L'ÉNERGIE

CONSERVATION D'ÉNERGIE MÉCANIQUE ET APPLICATIONS

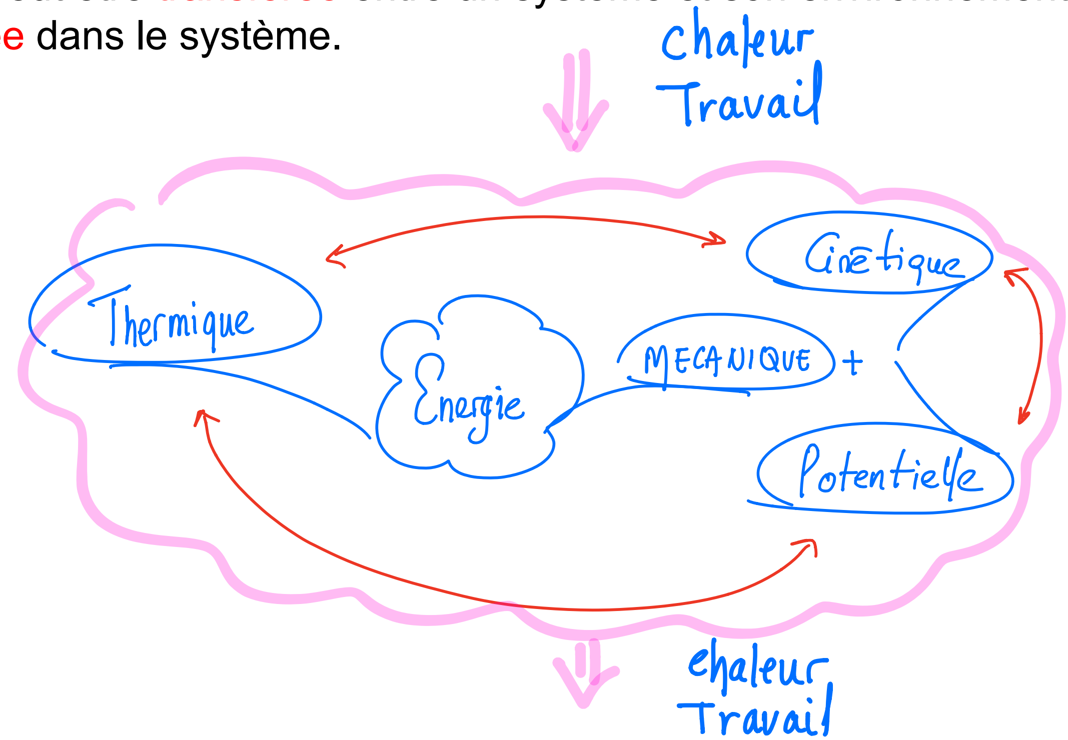
PGC-05



L'ÉNERGIE

Une mesure de l'état d'un système.

L'énergie peut être transferée entre un système et son environnement, ou transformée dans le système.



