



Ph.D. Qualifying Exam: Robotics

Department of Mechanical Engineering University of Utah

Exam Description:

This qualifying exam will test the student's graduate-level knowledge of robotics. The reference textbook and course material that serve as a basis for this exam are taken from ME EN 6220. The exam is focused on testing the knowledge and approach to problem solving involving fundamental concepts appropriate to the field of robotics.

Recommended Reference:

ME EN 6220 course notes: <https://my.eng.utah.edu/~cs5310/>, User ID: Robotics, Password: KUKABaxter.

Exam Materials:

An equation sheet will be provided to students for their preparation before the exam. The same sheet will be provided with the exam. Students may bring a department issued calculator. No other materials will be allowed during the exam.

Topics:

Spatial transformations and displacements:

- Rotation matrices
- Homogeneous transformations
- Angle-axis formula
- Euler angles
- Quaternions

Manipulator position kinematics:

- Denavit-Hartenberg parameters
- Forward kinematics
- Inverse kinematics
- Workspace

Trajectory planning:

- Polynomial trajectories
- Spliced trajectories
- Taylor trajectories

Kinematic Velocities and Accelerations:

- Velocity and acceleration kinematics
- Angular velocity vector
- Spatial motion of objects
- Forward velocity and acceleration kinematics
- Velocity Jacobian
- Inverse velocity and acceleration kinematics

Statics:

- Force and torque balance
- Center of mass
- Gravity forces and torques on manipulator joints

Dynamics:

- Inertia matrix
- Parallel axis theorem
- Newton-Euler equations
- Recursive Newton-Euler equations for manipulator dynamics