Normal Shock Waves

Lecture 24

ME EN 412
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Outline

Normal Shock Waves

Example

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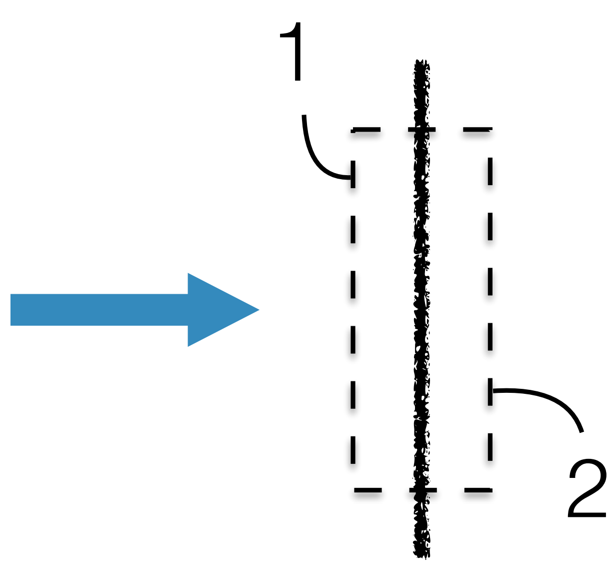


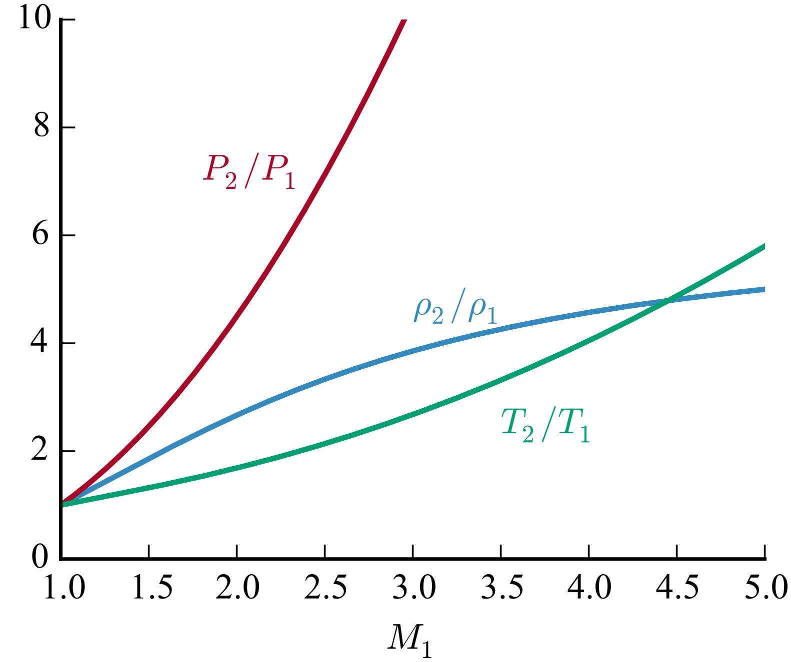
Prandtl relation

$$u_1 u_2 = a^{*2}$$

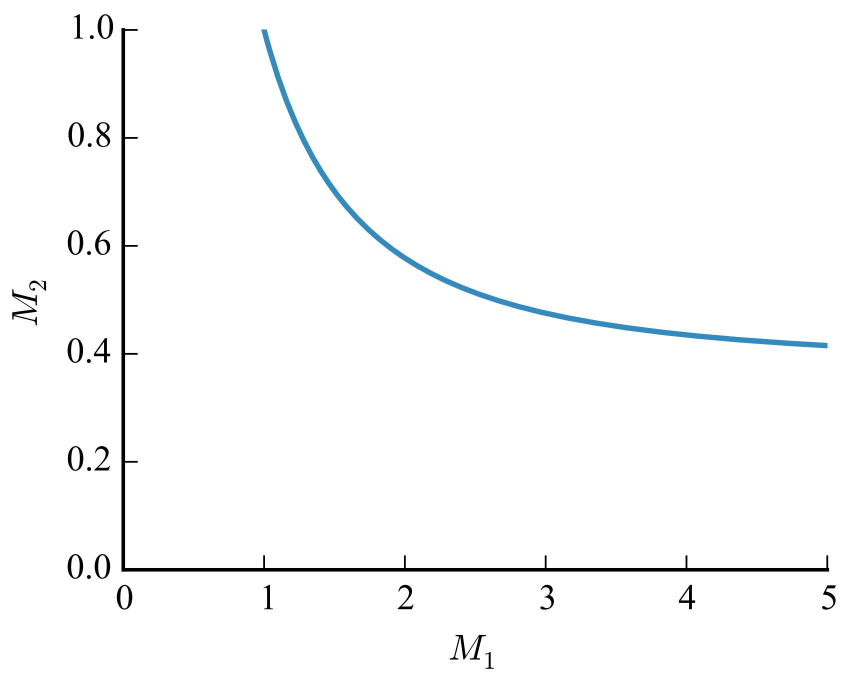
$$\frac{u_2}{u_1} = \frac{\rho_1}{\rho_2} = \frac{2 + (\gamma - 1)M_1^2}{(\gamma + 1)M_1^2}$$