ÉNERGIE MÉCANIQUE ET SA CONSERVATION

$$E_{MEC} = E_C + E_P$$

$$W = \Delta E_C$$

$$W_{EXT} = \Delta E_M = \Delta E_C + \Delta E_P = E_M^f - E_M^i$$

$$W_{EXT} = 0 \Rightarrow \Delta E_M = 0 \Rightarrow \boxed{E_M^f = E_M^i}$$

CONSERVATION D' ÉNERGIE MÉCANIQUE

$W_{F_w} = \Delta E_c$

$E_M^i = E_c + E_p$

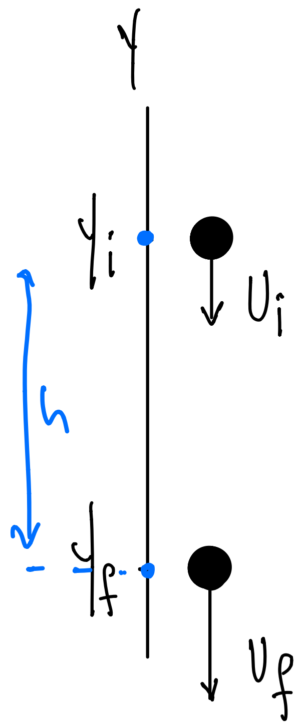
E_M^f

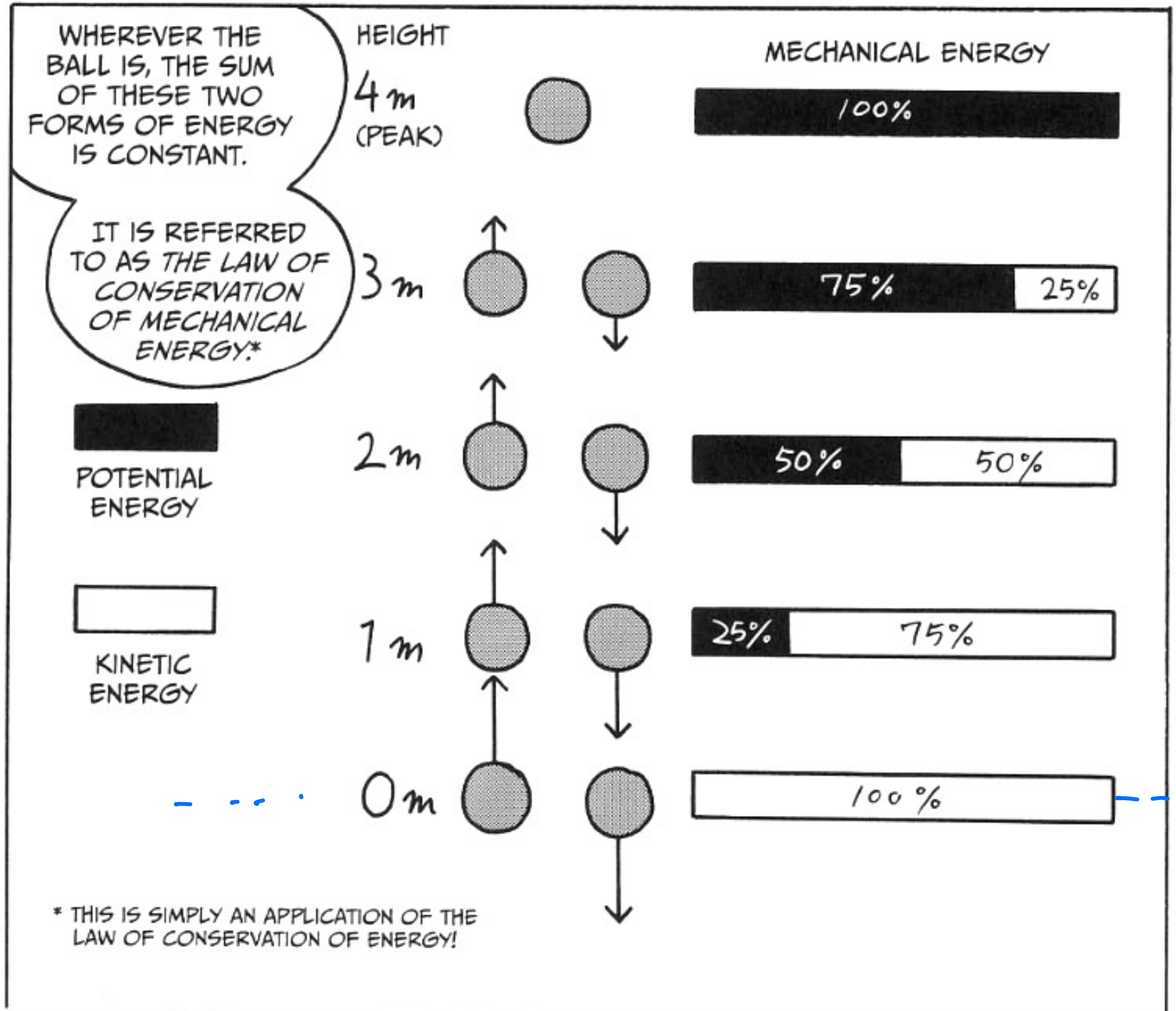
MRUA

E_c, E_p

$h = 0 \quad E_c, E_p$

$E_M^i = E_M^f$

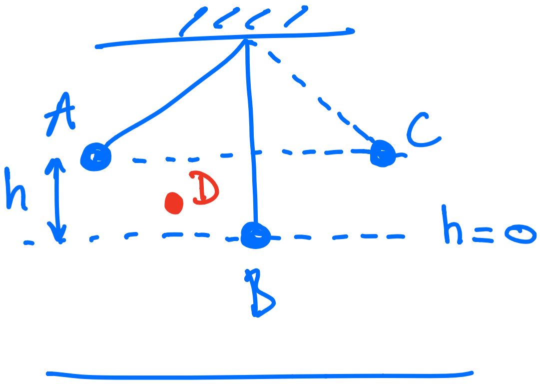



WHEREVER THE BALL IS, THE SUM OF THESE TWO FORMS OF ENERGY IS CONSTANT.
IT IS REFERRED TO AS THE LAW OF CONSERVATION OF MECHANICAL ENERGY.*
HEIGHT
