Assume Axi-Symmetric Conical Spike Inlet:
15° Spike Half Angle
40 cm Inlet Half Width

→ Calculate:

Shock Angle (β)
Radial (R), Longitudinal (x) Distance from Spike Tip to Cowl Inlet
Mach Number, Total, Pressure, Temperature Ratio Distribution vs. θ at Cowl Inlet
(1) → (2)
Homework 7.1. Part 2

• Calculate Area-Weighted Mean Mach Number, Pressure Ratio at Cowl Inlet (1) → (2)

Example …

\[
\bar{M} = \frac{2\pi \int_{\theta_{cone}}^{\beta} \sin \theta \cdot R \cdot d\theta}{\int_{\theta_{cone}}^{\beta} R \cdot \sin \theta \cdot R \cdot d\theta} = \frac{2\pi \cdot R^2 \int_{\theta_{cone}}^{\beta} \sin \theta \cdot d\theta}{\int_{\theta_{cone}}^{\beta} \sin \theta \cdot d\theta} = \frac{\int_{\theta_{cone}}^{\beta} \sin \theta \cdot d\theta}{\left(\cos \theta_{cone} - \cos \beta\right)}
\]
Homework 7.1. Part 3

- Based on Mean Conditions at Cowl Inlet, Calculate 1-D Mach Number, Compression Ratio, Stagnation Pressure Behind Normal Shock (2), Relative to Freestream

- Compare to 2-D Inlet Solution from Problem 4.3

- What is the Optimal Cone Angle for Minimum Stagnation Pressure Loss
Homework 7.1. Part 4

• What is the Optimal Cone Angle for Minimum Stagnation Pressure Loss

• Compare Optimal to 2-D Inlet Solution from Problem 4.3
Homework 7.1, Part 1

\[ \beta = 39.43515^\circ \]

\[ x = \frac{40 \text{ cm}}{\tan \left( \frac{\pi}{180} \times 39.43515^\circ \right)} = 48.6359 \text{ cm} \]

\[ R = \sqrt{x^2 + y^2} = \sqrt{40^2 + 48.6359^2}^{0.5} = 62.9718 \text{ cm} \]
Homework 7.1, Part 1

• Properties Behind Oblique Shock Wave and Cowl Inlet
Homework 7.1, Part 2

Mach Number

MACH DISTRIBUTION AT COWL INLET
MEAN MACH NUMBER

Mach Integral

Dtheta, deg.
0.007884
Scale factor
5.1649
Avg Mach
1.50462
Avg Theta
30.1243

Pressure Integral

Dtheta, deg.
0.007884
Scale factor
5.1649
Avg Pratio
1.33642
Avg Theta
29.9767

P1/Pinf

P1/Pinf DISTRIBUTION AT COWL INLET
MEAN Pressure Ratio

Theta, deg.
Homework 7.1, Part 3

Conditions Across Normal Shock

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{\rho_2}{\rho_1} )</td>
<td>1.869980</td>
</tr>
<tr>
<td>( \frac{P_2}{P_1} )</td>
<td>2.474536</td>
</tr>
<tr>
<td>( \frac{T_2}{T_1} )</td>
<td>1.323295</td>
</tr>
<tr>
<td>( \frac{P_02}{P_01} )</td>
<td>0.928315</td>
</tr>
<tr>
<td>( M_2 )</td>
<td>0.699459</td>
</tr>
<tr>
<td>( \frac{P_02}{P_1} )</td>
<td>3.430775</td>
</tr>
</tbody>
</table>

\( M_\infty = 1.7 \)

Conditions to Behind Normal Shock Freestream

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{\rho_2}{\rho_1} )</td>
<td>2.121801</td>
</tr>
<tr>
<td>( \frac{P_2}{P_1} )</td>
<td>2.953975</td>
</tr>
<tr>
<td>( \frac{T_2}{T_1} )</td>
<td>1.392202</td>
</tr>
<tr>
<td>( \frac{P_02}{P_01} )</td>
<td>0.927789</td>
</tr>
<tr>
<td>( P_02/P_1 )</td>
<td>16.924690</td>
</tr>
<tr>
<td>( M_1 \text{ Avg} )</td>
<td>1.50462</td>
</tr>
<tr>
<td>( M_2 )</td>
<td>0.699459</td>
</tr>
</tbody>
</table>
## Homework 7.1, Part 3

Compare to 2-D inlet, with 15 Degree Ramp Angle

<table>
<thead>
<tr>
<th>Inlet</th>
<th>$b$, deg</th>
<th>$M_1$</th>
<th>$M_2$</th>
<th>$\frac{p_1}{p_\infty}$</th>
<th>$\frac{p_2}{p_\infty}$</th>
<th>$\frac{P_{01}}{P_{0\infty}}$</th>
<th>$\frac{P_{02}}{P_{0\infty}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-D</td>
<td>55.984</td>
<td>1.122</td>
<td>0.895</td>
<td>1.302</td>
<td>2.800</td>
<td>0.956</td>
<td>0.954</td>
</tr>
<tr>
<td>3-D</td>
<td>39.435</td>
<td>1.581 (max)</td>
<td>0.674 $\leq$ 0.699 $\leq$ 0.720</td>
<td>1.194 (max)</td>
<td>1.94 (min)</td>
<td>1.446 (min)</td>
<td>1.336 (mean)</td>
</tr>
</tbody>
</table>

- Slightly Higher Compression, Slightly Larger Stagnation Pressure Loss
- Significantly Higher Capture Area for given Max Lateral Dimension
Homework 7.1, Part 4, Conical Inlet
Homework 4.3, 2-D Inlet

- What is the best turning angle $\theta$ in terms of highest pressure ratio, $\frac{P_{02}}{P_{0a}}$?

$\theta_{OPT} \approx 12.4^\circ$