

## 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  $D'_i$  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)