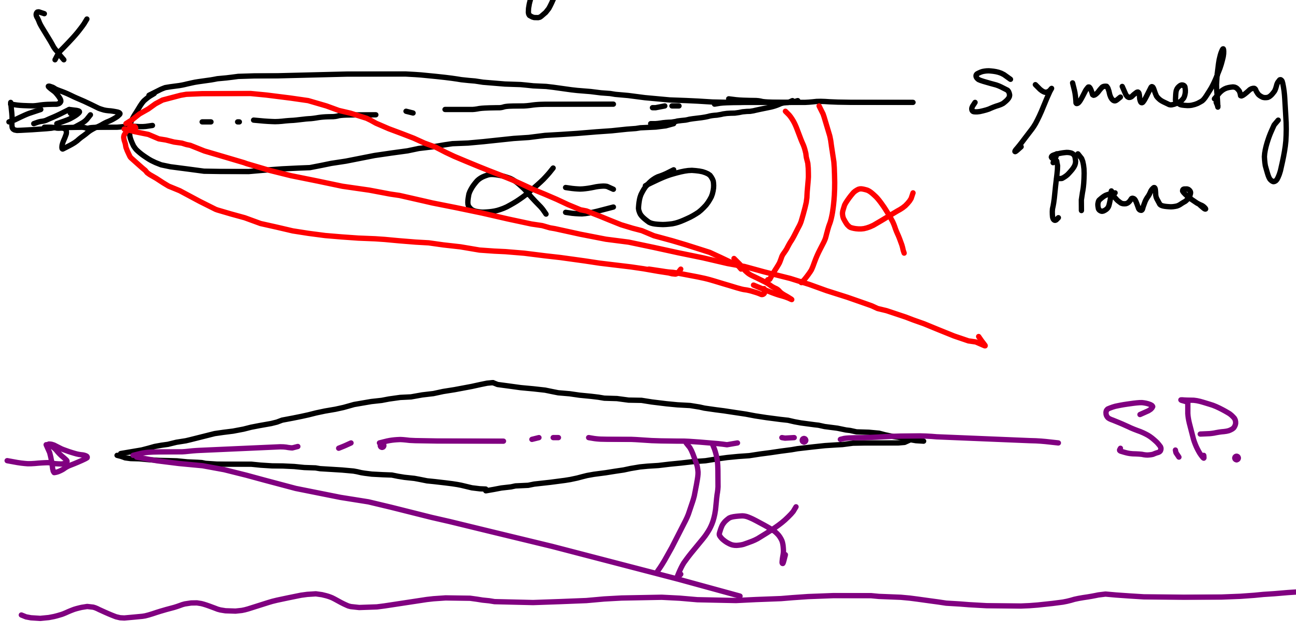
Lecture 19

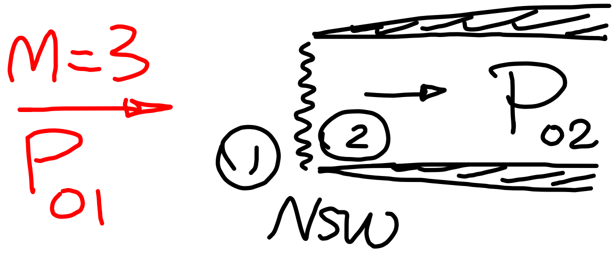
- HW Set 7 Returned
- Solution e-mailed!

