# Problem Set 6 (PS 6) Due Tuesday February 28

6.1 A wedge is flying at M=3. If the wedge half angle is 15 degrees determine the total pressure ratio across the oblique shock.

6.2 The conditions upstream of the leading edge of a flying wedge in air are M=3.5, .5 atm. Calculate the maximum pressure on the wedge surface that can be achieved before the oblique becomes detached.

6.3 Air is flowing past a compression corner at M= 4 and .8 atm. Downstream of the corner the pressure is 5 atm. What is the deflection angle of the corner ?

6.4 A flow of air has the properties M= 4. and 1 atm. Compare the total pressure loss for two shock structures,

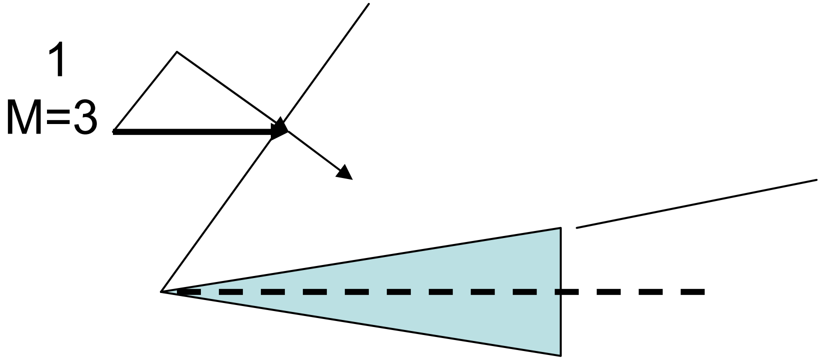
a) a normal shock
b) an oblique shock over a 25 degree corner followed by a normal shock.

Which configuration provides the lowest total pressure loss ? How does this apply to the inlet to a convention jet engine using subsonic combustion in supersonic flight?

6.5 Plot 4 points of a curve of inlet Mach number versus deflection angle for a corner and parallel wall, similar to Figure 4.18 in the text, that allows just exactly 3 reflections for each combination of Mach number and deflection angle. Sketch the shock polars for the first and last points of your curve.

6.6 For a corner and parallel wall if the Mach number and wave angle of the second reflection are 2.4 and 30 degrees how many regular reflections are there ? What is the initial Mach number ? If the pressure of the initial flow at the corner is .5 atm what is the pressure after the last regular reflection ?

## 6.1

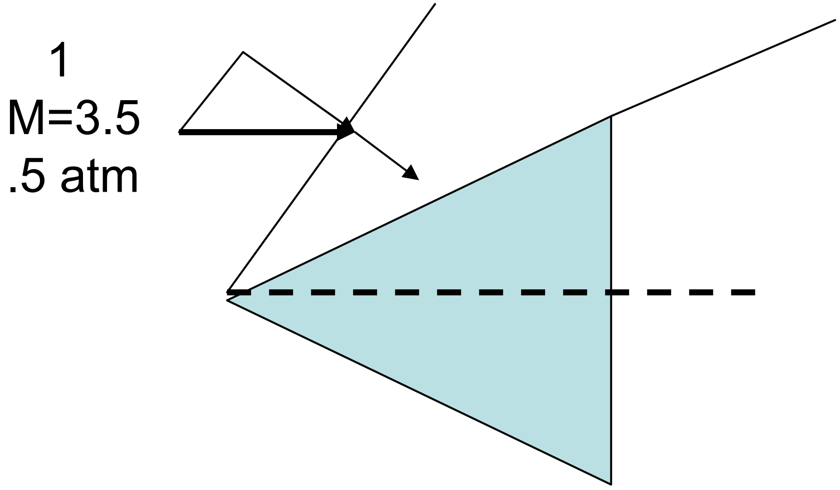


$$\theta - M - \beta \;\; @\, M_4 = 3, \theta = 15^{O} \Rightarrow \beta = 32.24$$

$$M_{1n} = M_1 \sin\beta = 3 \sin 32.24 = 1.600$$

$$\text{Table A.2}\, @\, M_{1n} = 1.6 \quad \Rightarrow \frac{p_2}{p_1} = 2.82$$

## 6.2



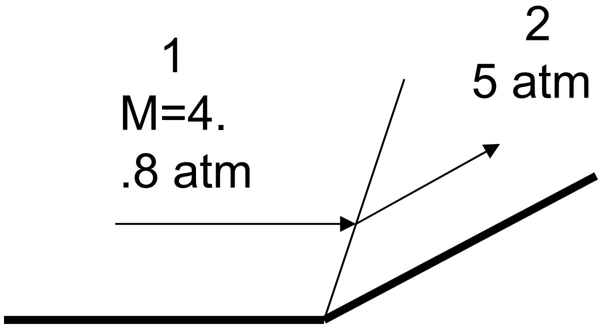
$$\theta - M - \beta \;\; @\, M_1 = 3.5, \theta_{max} = 36.8, \Rightarrow \beta = 64.2$$

