LOIS DE NEWTON

≃ réf. galilées

① Dans un réf inertiel, $\vec{a} = \vec{0}$, $\frac{d\vec{v}}{dt} = \dot{\vec{v}} = \vec{0}$
mouvement rectiligne uniforme ou immobile.

② $\vec{F} = m\vec{a}$ → nous dit à quel point on doit "faire d'effort" pour accélérer le système

forces mécaniques $[F] = \text{newton}$

$$= L \cdot M \cdot T^{-2}$$

$$= \frac{L \cdot M}{T^2} = \frac{m \cdot kg}{s^2}$$

③ A tt act°, il y a une réact° opposée et égale

$$\text{Système 1} \xrightarrow[\vec{F}_{1\to 2}]{} \text{Système 2}$$

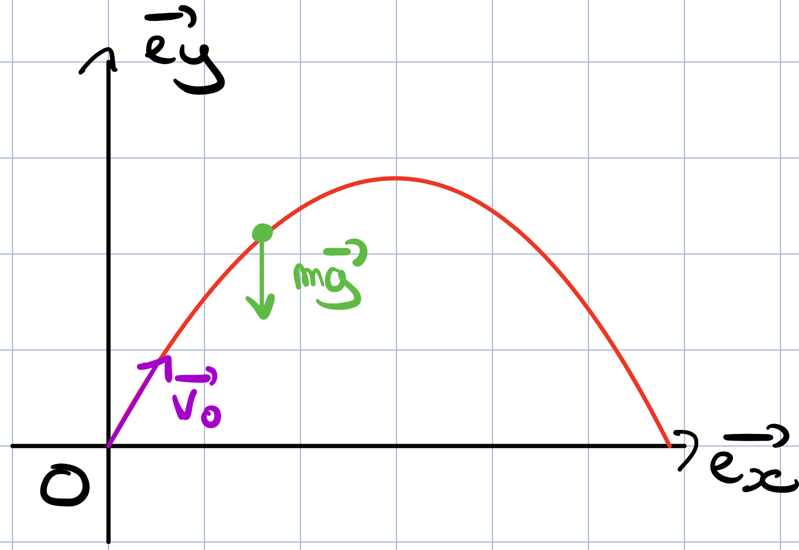
$$\Downarrow$$

$$\text{système 2} \longrightarrow \text{système 1}$$

$$\vec{F}_{2\to 1} = -\vec{F}_{1\to 2}$$

Balistique :

- **référentiel** : auditoire, supposé inertiel
- **repère** : cartésien $(O, \vec{o_x}, \vec{o_y})$



Forces :

- poids $\vec{P} = m\vec{g}$
  $= -mg\vec{e_y}$
- ~~frottements~~ → négligés
- ~~lancé~~ → inclus dans les conditions initiales, pas d'analyse avant pour simplifier

Condit° initiales

- position : $\vec{0}$
- vitesse : $\vec{v_0}$

2nd loi Newton : $\vec{F} = m\vec{a}$

$$\begin{cases} -mg = ma_y = m\ddot{y} & (\vec{e_y}) \quad (1) \\ 0 = ma_x = m\ddot{x} & (\vec{e_x}) \end{cases}$$

(1) : $\ddot{y} = -g$

$\Rightarrow \dot{y} = v_y = At + B$

or $\dot{v}_y = A = -g \Rightarrow v_y = -gt + B$

condit° initiale $t=0$ $\quad v_y(t=0) = B = v_{0y}$

$$v_y = -gt + V_{y0}$$

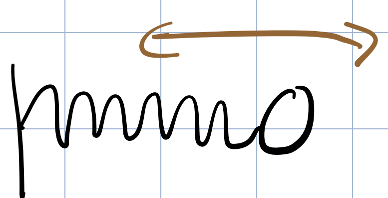
$$\Rightarrow y(t) = -\frac{1}{2}gt^2 + v_{y0}t + C$$

