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A parametric study of thrust and efficiency of an oscillating airfoil

A.W. MACKOWSKI, C.H.K. WILLIAMSON, Cornell University — An oscillating airfoil serves as a classic test case for a variety of unsteady phenomena in fluid mechanics. In nature, fish, birds, and insects oscillate their fins and wings to produce thrust and maneuvering forces, often studied by approximating the appendages as airfoils. On the other hand, the unsteady fluid mechanics of an oscillating airfoil involve vortex shedding and vortex advection, which are essential to understanding unsteady thrust, and worth studying in their own right. This information is useful in areas such as flow control, fluid-structure interaction, and undersea robotics. In this work, we examine the thrust and efficiency of a heaving (or pitching) foil as a function of variables such as the reduced frequency and amplitude (noting previous related studies such as Koochesfahani 1989; Anderson et al. 1998). Further, our novel experimental "cyber-physical" technique [Mackowski & Williamson, 2011] allows the airfoil to propel itself under its own thrust. Our experimental apparatus constantly monitors the fluid forces acting on the foil, and commands velocity to a carriage system in accordance with these forces. With this capability, we are able to measure the terminal velocity of a self-propelled airfoil, as well as its stationary thrust and efficiency.

Charles Williamson
Cornell University

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