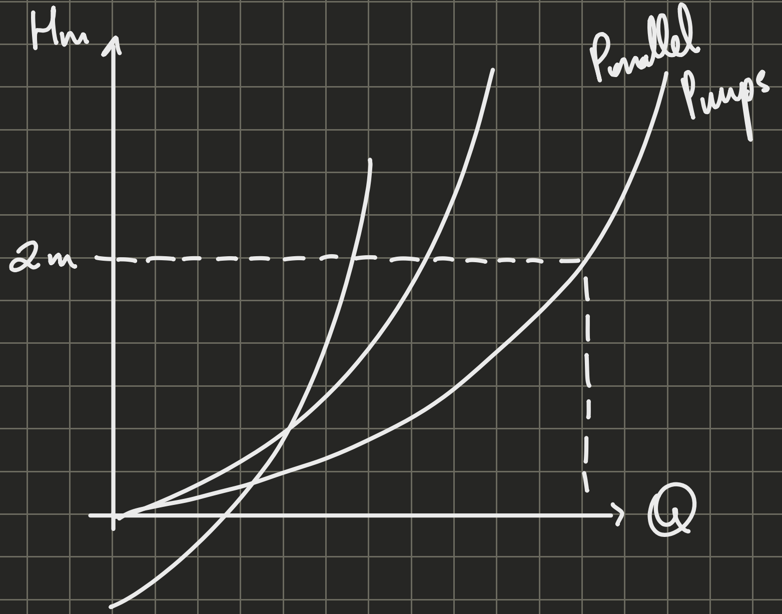
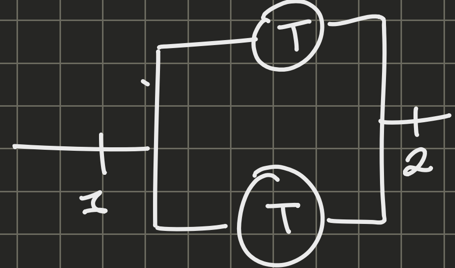
Esercitazione 10 -

Exercise 1 - Hydraulic Turbines in Parallel

$$H_m = 0.4\,Q^2 + 0.5\,Q$$

This is the first time we see the curve we see for turbines since they are generally useless, since in turbines we change geometry to regulate power.





$$H_{m//} = \frac{0.4}{4}Q^2 + \frac{0.5}{2}Q$$

$$Q_{T1} = Q_{T2} = \frac{1}{2}Q_{//} \triangleq 1/2\,Q$$

$g H_m = {}'T_1' - {}'T_2'$

↳ For this type of exercise

$$H_{m//}(n) = 0.1\,Q^2 + 0.25\,Q\left(\frac{n}{375}\right)$$

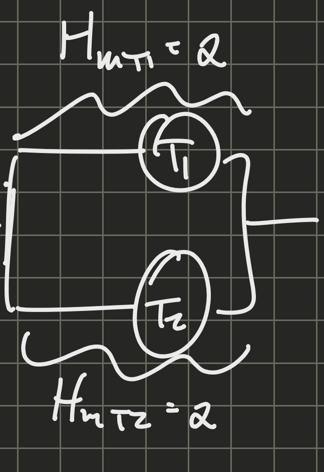
$\Rightarrow n = 825$ rpm

Once the pumps / turbines are different we can't apply simplifying rules:

spin at design speed.

$H_{T1} = 0.4\,Q_{T1}^2 + 0.5\,Q_{T1} = 2 \rightarrow Q_{T1}$ found

$H_{T2} = 0.4\,Q_{T2}^2 + 0.5\,Q_{T2}\left(\frac{n_{T2}}{375}\right) = 2$



We know $H_{T1} = H_{T2} = 2$, because $\Delta 'T'$ does not change.

