

## **Flow visualization using vortices**

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Applied aerodynamics has been revolutionised by Computational Fluid Dynamics. CFD is widely applied in industry and is becoming the dominant tool research. The teaching of aerodynamics has been adjusted to compensate, but there is a widening gap between the answers given by the CFD box of tricks and a real understanding of the aerodynamic problems. The problem is compounded by the reduced number of experiments, especially those with flow visualization. The power of the computer can be used to bring some of the simpler concepts to life, thus supporting theoretical models and experimental work.

The presentation is based on the concept of a vortex. The vortex shed from a wing tip was sketched by Lanchester, but Prandtl made the leap of imagination which gave us the most enduring concept of the bound vortex. Using simple concepts, it is possible to obtain convincing demonstrations of many useful fluid flows. The following will be included in the presentation.

Vortex pairing in a shear layer;  
Flow over a flat plate (2-d);  
Flow over a slender delta wing, (slender wing approximation);  
Instability of a vortex ring;  
Instability of a trailing vortex pair, Crowe instability.

Two ring vortices interact to give an approximate model of circular jet instability. This model gives a good representation of the dominant modes of the Proper Orthogonal Decomposition. It also gives insight into the mechanism of noise generation. The gain in understanding given by the combination of experiment, POD reconstruction and a simple model, is so significant, that it gives hope of further progress.

The above models use simple theory and (fairly) simple Matlab code, and give instructive movies of the main flow features. Perhaps, one day, it will be possible to show a simple reconstruction of the near wall region of the turbulent boundary layer.