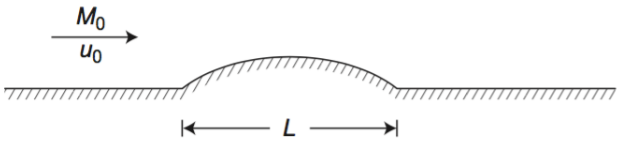
AE339: High-speed aerodynamics
Tutorial 6

1. Check whether the following flow-fields satisfy the linearized velocity potential equation in supersonic flow.
   (a) $\phi = \dfrac{-C}{2\pi h}$,
   (b) $\phi = \dfrac{C\lambda^2 z}{2\pi h^3}$, and
   (c) $\phi = \dfrac{Cxz}{2\pi(y^2+z^2)h}$,
   where C is an arbitrary constant and $h = \sqrt{x^2 - \lambda^2(y^2+z^2)}$

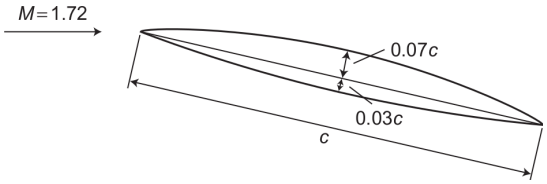
2. A shallow irregularity of length l in a plane wall along which a two-dimensional supersonic stream $M_0 = u_0/a_0$ is flowing is given approximately by the expression $y = kx[1 - x/l]$, where $0 < x < l$ and $k << l$ (see figure). Show that the velocity potential due to the disturbance in the flow is

$$\phi = \frac{-u_0}{\sqrt{M_0^2 - 1}} k(x - \sqrt{M_0^2 - 1}y)\left[1 - \frac{x - \sqrt{M_0^2 - 1}y}{l}\right]$$

   Also, obtain a corresponding expression for the local pressure coefficient anywhere on the irregularity.



3. Consider supersonic flow ($M_\infty = 1.72$) over an airfoil made up of two unequal circular arcs as shown in the figure. Measuring x from the leading edge, the local deflections from the freestream direction are:



$$\epsilon_U = 0.28\left(1 - 2\frac{x}{c}\right) - \alpha$$

$$\epsilon_L = 0.12\left(1 - 2\frac{x}{c}\right) + \alpha$$

   for the upper and lower surfaces, respectively.

   Compute the following:
   (a) lift coefficient, (b) wave-drag coefficient, (c) leading edge moment coefficient, and (d) center of pressure coefficient, x_{cp}/c in terms of the angle of attack. Neglecting skin friction, at what angle does the lift-to-drag ratio L/D reach a maximum? What is the maximum value of the L/D?