

Biology 427 Biomechanics

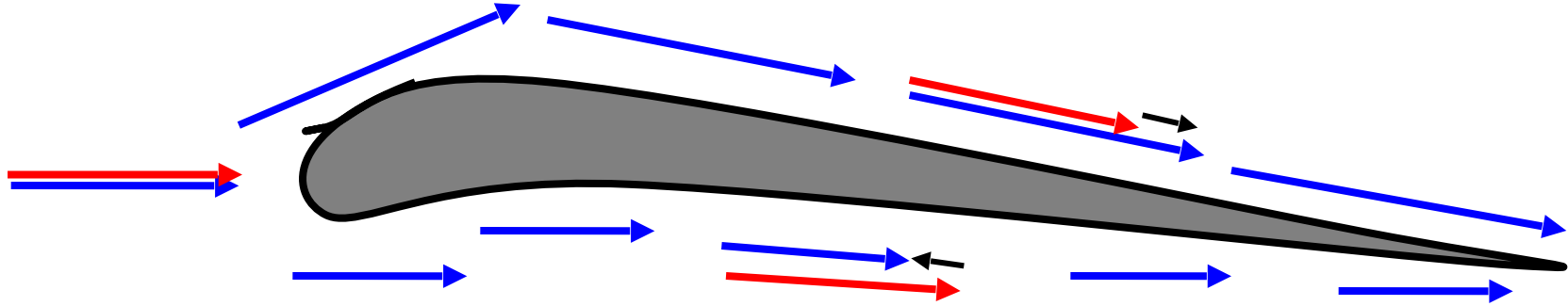
Lecture 20 Gliding flight: a soar topic.

- Recap basics of lift and circulation
- The lift coefficient (C_L) and aspect ratio
- Drag coefficients for wings
- Drag and lift together (polar plots)
- Gliding flight – gravity, drag and lift
- Soaring flight – gravity, drag, lift, and natural currents

Lift and Circulation:

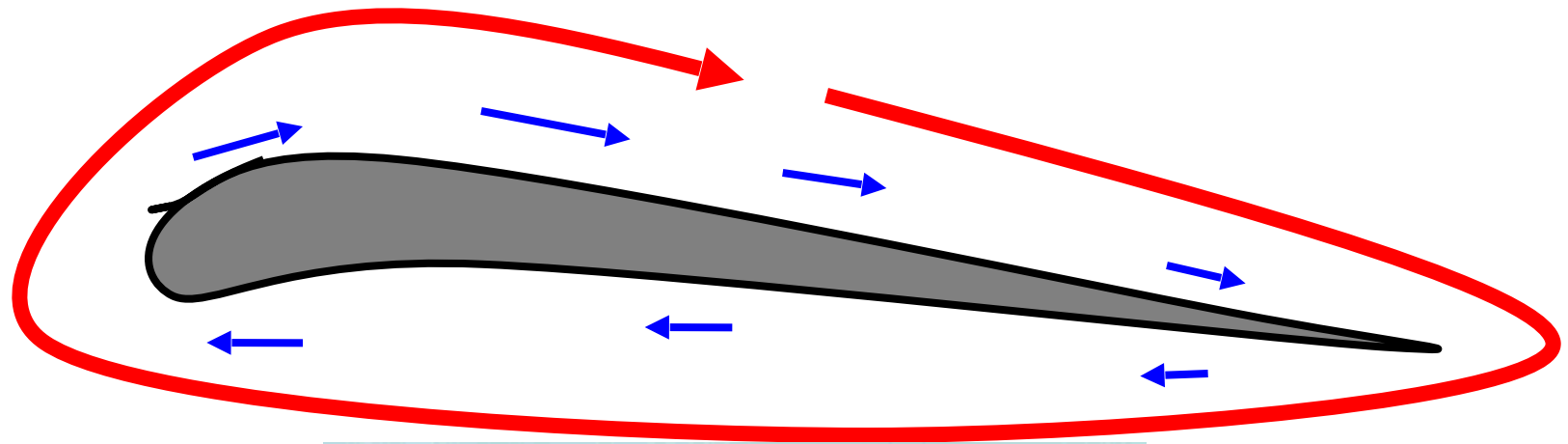
Subtract the mean velocity from all of these vectors

$$L = C_L \rho S U^2 / 2$$



Lift and Circulation:

