Stony Brook University

Course Syllabus

MEC 529: Introduction to Robotics (Theory and Applications)

Fall 2024

Instructor	Amin Fakhari, Ph.D., Department of Mechanical Engineering
Office	165 Light Engineering, Stony Brook University
Office Hours	MoWe 3:30 – 4:30 PM (and, any other time by appointment)
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* All non-personal course-related questions should be posted on Brightspace Discussions Forum (see section Tools below). Email should be used only for strictly personal issues. I will respond to your emails as soon as possible, however, please allow up to 48 hours for a response. Please use your SBU email for all your communications.

Course Detail

Title	MEC 529: Introduction to Robotics – Theory and Applications
Credit	3
Lecture	Thu 3:30 – 6:20 PM, Frey Hall 305
Prerequisites	A knowledge of undergraduate-level kinematics, a foundation in linear algebra and calculus, and an ability to program in MATLAB or Python.

Recommended References

- Kevin M. Lynch and Frank C. Park, *Modern Robotics: Mechanics, Planning, and Control*, Cambridge University Press, 2017 [Publisher, Amazon, PDF (freely available by publisher)].
- Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, *Robotics: Modelling, Planning and Control*, Springer, 2009 [Publisher, Amazon].
- Mark W. Spong, Seth Hutchinson, M. Vidyasagar, *Robot Modeling and Control*, 2nd Edition, John Wiley & Sons Inc, 2020 [Publisher, Amazon].
- Richard M. Murray, Zexiang Li, and S. Shankara Sastry, *A Mathematical Introduction to Robotic Manipulation*, CRC Press, 1994 [Publisher, Amazon].
- John Craig, *Introduction to Robotics: Mechanics and Control*, 4th Edition, Pearson, 2018 [Publisher, Amazon].

Course Description

This course provides an overview of fundamental concepts in robotics including kinematics, dynamics, and control. The aim is to provide the fundamental knowledge and tools needed for modeling, design, planning, and control of robotic systems. The main focus of the course will be on forward and inverse position kinematics and differential kinematics, dynamics, trajectory generation, motion planning, and feedback control within the context of serial robotic manipulators. This course is intended for graduate students with an interest in robotics. Advanced undergraduates with a demonstrated interest in robotics are also welcome.

Course Learning Objectives

- Understand Degrees of Freedom (DOF) and configuration space of robots.
- Know about different representations of the configuration of a rigid body.
- Solve forward and inverse kinematics and velocity kinematics problems of serial manipulators.
- Compute Jacobian of serial manipulators and use it in singularity and redundancy analysis.
- Know trajectory planning techniques for serial manipulators.
- Implement trajectory planning techniques in computer programs/simulations.

Tools

Brightspace: It is required that you use the Brightspace for this course. Brightspace is used for facilitation of communications between faculty and students, posting of the course materials, important announcements, and grades, and submission of assignments. You need to check your SBU email or Brightspace announcements regularly [Android App, iOS App].

Brightspace Discussions Forum: By using the Discussions tool/forum in Brightspace, you can get help fast and efficiently from your classmates, the TA(s), and the instructor. All non-personal course-related questions that might be of interest to other students should be posted (either anonymously or identified) on the Brightspace Discussions forum and not emailed to the TA(s) or the instructor. Email should be used only for strictly personal problems or issues.
Note that this discussion forum is for additional learning and assistance. It is not the place for cyber-bullying, memes, grade complaints, concerns/comments/criticisms about the course, or in general, anything unrelated to the course material and student learning. Improper behavior will result in reporting of the individual's behavior to the Office of Student Conduct and Community Standards.

MATLAB: It is a programming and numeric/symbolic computing environment developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages. An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamical systems and embedded systems. You can Download and Install MATLAB Software using your SBU email address. Make sure to install Robotics System Toolbox while installing MATLAB.

Python: It is an interpreted, object-oriented, high-level programming language. Python is open-source and free to use, has a large and active community, and offers a wealth of libraries.

