The Blasius Boundary Layer

1)Important Info’s: -

➔*The incompressible boundary layer on a flat plate in the absence of a pressure gradient I usually referred to as the Blasius boundary layer.*

➔*The steady, laminar boundary layer developing downstream of the leading edge eventually becomes unstable to Tollmien–Schlichting waves and finally transitions to a fully turbulent boundary layer.*

➔*Due to its fundamental importance, this type of flow has become the subject of numerous studies on boundary-layer flow, stability, transition, and turbulence.*

2)Model:-

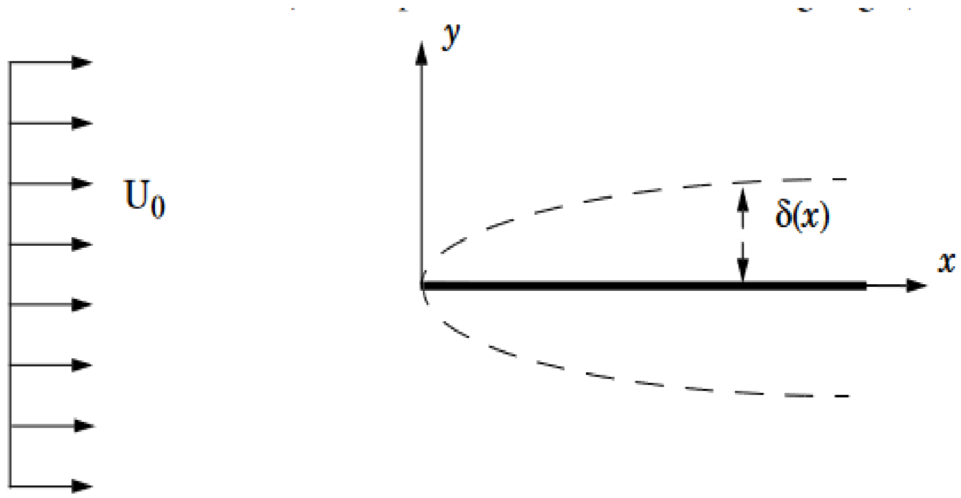


Figure 1: The boundary layer on a flat plate. $\delta(x)$ is the boundary-layer thickness, such that $u(x, \delta(x)) = U_0$.

➔*Consider a homogeneous free-stream flow with speed U_0 parallel to an infinitely thin, flat plate located along the positive x-axis.*

➔*The flow is assumed to be steady, symmetric with respect to y, and homogeneous in the z direction.*

➔*Due to friction, the flow adjacent to the plate is retarded and a thin boundary layer, where the velocity gradually grows from zero to the free-stream value, develops downstream of the leading edge*

3)Physics and Equations: -

➔*Navier Strokes Equations: -*

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \upsilon\frac{\partial^2 u}{\partial y^2}$$

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

Introducing a stream function,

$$u = \frac{\partial \Psi}{\partial y}, \quad v = -\frac{\partial \Psi}{\partial x}$$

and the similarity transformation,

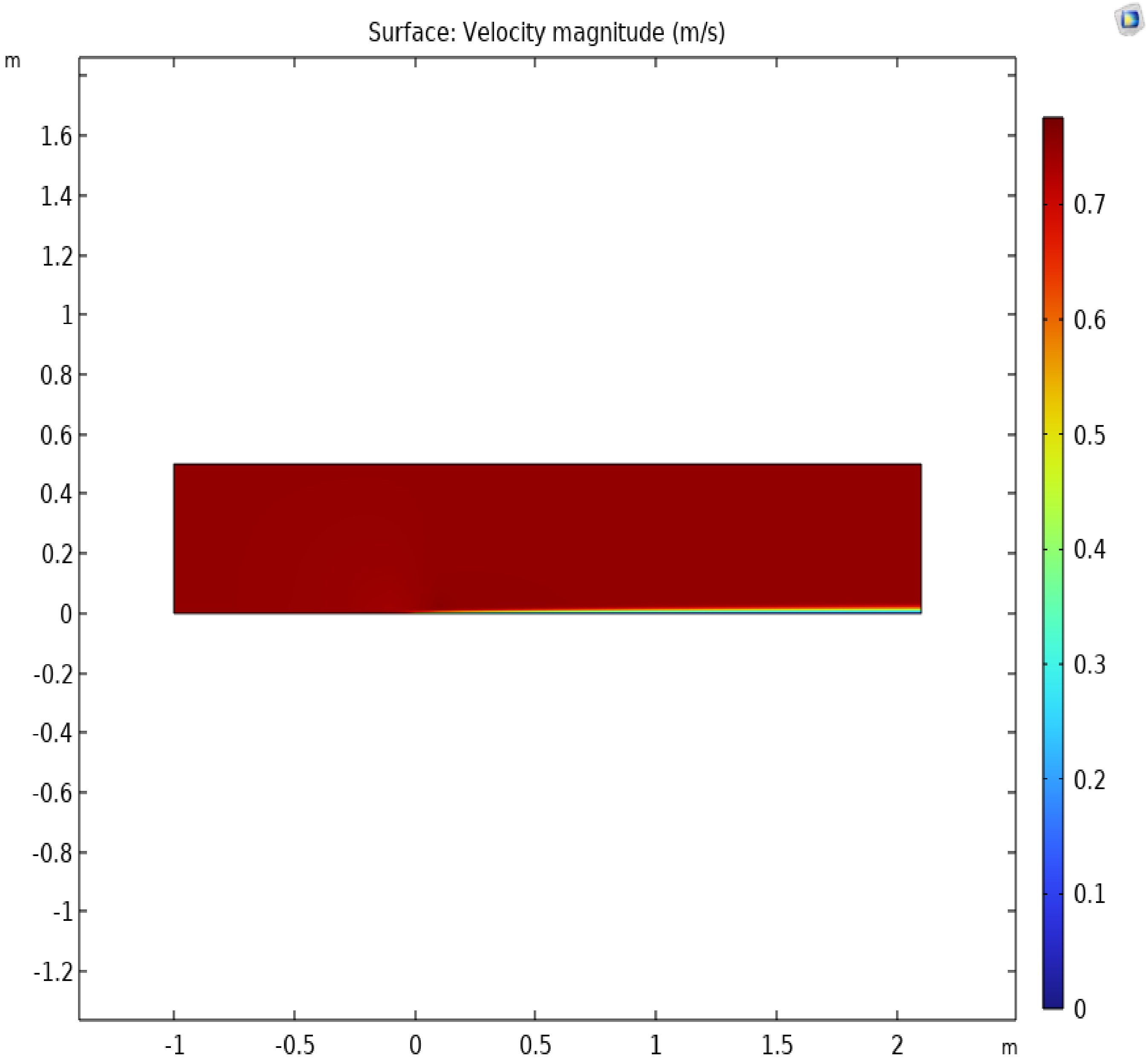
$$\psi = \sqrt{\upsilon x U_0} f(\eta), \quad \eta = \frac{y}{\sqrt{\upsilon x / U_0}}$$

