ECSE-4490 FUNDAMENTALS OF ROBOTICS

Fall 2005

COURSE OUTLINE

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Textbook: *Fundamentals of Robotics*, R. J. Schilling, Prentice Hall, 1990.

Exam Dates: Monday, October 17, 2005
Thursday, November 17, 2005

Grading:

Exam I	25%	*Cheating on exams will result in a grade of F for the course.*
Exam II	25%	
Final Exam	35%	
Homework	15%	*Homework is due in class. No credit for late homework. Copying homework will result in a grade of zero for that assignment. One assignment will be dropped.*

Academic Integrity: The Rensselaer Handbook of Student Rights and Responsibilities, http://www.rpi.edu/dept/doso/handbook.html , includes policies on academic integrity. The information on pages 10 and 11 (Additional Policies) is particularly relevant.

Date	Topic	Reading
8/29	**Introduction to Robot Dynamics and Control** Robot classification, basic components, motion classification, world coordinates vs. joint coordinates.	Schilling, Chapter 1.
9/1	**Introduction to Robotic Systems** Sensors, robot specifications, repeatability, precision, and accuracy, servo-controlled robots.	Schilling, Chapter 1.

Date	Topic	Reading
9/8	**Basic Robot Engineering Problems** Mobile robots and task planning, trajectory planning, trajectory generation, the inverse kinematics problem, manipulator control, forward kinematics problem, and joint coordinates vs. world coordinates.	Schilling, Chapter 9, pp. 357-378.
9/12	**Coordinate Transformations: Part I** The direct kinematics problem, dot products, transformation matrices between coordinate systems, inverse coordinate transformations, rotation transformations.	Schilling, pp. 18-35.
9/15	**Coordinate Transformations: Part II** Composite rotation matrices, yaw-pitch-roll transformations, equivalent angle-axis rotation matrix, composite rotations and translations in homogeneous coordinates, inverse homogeneous transformations.	Schilling, pp. 36-48.
9/19	**Link Coordinates** Link parameters, the Denavit-Hartenberg representation.	Schilling, pp. 51-57.
9/22	**The Arm Equation** Screw transformations, composite coordinate transformation matrices, mapping tool coordinates into base coordinates.	Schilling, pp. 57-61, 49-51.
9/26	**Inverse Kinematics** The inverse kinematics problem, tool-configuration space and joint space, the tool-configuration vector.	Schilling, pp. 81-90, 105-109.
9/29	**Kinematics and Inverse Kinematics of a SCARA Robot** Kinematics and inverse kinematics of robot arms with revolute and prismatic joints, the global tool roll angle.	Schilling, pp. 68-71, 96-100.
10/3	**Kinematics and Inverse Kinematics of the Rhino XR-3** Kinematics and inverse kinematics of a five-axis articulated robot.	Schilling, pp. 62-68, 90-96.
10/6	**Kinematics and Inverse Kinematics of the Intelledex 660** Kinematics and inverse kinematics of a six-axis articulated robot.	Schilling, pp. 71-76, 100-105.

Date	Topic	Reading
10/11	(*This is a TUESDAY, but classes follow a MONDAY SCHEDULE.*) **Trajectory Planning: Part I** Arm matrices for pick and place operations, nut fastening trajectories.	 Schilling, pp. 124-135.
10/13	**Trajectory Planning: Part II** Continuous-path motion, path vs. trajectory planning, speed profiles, straight-line motions, trajectory smoothing, interpolation, parabolic blending.	Schilling, pp. 135-146.
10/17	**EXAM I**	
10/20	**The Tool-Configuration Jacobian** Tool-configuration Jacobian matrix, joint-space singularities, resolved-motion rate control.	Schilling, pp. 153-165.
10/24	**The Manipulator Jacobian: Part I** The manipulator Jacobian matrix vs. the tool-configuration Jacobian matrix.	Schilling, pp. 174-186.
10/27	**Manipulator Dynamics** Kinetic and potential energy, inertia tensor, the link Jacobian, manipulator inertia tensor, the Lagrangian.	Schilling, pp. 194-201.
10/31	**The Lagrange-Euler Dynamic Model** The dynamic model of an *n*-link manipulator.	Schilling, pp. 201-212.
11/3	**Dynamic Model of a SCARA Robot**	Schilling, pp. 212-220.
11/7	**Single-Joint Controllers for Robots** Controller design problems, Stanford Manipulator case study, modeling the gear-load system, actuator modeling, velocity feedback, damping ratio and the natural frequency.	Motion Control article (handout) pp. 943-953. Schilling, pp. 256-276.
11/10	**Single-Joint Controller Design** Finding the damping ratio and natural frequency, limitations of the classical control approach, finding the steady-state errors for a step and ramp input.	Motion Control article, pp. 943-953. Schilling, pp. 256-276.

Date	Topic	Reading
11/14	**Positioning Errors with Single-Joint Controllers** Position and velocity errors for a single-joint control system, disturbances acting on the arm, steady-state errors when there are disturbances, compensating for steady-state errors.	Motion Control article, pp. 943-953. Schilling, pp. 256-276.
11/17	**EXAM II**	
11/21	**Multiple-Joint Control Issues** Problems involved in controlling multiple-joint manipulators, sources of dynamic interactions between joints, difficulties in compensating for joint-coupling effects.	Motion Control article, pp. 943-953. Schilling, pp. 256-276.
11/28	**Computed-Torque Control** State equations, application of the Lagrange-Euler dynamic model to robot control.	Schilling, pp. 234-237, 283-289.
12/1	**The Manipulator Jacobian: Part II** Induced joint torques and forces, stiffness and compliance matrix from the manipulator Jacobian, joint-space singularities.	Schilling, pp. 181-190.
12/5	**Impedance Control**	Schilling, pp. 298-303.
12/8	**Review**	

Some Robotic WEB Sites

1. FANUC Robotics

www.fanucrobotics.com

Click on **Robots** and you'll find a very good selection of robot designs and robot applications.

2. Adept Technology Inc.

www.adept.com

Click on **Products**. Under **Robot Systems** the **AdeptOne** is the SCARA robot used throughout this course.

3. HelpMate Robotics Inc.

www.helpmaterobotics.com

Click on the **HelpMate Robotic Courier System**. This is a hospital service robot.

4. ABB

www.abb.com

This one requires a little more work to get to their robotic products.

Click for Contents, then click on **Industrial and Building Systems**, then click on **Flexible Automation**, and there are several choices for robotics products, robotics systems, applications, etc.

5. Jet Propulsion Laboratory - Robotics and Mars Exploration Technology

rmet.jpl.nasa.gov

You can spend all day here. Start by clicking on **Rovers & Telerobotics**, then **Robotics Technology**, then **Planetary Exploration**, then **Sample Retrieval Rover**. **Nanorovers** is another interesting page.

If you go back to where you clicked on **Robotics Technology**, click again, then scroll down the text and click on **Robotic Technology and Terrestrial Spin-Offs**. Next, click on **Robotic-Assisted Microsurgery**. Read the background information and then **Visit the Robot Assisted Microsurgery Web Site.**