MAE 101B, Spring 2009

Homework 5

Due Thursday, May 21, in class

Guidelines: Please turn in a *neat* homework that gives all the formulae that you have used as well as details that are required for the grader to understand your solution. Required plots should be generated using computer software such as Matlab or Excel.

Please refrain from copying. Refer to the course outline for what constitutes copying

1. An airplane performs a steady level flight at $10\,km$ of altitude at a speed $V = 150\,m/s$. The wing-span is $b = 40\,m$ and has an aspect ratio $AR = 7.2$, and is at an angle of attack $\alpha = 8^o$, with a maximum relative camber of 0.2.

a) Calculate the average chord length and the planform area of the wing.

b) Calculate the mass of the airplane.

c) Calculate the thrust needed to withstand the drag, given that $C_{D\infty} = 0.02$.

2. Consider isentropic flow of air through a variable-area duct. Assume 1-D, steady flow. At section 1, $A_1 = 0.25\,m^2$, $p_1 = 15\,kPa$ (abs), $T_1 = 10^oC$, and $V_1 = 590\,m/s$. At section 2, the temperature is higher, $T_2 = 137^oC$ and the Mach number, $Ma_2 = 0.75$.

a) Compute the Mach number, Ma_1, and mass flow rate at section 1.

b) Determine the area, A_2, and pressure, p_2, at section 2.

3. A supersonic jet flies at $5\,km$ standard altitude at velocity of $1875\,m/s$. Assume the air flow over the jet is isentropic.

a) What is the temperature measured at the nose of the jet?

b) Dissociation and recombination reactions in air become important at $T = 2000\,K$. To prevent such reactions while maintaining the same speed, should the jet ascend or descend? Explain. In such case how does the Mach number change?

4. Air flows isentropically in a duct of varying area. At the inlet, $M_1 = 3$. At the outlet, $V_2/V_1 = 0.75$. Do not use any tables.

a) What is the exit Mach number, M_2 ?

b) What is the area ratio A_2/A_1? Comment on the shape of the duct.

5. An air tank of volume $2\,m^3$ is initially at $750\,kPa$ and $25\,^oC$. At $t = 0$, it exhausts through a converging nozzle to sea-level conditions. The throat area is $0.75\,cm^2$. For the purpose of this problem, assume that the tank is emptied at constant temperature.

a) Why is the flow choked initially? What is the initial mass flow rate?

b) Obtain a differential equation for the tank pressure, $p_0(t)$ assuming choked flow. Solve this equation to obtain the time, t, at which the tank blows down to $p_0 = 400\,kPa$.

Ungraded problems From text 9.46, 9.57