Mécanique du point

I - Cinétique du point

Exercice 1 : Un conducteur prudent

1) a) $a = \frac{dv}{dt} \Leftrightarrow v = \int a.dt = a.t$

AN : $24 = 2.t \Leftrightarrow t = 12 s$

b) $d = \int v.dt = \frac{1}{2} a t^2$

AN : $d = \frac{1}{2} . 2 . 12^2 = 144 m$

2) En file : $d = v.t \Rightarrow d = 288 m$
En insertion : $d = 144 m$
Pour $t = 12 s$

Il faut donc $288 - 144 + 20 = 164 m$ de distance

Exercice 2 : Mouvement circulaire uniforme

1) Base polaire :

$$\vec{v} = \dot{\rho} \vec{e_\rho} + \rho\dot{\varphi} \vec{e_\varphi} = R\omega$$

$$\vec{a} = \ddot{\rho} \vec{e_\rho} + \dot{\rho} \dot{\vec{e_\rho}} + (\rho\ddot{\varphi} + \dot{\rho}\dot{\varphi}) \vec{e_\varphi} + \rho\dot{\varphi} \dot{\vec{e_\varphi}}$$

$$= (\ddot{\rho} - \rho\dot{\varphi}^2) \vec{e_\rho} + (\rho\ddot{\varphi} + 2\dot{\rho}\dot{\varphi}) \vec{e_\varphi}$$

$$= -R\omega^2 \vec{e_\rho}$$

Dans le repère de Frenet : $\vec{a} = \frac{dv}{dt} \vec{\tau} + \frac{v^2}{R} \vec{n}$

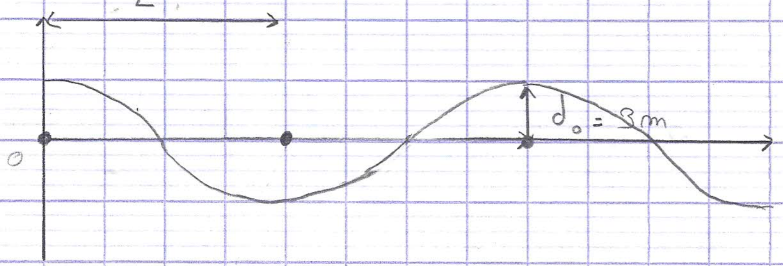
2) a) $\omega = \frac{nbr\ tour \times 2\pi}{\Delta t} = 6\pi$

$v = 6,60\ m.s^{-1}$, $a = 124,36\ m.s^{-2}$

b) $\omega = \int \dot{\omega}\, dt$ AN: $\frac{6\pi}{s} = \dot{\omega}$

$\frac{d\omega}{dt} = \dot{\omega}$

Exercice 3 Test de stabilité d'une voiture



1) Équation de la forme $y = A\cos Bx$

$y(x=0) = A = d_0$

$y(x=L) = A\cos BL = -d_0$

$\Leftrightarrow \cos BL = -1$

$\Leftrightarrow BL = \pi$

donc $y = d_0 \cos\left(\frac{\pi}{L} x\right)$

2) $v_y = \frac{dy(x)}{dt} = \frac{dy(x)}{dx} \frac{dx}{dt} = \left(-\frac{\pi}{L} d_0 \sin\left(\frac{\pi}{L} x\right)\right)\dot{x}$

$v_x = \dot{x} = v_0$

3) $a_y = \frac{dv_y(x)}{dt} = \frac{dv_y(x)}{dx} \frac{dx}{dt} =$

$-\frac{\pi^2}{L^2} d_0 \cos\left(\frac{\pi}{L} x\right) v_0^2$

$a_x = 0.$

4) $\|\vec{a}_y\| = \frac{\pi^2}{L^2} d_0 \left|\cos\left(\frac{\pi}{L} x\right)\right| v_0^2$

