Aerodynamics and Aeroelasticity

Homework 5

Due Feb. 17, 2017

Name:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Problem 1**

The geometric and aerodynamic data for a wing of a large white butterfly is as follows: Flight speed, U, = 1.35 m/s; Average chord, c = 25 mm; Average span, s = 50 mm; air density = 1.2 kg/m3; air viscosity, *μ*= 14.96 x 10 -6 Pa-s; Drag at zero lift = 120μN (measured on a miniature wind-tunnel balance). (1) Estimate the boundary-layer thickness at the trailing edge. (2) Also compare the measured drag with the estimated skin-friction drag. How would you account for any difference in value?

**Problem 2**

Suppose that the top surface of a light-aircraft wing travelling at an air speed of 55 m/s were assumed to be equivalent to a flat plate of length 2 m. Laminar-turbulent transition is known to occur at a distance of 0.75m from the leading edge. Given that the kinematic viscosity of air is 15 x 10-6 m2/s, estimate the coefficient of skin friction drag.

**Problem 3**

The wing on a Piper Cherokee is rectangular, the wing span is 9.75m and a chord of 1,6m. The cruising speed is 141mi/h. Calculate

1. Skin friction and boundary layer If the flow were completely laminar
2. Skin friction and boundary layer If the flow were completely turbulent
3. Calculate skin friction for transitional flow. Assuming Transitional Reynolds 500000.

Make your own assumptions to do the calculations. Compare both results.

**Problem 4**

A flat plate of chord is immersed on airstream of Mach 4. Assuming all laminar flow and adiabatic wall conditions, calculate the skin friction drag on the plate per unit span. Repeat the calculations for a turbulent flow. The effect of compressibility is to reduce the Cf about 88% for laminar flow and about 44% for turbulent flow.

**Problem 5**

The streamwise velocity component for a laminar boundary layer is sometimes assumed to be roughly approximated by the linear relation

u)

Where . Assume that we are trying to approximate the flow of air at standard sea-level conditions past a flat plate where U∞ = 2.337 rn/s. Calculate the streamwise distribution of the displacement thickness the velocity at the edge of the boundary layer (, and the skin-friction coefficient (Cf) and the velocity at the edge of the boundary layer (ve).

Plot displacement thickness vs x and Cf vs x. form x=0 and x=1m