





















**Figure 24.** Integration paths for the computation of circulation.

### 4.3 Flow Animations

The results exported to MATLAB were used to prepare an animation of the three different flow configurations considered in this work. The video with the flow animations can be found in <https://www.youtube.com/watch?v=bvV7-9wAXc0>. The flow animations are qualitatively similar to the historical flow visualization from Prandtl, see (National Committee for Fluid Mechanics Films, 1972), including the formation of starting and stopping vortices as well as oscillatory vortex shedding for the case of the stationary airfoil.

### 4.4 Further works

The inclusion of the non inertial term in the Navier-Stokes equations could be considered in future works to show if its influence is indeed negligible or not. In addition, other transient effects such as the vortices shed when the angle of attack is abruptly changed could be analyzed.

## 5 Conclusions

The transient flow around a NACA4612 airfoil profile was analyzed and simulated at  $Re = 1000$  and  $\alpha = 16^\circ$ . The main features of the flow were captured and the flow pattern agreed qualitatively with the flow visualizations from (National Committee for Fluid Mechanics Films, 1972).

The solution was confirmed to be grid independent and the C-mesh structured grid was found to be superior for this case as the flow was resolved with higher detail for the same number of cells.

Once the lift and drag coefficients were computed it was found that both peaked during the accelerations and decelerations due to added mass effects and that the effect of the viscous stresses on lift was modest even if viscosity is responsible for the development of lift. In addition, the solution was verified using the Kelvin's circulation theorem. Both the line integral of the velocity and the surface integral of vorticity matched with reasonable accuracy and were almost equal to zero for an inviscid contour and non-zero for viscous contours.

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