Problem 11.3

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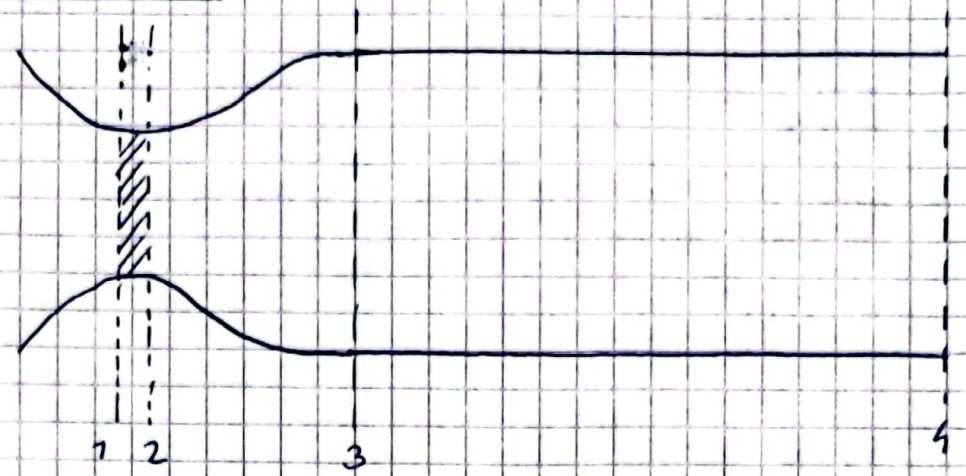
a. I.)



Sonic conditions in nozzle: $M = 1$

$\frac{A}{A^*} = 3 \rightarrow M_3 = 0.194$

$\frac{4fx}{D_H} = \frac{4f \cdot 2Dx}{\pi D^2} = \frac{8}{\pi^2} fx = 0.1488\ 0.168$

$\rightarrow M_4 = 0.1945$

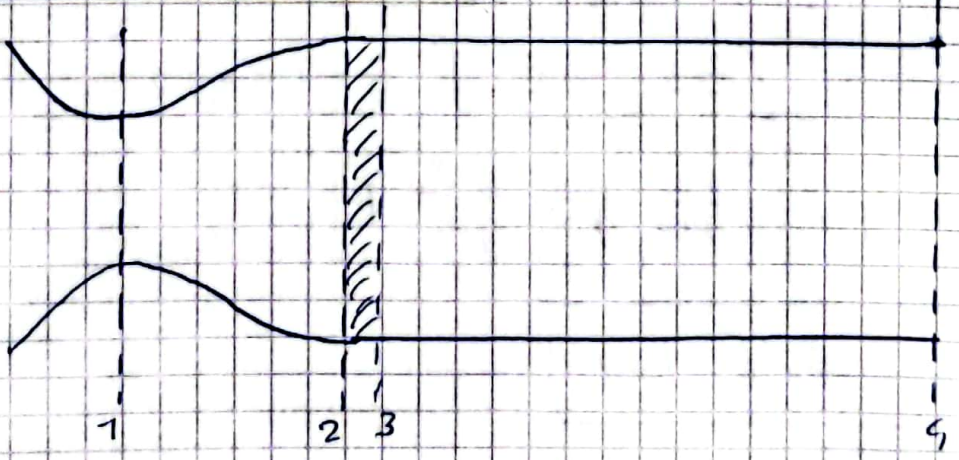
$p_3 = p_t (1 + 0.2 M_3^2)^{-3.5} = 9.738$ bar

$\frac{p_4}{p^*} = \frac{1}{M_4} \left[\frac{2 + 0.4 M_4^2}{2.4} \right]^3 = 3.0434$

$\frac{p_3}{p^*} = \frac{1}{M_3} \left[\frac{2 + 0.4 M_3^2}{2.4} \right]^3 = 3.0508$

$\rightarrow$ **pres = 9.7141 bar**

II.)



