Syllabus

Course Number: BMED 4739 / BMED 6739
Course Title: Medical Robotics; Credits: 3

Instructor Information

Instructor	Email	Office Hours & Location
Yue Chen	yue.chen@bme.gatech.edu	Office: U. A. Whitaker Bldg. Room 4105 Office Hours: Wednesday 11-12pm. Also, please contact me via teams whenever you need help.

General Information

Description

The evolution of robotics in surgery is a new and exciting development. Medical robotics brings together many disparate areas of research, such as design, development, and evaluation of robotic systems, control, manipulation, and ergonomics in minimally invasive procedures, to name a few. In addition to providing the students with a fundamental understanding of robotics and an overview of the application of robotics to the medical domain, this course will also introduce the students to different areas within medical robotics.

Pre- &/or Co-Requisites

BMED 3110 and BMED 3410

The students are expected to know **rigid body dynamics**, **linear algebra**, **and** have proficient skills in **MATLAB programming** and Arduino-based **mechatronic system implementation**.

Course Goals and Learning Outcomes

The primary goal of this course is to provide the students with fundamental knowledge of robotics that can be used to design and develop medical robotic systems. Upon successful completion of this course, you should be able to:

- Have a fundamental understanding of robot kinematics and dynamics
- Understand the challenges in the design of a medical robotic system given the specific requirements for a particular application
- Appreciate the design, development, and evaluation of a medical robotic system

Course Requirements & Grading

Assignment	Weight
Homework	**30%** (All homework have equal weightage)
Attendance	**10%**
Group project	**25%**
Mid-term exam	**25%**
Final exam	**10%**

Description of Graded Components

- There will be four equal-weighted homework assigned during the course delivery. Students are required to complete one group project (3-5 students in each group). The deliverables for the group project are multiple sub-tasks, including motor control, robot design, fabrication, modeling, assembly, and control, one final project presentation, and one final project report. There will be one mid-term exam, and one final exam in this course. Late submission of project report or homework or exams will, in general, not be permitted, unless there is permission from the instructor (see “Extensions, Late Assignments, & Re-Scheduled/Missed Exams” section below).
- For the group project, undergraduate students can team with graduate students freely. Each group is expected to build a robot with at least 4 degrees of freedom (DoF) for their project.
- **All final projects will be reviewed by the TA or instructor**.

- For group projects, it is your responsibility to return all the critical hardware components at the end of the course. The final grade for your entire group will not be released till your group has returned all the critical items by Noon on the day following the last date of the class for this course. Your participation in the group project is critical to the success of the project. All members of the group will receive the same score for the group project progress reports, final project presentation, and final project report of the course. Please refer to the final project guideline file for detailed information.
- See below (Attendance and/or Participation) for participation grade.

Grading Scale

Your numeric score in the course will be computed ONLY according to the weightage of the various graded components mentioned above. Any requests for supplemental coursework to increase the student's grade will not be entertained.
Your final grade will be assigned as a letter grade based on your numeric score in the course according to the following scale. This scale is subject to change by the instructor based on the overall grades of the class by the end of the academic semester.

A: $\text{Numeric score} \geq 90\%$
B: $80\% \leq \text{Numeric score} < 90\%$
C: $70\% \leq \text{Numeric score} < 80\%$
D: $60\% \leq \text{Numeric score} < 70\%$
F: $\text{Numeric score} < 60\%$

Course Materials

- **Here are the suggested reading materials:**
  - ***Robot Modeling and Control***, by Mark W. Spong, Seth Hutchinson, and M. Vidyasagar. Wiley Publishers. ISBN (10-digit): 0471649902; ISBN (13-digit): 978-0471649908
  - ***Modern Robotics Mechanics, Planning, and Control****,* by Kevin M. Lynch and Frank C. Park. Cambridge University Press, ISBN 9781107156302.
  - ***Medical Robotics: Minimally Invasive Surgery***, by Paula Gomes (Editor). Woodhead Publishing. ISBN: 9780857091307
  - ***Medical Robotics,*** by Achim Schweikard and Floris Ernst, Springer, ISBN 978-3-319-22891-4.

Group project, Final project presentation, and Project Report:
All the hardware and software required for the group project will be provided to you. Group project selection must be completed by the end of the third week of the course at the latest. It is your responsibility to return all the critical hardware components at the end of the course. The final grade for your entire group will not be released till your group has returned all the critical items by Noon on the day following the last date of the class for this course. For developing the robot prototype, you are encouraged to use the department machine shop as well as 3-D rapid prototyping facilities in the department as well as Invention Studio (http://inventionstudio.gatech.edu) and The Hive (https://hive.ece.gatech.edu). During the semester, depending on availability, you may work in the Lab classroom (Location and schedule will be confirmed at a later date) to present the progress on your group project OR we may also have these discussions in the regular classroom location. For example, in one of those classes, you could discuss ideas/brainstorm on feasible solutions for your group project.

Orders for all materials and supplies MUST be made through Georgia Tech. No individual purchases will be reimbursed without prior written permission from the instructor. You can purchase most of the items required for your group project through McMaster (http://www.mcmaster.com/), DigiKey (http://digikey.com/), or Amazon.com (http://www.amazon.com). Guidance will be provided later.

The project report must be no less than 5 and no more than 8 pages in length (Excluding the citation page). Citations must follow IEEE format. The report must contain the following sections: Abstract, Introduction, Materials and Methods, Experiments and Results, and Conclusions.

The detailed format and timeline of the final project presentation will be provided at a later date.

Course Expectations & Guidelines

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Individuals with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter.

