EAE 127 Applied and Computational Aerodynamics

Project 2

Fluids Review

DUE: Monday, 10/12/2015, 2:10pm

PROBLEM 1

The altimeter in a small aircraft flying at low speed indicates an altitude of 4500ft above sea level. The altimeter determines altitude from an atmospheric look-up table dependent on the static pressure of the atmosphere, which is sensed in a static port located on the aircraft's fuselage. **What is this static pressure** sensed by the transducer? The aircraft also has a Pitot tube located on its wing, which senses a stagnation pressure of 1813 lb./ft^2. Assuming incompressible flow, **what is the airspeed** of the aircraft? (See Anderson's Fundamentals 3.4).

Pitot tube with static port and angle-of-attack sensor

PROBLEM 2

Given the wake velocity distribution of an airfoil, **calculate the drag** using the momentum equation (See Anderson's Fundamentals 2.6). **Fit wake velocity data points** with a polynomial function before integration for greater accuracy. Assume air is incompressible with density ρ = 1.2 kg/m^2.

PROBLEM 3

Two important boundary layer properties are displacement thickness (δ^*) and momentum thickness (θ), which are defined for incompressible flow as follows (see Anderson Fundamentals Ch. 17.2):

$$\delta^* = \int_0^\delta \left(1 - \frac{u}{u_e}\right) dy$$

$$\theta = \int_0^\delta \frac{u}{u_e}\left(1 - \frac{u}{u_e}\right) dy$$

To estimate these properties for laminar and turbulent flows, we will assume an approximate boundary layer velocity distribution (u/u_e). For laminar flow over a flat plate, assume a parabolic boundary layer velocity profile:

$$\frac{u}{u_e} \approx \left(\frac{2y}{\delta} - \frac{y^2}{\delta^2}\right)$$

For turbulent flow over the length of full-scale aircraft, assume a one-seventh power relationship:

$$\frac{u}{u_e} \approx \left(\frac{y}{\delta}\right)^{\frac{1}{7}}$$

Consider the following flow conditions:

	Laminar/ Turbulent	**L_{ref} (ft)**	**Altitude (ft)**	**Velocity (Miles per hour)**
Flat Plate	Laminar	1	0	40
Cessna 150	Turbulent	24	10000	94
Boeing 747	Turbulent	232	35000	570

For each case, calculate and **plot the boundary layer velocity distribution** non-dimensionalized by the freestream velocity against the vertical distance within the boundary layer non-dimensionalized by the boundary layer height **(i.e. u/u_e vs. y/δ)**. Then calculate the non-dimensional displacement and momentum thicknesses by numerical integration. **Plot dimensional displacement/momentum thickness along the length of the body in x** by multiplying by boundary layer thickness $\delta(x) = f(Re_x)$. Estimate boundary layer thickness with formulas for a laminar or turbulent flat plate, as appropriate.