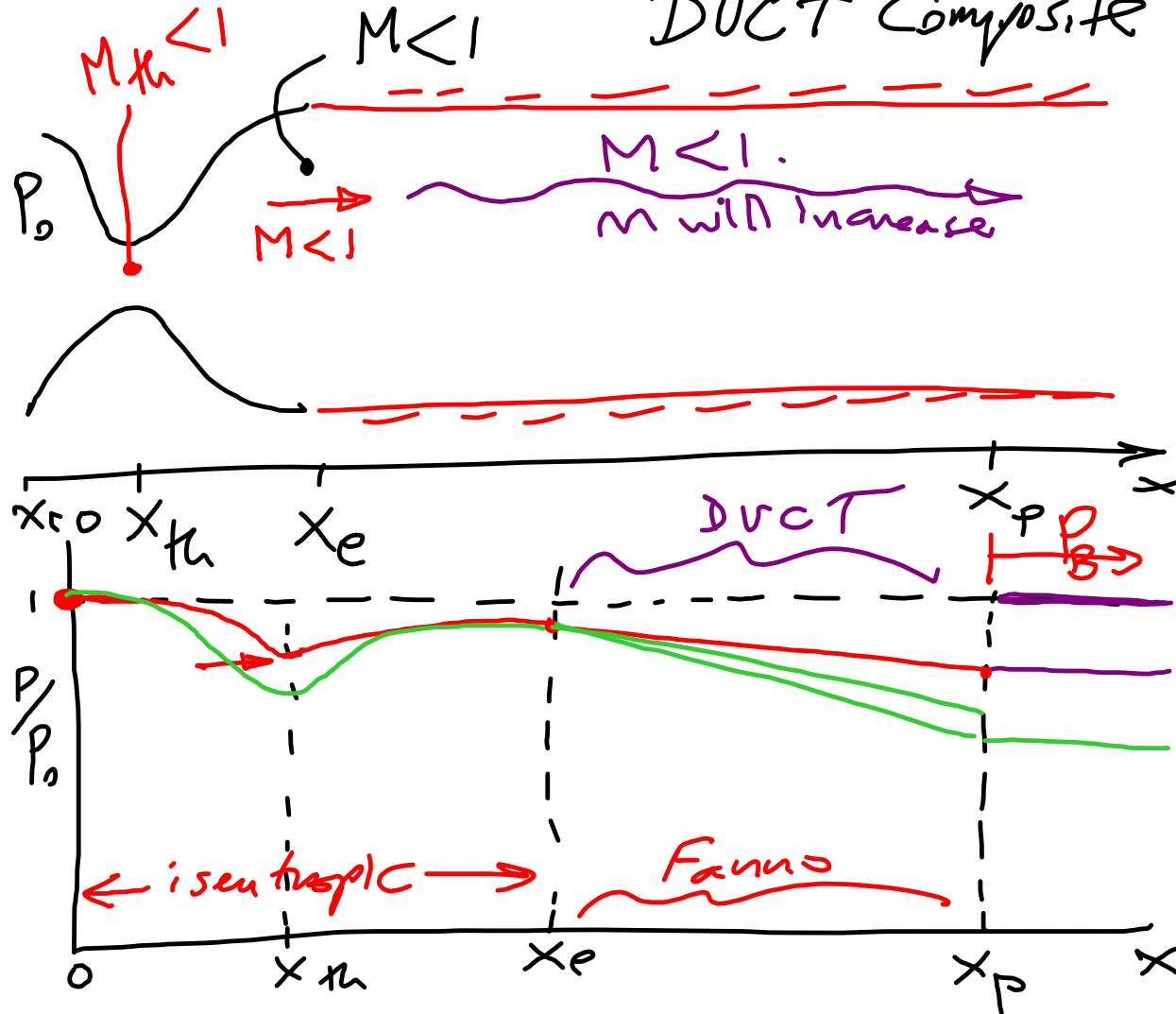