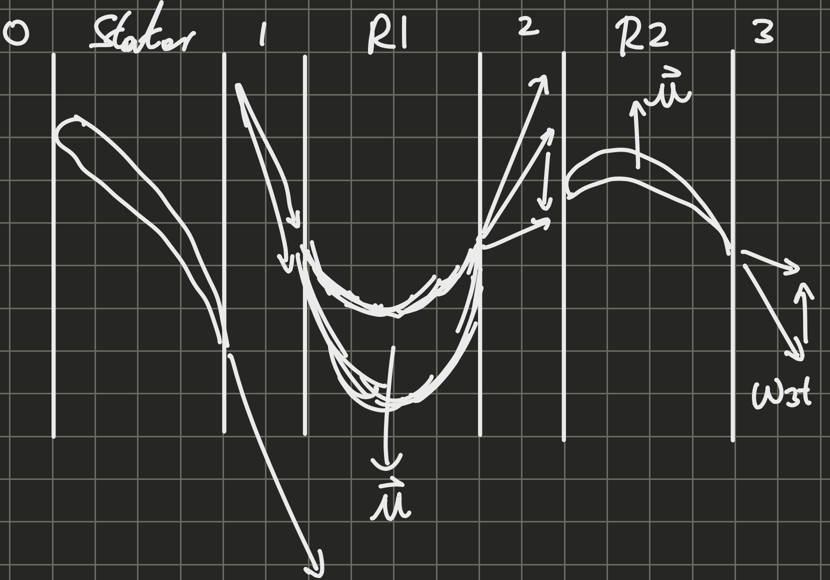
$Q_{11} = 2.5\, m^3/s = Q_{T1} + Q_{T2} \rightarrow Q_{T2} = 0.8\, m^3/s$

Calculate from first equation

$Q_{T2} = 0.8\, m^3/s \longrightarrow n_{T2}$

Exercise 2

$\left.\begin{array}{l}\text{Ideal} \rightarrow \Delta s = 0 \\ \text{Impulse } \chi = 0 \Rightarrow h_1 = h_2 = h_3\end{array}\right\} P_1 = P_2 = P_3 = P_{OUT}$

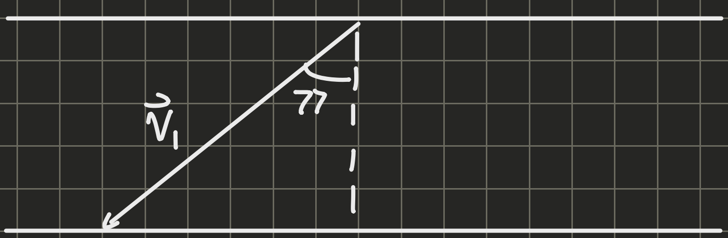


Axial $\Rightarrow \Delta u = 0$

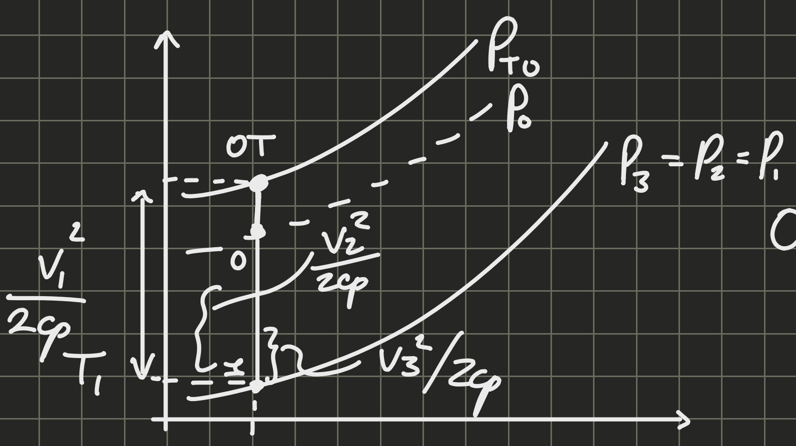
Not optimise:

$V_{3t} \neq 0$

Axial Velocity = constant + impulse $\Rightarrow$ rotors are symmetric.

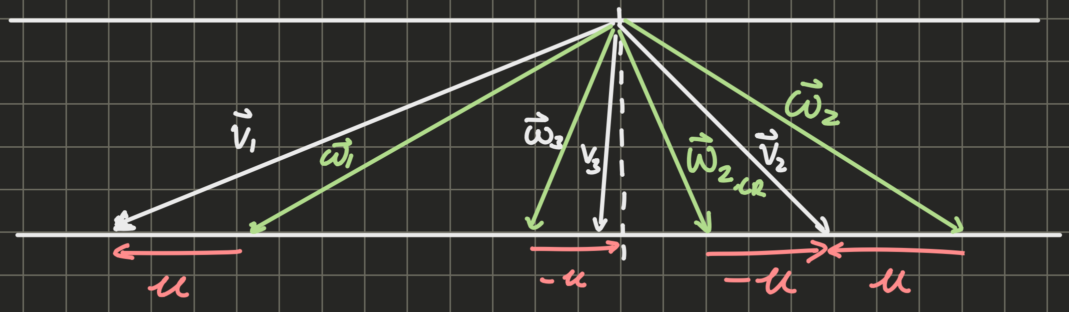


Isentropic flow
$\Rightarrow$ same blade height along flow.



