

Cleveland State University
Department of Electrical Engineering and Computer Science

EEC 647/747 Robot Dynamics and Control.

- Catalog Description:** MCE/EEC/647/747 (4-0-4) Robot Dynamics and Control.
Prerequisites: MCE441/ 541 or EEC510 or exposure to undergraduate controls, with instructor consent.
Study of robotic manipulator systems, with strong emphasis on dynamics and control. Energy-based nonlinear models. Motion control using PD, inverse dynamics and passivity. Force control. Geometric nonlinear control applied to robotic manipulators.
- Required text:** Robot Dynamics and Control by Spong, Hutchinson and Vidyasagar, Wiley, 2006
- References:** Robotics and Automation Handbook, T. Kurfess, editor, CRC Press 2004
Theory of Robot Control, Canudas de Wit and Siciliano, Springer, 2012
Linear Algebra and Its Applications, Strang, Brooks/Cole (any edition)
Other materials and software will be provided.
- Objectives:** This course introduces essential concepts and analytical tools to describe the kinematics and dynamics of robotic manipulators and to design nonlinear control systems. Upon completion of this course, students should be able to:
1. Obtain mathematical models and implement computer simulations of various robotic manipulator configurations.
 2. Design robust and adaptive controllers.
 3. Implement computer simulations of closed-loop control systems for robotic manipulators and perform tuning and simulation studies.
 4. Use analytical and simulation techniques to design a controller, followed by real-time deployment to robots available in the laboratory.
- Instructor:** Hanz Richter.
Email: h.richter@csuohio.edu
Office Hours: Tuesdays and Thursdays, 2:00-4:00 PM. Other times by
- Topics:**
1. Introduction. History of robotics. Common manipulator configurations. Task space, configuration space and state space.
 2. Review of linear algebra: linear transformations, basis and dimension. Subspaces and rank. Related Matlab commands. Application to forward and inverse kinematic problems.
 3. Some inverse kinematics solutions. Use of Peter Corke's Robotic Toolbox for Matlab.
 4. Velocity kinematics and the Jacobian. Singularities. Manipulability ellipsoid.
 5. Robot dynamic models by energy methods (Euler-Lagrange)
 6. Nonlinear dynamical systems. Overview of elementary Lyapunov stability theory.
 7. Robot motion control by PD, inverse dynamics and passivity methods.
 8. Adaptive motion control.
 9. Force and Impedance control
- Grading:** Homework problems will be assigned, but not all collected. There will be a midterm exam, with a weight of 30%. The exam may include a simple

laboratory experience with the available manipulators. A final project will be assigned, with a weight of 35%. As part of the final project, students will implement a real-time controller on actual robotic hardware.

The relative weights for arriving to the final numerical grade are given below:

$$GR = 0.35H + 0.3M + 0.35P$$

where H is the average of the homework grades, M is the midterm exam and P is the project. Cutoff numerical grades for conversion to letter grades will be as follows:

88 – 100 A

75 – 87 B

65 – 74 C

50 – 64 D

0 – 49 F

Late homework will be rejected and receive a grade of zero. Make-up examinations will be arranged only due to extenuating circumstances, after proper justification is submitted.

Doctoral-Level Work (747):

Although the subjects covered are the same for 647 and 747, there will be differences in the nature and scope of assignments, exams and projects. Some homeworks and all exams will contain additional or substitute questions intended only for doctoral students. The final project will contain additional activities to be carried out by doctoral students. These differences are meant to examine the doctoral student for his/her understanding of the subject matter at a higher level (breadth and depth). Course website http://academic.csuohio.edu/richter_h/courses/mce647 Class notes, announcements, homework and exam solutions will be posted. The site will also contain interesting links and Matlab program downloads. Academic Integrity Academic dishonesty will not be tolerated and will be handled accor