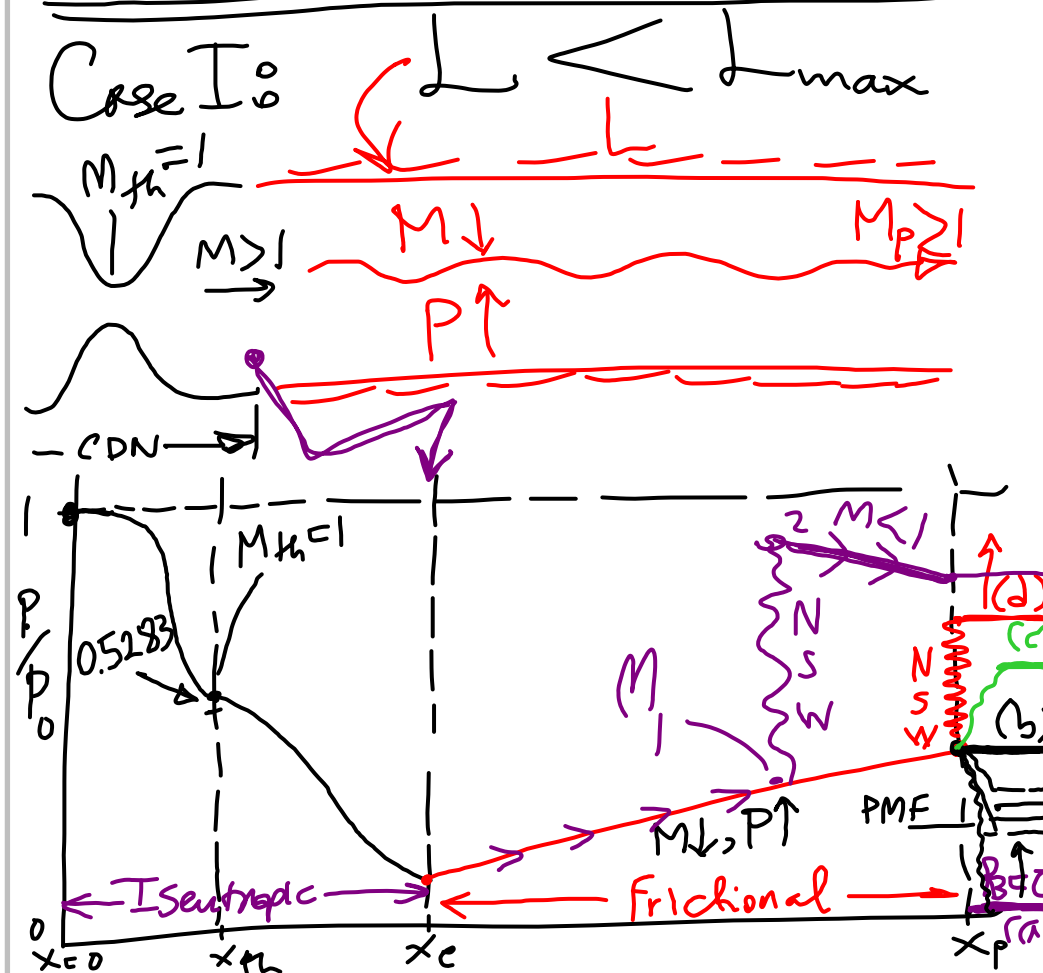


