Cankaya University

Faculty of Engineering

Mechanical Engineering Department

ME 613 Advanced Convection Heat Transfer

HW# 1

1) The approximate velocity profile for flow over a flat plate is given as

$$\frac{u}{U_\infty} = \begin{cases} \sin\left(\frac{\pi y}{2\delta}\right) & \text{for} \quad 0 \le y \le \delta \\ 1 & \text{for} \quad y > \delta \end{cases}$$

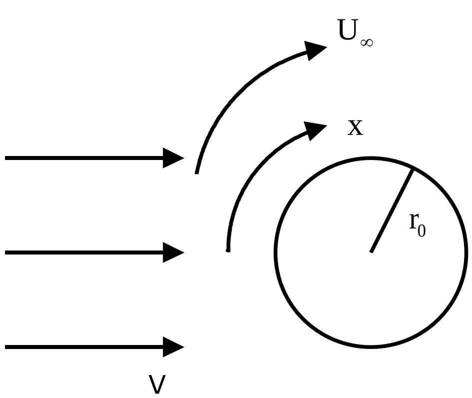
where δ is the velocity boundary layer thickness, determine:

a) The displacement thickness δ_1

b) The momentum thickness δ_2

c) The shape factor H

2) Air at $10\,^0\text{C}$ and 1 atm pressure flows normally to a 10 cm diameter sphere at a velocity of 10 m/s .In the vicinity of the forward stagnation point for flow normal to a sphere the velocity along the surface, U_∞ is given by



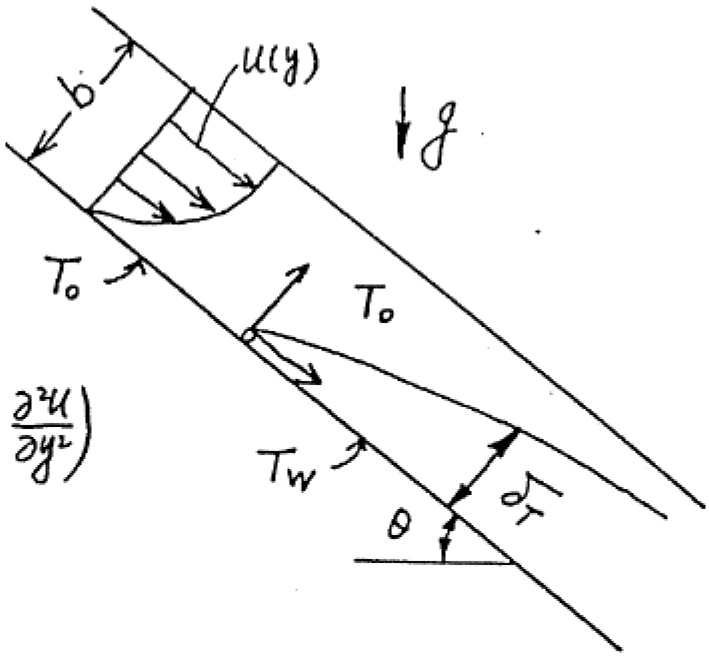
$$U_\infty = \frac{3Vx}{D}$$

where U_∞ is the velocity just outside the boundary layer. On the other hand, V is the oncoming normal velocity, x is the distance along the surface measured from the stagnation point and D is the cylinder diameter.

a) Determine the momentum displacement thickness of the boundary layer at the stagnation point using Twaites method.

b) Determine an expression for the Nusselt number at the stagnation point

3)A liquid film of constant thickness b and temperature T_0 flows in a steady laminar motion down an inclined solid surface under the influence of gravity as illustrated in the figure.



a) Develop an expression for the velocity distribution starting from differential formulation
b) At x=0, a step change in surface temperature from T_0 to T_w occurs Obtain by integral method, an expression for the local heat flux from the surface to the liquid film at those x locations where . Use a third degree polynomial in y for the temperature distribution in the boundary layer. Assume constant thermophysical properties and neglect viscous dissipation. Develop an expression for the local heat transfer coefficient based on the temperature difference $T_w - T_\infty$.