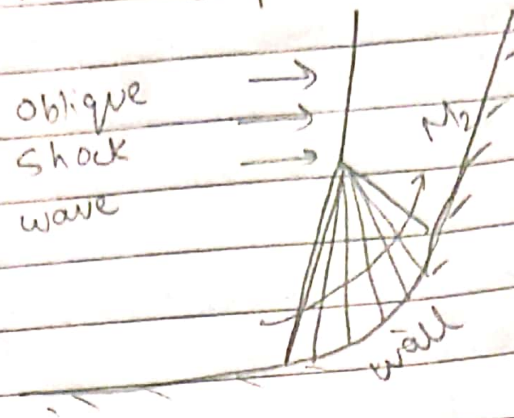
Ayan Adhya
180030007

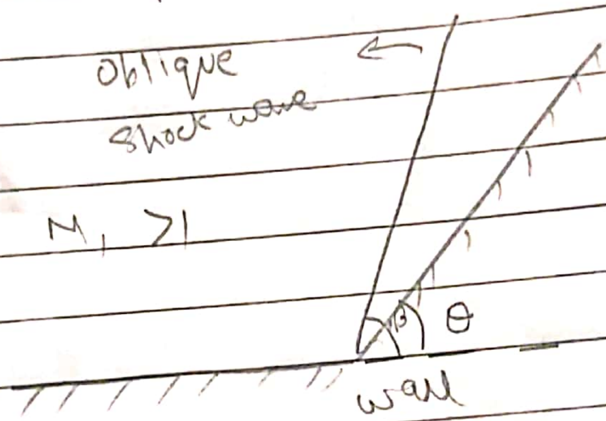
PAGE : DATE : / /

1.

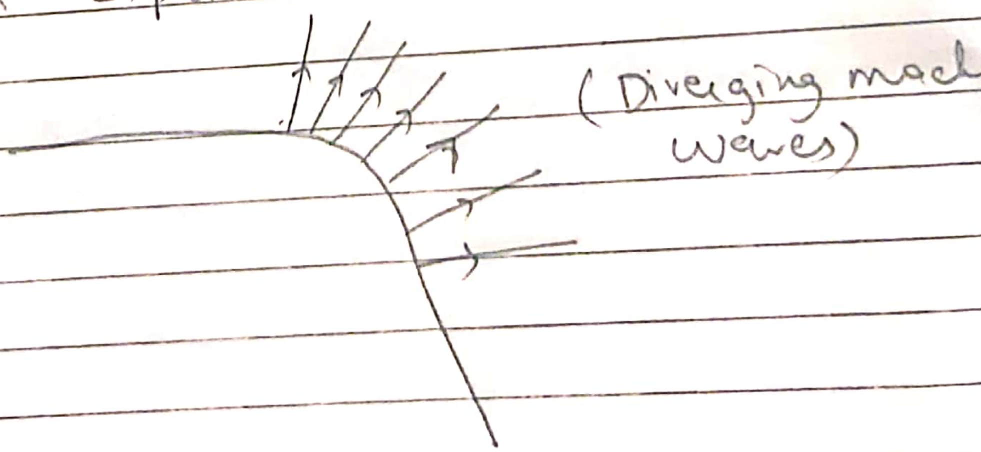
a) Smooth Compression corner – Infinite number of waves converge



