ME555 – Experiment Design and Research Methods

Course Description: Students define a hands-on project of their choice that would prepare them for research in their preferred master's study concentration. The design process is employed to identify a problem, formulate it, propose design alternatives and rank them, produce and test prototypes, refine and iterate on the selected design. The experiments that are developed are incorporated within the graduate and undergraduate curriculum. The course is composed of equal parts design, technical content, and communication skills (including an online portfolio). Projects can be further developed during the subsequent semester to fulfill the master's project requirement during the Poster Expo.

3 Graduate credits

- Prerequisites: Graduate standing or second semester in 4+1 Program
- Required course for MEMS MS students
- Strongly encouraged for MEMS MEng students

Instructor's information

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What is this course about?

Students produce a complete project that would be worthy of Graduate School degree requirement for a project that can be defended. The course website is found here:

https://sites.duke.edu/MEMScapstone

Given the highly interactive student/faculty learning environment, the objective is to develop a sense of community where everyone goes through the experience together while honing their skills in technical knowledge, communication and project management around a real-world challenge of the student's choice.
Students leave with higher order thinking skills, increased confidence in how they take on open-ended design problems, and increased awareness of modern research areas.

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What background knowledge do I need before taking this course?

Pre-requisite: Graduate MEMS standing

What will I learn in this course?

Students will learn to evaluate different methodologies and solutions available for the challenge in hand and will go on to design and create a highly scaffolded prototype contextualized to their local understanding and needs.

Students will design and create a technical solution for a real-world challenge in a highly scaffolded way.

The online mode of the class coupled with international student pool will add a unique dimension to the students experience regarding teamwork and project management, making them highly lucrative for employers hiring in the current and future scenarios.

What will I do in this course?

Students will do a detailed study of work done in available literature as well as previous groups in the initial 6 weeks of the course followed by final project development in the remaining time.

The whole process will involve designing an experiment with detailed instructions, in a way that an external manufacturing company could build and assemble the prototype.

The activities include in-class discussions peer reviews, team breakout rooms, weekly presentations. The rest of the week will be spent by the teams closely working together on individual components of the project with support provided by the faculty and peers through clear and open communication in team discussion forum (MS Teams).

How can I prepare for the class sessions to be successful?

Given the highly independent and project-based nature of the course, the students' needs to identify the questions they need to ask and be prepared to share the progress they have made in a professional way. Generally, they should be prepared with the questions including but not limited to:

- What has been the progress so far? Both as team and as individual
- Current roadblocks in their work
- Help required from the faculty
- Next steps for the project and why do you think this way. Both as team and as individual

What optional texts or resources might be helpful?

-to be provided in class

How will my grade be determined?

Refer to “ME555 – Syllabus – Capstone” for grading rubric
Grading will be combination of Score given by the Faculty, Peer Grading and Self-Grading exercises depending on the weekly presentations, involvement in discussions and final prototype.

What required texts, materials, and technologies will I need?

Students will ideally be working with all or some of the below mentioned tools depending on the project scope and their interest area.

Prototyping: CAD-assemblies

Skill	**Topic**	**Tool**
Prototyping	CAD-assemblies	Onshape.com
Sensor Design and Calibration	Real Time Data Plotting	Processing IDE, Arduino IDE, Python Script
Microcontroller/Electronics	Arduino or Raspberry Pi or Particle Argon Amplifier Circuit Solderable Breadboards	Wireless Telemetry
Project Management	Gantt Chart/Kanban Board	MS Planner
Documentation	Weekly Presentation Final Paper Weekly Drafts Poster	MS Word Journals/ PLC Log Notebook

What are the course policies?

Communications

The class will be extensively be using MS Teams MEMS Fall Capstone group for general discussions and every team will have a separate channel to share their progress and raise doubts. The folder option in MS Teams should be used to store all the files together at one central place.

Emails can be used for communicating highly detailed information and for quick response from the peers and faculty, MS Teams open channel use is encouraged.

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In case of any issue arising due to time zone or uncertain local conditions, it should be flagged to the faculty at the earliest.

Discussion Guidelines

Civility is an essential ingredient for academic discourse. All communications for this course should be conducted constructively, civilly, and respectfully. Differences in beliefs, opinions, and approaches are to be expected. Please bring any communications you believe to be in violation of this class policy to the attention of your instructor. Active interaction with peers and your instructor is essential to success in this course, paying particular attention to the following:

- Be respectful of others and their opinions, valuing diversity in backgrounds, abilities, and experiences.
- Challenging the ideas held by others is an integral aspect of critical thinking and the academic process. Please word your responses carefully, and recognize that others are expected to challenge your ideas. A positive atmosphere of healthy debate is encouraged.
- Read your online discussion posts carefully before submitting them.

Academic Integrity

As a student, you should abide by the academic honesty standard of the Duke University. Its Community Standard states: Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and nonacademic endeavors, and to protect and promote a culture of integrity.

To uphold the Duke Community Standard:

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised.

Academic Policy & Procedures

You are responsible for knowing and adhering to academic policy and procedures as published in the Duke Community Standard Guide. Please note, an incident of behavioral infraction or academic dishonesty (cheating on a test, plagiarizing, etc.) will result in immediate action from me, in consultation with university administration (e.g., Dean of Undergraduate Studies, the Office of Student Conduct, Academic Advising).

Academic Accommodations

If you need to request accommodation for a disability, you need to contact the Disability Management

System (DMS) office. I will work with that office to provide you with equal access to course materials and make accommodations for exams and other assessments.

What university resources can help me during this course?

In this section you may wish to highlight particularly relevant resources or other resources that are discipline-specific that are useful for students.

Student Support

Please consult with me about appropriate course preparation and readiness strategies, as needed. The Academic Resource Center (ARC) offers free services to all students (e.g., peer tutoring, learning consultations, ADHD/LD coaching, and help with online learning.

If you are concerned about your physical or mental health? DukeReach can connect you with departments across campus to get you help and you contact CAPS directly for counseling services.

Academic Advising

Consult your academic advisors on course performance (i.e., poor grades) and academic decisions (e.g., course changes, incompletes, withdrawals) to ensure you stay on track with degree and graduation requirements. The Academic Advising Center can help you navigate who to contact. The university publishes a full list of academic policies for graduates to review.

Week	Topic	
1	Introduction; Course Objectives; Work Session	
2	Project Proposals, Task Lists, Work Delegation, BOM	
3	Problem Formulation, Literature Review	
4	Functional Requirements, Engineering Specifications	**TechComm Workshop**
5	Design Alternatives, Ranking Methods	
6	Design Selection, Bill of Materials, Virtual Prototyping	
7	Simulation, Experimentation, System Behavior	
8	End of First Design Iteration Cycle	**TechComm Workshop**
9	Reiteration Process; New Considerations; Updated BOM	
10	Prototyping, Building, Instrumenting	
11	Experimentation, Data Collection and Reduction	
12	Uncertainty and Statistical Analyses	**TechComm Workshop**
13	Work Session to Finalize Project: One	
14	Work Session to Finalize Project: Two	
15	Final Deliverables, Conclusions	**TechComm Critique**

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