MECHANICAL ENERGY
4 m (PEAK)
100%
3 m
75%
25%
2 m
50%
50%
1 m
25%
75%
0 m
100%
POTENTIAL ENERGY
KINETIC ENERGY
* THIS IS SIMPLY AN APPLICATION OF THE LAW OF CONSERVATION OF ENERGY!

h

h=0

APPLICATIONS – PENDULE



$$E_M^A = E_p = mgh$$

$$E_M^B = E_c = \frac{1}{2} m v_{max}^2$$

$$E_M^C = E_p = mgh$$

$$E_M^D = E_p^D + E_c^D = mgh_D + \frac{1}{2} m v_D^2$$

<demonstation en classe!>

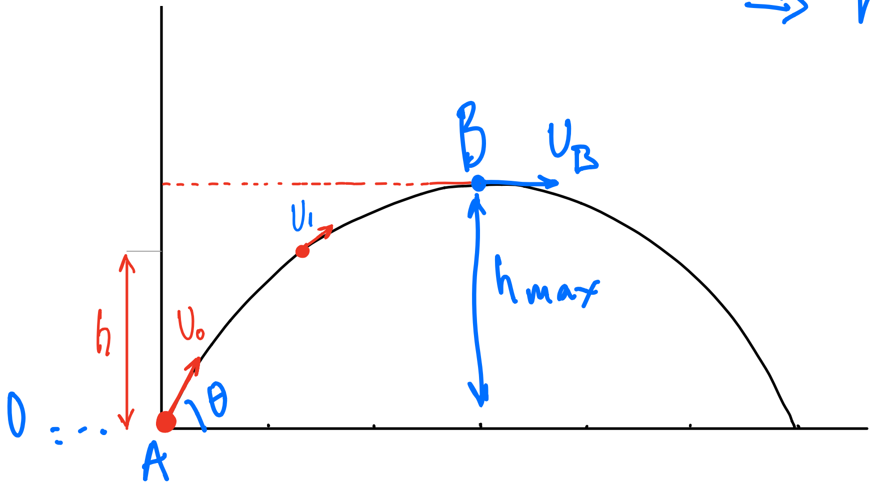
APPLICATIONS – MOUVEMENT BALISTIQUE

$$E_M^A = E_M^B$$

$$\frac{1}{2}\cancel{m}v_0^2 = \cancel{m}g h_{max} + \frac{1}{2}\cancel{m}v_B^2$$

$$\Rightarrow h_{max} = \frac{1}{2g}\left(v_0^2 - v_B^2\right)$$

(MRUA)



