Ideal Gas Dynamics Review

- Homework solutions should be neat and logically presented, see format requirements (seitzman.gatech.edu/classes/ae6050/homeworkformat.html). **Please note the requirement to draw some IMPLICATIONS/CONCLUSIONS from the results of each problem.** These could be how your findings would impact design/operation of a practical device, a comparison of the results of different parts of a problem, a physical interpretation of the results, etc.
- To receive credit, show ALL work in the format described above. If you use equations from the notes, the class textbook or another book, please cite the reference.
- For plots, use appropriate software to produce professional graphics - hand drawn plot are not acceptable.

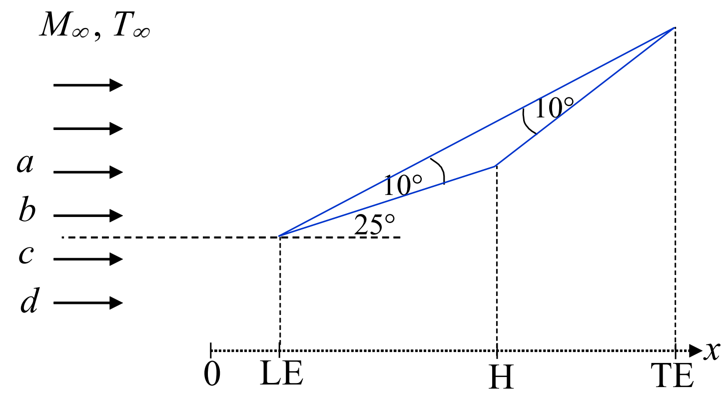
1. **Supersonic Diffuser**
   a) Write a complete set of expressions (DO NOT derive them, just cite your source) for a thermally and calorically perfect gas as it isentropically compresses as it passes through a supersonic (converging-diverging) diffuser that relate: the temperature (T), pressure (p), density (ρ), Mach number (M) and velocity (u) of a flow; the local cross-sectional area (A) and throat area (A_t) of the diffuser; and any necessary stagnation conditions. Make sure to include any additional assumptions that these expressions use (i.e., assumptions that are not specifically given to you in this problem).
   b) Plot T, p, ρ, M and u vs. A/A_t for a mixture that is 65% N_2 and 35% Ar by mole through such a diffuser with an exit area ratio (A_e/A_t) of 40 as it compresses from an inlet Mach number of 6, temperature of 200.0 K and pressure of 0.010 atm. Base your specific heat values for this mixture only on the modes you expect to be near fully-excited (and therefore approximately constant) over the **complete** range of temperatures covered.

2. **Normal Shocks**
   a) Write expressions (again no derivations, just cite your sources) that give the temperature ratio, T_2/T_1, pressure ratio, p_2/p_1, density ratio ρ_2/ρ_1, velocity ratio u_2/u_1 (in the shock's reference frame) and normalized entropy increase, $(s_2 - s_1)/R$, for a normal shock in a thermally and calorically perfect gas as a function of the shock Mach number, M_1. Again, be sure to include any additional assumptions used.
   b) Plot the 1) temperature ratio, 2) pressure ratio, 3) density ratio, 4) normalized entropy increase and 5) velocity ratio for normal shocks with Mach numbers up to at least 10 using the gas mixture described in Problem 1, with initial conditions of 200.0K and 0.010 atm. Base your specific heat values for this mixture only on the modes you expect to be near fully-excited at the pre-shock conditions.

3. **Supersonic Flowfield Temperature**

A uniform, supersonic gas flow with Mach number $M_\infty = 6$ and static temperature T_∞ approaches the two-dimensional body shown in the figure. Assume the gas is thermally and calorically perfect with $\gamma = 1.2$.

The figure also shows the beginning of a number of streamlines (labeled a-d) in the region upstream of the body. The streamlines are distributed uniformly in the vertical direction, and streamlines b and c are equally spaced above and below the leading edge of the body.



For each of these four streamlines, sketch (can be hand drawn) the gas temperature normalized by the freestream temperature (T/T_∞) as a function of horizontal distance from 0 to TE (the horizontal location of the trailing edge). On your horizontal axis, include the four locations indicated on the axis shown in the figure (0, LE and H and TE).

All four temperature sketches should be provided on a single graph (i.e., a single set of axes). The temperature sketches need to be qualitatively correct, including with respect to each other, in terms of both horizontal position and T/T_∞, but they do not need to be quantitative (i.e., no numbers are required on your graph).

Furthermore, you need to justify your sketches with explanations and/or calculations.