➔*the similarity solution* ***$u/U_0 = f'(\eta)$. At $\eta = 4.99$,*** *the deviation from the free-stream value is* ***1%.*** *This value can be used to define the boundary-layer thickness,*

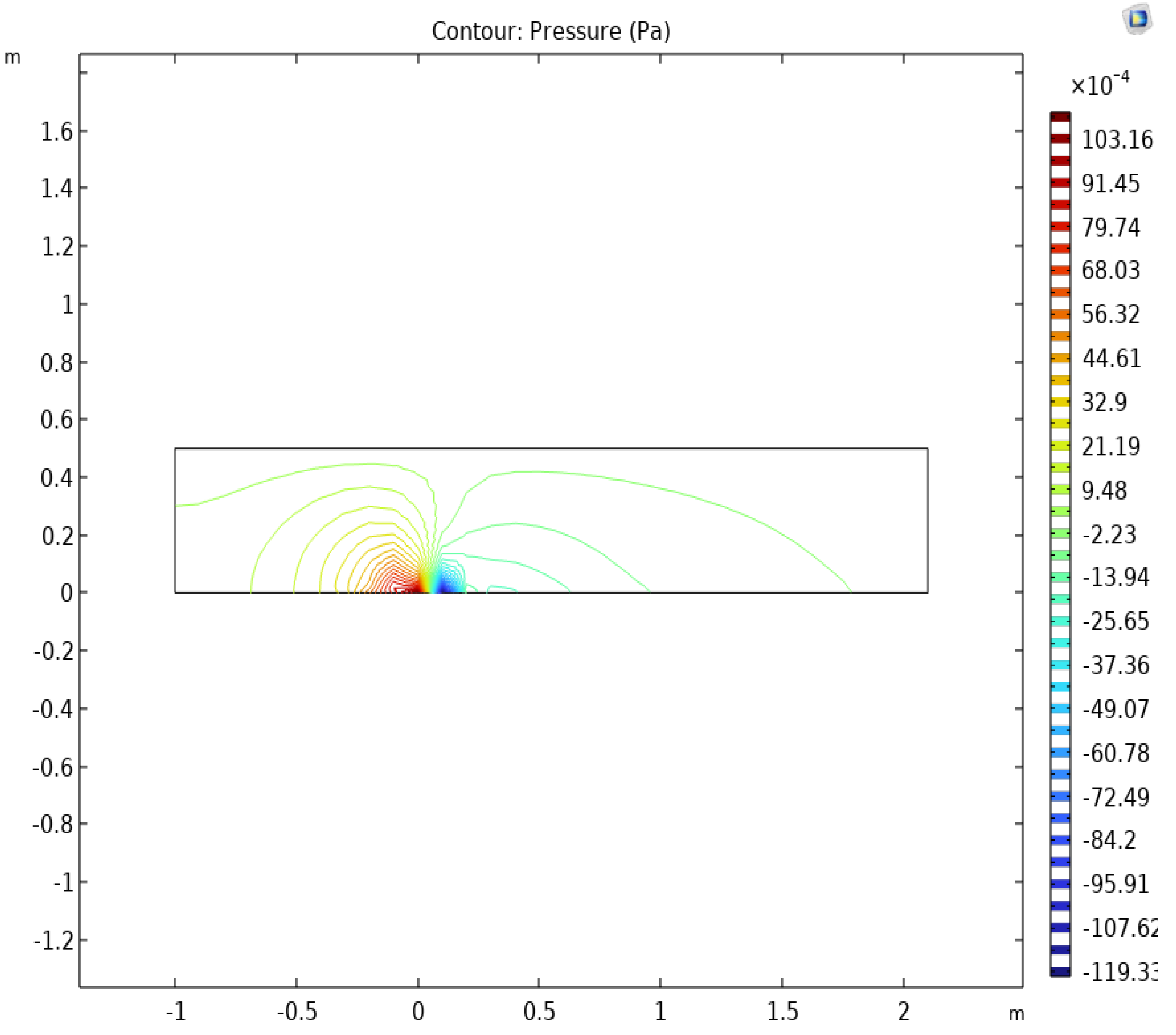
$$\delta_{99}(x) = 4.99\sqrt{\frac{\upsilon x}{U_0}}$$

3)Results: -

➔Velocity Plot: -



➔Pressure Plot: -



➔Similarity Solution: -