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Shape Optimization of Swimming Sheets JON WILKENING, University of California, Berkeley, ANETTE HOSOI, Massachusetts Institute of Technology — The swimming behavior of a sheet which moves via wave propagation was first studied by G. I. Taylor in 1951. In addition to being of theoretical interest, this problem serves as a useful model of the locomotion of various micro-organisms and a few larger animals such as snails. We show how the shape of the wave affects the swimming speed and power required to swim, and present numerical techniques to find these optimal shapes when arclength and fluid volume are constrained. In the (small amplitude) lubrication approximation, we solve the Euler-Lagrange equations using a quadratically convergent Levenberg-Marquardt method for varying the parameters of the ODE until the constraints are satisfied. For the full Stokes equations, we represent the wave profile using periodic cubic splines and use finite elements to solve an adjoint problem to compute the variation of the power and speed with respect to changes in wave shape; we then use a limited memory BFGS method to find the optimal shape. Finally, we validate the lubrication theory by comparing with finite element calculations for the full Stokes equations.

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