ME 600 Seminar
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Untangling the patterns of flow structure and forces in unsteady aerodynamic applications

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Abstract:
Unsteady and three-dimensional flow separation and vortex shedding are ubiquitous in practical aerodynamic applications, including fixed and active wings while maneuvering or in unsteady environments. The flow fields generated by these fluid-structure interactions are inherently nonlinear, three-dimensional, and unsteady, yet characteristic patterns often emerge and behave in ways that we work to diagnose and explain after the fact. An ongoing challenge is to map the formation and evolution of these patterns to the performance of the aerodynamic body, and to try to prescribe or control them. Are there oscillating forces to be reduced? Are there destabilizing moments to be mitigated? Is there an enhanced lift to be exploited?

In this talk, I will explore these questions using an example of bioinspired propulsion - from full fish models to pitching and heaving plates and airfoils as simple models of flapping wings or fins. Simple potential flow models allow us to connect flow structure, motion kinematics, and decomposed body forces in a time-resolved sense through the model equations. Volumetric reconstructions from experimental data show the phase-averaged 3D structure that shapes the pressure distributions on the fins and the injection of momentum into the wake. In my group, we consider the timing of force and vortex production within a cycle of motion, and find more direct connections between flow features and performance. This approach will enable instantaneous response to flow field unsteadiness, or enhanced performance of aperiodic motions. The goal is to determine how to anticipate or induce unsteady flow field interactions to maximize performance instantaneously over a broader range of applications.

Biography:
Dr. Melissa Green received her BS in Aerospace Engineering from the University of Notre Dame and her PhD in Mechanical and Aerospace Engineering from Princeton University. She was an NAS/NRC Postdoctoral Research Associate at the Naval Research Laboratory from 2009 to 2011. In 2012, she started her faculty career as an Assistant Professor in the Mechanical and Aerospace Engineering Department at Syracuse University, and joined the Aerospace Engineering and Mechanics Department at the University of Minnesota as an Associate Professor in 2021. She received the Air Force Office of Scientific Research Young Investigator Award in 2014, and was selected as an Associate Fellow of AIAA in 2020. She won her department's teaching award in 2015 and 2020, and the Dean's Award for Excellence in Engineering Education in 2016. Her research interests are primarily in the field of experimental fluid dynamics, particularly in vortex-dominated and bio-inspired applications.

***This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.**
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