L'accélération est maximale en $0\,[L]$

5) Il faut que $\|\vec{a}_{max}\| \leqslant 0,7\,g$

$$6,87 \geqslant \frac{\pi^2}{L^2} d_0 \left|\cos\frac{\pi}{L}\right| v_0^2$$

$$6,87 \geqslant \frac{\pi^2}{L^2} d_0 v_0^2$$

$$\frac{\pi^2 d_0 v_0^2}{6,87} \leqslant L^2$$

$$\underline{L \geqslant 28,8 \text{ m}}$$

6) Le mouvement n'est pas uniforme car $\vec{v} \neq$ cte

Exercice 4 : Mouvement hélicoïdal

1) $\vec{OM} = x\vec{e_x} + y\vec{e_y} + z\vec{e_z}$

$$= \rho\cos\varphi\,\vec{e_x} + \rho\sin\varphi\,\vec{e_y} + h\varphi\,\vec{e_z}$$

$$\vec{v} = \frac{d\vec{OM}}{d\rho}\frac{d\rho}{dt} + \frac{d\vec{OM}}{d\varphi}\frac{d\varphi}{dt} + \frac{d\vec{OM}}{dz}\frac{dz}{dt}$$

$$= (\cos\varphi\,\vec{e_x} + \sin\varphi\,\vec{e_y})\dot{\rho} + (-\rho\sin\varphi\,\vec{e_x} + \rho\cos\varphi\,\vec{e_y} + h\vec{e_z})\dot{\varphi}$$

$$= \dot{\rho}\,\vec{e_\rho} + \rho\dot{\varphi}\,\vec{e_\varphi} + h\dot{\varphi}\,\vec{e_z}$$

$$= \omega(\rho\vec{e_\varphi} + h\vec{e_z})$$

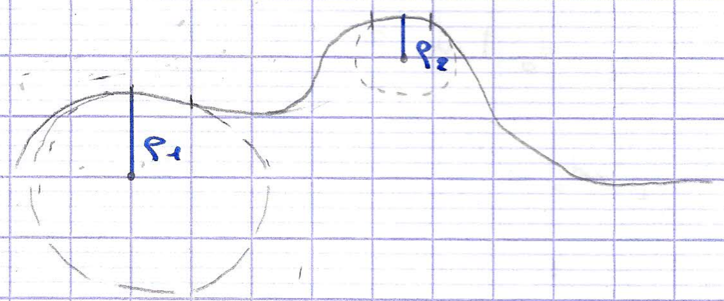
$$\|\vec{v}\| = \omega\sqrt{\rho^2 + h^2}$$

$$\vec{a} = (\dot{\omega}\rho + \omega\dot{\rho})\,\vec{e_\varphi} - \omega^2\rho\,\vec{e_\rho} + (\dot{\omega}h + \omega\dot{h})\,\vec{e_z}$$

$$= \dot{\omega}\rho\,\vec{e_\varphi} - \omega^2\rho\,\vec{e_\rho} + \dot{\omega}h\,\vec{e_z}$$

$$\|\vec{a}\| = \sqrt{\dot{\omega}^2\rho^2 + \omega^4\rho^2 + \dot{\omega}^2 h^2}$$

Rayon de courbure:



ρ : Rayon de courbure

$\omega = cte$

$\dot{\omega} = 0$

$$\vec{a} = \dot{\omega}\,\vec{\tau} + \frac{v^2}{R}\,\vec{n}$$

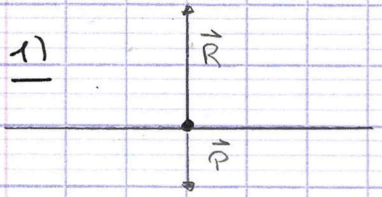
$$= \frac{v^2}{R}\,\vec{n}$$

$$= \frac{\omega^2 (\rho^2 + h^2)}{R}\,\vec{n}$$

II - Dynamique du point

Exercice 5 : Forces exercées par des sportifs

1)



PFD : $\sum \vec{F} = m.\vec{a}$

$\vec{P} + \vec{R} = m.\vec{a}$

où $\vec{a} = -3g$

$\vec{P} = mg$

donc $\vec{R} = -4m.\vec{g}$

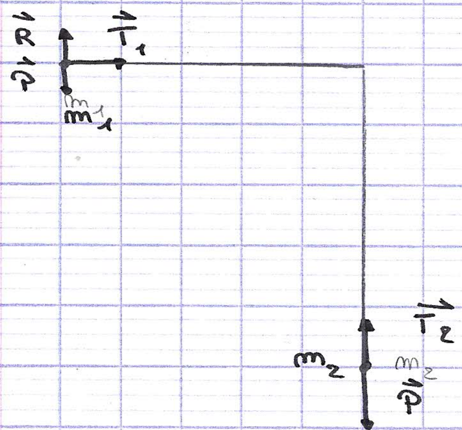
2) $v^2 - v_0^2 = 2a_0(x - x_0)$

$v^2 = 2a_0 x$

$a_0 = \dfrac{v^2}{2x} \Leftrightarrow a_0 = \underline{400\ m.s^{-2}}$

$\vec{F} = \vec{P} = m.\vec{a} = \underline{68\ N}$

Exercice 6 : Mouvement de deux blocs



Système 1 :