QUESTION

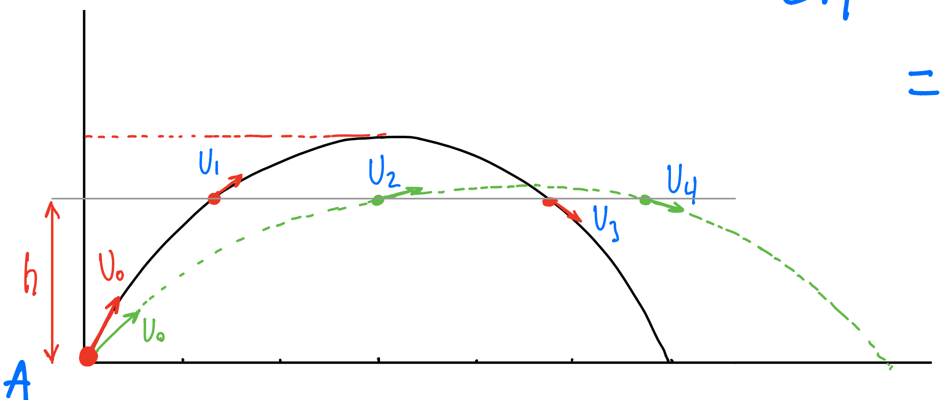
$E_M^A = \frac{1}{2} m v_0^2$

$E_M^A = \frac{1}{2} m v_0^2$

$E_M^h = E_c^h + E_p^h$

$= E_c^h + mgh$

$\Downarrow$



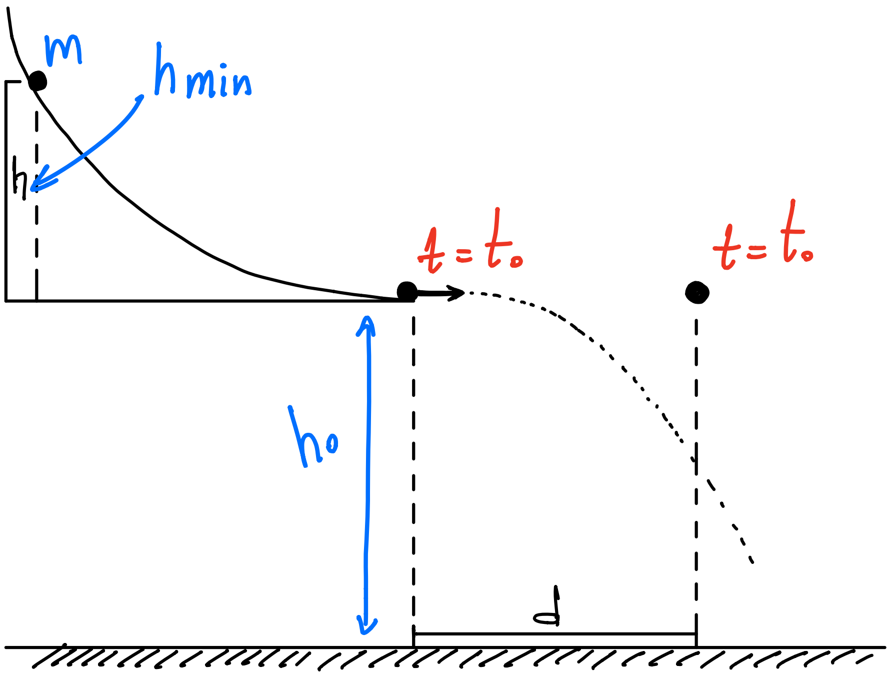
$v_1 > v_2 \quad v_3 > v_4$ (a)

$v_1 = v_3 > v_2 = v_4$ (b)

