National University of Singapore
Department of Mechanical Engineering
Faculty of Engineering

ME4245/ME4245E: Robot Kinematics, Dynamics and Control (4 MCs)

Introduction, Spatial Descriptions and Transformations, Manipulator Forward and Inverse Kinematics, Mechanics of Robot Motion, Robot Dynamics, Static Forces and Torques, Trajectory Planning, Robot Control

Contents	Hours (lecture + tutorial)

1. Introduction, Spatial Descriptions and Transformations **5**
Robot definition. Robot classification. Robotics system components. Notations. Position definitions. Coordinate frames. Different orientation descriptions. Free vectors. Translations rotations and relative motion. Homogeneous transformations.

2. Manipulator Forward and Inverse Kinematics **6**
Link coordinate frames. Denavit-Hartenberg convention. Joint and end-effector Cartesian space. Forward kinematics transformations of position. Inverse kinematics of position. Solvability. Trigonometric equations. Closed-Form Solutions. Workspace.

3. Mechanics of Robot Motion **6**
Translational and rotational velocities. Velocity Transformations. The Manipulator Jacobian. Forward and inverse kinematics of velocity. Singularities of robot motion.

4. Static Forces and Compliance **3**
Transformations of static forces and moments. Joint and End-Effector force/torque transformations.

5. Robot Dynamics and Trajectory Planning **10**
Lagrangian formulation. Model properties. Newton-Euler equations of motion. Simulations. Joint-based motion planning. Cartesian-based path planning.

6. Robot Control **9**
Independent joint control. Feedforward control. Inverse dynamics control. Robot controller architectures. Implementation problems.

Total **39**

Assessment
2 Quizzes (30 %)
Final Exam (70%)
Completion of Mandatory Laboratory Exercise

(All quizzes and final examination are open book/notes.)

References

1. Sciavicco L. and Siciliano B., *Modeling and Control of Robot Manipulators.* Second Edition (ISBN 1-85233-221-2), Springer Verlag, London, 2000. (Recommended for purchase)
2. Fu K.S.,, Gonzalez R.C., and Lee C.S.G. *Robotics: Control, Sensing, Vision and Intelligence.* McGraw-Hill, NY, 1987. (Recommended for purchase)
3. Sciavicco L. and Siciliano B., *Modeling and Control of Robot Manipulators.* McGraw Hill, 1996.
4. Craig, J.J., *Introduction to Robotics, Mechanics, and Control.* 2nd Edition. Addison Wesley, MA, 1989. (3rd Edition, if available)
5. Spong, M.W. and Vidyasagar, M., *Robot Dynamics and Control,* Wiley, New York, 1989.
6. Paul, Richard P., *Robot Manipulators : Mathematics, Programming, and Control : the Computer Control of Robot Manipulators,* MIT Press, Cambridge, Mass., 1981.
7. Lewis F.L., Abdallah C.T., and Dawson D.M., *Control of Robot Manipulators,* Maxwell Macmillan International, 1993.

References are available in Recommended Book Room (Central Library)

Lecturers:

Topics 1-4:
Dr. Marcelo H. Ang Jr. E3A-04-09   6516-2555 mpeangh@nus.edu.sg

Topics 5-6:
Prahlad Vadakkepat   E4-08-04   6516-2296 elepv@nus.edu.sg

WWW Page: http://guppy.mpe.nus.edu.sg/~mpeangh/me4245
Please refer to this webpage regularly. Webpage has exercises and past quizzes/exams.

Class schedule

ME4245   Mondays, 4-6 pm, E1A-04-02 (Smart Classroom)

ME4245E   Tuesdays, 6-9:30 pm, EA-06-04