$\vec{P} + \vec{R} + \vec{T} = m.\vec{a}$

$m.g.\vec{e_y} - R\vec{e_y} + T_1\vec{e_x} = m_1 a_1 \vec{e_x}$

$\begin{cases} R = m.g \\ T_1 = m_1 a_1 \end{cases}$

Système 2

$\vec{P} + \vec{T} = m.\vec{a}$

$m.g\vec{e_z} - T_2\vec{e_z} = m.a\vec{e_z}$

$m_2 a_2 = m_2 g - T_2$

or $a_1 = a_2 = a$

$T_1 = T_2 = T$

donc $\quad m_1 a = m_2 g - m_2 a$

$$a = \frac{m_2 g}{m_1 + m_2}$$

$$= \underline{3,27 \ m.s^{-2}}$$

$$T = \underline{65,4 \ N}$$

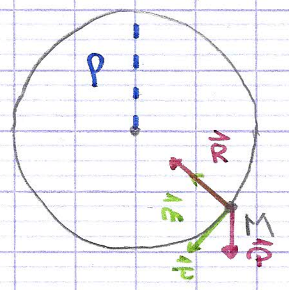
$\underline{2)}$ $\quad x = \iint a \, dt$

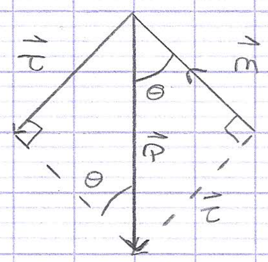
$$= \frac{1}{2} a t^2$$

$$= \underline{6,54 \ m} \qquad \text{pour } t = 2s$$

Exercice 7 : Le guide circulaire

$\underline{a)}$ PFD : $\vec{P} + \vec{R} = m.\vec{a}$





$\vec{P} = \sin\theta mg \vec{\tau}$
$\qquad - \cos\theta mg \vec{n}$

$\vec{R} = R\vec{n}$

$$\sin\theta mg \vec{\tau} - \cos\theta mg \vec{n} + R\vec{n} = m\left(\frac{dv}{dt}\vec{\tau} + \frac{v^2}{\rho}\vec{n}\right)$$

donc $\begin{cases} \sin\theta mg = m \dfrac{dv}{dt} & (\tau) \\ R - \cos\theta mg = m \dfrac{v^2}{\rho} & (n) \end{cases}$ $\qquad$ or $\quad v = \rho\dot{\theta}$

$$\begin{cases} \rho\ddot{\theta} = \sin\theta g \\ \rho\dot{\theta}^2 m = R - \cos\theta mg \end{cases}$$

$\underline{b)}$ TMC : $\sum M_O = \dfrac{d\vec{\sigma}_O}{dt}$

$M_O(R) = \vec{OM} \wedge \vec{R} = -\rho\vec{n} \wedge R\vec{n} = \vec{0}$

$M_O(P) = \vec{OM} \wedge \vec{P} = -\rho\vec{n} \wedge \sin\theta mg \vec{\tau} - \cos\theta mg \vec{n} = \rho\sin\theta mg \vec{b}$

$\vec{\sigma}_O = \vec{OM} \wedge m\vec{v} = -\rho\vec{n} \wedge mv\vec{\tau} = \rho^2 m \dot{\theta} \vec{b}$

$$M_o(\vec{R}) + M_o(\vec{P}) = \ell^2 m \ddot{\theta} \vec{b}$$

$$\sin\theta\, g\, \ell \cancel{m} = \ddot{\theta}\, \ell^2 \cancel{m}$$

$$\ell\ddot{\theta} = \sin\theta\, g.$$

Exercice 8 : Mouvement vertical d'une goutte d'eau

1) a)

PFD : $\sum \vec{F} = m.\vec{a}$

$$\cancel{m_o}\, g\vec{e_z} - \alpha\, \cancel{m_o} v\, \vec{e_z} = \cancel{m_o}.a\, \vec{e_z}$$

$$= \cancel{m_o}.\frac{dv}{dt}\vec{e_z}$$

donc $\dot{v} = g - \alpha v$

$v = v_p$ quand $a = \dot{v} = 0$

$g - \alpha v_p = 0$ $\qquad [v_p] = \frac{1}{4}\, m.s^{-1}$

$\alpha v_p = g$

$v_p = \frac{g}{\alpha}$

b) $y' = g - \alpha y$ $\qquad y_H = C.e^{-\alpha x}$ $\qquad y_p = \frac{g}{\alpha}$

