ENGR 4010 and ENGR 4020

MULTIDISCIPLINARY DESIGN and DEVELOPMENT I and II

2017 – 2018

Beginning of Course Memo and Syllabus

Class sessions:	Monday, Wednesday, & Friday 12 – 12:50 p.m.
Course credit:	4010 (3 credits), 4020 (3 credits)
Course website:	collab.itc.virginia.edu (ENGR 4010-4020 1718)
Course instructor:	James Groves
Office hours:	See the front page of the course website for up-to-date details

COURSE OVERVIEW

UVA undergraduate record description of course

A two-semester, multidisciplinary, capstone engineering design sequence; the primary objective of ENGR 4010/4020 is to provide students with a realistic and rigorous, culminating engineering design experience, which is reflective of contemporary professional practice. Key course attributes include the multidisciplinary composition of engineering design teams (students and faculty from any department within SEAS, Commerce, Darden, Nursing, etc.), emphasis on aspects of modern practice (e.g., concurrent engineering, total quality management, and balanced consideration of the technological, organizational and cultural context) and realistic problems and client-stakeholders. A disciplined design/development process is followed that incorporates the important activities of contextual analysis, problem definition, customer needs definition, concept generation and selection, product specification, modeling and engineering analysis, proof of concept prototyping, design verification, cost analysis and project management and scheduling.

Pre- or co-requisite courses or topics

4th year standing at the University of Virginia. Students in all majors across the university are encouraged to enroll.

A description of this year's course section

This two-semester design course sequence is intended to serve as an opportunity for students to draw together their college studies and apply them deliberately towards the design, development, and preparation for market of an engineering technology solution. The courses guide student design, development, and market preparation efforts by means of the engineering design process (Figure 1). That framework will be used as a guide for both team-based engineering work and professional project management efforts (in the areas of design, development, and market preparation) throughout the year.

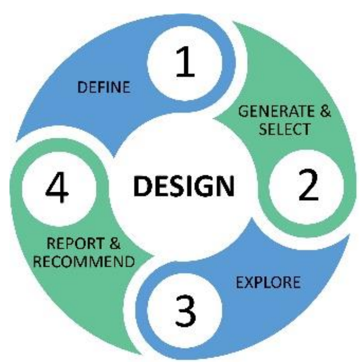

Fig. 1: The engineering design process

At the outset of this two course sequence, students will share their professional interests with one another and form into teams of 4 – 8 students with similar interests. Each team will then work through the major steps of the engineering design process (i.e., DEFINE, GENERATE &

SELECT, EXPLORE, and REPORT & RECOMMEND) on a project of their choosing. The course does not suggest a challenge space for each team. Rather, students define the area of activity for themselves. While all teams will center their efforts around the technical development of an engineering technology solution, multidisciplinary teams that include students from other disciplines will be strongly encouraged to develop additional project elements that are known to be important to the successful introduction of new technology into society. Examples of these additional project elements include marketing and branding strategies, financial plans, intellectual property protection proposals, cultural assessment studies, environmental impact assessments, and public policy position papers relevant to the specific technology under development. Students who are considering enrollment in this course are strongly encouraged to recruit other students to enroll, from engineering and from across all other undergraduate majors at the university.

As needed by each team, the instructor will provide personalized instruction on the finer points of the engineering design process and teamwork. To ensure proper support of students across the potentially broad array of intellectual endeavors of the course, the instructor will challenge students to engage with knowledgeable subject matter experts to ensure full support of their team projects. While the majority of student effort in the course will center upon the team activities, students will be expected to develop and maintain a personal design notebook, exploring design concepts of particular interest to them as individuals.

LEARNING OBJECTIVES

Overall course objectives

All students in the course will confirm or enhance their:

1. Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability (ABET[1] outcome “c”).
2. Ability to function on multidisciplinary teams (ABET “d”).
3. Understanding of professional and ethical responsibility (ABET “f”).
4. Ability to communicate effectively (ABET “g”).
5. Broad education, as necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context (ABET “h”).
6. Recognition of the need for, and an ability to engage in life-long learning (ABET “i”).
7. Knowledge of contemporary issues (ABET outcome “j”).