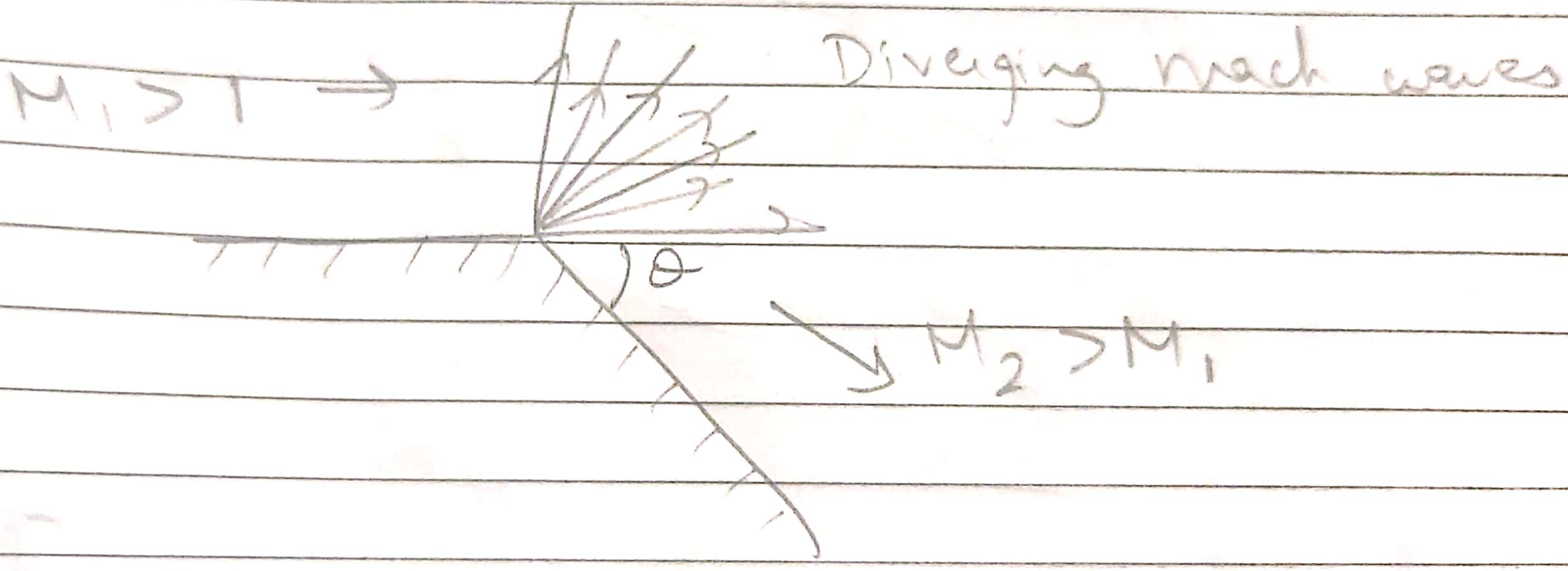
b) Sharp Compression Corner



c) Smooth Expansion Corner



d) Sharp Expansion Corner

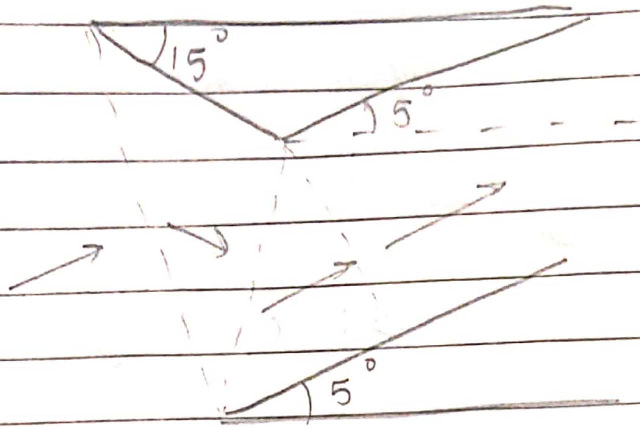


3. $\delta = 50^\circ$ is beyond the maximum deflection angle $\therefore$ attached shocks are not possible

At $\delta = 40^\circ$, attached shocks will occur at this angle. $(\delta < \theta_{max})$

II)

1.



$\delta = 15^\circ$ (deflection angle)

$$\tan\delta = \frac{\left(\frac{2}{\tan\theta}\right)\left(M_1^2 \sin^2\theta - 1\right)}{M_1^2(\gamma + \cos 2\theta) + 2}$$

$M_1 = 3$

$$\tan 15^\circ = \frac{\frac{2}{\tan\theta}\left(9\sin^2\theta - 1\right)}{9(1.4 + \cos 2\theta) + 2}$$

$\theta = 33^\circ$

Now,

$$M_2^2 \sin^2(\theta - \delta) = \frac{M_1^2 \sin^2\theta + 2/\gamma-1}{\frac{2\gamma}{\gamma-1} \; M_1^2 \sin^2\theta - 1}$$

$$M_2^2 \sin^2(33 - 15) = \frac{9\sin^2 33 + \frac{2}{0.4}}{\frac{2.8}{0.4} \times 9\sin^2(33)-1}$$

$$M_2^2 = \frac{9 \times 0.285 + 5}{(7 \times 9 \times 0.285 - 1)(0.088)}$$

$$M_2^2 = \frac{7.565}{14.96 \times 0.088}$$

$$M_2 = 2.4$$

$$\Rightarrow \frac{P_{02}}{P_{01}} = \left(\frac{\frac{\gamma+1}{2} M_1^2 \sin^2\theta}{1 + \frac{\gamma-1}{2} M_1^2 \sin^2\theta}\right)^{\gamma/\gamma-1} \left[\frac{2\gamma}{\gamma+1} M_1^2 \sin^2\theta - \frac{\gamma-1}{\gamma+1}\right]^{\frac{1}{1-\gamma}}$$

$$\frac{P_{02}}{P_{01}} = \left(\frac{\frac{1.4+1}{2} \times 9 \times \sin^2 33}{1 + \frac{1.4-1}{2} \times 9 \sin^2 33}\right)^{\frac{1.4}{0.4}} \left(\frac{2 \times 1.4}{1.4+1} \times 9 \sin^2 33 - \frac{0.4}{2.4}\right)^{1/0.4}$$

$$\frac{P_{02}}{P_{01}} = 0.44$$

$$\frac{P_1}{P_{o_1}} = \left(1 + \frac{\gamma-1}{2} M_1^2\right)^{-\gamma/\gamma-1}$$

$$= \left(1 + \frac{1.4-1}{2} \times 3^2\right)^{-\frac{1.4}{1.4-1}}$$

$$\frac{P_1}{P_{o_1}} = 0.04$$

$$\frac{P_2}{P_{o_2}} = \left(1 + \frac{\gamma-1}{2} M_2^2\right)^{-\gamma/\gamma-1}$$

$$\frac{P_2}{P_{o_2}} = \left(1 + \frac{1.4-1}{2} (2.4)^2\right)^{-\frac{1.4}{0.4}}$$

$$\frac{P_2}{P_{o_2}} = 0.1$$

$$\frac{T_1}{T_{o_1}} = \left(1 + \frac{\gamma-1}{2} M_1^2\right)^{-1}$$

$$= \left(1 + \frac{1.4-1}{2} \times 9\right)^{-1}$$

$$\frac{T_1}{T_{o_1}} = 0.36$$

From 2 to 3

$$\gamma = 15^\circ + 5^\circ = 20^\circ$$

We have to perform the same calculations for 2 to 3

From 3 to 4, normal shock wave would occur,

$$M_4^2 = \frac{(\gamma-1) M_3^2 + 2}{2\gamma M_3^2 - (\gamma-1)}$$

$$\frac{P_{o4}}{P_{o3}} = \left(\frac{(\gamma+1) M_3^2}{(\gamma-1)M_3^2+2}\right)^{\gamma/\gamma-1} \left(\frac{\gamma+1}{2\gamma M_3^2 - (\gamma-1)}\right)^{\gamma/\gamma-1}$$