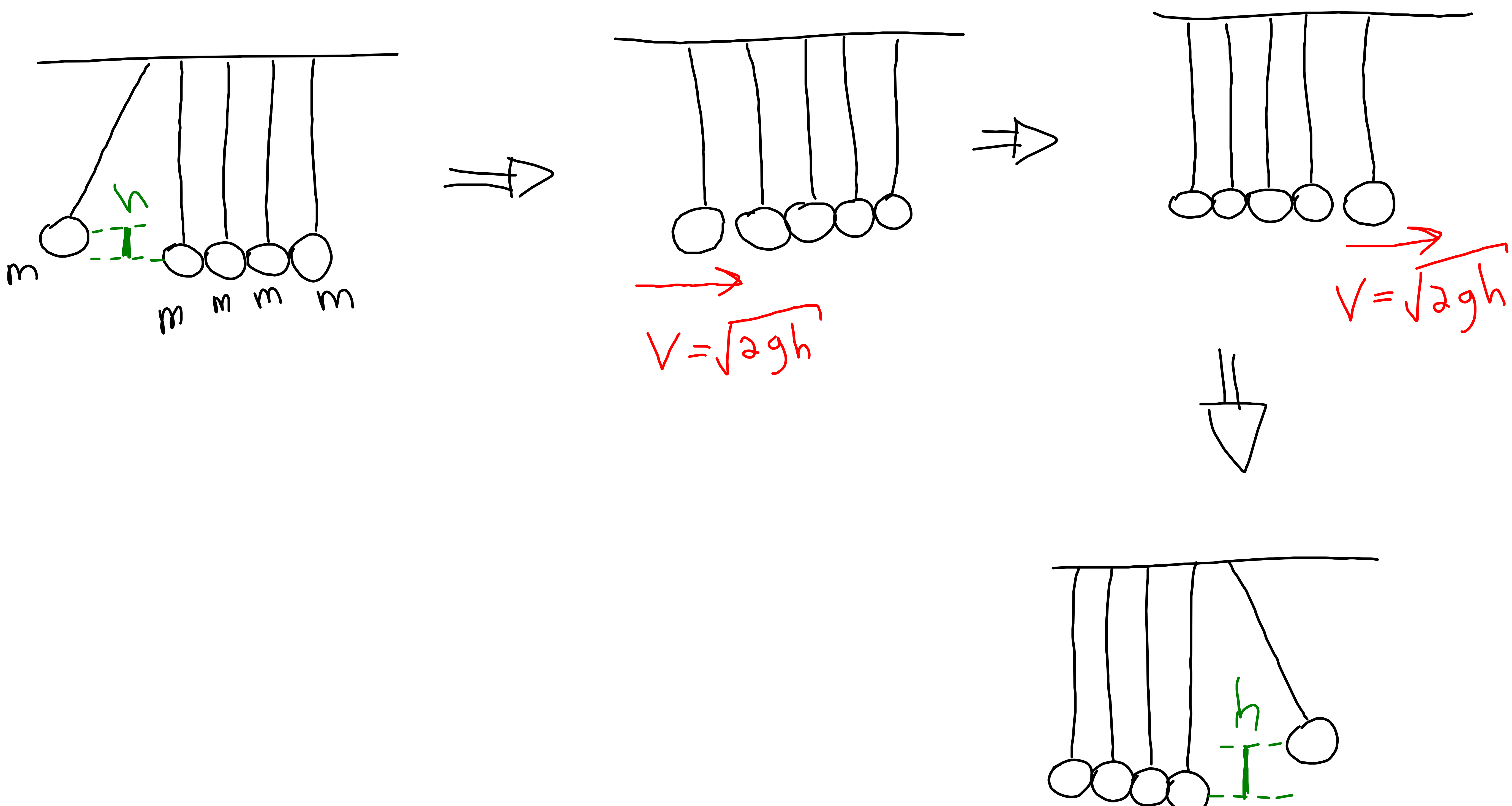
Consider the following situation just before a head-on collision. What is the total energy involved in the collision?

