MAE 104 - SUMMER 2015
Problem Session 1

08-06-2015

Problem 1:
An Airbus A320-200 is flying at steady level flight. Its mass is $m = 78,000$ kg, its wing area is $S_W = 122.6$ m^2 and the air density is $\rho = 1.23$ kg/m^3.

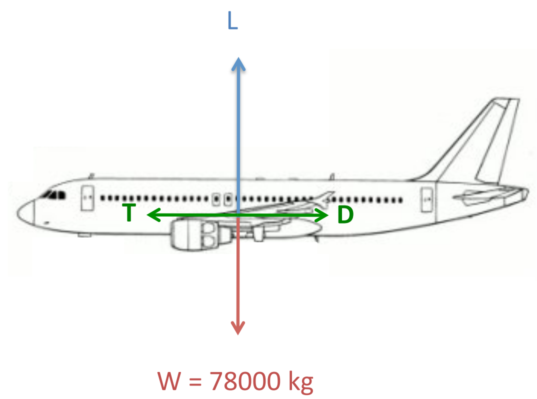

Figure 1: Force distribution in an A320.

1. Knowing that $C_{L,max} = 1.8$ and the drag coefficient at that angle of attack is $C_D = 0.1$, calculate the stall velocity of the airplane. Calculate also the lift, drag, thrust and lift-to-drag ratio under these conditions.

2. Knowing that $T_{max} = 240$ kN, $C_{D,min} = 0.02$ and the lift coefficient at that angle of attack is $C_L = 0.2$, calculate the maximum velocity of the airplane. Calculate also the lift, drag, thrust and lift-to-drag ratio under these conditions.

Problem 2:
We want to obtain the lift and drag of a wedge. Its upper and lower sides are given by the equations:

$$y_u = \begin{cases} \frac{x}{\tan\gamma} & ; \quad x < c \cdot \sin^2\gamma \\ (c-x)\cdot\tan\gamma & ; \quad x > c\cdot\sin^2\gamma \end{cases}$$
$$y_l = 0$$

as shown in Figure 2.

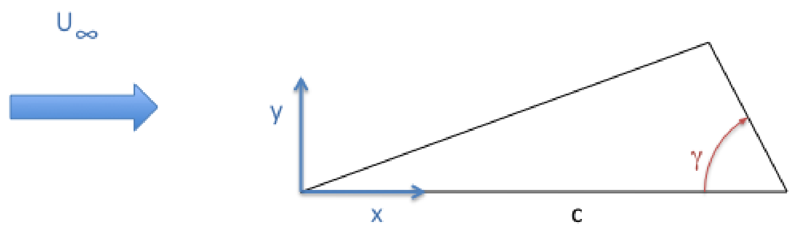

Figure 2: Wedge that we are studying.

Testing it in a wind tunnel, applying a uniform flow of velocity U_∞, density ρ and pressure p_∞, we measure a coefficient of pressure:

$$c_{p,u} = \frac{p_{upper} - p_\infty}{\frac{1}{2}\rho U_\infty^2} = k\left[\left(1 - \frac{10x}{c}\right)e^{10\left(1-\frac{x}{c}\right)} + 9\right]$$

for the upper side, where $k = \frac{e^{1/5}}{e^{10}+9}$, and:

$$c_{p,l} = \frac{p_{lower} - p_\infty}{\frac{1}{2}\rho U_\infty^2} = \left(1 - \frac{x}{c}\right)e^{\frac{1}{5} - \frac{10x}{c}}$$

for the lower side.

Integrate c_p along the surface of the wedge to obtain the lift and drag coefficients.

Problem 3:
An airfoil model is tested in a wind tunnel, as seen in Figure 3.

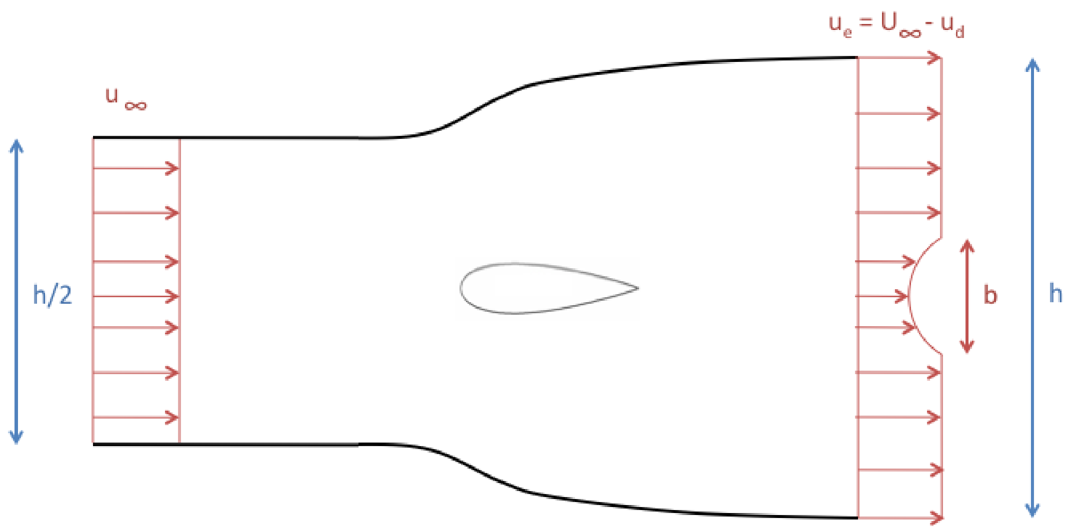

Figure 3: Wind tunnel setup.

We measure an upstream velocity of U_∞ and a downstream velocity distribution of $U_\infty - u_d$ such that:

$$u_d(x,z) = \begin{cases} \frac{A}{\sqrt{x}} cos \frac{\pi z}{b(x)} & ; \quad |z| < \frac{b(x)}{2} \\ 0 & ; \quad |z| \geq \frac{b(x)}{2} \end{cases}$$

where $b(x)$ is the wake thickness.

Both upstream and downstream pressure are constant of value p_∞. The pressure on the walls of the tunnel is also p_∞.

We want to calculate the drag on the airfoil.

1. Apply the integral form of the continuity equation to the control volume and obtain the wake thickness, $b(x)$.

2. Apply the integral form of the momentum equation to the control volume and obtain the drag.