# Mechatronics System Design
# MTRE 4800 – Spring 2020

## Instructor

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## Course Description

### Catalog Description

The design of mechanical and electrical devices and systems, and cost considerations are covered. The course focuses on reliability, safety, energy and environmental issues, ethics, patents, product liability, time value of money, return on investment, and breakeven analysis. The design project is a capstone for the Mechatronics Engineering program. Projects are assigned based on interest, equipment and software availability, and the specific background of the student. Projects require planning, proposal presentation, scheduling, engineering, implementation, and written and oral presentations of project results. Students are encouraged to "design and build" and utilize concepts learned from courses throughout the program.

### Course Details

Term: Spring 2020
Course name: Mechatronics System Design
Course number: MTRE 4800
Section number(s): 01
Meeting times: Lecture MF 8:00 am - 8:50 am, Laboratory F 9:30 am - 3:15 pm
Room number: Lecture Q 104, Laboratory Q 118

### Learning Outcomes

By the end of this course, students should:

- Be able to apply mathematics, science, and engineering to the project.
- Be able to design systems, components and processes to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- Be able to function in multi-disciplinary teams.
- Be able to identify, formulate and solve engineering problems (analysis, design, verification, validation, implementation, application, and maintenance of a system).
- Understanding professional and ethical responsibility.
- Be effective communicators – oral & written (i.e. presentation & report).
- Be able to use the techniques, skills, and modern engineering tools necessary for engineering practice.

## Textbook

Required: *Engineering Design*, 2nd Ed, Rudolph J. Eggert, High Peak Press, ISBN 978-0-615-31938-4
https://www.barnesandnoble.com/w/engineering-design-rudolph-eggert/1101879975
Required: *The Scrum Guide*, K. Schwader and J, Sutherland,
https://www.scrumguides.org/docs/scrumguide/v2017/2017-Scrum-Guide-US.pdf

# Design Project

The primary deliverable in this course is a physical prototype of a functional mechatronic system. The actual systems can vary greatly, and examples of previous projects appear in a YouTube playlist[1]. However, all projects must include the following elements:

- Mechanical design
- Data acquisition from sensor(s)
- A programmable computing device
- Actuation control

Teams will consists of 3 or 4 members, one of which will be designated as the team lead who is responsible for managing communication with the instructor. The team lead will also serve as the product owner on the Scrum team. A different member will be assigned the role of scrum master, responsible for ensuring the team remains true to the scrum method and serving as the single point of contact to the instructors with respect to scrum questions.

# Grading Policy

| | |
|---|---|
| Textbook chapter presentation | 5% |
| Ethics case study | 5% |
| Quizzes | 15% |
| Initial product backlog | 3% |
| Sprint review, retrospective, and planning | 6% |
| SCR | 3% |
| SRR | 4% |
| PDR | 4% |
| Subsystem demonstration | 5% |
| Subsystem interaction demonstration | 5% |
| CDR | 10% |
| Demo day presentation | 5% |
| Final demonstration | 30% |
| **Total** | **100%** |

**Grade Conversion:** A: (90-100), B: (80-89), C: (70-79), D: (60-69), F: (0-59)

## Textbook chapter presentation

Each team will be assigned a portion of a chapter from the textbook, whose content they will present to the class. The presentation will include provide an overview of the content, examples of how to apply it to the capstone project, and contrasting it with agile project management.

## Ethics case study

Students will be presented with an ethical dilemma in the engineering profession and develop an appropriate response to the situation.

[1] https://www.youtube.com/playlist?list=PLiAXye54pUSa_cAqUE8SSpSBQgRWPG4lA

## Quizzes

Three in-class quizzes will be administered where the first two test understanding of the material from the textbook and the third involves questions for sample Fundamentals of Engineering (FE) exams.

## System Concept Review (SCR)

It aims to assure that the objectives and requirements of the item being designed are understood and that the proposed approach will meet these requirements. The emphasis should be on the proposed design concept, system functionality, and the definition of major system interfaces. A major result of the SCR is identification of the ***parameters*** (time for assembly, success rate, positional accuracy, etc.) which will be used to identify the minimum success criteria (MSC) upon which the final prototype will be judged.

## Initial Product Backlog

The product backlog will be submitted with entries for all the features and sub-features necessary to complete the project. Each entry will be described by a sentence, accompanied with a definition of "done", assigned a story point estimation, and receive a rank ordered priority.

## Sprint Review, Retrospective, and Planning

At the end of each sprint, the team must submit documentation of the results of the sprint review (how the product backlog is updated), sprint retrospective (assessment of sprint activity effectiveness), and sprint planning (what will be completed and how).

