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A Study of Planning Hydrodynamics

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COMSOL-09

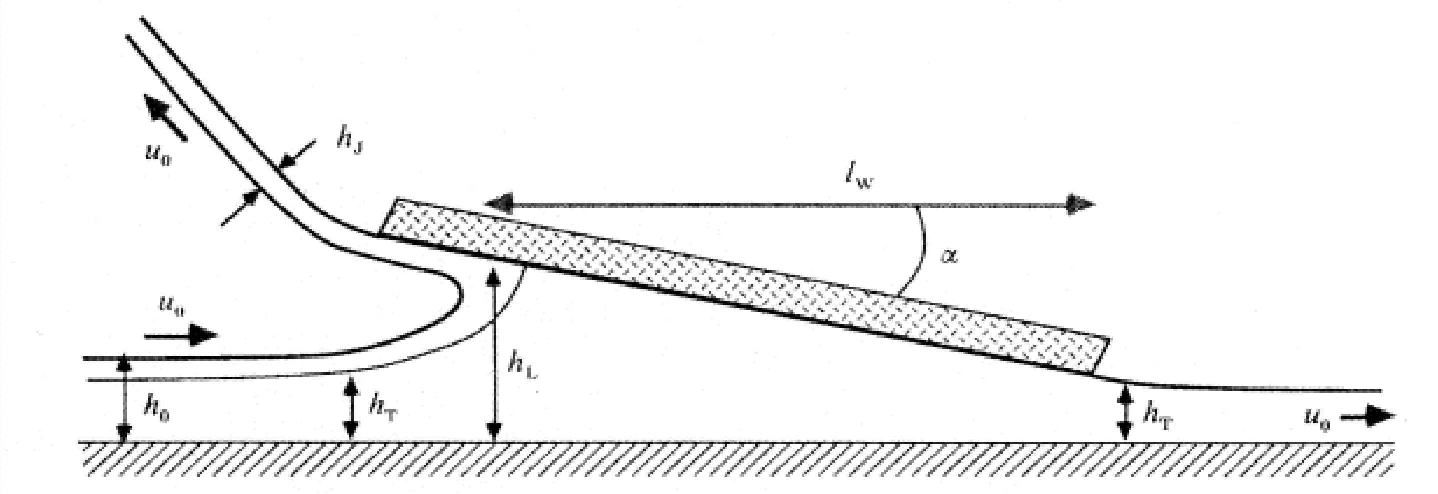
Scope of the Project

- Use COMSOL Multiphysics to analyze the flow under a skim board.
- Compared the results of the COMSOL model to previously published works.
- Analyze the flow under three different sets of boundary conditions and identify the best.
- Show how simplified 2-d models can provide useful information for designers.
- Work carried out to fulfill requirements for the Masters degree in Mechanical Engineering at Rensselaer-Hartford.

Background

- A skim board is a flat board approximately 1-2 m in length and 1m in width that is used to plane on shallow water along a shoreline for short distances
- A small manufacturing company cannot afford the time and resources required to create extensive models.
- It would be useful to have available a reliable and easy to use computational tool that could allow the building of virtual design prototypes to identify best candidates for actual board construction.

Sketch of the flow under a skim board



Sugimoto's schematic representation of the planning of a skim board over a thin water layer used to develop the COMSOL model.

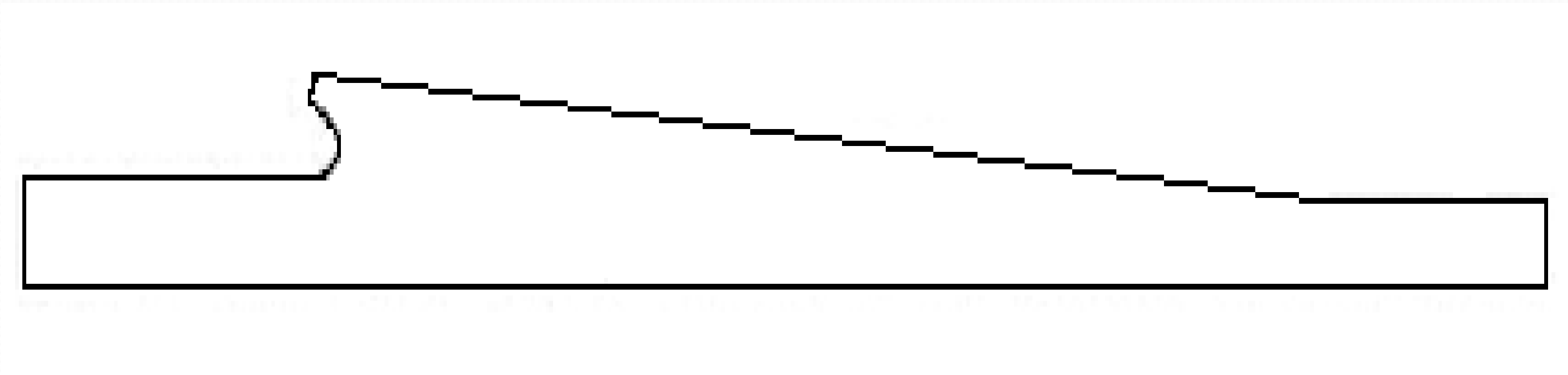
Previous Work (Sugimoto)