$\frac{A}{A^*} = 3 \rightarrow M_2 = 2.64$

Shock table $\rightarrow M_3 = 0.5005$

$\left.\begin{matrix} \frac{A}{A^*} = 3 \rightarrow M_2 = 2.64 \\ \text{Shock table} \rightarrow M_3 = 0.5005 \end{matrix}\right\} \frac{p_{03}}{p_{02}} = 0.4452$

$\rightarrow$ $p_{03} = 10$ bar , $p_{04} = 4,452$ bar

$M_4 = 0,514$ (fanno line)

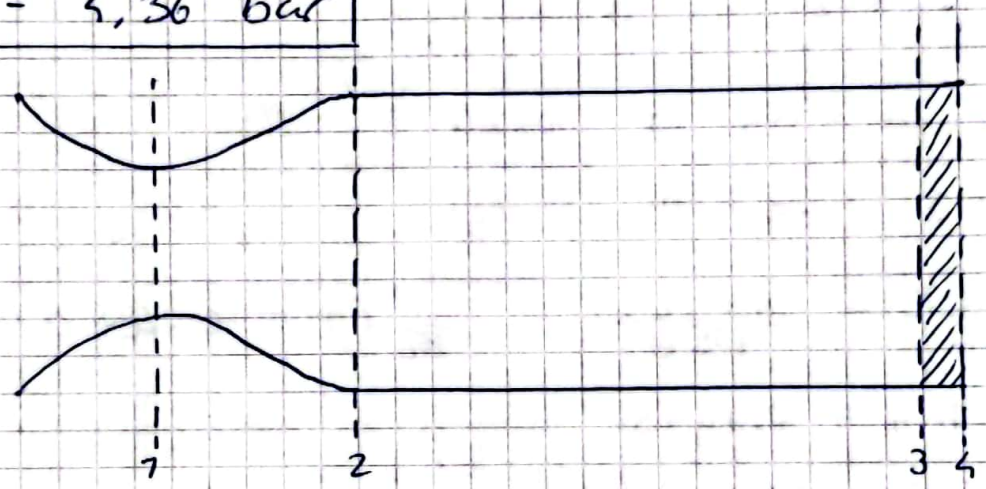
$$\frac{p_{04}}{p_0^*} = \frac{1}{M_4}\left[\frac{2+0,4M_4^2}{2,4}\right]^3 = 1,3186$$

$$\frac{p_{03}}{p_0^*} = \frac{1}{M_3}\left[\frac{2+0,4M_3^2}{2,4}\right]^3 = 1,3389$$

$$p_{04} = \frac{p_{04}}{p_0^*} \cdot \frac{p_0^*}{p_{03}} \cdot p_{03}$$

$$\boxed{p_{04} = 4,36 \text{ bar}}$$

III.)



$M_2 = 2,64$, $M_3 = 2,122$ (fanno line)

$M_4 = 0,5583$ (shock table)

$$\rightarrow \frac{p_{04}}{p_{03}} = 0,6649$$

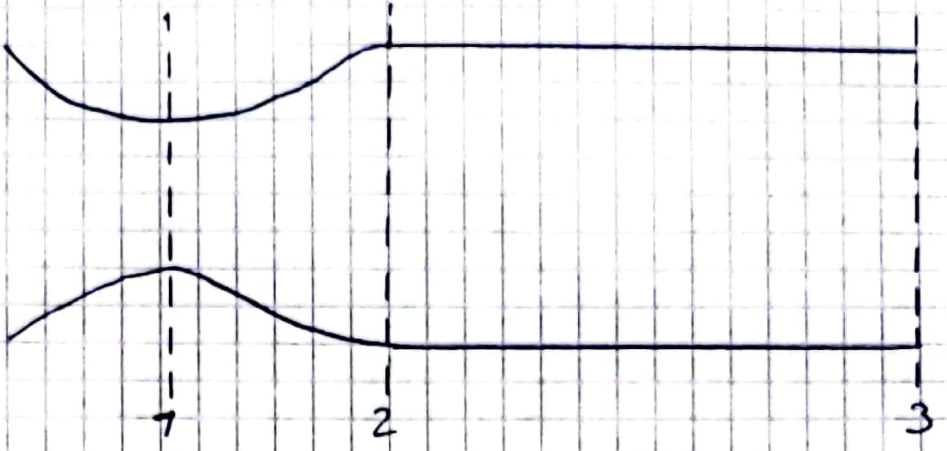
$$\frac{p_{02}}{p_0^*} = \frac{1}{M_2}\left[\frac{2+0,4M_2^2}{2,4}\right]^3 = 3,0073$$