## System Requirements Review (SRR)

The SRR is a formal review conducted to ensure that system requirements have been completely and properly identified. It ensures that the system under review can proceed into initial systems development. SRR assesses the system requirements captured in the system specification and ensures that the system requirements are consistent with the approved materiel solution, enabling concepts, and available technologies. The primary result of the SRR is an initial estimation of ***values*** for the parameters identified in the SCR that will appear in the MSC.

## Preliminary Design Review (PDR)

PDR is a formal inspection of the high-level architectural design of a system and its software, which is conducted to achieve confidence that the design satisfies

- The functional and nonfunctional requirements
- Overall project status, proposed technical solutions, evolving software products, and associated documentation

The review is at a high level

- To determine completeness and consistency with standards
- To raise and resolve any technical and/or project-related issues
- To identify and mitigate project, technical, security, and/or business risks affecting continued detailed design and subsequent development, testing, implementation, and operations & maintenance activities.

Significant simulation and/or prototyping work must be completed for the PDR in order to finalize the values of MSC performance parameters.

## Subsystem Demonstration

Demonstration of a project subsystem will accompany the PDR. The subsystem can be demonstrated physically or with an appropriate simulation. The chosen subsystem should ideally be one least understood at the project outset so that development of the partial prototype can inform setting MSC. The scope of the subsystem to be developed must be approved by the laboratory instructor during sprint planning on January 24. Examples of potential subsystems are motion control of a motor, verification of kinematics in the mechanical design, processing complex sensor data such as image processing or point cloud data analysis, etc.

## Subsystem Interaction Demonstration

This demonstration will show the interaction between two subsystems of the final prototype. If the project includes two different hardware devices (Arduino, Raspberry Pi, laptop, robotic platform, etc.), this demonstration would ideally involve proof-of-concept communication between the devices. The scope of the interaction developed must be approved by the laboratory instructor during sprint planning on February 21. Examples of potential subsystem interactions are actuation control driven by sensor data, communication between computer and robotic platform, computer control of a complex mechanical design, etc.

## Critical Design Review (CDR)

The CDR will

- Ensure that the "build-to" baseline contains detailed hardware and software specifications that can meet functional and performance requirements.
- Ensure that the design has been satisfactorily audited by production, verification, operations, and other specialty engineering organizations
- Ensure that the production processes and controls are sufficient to proceed to the fabrication stage
- Establish that planned Quality Assurance activities will establish perceptive verification and screening processes for producing a quality product
- Verify that the final design fulfills the specifications established at PDR

## Demonstration Day Presentation

On demonstration day (April 24), each team will have 5 minutes to present their project to a non-technical audience. The presentation will include a short (no longer than 2 minutes) video documenting project progress and demonstration of the working prototype satisfying MSC.

## Prototype Demonstration

The general public and campus community will be invited to observe the working prototypes on demonstration day. Prototypes not meeting the minimum success criteria on demonstration day will receive a zero grade for this item. The score for this item on successful teams will be scaled dependent on a peer evaluation of team members as follows:

- Assign each team member (not yourself) a “grade” of 100%, 90%, 80%, 70%, or 60%
- Each grade must be distinct, i.e. two members cannot both receive 100%
- Teams of four drop the lowest “grade” received from their peers
- Team members are evaluated on the average “grade”
- Points for the prototype demonstration portion of the course are scaled by this average

# Course Expectations

## Attendance Policy

Students are expected to attend every class session, both lecture and laboratory. Each unexcused absence from a "daily" scrum or sprint review/retrospective/planning beyond the first will count against them. The fraction of meetings beyond the first missed will scale the raw score on subsequent SCR, SRR, PDR, or CDR submissions. The breakdown of which scrums affect which scores are:

- Meetings for weeks 2-3 (five meetings): SRR
- Meetings for weeks 4-7 (eleven meetings): PDR
- Meetings for weeks 8-11 (eleven meetings): Subsystem interaction demonstration
- Meetings for weeks 9-15 (ten meetings): CDR

For example, team member A would receive 100% of their SRR grade even with a missed scrum in week 2. However, if the same student missed a scrum in each week 5 and 6, the final PDR score would be 8/11 = 72.7% of the raw grade.

## Course Communication

Course material will be disseminated in D2L. All official course announcements, including instructions when class may be cancelled, will be posted in the D2L course news. Be sure to check D2L regularly.

