Ph.D. Qualifying Exam: Biomechanics of Human Movement

Department of Mechanical Engineering University of Utah

Exam Description:

This qualifying exam will test the student's graduate-level knowledge of human movement biomechanics. The reference course material that serves as a basis for this exam are taken from ME EN 5960/6960 Biomechanics of Human Movement. The exam will focus on the process of how humans produce movement from neural control (forward dynamics), techniques for measuring human movement, and how neural control is estimated from measured movement data (inverse dynamics). Students should be familiar with simple models of biomechanical systems, mathematical and biological principles governing muscle force production, experimental techniques for measuring movement, the inverse dynamics problem, the muscle redundancy problem, and basic computational tools used to analyze movement data (OpenSim).

Recommended References:

Uchida TK., Delp Scott. Biomechanics of Movement: the Science of Sports, Robotics, and Rehabilitation, 1st ed. Cambridge, MA: The MIT Press, 2021, ISBN 978-0253330581.

Exam Materials:

The exam requires a laptop or other word processing device.

Topics:

The exam covers all content covered in ME EN 5960/6960: lectures, assignments, exams, and assigned book chapters (Chapters 1–9). The following is a list of relevant topics from the course.

- Simple models of walking and running (e.g., mass-spring-damper models; ballistic walking)
- Running and walking gait (spatiotemporal parameters, ground forces, Froude number)
- Muscle structure, force generation, and interaction with tendon
- Neuromuscular control
- Muscle adaptation
- Musculoskeletal geometry (e.g., moment arms, muscle-generated joint moments)
- Lab-based motion capture (optical motion capture, force plates)
- Mobile sensing techniques
- Inverse kinematics from marker data (unconstrained and constrained)
- Inverse dynamics
- Muscle redundancy problem (static and dynamic optimization techniques, general optimization equations)
- Clinical and sports applications in biomechanics