Attendance Requirement:

- Attendance is **required**. Starting the second lecture, attendance is taken for every lecture. Each student shall sign in on the attendance sheet prior to the start of each lecture. A student is allowed to miss **two** classes without penalty.
- A student who is late for class for **10** or more minutes cannot sign the attendance sheet.
- A student who signs the attendance but leaves prior to the end of class will void the signed attendance.
- Signing in on behalf of another student is strictly prohibited. Once discovered, both students involved will receive warning, and the instructor reserves further right to reflect sign-in cheating on the final grades of both.
- Please use your consistent signature in the attendance sign-in.
- Per GT policy, a student is allowed to miss class without penalty for participation in approved institute activities and in specific religious observances (check here for details). To be qualified for this, a student needs to get the approval letter from the Office of the Dean of Students.

Generative AI is permitted in specific contexts and with acknowledgment

To ensure all students have an equal opportunity to succeed and to preserve the integrity of the course, students are not permitted to submit text that is generated by artificial intelligence (AI) systems such as ChatGPT, Bing Chat, Claude, Google Bard, or any other automated assistance for any classwork or assessments. This includes using AI to generate answers to assignments, exams, or projects, or using AI to complete any other course-related tasks. Using AI in this way undermines your ability to develop critical thinking, writing, or research skills that are essential for this course and your academic success. Students may use AI as part of their research and preparation for assignments, or as a text editor, but text that is submitted must be written by the student. For example, students may use AI to generate ideas, questions, or summaries that they then revise, expand, or cite properly. Students should also be aware of the potential benefits and limitations of using AI as a tool for learning and research. AI systems can provide helpful information or suggestions, but they are not always reliable or accurate. Students should critically evaluate the sources, methods, and outputs of AI systems. Violations of this policy will be treated as academic misconduct. If you have any questions about this policy or if you are unsure whether a particular use of AI is acceptable, please do not hesitate to ask for clarification.

Collaboration & Group Work

- The students are allowed and encouraged to collaborate with each other on solving the homework problems, since it enriches the learning experience. However, it is important that each student understands how to solve those HW problems.
- No collaboration of any type will be permitted for mid-term exam and final exam.

- For the group project progress reports, final project presentation, and the project report, the students in different groups are allowed to help and clarify concepts on a limited basis as long as it does not overly burden the other group.

Extensions, Late Assignments, & Re-Scheduled/Missed Exams

- For HW and report submission, there is a grace period of 2 hours. The late penalty is 30% of the assignment per day late for the first two days after the required submission date. After 2 days, a student will receive a zero.
- If cases where there may be a legitimate reason for missing the turn-in date (e.g. hospitalization, emergency vacation, family reasons, etc.), contact the instructor as soon as possible to coordinate the late submission with the **official letter from Office of the Dean of Students** https://studentlife.gatech.edu/about/dean-students. If you coordinate a late submission **in advance of** the required submission date and receive approval, you will not incur a late penalty.
- All group members must be present at the final project presentation unless there is a valid justification for being absent (from the Office of the Dean of Students). The final decision on whether the absence is valid or not rests with the instructor.
- Additional details about medical emergency or an illness as well as other class attendance matters can be found at: http://www.catalog.gatech.edu/rules/4/ and https://studentlife.gatech.edu/about/dean-students.

Student Use of Mobile Devices in the Classroom

The use of mobile device(s) and laptop(s) in the class, without the instructor's approval, is prohibited since it causes unnecessary distraction for other students as well as the instructor.

Student-Faculty Expectations

At Georgia Tech we believe that it is important to continually strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See http://www.catalog.gatech.edu/rules/22/ for an articulation of some basic expectations – that you can have of me, and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech, while in this class.

Resources Related to Mental Health

Your instructors, and the BME department as a whole, care about student mental health. While your instructors can be a resource, we also want to make sure you are aware of the formal resources for receiving mental health assistance in BME and at GT. More information about these resources can be found here: https://mentalhealth.gatech.edu/

- **Mental Health Care & Resources** – The Center for Mental Health Care and Resources (CMHCR) is the best place to engage with mental health care at GT. They are found in the Smithgall Student Services Building and can also be reached at **404-894-2575**. Their normal hours of operation are 8am to 5pm Monday through Friday. CMHCR can connect you with services including individual or group counseling, academic or personal support services, assessment and testing for learning disabilities, and other mental health providers. They can help you find the right resources for a crisis, an acute issue, or a longer-term concern.
- **BME Satellite Counselor** – In addition to the Center for Mental Health Care's centralized services, BME hosts a counselor, Kate Silverio, in Room 1105 of the Whitaker Building (in the back of the academic office). The Satellite Counselor offers 15 min appointments (in-person or virtual) during which students can discuss a brief or specific, non-emergency concern, and/or learn about mental health resources on campus. To schedule with the Satellite Counselor, please email her (**kate.silverio@studentlife.gatech.edu**).
- **Crisis Services -** If you require immediate support for mental health difficulties you have several options: During business hours (8 a.m.-5 p.m.). Call **404-894-2575** or go to Suite 238 in the Smithgall Student Services Building. Outside of business hours, call **404-894-2575** and select the

option for the after-hours counselor. In an emergency, call Georgia Tech Campus Police at **404-894-2500** on campus or **911**.

Course Outline[1]

The following material will be covered in the course:

1. Introduction to Medical Robotics
2. Review of Mechatronics
3. Robot Forward Kinematics
4. Screw Theory
5. Robot Inverse Kinematics
6. Manipulator Jacobian
7. Path Planning and Control
8. Image-guided surgical robotics (via guest lectures)
9. Medical Robotics Design & Control

Guest Lectures are planned in the course and their schedule will be provided as it becomes available.

[1] Parts of the course materials are subject to change by Dr. Yue Chen