HW 8: Angle of attack = α



Supersonic Inlets

Ex. Supersonic 2-D inlet

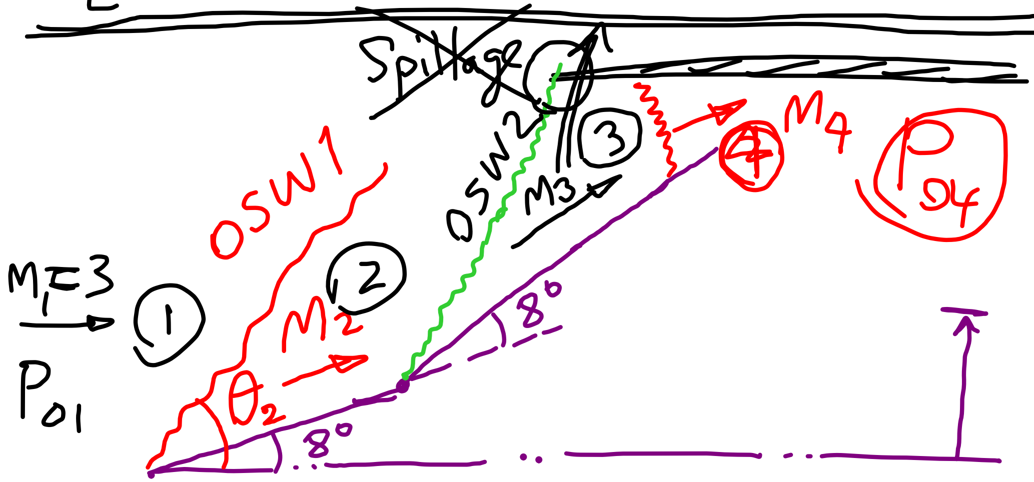


$\Rightarrow$ Loss of Stagnation press.?

$M_1 = 3 \Rightarrow$ App. C.

$$\Rightarrow P_{02}/P_{01} = 0.328$$

[BAD DESIGN]



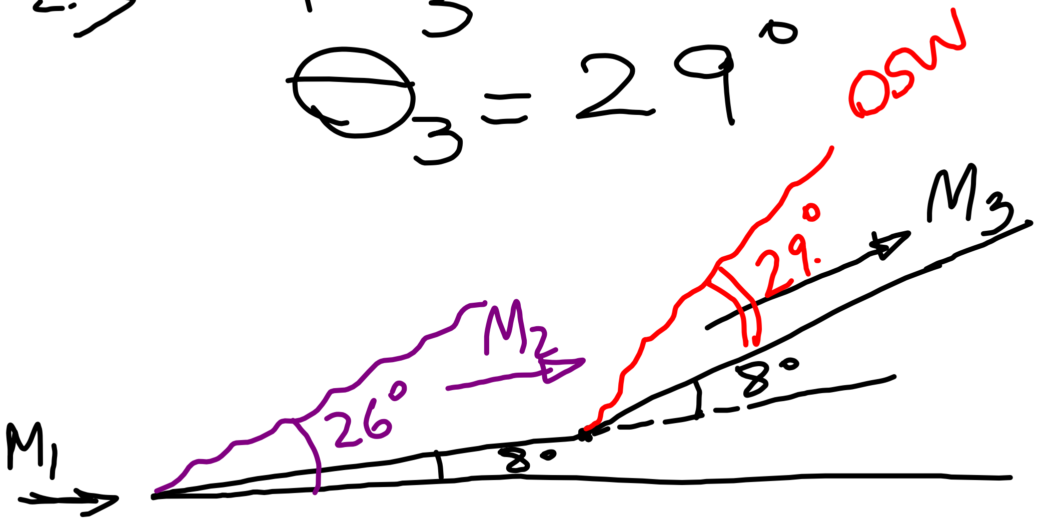
Figs. D1–D6: $M_1 = 3$, $\delta = 8^\circ$ $\Rightarrow \theta_2 \approx 26^\circ$

$\Rightarrow M_2 = 2.60$

$M_2 = 2.60$ & $\delta = 8^\circ$

$\Rightarrow$ $M_3 = 2.2\overline{55}$

$\theta_3 = 29^\circ$



$$M_{1n} = 3\sin 26^\circ = 1.30$$
(supersonic)

$$M_{2n} = M_2 \sin 29^\circ = (2.6)(\sin 29) = 1.26$$
(supersonic)

M_{1n} [OSW1]
M_{2n} [OSW2]
M_3 [NSW]

