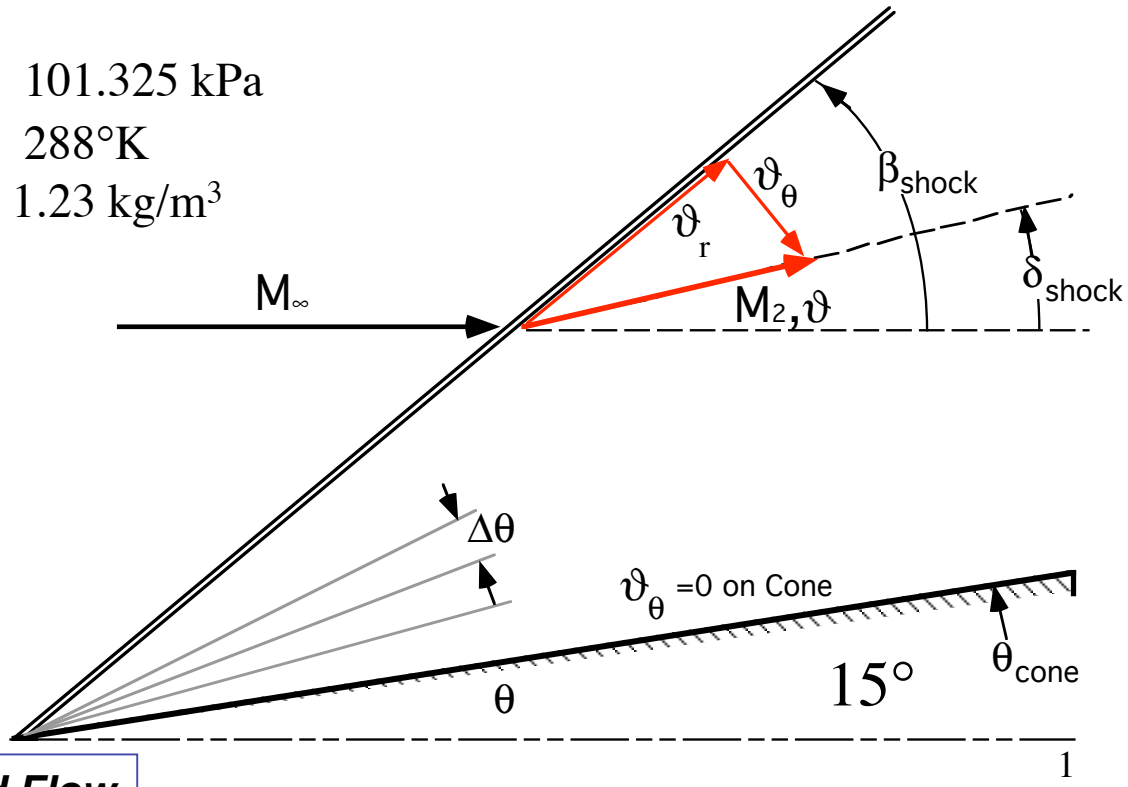
Homework 12

- Code Taylor-Maccoll algorithm for cone flow

- Solve for flow conditions on surface of Cone at freestream Mach 2.0 with 15° half angle

