

Work in Progress: Merging Departmental Capstone Courses into a Single College-Wide Course

Dr. David R. Mikesell, Ohio Northern University

David R. Mikesell is an associate professor of mechanical engineering at Ohio Northern University. His research interests are in land vehicle dynamics, autonomous vehicles, and robotics. He joined the faculty in 2007 after work in automotive engineering at Ohio State (PhD 2008), six years designing automated assembly machines and metal-cutting tools for Grob Systems, and four years' service as an officer in the U.S. Navy. He holds bachelor degrees in German (Duke 1990) and Mechanical Engineering (ONU 1997).

Dr. John-David S. Yoder, Ohio Northern University

John-David Yoder is Professor and Chair of the mechanical engineering at Ohio Northern University, Ada, OH. He has previously served as Proposal Engineer and Proposal Engineering Supervisor at Grob System, Inc. and Software Engineer at Shaum Manufacturing, Inc. He has held a number of leadership and advisory positions in various entrepreneurial ventures. He is currently a KEEN (Kern Entrepreneurial Education Network) Fellow, and has served as a Faculty Fellow at the Jet Propulsion Laboratory, Pasadena, CA and an Invited Professor at INRIA Rhone-Alpes, Monbonnot, France. Research interests include computer vision, mobile robotics, intelligent vehicles, entrepreneurship, and education. He has served in leadership positions in the Mechanical Engineering Division of ASEE, and serves on multiples ASEE ad-hoc committees.

Dr. John K. Estell, Ohio Northern University

Dr. John K Estell is Professor of Computer Engineering and Computer Science at Ohio Northern University, providing instruction primarily in the areas of introductory computer programming and first-year engineering. He has been on the faculty of the Electrical & Computer Engineering and Computer Science Department since 2001, and served as department chair from 2001-2010. He received a B.S.C.S.E. degree from The University of Toledo and the M.S. and Ph.D. degrees in Computer Science from the University of Illinois at Urbana-Champaign. Dr. Estell is a Fellow of ASEE, a Senior Member of IEEE, and a member of ACM, Tau Beta Pi, Eta Kappa Nu, Phi Kappa Phi, and Upsilon Pi Epsilon.

Dr. Estell is active in the assessment community with his work in streamlining and standardizing the outcomes assessment process, and has been an invited presenter at the ABET Symposium. He is also active within the engineering education community, having served ASEE as an officer in the Computers in Education and First-Year Programs Divisions; he and his co-authors have received multiple Best Paper awards at the ASEE Annual Conference. His current research includes examining the nature of constraints in engineering design and providing service learning opportunities for first-year programming students through various K-12 educational activities. Dr. Estell is a Member-at-Large of the Executive Committee for the Computing Accreditation Commission of ABET, and also serves as a program evaluator for the Engineering Accreditation Commission. He is also a founding member and serves as Vice President of The Pledge of the Computing Professional, an organization dedicated to the promotion of ethics in the computing professions through a standardized rite-of-passage ceremony.

Dr. Ahmed Abdel-Mohti P.E., Ohio Northern University

Dr. Firas Hassan, Ohio Northern University

Firas Hassan is an associate professor at Ohio Northern University. He got his Ph.D. from The university of Akron. His research interest are in the area of embedded computing of real-time image processing techniques.

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Abstract

All three engineering departments at Ohio Northern University, a small, private comprehensive university, have long required that students complete a capstone design project. Until this year, however, each department managed the course independently, resulting in substantial variation in requirements, course outcomes, schedules, and expectations. Over the past ten years, the college, which comprises a total of six majors, has increased the number of multi-disciplinary projects to better reflect the environment in which most engineers will ultimately be employed. Involving students and advisors from multiple departments on the same project, though, often resulted in uncertainty from the varied course schedules and expectations.

In the spring of 2016, the college faculty voted to create one college-wide capstone course to replace the departmental courses. This course governs only the project-based portion of capstone design; each department still retains complementary senior-level lecture-based courses tailored to its discipline that cover project management and design process topics. The 2016-17 academic year is the first offering for this new course. The goals, structure, and grading of the course are discussed, as well as challenges to its implementation. Those faculty who have advised multidisciplinary capstone teams in the past are already appreciating the new structure. For some others, the new course represents a significant departure from past routine and course content, and further work is required to better accommodate the interests of all departments.