With the mean subtracted, there is an effective circulation (Γ) about the wing. Greater Γ implies a greater velocity difference



Lift and Circulation:

Message: lift can be measured by the amount of circulation held by a wing

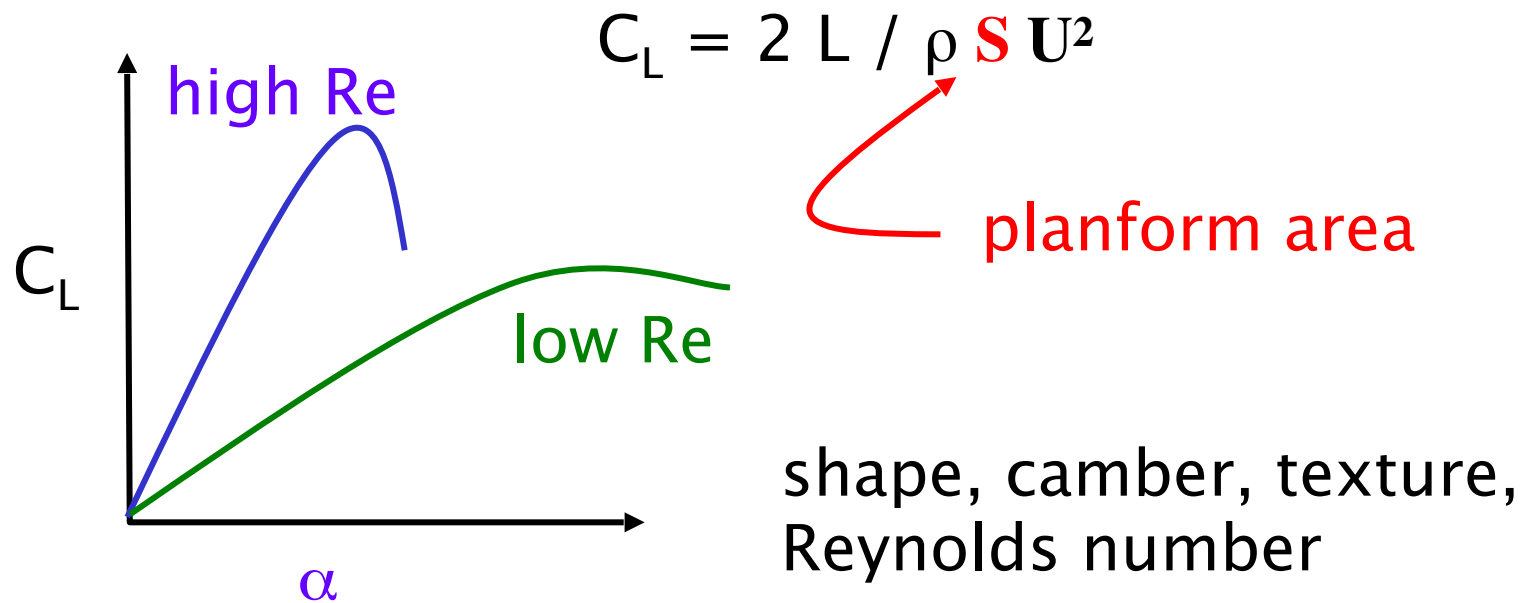
Circulation can be lost from the wing as a tip vortex

