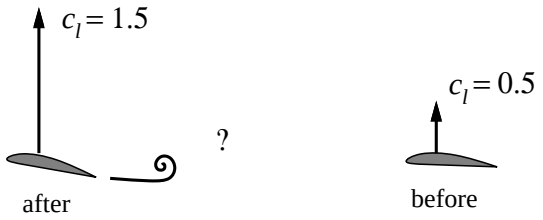
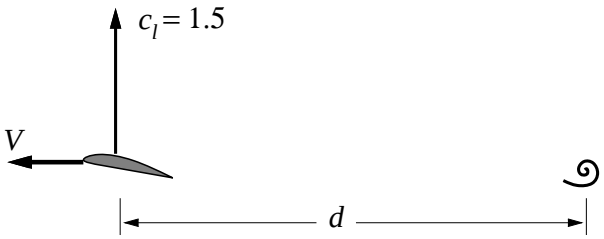
Unified Engineering Spring 2008
Fluids Problem F1

An airplane wing's airfoil of chord $c = 1\,\text{m}$ is operating at a steady velocity $V = 30\,\text{m/s}$, at lift coefficient $c_\ell = 0.5$. Its angle of attack is suddenly increased so that now $c_\ell = 1.5$.

1) Determine the circulation of the vortex shed by the airfoil as a result of this maneuver.



2a) A short time later, the shed vortex at distance $d = 10\,\text{m}$ downstream, and the wing is moving horizontally with velocity V at this instant. Determine the apparent freesteam flow velocity vector seen by an observer on the airfoil.



2b) Let us assume that the wing has a very large aspect ratio and is effectively inviscid, so that in steady flow in isolation it would have a drag force, defined opposite to V, of $c_d = 0$ (d'Alembert's Paradox). But this wing is not isolated — there's the shed vortex. Determine the wing c_d caused by the presence of the vortex.