Aerospace 312: Aerodynamics II

Sample Second Mid-Term Examination

<u>Answer 4 out of 5 questions ONLY</u>

You have 75 minutes to complete the Examination

<u>Please check the questions you wish to be graded.</u>

Problem	Points	☑
1	25	
2	25	
3	25	
4	25	
5	25	
	Total	

Name: _____

On the actual examination each problem will be on a separate page with additional blank pages at the end to allow plenty of space to show your work.

Also for air, use $\gamma = 1.4$, $R = 287$ J/(kg.K).

1) Consider the wing leading edge of an SR-71 flying at Mach 3.0 at 25km where the static temperature is 222K. The integral form of the energy equation for isentropic flow is,

$$h_t = h + \frac{1}{2}u^2$$

For a perfect gas $h = c_p T$. Also, $a^2 = \gamma RT$ and $R = c_p - c_v$. If $\gamma = 1.4$ and $c_p = 1005$ J/kg.K, ***use the energy equation*** to calculate the temperature at the leading edge of the wing, assuming it is a stagnation point and that the flow is isentropic up to the wing leading edge.

2) Air flows isentropically through a variable area duct. At station 1 $A_1 = 20$ cm^2, $p_1 = 300$ kPa, $\rho_1 = 1.75$ kg/m^3, and $M_1 = 0.25$. At station 2 the area is exactly the same but the flow is supersonic. Calculate,
   a) the mass flow rate, $\dot{m}$
   b) the Mach number at station 2, M_2
   c) the temperature at station 2, T_2
   d) the velocity at station 2, u_2.

3) Flow from a converging-diverging nozzle exits smoothly (no shocks or expansions) at atmospheric pressure of 100 kPa. The flow is supplied from a 40 m^3 tank, initially at 800 kPa and 373 K. Assume isentropic flow and an exit area of 10 cm^2.
   a) Calculate the exit Mach number
   b) Calculate the mass flow rate
   c) Estimate the tank pressure after 10 seconds of operation if the tank temperature is assumed to remain constant.

4) Just behind a normal shock the Mach number is $M_2 = 0.7$ and the temperature $T_2 = 361$ K. What are values of M_1 and T_1 (the conditions ahead of the shock) for,
   a) air, $\gamma = 1.4$,
   b) helium, $\gamma = 5/3$?

   Use either the normal shock tables, where they apply, or the normal shock formulas.

5) Air from a reservoir at 293 K and 500 kPa flows through a duct and forms a normal shock downstream of the throat. The throat area is 10 cm^2. By an odd coincidence it is found that the total pressure downstream of the shock exactly equals the throat pressure. Estimate the duct area at the location of the shock.