$v_1 = v_2 = v_3 = v_4$ (c)

APPLICATIONS – MOUVEMENT BALISTIQUE

Calculer @ maison:
Quelle est l'hauteur min h_{min} pour que les deux balles entrent en collision?
On connait:
h_0, d, m



<voir démonstration en classe!>

COLLISIONS

ET LA CONSERVATION DE LA QUANTITÉ DE MOUVEMENT

PGC-05

LA QUANTITÉ DE MOUVEMENT

$\vec{F} = \dfrac{d\vec{P}}{dt}$ $\qquad$ $\vec{F}_m = \dfrac{\Delta\vec{P}}{\Delta t}$ $\qquad$ $(\vec{P} = m\vec{v})$

$\Delta\vec{P}$ $\qquad$ $\vec{F}$

$\checkmark$

pas $\vec{P}$

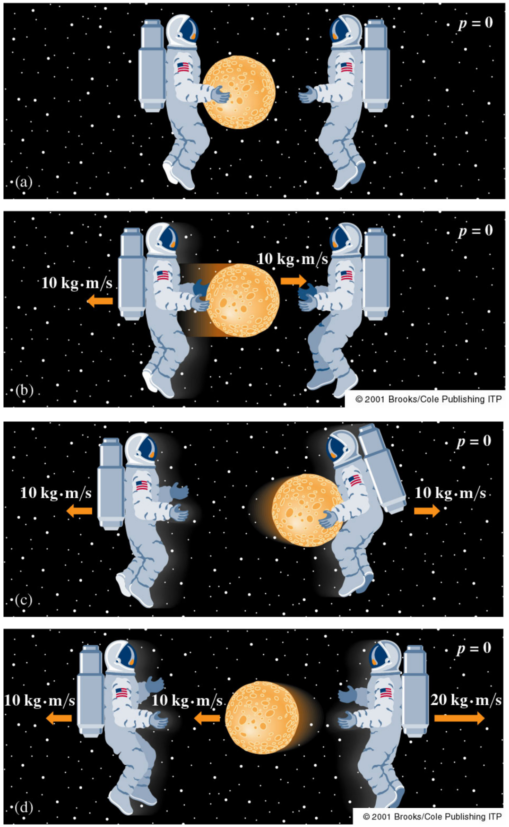
Si $\vec{F}_m = 0 \Rightarrow \Delta\vec{P} = 0 \Rightarrow \vec{P}_i = \vec{P}_f$

CONVERVATION DE LA QUANTITÉ DE MOUVEMENT

$$F_{m\to M} = -F_{M\to m} \Rightarrow M\cdot\frac{d\vec{v}}{dt} = -m\cdot\frac{d\vec{u}}{dt}$$

$$\Rightarrow \frac{d}{dt}\left(M\vec{v} + m\vec{u}\right) = 0 \Rightarrow \underline{M\vec{v} + m\vec{u} = \text{const}}$$

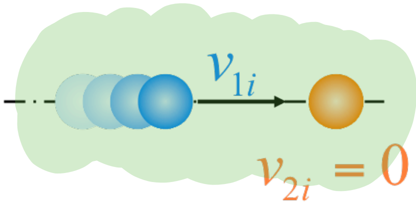
$$\vec{P}_i = \vec{P}_f \Rightarrow \underbrace{m_1\vec{v}_1^{\,i} + m_2\vec{v}_2^{\,i} = m_1\vec{v}_1^{\,f} + m_2\vec{v}_2^{\,f}}$$

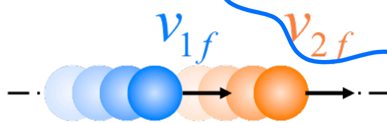


COLLISIONS ÉLASTIQUES EN 1-D

(*) Faire calul à la maison!