Engineering students will also confirm or enhance their:

1. Ability to apply knowledge of mathematics, science, and engineering (ABET “a”).
2. Ability to design and conduct experiments, as well as to analyze and interpret data (ABET “b”).
3. Ability to identify, formulate, and solve engineering problems (ABET “e”).
4. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (ABET “k”).

[1] ABET is an engineering accrediting agency that has articulated specific learning criteria for all programs that it approves. Given that most UVA undergraduate engineering degree programs are ABET accredited, there is a conscious effort to align the learning outcomes of ENGR 4010/4020 with ABET requirements.

ENGR design-specific learning outcomes

1. Students will deepen their knowledge of the engineering design process, learn the key steps of the process, understand the essential activities of each step, and apply the process as a tool in development of an original solution concept and in project management.
2. Students will better appreciate the many ways in which multiple engineering and non-engineering disciplines work together to bring a substantive product design solution successfully to market.

Topics covered

1. DEFINE a challenge space.
2. GENERATE solution requirements and concepts.
3. SELECT key solution requirements and a most promising solution concept.
4. EXPLORE a most promising solution concept, by means of prototyping and testing.
5. REPORT the results of a professional engineering design, development, and market preparation project.
6. RECOMMEND future work on a significant project.

ASSESSMENT & MEASUREMENT

How course outcomes will be assessed

<u>Oral and Poster Presentations</u> (20%)

Throughout the year, student teams will participate in four presentations regarding their projects. During each semester, teams will make both an oral and a poster presentation regarding their collaborative design project. During both semesters, the oral presentation will occur in the middle of the semester, and the poster presentation will occur near the end of the semester. For each presentation, a grading rubric will be provided when the presentation is announced.

<u>Design Notebook</u> (15%)

Throughout the academic year, students will maintain a design-related notebook. Throughout the year, students will use the notebook as a repository for their individual thinking and effort on their team project. Also, students will use the notebook as a record of their individual intellectual exploration of design, beyond the group project. During the early portion of the fall semester, students will use the notebook as a scratch pad where they identify and briefly describe many different design spaces that they identify. During the second half of the fall semester, students will transition from mental exploration of many design spaces to a more focused exploration and development of thoughts surrounding one design space of their choosing. Then, throughout the remainder of the academic year, students will develop their thoughts about and understanding of their selected personal design space in much greater depth. The guidelines for the design notebook will be provided at the start of the fall semester.

<u>Design Reports</u> (60%)

Throughout the academic year, student teams will complete four team design activities and reports, one on each major stage of the design process: DEFINE, GENERATE & SELECT, EXPLORE, and REPORT & RECOMMEND. The first, second, and fourth reports will each count for 10% of the course sequence grade. The third report will count for 30% of the course grade. Students will complete their project work via self-directed meetings and task orders with their team members. They will also meet weekly as a team with their course instructor for expert “guide on the side” instruction. As each of the four major assignments is issued, students will simultaneously receive a detailed grading rubric. See Appendix A for those rubrics.

Participation and Collaboration: Teamwork, Assessment (5%)

Throughout the course, students will work extensively on team-based activities. Student engagement in weekly meetings with their course instructor will be evaluated. Students will be asked to evaluate their teamwork contributions and the contributions of their partners using an online tool - CATME. When difficult interpersonal situations arise with team members, students will be evaluated on their willingness to work through those difficult situations in an open, supportive, and professional manner. Students will be asked to complete end-of-semester evaluations of their instructor.

The timeline for assignments and overall course activity is provided in Appendix A.

Late policy

All graded assignments in ENGR 4010/4020 will have specific due dates and times listed in the weekly handouts provided by your instructors. Assignments may be turned in up to 48 hours after the assigned due date and time. When assignments are turned in late (by any amount of time), a 10% grade penalty will be assessed. After a student misses the 48 hour “late submission” window, there will be no opportunity to turn in assignments late for grading, except when a student is able to document a health, family, or similarly significant emergency.

