

## Fluids Lab-1 Lecture Mud

(42 respondents)

1. **Why is it that  $p_o$  is constant along a streamline?** (1 student)

We can conclude this from the equations of motion ( $F=ma$ ) for a fluid, after some algebra and calculus work. We will get to this later in the course. For the purposes of the upcoming Lab, we ask you to take it on faith for now. And the class tunnel demo experimentally showed that  $p_o$  is indeed constant.

2. **What are  $V_\infty$  and  $p_\infty$  as opposed to  $V$  and  $p$ ?** (6 students)

The subscript  $( )_\infty$  indicates a quantity “at infinity”, in the mathematical-limit sense. So the pressure field  $p(x, y, z)$  near the wing asymptotes to  $p_\infty$  as we move farther and farther away. Likewise for  $V(x, y, z)$  and  $V_\infty$ . In practice, the pressure field asymptotes very quickly, so we don’t have to move very far from the wing to get very close to  $p_\infty$ . Commonly used names for  $p_\infty$  are “freestream pressure” or “far-upstream pressure”. For an airplane,  $p_\infty$  is the same as ambient atmospheric pressure, and  $V_\infty$  is the same as the flight airspeed.

3. **Lost track of all the various  $p$ ,  $p_o$ ,  $q_\infty$ , etc.** (1 student)

They will become more intuitive as you work with them more. However, it’s useful at this point to distinguish between fundamental and derived (but very practical!) quantities:

$\rho, p, V$	fundamental flow quantities
$q$	derived quantity ( $\equiv \frac{1}{2}\rho V^2$ )
$p_o$	derived flow quantity ( $\equiv p + \frac{1}{2}\rho V^2 = p + q$ )

4. **Why are the isobars around the airfoil shaped the way they are?** (1 student)

The isobar shapes are the result of some fairly detailed computer calculations which numerically solve the equations of fluid flow. You will be exposed to some of these calculation methods later in Unified.

5. **Didn’t understand the boundary layer. What’s  $dp/dn$ ?** (4 students)

The boundary layer is where viscosity does its thing, and brings  $V$  to zero at the wall, over a short distance from the wall. Within this small distance (the boundary layer thickness),  $p_o$  has some unknown value, so the Bernoulli Equation is not usable for relating  $p$  and  $V$ . However, we are rescued by also knowing that the pressure gradient  $dp/dn$  in the wall-normal direction must be nearly zero (since the flow doesn’t curve into the wall). So the wall pressure must be nearly the same as the pressure just outside the boundary layer, where Bernoulli is usable.

6. **I didn’t understand how the probe and the manometer work** (4 students)

Tough to explain here. I suggest reading the notes again, and maybe talk to me or one of the TA’s.

7. **Why did  $p_o$  decrease as you moved the probe near the wall?** (1 student)

As we move towards the wall inside the boundary layer,  $p$  stays nearly the same, but  $q = 0.5\rho V^2$  decreases to zero in some manner. So  $p_o = p + q$  must decrease as well. At the wall itself, we have  $V = 0$ ,  $q = 0$ , and  $p_o = p$ .

8. **Does the probe's disturbance of the boundary layer affect the probe's own measurement?** (1 student)

The effect is surprisingly small on the static  $p$  measurement. As long as the probe is held parallel to the flow (inside or outside the boundary layer), the streamlines will stay parallel, and the probe's static  $p$  measurement will be fairly accurate. The effect on the  $p_o$  measurement is stronger, since the probe's nose certainly pushes the streamlines around. So it's not clear which streamline's  $p_o$  you are actually sensing. To accurately sense the  $p_o(n)$  distribution inside the boundary layer, the probe must be very much smaller than the boundary layer thickness (not true in the class demo!).

9. **No mud** (13 students)