 ***Name*_____**

Unified Quiz 4F

March 31, 2004

- Put your name on each page of the exam.
- Read all questions carefully.
- Do all work for each problem on the two pages provided.
- Show intermediate results.
- Explain your work --- don't just write equations.
- Partial credit will be given, but only when the intermediate results and explanations are clear.
- Please be neat. It will be easier to identify correct or partially correct responses when the response is neat.
- Show appropriate units with your final answers.
- Calculators and a 2-sided sheet of paper are allowed
- Box your final answers.

Exam Scoring

#1 (40 %)	
#2 (30%)	
#3 (30%)	
Total	

1. (40 %) Air flows at low speed in a duct of constant area $A = 0.1\,\mathrm{m}^2$, through a resistive heater delivering $\dot{Q} = 5000\mathrm{W}$. The heater is a grid of very fine wires which have negligible frictional resistance. The upstream flow has

$$V_1 = 1\,\mathrm{m/s}$$
$$\rho_1 = 1\,\mathrm{kg/m}^3$$
$$T_1 = 250\,K^\circ$$

Also, $c_p = 1000\,\mathrm{J/kg\,K}^\circ$ everywhere.

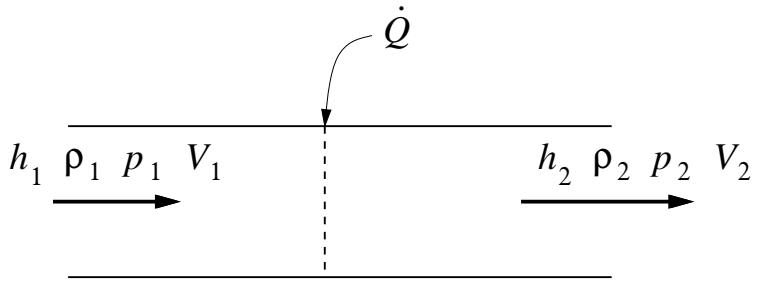
a) Using a control volume spanning the heater, determine the enthalpy equation relating stations 1 and 2.

b) Assuming $V^2 \ll h$ (low speed flow), determine the air temperature T_2 behind the heater.

Since this is a low speed flow, you can also assume that the pressure changes are very small relative to ambient pressure, i.e. $p_2/p_1 \simeq 1$.

c) Determine the density ratio ρ_2/ρ_1, and the velocity ratio V_2/V_1.

d) Determine the pressure change $p_2 - p_1$ across the heater.



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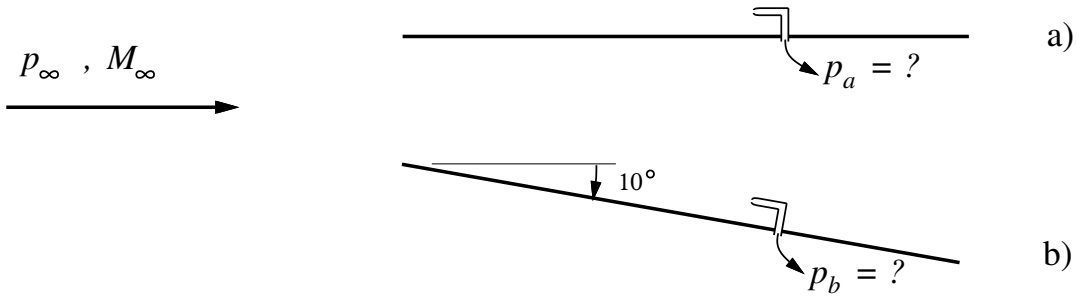
Problem #1 (continued)

2. (30 %) A thin supersonic airfoil has a pitot tube mounted on top. The freestream Mach number is $M_\infty = 1.3$, and the freestream pressure is some known p_∞.

a) Determine the pitot pressure p_a with the airfoil at $\alpha = 0°$.

b) Determine the pitot pressure p_b with the airfoil at $\alpha = 10°$.



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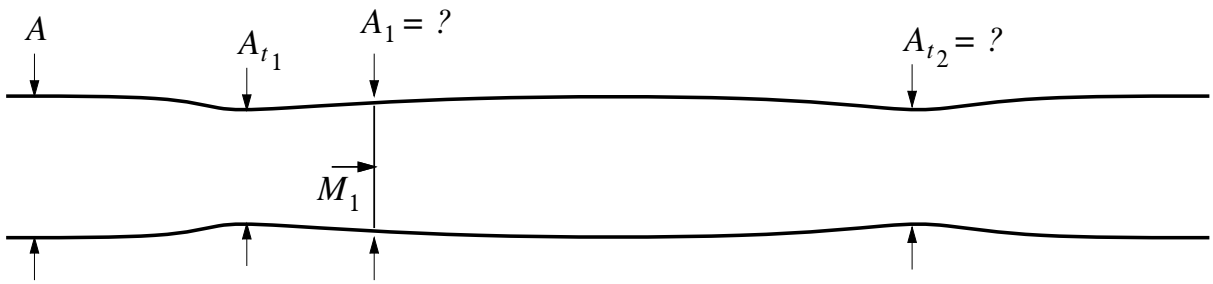
Problem #2 (continued)

3. (30 %) A duct with air flow has a constant area $A = 1\,\mathrm{m}^2$, except for two throats. The front throat area is $A_{t_1} = 0.8\,\mathrm{m}^2$.

a) The front throat is choked, and has a shock behind it. If the Mach number into the shock is $M_1 = 1.5$, what is the duct area A_1 at the shock location?

b) The adjustable area of the second throat is now closed down until the flow there just barely reaches $M = 1$. What is this resulting throat area A_{t_2}?



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Problem #3 (continued)