AS – 5680 High Temperature Gas Dynamics
Dr. T. M. Muruganandam
Assignment – 1, Weightage: 15%, Due date: Mar 21, 2020 5pm.

Assignments must be submitted electronically to murgi@ae.iitm.ac.in and the reports must contain:

1. Only the results in the form of plots and discussions related to them. If there are no interpretations, there will be no scores. If submitted late, there will be negative points of -2% of grade every one hour. (need not submit after 7.5 hrs!)
2. Appendix which must include the codes used or the procedures/algorithms used if no softwares used. The codes will be checked for its running ability during evaluation. If codes don't give the plots presented, score will be zero.

Assume the fluid used to be air with composition of N_2 79% and O_2 21% by volume. The incoming flow has a **static pressure of 1 atm** and **static temperature of 300K**.

1. **Normal Shock:** Plot the variation of T_2/T_1, P_2/P_1, rho_2/rho_1, u_2/u_1, S_2/S_1 and M_2/M_1 across a normal shock for various mach numbers M1 in the range 1.5 to 20. The each plot must contain three curves: 1) flow with frozen vibration and chemistry, 2) flow with only chemistry frozen, and 3) equilibrium flow. Interpret the results. Plot percentage energy/mass in each of the energy modes (including Bulk KE) along with total enthalpy/mass as a function of Mach number. Interpret the results. [12]

2. **Oblique Shock:** A Mach 6 flow streamline has been turned by 15 degrees by a wall. Calculate the (weak) shock angle, density ratio, pressure ratio, velocity ratio (overall velocity, not components) and entropy ratio for the first two flow cases mentioned in problem 1. Calculate the same for strong shock cases with same deflection angle of 10 degrees. Show these results on a Theta-Beta-M plot with frozen curves. Also interpret the results. [8]

3. **Nozzle flow:** Consider a straight line CD nozzle with area ratio 15 (both inlet and outlet) and half-angle of 45^o(conv) and 15^o(div). The stagnation temperature for the flow is 4500K. Assume the flow to be perfectly expanded. Solve the flow for the first two cases mentioned in problem 1. Calculate (a) the flow velocity, (b) the temperature of various modes, (c) the Mach number (d) pressure (e) specific entropy and (f) gamma as a function of distance from the throat. Also interpret the results. [10]

[Bonus] Solve the problems 2&3 with the third flow case mentioned in problem 1!! [8]

The required thermodynamic data are available on the class website. Lets use only the following species in the code: N2, O2, NO, N, and O.