ADIAB. IRR. : $\Delta S_a = \Delta S_u > 0$

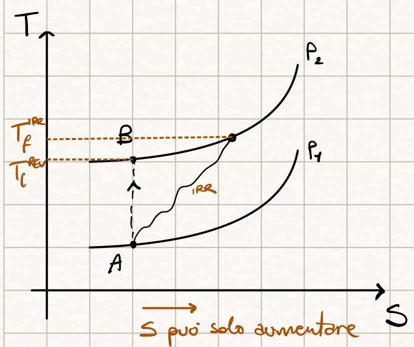
$\mathcal{L}_{IRR} < \mathcal{L}_{REV}$ , $Q = 0$

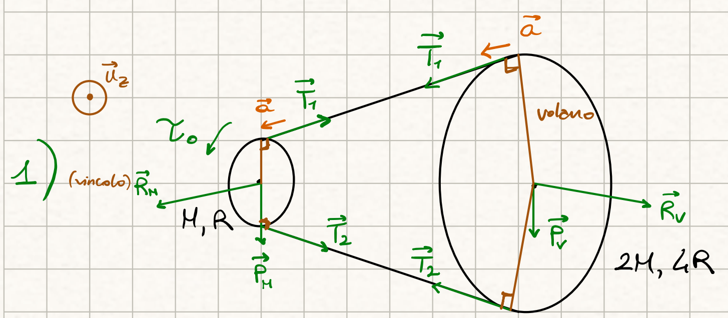
$\Rightarrow Q = \mathcal{L} + \Delta U \Rightarrow \Delta U = -\mathcal{L}$

$\Rightarrow -\Delta U_{IRR} < -\Delta U_{REV}$

$\Rightarrow -\cancel{n c_v}(T_f^{IRR} - T_i^{IRR}) < -\cancel{n c_v}(T_f^{REV} - T_i^{REV})$

$\Rightarrow T_f^{IRR} - \cancel{T_i^{IRR}} > T_f^{REV} - \cancel{T_i^{REV}} \Rightarrow \boxed{T_f^{IRR} > T_f^{REV}}$




a) ? $\alpha_V$

b) ? $P_m$ (N giri)

$\Sigma \vec{F}^{est} = m\vec{a} = 0$ (non serve)

$\Sigma \vec{\tau}^{est} = I\vec{\alpha}$

MOTORE : $\tau_0 - \tau_{T_{1M}} + \tau_{T_{2M}} = I_M \alpha_M$ ; $I_M = \frac{1}{2} MR^2$

VOLANO : $\tau_{T_{1V}} - \tau_{T_{2V}} = I_V \alpha_V$ ; $I_\alpha = \frac{1}{\cancel{2}} \cancel{2}M(4R)^2 = 16MR^2$ } cilindri

$$\begin{cases} \tau_0 - R\underline{T_1} + R\underline{T_2} = \frac{1}{2} MR^2 \underline{\alpha_M} \\ 4R\underline{T_1} - 4R\underline{T_2} = 16MR^2 \underline{\alpha_V} \end{cases}$$

se $T_1$ fosse $= T_2$ $\alpha = 0 \Rightarrow$ il volano non ruoterebbe

$$\begin{cases} \alpha_M = \frac{a_{tgM}}{R} \\ \alpha_V = \frac{a_{tgV}}{4R} \end{cases}$$

affinché la fune non strisci e sia inestensibile $a_{tgM} = a_{tgV} = a$

$$\Rightarrow \begin{cases} \alpha_M = \frac{a}{R} = 4\alpha_V \\ \alpha_V = \frac{a}{4R} \end{cases}$$

$$\Rightarrow \begin{cases} \tau_0 - RT_1 + RT_2 = \frac{1}{\cancel{2}} MR^2 \overset{2}{\cancel{4}}\alpha_v \\ 4RT_1 - 4RT = 16MR^2\alpha_v \end{cases} \Rightarrow \begin{cases} \tau_0 - RT_1 + RT_2 = 2MR^2\alpha_v \\ T_1 - T_2 = 4MR\alpha_v \end{cases}$$

$$\Rightarrow \begin{cases} \tau_0 - R(T_1 - T_2) = 2MR^2\alpha_v \\ R(T_1 - T_2) = 4MR^2\alpha_v \end{cases} \Rightarrow \tau_0 - 4MR^2\alpha_v = 2MR^2\alpha_v$$

$$\boxed{\alpha_v = \frac{\tau_0}{6MR^2}}$$

Potenza media fornita dal motore affinché faccia N giri:

$$P_m = \frac{L}{\Delta t} \quad ; \quad L = \underset{(\Delta E_p = 0)}{\Delta E_m} = \underset{E_K = \frac{1}{2}I\omega^2}{\Delta E_K} = \int_{\theta_i}^{\theta_f} \tau_0 \, d\theta = \tau_0 \Delta\theta = \tau_0 \cdot 2\pi N$$

$$\Delta\theta = \cancel{\theta_0} + \cancel{\omega_0 t} + \frac{1}{2}\alpha_M \Delta t^2$$