Course grade scale

A+	> 97%	**B+**	87 – 90%	**C+**	77 – 80%	**D+**	67 – 70%
A	93 – 97%	**B**	83 – 87%	**C**	73 – 77%	**D**	63 – 67%
A-	90 – 93%	**B-**	80 – 83%	**C-**	70 – 73%	**D-**	60 – 63%

F <60%

INSTRUCTIONAL MATERIALS

As student teams begin work on each of the four major assignments of this course sequence, they will receive an assignment handout with grading rubric. At the same time they will receive a multi-page document with additional, detailed guidance for the assignment. As needed, students will be provided with instructional materials that explain the activities and goals of each major step of the engineering design process. In addition to written and multimedia instructional materials that will be provided, student teams will receive weekly, individualized instruction intended to guide their project work.

LEARNING COMMUNITY INTERACTION & ENGAGEMENT

Individual student engagement

To learn about oneself, students will need to be active participants and learners in this course. As students seek to learn and commit concepts to long-term memory, they will need to initiative questions to and request assistance from their instructors and classmates. Personal growth requires some risk. So, do not be hesitant to speak up, ask questions, and offer new or different types of insight. If you do not feel safe in class or in your team, bring your concerns to the attention of your instructors as soon as possible. You are also encouraged to come to instructors' open office hours to discuss concerns, to seek assistance, or to deepen your understanding of a topic.

Your success in this course will depend on *your* individual efforts and on *our* ability to work together to build a cooperative learning environment. Questions and sharing of beliefs, opinions, and feelings are strongly encouraged. In order to maximize our learning, we will need to create a safe community in which we will feel comfortable sharing ideas and providing constructive feedback. Achieving a safe learning environment requires practice and effort. It will require each of us to behave professionally and respectfully at all times, and to adhere to our course norms. Throughout the semester, we want you to examine your perspectives and values as individuals, students, and as people situated in a broader society and the environment. As you learn about you and your classmates, we encourage you to respect and appreciate differences.

Learning community values

Meaningful and constructive teamwork and courteous dialogue are expected in this course. Both require a degree of respectful understanding and a willingness to listen to all course participants. You may not agree with another person's point-of-view, or you may already understand a concept and feel frustrated with the pace of team efforts. Give others a chance to contribute and learn. Encourage one another politely. Seek to understand and appreciate the ideas of others. Learn from one another. Be patient and encouraging as we *all* seek to advance our knowledge of important professional engineering concepts. Since every student is entitled to full participation in this course without interruption, all students are expected to come to class session and team meetings prepared and on time. You are always expected to refrain from undertaking any activities that might be considered disruptive.

Respect and safety

Your instructor is committed to supporting and encouraging students, staff, and faculty to take responsibility for safety on our campus. If you or someone you know experience stalking, partner violence, or sexual assault, please remember that you (or he or she) is not alone. If for any reason you do not feel safe in class, on grounds, or in your personal life, then please do not hesitate to contact your instructor or the Student Health Center. Counseling and Psychological Services (CAPS) is available for all students. Call 434-243-5150 (or 434-972-7004 after hours and weekend) to get started and to schedule an appointment. Call Madison House's HELP Line at 434-295-8255, if you prefer to speak anonymously and confidentially. If you or someone you know is struggling with gender, sexual, or domestic violence, there are many community and University of Virginia resources available to help you. The Office of the Dean of Students, Sexual Assault Resource Agency (SARA), Shelter for Help in Emergency (SHE), and the UVA Women's Center are excellent resources for both men and women. Contact the Director of Sexual and Domestic Violence Services at 434-982-2774.

Honor code

The School of Engineering and Applied Science relies upon and cherishes its community of trust. We firmly endorse, uphold, and embrace the University of Virginia's Honor principle that students will not lie, cheat, or steal, and we expect all students to take responsibility for the System and the privileges that it provides. We recognize that even one Honor infraction can destroy an exemplary reputation that has taken years to build. Acting in a manner consistent with the principles of Honor will benefit every member of the community both while enrolled in the Engineering School and in the future.