$y' + \alpha y = g$ $\qquad y_0 = e^{-\alpha x}$

$C'(x) = g e^{\alpha x}$ $\qquad v = v_p + e^{-\alpha t} . -v_p$

$C(x) = \frac{g}{\alpha} e^{\alpha x}$ $\qquad$ à $t=0$, $v=0$ donc

$C = -v_p$

c) On cherche $\frac{v_p - v(T)}{v_p} = \frac{1}{1000}$

$$v(T) = v_p - \frac{v_p}{1000}$$

$$\cancel{v_p} + e^{-\alpha t} . -\cancel{v_p} = \cancel{v_p} - \frac{\cancel{v_p}}{1000}$$

$-\alpha t = \ln\left(\frac{1}{1000}\right)$, $t = \frac{\ln(1/1000)}{-\alpha}$ $\qquad \underline{t = 0,17\,s}$

2) $\rho = \dfrac{m}{\frac{4}{3}\pi R^3} \Leftrightarrow \dfrac{4}{3}\pi R^3 \rho = m$

a) $\dfrac{dm}{dt} = \dfrac{dm}{dR}\,\dfrac{dR}{dt} = 4\pi R^2 \rho \cdot R_0 b$

b) PFD : $\sum \vec{F} = \dfrac{dm}{dt}\vec{v} + m\dfrac{d\vec{v}}{dt}$

$m.g = (4\pi R^2 \rho R_0 b)v + m\dot{v}$

$g = \dfrac{3R_0 b}{R} v + \dot{v}$

c) $\dot{v} + \dfrac{3R_0 b}{R} v = g \Leftrightarrow \dot{v} + \dfrac{3}{R} v = \dfrac{g}{R_0 b}$

$v_H = C.e^{\int -3/R \, dR} = C.R^{-3}$

$v_0 = R^{-3}$ $\qquad v_p = \dfrac{gR}{4R_0 b}$

$C'(R) = \dfrac{g}{R_0 b} R^3$

$C(R) = \dfrac{gR^4}{4R_0 b}$

$v = C.R^{-3} + \dfrac{gR}{4R_0 b}$

à $t = 0s$, $v = v_p$, $R = R_0$ donc

$v_p = C.R_0^{-3} + \dfrac{g}{4b}$

donc $C = \left(v_p - \dfrac{g}{4b}\right) R_0^3$

Ainsi $v = \left(v_p - \dfrac{g}{4b}\right) R_0^3 R^{-3} + \dfrac{gR}{4bR_0}$

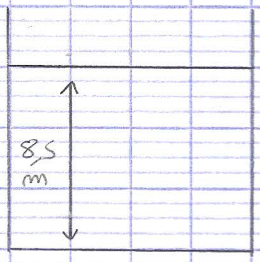
$v(t) = \left(v_p - \dfrac{g}{4b}\right)(1+bt)^3 + \dfrac{g(1+bt)}{4b}$

d) $a = \dfrac{dv}{dt} = \dfrac{-3b\left(v_p - g/4b\right)}{(1+bt)^4} + \dfrac{g}{4}$

$\lim_{t \to \infty} a = \dfrac{g}{4}$

III - Travail et énergie

Exercice 9 : Intérêt des usines marémotrices



$$\delta W = \vec{F}\, d\vec{R} = \vec{F}\vec{v}\, dt$$
$$= -dE_p$$

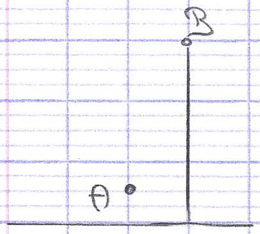
On décompose en tranche élémentaire de hauteur z et d'épaisseur dz, de masse dm

$$dm = \rho dV \qquad dV = S dz \qquad dm = \rho S dz$$

$$dE_p = dm\, g z$$
$$\delta W = -dm\, g z$$
$$= -\rho S g z\, dz$$
$$W = -\frac{1}{2} \rho S g z^2$$

AN : $W = \left[-\frac{1}{2} \rho S g z^2\right]_{8,5}^{0} = 8,15 \cdot 10^{12}$ J