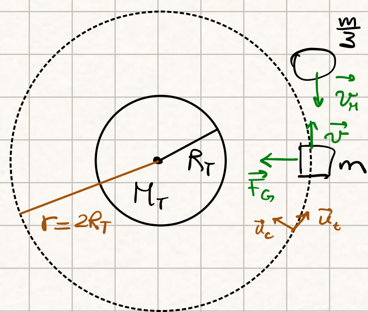
$$\rightarrow \Delta\theta = \frac{1}{2} 4\alpha_v \Delta t^2 = \cancel{2}\frac{\tau_0}{\underset{3}{\cancel{6}}MR^2}\Delta t^2 = 2\pi N \Rightarrow \Delta t = \sqrt{\frac{2\pi N \, 3MR^2}{\tau_0}} = \sqrt{\frac{6\pi MNR^2}{\tau_0}}$$

$$P_m = \tau_0 2\pi N \sqrt{\frac{\tau_0}{6\pi MNR^2}} = \sqrt{\frac{\overset{2}{\cancel{4}}\pi^{\cancel{2}} N^{\cancel{2}} \tau_0^3}{\underset{3}{\cancel{6}}\cancel{\pi} M \cancel{N} R^2}} = \sqrt{\frac{2\pi N \tau_0^3}{3MR^2}}$$

2) $R_T = 6,37 \cdot 10^6 \, m$

URTO PERFETTAM. ANAELASTICO

$?\vec{v}_1$ ?orbita




PRE-URTO:
$$F_G = \gamma \frac{M_T m}{r^2} = m a_c = m\frac{v^2}{r} = m\frac{v^2}{2R_T}$$

$$\Rightarrow \vec{v} = \sqrt{\frac{\gamma M_T}{2R_T}} \, \vec{u}_t$$

$$\Rightarrow \vec{v}_M = -\sqrt{\frac{\gamma M_T}{2R_T}} \, \vec{u}_t$$

DURANTE L'URTO: $\Delta\vec{Q} = 0 \quad \Delta E_K \neq 0 \quad (E_{Kf} < E_{Ki})$

$$\vec{Q}_s + \vec{Q}_M = \vec{Q}_i = \vec{Q}_f = \left(m + \frac{m}{3}\right)\vec{v}_1$$

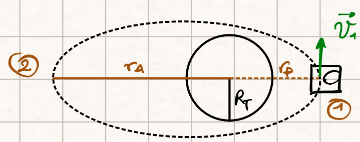
$$m v \vec{u}_t - \frac{m}{3} v \vec{u}_t = \left(m + \frac{m}{3}\right) v_1 \vec{u}_t$$

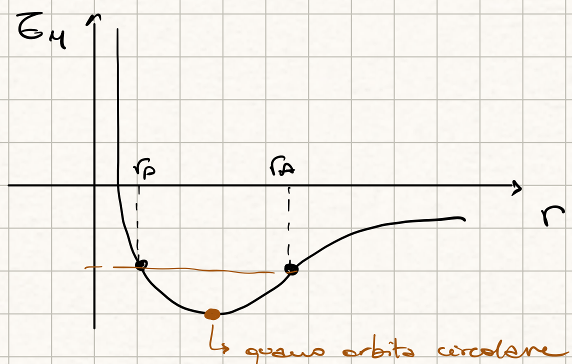
$$\frac{2}{\cancel{3}} \cancel{m} v = \frac{\overset{2}{\cancel{4}}}{\cancel{3}} \cancel{m} v_1 \Rightarrow v_1 = \frac{v}{2} \rightarrow \vec{v}_1 = \frac{v}{2} \vec{u}_t$$

$$E_K = \frac{1}{2}\left(m + \frac{m}{3}\right) v_1^2 = \frac{1}{2}\left(m + \frac{m}{3}\right)\frac{v^2}{4} = \gamma \frac{M_T m}{12 R_T}$$

$$E_m = E_K + E_p = \frac{\gamma M_T m}{12 R_T} - \frac{\gamma M_T \left(\frac{4}{3}m\right)}{2 R_T} = -\frac{7}{12}\gamma \frac{M_T}{R_T} < 0 \implies \text{orbita ellittica}$$

orbita nuova:




$r_p = 2R_T$

- $\Delta E_m = 0 \Rightarrow E_{m_1} = E_{m_2}$

$$-\frac{7}{12}\frac{\gamma M_T m}{R_T} = \frac{1}{2}\left(\frac{4}{3}m\right) v_2^2 - \gamma \frac{M_T}{r_2}\frac{4m}{3} \quad *$$

- $\vec{L}_1 = \vec{L}_2$ $\quad \odot \, \vec{u}_z$

$$\vec{L}_1 = \vec{r}_1 \times \left(\frac{4}{3} m \vec{v}_1\right) = \frac{2}{3} m \sqrt{2\gamma M_T R_T} \, \vec{u}_z$$

