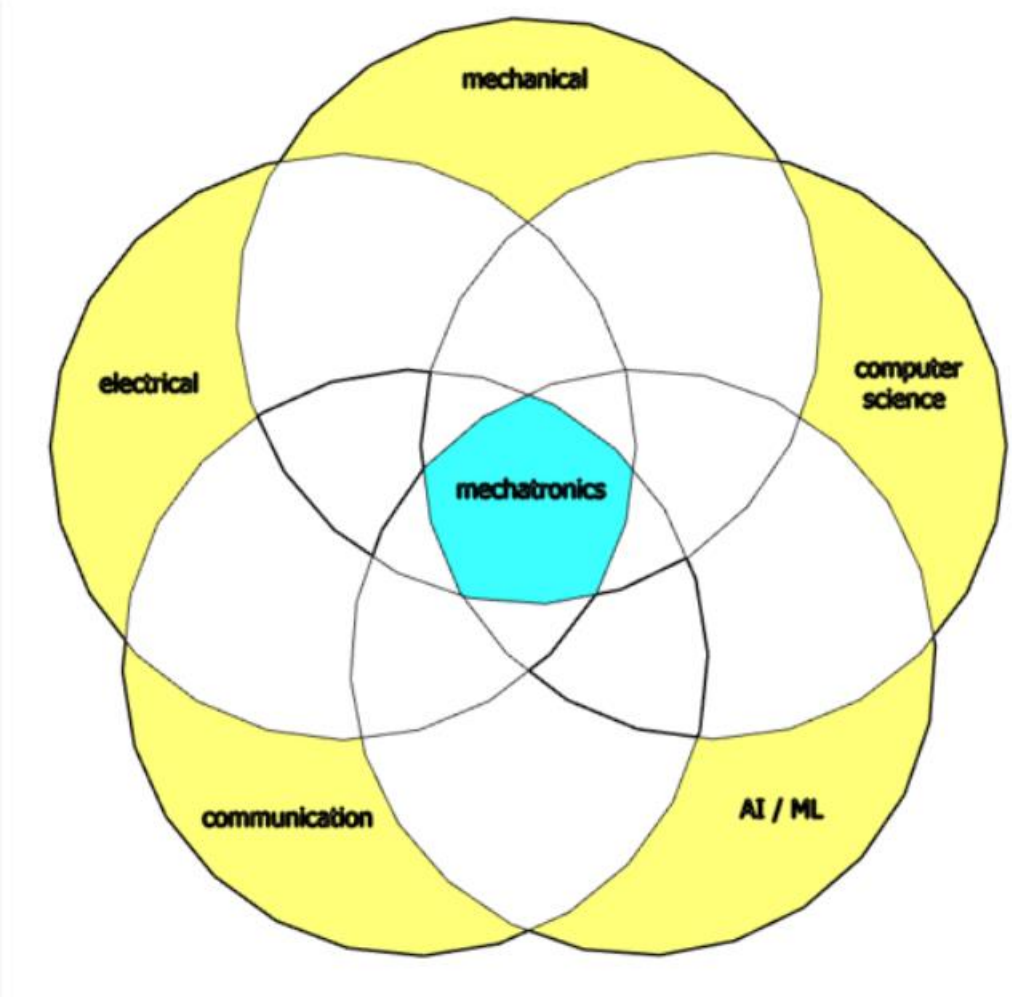
Course Syllabus - MEC 634 -

Course Name: MEC 634 - “Advanced topics in kinematics and dynamics of machines”, as used in Mechatronics systems, enhanced with state-of-the-art AI/ML (3 credit hours).
Course Organization - Online Modules on Blackboard with weekly in-class meetings

Instructor: Boaz Eidelberg, Ph.D.

Office phone (Optinet Inc.) : 631-833-8300
Email: boaz.eidelberg@stonybrook.edu
Office hours: Before and after weekly class meetings and by appointment on Telecon or in office meeting



Course Orientation:

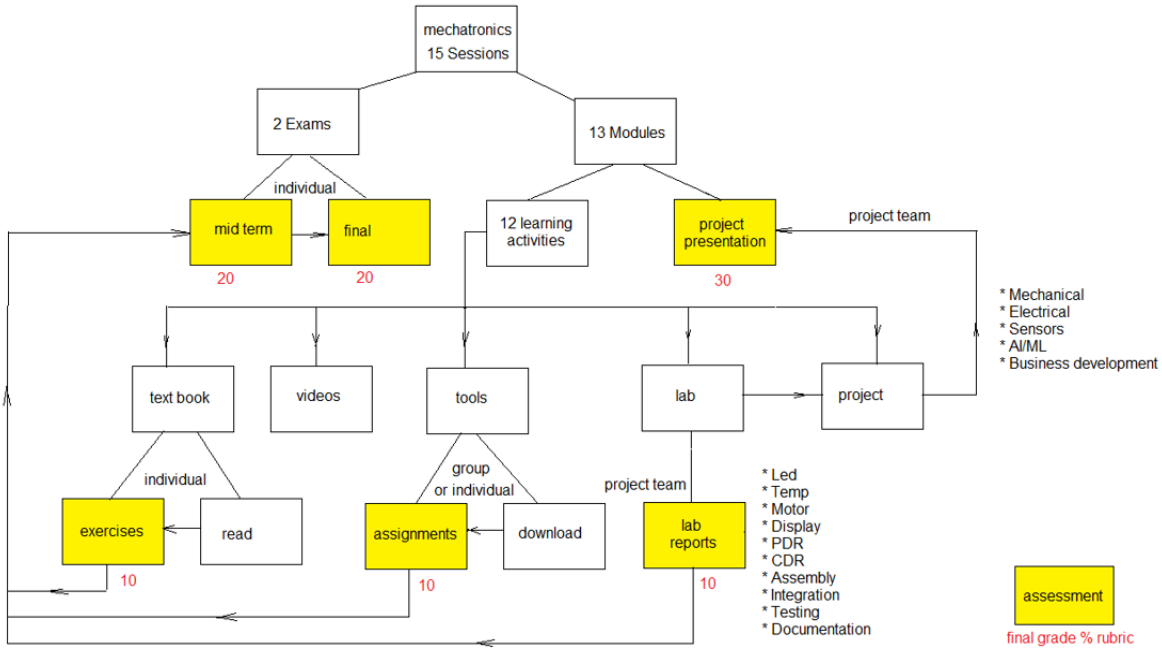
Mechanical manipulation is the lowest level of machine intelligence involving kinematics and dynamics of mechanical components in pure motion. It is further elevated, on the machine intelligence scale, by adding electronics sensors and controls, termed as Mechatronics. In the last few years it is further being advanced, on the intelligence scale, by adding Artificial Intelligence (AI) and machine learning (ML) features into such Mechatronic devices and robotic systems.

Mechatronics is an interdisciplinary subject, including mechanical, electrical and software engineering disciplines integrated into a single product. Mechatronic products exist for over 60 years, starting at the arrival of microprocessors and the first industrial robots. In recent years, lower cost computing and communication services in the cloud, Internet of Things (IoT), Industry 4, Artificial Intelligence (AI) and Machine Learning (ML), have gained increased popularity in many markets. They provide differentiating features, which are add to products and services, for higher levels of reliability, accuracy and safety, faster process time and lower downtime. Learning these fast-changing technologies, may be done individually, anywhere, online, 24/7, with free tutorials lessons and start up tools which are provided by companies such as Amazon, Microsoft, IBM and Google. However, to develop a new competitive AI/ML, Mechatronic, product, for markets such as healthcare, transportation, manufacturing, agriculture, sports, consumer products etc', it takes a seamless, interdisciplinary, team of experts, which cover all of the related disciplines. This course will not make you a quick expert in any one of these fields. It takes years to get there. It may motivate you, however, to start your academic, business or industrial career as a higher-level student, entrepreneurial partner or a valuable player with such a team of experts.

Course Objectives

- Learn industrial differentiation techniques in Mechatronics including: *innovation, modeling, analysis, design and manufacturing optimization, cost/effective solutions*
- Learn how State-of-the-art AI/ML is being used as a differentiator in Mechatronics technology (autonomous learning, performance monitoring and system control)
- Learn basic mechanical, electrical and communication components used in mechatronic devices
- Have hands on experience using electronic components in circuits and mechanical designs
- Experience the process of an innovative, patent pending, industrial product development
- Experience applications of engineering tools for system analysis, programming, simulation, design, sizing and project management
- Prepare for product assessment by industrial business development specialists (TBD)

Course Organization



Textbook – Mechatronics - Electronics Control Systems in Mechanical Engineering, Fourth Edition, by W. Bolton, Pearson, 1 per student)

Arduino Projects Book - Provided as part of the Arduino Starter Kit

Lab Projects – Building learning circuits with Arduino

Mechatronics Project –

Development of a proof of concept Mechatronics Device with AI/ML features, using Arduino and supplementary components

Online Software Tools – Practicing applications of useful tools in engineering product development work

- GanttProject – Project management
- SketchUp - CAD
- Mathcad – Vector Algebra
- LISA - FEA
- MATLAB - Control
- MS Azure – AI/ML Cloud
- Repl.it - Python, C Editors
- RoboDK – dynamic simulator
- Optinet Inc. – PID, Kinematics, Dynamics, Precision Sizing Tools
- AWS Deep Racer - Amazon Car Racing with AI/ML Neural Network (optional)

The students may be required to download the listed software tools to their personal computers or laptops and solve an assigned problem.