$$p_i = p_f$$
$$E_{Mi} = E_{Mf}$$





$$p_i = m_1 v_1^i + m_2 \cancel{v_2^i} \rightarrow 0$$

$$E_M^i = \frac{1}{2} m_1 {v_1^i}^2 + \cancel{\frac{1}{2} m_2 {v_2^i}^2} \rightarrow 0$$

$$p_f = m_1 v_1^f + m_2 v_2^f$$

$$E_M^f = \frac{1}{2} m_1 {v_1^f}^2 + \frac{1}{2} m_2 {v_2^f}^2$$

$$\left.\begin{array}{l} (1)\quad m_1 v_1^i = m_1 v_1^f + m_2 v_2^f \\ (2)\quad \frac{1}{2} m_1 {v_1^i}^2 = \frac{1}{2} m_1 {v_1^f}^2 + \frac{1}{2} m_2 {v_2^f}^2 \end{array}\right\} \overset{(*)}{\Rightarrow} \left\{\begin{array}{l} v_1^f = \dfrac{m_1 - m_2}{m_1 + m_2} v_1^i \\ v_2^f = \dfrac{2 m_1}{m_1 + m_2} v_1^i \end{array}\right.$$

COLLISIONS ÉLASTIQUES EN 1-D

<voir demonstrations en classe!>

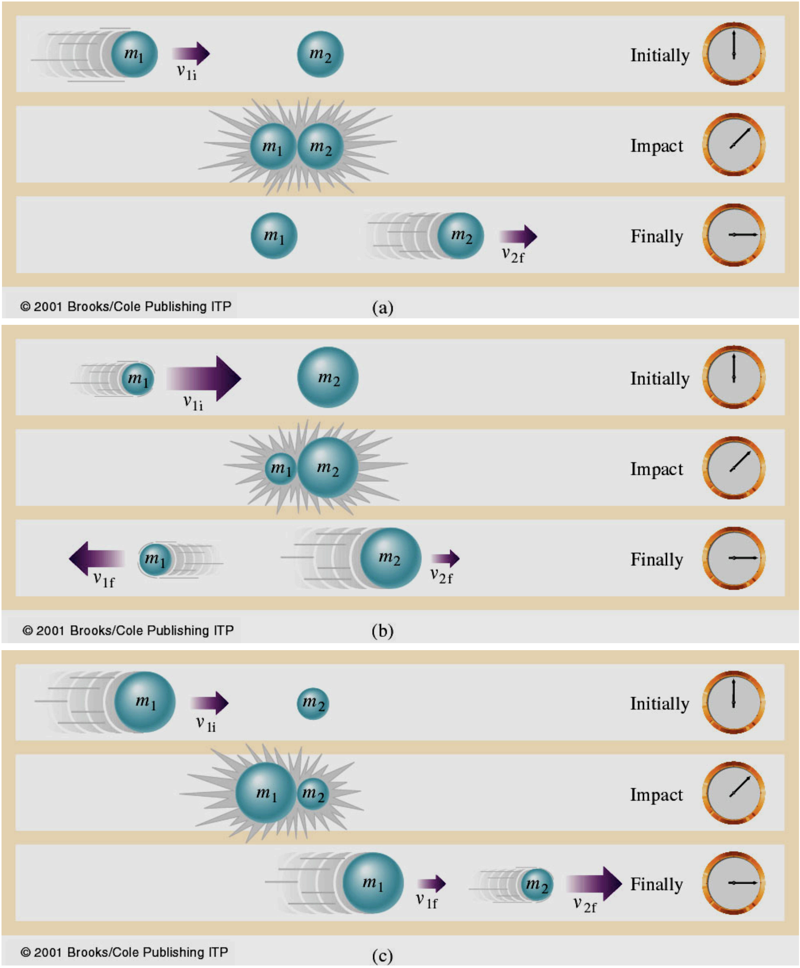
$$v_1^f = \frac{m_1 - m_2}{m_1 + m_2} v_1^i$$