NSW Table $\Rightarrow$

$$\frac{P_{02}}{P_{01}} = 0.979$$

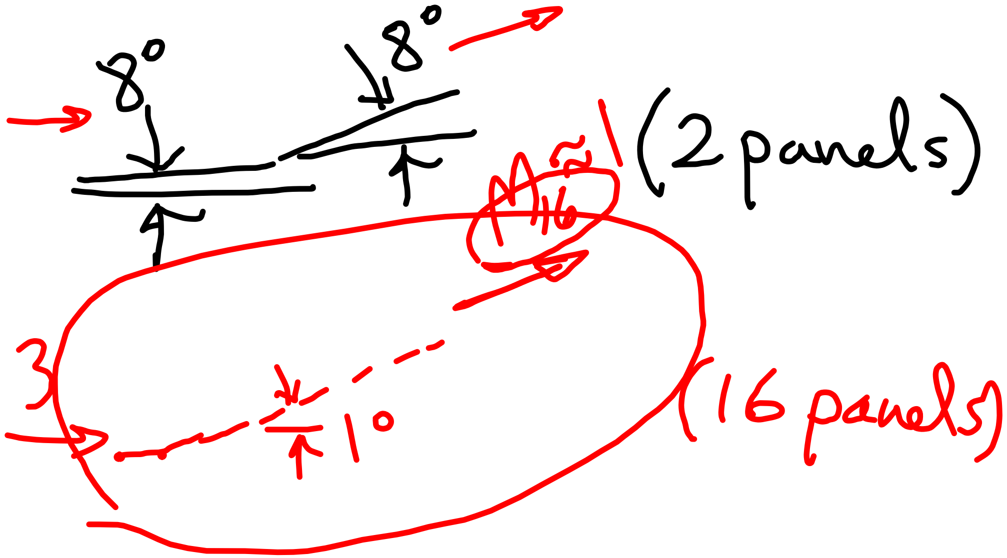
$$\frac{P_{03}}{P_{02}} = 0.986$$

$$\frac{P_{04}}{P_{03}} = 0.603$$

$$\frac{P_{o4}}{P_{o1}} = \frac{P_{o4}}{P_{o3}}\,\frac{P_{o3}}{P_{o2}}\,\frac{P_{o2}}{P_{a}} = (0.979)(0.988)(0.683)$$

$$= \underline{\underline{0.582}}$$

Compared: 0.328 NSW



$$\underline{0.328}$$
$$\Downarrow$$
$$0.582$$
$$\Downarrow$$
$$1$$

$\Rightarrow$ Small-angle wedges

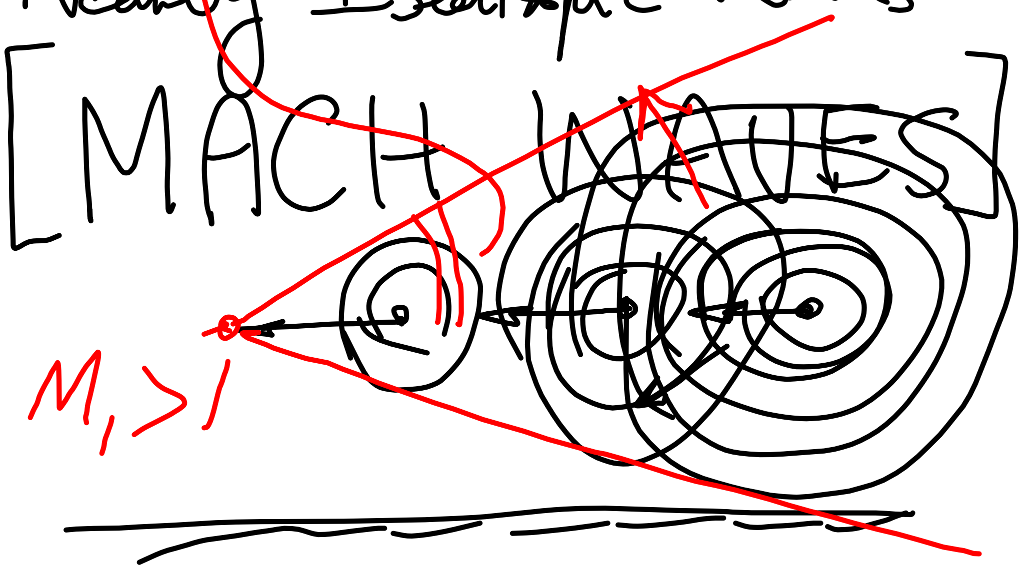
$\Rightarrow$ $M_1 \approx M_2$. [Figs. D's]

when $\delta \approx 0$.