Lab Kit – Arduino UNO Starter Kit - Electronics kit (1 kit per team of maximum 4)

Additional Project Components – As described in project specification ($100 per team of maximum 4 students)

Attendance policy:

Both lectures and lab sessions are online. Class will meet once a week (Th. 4-6:30) for questions and answers about homework assignments, lab activities and project progress reports. Team's attendance in lab and project sessions is mandatory. A reported unauthorized absence of a project team member by the project manager to the instructor, will result after one warning a loss of 1 point in the final grade.

Learning Methods –

- **Learning Method 1 - Textbook Reading Assignments:** Individual weekly reading assignments of two textbook chapters per week (estimated reading time 2 hrs) as listed in the Module Description (shown as a reference below).
- **Learning Method 2 - Online Lectures:** Each Module includes an online lecture (estimated watch time 20 min) related to the lecture topic. Students are required to watch the lectures and follow the instruction related to homework assignments.
- **Learning Method 3 - Online Lab Tutorials:** Lab tutorials and analysis tools instruction are provided with short videos. (estimated 5 min). Students will follow the instruction on the video

regarding the lab or project assignment and the analysis tools. The analysis tools are relatively easy to learn and apply and may serve as a good toolkit for future engineering work

- **Learning Method 4** - **Arduino Projects Book reading.** Four electronic circuit exercises will be done with Arduino Starter kit, step by step, as described in the project book. (estimated 1 hr each)
- **Learning Method 5** - **Engineering Tools Practice** - Estimated 10 engineering tools will be practiced in this course. Learning may be done individually or in a group
- **Learning Method 6 - Arduino and Mechatronics Project Teams** - Students will form into teams of maximum 4 students per team on the first day of the course. Project team members are expected to plan, work and solve problems together on Arduino lab assignments and on the Mechatronics project, followed up by individual work per project manager Action Items (AI) assignments. Students must attend assigned meeting schedule for group work.

Exercises –

- **Homework exercises - <u>Submitted on Blackboard individually</u>:** Homework exercises from text book reading are assigned weekly (estimated 1 hr) and due on Blackboard at the beginning of the next Module. Late assignment will not be accepted, unless approved by the instructor per justified reason.
- **Analysis Tools Exercises - <u>Submitted on Blackboard Individually or as any group of 2 to 4 members (not nessesarily the same as the Mechatronics team).</u>** The students will practice using common analysis, design and programming tools and will submit the results in a separate report individually or as part of a (2-4) team. Tool reports will include: 1. Title 2. Tool Objective 3. Names of submitting student or students in the submitting group 4. Date Conducted 5. Results 6. Comments.(Note: If a student's name appears on more than one report, individual reports take precedence for grading, over group reports)
- **Lab assignments - <u>Submitted on Blackboard as a Team</u>:**There will be 4 Arduino UNO experiments (Modules 3,4,5,6) including lighting a led indicator, driving a piezo oscillator, driving a dc motor, displaying a message on LCD screen and activating the microcontroller by a cell phone. Each student will serve as a project manager for at least one lab assignment. These lab assignments will be described in a short video tutorial. The team will run it together and will submit a report, including a short video which shows all team members running lab experiment. The project manager will submit the report before the beginning of the next Module. Lab reports will include: 1. Title 2. Lab Objective 3. Team members 4. Date / Hour / Location Conducted (to be agreed by the team members) 5. Results 6. Conclusion 7. References: pictures and videos

Mechatronics Project - Product Development - <u>Conducted, Presented and Submitted as a Team</u>

The project is intended to simulate industrial mechatronics product development. The device which will be developed will relate to a certain market need selected by the team members, such as healthcare, transportation, manufacturing, agriculture, sports, and consumer products. Alternatively the team may select to mimic the example product which will be presented. The team will go through the product development phases similar to the way it is done in industry, including market search of existing products, specifications of a new innovative product, business planning, preliminary design, detailed design, procurement, manufacturing, integration, testing and presentation. The Mechatronics team groups, the Mechatronics project manager and the Mechatronics purchasing manager will be decided by the students in the first meeting. The instructor will assist in team organization as needed. Mechatronics Project managers and Mechatronics purchasing managers will receive up to 2 extra points towards their final grade, based on their performance.