Exercice 10 : Saut à la perche



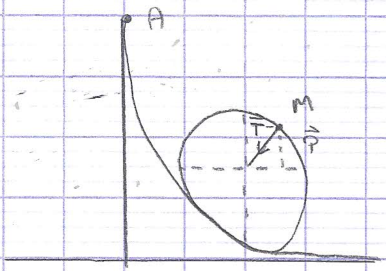
$$E_m(A) = E_c(A) + E_c(B) \qquad (1)$$
$$= \frac{1}{2} mv^2 + mgz$$
$$E_m(B) = mgh \qquad (2)$$

La seule force étant conservative il y a conservation de l'énergie mécanique donc (1) = (2)

$$\frac{1}{2} \cancel{m} v^2 + \cancel{m} g z = \cancel{m} g h$$
$$h = \frac{1}{2g} v^2 + z$$

$h = 6,09$ m

Exercice 11 : Le Looping   Repère de Frenet



PFD (M) : $\sum \vec{F} = m . \vec{a}$

$\vec{T} + \vec{P} = m . \vec{a}$

$T . \vec{n} + mg(-\sin\theta \, \vec{n} + \cos\theta \, \vec{\tau}) = m\left(\frac{dv}{dt}\vec{\tau} + \frac{v^2}{R}\vec{n}\right)$

$$\begin{cases} T + \sin\theta \, mg = \frac{v^2}{R} m & (n) \\ \cos\theta \, g = \frac{dv}{dt} & (\tau) \end{cases}$$

donc $T = \frac{v^2}{R} m - \sin\theta \, mg$ ~~avec z~~

Il y a conservation de l'énergie mécanique, P est une force conservative, T est perpendiculaire.

$E_m(A) = E_m(M)$

$mgh = \frac{1}{2} m v^2 + mgz$ avec $z = R + R\sin\theta$

$v^2 = 2g(h - z)$

$v^2 = 2g(h - R - R\sin\theta)$

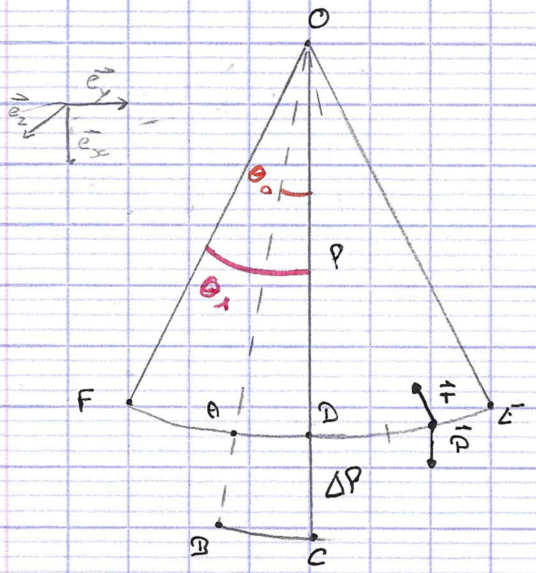
donc $T = \frac{2g(h - R - R\sin\theta)}{R} m - \sin\theta \, mg$

$= mg\left(\frac{2h}{R} - 2 - 3\sin\theta\right)$

en $\theta = \frac{\pi}{2}$: $T_m = mg\left(\frac{2h}{R} - 5\right) \geq 0$

$$\boxed{h \geq \frac{5}{2} R}$$

Exercice 12 : Mouvement de la balançoire



1) $\vec{\sigma}_O(C) = \vec{\sigma}_O(D)$

$\vec{\sigma}_O(C) = \vec{OC} \wedge m\vec{v}$

$= (l+\Delta l)\,\vec{e}_x \wedge m v_C\,\vec{e}_y$

$= (l+\Delta l)\, m v_C\,\vec{e}_z$

$\vec{\sigma}_O(D) = \vec{OD} \wedge m\vec{v}$

$= l\vec{e}_x \wedge m v_D\,\vec{e}_y$

$= l m v_D\,\vec{e}_z$

donc $v_D\, l m = (l+\Delta l)\, m v_C$

$v_D = \frac{l+\Delta l}{l} v_C > v_C$ $\qquad \frac{l+\Delta l}{l} > 1$

Ainsi il gagne de la vitesse

2) $E_m(A) = E_m(C)$

$m g z_A = \frac{1}{2} m v^2$ avec $z_A = R - R\cos\theta$

$v^2 = 2g(R - R\cos\theta)$

$v_C^2 = 2g\,(l+\Delta l)(1-\cos\theta_0)$

$v_D^2 = 2g\,l(1-\cos\theta_1) = \left(\frac{l+\Delta l}{l}\right)^2 v_C^2$

$2g\,l(1-\cos\theta_1) = \left(\frac{l+\Delta l}{l}\right)^2 2g\,(l+\Delta l)(1-\cos\theta_0)$