Lecture 24

Subsonic Flow in a CDN & DUCT Composite



- No change in $\dot{m}$ is possible
- L of the duct will not affect the mass flow rate



(a) $P_B \approx 0 \Rightarrow$ Expansion Waves
(PM Fan)

$M_P = 1$ is not possible, since
 $L < L_{max} \Rightarrow M_P$ will be
supersonic!

(b) $P_P = P_B$ (no PM-fan)
(flow still supersonic in the duct)

(c) OSW at the end of
the duct!

(d) NSW at the duct exit!

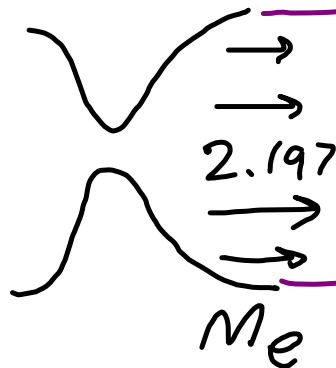
- Higher P_B will force the NSW into the duct

- A very high P_B will take NSW into the nozzle.

Example: CDN ($AR = 2$)
 $P_0 = 500 \text{ kPa abs.}$

$$L/D = 10$$

$$f = 0.02$$



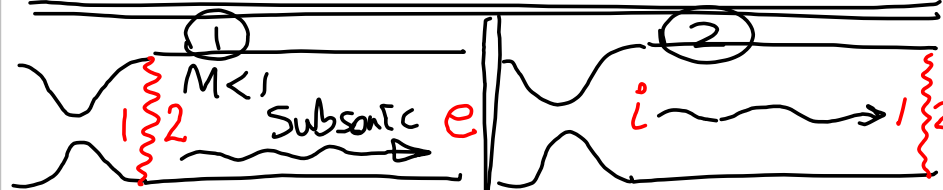
Find the range of P_B
 P_B over which NSW appears in the duct.

$$AR=2 \Rightarrow M_{\text{supdes}} = 2.197$$

$$\left. \frac{fL_{\max}}{D} \right|_{\text{App F}} = \underline{\underline{0.3601}}$$

$$\frac{fL}{D} = (0.02)(10) = 0.2 < 0.3601$$

($L < L_{\max}$)



$$M_1 = 2.197$$

$$M_2 = 0.5475$$

$$\text{App. F.} \Rightarrow \frac{fL_{\max}}{D} = 0.7427$$

$$\left. \frac{fL}{D} \right| = 0.7427 - 0.2$$

$$e = 0.5427$$

$$\Rightarrow M_e = 0.5875$$

$$M_i = 2.197$$

$$M_1 = ? \text{ (sup.)}$$

$$\text{App. F.} \left. \frac{fL_{\max}}{D} \right| = 0.3601$$

$$\left. \frac{fL}{D} \right| = 0.3601 - 0.2$$

$$= 0.1601$$

$$P_B = P_e = \frac{P_e}{P^*} \frac{P^*}{P_2} \frac{P_2}{P_1} \frac{P_1}{P_{01}} \cdot P_{01}$$

$\underbrace{\frac{P_e}{P^*}}_{\text{App. F}} \quad \underbrace{\frac{P^*}{P_2}}_{\text{NSW}} \quad \underbrace{\frac{P_2}{P_1}}_{\text{isent.}}$

500 kPa

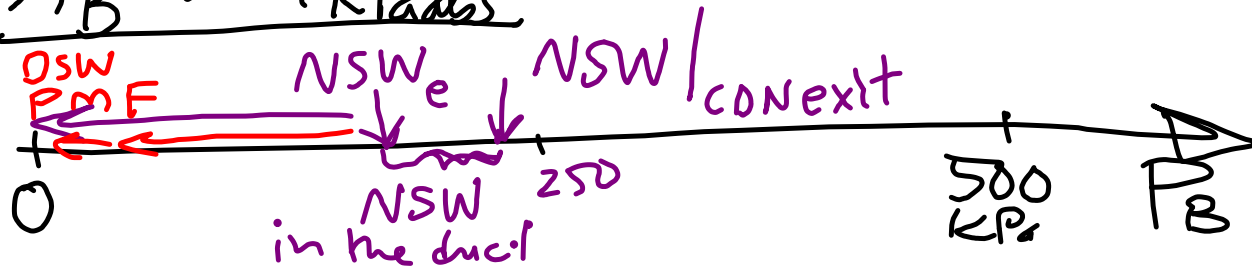
$M_1 = 1.566$
 NSW table
 $P_2/P_1 = 2.695$