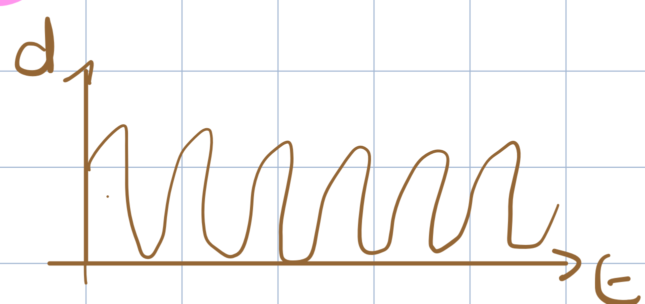
$$y(t=0) = 0 \Leftrightarrow C = 0$$

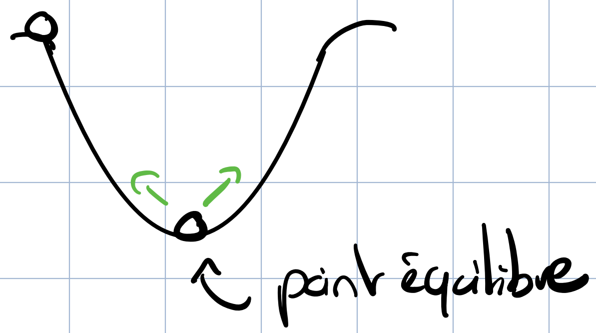
$$\begin{cases} y(t) = -\frac{1}{2}gt^2 + V_{y0}t & (2) \\ x(t) = V_{x0}(t) & (3) \end{cases}$$

$$y(x) = -\frac{g}{2}\left(\frac{x}{V_{x0}}\right)^2 + V_{y0}\left(\frac{x}{V_{x0}}\right)$$