$OT = 1T > 2T > 3$

$S_0 = S_1 = S_2 = S_3$



Symmetric $\beta_1 = \beta_2$

$\beta_{2CR} = \beta_3$

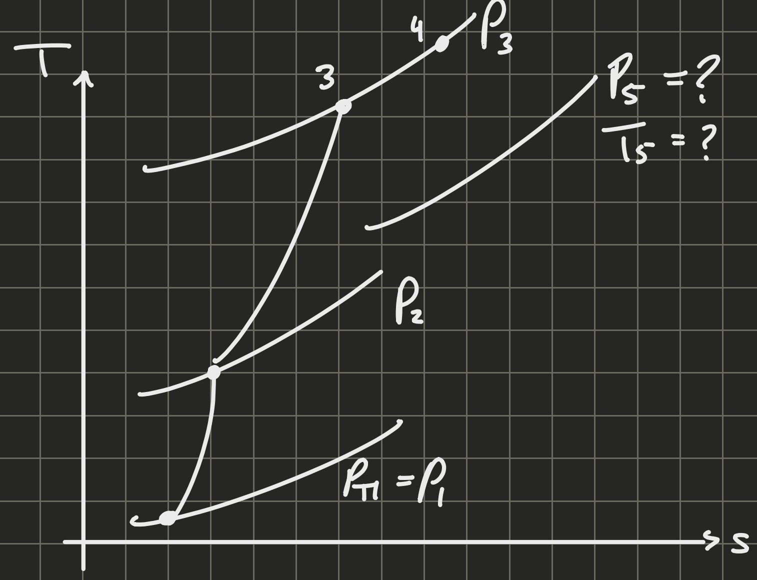
This is like a Curtis which exchanges a lot of energy at the expense of some high tangential flow.

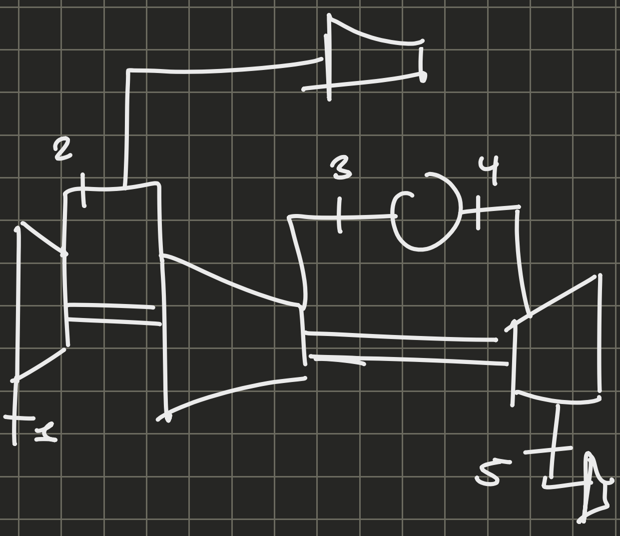
$$\omega_{2CR,t} = V_{2t} - (u_{CR}) = V_{2t} - (-u) = V_{2t} + u$$

$$V_{3t} = \omega_{3t} + u_{CR} = \omega_{3t} - u$$

Exercise 3

Total = Static since considered black box





We need $P_5 > P_0$ since this is propulsion system so we need residual pressure to propel us.

Balance Shaft:

$$\dot{L}_F + \dot{L}_C + \dot{L}_E = 0$$

$$\dot{m}_{IN} c_p (T_2 - T_1) + \underbrace{\dot{m}_{CORE}}_{\dot{m}_{IN} - \dot{m}_{BY}} c_p (T_3 - T_2) + \dot{m}_{FG} c_p (T_5 - T_4) = 0$$

$\hookrightarrow \dot{m}_{CORE} + \dot{m}_F$

$\rightarrow T_5$

$$\alpha = \frac{\dot{m}_{CORE}}{\dot{m}_F}$$

$$\frac{T_5}{T_4} = \left(\frac{P_5}{P_4}\right)^{\frac{n_T - 1}{n_T}}$$

Nozzles: (Always isoentropic for exam)

We find β, if $\beta > \beta_{crit}$ and the nozzle is purely convergent we can impose $M = 1$