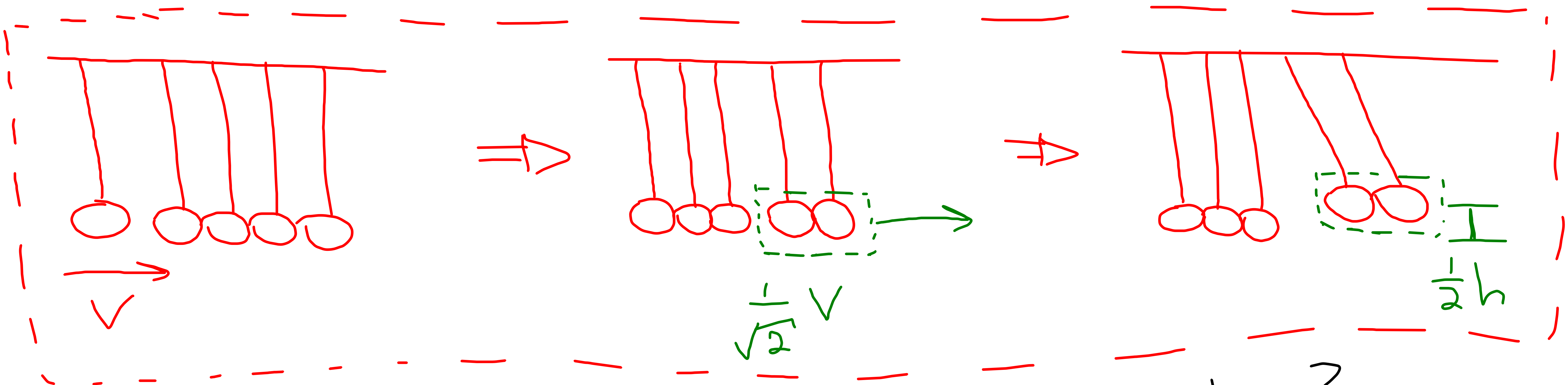
$$E_{total} = \frac{1}{2}(500)(30)^2 + \frac{1}{2}(400)(20)^2 = \boxed{305{,}000\,J}$$

* Energy is a scalar → add, don't subtract!

Momentum

Newton's cradle:





$\hookrightarrow$ This does not happen! Why?

- Energy conservation allows it.

<u>Answer</u>: there is another conservation law that doesn't allow it.

$\longrightarrow$ <u>momentum</u> conservation

It can be shown using Newton's laws (see textbook) that the sum of the products

$m_j \vec{V}_j$ for an isolated system is conserved.

("j" is a summation index)

i.e. $$\left(\sum_j m_j \vec{V}_j \right)_{\text{initial}} = \left(\sum_j m_j \vec{V}_j \right)_{\text{final}}$$

We define the product $m\vec{V}$ to be $\vec{P}$ ("momentum").

$$\boxed{\text{momentum: } \vec{P} = m\vec{V}}$$

units: $\frac{kg \cdot m}{s}$

(no abreviation)

- Vector
- conserved

Example

An object has $KE = 275\,J$ and $p = 25\,\frac{kg\cdot m}{s}$.

Find M and V of the object.

