CHE G552- Mid-term Examination, 2nd Semester 2021-22

Mid-term Examination- Advanced Transport Phenomena [50 points]

Consider a jet-testing facility at the Indian Air Force Pilot-scale Wind tunnels. The Wind hits the nose of the MIG-29 aircraft which is known as a Taylor-Maccoll Cone. For simplification, we can assume is to be a 2-D wedge-like flow. The free stream wind velocity at the time of contact is approximately V_∞ **which is a function of space and time itself.** Also, assume there is a **non-zero pressure gradient along the surface** of the wedge (i.e., the X-direction). See Figure 1 below.

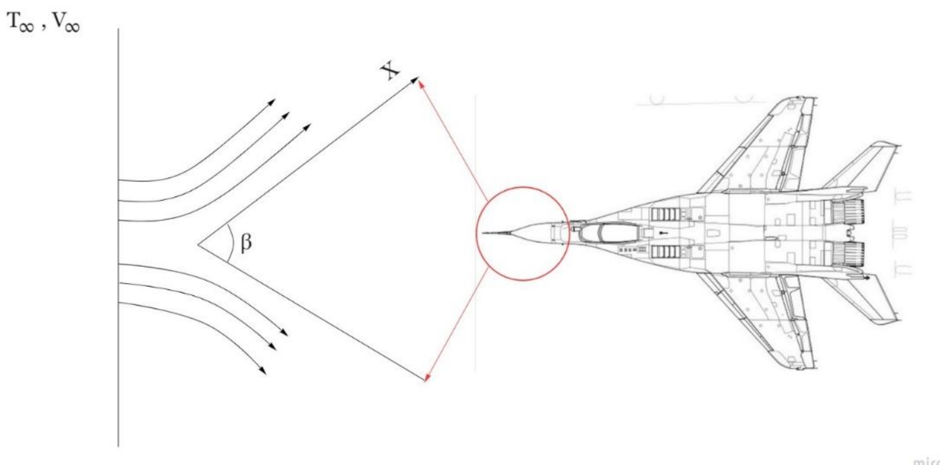

Figure 1: The wind flow bifurcates at the edge of the nose-tip of a MIG-29.

From standard literature, the flow of wind along the aircraft surface can be considered to be a 2D potential flow defined as $V_\infty(x) = x^m$ Where $m = \frac{\beta}{2\pi - \beta} = \frac{x}{V\infty}\frac{dV\infty}{dx}$

- Assuming the presence and formation of a boundary layer, apply the stream function analysis to obtain the Falkner-Skan wedge flow momentum equation, (i.e. show that)

$$f''' + \frac{1}{2}(m+1)\, f \cdot f'' + m[1-[f']^2] = 0$$

Where $f'(\eta) = u/V_\infty$ and $\eta = y \cdot \sqrt{\frac{V\infty}{\nu x}}$; $u = u(f', \eta)$ and $v = v(f', \eta)$

- From the nature of the function $f(\eta)$ and its derivatives, where and when can the boundary layer separate? EXPLAIN!