National University of Singapore
Department of Mechanical Engineering
College of Design and Engineering

ME5421: Robot Kinematics (2 MCs)

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

	Contents	**Hours (lecture + tutorial)**
1.	**Introduction, Spatial Descriptions and Transformations** Robot definition. Robot classification. Robotics system components. Notations. Position definitions. Coordinate frames. Different orientation descriptions. Free vectors. Translations, rotations and relative motion. Homogeneous transformations.	**5**
2.	**Manipulator Forward and Inverse Kinematics** 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.	**6**
3.	**Mechanics of Robot Motion** Translational and rotational velocities. Velocity Transformations. The Manipulator Jacobian. Forward and inverse kinematics of velocity. Singularities of robot motion.	**5**
4.	**Static Forces and Compliance** Transformations of static forces and moments. Joint and End-Effector force/torque transformations.	**3**
	Total	**20**

Assessment
At least 1 Quiz (40 %)
1 Final Quiz (60%)
(All quizzes 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)

Lecturer:

Prof Marcelo H. Ang Jr E1-07-07 6516-2555, 9699-6759 mpeangh@nus.edu.sg

Graduate Tutors for **Consultation and Problem Solving Sessions**

Christina Lee, <mpecldw@nus.edu.sg>,
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Tuesdays (starting 15 Aug), 3-5 PM -
Advanced Robotics Centre – Bldg E6, Level 7

Class schedule

Mondays, 6-9 pm, SDE3-LT421 (14 Aug to 18 Sep 2023) – 1st half of the semester
Final Exam – 23 Sept 2023 (AM)