$\Rightarrow$ $\Theta \approx \sin^{-1} \dfrac{1}{M_1}$ [$\delta \approx 0$]

$\Rightarrow$ Nearly Isentropic Waves

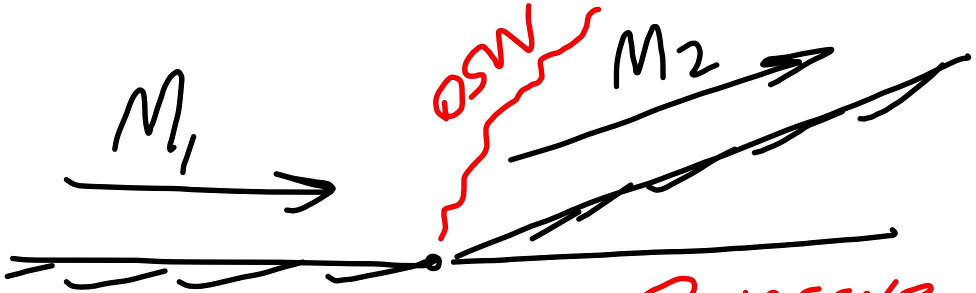
[MACH WAVES]

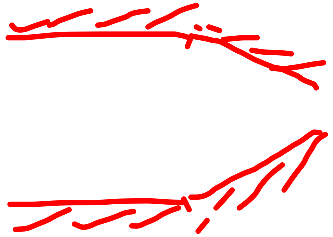


⇒ As the half angle is lowered, "Near" isentropic conditions are realized!

Chapter 7 Prandtl-Meyer Flows (PM Flows)

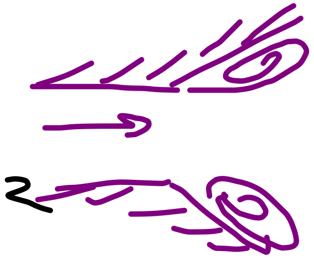
Ludwig Prandtl → PhD Thesis in 1908!





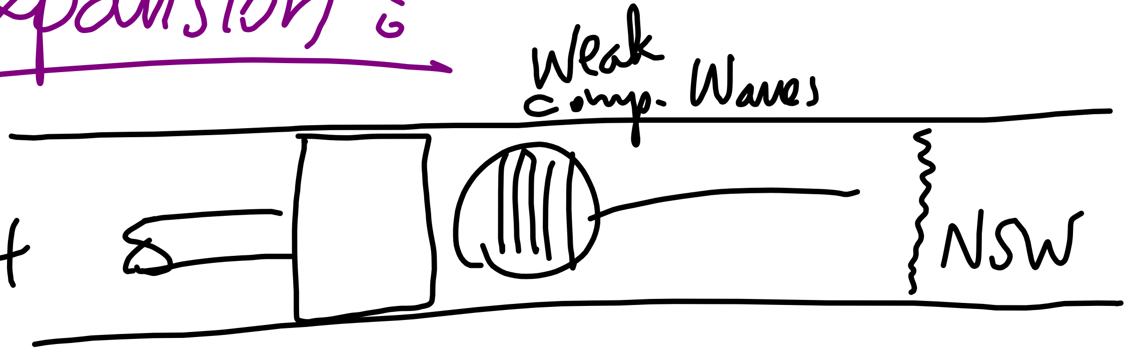
Supersonic Compression

Concave corner



Convex corner

Supersonic Expansion?



CH. 4

We showed in Ch. 4 that Normal Expansion Waves are Impossible!

7.2 Thermodynamic Considerations

Since (Ch. 6): $V_{1t} = V_{2t}$

$\Rightarrow$ Geometry $\Rightarrow$ $\underline{\underline{V_{2n} > V_{1n}}}$

$\Rightarrow$ n-dir. momentum eq.

$$P_1 + \rho_1 V_{1n}^2 = P_2 + \rho_2 V_{2n}^2$$

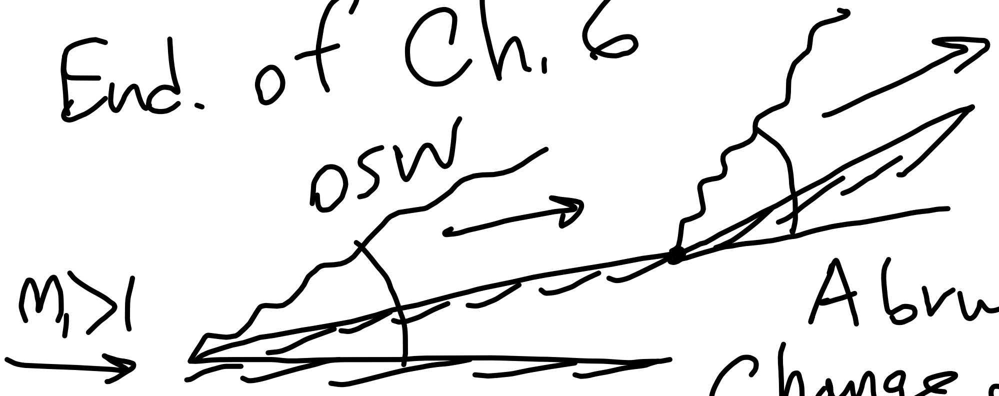
Continuity: $\rho_1 \underline{\underline{V_{1n}}} = \rho_2 \underline{\underline{V_{2n}}}$