OSCILLATEUR HARMONIQUE



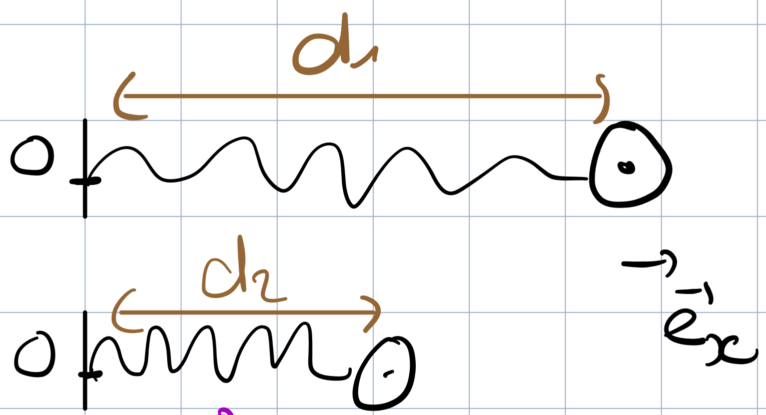


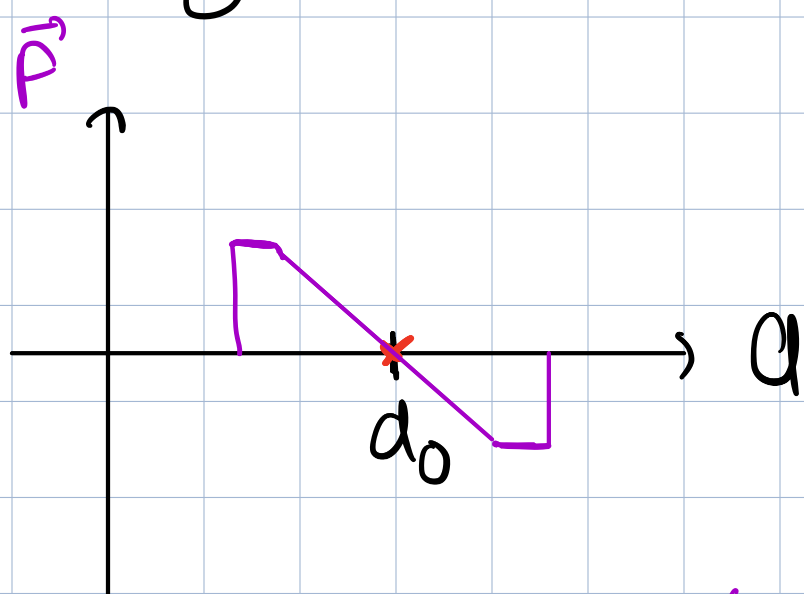


$\vec{a} = \vec{0}$

$\vec{F} = \vec{0}$

Modèle de force



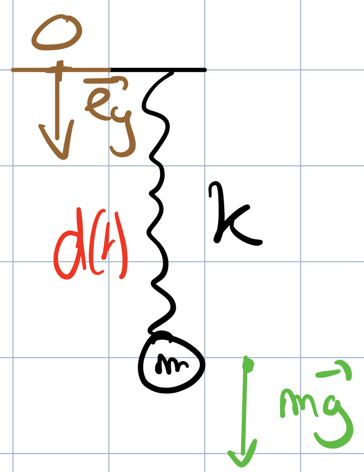


$$F = C(d-d_0)$$
$$= -k(d-d_0)$$

k constante de raideur

$k > 0$

Ressort avec poids



Référentiel : laboratoire, supposé inertiel

Repère : cartésien $(O, \vec{e_y})$

Forces : Poids : $\vec{P} = m\vec{g}$

Rappel : $\vec{F_R}$

$= -k(d(t)-d_0)\cdot\vec{e_y}$

Project° :

$$\vec{F} = \vec{P} + \vec{F_R}$$

$$= mg\vec{e_y} - k(d(t)-d_0)\cdot\vec{e_y}$$

$$= \big(mg - k(d(t)-d_0)\big)\cdot\vec{e_y}$$

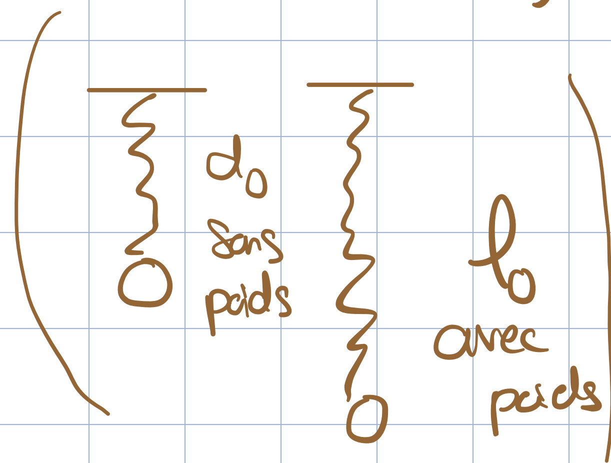
• $\vec{F} = m\vec{a}$ $\Rightarrow$ $mg - k(d-d_0) = m\ddot{y}$

$= m\ddot{d}$

$$m\ddot{d} = -k\Big(d - \underbrace{d_0 - \frac{mg}{k}}_{l_0}\Big)$$

(en fait on fait comme si on avait un nouveau d_0)

