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Evaluation of the unsteady aerodynamic forces of an oscillating airfoil undergoing dynamic stall using impulse theory[1] FIRAS SIALA, JAMES LIBURDY, Oregon State University — The unsteady forces generated by a heaving and pitching airfoil are evaluated from velocity fields using the finite-domain vortex impulse theory. Time-resolved velocity fields are obtained experimentally using two-component particle image velocimetry measurements at reduced frequencies of $k = fc/U = 0.060.16$ (where f is oscillation frequency, c is chord length and U is free stream velocity) with heaving and pitching amplitudes fixed at $h_0 = 0.6c$ and θ_0=75°, respectively. The concept of moment-arm dilemma associated with the impulse equation is revisited to shed-light on its physical impact on the calculated forces. It is shown that by selecting an objectively defined origin of the moment-arm, the finite-domain impulse force formulation can be greatly reduced to two terms that have a clear physical interpretation: (i) the time rate of change of the impulse of vortical structures within the control volume and (ii) the Kutta-Joukowski force that indirectly captures the contributions of vortical structures outside of the control volume. Furthermore, it is shown that for the reduced-form of the impulse equation to be valid, a critical distance of $0.85c$ or greater from the airfoil trailing edge to the downstream control volume boundary is required.

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