$[\rho_2 < \rho_1 \Rightarrow \text{expansion}]$

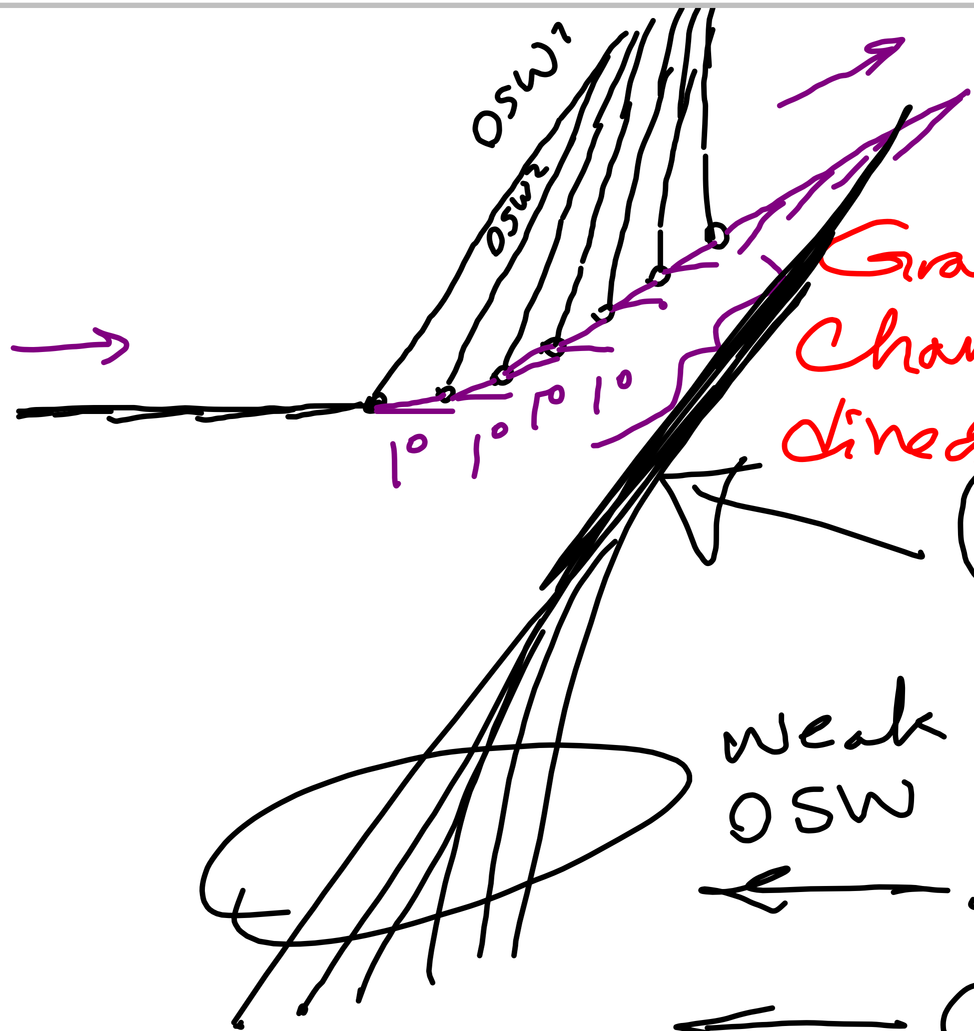
$$P_2 - P_1 = \rho_1 V_{1n} \underbrace{(V_{1n} - V_{2n})}_{(-)}$$

