Course Syllabus

MEC 549: Robot Dynamics and Control

Spring 2026

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Office	165 Light Engineering, Stony Brook University
Office Hours	TuTh 11:00 AM – 12:00 PM (or by appointment)
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* All course-related questions should be asked during lectures and office hours. Email should be used only for personal issues. I will respond to your emails as soon as possible, however, please allow up to 2 business days for a response. Your SBU email must be used for all your communications. Please include the course number in the subject line and your full name in your emails.

Course Detail

Title	MEC 549: Robot Dynamics and Control
Credit	3
Lecture	Thu. 3:30 – 6:20 PM, Fray Hall 328
Prerequisites	Students are expected to have taken MEC 529 (Introduction to Robotics: Theory and Applications) or an equivalent course that covers the kinematics of rigid bodies and robotic manipulators, and trajectory planning. Students should be comfortable with programming in 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 its publisher)].
- Bruno Siciliano, Luigi Villani, Giuseppe Oriolo, Alessandro De Luca, *Foundations of Robotics*, Springer, 2025 [Publisher, Amazon].
- 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*, Wiley, 2020 [Publisher, Amazon].
- Rafael Kelly, Victor Santibáñez Davila, and Julio Antonio Loría Perez, *Control of Robot Manipulators in Joint Space*, Springer, 2005 [Publisher, Amazon].
- Christopher M. Kellett and Philipp Braun, *Introduction to Nonlinear Control: Stability, Control Design, and Estimation*, Princeton University Press, 2023 [Publisher, Amazon].
- Jean-Jacques Slotine, Weiping Li, *Applied Nonlinear Control*, Pearson, 1991 [Amazon].

Course Description

This course will cover the fundamentals of dynamic modeling and control techniques for robots, focusing mainly on robot manipulators. The **dynamic modeling** part includes Lagrange formulation, Newton–Euler formulation, properties of the dynamic equations, and trajectory planning with dynamic constraints, and the **control** part includes nonlinear systems, state-space representation, Lyapunov stability theorems, feedback linearization, linear controller design, position control, motion control, inverse dynamics control, robust control, adaptive control, force control, impedance control, hybrid motion–force control, and implementation of controllers.

Course Learning Objectives

Upon completion of this course, students will be able to

- Derive the dynamic equations of motion of a robot manipulator.
- Plan trajectories subject to the robot's actuator limits.
- Understand the concepts of stability and the basis of feedback controller design for manipulators.
- Understand and implement the different position, motion, and force control algorithms.

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].

Python: It is required to use the Python programming language for all homework and projects in this course. You will need to use Python 3.12.x along with the following libraries: NumPy, SciPy, SymPy, Matplotlib, and pytransform3d. Refer to the following tutorials to get started with Python and Jupyter Notebooks:

- Getting started with Python in VS Code: YouTube
- Getting started with Jupyter Notebooks in VS Code: YouTube
- A concise tutorial on NumPy, SciPy, SymPy, and Matplotlib: GitHub or Google Colab
- MATLAB users can use NumPy for MATLAB users to transition to Python.
- Markdown cheatsheet: GitHub or Google Colab

Homework Assignments, Paper Presentation, and Final Project

- Homework assignments will be posted on Brightspace.
- Students are allowed to discuss assignments with their classmates; however, they must submit their own work. Any discussion or assistance received from classmates should be explicitly acknowledged by including their names and the type of help provided. A student's homework must not be a copy of another classmate's work.
- If students use AI tools to assist with homework or projects, they must clearly cite and acknowledge the use of such tools in the acknowledgment section, specifying the type and extent of assistance received.
- Students are permitted up to 15 late days for use on homework assignments throughout the semester; however, no assignment may be submitted more than 5 days late. Once the 15-day allowance is used, no late submissions will be allowed.
- Each student will review, present, and discuss a related scientific paper with the class.

- No late submission is allowed for the final project report. More information will be provided during the semester.
- All students are expected to attend all paper presentations and final project presentations.
- Students' code will not be debugged during office hours or over email; they are responsible for troubleshooting their own code.

Homework and Final Project Submission Guidelines

1. **Submission Format**
   - Submit your report as a **single Jupyter Notebook (.ipynb)** file, which should include your Python code, report text (in Markdown cells), mathematical expressions (in LaTeX math format), and figures. Do not submit your virtual environment files.
   - Name your notebook as `HW#1_FirstName_LastName.ipynb`.
2. **Notebook Requirements**
   - The notebook must run from top to bottom without errors on a fresh kernel.
   - Include all the necessary helper or auxiliary functions (if any) inside the notebook (no external .py files). Place them in an "Helper Functions" section near the top of the notebook.
   - Before submitting, run all cells in your notebook so that the outputs are visible.
3. **Figures and Animations**
   - Embed small/medium figures directly in the notebook using `matplotlib`. These figures are usually the output of your code.
   - If you have external figures or animations that do not embed well in notebooks, save them in a folder named `figures` and reference them in the notebook where relevant.
   - Submit both the notebook `HW#1_FirstName_LastName.ipynb` and the `figures` folder as a single zipped archive and name it as `HW#1_FirstName_LastName.zip`.
4. **Readability**
   - Code must be accompanied by supporting explanations. Utilize Markdown cells for section headers, result explanations, and conclusions.
   - Add proper comments to your code, which detail what each part of the code is doing.
5. Reports will be graded on code and results correctness, explanation clarity, and notebook organization.
6. A minimal sample report template in Jupyter Notebook format to use for your homework and final project submissions: GitHub or Google Colab

Examinations

Midterm Exam	Thursday, March 12, 2026
Final Project	Thursday, May 14, 2026, 5:30 – 8:00 PM

(a) Make-up exams are considered only for students who provide official documentation of a compelling reason (e.g., medical emergency) before, or within three 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	45%
Midterm Exam	25%
Paper Review & Presentation	10%
Final Project	20%

(a) Above distributions are subject to minor adjustments.

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

Week 1: Review of kinematics of robot manipulators, trajectory planning, and linear algebra
Week 2: Dynamic modeling using Lagrange formulation
Week 3: Dynamic modeling using Newton–Euler formulation
Week 4: Properties of the dynamic equations, Constrained dynamics
Week 5: Trajectory planning with dynamic constraints
Week 6: Introduction to nonlinear systems and state-space representation
Week 7: Midterm Exam
Week 8: Phase plane analysis
Week 9: Lyapunov stability theorems for autonomous and non-autonomous systems
Week 10: Robot independent joint control
Week 11: Robot nonlinear and multivariable control - position control
Week 12: Robot nonlinear and multivariable control - motion control
Week 13: Force control and feedback linearization
Week 14: Paper presentation

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 in the Blackboard Announcements. Please remember to check your SBU email or Blackboard Announcements regularly.

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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