$\frac{\sin\theta_1/2}{\sin\theta_0/2} = \left(\frac{l+\Delta l}{l}\right)^{3/2}$

3) $\theta_0 = \varepsilon$, $\sin\theta \xrightarrow[\theta\to 0]{} 0$, $\sin\frac{\theta_0}{2} = \frac{\varepsilon}{2}$

$\sin\frac{\theta_1}{2} = \sin\frac{\theta_0}{2}\cdot k = k\frac{\varepsilon}{2}$

$\sin\frac{\theta_2}{2} = k^2\frac{\varepsilon}{2}$

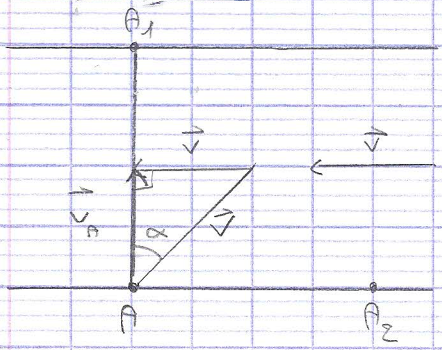
$\sin\frac{\theta_n}{2} = k^n\frac{\varepsilon}{2}$

Horizontal si $\theta_n \geq \frac{\pi}{2} \Leftrightarrow \frac{\theta_n}{2} \geq \frac{\pi}{4} \Leftrightarrow \sin\frac{\theta_n}{2} \geq \frac{\sqrt{2}}{2}$

$n \geq \frac{\frac{1}{2}\ln 2 - \ln\varepsilon}{\ln k}$

IV - Changement de référentiel

Exercice 13 : Problème du nageur



(R) : la berge

(R') : l'eau

$\vec{v} = \vec{v}_e$ = vitesse de l'eau R'/R

$\vec{V} = \vec{v}_R$ = vitesse nageur /eau /R'

$\vec{v}_a = \vec{v}_e + \vec{v}_R$ vitesse nageur /berge /R

1)

Trajet AA_1A : donnée t_1, $t_1 = t_1' + t_1'' = 2t_1'$

$t_1 = \dfrac{2d}{v_a}$ $\quad v_a^2 = V^2 - v^2$ pythagore

$t_1 = \dfrac{2d}{\sqrt{V^2 - v^2}}$ $\qquad \dfrac{t_2}{t_1} > 1$ donc $t_2 > t_1$

Trajet AA_2A :

$t_2 = t_2' + t_2''$ $\qquad t_2' = \dfrac{d}{V-v}$

$t_2 = \dfrac{2dV}{V^2 - v^2}$ $\qquad t_2'' = \dfrac{d}{V+v}$

2) $t_2 = 2t_1 = 7$ min , $\sin\alpha = \dfrac{v}{V}$

$$\frac{1}{\sqrt{1 - \frac{v^2}{V^2}}} = 2 \Leftrightarrow 1 - \frac{v^2}{V^2} = \frac{1}{4} \Leftrightarrow \frac{v}{V} = \frac{\sqrt{3}}{2} \Leftrightarrow \alpha = \frac{\pi}{3}$$

$$t_0 = \frac{2d}{V} \quad , \quad t_2 = \frac{2dV}{V^2 - v} = \frac{2d}{V} \cdot \frac{1}{\sqrt{1 - \frac{v^2}{V^2}}}$$

$$t_1 = \frac{t_0}{\sqrt{1 - \frac{v^2}{V^2}}}$$

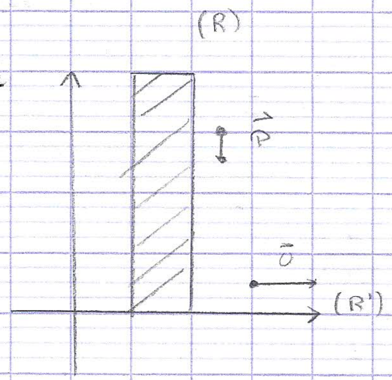
avec $\frac{v^2}{V^2} = \frac{3}{4}$, $t_1 = \frac{t_0}{\sqrt{1 - \frac{3}{4}}} = 2t_0$

$$\begin{cases} t_0 = \frac{7}{4} \text{ min} \\ t_1 = \frac{7}{2} \text{ min} \\ t_2 = 7 \text{ min} \end{cases}$$

