Department of Mechanical Engineering
MCL814 Convective Heat Transfer
Minor Test - 1

Max. Marks: 30 March 18, 2021
Duration: 1 hr

Answer all questions. Marks for each question is indicated. Only what you write on the paper can be evaluated, not what you think. Please write all assumptions and steps explicitly. Often, correct final answer does not assure you marks: the right approach does. Use sketches where necessary.

1. Consider laminar boundary layer over a flat plate, with constant heat flux q_w from the plate. Consider the case when $Pr \ll 1$, where the momentum boundary layer is much thinner than thermal boundary layer $\delta \ll \delta_T$, such that you can assume $u = u_\infty$ throughout the thermal boundary layer. Use a cubic temperature profile assumption in integral method, and derive an expression for the normalized thermal boundary layer thickness δ_T/x and hence the Nusselt number Nu_x as a function of the local Reynolds number Re_x and Prandtl number Pr. (20)

2. For a turbulent boundary layer on a flat plate tripped at the leading edge (turbulent over the entire length of the plate), where the working fluid has a constant density of ρ =1 kg/m^3, constant viscosity of $\mu = 2 \times 10^{-5}$Nsm^{-2} and the free stream velocity is 25 m/s. (10)

   (a) At a distance of 1 m from the leading edge, compute the following: boundary layer thickness δ in mm, value of y^+ at the edge of the boundary layer ($y = \delta$), local skin friction coefficient $C_f(x)$.

   (b) Can we say that the local shear stress at the wall $\tau_w(x)$ is of the order of $\mu u_\infty/\delta$, as we did in laminar flow? Give reasons.

   (c) Compute the local shear stress and compare with $\mu u_\infty/\delta$ at this location. Does this agree with your reasoning? Discuss