$$v_2^f = \frac{2m_1}{m_1 + m_2} v_1^i$$

a) $m_1 = m_2$

b) $m_1 > m_2$ $\quad m_1 - m_2 > 0$

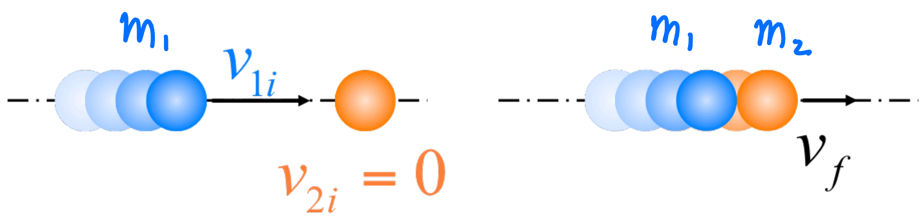
c) $m_1 < m_2$ $\quad m_1 - m_2 < 0$



COLLISIONS INÉLASTIQUES EN 1-D

$E_M^i \neq E_M^f$

$p^i = p^f$



$p_i = m_1 \cdot v_1 i$

$p_f = (m_1 + m_2) v_f$

$m_1 v_1^i = (m_1 + m_2) v_f \Rightarrow \boxed{v_f = \frac{m_1}{m_1 + m_2} v_1^i}$

$E_{cf} = \frac{m_1}{m_1 + m_2} E_{ci}$

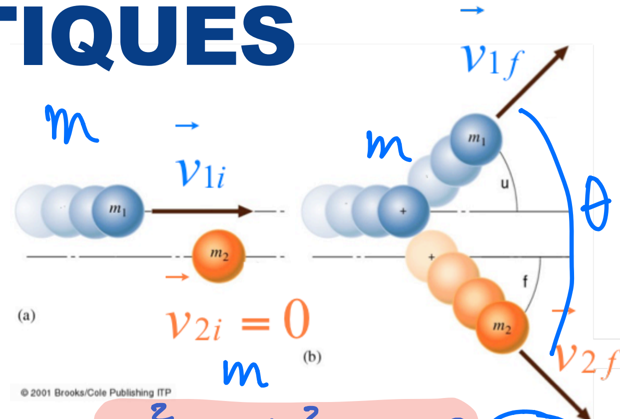
COLLISIONS ÉLASTIQUES EN 2-D

$$E_M^{i} = E_M^{f} \quad (1)$$

$$P_{ix} = P_{fx} \quad (2)$$

$$P_{iy} = P_{fy} \quad (3)$$

$$\vec{P}_i = \vec{P}_f$$



$$(1) \Rightarrow \cancel{\tfrac{1}{2}}\cancel{m}\, v_{1i}^2 = \cancel{\tfrac{1}{2}}\cancel{m}\, v_{1f}^2 + \cancel{\tfrac{1}{2}}\cancel{m}\, v_{2f}^2 \Rightarrow v_{1i}^2 = v_{1f}^2 + v_{2f}^2 \quad (\mathrm{I})$$

$$m\vec{v}_{1i} = m\vec{v}_{1f} + m\vec{v}_{2f} \Rightarrow \vec{v}_{1i} = \vec{v}_{1f} + \vec{v}_{2f} \Rightarrow$$

$$\Rightarrow |\vec{v}_{1i}|^2 = |\vec{v}_{1f}|^2 + |\vec{v}_{2f}|^2 + \underbrace{2|\vec{v}_{1f}||\vec{v}_{2f}| \cdot \cos\theta}_{0} \quad (\mathrm{II})$$

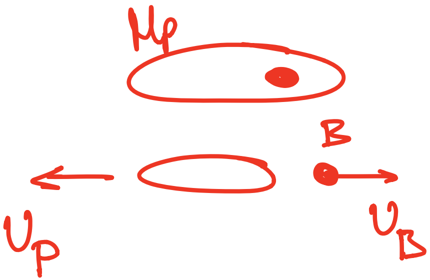
$v_{1f} = 0 \rightsquigarrow$ collision frontale