$$\Rightarrow P_1 > P_2$$ Expansion Process

End. of Ch. 6



Abrupt change of direction



Gradual change of directions

OSW

weak OSW

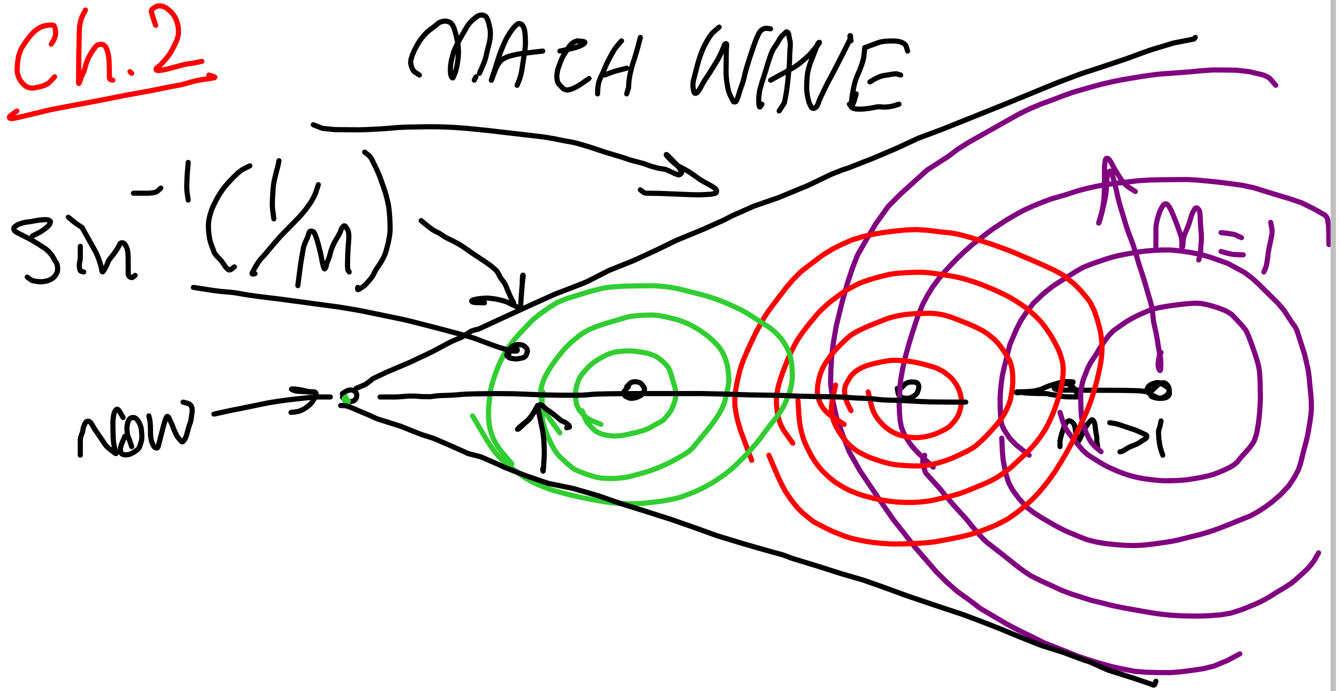
Better design

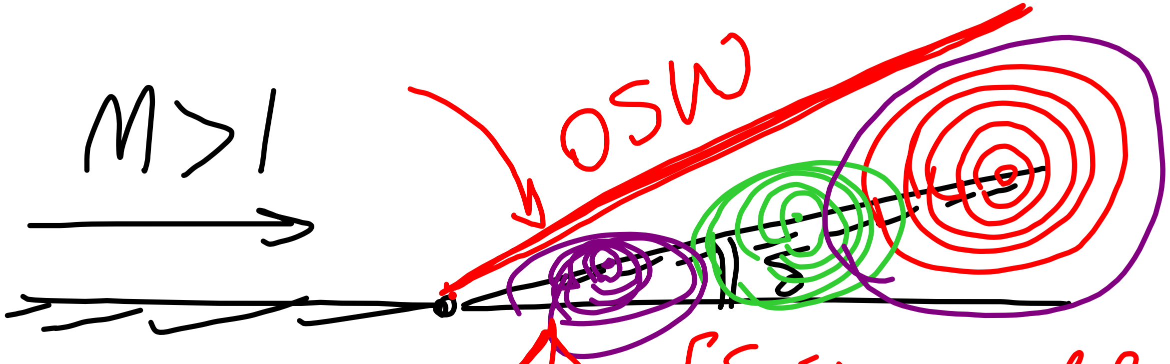
Costs more!

Reduced loss of P_0!

⇒ As the # of oblique shock waves becomes greater & greater, the OSW behaves more like "MACH WAVES"

Ch. 2





[δ is small

Mach Angle $= \mu$

$$\Rightarrow \mu = \sin^{-1}\left(1/M\right)$$

Fig. D