



UNIVERSITY of HAWAII at MĀNOA™
MECHANICAL ENGINEERING

Tuesday, December 9, 2025
11:00 AM – 12:00 AM
Moore 394

or online via Zoom:

<https://hawaii.zoom.us/j/88549259709>

Meeting ID: 885 4925 9709

Passcode: 731288

**Bio-inspired Rigid-Body Oscillation at Low Reynolds Number for Fluid Transport,
Locomotion, and Particle Detection**

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Abstract

Flows at low Reynolds numbers are dominated by viscosity, governed by the linear and time-reversible Stokes equations. In this regime, actuation and sensing mechanisms that rely on inertial effects lose much of their effectiveness, motivating the development of alternative approaches that instead exploit viscous effects. Understanding physical processes in these environments is important for applications such as microfluidics and microscale pump, swimmer, and sensor design. Copepods are small aquatic organisms that effectively generate feeding currents, swim, and detect suspended particles by oscillating their appendages. Drawing inspiration from copepod biomechanics, this dissertation develops minimal models and scaled tabletop experiments that demonstrate flow generation, locomotion, and particle detection in the low Reynolds number regime. First, we demonstrate that asynchronous oscillations of rigid rods generate swirling flow fields and net fluid transport, establishing a minimal system for pumping and mixing in highly viscous environments. Second, we demonstrate low Reynolds number swimming using rigid arms and show that only asynchronous oscillatory motion with distinct orientation angles generates net displacement, which is enhanced near bounding walls. Third, we demonstrate pressure-based imaging of an inert sphere suspended in a highly viscous fluid, enabling object detection and image reconstruction from pressure signals alone. Together, these studies show that simple rigid-body oscillations can achieve flow generation, locomotion, and particle detection at low Reynolds numbers, providing a foundation for studying more complex systems and motivating the design of pumps, swimmers, and sensors for microfluidic and other viscous-flow systems.

About the Speaker

Rintaro Hayashi received his M.S. in Mechanical Engineering from the University of Hawai'i at Mānoa in 2015, then spent 2016 as an intern at the Okinawa Institute of Science and Technology (OIST), where he studied microfluidics in Amy Shen's group. He began his Ph.D. work in 2017 under the supervision of Daisuke Takagi. His research focuses on bio-inspired low-Reynolds-number fluid mechanics.