Exercice 14 : Chute d'un objet dans différents référentiels

1) La masse va tomber en bas du mat

2) a)



• dans (R)

$\vec P = m\vec g = m\vec a \Leftrightarrow \vec a = \vec g$

$$\begin{cases} a_x = 0 \\ a_y = -g \end{cases} \Leftrightarrow \begin{cases} v_x = c_1 \\ v_y = -gt + c_2 \end{cases}$$

à $t = 0$ la masse est au repos

donc $v_x = v_y = 0$

$c_1 = c_2 = 0$

$$\begin{cases} x = d_1 \\ y = -\frac{1}{2} g t^2 + d_2 \end{cases}$$

à $t = 0$ $d_1 = 0$

$d_2 = h$

$\longrightarrow y = \frac{1}{2} g t^2 + h$

• dans (R'), référentiel galiléen on a encore $\vec a' = \vec g$

$\vec v_a = \vec v_R + \vec v_e \Leftrightarrow \vec v = \vec v' + \vec u \Leftrightarrow \vec v' = \vec v - \vec u$

$$\begin{cases} v'_x = -u \\ v'_y = v_y = -gt \end{cases} \Leftrightarrow \begin{cases} x' = -ut + k_1 \\ y' = \frac{1}{2} g t^2 + k^2 \end{cases} \quad k_1 = 0, \ k_2 = h$$

b) $\vec{a'} = \vec{a} - \vec{a_e}$
$= -g\vec{e_y} - a_e\vec{e_x}$

$\vec{a'} \begin{cases} a'_x = -a_e \\ a'_y = -g \end{cases} \Rightarrow \begin{cases} x' = -\frac{1}{2} a_e t^2 \\ y' = -\frac{1}{2} g t^2 + h \end{cases}$

$\Rightarrow \begin{cases} v'_x = -a_e t \\ v'_y = -gt \end{cases}$ $\qquad y' = \dfrac{g}{a_e} x' + h.$

mouvement linéaire

Exercice 16 Référentiel terrestre non galiléen (R)

1) $\Sigma \vec{F} + \vec{F_{ie}} + \vec{F_{ic}} = m.\vec{a_R}$
$\vec{F_g} - m\vec{a_e} - m\vec{a_c} = m.\vec{a_R}$
$m\vec{g} - 2m\vec{\omega} \wedge \vec{v_R} = m.\vec{a_R}$
$\vec{g} - 2\vec{\omega} \wedge \vec{v_R} = \vec{a_R}$

2) $\vec{g} = -g\vec{e_z}$
$\vec{\omega} = \omega\cos\lambda\,\vec{e_y} + \omega\sin\lambda\,\vec{e_z}$

$\vec{v} = \dot{x}\vec{e_x} + \dot{y}\vec{e_y} + \dot{z}\vec{e_z}$
$\vec{\omega} \wedge \vec{v} = (\dot{z}\omega\cos\lambda - \dot{y}\omega\sin\lambda)\vec{e_x} + \dot{x}\omega\sin\lambda\,\vec{e_y} - \dot{x}\omega\cos\lambda\,\vec{e_z}$

$\vec{a_x} = -2\omega(\cos\lambda\,\dot{z} - \dot{y}\sin\lambda)$
$\vec{a_y} = -2\omega\dot{x}\sin\lambda$
$\vec{a_z} = -g + 2\omega\dot{x}\cos\lambda$

3) $\dot{y} = -2\omega x\sin\lambda + cte$, $cte = 0$
$\dot{z} = -gt + 2\omega x\cos\lambda + cte$, $cte = 0$

4) $\ddot{x} = -2\omega(-gt\cos\lambda + 2\omega x\cos^2\lambda + 2\omega x\sin^2\lambda)$
$= +2\omega gt\cos\lambda - 4\omega^2 x$

5) $\omega = \frac{2\pi}{T} = 7,3 . 10^{-5}$ Rad.s^{-1}

avec $T \simeq 24$h.

