ENG ME 460 Senior Design I
(Fall 2018)

Instructors:

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Graduate Student Teacher(s)

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Class Meeting Places and Times

A2	MW	10:10 AM	11:55 AM	EMA	215	ESGW
A3	MW	12:20 PM	2:05 PM	EMA	215	
A4	TR	1:30 PM	3:15 PM	EMA	215	
A5	MW	10:10 AM	11:55 AM	EPC	203	WMH
A6	MW	12:20 PM	2:05 PM	EPC	206	
A7	TR	1:30 PM	3:15 PM	EPC	206	

Catalog Course Description:
The course develops skills that are crucial to the successful completion of the Senior Capstone Design project. The core technical framework is electro-mechanical systems. Through lectures, workshops, and online materials, students gain practical experience in component and system design, project planning, and engineering communications. The course guides students through execution and documentation of the conceptual design stage of their Capstone projects. (4 cr., 1st sem.)

Prerequisites:
Students enrolled in ME 460 must have completed ME 302, Mechanics II; and ME 360, Product Design. Students wishing to undertake an aerodynamics capstone project must have completed or be concurrently enrolled in ME 308, Aircraft Performance and Design.

Extended Course Description:
ME 460 is the first semester of a two semester sequence (ME460/ME461). During the first semester students complete the definition of requirements for the senior capstone design project. Most assignments, both those directly related to the teams' own projects, and those related to developing competencies more generally, will be completed collaboratively within the capstone teams.

The overall objective of the ME460/ME461 sequence is the completion of the capstone project. ME460 develops skills that are crucial to the successful completion of the project. The importance of your interaction with customers, peers, and technicians is emphasized through lectures, discussion, and class exercises that immerse you in realistic scenarios, with many of the design challenges discussed drawn from capstone projects of previous years.

The technical component of the course (math and physics based) will support your work in both the preliminary and the detail design stages. Lectures and assigned readings will expose you to principles, tools, and practices of electro-mechanical design. In-class experiential learning, through hands-on contact with the hardware, and short exercises, will reinforce these concepts.

As the term progresses, the emphasis will shift from the mastery of technical concepts, including their application to an electro-mechanical mini-project, to formulating the conceptual design and project plan for the teams' capstone projects (to be completed in the spring semester in ME461). The final deliverable of the Fall term will be an oral presentation and written report of the conceptual design.

Course Outcomes:

Students successfully completing ME 460 will have

1 Gained appreciation for the breadth of knowledge, skills, and effort required to solve complex engineering problems within technical, economic, and societal constraints.

2 Applied engineering principles and methods to the design, selection and integration of electro-mechanical system components.

3 Developed an ability to design, understand, and troubleshoot systems that comprise mechanical, electrical, and control hardware.

4 Established the stages and activities of a design project and made objective estimations of the required resources.

6 Developed skills required to communicate effectively with a variety of constituencies, technical and non-technical, in a variety of scenarios associated with a design project.

7 Developed effective means for collaboration on a team whose members represent diverse skills and perspectives.

8 Established the platform for rapid progress toward the completion of the Senior Design Project in the second semester.

9 Documented the conceptual design stage of the Senior Capstone design project.

Technical Topics Covered:

1. Machine kinematics and dynamics
    a. Velocity profiles
    b. Relative importance of gravity loads and imposed accelerations
    c. Relationship between cycle times and force (or torque) requirements
2. Acuators
    a. Rotary with continuous motion
        i. Brushed vs. brushless motors
        ii. AC vs. DC motors
    b. Stepper motors
    c. Hydraulic & Pneumatic Actuators
    d. Match of actuator type to application requirements
3. Transmission Elements
    a. Devices analyzed through generalized input-output energy balance
        i. Gear boxes, lead screws, belts/chains

   b. Deviations from ideal behavior
      i. Backlash, stiction, friction
4. Joints, Bearings, and Shaft Supports
5. Sensors
   a. Measurement of position and velocity: incremental and absolute encoders
6. Elements of control
   a. The closed loop concept
   b. PID control
   c. Modeling and simulation of a 2^{nd} order system via program code or a spreadsheet

Project Management Topics Covered

1. Project objectives, goals, and constraints
2. Capture and documentation of customer and technical requirements
3. Collaboration and teamwork
4. Project planning and tracking
5. Resource management
6. Communication

Books and Other Printed References

Some in-class exercises will require the availability of a laptop computer or tablet. At least one member of each team should have access to such a device.