Introduction

The context of this paper is Ohio Northern University, a small private undergraduate institution in the Midwest U.S. The ONU College of Engineering houses roughly 450 students in five majors residing in three departments. Mechanical (ME) and civil engineering (CEE) are both one-major departments, while electrical engineering, computer engineering, and computer science majors compose the ECCS Department. A sixth major, engineering education (EngEd), is housed within the college but is not part of any department. There is no graduate program in the college.

The senior design project, or capstone, has been a required part of each engineering major since the 1980s. Each department developed its course independently, and they remained independent until combined for the 2016-17 academic year. So long as each capstone project was contained entirely within one department, the separate capstone courses served their purpose well. But in 2004, the college began to experiment with multidisciplinary capstone projects.¹ Since then, the proportion of projects involving multiple engineering and computer science disciplines has grown to nearly one-third of all projects, though this varies year to year. Joint ME / ECCS projects have been common.² Students of the CEE department have participated in multidisciplinary projects such as the design of a solar array for a partner in Haiti, an alarm

system for snow-loading on a factory roof, and another which culminated in the construction of three 400 kW wind turbines on the west edge of campus.³ Engineering education majors have also been integrated into multidisciplinary capstone projects with students both inside and outside the college.

Interdisciplinary projects have been a growing trend in undergraduate engineering education for some time now.^{4,5} Indeed, the ABET Engineering Accreditation Commission criterion 3(d) specifies that students should demonstrate an ability to function on multidisciplinary teams.⁶ Engineers and computer scientists quite often work in multidisciplinary teams,^{7,8} thus it is proper that undergraduate education should model this environment whenever possible.

Yet the department-specific capstone structure set unnecessary hurdles in the path of students on multidisciplinary projects. Each course had its own schedule and set of requirements. A faculty member sometimes advised two different teams running on two different syllabi, leading to misinformation given to students as well as frustration on the part of the advisor. Students on a multidisciplinary project running on the rules from another department would hear deadlines announced in class that did not apply to them, and would likewise be surprised by other deadlines that were only announced to their teammates in another department. The number of credit hours assigned to the experiential capstone course also varied by department, so teammates were often receiving different credit for the same project. Such challenges are typical for multidisciplinary team efforts and have also been documented by others.^{9,10,11}

Courses exist at other universities to support multidisciplinary capstone efforts, but no analog was readily found of a single college-wide, two-semester capstone course which is the default option for all students in a multiple-department engineering school. A number of universities include an optional multidisciplinary capstone experience, such as The Ohio State University,¹² University of Florida,^{13,14} Carnegie Mellon,¹⁵ and Cal. Polytechnic SLO,¹⁶ but list a department- or major-specific course as the standard capstone experience. Marquette University has a one-semester Senior Design Project course cross-listed in four departments (e.g. BIEN 4998¹⁷), though projects are still primarily identified with a particular discipline.¹⁸ The Colorado School of Mines (CSM) originally piloted a multidisciplinary capstone option in the early 1990s which spanned eight engineering disciplines.¹⁹ CSM now lists a common two-semester capstone course for all civil, electrical, environmental, and mechanical engineering undergrads,²⁰ which covers four of the eleven engineering majors offered. This is the most similar to the new course at ONU, except that the CSM course does not include computer engineering or computer science majors.

Goals and Challenges

The initiative to harmonize the capstone experience through a single college-wide course began in earnest in 2015-16, when an ad hoc committee represented by one member of each department met to work out a proposed framework for the new course. The goal was to create a single course to unify the project portion of the capstone design experience. This two-semester course sequence would enroll all students with senior standing in the college, synchronizing the number of credit hours in each course, outcomes, deliverables, grading, and schedule. The efforts of this committee and further detail of the prior state of departmental capstone and design courses can

be found in the referenced paper.²¹ (It should be noted that each department retained discipline-specific courses to cover project management skills, engineering economics, and the process of design.)

