Abstract Submitted
for the DFD14 Meeting of
The American Physical Society

Force and vortical flow development on pitching wings at high rates LUIS BERNAL, HUAI-TE YU, Univ of Michigan - Ann Arbor, MICHAEL OL, KENNETH GRANLUND, Air Force Research Laboratory — Recent experimental results of pitching flat plate wings are presented. High pitch-rate perching maneuvers are frequently used by birds for feeding and landing. Insects use very fast rotation rates at the end of each flapping stroke, which results in high thrust and precise flight. These wing motions are also of interest for engineered micro air vehicles to achieve semi-autonomous landing by unskilled operators. The wing motion considered is a constant rotation rate pitch motion from 0 to 45 degrees of an aspect-ratio-4 flat-plate wing. The goal is to gain a better understanding of force generation mechanisms and their relationship to two- and three-dimensional vortical flow structures. Leading edge, trailing edge, and tip vortices form with large separated flow regions over the wing, however comparison with linear potential flow theory gives good agreement. The evolution of the leading edge vortex is delayed for pivot axes locations downstream of the leading edge. Large forces at the end of the motion slowly return to the steady state value over more than 30 convective times. The flow in the near wake shows a brief period of vortex shedding and strong three dimensional effects. Two different three-dimensional flow features are observed: A rapid development of three-dimensionality in the core of the leading and trailing edge vortices and a swirl motion in the near wake. However the impact of these three-dimensional flow features on force development is small.

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Date submitted: 01 Aug 2014 Electronic form version 1.4