$$p(x) = p_0 + \frac{1}{2}\rho\left[u_0^2 - u(x)^2\right] = p_0 + \frac{1}{2}\rho u_0^2\left[\left[1 - \frac{h_T^2}{h(x)^2}\right]\right.$$

$$F = \int_{x_L}^{x_T}(p - p_0)\,dx = \frac{1}{2}\rho u_0^2\int_{x_L}^{x_T}\left[\left[1 - \frac{h_T^2}{h(x)^2}\right]\right.dx$$

- The lift force shown here is compared to the lift force determined by COMSOL Multiphysics.

Model and Boundary Conditions



- Case 1 - Skim board set as a sliding wall
- Case 2 – The board is held stationary, while the lower bound and entry flow are set.
- Case 3 – The board is moved horizontally

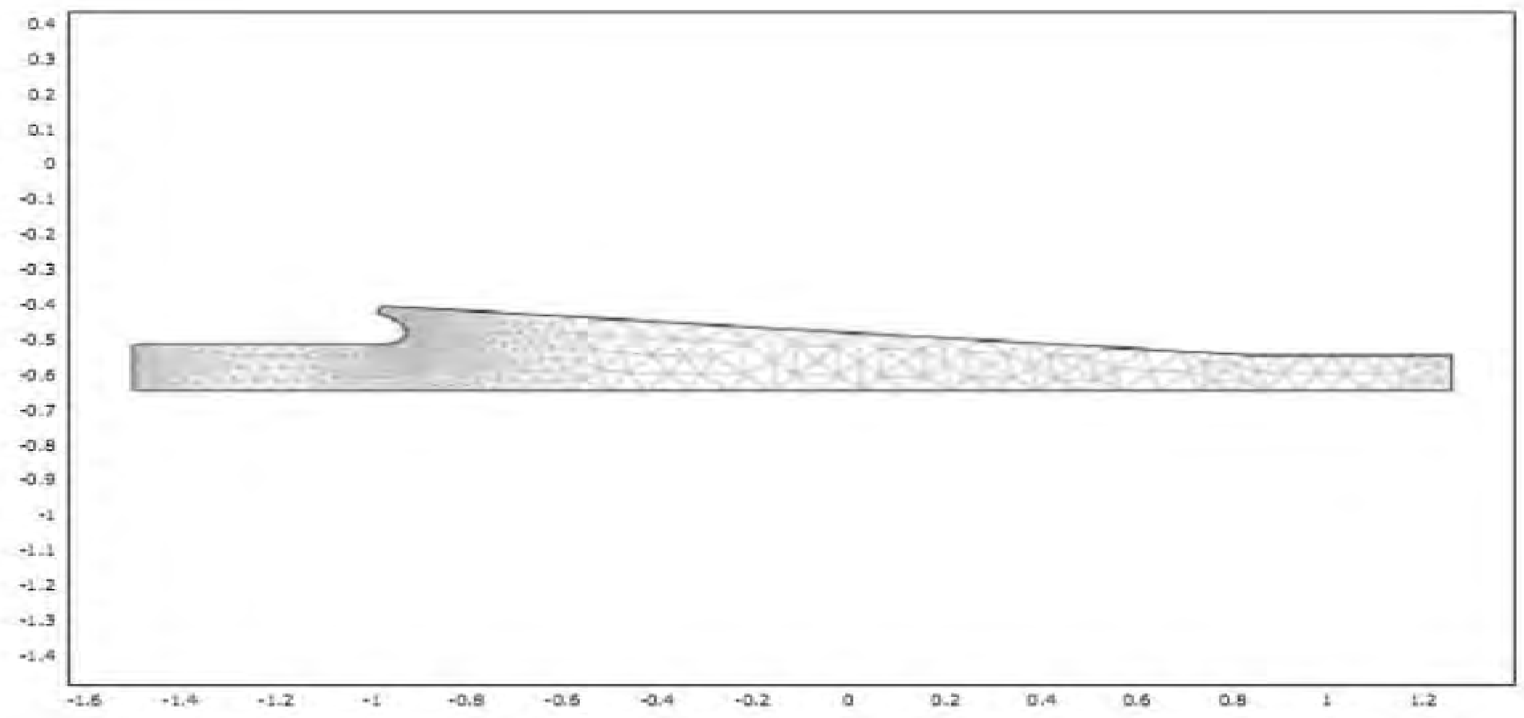
Governing Equations

$$\nabla \cdot \mathbf{U} = 0$$

$$\rho \frac{D\mathbf{U}}{Dt} = \rho g - \nabla p + \mu \nabla^2 \mathbf{U}$$

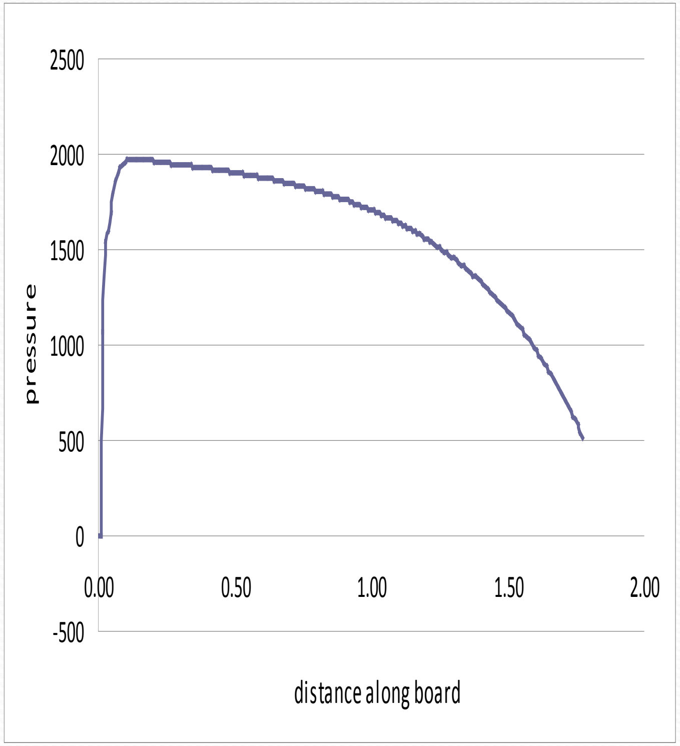
- Solved the governing equations for a laminar, incompressible, Newtonian fluid (mass and momentum conservation) in 2D rectangular Cartesian coordinates.

