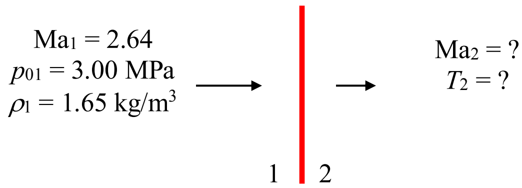
An air stream approaches a normal shock at $Ma_1 = 2.64$. Upstream, $p_{01} = 3.00$ MPa (abs) and $\rho_1 = 1.65$ kg/m^3. Determine the downstream Mach number and temperature.

SOLUTION:



The downstream Mach number may be found from the normal shock relations:

$$\text{Ma}_2^2 = \frac{(\gamma-1)\text{Ma}_1^2 + 2}{2\gamma\text{Ma}_1^2 - (\gamma-1)} \tag{1}$$

where $\text{Ma}_1 = 2.64$ and $\gamma = 1.4$.

$\boxed{\therefore \text{Ma}_2 = 0.50}$

One method of finding the downstream temperature is to determine the upstream stagnation temperature and then use the downstream Mach number and the adiabatic stagnation temperature ratio along with the fact that the stagnation temperature remains constant across the shock wave to determine the downstream static temperature.

$$\frac{\rho_1}{\rho_{01}} = \left(1 + \frac{\gamma-1}{2}\text{Ma}_1^2\right)^{\frac{1}{1-\gamma}} \Rightarrow \rho_{01} = 14.6 \text{ kg/m}^3 \text{ (where } \rho_1 = 1.65 \text{ kg/m}^3\text{)} \tag{2}$$

$$T_{01} = \frac{p_{01}}{\rho_{01} R} \Rightarrow T_{01} = 714 \text{ K} \quad \text{(where } R = 287 \text{ J/(kg}\cdot\text{K))} \tag{3}$$

$$T_{02} = T_{01} \Rightarrow T_{02} = 714 \text{ K} \tag{4}$$

$$\frac{T_2}{T_{02}} = \left(1 + \frac{\gamma-1}{2}\text{Ma}_2^2\right)^{-1} \Rightarrow \boxed{T_2 = 680 \text{ K}} \text{ (where } \text{Ma}_2 = 0.50\text{)} \tag{5}$$