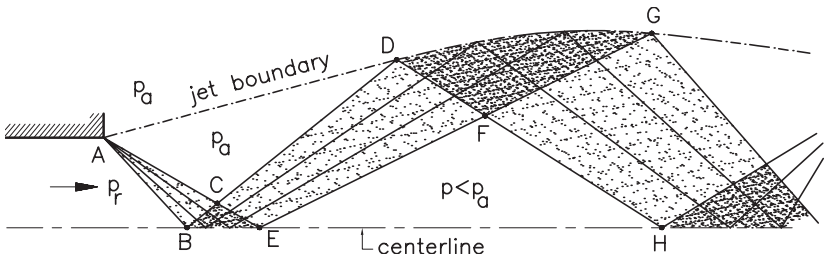
Gasdynamics task 2

2020/2021

Consider the underexpanded jet that is discussed in Chapter 7 of the Gasdynamics Course Notes.



Apply the M.O.C. to find the development of the jet flow downstream of the nozzle. The flow in the exit of the nozzle has a Mach number $M_e = 2$. The exit flow is parallel and underexpanded, which means that the pressure in the exit (p_e) is higher than the pressure of the ambient (p_a). Assume $p_e = 2p_a$.

- Write a computer program based on the M.O.C. to determine the flow field in the jet. Try to write your code for an arbitrary number of characteristics (e.g. determined by the user when the code is executed).
- Describe your approach and include the essential parts of the source code (no need to include all plotting routines) in your report. You may stop the calculations when shocks appear where characteristics of the same family intersect (downstream of point H in the figure above).
- Take enough characteristics (>10) inside the centered expansion in order to see the details (converging/diverging characteristics, shock formation, etc) of the flow field.
- Produce a detailed picture of the characteristic pattern, including the shape of the jet boundary. *Comment/discuss* the pattern of characteristics and jet boundary shape.
- Show and discuss the Mach distribution in the jet area.
- Take a streamline starting on the centerline of the jet exit (y = H/2) and plot it in the picture showing the characteristics. In a separate figure, plot the pressure along the streamline. *Comment* on your observations.
- Repeat the same process for a streamline starting at y = 3H/4 (H is the height of the jet exit). Comment on your observations.
- *Comment* on the accuracy of you computations, does it matter how many characteristics you use in the computation?

Extra question (in case you have time left)

- How does the location where the shock appears vary when the exit Mach number or exit pressure is changed? You can answer this question either quantitatively by performing additional simulations or qualitatively (by looking at the slope of the characteristics).