Higher aspect ratio wings loose proportionately less



Formation flight:
recovers some lost

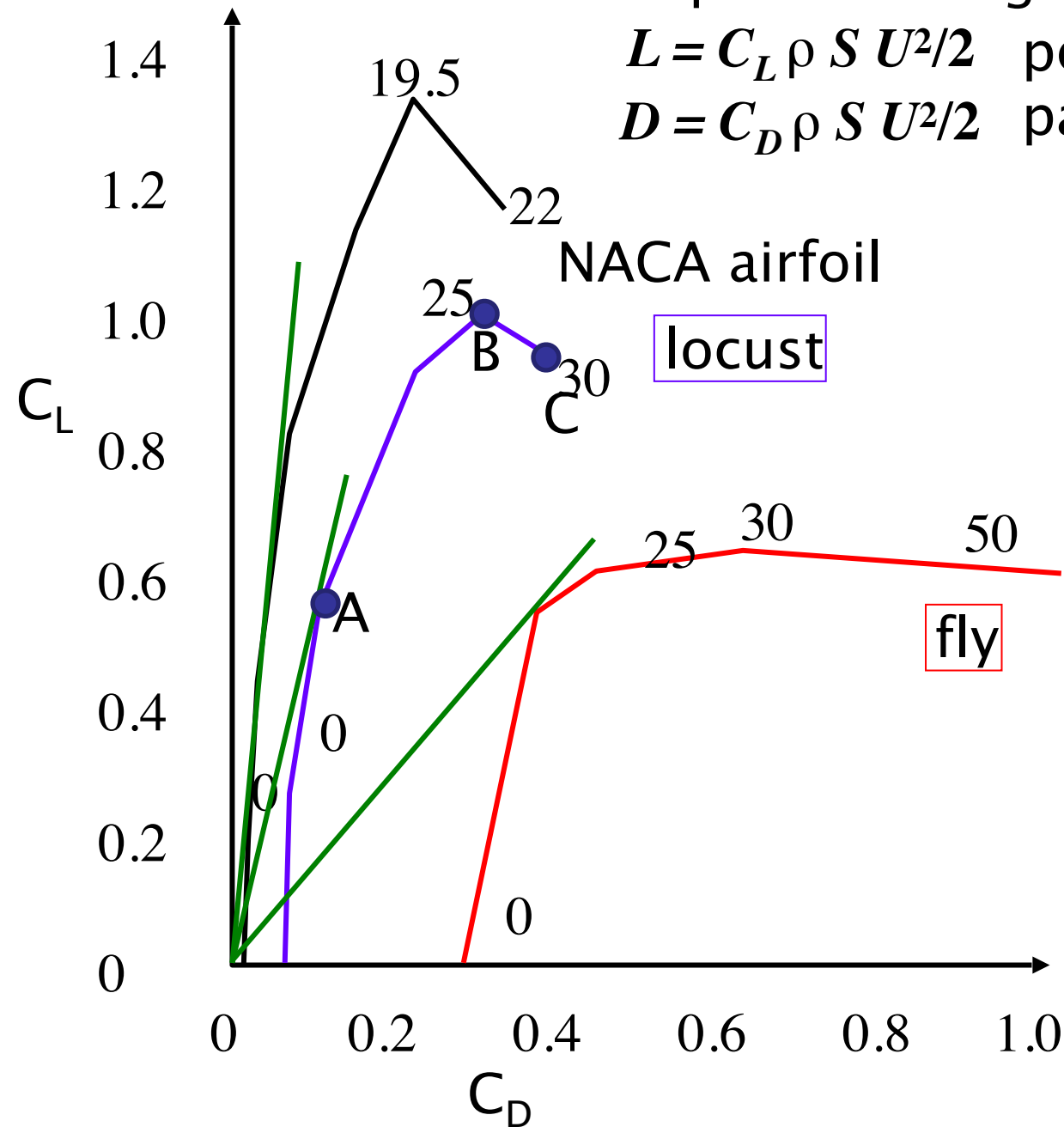
For real wings in real fluids, we cannot ignore viscosity and the finite span of the wings.



Polar plots of wings

$$L = C_L \rho S U^2 / 2 \quad \text{perpendicular}$$

$$D = C_D \rho S U^2 / 2 \quad \text{parallel}$$



Where, for locust wings, is the **ratio of lift to drag** greatest? A, B, C?

Gliding: “falling with style”



Gliding: “falling with style”



Gliding: “falling with style”