$\omega^2 \ll \omega$

$\ddot{x} \simeq 2\omega g t \cos\lambda$

6) $\dot{x} = +\omega g t^2 \cos\lambda$

$x = \frac{1}{3}\omega g t^3 \cos\lambda + cte$

$\dot{y} = -\frac{2}{3}\omega^2 g t^3 . \frac{\sin(2\lambda)}{2}$

$y = -\frac{1}{12}\omega^2 g t^4 \sin 2\lambda$

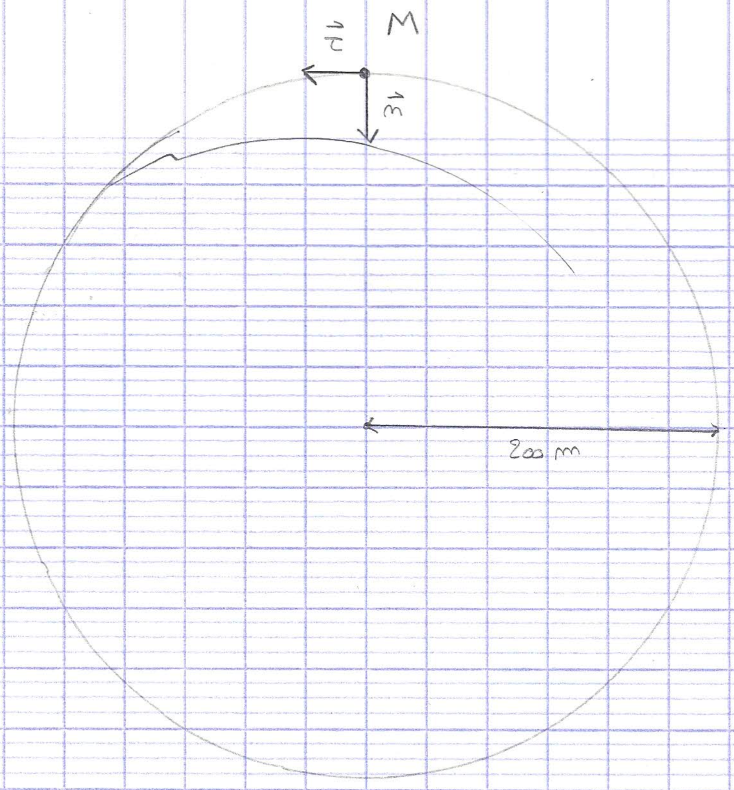
$\dot{z} = -gt + \frac{2}{3}\omega^2 g t^3 \cos^2\lambda$

$z = -\frac{1}{2}gt^2 + \frac{1}{6}\omega^2 g t^4 \cos^2\lambda + h$

7) Déviation vers Est > Déviation vers Sud

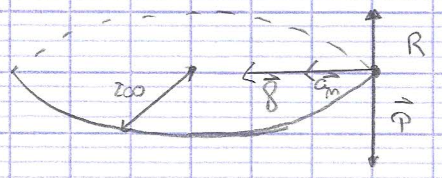
4,3 cm 7 µm

plat



$a_n = \frac{v^2}{R}$

$a_\tau = \frac{dv}{dt}$

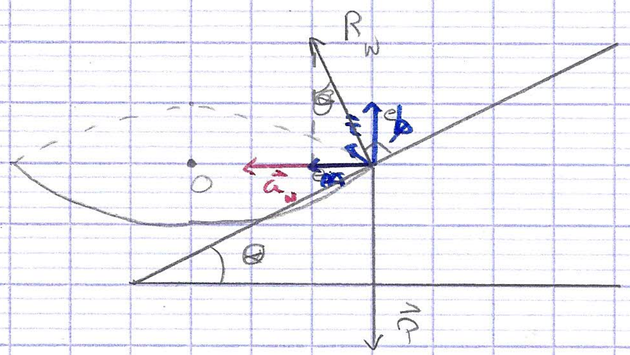


$\sum \vec{F}_{ext} = m \cdot \vec{a} \Rightarrow \vec{P} + \vec{R}_N + \vec{f} = m \cdot \vec{a}$

selon $\vec{a}_N$: $f = m \cdot a_N \Rightarrow f = m \frac{v^2}{R}$

Si $m \simeq 1000$ kg, $f \simeq 4500$ N

Relevé



$\sum \vec{F} = m \cdot \vec{a} \Rightarrow \vec{P} + \vec{R}_N = m \cdot \vec{a}$

$\begin{cases} R_N \sin\theta = m \cdot \frac{v^2}{R} & (\vec{n}) \\ R_N \cos\theta = mg & (\vec{b}) \end{cases} \Leftrightarrow \frac{mg}{\cos\theta} \sin\theta = m \frac{v^2}{R}$

$\Leftrightarrow v^2 = Rg \tan\theta$

$\Leftrightarrow \tan\theta = \frac{v^2}{Rg} \Rightarrow \theta = 23{,}27°$