## Course Outline

| Day | Date | Lecture |
|---|---|---|
| Mon | Jan 06 | Introduction and team finalization |
| Fri | Jan 10 | Scrum overview |
| Lab | Jan 10 | Finalization of project idea and sprint planning* |
| Mon | Jan 13 | Realistic design constraints and engineering standards – **SCR due** |
| Fri | Jan 17 | Implementing Scrum |
| Lab | Jan 17 | Sprint work |
| Mon | Jan 20 | No class – MLK day |
| Fri | Jan 24 | Project management life-cycles |
| Lab | Jan 24 | **SRR presentations** and **product backlog due** – sprint review/retrospective/planning* |
| Mon | Jan 27 | Agile project management |
| Fri | Jan 31 | Chapter 1 presentations |
| Lab | Jan 31 | Safety training |
| Mon | Feb 03 | Chapter 3 presentations |
| Fri | Feb 07 | Chapter 4 presentations |
| Lab | Feb 07 | Sprint work |
| Mon | Feb 10 | **Quiz 1** |
| Fri | Feb 14 | Chapter 7 presentations |
| Lab | Feb 14 | Sprint work |
| Mon | Feb 17 | Chapter 8 presentations |
| Fri | Feb 21 | Class cancelled – weather |
| Lab | Feb 21 | **Subsystem demonstration** and **PDR due** – sprint review/retrospective/planning* |
| Mon | Feb 24 | Chapter 13 presentations |
| Fri | Feb 28 | Resume writing and interview skills |
| Lab | Feb 28 | Sprint work |
| Mon | Mar 02 | **Quiz 2** |
| Fri | Mar 06 | System integration |
| Lab | Mar 06 | Sprint work |
| Mon | Mar 09 | Guest speaker – Dr. Ham – future plans, industry vs. graduate school |
| Fri | Mar 13 | FE exam |
| Lab | Mar 13 | Sprint work |
| Mon | Mar 16 | No class meeting |
| Fri | Mar 20 | FE exam |
| Lab | Mar 20 | **Subsystem interaction demonstration** – sprint review/retrospective/planning* |
| Mon | Mar 23 | Guest speaker – Greg Quinet – Entrepreneurship Center Executive Director |
| Fri | Mar 27 | **Quiz 3** |
| Lab | Mar 27 | Sprint work |
| Mon | Apr 06 | Ethics |
| Fri | Apr 10 | Ethics |
| Lab | Apr 10 | Sprint work |
| Mon | Apr 13 | Guest speaker – **ethics assignment due** |
| Fri | Apr 17 | Guest speaker – recent graduate Hugh Cathey |
| Lab | Apr 17 | Sprint work |
| Mon | Apr 20 | Graduate education |
| Fri | Apr 24 | **Demo day presentation** – no class meeting |
| Lab | Apr 24 | **Final demonstration** – no class meeting |
| Mon | Apr 27 | Exit interviews – **CDR due** |

* These laboratory meetings mark the beginning of a new sprint.

Every lecture and laboratory meeting beginning January 10 that does not mark a new sprint will end with a "daily" scrum.

## Federal, BOR, & KSU Course Syllabus Policies

*Information contained in the links below constitutes the Federal, BOR, and KSU course syllabus policies and procedures and may be referenced by faculty members in their course syllabi. These policies are updated on the Academic Affairs Website annually.*

**Academic Affairs - Federal, BOR, & KSU Policies**

**Academic Affairs - KSU Student Resources for Syllabus**

**Note to Faculty:** The KSU faculty handbook requires the Academic Integrity Policy in the course syllabus.

**Note to Faculty and Students:** The Office of the Provost will work to keep the policies and links in this document as accurate as possible.

## Academic Integrity Statement

Every KSU student is responsible for upholding the provisions of the Student Code of Conduct, as published in the Undergraduate and Graduate Catalogs. Section 5c of the Student Code of Conduct addresses the university's policy on academic honesty, including provisions regarding plagiarism and cheating, unauthorized access to university materials, misrepresentation/falsification of university records or academic work, malicious removal, retention, or destruction of library materials, malicious/intentional misuse of computer facilities and/or services, and misuse of student identification cards. Incidents of alleged academic misconduct will be handled through the established procedures of the Department of Student Conduct and Academic Integrity (SCAI), which includes either an "informal" resolution by a faculty member, resulting in a grade adjustment, or a formal hearing procedure, which may subject a student to the Code of Conduct's minimum one semester suspension requirement. See also KSU Student Code of Conduct.

## Electronic Communication

The University provides all KSU students with "official" email accounts with the addresses "students.kennesaw.edu" and "kennesaw.view.usg.edu" (in D2L). As a result of federal laws protecting educational information and other data, these are the sole email accounts you should use to communicate with your instructor or other University officials.