If you have questions about the Honor System or would like to report suspicions of an Honor offense, please contact your instructor. For more information on the UVA Honor System, please visit the following web resource: http://www.virginia.edu/honor/

Class schedule and time commitment

ENGR 4010 and 4020 are organized as semi-independent, team-based courses. As a result, there will be few times during the school year when the entire class meets in a classroom to listen to a lecture or presentation. Even though there will be few class sessions involving the entire class, student teams will be expected to organize and lead weekly meetings with their course instructor, with each meeting lasting on the order of one hour. During the meeting, teams will provide an update on their recent project activities and their upcoming plans. Their instructor will provide commentary and guidance on their project, including assistance with teamwork and engineering technical activities. Most student time for this course (i.e., eight or more hours each week) should be spent working alone and with team members to conceive of and develop an engineering design concept.

ENGR 4010 and 4020 are 3 credit hour courses at UVA. Students should understand that the U.S. federal government mandates a certain *minimum* student workload for each credit hour earned while in college. By the federal definition, a credit hour is an amount of work that reasonably approximates *not less than* one hour of classroom or direct faculty instruction and a minimum of two hours of out of class student work each week for approximately fifteen weeks for one semester hour of credit, or the equivalent amount of work over a different amount of time.

In ENGR 4010 and 4020, students are expected to average a *minimum* of nine hours per week (both in and outside of class) for all fifteen weeks of the semester on assignments and activities associated with this course. Students who spend less than the minimum should have no expectation of passing the course.

Use of email

Your instructor will seek to minimize the number of course related messages sent to you by email. Still, email messages to the class, to teams, or to individual students will be necessary from time-to-time. Your instructor expects that you will check your university email account at least one time each day, Monday – Friday during the semester. If an email includes a specific request for a response, it is your instructor’s expectation that you will respond in no more than two business days from the time that the email was *sent* to you (not from the time that you read the email). Failure to read and respond to emails from your instructor in a timely manner (as defined above) will have a negative impact upon your participation and collaboration grade.

Appendix A

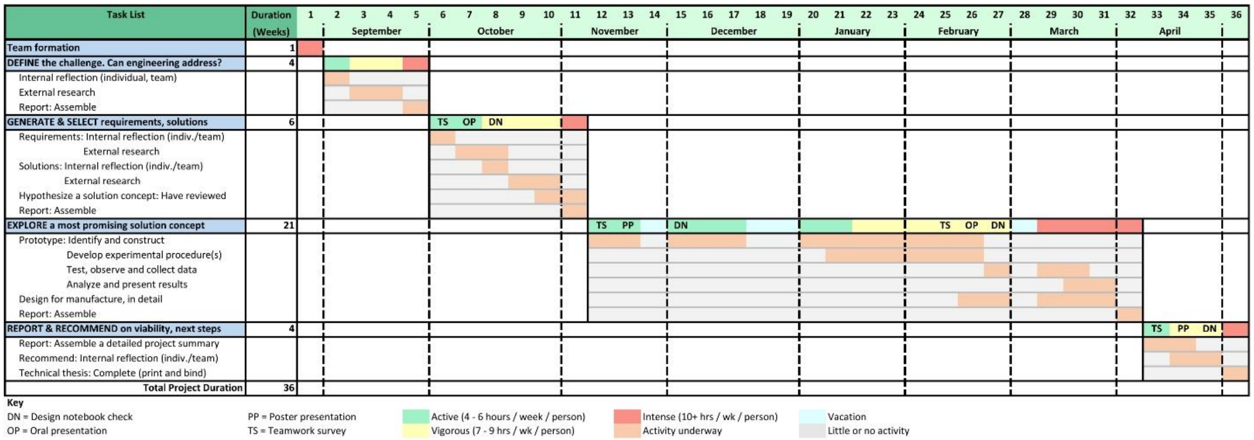

Figure A: This Gantt chart illustrates the expected timeline of activity in ENGR 4010 / 4020.

The following pages provide the grading rubrics used to assess the four major team assignments of ENGR 4010 / 4020.

DEFINE

Define, a challenge that engineering can reasonably be expected to address: The challenge is clearly and objectively identified and defined with considerable depth, and it is well elaborated with specific detail; the justification of the challenge highlights the concerns of many primary stakeholders and is based on comprehensive, timely, and reliably credible sources; it offers consistently objective detail from which it should be possible to determine multiple, measurable design requirements.