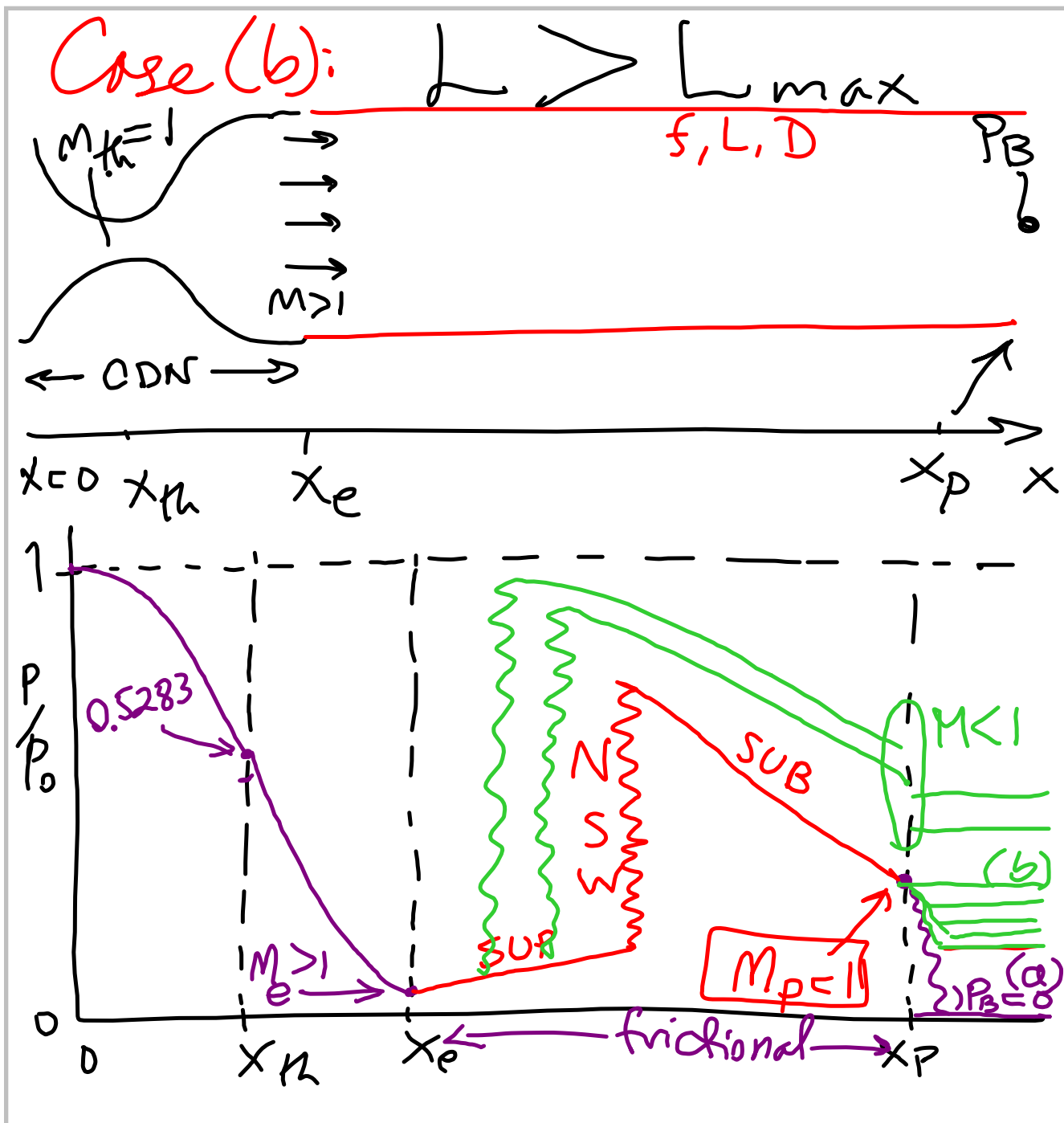
= 238.2 kPa_{abs}

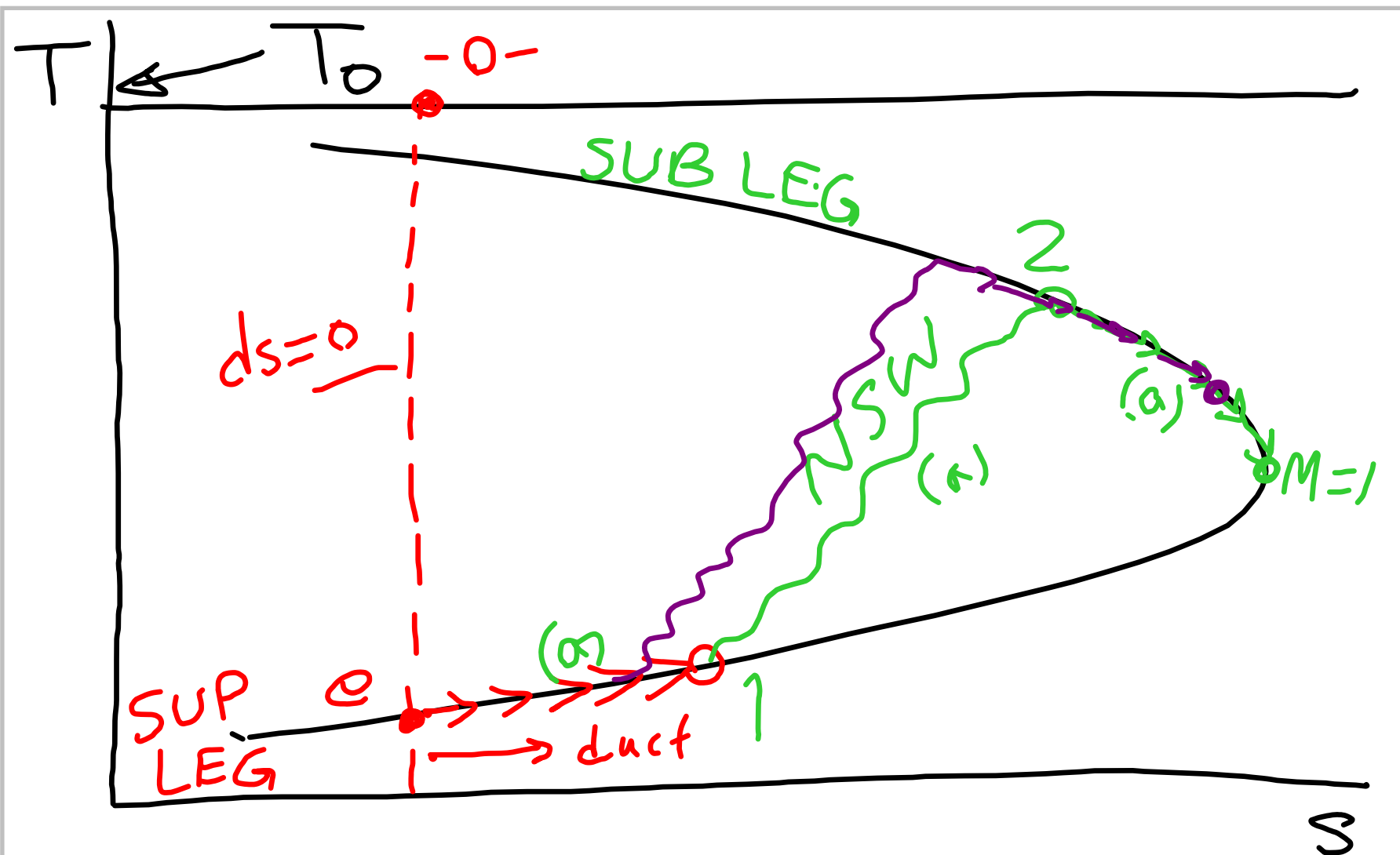
$$P_B = P_2 = \frac{P_2}{P_1} \frac{P_1}{P^*} \frac{P^*}{P_i} \frac{P_i}{P_{01}} P_{01}$$

$\underbrace{\frac{P_2}{P_1}}_{\text{NSW}} \quad \underbrace{\frac{P_1}{P^*} \frac{P^*}{P_i}}_{\text{App. F}} \quad \underbrace{\frac{P_i}{P_{01}}}_{\text{isentropic}}$

$\Rightarrow P_B = 204 \text{ kPa}_{\text{abs}}$







(a) $P_B = 0 \Rightarrow$ Expansion Waves
at $X_p \Rightarrow$ PMF

PM fans occur when
 $M_p \geq 1$

① ~~$M_p > 1$~~
② $M_p = 1$

$\Rightarrow M_p = 1$ when $P_B = 0$

$M_u = 1, M_e > 1, \Rightarrow$ NSW