Material Cost:

Each team will select a Mechatronics purchasing manager who will collect total $200 per team (of maximum 4) and be responsible for issuing purchase orders for Arduino UNO lab kit (~$100) and additional material as needed for building the product proof of concept ($100 max). The purchasing manager will keep the material in a special container and will bring it all to a lab session with his team members. At the end of the semester the students will keep the products. There will be no reimbursement for this cost. Manufacturing processes in this project may only include gluing, drilling, sawing, filing, soldering and 3D printing. Size of product is limited to 150 x 150 x 150 mm.

Progress reports:

Each Mechatronics project manager and Mechatronics purchasing manager will meet with the project teams at least twice a week and will send a short weekly email progress report to all team members and the instructor as follows: Purchasing Manager- net worth (NW) and cash flow (CF) status including cash sources, parts in stock and cash spent. Project Manager - progress status on Action Item (AI) list. Who is doing what, how is the plan progressing, any problems, recommended solutions.

Exams: Time Limited Conducted Individually
There will be two in class online exams. One mid-term exam and one final exam. All exams are on Blackboard, individual work, open textbook.

Grading, Rubrics, Weights and Scale:

Exercise assignments 10%, Tool assignments 10%, Lab assignments 10%, Mid-term Examination 20%, Final Examination 20%, project 30%. Projects will be graded by the instructor based on the following Rubric: 20% mechanical design, 20% electrical design, 20% sensors, 20% AI/ML, 20% Business Development. Best team in each rubric classification will get 3 bonus points, second team 2, third 1, with a total project score of 100 points plus 5 x 6= 30 maximum bonus points divided among winners. Extra credit points, up to 5 points towards the final grade, may be assigned by a team of professional industrial specialists (TBD) to the winning team. Final Course letter grade will be determined by the following grading scale.

Grading Scale

Grade Scale	Grade Conversion	Grade Scale	Grade Conversion
93-100	A	73-76	C
90-92	A-	70-72	C-
87-89	B+	67-69	D+
83-86	B	63-66	D
80-82	B-	60-62	D-
77-79	C+	Grade < 60	E

.

Detailed Module Description

Module	Topic	Ch'	Pages book	Pages total	Exercise #	YouTube Lecture	Lab & project activities	Y-tube Lab
1	Introduction	1	1-21	20	tbd	1	Project Definition	1
1.30	Sensors	2	22-58	36	tbd			
2	Signal Condit.	3	62-82	20	tbd	2	Mkt Research	2
2.6	Digital Signals	4	84-99	15	tbd			
3	Digital Logic	5	101-121	20	tbd	3	Arduino exe' 1	3
2.13	Data present.	6	123-147	24	tbd			
4	Pneu. actuator	7	150-171	21	tbd	4	Arduino exe' 2	4
2.20	Mech. actuator	8	173-190	17	tbd			
5	Elec. actuator	9	192-216	24	tbd		Arduino exe' 3	5
2.27	Bsc. Sys. Modl.	10	218-240	22	tbd			
6	Sys. modeling	11	243-252	9	tbd	6	Arduino exe' 4	6
3.5	Dyn. Resp. sys	12	253-273	20	tbd			
7	Sys trans. Fnct	13	275-288	13	tbd	7	Prelim design	7
3.12	Freq. response	14	290-308	18	tbd			
8	Cls lp control	15	309-329	20	tbd	8	Detail Design	8
3.26	Artif. Intellige.	16	331-337	6	tbd			
Mid Term	4.2						Procurement	
9	Micro process	17	338-372	34	tbd	9	Subassemblies	9
4.9	Assembly langug.	18	373-395	22	tbd			
10	C language	19	397-415	18	tbd	10	Integration	10
4.16	I/O systems	20	417-439	22	tbd			
11	PLC	21	440-465	25	tbd	11	Testing	11
4.23	Comm System	22	467-485	18	tbd			
12	Fault Finding	23	486-499	13	tbd	12	Refining	12
4.30	Mechtrnc system	24	500-526	26	tbd			
13							Presentation	13
5.7								
Final Exam	5.14							

Student Accessibility Support Center Statement

If you have a physical, psychological, medical or learning disability that may impact your course work, please contact Student Accessibility Support Center, ECC (Educational Communications Center) Building, Room 128, (631)632-6748. They will determine with you what accommodations, if any, 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 Student Accessibility Support Center. For procedures and information go to the following website: http://www.stonybrook.edu/ehs/fire/disabilities.

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

Critical Incident Management

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University 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.