Syllabus/Course Information

Course Description:

ECE 425 **Introduction to Mobile Robotics***

3R-3L-4C W

Prerequisites: CSSE120 and (ECE320 or ME406 or BE350 or CHE440)

This course will introduce the basic principles of mobile robotics history, theory, hardware and control. Topics will include robot components, effectors and actuators, locomotion, sensors, feedback control, control architectures, representation, localization and navigation. This is a project-oriented course and the student will have hands-on experience with a real mobile robot. The student will be required to complete several laboratory assignments and a multidisciplinary team design project.

Instructor:

Dr. Carlotta A. Berry, Professor, Electrical and Computer Engineering

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Required Textbook:

Berry, C.A., "Mobile Robotics for Multidisciplinary Study", Synthesis Lectures on Control and Mechatronics, Morgan and Claypool, 2012. Download PDF from Logan Library or link on Moodle.

References:

1. Arkin, Ronald C., "Behavior-Based Robotics", The MIT Press, 1998
2. Bekey, George A., "Autonomous Robots: From Biological Inspiration to Implementation and Control", The MIT Press, 2005
3. Jones, Joseph L., Flynn, Anita, M., and Seiger, B.A., "Mobile Robots: Inspiration to Implementation", AK Peters, 1999
4. Martin, Fred G., "Robotic Explorations: An Introduction to Engineering through Design", Prentice Hall, 2001
5. Matarić, M.J., "The Robotics Primer", The MIT Press, Cambridge, Massachusetts, 2007, 300 pp, ISBN 0-262-63354-X
6. Murphy, Robin R., "Introduction to AI Robotics", The MIT Press, Cambridge, Massachusetts, 2001, 466 pp, ISBN 0–262-13383-0
7. Siegwart., R. and Illah R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", The MIT Press, 2004. (http://autonomousmobilerobots.epfl.ch/)
8. Kortenkamp, D., Bonasso, R.P., and Murphy, R., (Eds.), "Artificial Intelligence and Mobile Robots: Case Studies of Successful Robot Systems", The MIT Press, 1998.
9. Weekly Readings available on Moodle

Expectations for You:

First and foremost, professional work is the standard in this course. All of your written work and your conduct in class are to be at the level of one who is studying a profession such as engineering. This means a number of things:

1. Your work is neatly done in a professional manner, using formats specified.

2. Your work is honestly done. You are encouraged to discuss course material with classmates to help each other understand and assimilate the concepts. Nevertheless, distinguish between helping someone understand concepts and providing them with specific answers. You are expected to work individually on individual assignments and to be a significant contributor on team assignments.
3. Your work is submitted on time. As a rule of thumb, expect to put in **eight hours** per week outside of class doing assignments and meeting with your team.
4. You are attentive and engaged in the lecture (i.e. not sleeping, reading the newspaper, surfing the web, on social media, texting, doing homework for other courses, disturbing others with electronics).

Hardware and Software:

You will receive a base robot with all of the peripherals including batteries and charger on the first day of class. You and your lab partner will check out the robot for the quarter and it must be returned by the first day of finals week at the end of the quarter. You and your lab partner are solely responsible for the robot's care and security. If the robot is **not** returned with all peripherals in its original condition, you will receive an incomplete in this course and a charge will be placed on your account in the business office. If it is lost, you must purchase the robot and peripherals at cost in order to receive a grade in this course. The robot must be returned to the instrument room in the same condition it was received or the student will be charged the complete cost of repair or replacement.

Grading:

Grades will be assigned at the end of the quarter based on the grade weights and grading scale shown below:

Participation	10%	A	90 – 100
Quizzes	30%	B+	87 - 89
Labs and Memos	30%	B	80 – 86
Final Project	30%	C+	77 – 79
		C	70 – 76
		D+	67 – 69
		D	60 – 66
		F	Below 60

Participation:

Classroom participation actually counts toward your grade in this class. Not participating in classroom activities or excessive absences will have a measurable detrimental effect on your grade. You are expected to be attentive and engaged in the lecture (i.e. not sleeping, reading the newspaper, surfing the web, doing homework for other courses, disturbing others with electronics). As a rule of thumb, you should expect to put in **eight hours** per week outside of class reading the text, preparing for quizzes, completing the laboratory assignments and final project.