$$= -k(d - l_0)$$



on s'attend à ce que $d(t)$ soit comme ça

$$f(x) = A\cos(Bx)$$

$$f'(x) = -AB\sin(Bx)$$

$$f''(x) = -AB^2\cos(Bx)$$

$$= -B^2 f(x)$$

$$m f''(x) = -mB^2 f(x)$$

$$m\ddot{x} = -kx$$

$$x = d - l_0$$

$$\ddot{x} = \frac{-k}{m} x$$

$$\beta^2 = \frac{k}{m}$$

$$\Rightarrow \beta = \sqrt{k/m}$$

$$x(t) = A\cos\left(\sqrt{\frac{k}{m}}\, t\right)$$

$$\dot{x}(t) = -A\sqrt{\frac{k}{m}} \sin\left(\sqrt{\frac{k}{m}}\, t\right)$$

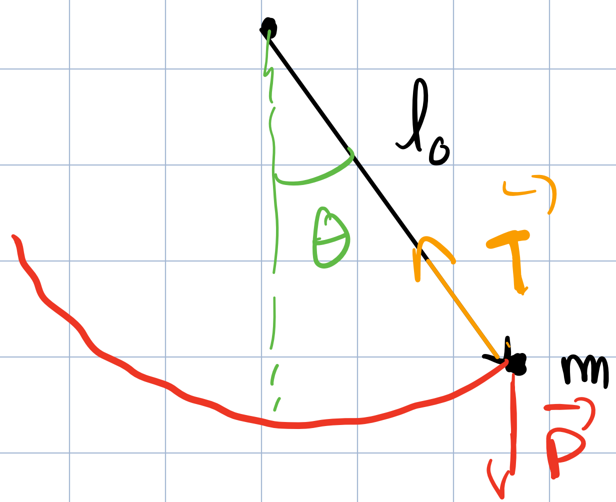
$$\dot{x}(t=0) = -A\sqrt{\frac{k}{m}} = v_0$$

$$\Rightarrow A = \frac{-v_0}{\sqrt{k/m}}$$

$$x(t) = \frac{-v_0}{\sqrt{k/m}} \cos\left(\sqrt{\frac{k}{m}}\, (t)\right)$$

$$d(t) = l_0 - \frac{v_0}{\sqrt{k/m}} \cos\left(\sqrt{\frac{k}{m}}\, t\right)$$

Physique Cours 2



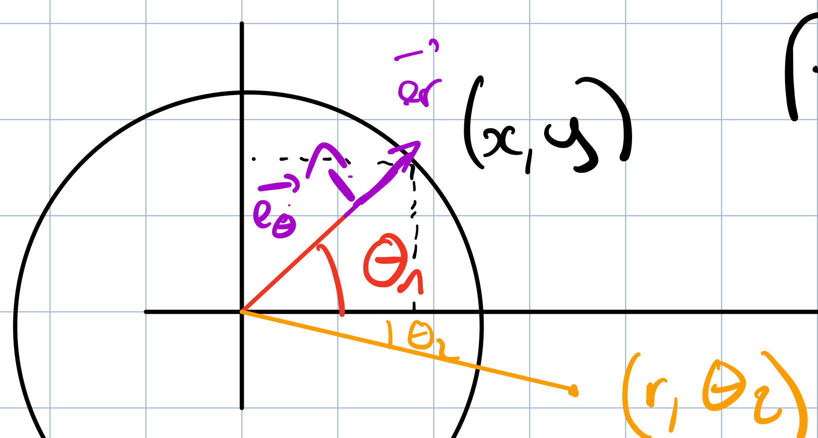
$\theta(t)$?

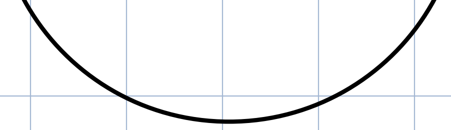
$$\cancel{\vec{P} = m\vec{a}}$$

$$\cancel{\vec{F_x} e_x + F_y \vec{e_y} = m\left(a_x \vec{e_x} + a_y \vec{e_y}\right)}$$

