King Fahd University of Petroleum & Minerals
Chemical Engineering Department
CHE 204 – Transport Phenomena I
2008 - 2009 (081)

HW#11
Due: no submission required

Problem 1. (30 ponints)

In the analysis of laminar boundary layer flow over a flat plate, a velocity profile is assumed as folloews:

$$\frac{v_x}{v_{x\infty}} = f(\zeta),$$

where $\zeta \equiv \frac{y}{\delta(x)}$ and then substituted in the momentum balance equation eqn. (8.4). Assuming the following form: $f(\zeta) = a + b\zeta + c\zeta^2 + d\zeta^3$, where *a*, *b*, *c* and *d* are constants. Answer the following questions:

(a) Use the properties of the function $f(\zeta)$ to evaluate the constants *a*, *b*, *c* and *d*.
(b) Obtain an experssion for the thichness of the boundary layer, δ, along the plate, as function of *x* and Re_x where *x* is the distance from the edge of the plate.
(c) Show that the drag coefficient c_f, is given by: $c_f \sqrt{\mathrm{Re}_x} = 0.646$.

Problem 2. (30 ponints)

Carbon dioxide gas (ρ = 1.8 kg/m^3 and μ = 1.5 x 10^{-5} Pa s) flows parallel to a flat plate at a velocity 1 km/hr. Use the simplified analysis of the boundary layer flow discussed in sections 8.2 and 8.5 of your textbook to answer the following questions:

(a) Calculate the distance L_t at which the boundary layer undergoes a transition from laminar to turbulent flow.
(b) Calculate the thickness of the boundary layer at a distance L_t -1 and L_t +1 meters.
(c) Calculate the drag force over the flat plate at a distance L_t +1 meters.