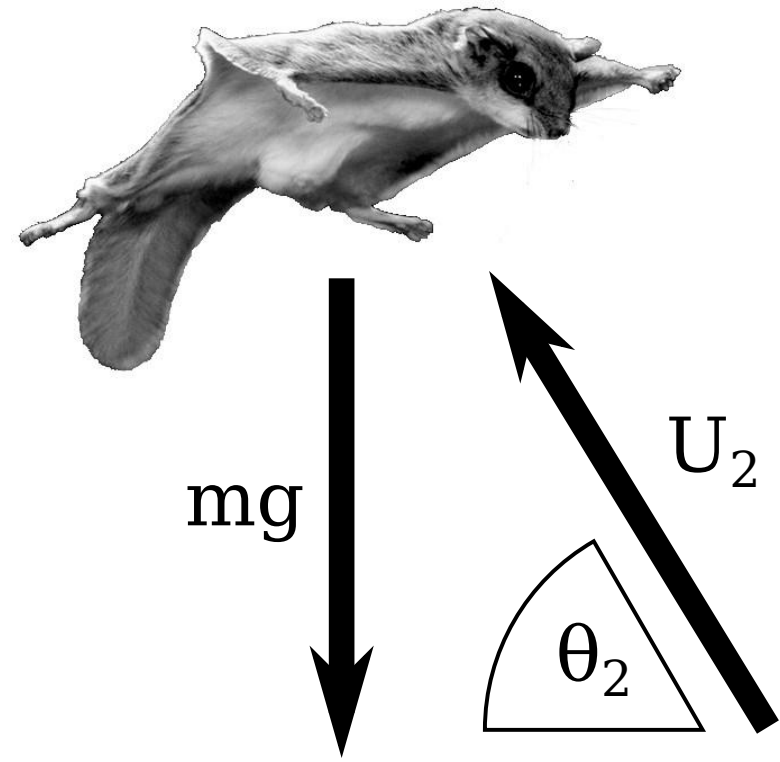
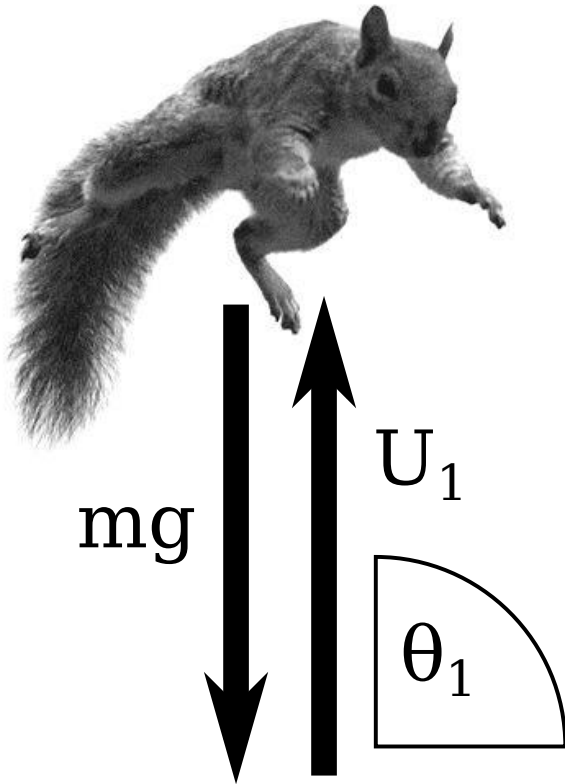
Gliding: “falling with style”



Gliding: “falling with style”



Gliding: “falling with style”



- 1: Draw the forces (lift and drag)
- 2: How does the glide angle depend on the ratio of lift to drag?

GLIDING: how does weight affect trajectory?

