Lecture F15 Mud: Uniform flow, sources, sinks, doublets
(27 respondents)

1. **In the freestream+source case, if V_∞ increases, will the picture change?** (1 student)
   The streamline pattern depends only on the ratio Λ/V_∞. So let's say you double both Λ and V_∞, all the velocities will double, but the streamline pattern won't change. If you change only V_∞, then the streamline pattern will change.

2. **How do we model more complicated flows like airfoils or wings?** (2 students)
   With more complicated arrangements of sources, sinks, vortices, and doublets. The most complicated 3-D models might have thousands of sources or doublets. The necessary bookkeeping must be done by computer programs.

3. **How do we select the source, sink, doublet, etc. required to model a specific flow?** (2 students)
   In our examples we superimposed a source or doublet of prescribed strength with a freestream of prescribed strength. We then obtained the shape of the implied body via the dividing streamline. In aerodynamic applications, the problem is somewhat in reverse – the shape of the body (airfoil or wing) is a given, and we have to determine out the source and doublet strengths which are necessary to produce a flow about the body. One technique for doing this is *thin airfoil theory*, which we will address later in considerable detail. Other techniques are *panel methods*, which are rather complicated, so we will only mention these in passing.

4. **In the doublet construction, when is $\Lambda = +\kappa/\ell$, and when is $\Lambda = -\kappa/\ell$?** (1 student)
   The left source has positive $\Lambda = \kappa/\ell$, and the right source (sink, actually), has a negative $\Lambda = -\kappa/\ell$. We picked the signs this way to get a doublet which has the flow along the x-axis going to the left. Picking opposite signs would simply reverse the doublet's flow direction. A right-going doublet superimposed with a right-going uniform flow will not give the flow about a cylinder.

5. **How do we know the value of κ so we can apply the results for the cylinder?** (1 student)
   You can set κ from the radius and freestream speed:
   $$\kappa = 2\pi R^2 V_\infty$$

6. **How does ψ go to $-(\kappa/2\pi)\sin\theta/r$ in the limit?** (1 student)
   You gave to plug in the flowfield geometry, and take the limit. Andreson does this on pp. 221–222.

7. **Does the $C_p(\theta) = 1 - 4\sin^2\theta$ correspond to what we will plot for our lab?** (1 student)
   Yes, it's one of the curves.

8. **What makes this flow non-lifting?** (1 student)
   It's symmetrical between top and bottom, so there's no net y-force.

9. **How do you take friction into account?** (1 student)
   Predicting viscous separated flow on a bluff body like the cylinder is extremely difficult. In contrast, prediction of viscous flow about a streamline shape is much easier and faster. Either one is beyond the scope of Unified Fluids, however. This is addressed to some extent in 16.110 (Senior/Grad aerodynamics course), and in a few other courses.

10. **Confused about PRS question at the end. How did you get $h = \Lambda/V_\infty$?** (6 students)
    The source's contribution to the velocity decreases with distance as $1/r$. Hence, the velocity very far downstream is just $V_\infty \hat{\imath}$ (i.e. only the freestream part), since far away the contribution of the source decreases to nothing.

    The volume flow rate between the two streamlines is therefore computed to be $\dot{v} = \oint \vec{V} \cdot \hat{n}\, dA \;=\; V_\infty\, h$. But the volume flow rate between the two streamlines is equal to Λ, which is what the source cranks out. Hence $\dot{v} = V_\infty\, h \;=\; \Lambda$, or $h \;=\; \Lambda/V_\infty$. I apologize again for the typos on the PRS answer list.

11. **No mud** (10 students)