$$\frac{1}{2} M V^2 = 275 \longrightarrow \frac{1}{2}(M V) V = 275$$

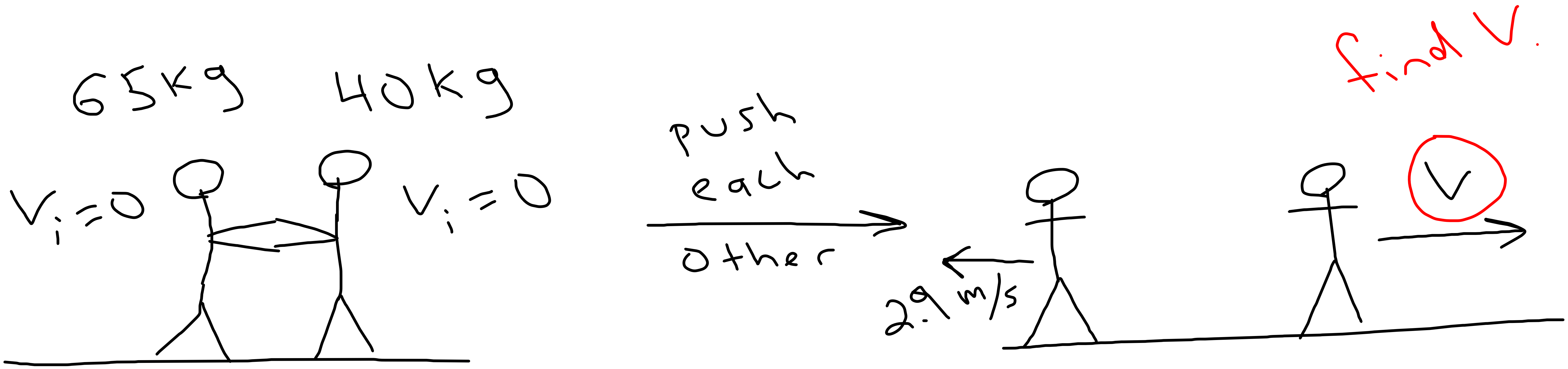
$$M V = 25$$

$$\frac{1}{2}(25) V = 275$$

$$\boxed{V = 22\ m/s}$$

$$\boxed{M = \frac{25}{22} = 1.14\ kg}$$

Example



frictionless

$$P_i = 0$$

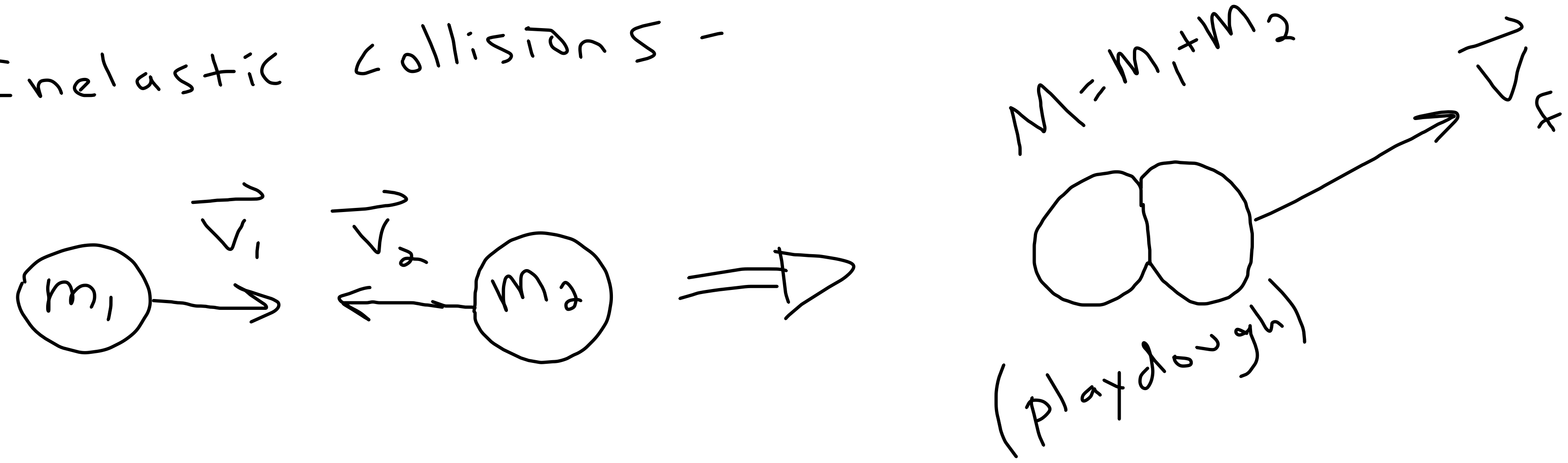
$$P_f = (65)(-2.9) + (40)V = 0$$

$$\Longrightarrow \boxed{V = 4.71 \frac{m}{s}}$$

Collisions

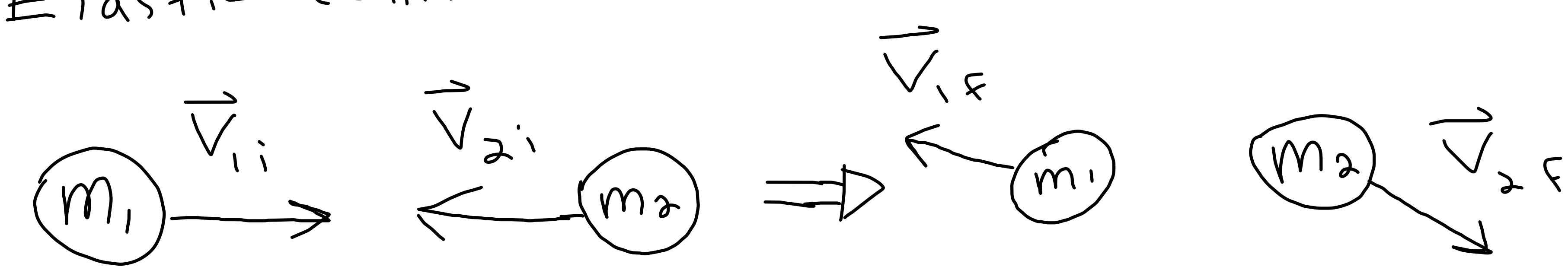
Definitions:

- Inelastic collisions -



due to the deformation of materials, energy is <u>not</u> conserved.