$v_{2f} = 0 \rightsquigarrow$ pas de collision

$\cos\theta = 0 \rightsquigarrow \theta = 90°$

EXEMPLE

Une balle de masse m = 8.0 g est tirée horizontalement avec une vitesse v = 352.0 m/s avec un pistolet Luger de 0.90 kg au repos. Quelle est la vitesse de recul? Négligez l’effet de l’échappement des gaz.



$$P_i = P_f$$

$$0 = M_p \cdot V_p - m_B \cdot V_B$$

$$\Rightarrow V_p = \frac{m_B \cdot V_B}{M_p}$$

FUSÉE

P_1 : $0 = (M-m)V_1 - mu \Rightarrow$

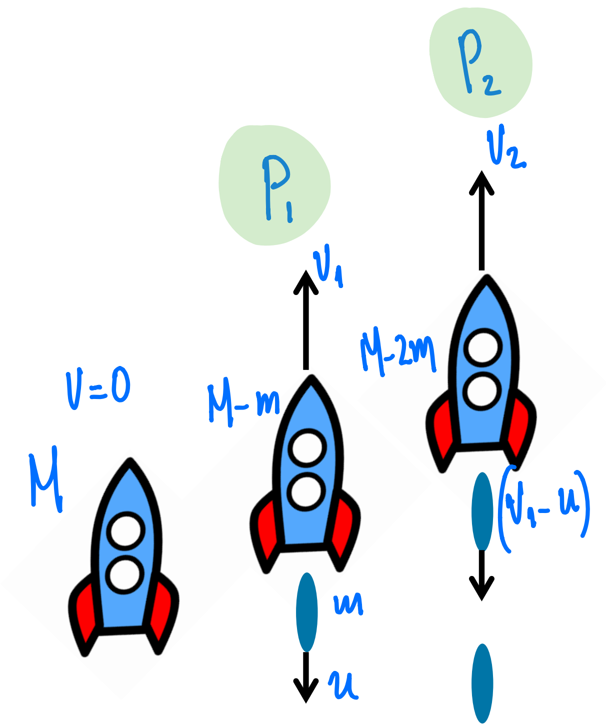
$$V_1 = mu/(M-m)$$

P_2 : $(M-m)V_1 = (M-2m)V_2 - m(V_1 - u)$

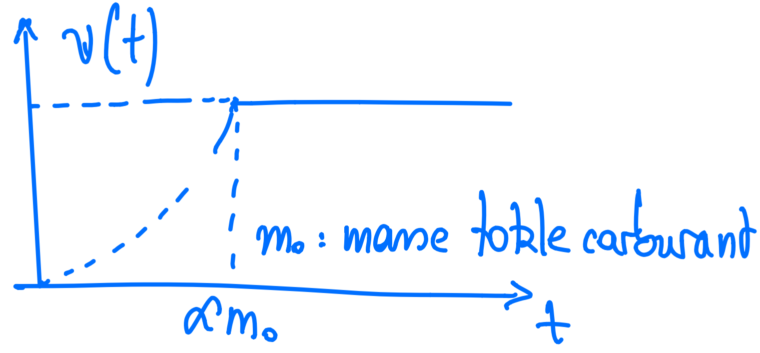
$$\Rightarrow V_2 = V_1 + mu/(M-2m)$$

$$\Rightarrow V_2 = mu/(M-m) + mu/(M-2m)$$

$$\Rightarrow V_2 = mu\left[1/(M-m) + 1/(M-2m)\right]$$



Pour flux continu :



FUSÉE SUR FIL

Une fusée peut être remplie d’air comprimé ou d’un mélange d’eau et d’air comprimé. Dans quel cas s’envole-t-elle le plus loin ?

⟨voir demonstation en classe!⟩