At equilibrium

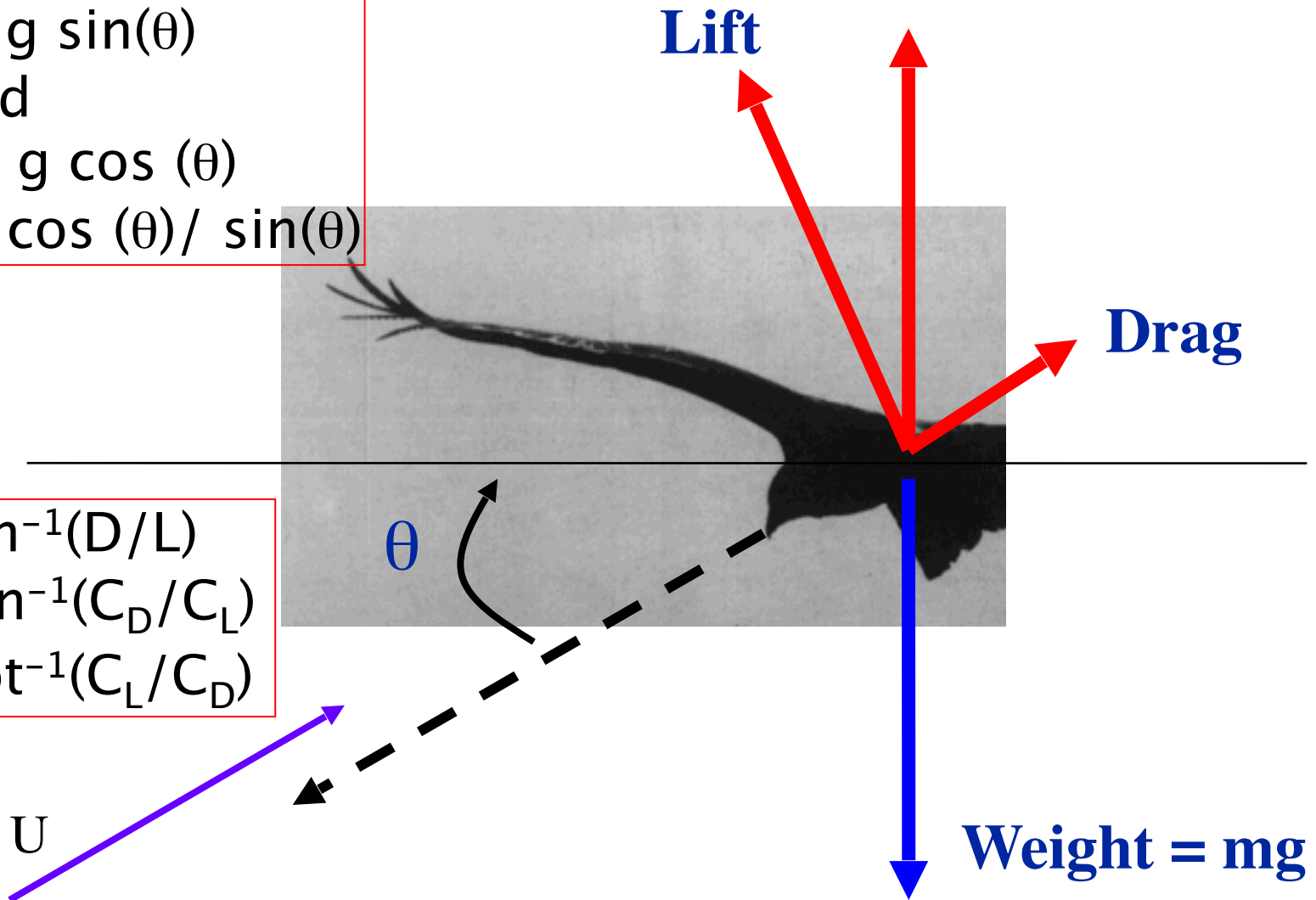
$$L = m g \sin(\theta)$$

and

$$D = m g \cos(\theta)$$

$$D/L = \cos(\theta) / \sin(\theta)$$

$$\begin{aligned}\theta &= \tan^{-1}(D/L) \\ &= \tan^{-1}(C_D/C_L) \\ &= \cot^{-1}(C_L/C_D)\end{aligned}$$