$$\frac{p_{03}}{p_0^*} = \frac{1}{M_3}\left[\frac{2+0,4M_3^2}{2,4}\right]^3 = 1,8723$$

$$p_{res} = p_{04} = \frac{p_{04}}{p_{03}} \frac{p_{03}}{p_0^*} \frac{p_0^*}{p_{02}} p_{02}$$

$$\boxed{p_{res} = 4,14 \text{ bar}}$$

b.



$M_2 = 2.64$, $M_3 = 2.122$

$$\frac{p_{02}}{p_0^*} = \frac{1}{M_2}\left[\frac{2 + 0.4 M_2^2}{2.4}\right]^3 = 3.0073$$

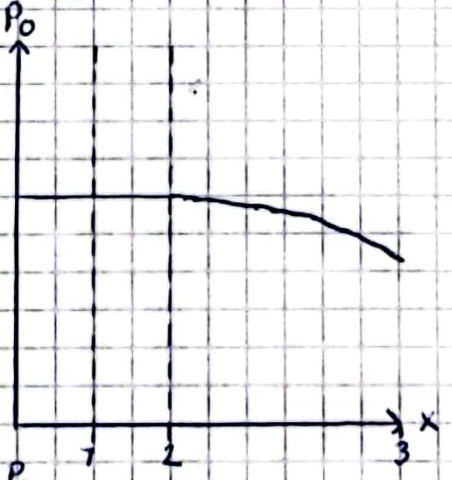
$$\frac{p_{03}}{p_0^*} = \frac{1}{M_3}\left[\frac{2 + 0.4 M_3^2}{2.4}\right]^3 = 1.8723$$

$$p_{res} = \frac{p_{03}}{p_0^*}\,\frac{p_0^*}{p_{02}}\,p_{02}$$

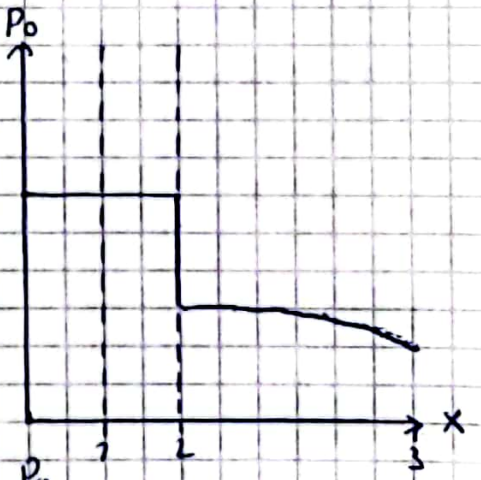
$$\boxed{p_{res} = 6.23 \text{ bar}}$$

c. Use figure above for points 1, 2, 3

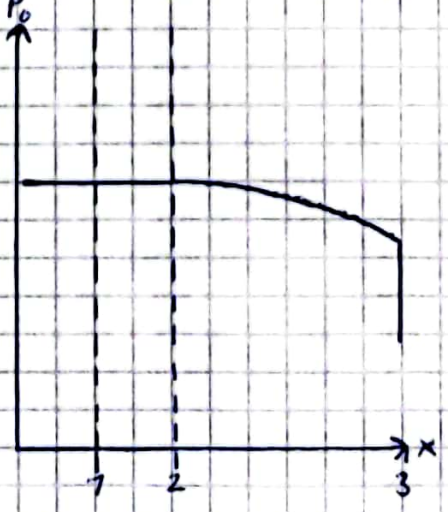
a I.)



a II.)



a III.)



b.)