Quizzes:

There are no exams in this course by design; however, there will be weekly quizzes over the required reading and lectures. These quizzes will represent **30%** of your grade, equivalent to two exam grades. The purpose of the quizzes is to assess the student's understanding of the concepts presented in the course and robotics state of the art. The required reading includes not only the textbook but literature that will be posted to the Moodle course website. Reviewing literature in the field is important because robotics is a very theoretical and application-based field; therefore there is minimal benefit to working with the robot in lab and not being informed about robotic history, theory and application. Thus, it is

very important that you complete all of the required reading and be conscientious about preparing for these quizzes.

Laboratory Assignments:

There are no exams or homework in this course by design because it is expected that the labs will require a significant time commitment. The purpose of the laboratory assignments is to develop the robot's human-robot interface and basic behaviors in order to increase its artificial intelligence. In addition, these components will build upon each other from week to week to help the student team prepare for the final project. Thus, it is *very important* to do a good job on the primitive behaviors by writing modular well-commented code and not to get behind because this will prove detrimental in future labs and the final project.

All of the programming will be completed in Arduino Sketch with is similar to C or C++. Each student is required to have a basic programming proficiency and is expected to be able to perform object-oriented programming independently even in an unfamiliar language. Since this is not a programming course, students will be provided with only a very brief lecture on the programming environment and starter code on the first day of class and expected to learn the rest independently. A very useful reference for C is the MSDN library. There are also numerous web resources for Arduino Sketch available by performing an internet search.

Each week, the laboratory assignment grade will include a pre-lab of a software design plan, demonstration and submission of the well-documented code and lab memo (technical report). The code and memo should be zipped in a file and uploaded to the course Moodle Lab DropBox by **midnight on the Sunday** after the demonstration. Laboratory memos must follow the format provided by the instructor. One laboratory memo should be submitted per team and should be a product of the joint effort between the members. The team member roles should alternate on a weekly basis between programmer, technician and reporter.

If there is a pre-lab associated with a laboratory assignment, it will be due at the beginning of the class prior to the laboratory demonstration. The pre-labs, demonstration and reports will receive a **20% late penalty** per day if not submitted on time. A missed laboratory assignment **must** be made up but the students may not receive full or any credit for the lab.

Since this is a hands-on course, **always** bring your laptop computer and the robot fully charged to class. If possible, use the slow charger (~5 hours) to charge the robot overnight before class because it provides a longer and better charge than the RC quick charger.

Final Project:

The final project report and demonstration will be due during the last couple of weeks of class. The final project demonstration typically involves a team exhibition and class competition. The final report must follow the format described in the assignment. **No incomplete will be given on the final project.**

Course Policies:

- Students are encouraged to check their RHIT email account daily for information regarding the class. You are responsible for all information sent to your account from the professor, whether read or not. Students should also regularly check your grades on Moodle to make sure there is not a recording error.
- All students are expected to join in class discussion and all activities with a positive attitude. All students are expected to exhibit an attitude that is appropriate to one studying a profession and such

that everyone has an engaging, fulfilling and successful experience. Please also leave the classroom neater than you found it.

- Operating your computer in class for anything other than an approved course activity is not permitted. Students must not hinder the learning environment of their fellow classmates with any other distracting behavior such as talking, sleeping, doing homework, playing on mobile phone or reading the newspaper. Continued disruptive conduct will lead to the student being asked to leave class and marked absent for that class period. The student will remain responsible for all class assignments.

Attendance:

- Regardless of whether formal attendance is recorded, attendance at each class is expected. Experience has shown that regular attendance and engagement improves learning and consequently improves quiz and assignment performance. According to the Academic Rules and Procedures, "A student whose total absences in a course, excused or unexcused, exceed two per credit is liable to fail the course." For the purposes of this class, that limit will be set at **no more than 8 absences per quarter**.
- If you must be absent from class for any reason including a sports participation, job interview or illness, you must let the instructor know as far in advance as possible.
- Students are responsible for all information presented in class whether present or not.

Excused Absence (RHIT Academic Policies):

Instructors will normally permit make-up work to be done when a student has legitimate conflicting obligations, such as illness or emergency, Institute-sponsored activities, plant trips or interviews. These conflicts do not excuse the student from course responsibilities. The student is responsible for informing the instructor of any legitimate excuses and making arrangements for make-up work, if permitted, as soon as possible. Whenever possible, the student must discuss unavoidable absences with instructors in advance.

