AS – 203 Gas Dynamics
Dr. T. M. Muruganandam
Assignment – 2,

Due: start of class on 10 Mar 2008. **Total score: 35.** **Weightage on final grade 7%**

*For the purpose of this assignment, **AE04B033 will be treated as AE06B011** and **AE05B002 will be treated as AE06B028**. The last two digits in your roll number is taken as 'n'. If your **'n' is even**, you are to design a nozzle (**Part A**), **else** you characterize a flow through a nozzle(**Part B**). **All of you are expected to solve the second question**.*

The submission is expected to be in electronic form with **one zip file** comprising the following:

(a) codes used (they must run when used in my comp),

(b) a report which explains the program and the techniques used, the plots required (with discussion), and

(c) an undertaking that the work was done independently/with discussion with xyz, abc etc.

The file is due to my account (tmmuruganandam@gmail.com) on **15 Apr 2008, 12PM** (receiving time at my end). **Any of these parts missing will render the report incomplete. Late submissions will not be entertained.**

1. (A) Design of a 2D supersonic nozzle. **[20]**

The design Mach number of your nozzle is M=2+0.1n. The throat is having a height of **1 unit**. Assume that flow is sonic everywhere in the throat section and flow is parallel to the axis. Find the nozzle shape. (list points data) Plot the nozzle shape and the characteristic fabric you calculated. (see example next page) Plot the distribution of Mach number and theta at the exit plane. (if you don't have points there, interpolate along the characteristic lines) Plot the error in the average exit plane Mach number w.r.t. the design target Mach number M. What does it depend on? What do you expect the Mach number distribution to be when the nozzle shape is a straight line and not the curve you obtained?

1. (B) Characterising a supersonic nozzle. **[20]**

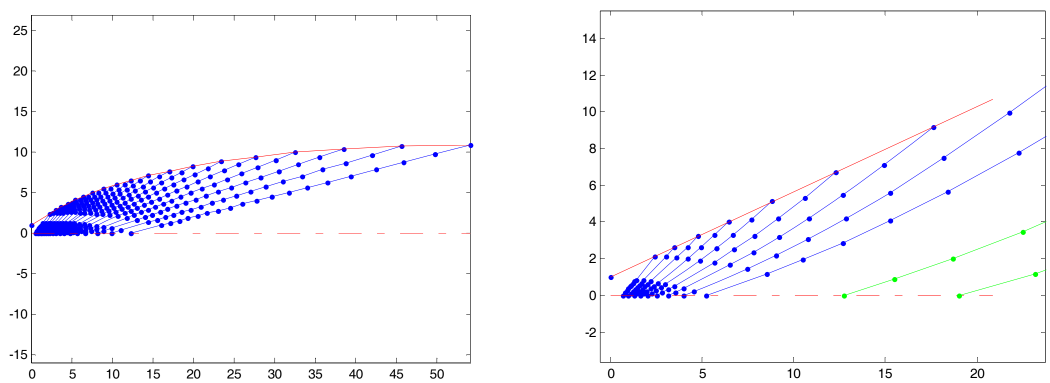
Lets say the Mach number of your nozzle is M=2+0.1n. The throat is having a height of **1 unit**. And the slope of the wall is 15^o w.r.t. axis of nozzle. Assume the nozzle is perfectly expanded. Solve for the flow in the nozzle assuming the flow is sonic everywhere in the throat section, with flow parallel to the axis. Plot the nozzle and the characteristic fabric you calculated. Plot the distribution of Mach number and theta at the exit plane. (if you don't have points there, interpolate along the characteristic lines) Plot the error in the average exit plane Mach number w.r.t the design Mach number M. What does it depend on? Explain the features observed in your flow and plots.

2. Solve the quasi-1D flow through **your nozzle from question 1**. Assume that the convergent section is having the inlet to exit area ratio of 1, and the convergence half angle is 15^o. Plot Pressure vs x **in the nozzle,** for back pressures starting from Po and decreasing to below second critical pressure. **[15]**

3. [BONUS] [20]

A symmetric airfoil is such that the top surface represented by a parabola with the peak at mid chord. The beginning and the ending angle for the parabola are same. The thickness (total) to chord ratio is given by 0.1+n/250. It is in a supersonic flow with Minf = 6-$M_{1,}$ where M_1 is the Mach number used in problem 1. Find the pressure distribution on this airfoil

---



Example of plot of characteristic fabric calculated for (a) nozzle design, (b) straight line nozzle flow. For clarity I have omitted the negative characteristics from the plots. But they can also be plotted.