$\perp$

$$L_2 = \frac{4}{3} m v_2 r_2 \vec{u}_z$$

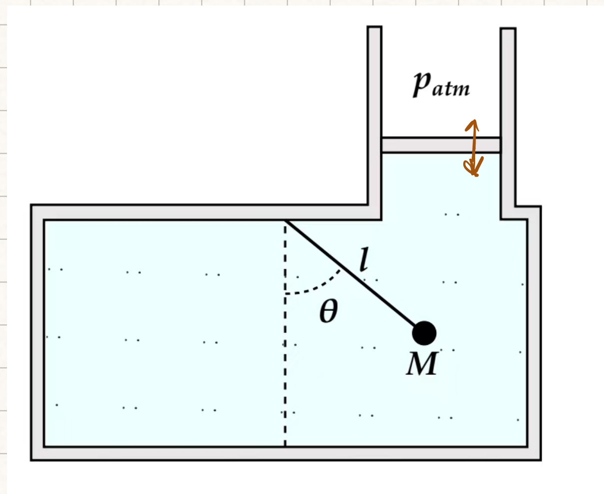
$$\Rightarrow \frac{2}{\cancel{3}} \cancel{m} \sqrt{2\gamma M_T R_T} = \frac{\overset{2}{\cancel{4}}}{\cancel{3}} \cancel{m} v_2 r_2 \Rightarrow v_2 = \frac{\sqrt{2\gamma M_T R_T}}{2 r_2}$$

$$\rightarrow * \quad -\frac{7}{12}\gamma \frac{M_T m}{R_T} = \frac{2}{3} m \frac{2\gamma M_T R_T}{4 r_2^2} - \gamma \frac{M_T}{r_2}\frac{4}{3} m$$

$$\rightarrow 7 r_2^2 - 16 R_T r_2 + 4 R_T^2 = 0 \rightarrow r_2 = \frac{8 R_T \pm \sqrt{36 R_T^2}}{7} = \frac{8 \pm 6}{7} R_T = \begin{cases} ① \; 2R_T = r = r_A \\ ② \; \frac{2}{7} R_T = r_p \end{cases}$$

$< R_T \Rightarrow$ si schianta sulla Terra

3) $M = 20\ Kg$
$\ell = 1{,}5\ m$
$n = 3\ mol$
BIATOMICO
$T_0 = 300K$
$\vartheta = 60°$
$P_0 = P_{atm}$




a) ? $\Delta T_{gas}$

b) ? $\Delta S_{gas}$ (tutto fermo)
↳ per l'attrito viscoso

Il pendolo ha $E_p$ iniz. $\Rightarrow$ convertito in calore, assorbito dal gas $\Rightarrow \Delta T_{gas}$

$$Q_G \overset{(?)}{=} \Delta E_p = E_p - 0 = Mg\,\ell(1-\cos\vartheta) \quad (>0)$$

$\Rightarrow$ IRREVERSIBILE (attrito viscoso)

$$\mathcal{L} = \int_{V_i}^{V_f} P_{atm}\, dV = P_{atm}\,\Delta V = P_{atm}(V_f - V_i)$$

eq. di stato : $PV = nRT$ $\Rightarrow$ $\mathcal{L} = \cancel{P_{atm}}\left(\frac{nRT_f}{\cancel{P_{atm}}} - \frac{nRT_i}{\cancel{P_{atm}}}\right) = nR\Delta T$

$P_i = P_f = P_{atm}$ (equilibrio meccanico)

$\Delta U = nc_v \Delta T$ ; $Q = \mathcal{L} + \Delta U$

$$\Rightarrow Mg\ell(1-\cos\vartheta) = nR\Delta T + nc_v\Delta T = nc_p\Delta T$$

$$\Rightarrow \Delta T = \frac{Mg\ell(1-\cos\vartheta)}{nc_p} = 1{,}68\ K$$

$$\Delta S_G = \int_{Rev} \frac{\delta Q}{T} = nc_v \ln\left(\frac{T_f}{T_i}\right) + nR\ln\left(\frac{V_f}{V_i}\right) = nc_v\ln\left(\frac{T_f}{T_i}\right) + nR\ln\left(\frac{T_f}{T_i}\right) = nc_p \ln\left(\frac{T_f}{T_i}\right)$$

$V = \frac{nRT}{P}$

$= 0{,}48\ J/K$ $\geq 0$ ok

$= \Delta S_U$ ($\Delta S_{AMB} = 0$)

→ trasf. equiv. rev. : ISOBARA (oppure ISOCORA + ISOTERMA) oss.

$T_G = 0°C$ — ghiaccio, $m_G$; $Q = \lambda_G m_G$ $\xrightarrow{p_{atm}}$ $H_2O$, $T_A = 0°C$

$m_A = m_G = V_A \rho_A = V_G \rho_G$

$? \; \Delta U = \cancel{0}$ **NO**

perchè non si può usare $\Delta U = n c_p \Delta T$ poichè non è un gas perfetto

NO : $dQ = n c \, dT$

Sì : $\boxed{Q = L + \Delta U}$

$\rightarrow \Delta U = Q - L = Q - p_{atm} \Delta V$