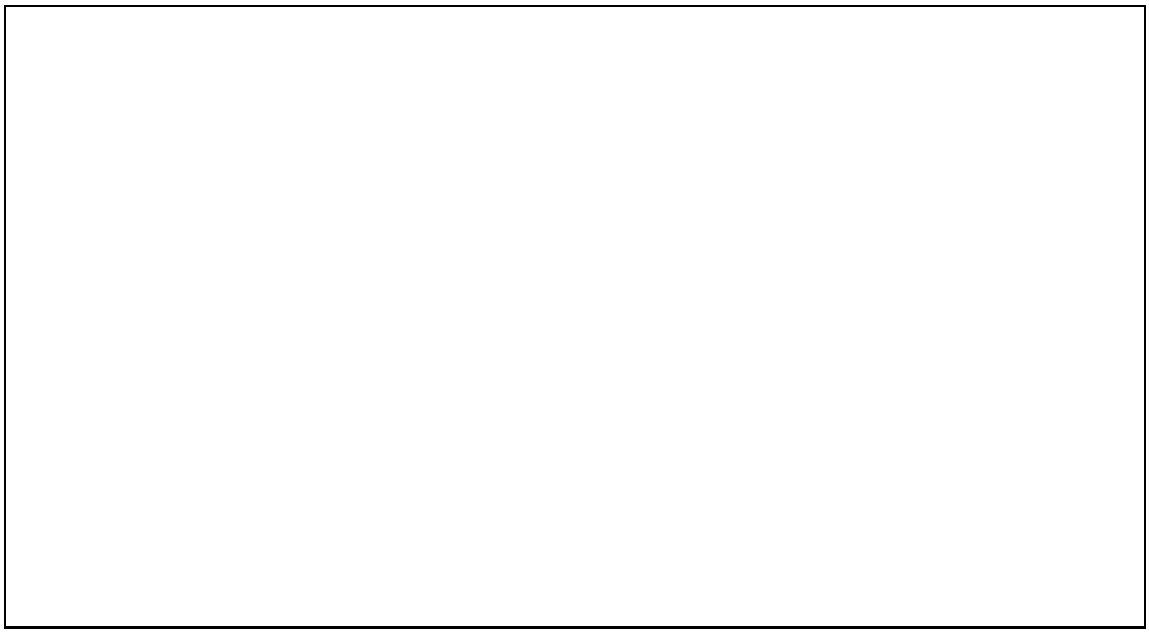
Teaser Question
Basic Training in Condensed–Matter Theory
James Sethna; Due Friday, January 23, 2009
Last revised: January 20, 2009, 3:07 pm

Why are fluids incompressible?

A one-component fluid has three conserved fields: the energy density $\epsilon(\mathbf{r})$, the mass density $\rho(\mathbf{r})$, and the momentum density $\mathbf{g}(\mathbf{r})$. But for fluid flows on human scales, one can usually ignore both the energy density ϵ and the variations in the density $\rho - \rho_0$, leading to the Navier-Stokes equations. We argued in class that Navier Stokes is an expansion at small Mach numbers, where the velocities $\mathbf{v} = \mathbf{g}/\rho$ in the fluid are low compared to the speed of sound c. This we argued was equivalent to the translational kinetic energy density $\rho\mathbf{v}^2/2$ being low compared to the internal energy of the fluids involved.

Why are Mach numbers small in day-to-day life? Is there a fundamental mechanical reason why beings which could run faster than the speed of sound in their atmosphere would not survive? What would happen if they collided at a velocity comparable to their internal *speed of sound?* If possible, relate this to the practical limits to the strength and toughness of biological and other materials.



Answer in box above. Bring to class Friday. Will be graded, in lieu of homework.

Name: _____