Did you offer: (1 Poor to 5 Excellent)

- A clear and concise challenge definition that offers cause and effect phrasing and includes quantitative data and / or statistics about the magnitude of the challenge?
- Sufficient and timely evidence supporting your assertion that the challenge identified is indeed worth addressing? Does the benefit of a possible solution justify the effort that will be required to bring a solution to fruition, as weighed against the magnitude of the need?
- A researched and documented determination of what any solution to the challenge should be able to do? Have you positioned yourself to state measurable design requirements, i.e., metrics?
- Evidence of why you chose the reference sources that you did and why you consider those references to be credible and significant?
- Information from a broad range of reference sources, including stakeholder interviews, library accessible references, and selected, high quality internet results?

GENERATE & SELECT

Generate, requirements: Design requirements are listed and prioritized, and they are consistently clear and detailed; these design requirements are consistently measurable. Designs that fulfill the articulated requirements should lead to a tangible and viable solution to the identified challenge. The requirements embody the needs of many if not all primary stakeholder groups.

Did you offer: (1 Poor to 5 Excellent)

- Prioritized design requirements that are objective, measurable, and clearly defined with acceptable and ideal values?
- Evidence that the defined design requirements are likely to lead to a tangible and viable solution?
- Evidence that the defined design requirements have the prospect of satisfying many if not all primary stakeholders?
- Metrics with numbers that have some underlying basis rather than completely unsubstantiated guesses about what functionality, cost, or human value needs to be satisfied in a viable solution?

Generate, solution concepts: The process for generating and comparing possible solutions was comprehensive, iterative, and consistently defensible; it demonstrated methodical creativity, and it positioned the designers to make a viable and well-justified selection decision. Prior engineered solutions by others have been researched and critiqued in the report. Analysis of the solutions of others, including strengths and weaknesses, is consistently clear, detailed, and supported by relevant data.

Did you offer: (1 Poor to 5 Excellent)

- Evidence of a defensible process by which multiple design solutions were identified?
- Evidence of a systematic and thoroughly documented search to identify and present all plausible prior solution attempts to address the challenge?
- Evidence and explanation of why prior solution attempts were or were not effective? Was some of this explanation based upon stakeholder input to your review?
- Documentation that your search and analysis came from a wide array of clearly identified and consistently credible sources?

Select, key requirements and a most promising solution concept: The design selection process showed close attention to key requirements; the plan of action has considerable merit and would support repetition and testing for effectiveness by others.

Did you offer: (1 Poor to 5 Excellent)

- Evidence of a defensible process by which multiple design solutions were organized and narrowed down to a list of most promising solution concepts?
- Evidence that the most promising concepts were numerically evaluated against a prioritized list of design requirements?

Review, the selected solution concept: The proposed design solution does not obviously violate science, technology, engineering, or math (STEM) principles and practices; there is evidence that the application of STEM principles and practices to the proposed solution has been discussed with and reviewed by one or more subject matter experts and that those reviews either confirmed the soundness of the proposed solution or motivated appropriate corrective, iterative review of the design selection decision.

Did you offer: (1 Poor to 5 Excellent)

- Evidence that design decisions were informed ones, based on sound STEM principles and / or basic calculations? Design selection decisions were not purely best guesses.
- Evidence that your solution selection process was discussed with and reviewed by an expert possessing reasonable competence in one or more relevant STEM disciplines?

EXPLORE

Identify and construct prototypes: Prototypes have been introduced, placed in a context of STEM principles, planned, clearly and fully explained in text and drawings, and constructed with enough detail to assure that useful, objective data on high priority design requirement(s) can be collected; important solution attributes that need evaluation are accurately built into prototypes.

Did you offer: (1 Poor to 5 Excellent)

- Sufficient background commentary to understand the STEM foundations of your efforts?
- A clear, comprehensive description of final prototype design(s)? Could others reproduce your work based on the information given in your report?
- Evidence of how the prototype design(s) will make possible valid, rigorous testing and / or mathematical modeling that can be confidently compared against measurable design requirements? Assertions of rigor could be supported by reference to testing standards and to accepted scientific concepts found in the literature.
- A summary of prototype review, as given by one or more subject matter experts?

