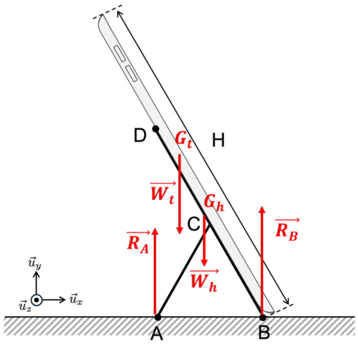
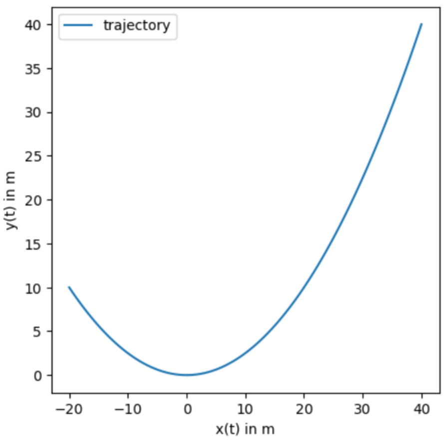
INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

IE2-S1 - Physics - correction

SCAN
2024-2025

Exercise 1 : Design of a tablet holder (8/20 + bonus 1)	/8
 1.	0.5
2. At equilibrium, $\overrightarrow{R_A}+\overrightarrow{R_B}+\overrightarrow{W_t}+\overrightarrow{W_h}=\overrightarrow{O}$ and $\overrightarrow{M}_{\overrightarrow{R_A}}(B)+\overrightarrow{M}_{\overrightarrow{R_B}}(B)+\overrightarrow{M}_{\overrightarrow{W_t}}(B)+\overrightarrow{M}_{\overrightarrow{W_h}}(B)=\overrightarrow{O}$ $\overrightarrow{M}_{\overrightarrow{R_A}}(B)=-hR_A\overrightarrow{u_z}$ $\overrightarrow{M}_{\overrightarrow{R_B}}(B)=\overrightarrow{O}$ $\overrightarrow{M}_{\overrightarrow{W_t}}(B)=\frac{HMg}{4}\overrightarrow{u_z}$ $\overrightarrow{M}_{\overrightarrow{W_h}}(B)=\frac{lmg}{4}\overrightarrow{u_z}$ Hence $R_A=\frac{(HM+\ell m)g}{4h}$ and $R_B=(M+m)g-\frac{(HM+\ell m)g}{4h}$	0.25 0.25 0.25 0.25 0.25 0.25 0.5 0.5
3. The tablet flips backwards when there is no contact anymore at point B, *i.e.* when $R_B=0$. This gives $h_{min}=\frac{HM+\ell m}{4(M+m)}$ N.A. : $h_{min}=6\ cm$ This is a realistic value.	0.25 0.5 0.5 0.25
4. It is not possible to maintain the system at equilibrium as $\overrightarrow{F_u}$ is the only force having a component along the x-axis.	0.5
5. The new equilibrium is obtained for $\overrightarrow{R_A}+\overrightarrow{R_B}+\overrightarrow{W_t}+\overrightarrow{W_h}+\overrightarrow{F_u}=\overrightarrow{O}$ and $\overrightarrow{M}_{\overrightarrow{R_A}}(B)+\overrightarrow{M}_{\overrightarrow{R_B}}(B)+\overrightarrow{M}_{\overrightarrow{W_t}}(B)+\overrightarrow{M}_{\overrightarrow{W_h}}(B)+\overrightarrow{M}_{\overrightarrow{F_u}}(B)=\overrightarrow{O}$ with $\overrightarrow{M}_{\overrightarrow{F_u}}(B)=\ell' F_u\overrightarrow{u_z}$ Hence $R'_A=\frac{(HM+\ell m)g}{4h}+\ell' F_u=R_{A0}+\ell' F_u$ and $R_{B_N}=(M+m)g-R'_A+\frac{F_u}{2}=R_{B_0}+(\frac{1}{2}-\frac{\ell'}{h})F_u$	0.25 0.25 0.5 0.5
6. N.A. : $R_{B_0}=2.7\ N$ $\quad R_{B_N}=R_{B_0}-\frac{3}{2}F_u$ $\quad R_{B_T}=\frac{\sqrt{3}}{2}F_u$ The tablet flips if $R_{B_N}=0$, *i.e.* $F_u=\frac{2}{3}R_{B_0}=1.8\ N$ The tablet slides if $R_{B_T}=\mu R_{B_N}$, *i.e.* $F_u=1.04\ N$. So the system will first slide. *Also accepted, on 1.5pts maximum :* With $h=11$ cm, the term before F_u in R_{B_N} is negative $\Rightarrow$ R_{B_N} decreases when F_u increases. Whereas R_{B_T} increases with F_u. So the condition for friction will break before the condition for flipping, the tablet will first slide.	0.25 0.5 0.5 0.25
7 (BONUS). The system remains at equilibrium until $R_{B_T}=\mu R_{B_N}$. Replacing R_{B_T} and R_{B_N} by their expressions, we obtain $h^*_{min}=\frac{2\mu\ell'}{(\mu-\sqrt{3})F_u+2\mu R_{B_0}}$ N.A. : $h^*_{min}=10.4\ cm$.	+1