Honor Policy:

Rose-Hulman Institute of Technology does not tolerate plagiarism or cheating in any form. The penalties for these and other forms of academic misconduct range from a lowered course grade, through failure in the course, up to and including suspension from the Institute.

***Disclaimer:**

Robotics is not like a traditional engineering class with well-defined static content and assignments, it is in continuous update and development. Therefore, the instructor requests flexibility and patience as the course materials, format, robot hardware, quizzes laboratory assignments are evaluated and modified as deemed necessary. In addition, although a robotic platform is a great learning resource, it is ***not perfect***. However, this platform does provide you with exposure to real-world open research areas and problems in robotics (i.e. memory constraints, odometry, sensor and bandwidth error) and you are expected to work around these deficiencies to complete all assignments.

Course Calendar*

Class	Day	Date	Topic/Activity	Reading	Assignment Due
0	T	11/30	Read Syllabus, Schedule, Concept Map		Quiz 0**
1-1 1-2	W	12/1	Robotics Overview Robotics History **Lab 01 Recitation** Robot Delivery	Ch. 1 Ch. 2 Niemueller	
1-L	F	12/3	Lab 01 classwork		Pre-Lab 01 Quiz 1 – W1 lecture** Quiz 2 – Niemueller**
2-1 2-2	W	12/8	Robot Control Overview/Reactive Control Sensors and Perception **Lab 02 Recitation**	Ch. 2 Ch. 3 Martin	Lab 01 Demo Lab 01 Memo/Code**
2-L	F	12/10	Lab 02 classwork		Quiz 3 – W2 lecture** Quiz 4 – Martin**
3-1 3-2	W	12/15	Schema Theory and Potential Fields Feedback Control Lab 02 Classwork	Ch. 3 Brooks	Pre-Lab 02
3-L	F	12/17	Behavior-Based Architecture **Lab 03 Recitation**		Lab 02 Demo Lab 02 Memo/Code** Quiz 5 – W3 lecture** Quiz 6 – Brooks**
WINTER BREAK (12/18/21-01/02/22)					
4-1 4-2	W	1/5	Hierarchical Paradigm and Representation Lab 03 classwork	Ch. 3 Arkin	
4-L	F	1/7	Lab 03 classwork		Pre-Lab 03 Quiz 7 – W4 lecture** Quiz 8 – Arkin**
5-1 5-2	W	1/12	The Hybrid Deliberative/Reactive Paradigm Navigation **Lab 04 recitation**	Ch. 3/4 Mataric	Lab 03 Demo Lab 03 Memo/Code**
5-L	F	1/14	Topological Path Planning Lab 04 Classwork		Quiz 9 – W5 lecture** Quiz 10 – Mataric**
6-1 6-2	W	1/19	Metric Path Planning Lab 04 Classwork	Ch. 4 Grabowski	
6-L	F	1/21	Lab 04 Classwork		Pre-Lab 04 Quiz 11 – W6 lecture** Quiz 12-Grabowski**
7-1 7-2	W	1/26	Map Making and Localization **Final Project Recitation**	Ch. 4 Murphy	Lab 04 Demo Lab 04 Memo/Code**
7-P	F	1/28	Final Project Classwork		Quiz 13 – W7 lecture** Quiz 14 – Murphy**
8-1 8-2	W	2/2	Final Project Classwork **Final Project Report**		Phase I Software Design Plan
8-P	F	2/4	Final Project Classwork		Phase I Demo
9-P	W	2/9	Final Project Classwork		Phase II Software Design Plan
	F	2/11	Final Project Classwork		Phase II Demo
10-P	W	2/16	Final Project Classwork		Phase III Software Design Plan
	F	2/18	Course Evaluations		Phase III Demo
11	Sun	2/20			Final Project Report & Code due Sunday

*This schedule, topics and assignments may be modified at the discretion of the instructor
**LAB MEMOS AND CODE due Sunday after Demo by 11:59 pm, All quizzes due Monday by 11:59 pm except quiz 0 due before first day of class
***When Dr. Berry is out of town or traveling class may be abbreviated or cancelled