Soaring: gliding without much falling

use external currents to compensate
for descending velocity

slope soaring



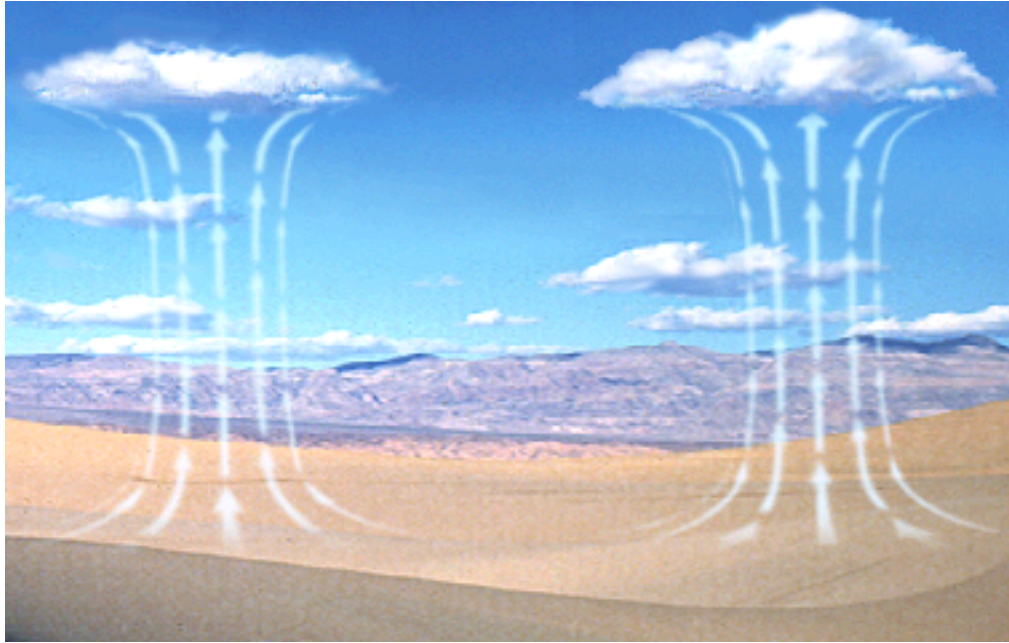
wave soaring



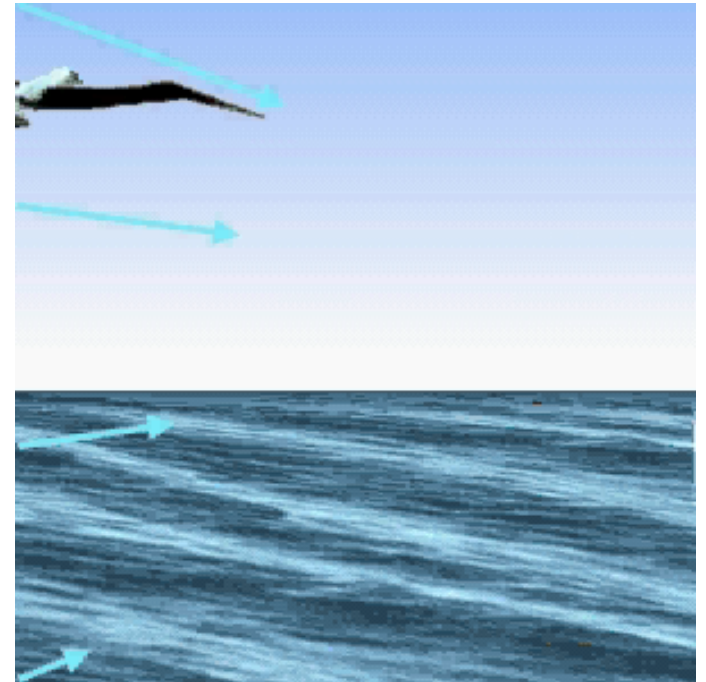
Soaring: gliding without much falling

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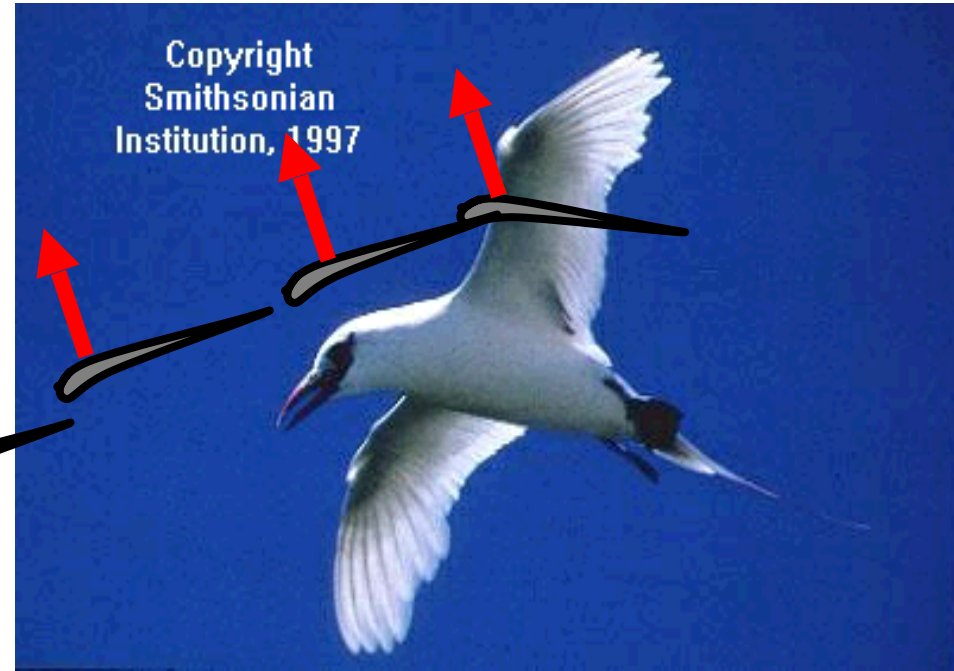
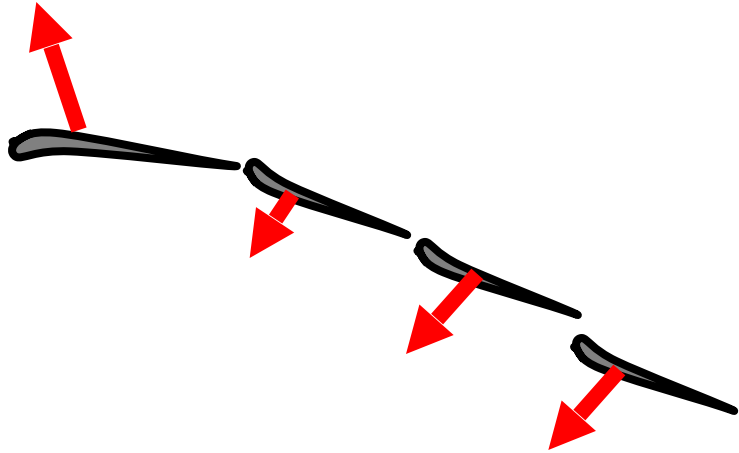
thermal soaring