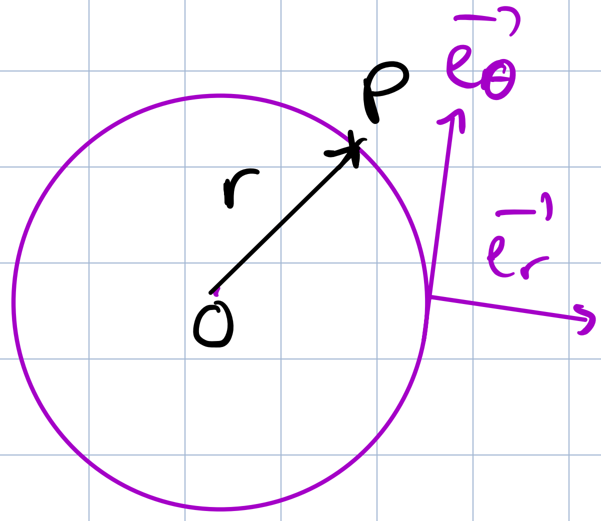
trop compliqué

POLAIRE





$$\vec{v} = \ldots \vec{e_r} + \ldots \vec{e_\theta}$$



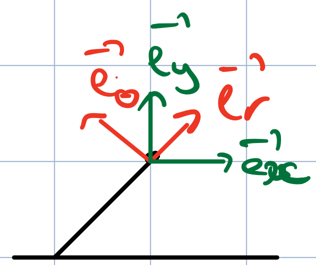
$$\boxed{\vec{OP}(t) = r(t)\vec{e_r}(t)}$$

$$v = \frac{d\vec{OP}}{dt}$$

$$= \frac{dr(t)}{dt}\vec{e_r}(t) + \frac{d\vec{e_r}(t)}{dt}r(t)$$

mais... $\frac{d\vec{e_r}(t)}{dt}$?

$$= \ldots \vec{e_r} + \ldots \vec{e_\theta}$$



$$\vec{e_r}(t) = \cos(\theta(t))\vec{e_x} + \sin(\theta(t))\vec{e_y}$$

$$\vec{e_\theta}(t) = -\sin(\theta(t))\vec{e_x} + \cos(\theta(t))\vec{e_y}$$

↳ car $\cos(\theta + \frac{\pi}{2}) = -\sin(\theta)$

$$\frac{d\vec{e_r}(t)}{dt} = \frac{d}{dt}\left(\cos(\theta(t))\vec{e_x} + \sin(\theta(t))\vec{e_y}\right)$$

$$= \frac{d\theta}{dt}(t)\left(-\sin(\theta(t))\right)\vec{e_x} + \frac{d\theta}{dt}(t)\cos(\theta(t))\vec{e_y}$$

$$= \frac{d\theta}{dt}(r)\left(-\sin(\theta(r))\vec{e_x} + \cos(\theta(r))\vec{e_y}\right)$$

$$= \dot{\theta}(r)\left(\vec{e_\theta}(r)\right)$$

$$\frac{d\vec{e_\theta}(r)}{dt} = \frac{d}{dt}\left(-\sin(\theta(r))\vec{e_x} + \cos(\theta(r))\vec{e_y}\right)$$

$$= -\dot{\theta}(r)\left(\cos(\theta(r))\vec{e_x} + \sin(\theta(r))\vec{e_y}\right)$$

$$= -\dot{\theta}\,\vec{e_r}(r)$$

$$\frac{d\vec{OP}}{dt} = \dot{r}(r)\vec{e_r}(r) + r(r)\dot{\theta}(r)\vec{e_\theta}(r)$$

$$= \vec{v}(r)$$

$$a(r) = \frac{d\vec{v}(r)}{dt}$$

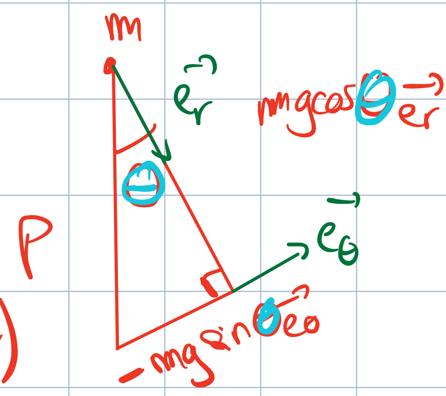
$$= \frac{d}{dt}\left(\dot{r}(r)\vec{e_r}(r) + r(r)\dot{\theta}(r)\vec{e_\theta}(r)\right)$$