Develop experimental procedures: The prototype testing plan addresses one or more high priority design requirements by effectively describing the conduct of tests (physical and / or mathematical modeling) intended to generate data useful for evaluation of solution concept viability; the testing plan is logical and well-developed; if relevant testing standards are available in the literature, they have been followed; the testing form and plan have been confirmed by one or more subject matter experts as likely to yield objective data regarding the effectiveness of the design.

Did you offer: (1 Poor to 5 Excellent)

- Easy to read, step-by-step testing procedure(s)?
- Evidence that the plan focuses on gaining objective and measurable testing data for evaluating design concept viability against one or more of highest priority requirements?
- Evidence that technically-competent subject matter experts agree with your prototyping efforts?

Test, observe, and collect data; analyze and present results: Through the conduct of tests of high priority requirements, the design team demonstrates an understanding of testing procedures, including the gathering and analysis of resultant data. The analysis of the effectiveness with which the design meets stated goals includes a consistently detailed explanation of the data from each portion of the testing; the testing activity is generously supported by pictures, graphs, charts and other visuals; the analysis includes an overall summary of the implications of all collected data relative to a decision to proceed with the design and address the challenge.

Did you offer: (1 Poor to 5 Excellent)

- Evidence of testing procedure understanding, including:
    - The gathering, presentation, and analysis of data.
    - Pictures, graphs, charts and other visuals to provide a complete record of testing.
    - Evaluation of the extent to which the qualitative data collected allows assessment of design requirements.
    - A summary discussion of the broader implications of the data.
- Evidence that one or more subject matter experts reviewed and provided feedback?

Design for manufacture: The selected solution concept has been presented and described clearly and in detail – in text and images; perspective and engineering drawings convey understanding about the dimensions of physical solutions; software wireframes, code and / or wiring diagrams define digital design elements; text, flowchart, and step-by-step operation instructions convey the understanding necessary to move the design towards production. If appropriate, decision trees have been completely constructed.

Did you offer: (1 Poor to 5 Excellent)

- A verbal description of your design that allows others to understand its purpose and essential design features?
- A comprehensive set of drawings of your physical design solution that would enable fabrication?
- A complete copy of software wireframes, wiring diagrams, or computer code developed for the design solution?
- Instructions (and decision trees) that allow others to implement your design solution?

REPORT & RECOMMEND

Assemble a detailed project summary: The report is delivered in a highly professional manner. Its language and visual materials are appropriate for an executive team that expects to see a quality presentation and desires to understand and pass judgment after quick, high-level review. The project's testing and results were succinctly presented; relevant extra-functional considerations (e.g. cost, values) were considered in addition to core functional requirements; all were commented upon;

Did you offer:

- A compelling explanation for why this challenge space is significant?
- A structured, believable generate and select process?
- A well-illustrated, cleanly articulated description of the solution that you developed and explored throughout the course?
- A project summary that shows a command and use of science, technology, engineering, and math principles to design, develop, and analyze your solution concept?

Recommend, next steps: The report provides an easily identified judgment about design viability – the capacity of the proposed solution to address the challenge. The judgment is clearly stated and supported with credible evidence. The project designers included consistently detailed and salient recommendations regarding the conduct of the same or similar projects in the future; recommendations include caveats as warranted and specific ways the project could be improved with consistently detailed plans for the implementation of those improvements.

Did you offer:

- A succinct design viability statement?
- A prioritized list of obstacles to transitioning the solution design into actual use, supported by a subject matter expert review?
- Evidence that the obstacles can be addressed in a realistic and sustainable way when recommending to move forward.
- Is the judgment supported by a subject matter expert review?
- Recommendations regarding the conduct of the same or similar project in the future should someone choose to repeat or continue your work?
- Recommendations on how the project could be improved with consistently detailed plans for the implementation of those improvements?

Appendix: The designers provided consistently clear, insightful, and comprehensive reflection upon each step in the design process as undertaken during the year; the reflection(s) included a substantive summary of lessons learned that would be clearly useful to others attempting the same or similar projects.

Did you offer:

- Comments about the utility of the different steps in the engineering design process?
- Prioritized recommendations to others redoing this project where you would suggest more focus and effort?
- Justification for why these recommendations might have led to a better result?