The following texts are useful references, but are not required:

Jack A. Collins, Henry R. Busby, George H. Staab, Mechanical Design of Machine Elements, John Wiley and Sons, ISBN-13: 978-0470413036, any edition

Robert C. Juvinall, Kurt M. Marshek, Fundamentals of Machine Component Design, John Wiley and Sons,
ISBN-13: 978-1118012895, any edition

Andre Sharon, Machine Design and Control – A Systems Level Approach, Custom Printing , John Wiley and Sons, any edition

Machinery's Handbook, 29th ed., Industrial Press, 2012, ISBN 9780831129002, Any recent edition is useful. Check for online availability.

Edward R. Tufte, The Visual Display of Quantitative Information, 2nd ed., ISBN 978-0961392147. The classic treatise on "how to communicate information through the simultaneous presentation of words, numbers, and pictures."

Manufacturing Methods Available in EPIC

[https://docs.google.com/document/d/1KdZnh55L0mH46BKxQdRehMyq_loJCq1m259YgNMujvI/edit]

This set of files, compiled by Professor Thornton, contains a basic introduction to the manufacturing methods that are available in EPIC for use in projects or for personal use.

Courseware

Course reading material and assignments will be distributed online through Blackboard Learn.

Assignments and Grading

In-class exercises to reinforce comprehension of lecture material (individual, unless otherwises indicated)	5%
Homework (individual, unless otherwise indicated)	15%
Electro-mechanical mini-project (team based)	40%
Senior capstone conceptual design report (written and oral)	40%

Capstone Qualifying Exam
Students undertaking capstone projects are expected to be competent in basic electro-mechanical theory and practice. At a time no later than the mid-point of the course, students will be required to pass a written test on the topics covered in the course. This is a pass/fail test to be completed in one class session. A passing grade is required to receive a grade higher than C in the course.
At the start of the term, students will be offered a diagnostic exam that will cover the main topics of the course . This exam will serve as a reference for the instructors of the initial knowledge of the students in those topics, and will help students assess the breath and depth of the course and the expected depth of understanding required for the qualifier exam. The diagnostic exam will not count towards the course grade.

Resources

- Abstracts of final reports, as well as video recordings of final presentations for the past several years, are available at the department website. They are indexed at the course website.
- Graduate Student Teachers will be available to support teams in mechanics, Matlab and Arduino programming environments, and use of CAD tools.
- We anticipate being able to assign each team its own project-storage locker space.

Academic Behavior Standards: Your behavior in this course is bound by the Boston University Academic Conduct Code found at the website http://www.bu.edu/academics/academic-conduct-code. You are responsible for understanding the requirements of this code. If you are in doubt about whether any contemplated action in the course would violate the code, ask your instructor before doing it. Since this course has few objective exams, opportunities for cheating are reduced, but any work presented as your own must in fact be your own, and any work quoted or otherwise reused from others must be explicitly acknowledged. The source of images included in reports or presentations must be referenced.

Attendance and Team Contribution:
The primary metric of responsible attendance will be the student's degree of contribution to the team. Members are expected to inform their peers in a timely manner if unavoidable circumstances prevent their participation in scheduled team meetings. Team assignments will require all students to identify their unique contribution. Students will receive no credit for in-class exercises for which they are not present. Non-contribution to the team's progress will result in a failing grade for a given assignment, and sustained non-contribution, after warning, will result in a failing grade in the course.

Course Calendar
(Dates subject to adjustment**)**

Sep 04 – Sep 05	First Day of Classes Team membership confirmation Team exercise #1 – Functional decomposition
Sep 06 – Sep 10	Design strategy and examples from previous projects
Sep 11 – Sep 19	Motion interpretation: Kinematics, dynamics, and motor selection
Sep 20 – Oct 01	Motion conversion: efficiency and energy loss, kinematic and dynamic parameters for rotary-to-rotary and rotary-to-linear conversion. Gears, lead screws, chains, belts
Oct 04 – Oct 18	Actuators: Brushed and brushless DC motors, solenoics, servos, stepper teardown and control, control valves, cylinders, and circuits circuits, pneumatic stepper example
Oct 22 – Oct 23	Other components: bearings and component mounting on shafts
Oct 24 – Oct 30	Sensors and control
Oct 29 – Oct 30	Capstone Qualifying Exam
Nov 01– Nov 20	Capstone team meetings and coaching sessions
Nov 21 – 25	Thanksgiving Recess
Nov 26 – Dec 03	Capstone team meetings and coaching sessions
Dec 4	Conceptual design presentation files due; Presentations Start
December 10	Conceptual design written reports due; Last day of Presentations
December 11 & 12	Course Debriefing and Evaluations