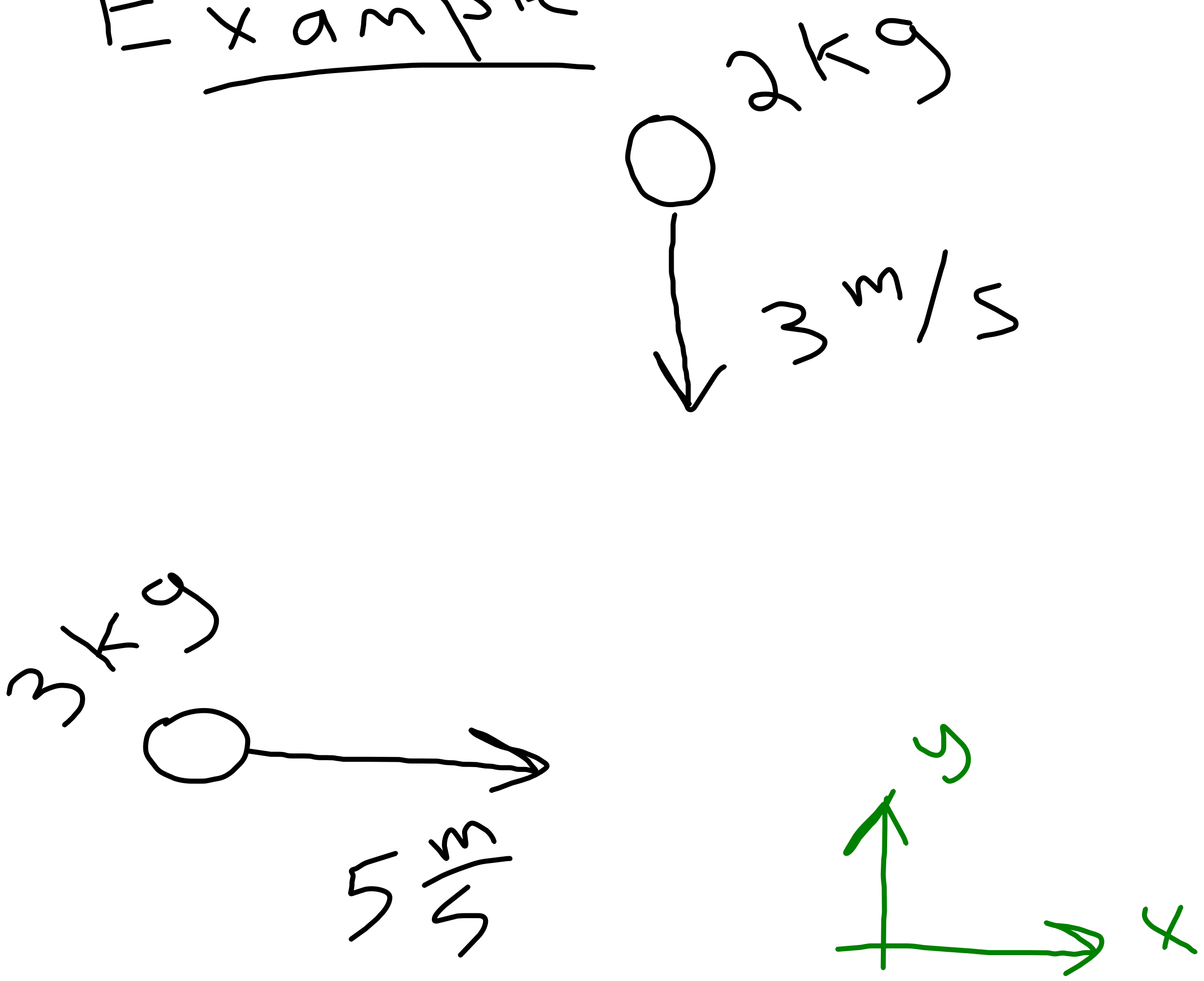
- Elastic collisions



no deformation of materials.

<u>Both</u> energy and momentum are conserved.

Example



the two objects collide and stick together.

find $\vec{V}_f$.

$$\boxed{\vec{V}_f = (3, -1.2)\ \frac{m}{s}}$$