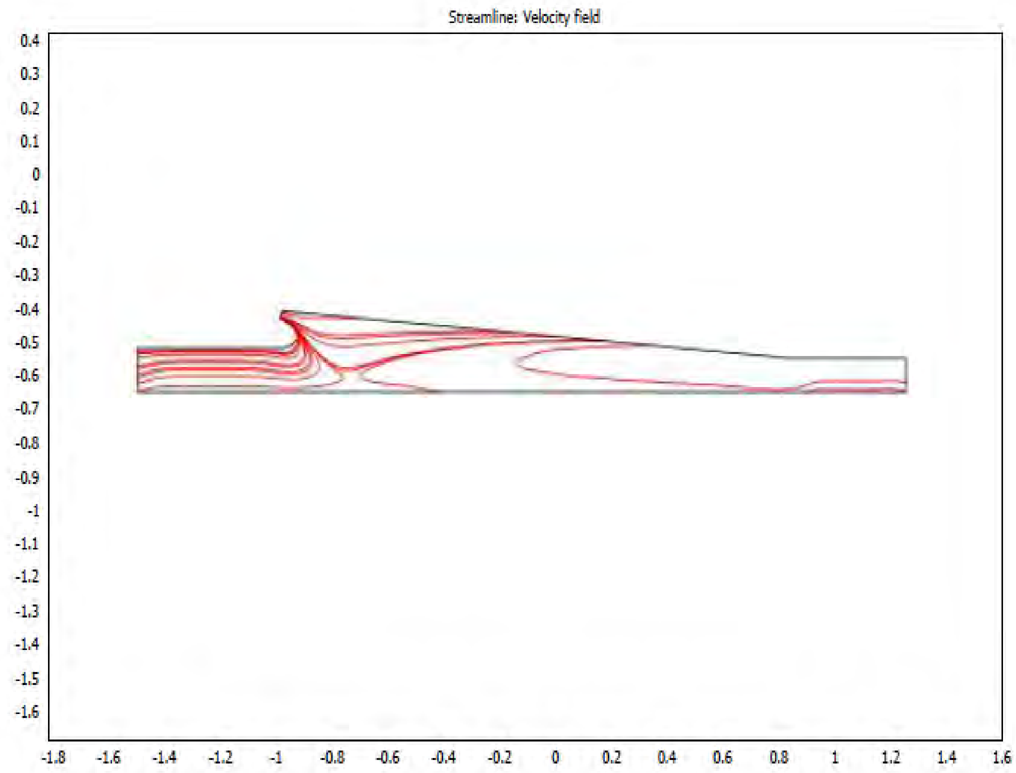
COMSOL Model



- 1464 Lagrangian quadratic elements used
- Geometry meshed automatically

Pressure profile and streamlines





Conclusions

- Useful information about the details of the flow underneath skim boards can be obtained from models readily built using the CFD module in COMSOL Multiphysics.
- Some knowledge of the particular flow and forces was vital in being able to identify the boundary conditions that provided the best agreement with prior work and to determine the viability of the data obtained.
- Results showed that the best representation of the flow is case 3. The model for case 3 was able to generate the lift force necessary to allow the device to glide with a rider on top of it.

References

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