Exercise 2 : Jordan and the lion (5/20)	/5
Analyze : The lion and Jordan have rectilinear motions at constant velocities. To find out whether Jordan is escaping, we need to determine his position and the lion's position in relation to time. We can then find out where the lion is when Jordan reaches the car.	0.5
Realize : we define the x-axis as the horizontal axis, oriented from the lion to the car, with its origin at the initial position of the lion. Lion's trajectory : $x_L(t) = V_L t$ with $V_L = 13.9\ m/s$ the lion's speed. Jordan's trajectory : $x_J(t) = V_J(t-1) + X_{JO}$ for $t \geqslant 1s$ with $V_J = 5\ m/s$ and $X_{J0} = 26\ m$ Jordan reaches his car at time t' such that $x_J(t') = V_J(t'-1) + X_{JO} = 32$, with means $t' = 2.2\ s$. At that time, the lion is at $x_L(t') = V_L t' \approx 30.5 m$. In conclusion, Jordan escapes and the lion is approximately 1.5 m away from the car.	0.5 2 1 0.5
Communicate : Clear reasoning and logical flow.	0.5

Exercise 3 : 2D motion (7/20)	/7
1. $y(t) = \frac{x^2}{40\alpha\tau}$ 	1.5
2. $\vec{v}(t) = \dot{x}\vec{e}_x + \dot{y}\vec{e}_y = 20\alpha\vec{e}_x + \frac{20\alpha}{\tau}(t-\tau)\vec{e}_y$ $\vec{a}(t) = \ddot{x}\vec{e}_x + \ddot{y}\vec{e}_y = \frac{20\alpha}{\tau}\vec{e}_y$	0.5 0.5
3. $\vec{v} = \\|\vec{v}\\|\vec{u}_T$ $\\|\vec{v}\\| = 20\alpha\sqrt{1+(\frac{t}{\tau}-1)^2}$ so $\vec{u}_T = \frac{\vec{e}_x + (\frac{t}{\tau}-1)\vec{e}_y}{\sqrt{1+(\frac{t}{\tau}-1)^2}}$ and as $\vec{u}_N \perp \vec{u}_T$ and $\vec{u}_N$ is oriented towards the interior of the trajectory, we have $\vec{u}_N = \vec{e}_z \times \vec{u}_T$, and we get $\vec{u}_N = \frac{-(\frac{t}{\tau}-1)\vec{e}_x + \vec{e}_y}{\sqrt{1+(\frac{t}{\tau}-1)^2}}$	0.25 0.25 0.5 0.5 + 0.5
4. With the previous expressions of $\vec{u}_T$ and $\vec{u}_N$, we obtain $\vec{e}_y = \frac{(\frac{t}{\tau}-1)\vec{u}_T + \vec{u}_N}{\sqrt{1+(\frac{t}{\tau}-1)^2}}$ Therefore $\vec{a} = a_T\vec{u}_T + a_N\vec{u}_N = \frac{2\alpha}{\tau}\frac{(\frac{t}{\tau}-1)\vec{u}_T + \vec{u}_N}{\sqrt{1+(\frac{t}{\tau}-1)^2}}$ And $a_N = \frac{\\|\vec{v}\\|^2}{R_c}$ therefore $R_c = 200\alpha\tau[1+(\frac{t}{\tau}-1]^{3/2}$ N.A. : for $t = 1\ s$, $R_c = 200\ m$ for $t = 3\ s$, $R_c = 2236\ m$	0.5 0.5 0.5 2*0.25
5. $\\|\vec{a}\\| = cst$ so the movement is uniformly accelerated.	0.5