Homework Assignments, Paper Review, and Final Project

- Homework assignments will be posted on Brightspace.
- You are allowed to discuss with your classmates, however, you must submit your own homework. Any discussion or help that you have taken from your classmates should be acknowledged explicitly by writing their names and the kind of help you have received. Note that your homework should not be a copy of your classmate's homework.
- You have up to 15 late days for use on any homework assignment throughout the semester, but no homework may be more than 5 days late. Once you used your budget of 15 late days for the semester, each late day will be assessed a 25% penalty on your grade for that assignment(s).
- Each student will review, present, and discuss a related scientific paper with the class. Each presentation should follow the following format:
  (a) Title Slide: Including authors names and institutions, the presenter's name, and date,
  (b) Summary Slide: Summary of the main contributions of the paper,
  (c) Background Slide(s): Summary of the relevant background of the problem to be solved,
  (d) Method Slide(s): Summary of the methods used,
  (e) Results Slide(s): Details of the paper's main results including supporting figures,
  (f) Strengths Slide(s): Discussion of at least one major strength of the paper,
  (g) Weakness Slide(s): Discussion of at least one major weakness and how it might be improved.
- Final project will be done in groups of 2–4 students. You have to submit a final project report and present it in the class.
- No late submission is allowed for the final project report.
- All students are expected to attend all paper review and final project presentations.
- I will not debug your code during office hours or by email.

Examinations

Midterm Exam	Thursday, Oct. 10, 2024 (in class)
Final Exam/Project	Thursday, Dec. 12, 2024, 5:30 – 8:00 PM (in class)

(a) Make-up exams are considered only for students who provide documentation of a compelling reason (e.g., medical emergency) before or within two days following the missing exam. There will be no make-up exams for reasons that can be within your control (e.g., pre-arranged travel or other engagements).
(b) The exam dates are subject to change. Students will be notified in a timely manner of any changes.

Grading Policy

Homework	35%
Paper Review & Presentation	10%
Midterm Exam	20%
Final Project & Presentation	35%

Grading Scale

A	[100, 90]%	**A**$^-$	(90, 85]%		
B$^+$	(85, 80]%	**B**	(80, 75]%	**B**$^-$	(75, 70]%
C$^+$	(70, 65]%	**C**	(65, 60]%	**C**$^-$	(60, 55]%
F	(55, 0]%				

Tentative Course Schedule

	Date	Topic
1	08/29	A Review of Linear Algebra
2	09/05	An Introductory Example
3	09/12	Configuration Space
4	09/19	Rigid-Body Motions - Rotation
5	09/26	Rigid-Body Motions - Rotation/Transformation
6	10/03	Rigid-Body Motions - Transformation
7	10/10	**Midterm Exam**
8	10/17	Forward Kinematics
9	10/24	Velocity Kinematics and Statics
10	10/31	Velocity Kinematics and Statics
11	11/07	Inverse Kinematics
12	11/14	Trajectory Generation and Motion Planning
13	11/21	Paper Presentation
14	10/28	Thanksgiving Break
15	12/05	Paper Presentation
16	12/12	**Final Project Presentation and Report Due**

Syllabus Disclaimer

The instructor views the course syllabus as an educational understanding between the instructor and students. Every effort will be made to avoid changing the course schedule, materials, assignments, and deadlines, but the possibility exists that unforeseen events will make syllabus changes necessary. The instructor reserves the right to make changes to the syllabus as deemed necessary. Students will be notified in a timely manner of any syllabus changes via email or Brightspace announcements.

University Policies and Statements

Academic Integrity Statement

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at http://www.stonybrook.edu/commcms/academic_integrity/index.html.

Student Accessibility Support Center (SASC) Statement

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, Stony Brook Union Suite 107, (631) 632-6748, or at sasc@stonybrook.edu. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential. Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and the Student Accessibility Support Center (SASC). For procedures and information go to Evacuation Guide for People with Physical Disabilities and search Fire Safety and Evacuation and Disabilities.

Critical Incident Management Statement

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Student Conduct and Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.

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