$$= \ddot{r}(r) - r(r)\dot{\theta}^2(r))\vec{e_r}(r) + \left(2\dot{r}(r)\theta(r) + r(r)\ddot{\theta}(r)\right)\vec{e_\theta}(r)$$

$$\sum \vec{F} = \vec{T} + \vec{P} = m\vec{a}$$

$$\vec{T} = T(t)\vec{e_r}(t)$$

$$\vec{P} = mg\cos\theta(t)\vec{e_r}(t) - mg\sin\theta(t)\vec{e_\theta}(t)$$



$$r(t) = l_0$$
$$\dot{r}(t) = \ddot{r}(t) = 0$$

$$m\vec{a} = m\left(-l_0\theta^2(t)\right)\vec{e_r}(t) + \left(l_0\ddot{\theta}(t)\right)\vec{e_\theta}(t)$$
$$= \left(-T(t) + mg\cos(\theta)\right)\vec{e_r}(t) - mg\sin\theta(t)\vec{e_\theta}(t)$$

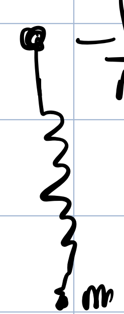
$$\text{donc} \begin{cases} m\left(-l_0\theta^2(t)\right) = -T(t) + mg\cos(\theta) \\ l_0\ddot{\theta}(t) = -mg\sin(\theta(t)) \end{cases}$$

useless, relie $T(t)$ et $\theta(t)$

$$\Leftrightarrow \ddot{\theta} = -\frac{g}{l_0}\sin(\theta(t))$$

$\sin(\theta) \simeq \theta$ pour petits angles

$$\Rightarrow \ddot{\theta} = -\frac{g}{l_0}\theta(t)$$



$$-\frac{k}{m}y(t) = \ddot{y}(t)$$

$\Rightarrow \theta(t) = A\cos(\omega t + \varphi_0)$ avec $\omega = \sqrt{\frac{g}{l_0}}$

$\dot{\theta}(t) = -A\omega\sin(\omega t + \varphi_0)$

$\theta(t) = \theta_0$

$\dot{\theta}(t) = 0$

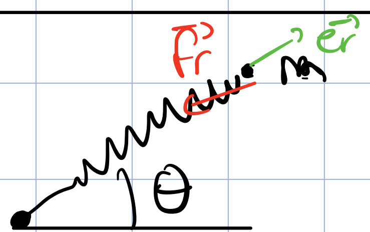
$\dot{\theta}(0) = -A\omega\sin(\varphi_0) = 0$.

$\boxed{\text{Solution } \varphi_0 = 0\ [\pi]}$

$\theta(t) = -A\cos(\omega t)$

$\theta(0) = A\cos(0) \Leftrightarrow A = \theta_0$

$\theta(t) = \theta_0\cos\left(\sqrt{\frac{g}{l_0}}\, t\right)$



$\vec{F_r} = -k\Delta\vec{e_r}$

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

$$= m(-k(r-l_0))\vec{e_r}$$

$$= m(-r\dot{\theta}^2\vec{e_r} + r\ddot{\theta}\vec{e_\theta})$$

$$\begin{cases} -k(r-l_0) = mr\dot{\theta}^2 \\ 0 = r\ddot{\theta} \end{cases}$$

$$\Leftrightarrow \left\{ \ddot{\theta} = 0 \text{ donc } \dot{\theta} = v_0 \text{ et } \theta = v_0 t + \theta_0 \right.$$

$$-k(r - l_0) = -m r v_0^2$$

$$\Leftrightarrow v_0 = \sqrt{\frac{k}{m}\left(1 - \frac{l_0}{r}\right)}$$