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 α_{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 α, and the induced angle α_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, $L =$ weight which is fixed. So as the airplane slows down and V_∞ 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_ℓ and Reynolds number.

10. **What's $\bar{c}$? Why isn't it the same as c_{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_{avg} and $\bar{c}$ to convince yourself.

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

12. **Why is L' perpendicular to V_∞, and D_i' 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)