$$\frac{P_2}{P_1} = 1 + \frac{2\gamma}{\gamma + 1}(M_1^2 - 1)$$

$$\frac{T_2}{T_1} = \frac{h_2}{h_1} = \frac{P_2}{P_1}\frac{\rho_1}{\rho_2}$$



$$M_2 = \sqrt{\frac{2 + (\gamma - 1)M_1^2}{2\gamma M_1^2 - (\gamma - 1)}}$$

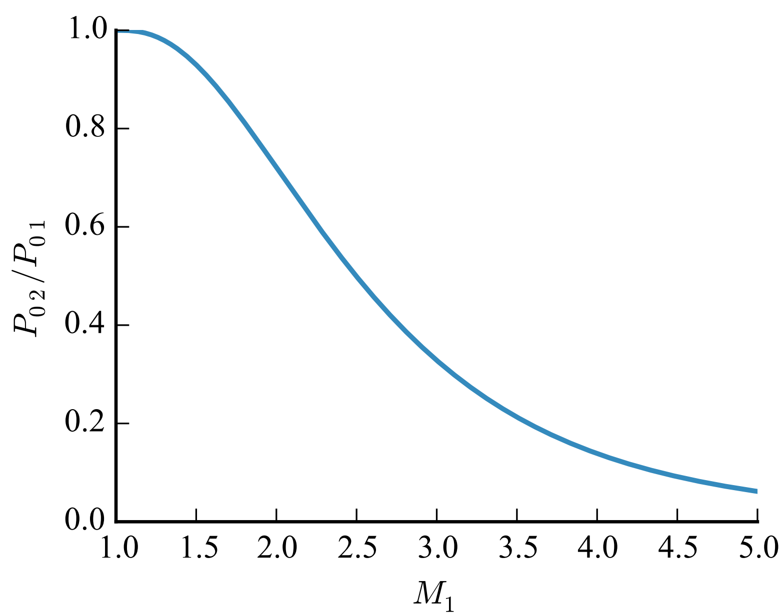


Total temperature is constant across a shock wave

$$T_{01} = T_{02}$$

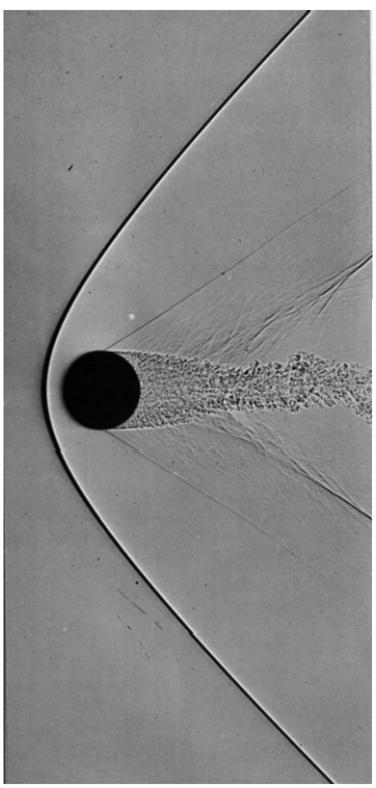
Total pressure decreases.

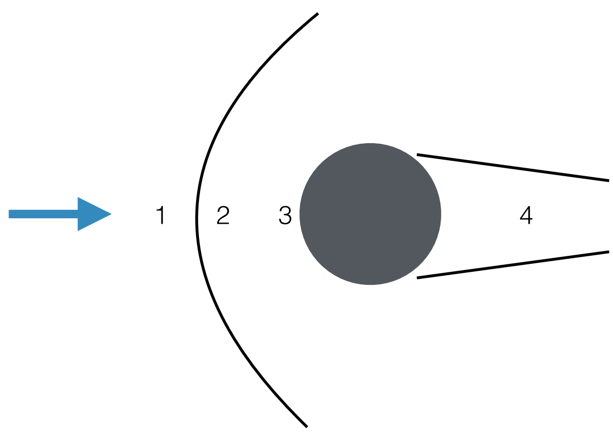
$$\frac{P_{02}}{P_{01}} = \left(\frac{\gamma + 1}{2\gamma M_1^2 - (\gamma - 1)}\right)^{\frac{1}{\gamma-1}} \left(\frac{(\gamma + 1)M_1^2}{2 + (\gamma - 1)M_1^2}\right)^{\frac{\gamma}{\gamma-1}}$$



For each of these quantities, do they increase, decrease, or stay the same after passing through a normal shock wave?

- Mach number
- velocity
- pressure
- stagnation pressure
- temperature
- stagnation temperature
- density
- entropy





An Album of Fluid Motion, Van Dyke

Example

The SR-71 aircraft was design to fly at $M_\infty = 3.2$ at 85,000 feet. Assume there was a bow shock in front of the aircraft[1], what would the stagnation temperature and pressure be at the nose.

[1]the aircraft is designed with a pointed nose to create oblique shocks, but we haven't covered oblique shocks yet, instead think of a blunt nosed missile