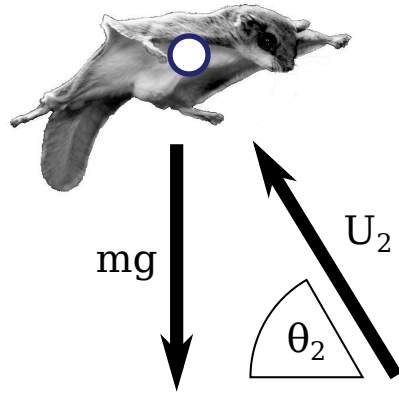
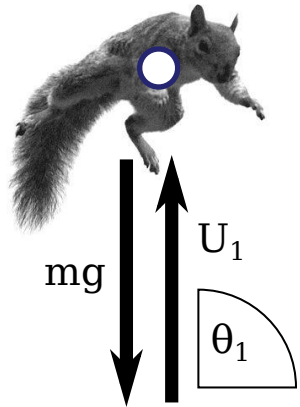


dynamic soaring

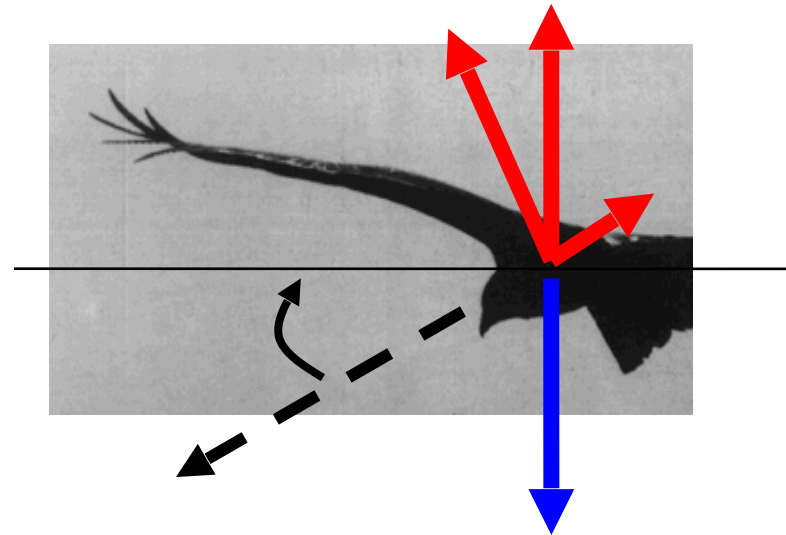


Flapping flight: powering lift and thrust





- 1: Draw the forces (lift and drag)
- 2: How does the glide angle depend on the ratio of lift to drag?



How does weight affect trajectory?