$$M_{1n} = M_1 \sin\beta = 3.5 \sin 64.2 = 3.151$$

$$\text{Table A.2}\, @\, M_{1n} = 3.151, \frac{p_2}{p_1} = 11.41$$

$$p_2 = .5 \times 11.41 = 5.71$$

## 6.3



$$\frac{p_2}{p_1} = \frac{5}{.9} = 6.25$$

$$\text{normal shock, Table A.2 @ } \frac{p_2}{p_1} = 6.25$$

$$M_{1n} = 2.35$$

$$M_{2n} = .5286$$

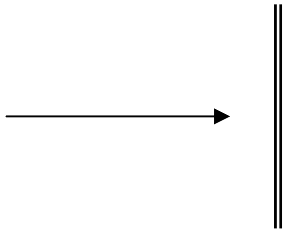
$$M_{1n} = M_1 \sin\beta$$

$$\beta = \sin^{-1}\frac{M_{1n}}{M_1} = \sin^{-1}\frac{2.35}{4} = 35.98$$

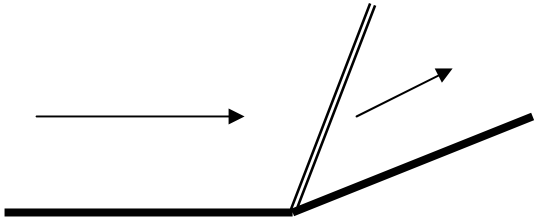
$$M - \beta - \theta \text{ Chart @ } M_1 = 4,\ \beta = 35.98$$

$$\theta = 22^{O}$$

## 6.4



$$\text{Isentropic Table @ } M_1 = 4, \Rightarrow \frac{p_O}{p_1} = 151.8$$



$$\text{normal shock, Table A.2 @ } M_1 = 4 \Rightarrow \frac{p_{O2}}{p_{O1}} = .1388$$

$$\Delta p_O = p_{O1}\left(1 - \frac{p_{O2}}{p_{O1}}\right) = 151.8(1 - .1338) = 131.49, \quad 87\,\%$$

$$M - \theta - \beta \text{ Chart @ } M = 4, \theta = 25 \Rightarrow \beta = 38.45$$

$$M_{1n} = M_1 \sin\beta = 4 \times \sin 38.46 = 2.488$$

$$\text{normal shock, Table A.2, @ } M_{1n} = 2.488 \Rightarrow \frac{p_{O2}}{p_{O1}} = .5039$$

$$\Delta p_O = p_{O1}\left(1 - \frac{p_{O2}}{p_{O1}}\right) = 151.8(1 - .5039) = 75.30, \ 49.6\%$$

<u>6.6</u>

Assume values of $M_3$ with $\beta = 30$ until $M_4 = 2.4$

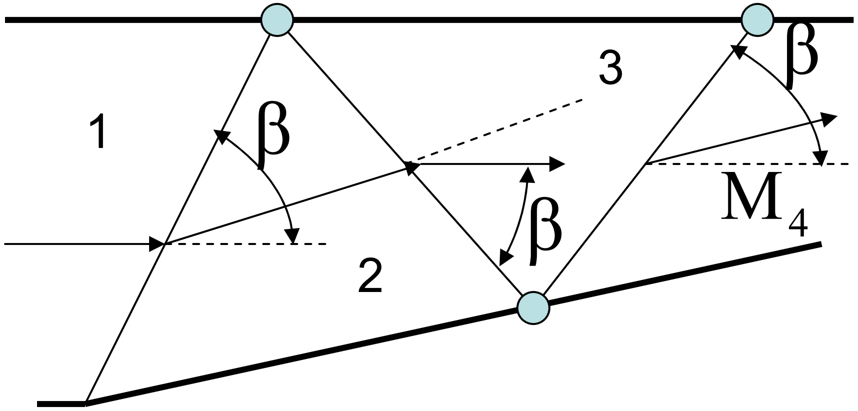
assume $M_3$

$\beta - M - \theta$ Chart @ $M_3, \beta = 30; \theta =$

$M_{3n} = M_3 \sin\beta$

Table A.2 @ $M_{4n}; M_{2n} =$

$M_4 = M_{3n}/\sin(\beta - \theta)$



| $M_3$ | $\beta$ | $\theta$ | $M_{3n}$ | $M_{4n}$ | $M_4$ |
|---|---|---|---|---|---|
| 3.4 | 30. | 15.25 | 1.698 | .6410 | 2.533 |
| 2.8 | 30. | 11.10 | 1.390 | .7403 | 2.289 |
| 3.1 | 30. | 13.45 | 1.548 | .6846 | 2.409 |
| 3.085 | 30. | 13.38 | 1.542 | .6866 | 2.400 |

$\theta = 13.38$