Lecture F05 Mud: Intro to 3-D Wings

1. **What exactly is downwash?** (1 student)
   A vertical velocity component which is due to the presence of the tip vortices. If the wing has infinite span (is 2-D), there are no vortices and no downwash.

2. **Why do we look at only the vertical \( z \)-velocity of the vortex, and not the horizontal \( y \)-velocity?** (1 student)
   Only the vertical component affects the velocity triangle and the angle of attack in the \( x-z \) airfoil plane.

3. **How do the vortices affect the flow in front of the wing?** (1 student)
   The vortices do have downwash ahead of the wing, but it rapidly decays to zero as we move upstream.

4. **Does the downwash have any affect below the wing?** (1 student)
   The downwash is maximum directly behind the wing, and gradually dies off to zero as we go up or down.

5. **How do you design a plane to minimize the downwash?** (1 student)
   The surest way is to increase the span, but this has other drawbacks. In the UE Dragonfly competition you will be looking at these tradeoffs.

6. **What is the significance of \( \alpha_{\text{eff}} \)?** (1 student)
   It’s the effective angle of attack seen by the wing. The diagram in the notes shows how it relates to the geometric \( \alpha \), and the induced angle \( \alpha_i \) caused by the downwash.

7. **How does \( w \sim 1/V_\infty \)?** (2 students)
   The simple momentum analysis indicated that \( L = \rho V_\infty w b^2 \). In level flight, \( L = \text{weight} \) which is fixed. So as the airplane slows down and \( V_\infty \) decreases, \( w \) must increase in proportion to maintain the constant lift.

8. **Do upturned wings (dihedral) affect the tip vortices?** (2 students)
   For small dihedral angles, it’s not significant. Sharply-angled winglets do have a significant effect.

9. **What is \( C_{D_p} \)? ** Is viscosity important?** (1 student)
   This is profile drag, or viscous drag. On a wing, it is the chord-weighted average 2-D viscous \( c_d \), which is what Xfoil or airfoil tunnel data gives. In general, \( c_d \) and hence \( C_{D_p} \) significantly depends on \( c_\ell \) and Reynolds number.

10. **What’s \( \bar{c} \)? ** Why isn’t it the same as \( c_{\text{avg}} \)?** (1 student)
    A simple average and an r.m.s. average do not give the same results. You can try a simple \( c(y) \) function, and compute both \( c_{\text{avg}} \) and \( \bar{c} \) to convince yourself.

11. **If we use different \( c_{\text{ref}} \), won’t we get different \( C_M \)?** (1 student)
    Yep. But this doesn’t matter, as long as you use the same \( c_{\text{ref}} \) to get back the dimensional \( M \) values from \( C_M \).

12. **Why is \( L' \) perpendicular to \( V_\infty \), and \( D'_\ell \) perpendicular to \( w \)?** (1 student)
    By definition, really. Maybe go through the notes to see how the formulas are obtained.

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