p_∞ = 101.325 kPa
T_∞ = 288°K
ρ_∞ = 1.23 kg/m^3

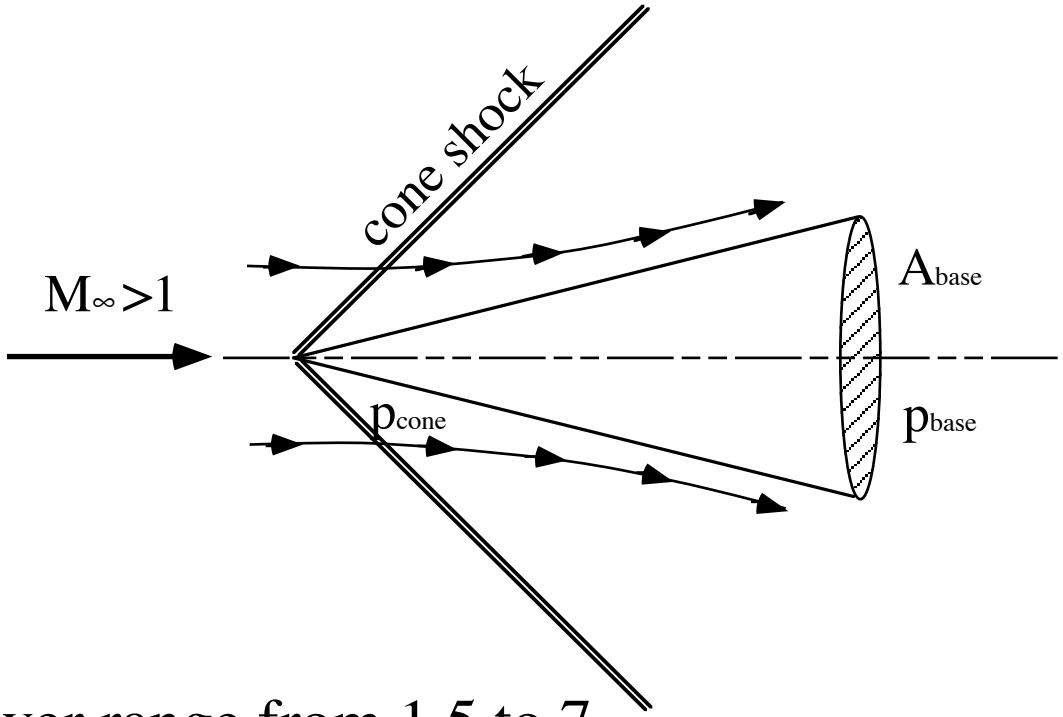


Homework 12 (Continued)

- Define $C_{D_{cone}} = \dfrac{D_{cone}}{\bar{q}_\infty A_{base}}$

• Hint: You'll have to do trial And error for each mach number to get the Shock angle correct

- Derive an expression for the cone wave drag as a function of the cone surface pressure (p_{cone}) and the base pressure (p_{base})



- Assume $p_{base} = p_\infty$
  plot $C_{D_{cone}}$ versus Mach over range from 1.5 to 7

Part 1 Solution

11.1 (a) $\theta_{shock} = 0.592 \text{ rad} = \boxed{33.9°}$ 33.933 deg

(b) $p_s/p_\infty = 1.286 \therefore p_s = 1.286\ (1.01 \times 10^5) = \boxed{1.3 \times 10^5 \text{ N/m}^2}$

$\rho_s/\rho_\infty = 1.196 \therefore \rho_s = 1.196\ (1.23) = \boxed{1.47 \text{ kg/m}^3}$

$T_s/T_\infty = 1.075 \therefore T_s = 1.075\ (288) = \boxed{310°\text{K}}$

$M_s = \boxed{1.835}$

(c) $p_c/p_\infty = 1.566$ $\boxed{p_c = 1.58 \times 10^5 \text{ N/m}^2}$ 158.88 N/m^2

$\rho_c/\rho_\infty = 1.377$ $\boxed{\rho_c = 1.69 \text{ kg/m}^3}$ 1.70 kg/m^3

$T_c/T_\infty = 1.137$ $\boxed{T_c = 327°\text{K}}$ 327.65 K

$\boxed{M_c = 1.707}$ 1.7061

Part 2 Solution

11.2

$$dA = 2\pi r ds = 2\pi r \frac{dx}{\cos\theta}$$

$$dD = p_c (2\pi r \frac{dx}{\cos\theta}) \sin\theta - 2\pi r\, p_b\, dr$$

$$\frac{r}{x} = \text{Tan}\,\theta \;\therefore x = \frac{r}{\text{Tan}\theta} \text{ and } dx = \frac{dr}{\text{Tan}\theta}$$

$$dD = 2\pi r\, p_c\, dr - 2\pi r\, p_b\, dr$$

$$D = \int_o^{r_b} dD = 2\pi (p_c - p_b) \frac{r_b^{\,2}}{2} = \pi (p_c - p_b)\, r_b^{\,2}$$

$$C_D = \frac{D}{q_\infty A_b} = \frac{D}{q_\infty \pi r_b^{\,2}} = \frac{p_c - p_b}{q_\infty}$$

$$C_{D_{cone}} = \frac{D_{cone}}{\bar{q}_\infty A_{base}} = \frac{1}{\frac{\gamma}{2} M_\infty^{\,2}} \left[\frac{p_c}{p_\infty} - \frac{p_b}{p_\infty} \right]$$

Part 2 Solution (cont'd)

when $p_b = p_\infty$, For $\theta_c = 15°$

M_∞	$C_{D_{cone}}$	
1.5	0.24	0.2400
2.0	0.202	0.2029
3.0	0.173	0.1736
4.0	0.161	0.1610
5.0	0.154	0.1542
6.0	0.150	0.1504
7.0	0.148	0.1478

Part 2 Solution (concluded)