The general framework created by the ad hoc committee was passed to a single faculty member to act as the course administrator. This administrator, or Capstone Coordinator, worked with departmental representatives to create a syllabus, schedule, and assessment tools and methods for the course. Negotiation was required to reach agreement on common objectives, language, grading, content of student reports, and presentations. The biggest challenge in this phase was to reconcile the course schedule and requirements to accommodate two different types of projects: those in which a prototype is created, and those which culminate in a detailed design where a prototype is not feasible (generally due to the scale or cost of the project).

The capstone processes for the ME and ECCS departments were focused around the design and construction of a prototype. This was most often a physical prototype, but also included coding projects and website designs. The fall semester project goal was the prototype design and purchase of required prototype components. Spring semester was spent building and testing the prototype, redesigning as required.

Civil engineering capstone projects, by contrast, rarely involve the construction of a prototype, but are rather focused on creating a detailed design and engineering drawings with an accurate cost estimate for a construction firm to implement. Rather than design in the fall and build in the spring, the various phases of the design process are spread over two semesters. Civil engineering projects are also much more driven by regulatory and professional design codes.

Due to this dichotomy, the Capstone Committee was unable to generate a single, completely unified set of report and presentation topics for all teams. On some items, separate provisions are specified for prototype-generation projects and engineering system projects. See the syllabus in the Appendix for examples, particularly “Report templates.”

New Course Details

The new two-course sequence, entitled Capstone Design Experience 1 and 2, represents the experiential portion of the capstone design course which is common to all majors in the college. The fall semester course is one credit hour, and the spring course is two credit hours. The entire syllabus for the year-long course is provided in the Appendix, showing the list of course objectives and full details of the course structure and administration.

There is no uniform scheduled meeting time for either course. Teams are required to meet weekly with their faculty advisor to report their progress. Teams must also schedule their own meeting times to work on the project. With no common meeting time, all communication with the approximately 100 students must be done through the learning management system (Moodle) and email. The course coordinator has attempted to communicate as much information as possible through the detailed syllabus.

Capstone projects come from various sources, including corporate, government, or private sponsors, faculty, students, and external competitions. There is no project fee for capstone projects; external corporate or private project sponsors must only pay for any components purchased specifically for the project. Projects are identified in the spring semester, and juniors are assigned to project-specific teams before they leave for the summer.

All faculty in the college advise one or two capstone teams. This is and has long been part of the standard faculty load for engineering and computer science faculty. Multidisciplinary teams generally have one faculty advisor from each represented department. The Capstone Coordinator is currently a college faculty member receiving one course release per year for the duty. Once the course is well-defined, this role may be transferred to an administrative position.

The Capstone Coordinator and the faculty advisor(s) share access to a common gradebook, one for each team. The coordinator enters some data which is collected centrally from peer evaluations or presentation reviewers, and the advisor enters grades for other items such as report grades and the completion of team objectives. The grading breakdown is fundamentally the same for both semesters. The following four categories are assigned equal weight for grading: objectives completed, peer and advisor ratings, presentations, and documentation.

Objectives Completed: In the fall, students are graded on whether they have completed their design objectives and how well they have adhered to their own project schedule. Prototype project teams must also order their parts before leaving for break. In the spring, advisors score their teams in this category according to how well they have completed the project, whether prototype or system design.

Peer and Advisor Ratings: Students rate themselves and their peers' performance twice each semester using the standard CATME (Comprehensive Assessment of Team Member Effectiveness) instrument.²² The Capstone Coordinator converts these numerical results into a percentage score for each student. These scores are then combined with an advisor-assigned rating for each team member to complete the score for this category.

Presentations: A total of seven presentations are required of capstone students. Three of these, two in the fall and one in the spring, are "Project Review Boards" (PRB).^{23,24} These are informal, 30-minute sessions, modeled after the review practice at an industrial partner firm, in which the team presents its progress by addressing a list of topics specified for that PRB in the syllabus. The board is composed of 3-5 engineering faculty, often joined by college alumni, representatives from local professional societies, and project sponsors. The purpose of the PRB is to provide critical feedback, suggestions, and guidance for the teams with the goal of improving project quality. Board members evaluate the team's progress and presentation according to a concise rubric, and these rubric scores are compiled and converted into a percentage score by the Capstone Coordinator.

Four other presentations are required in the spring. The Design Showcase is an opportunity for all teams to present their poster and prototype (as applicable) in a public forum in the campus student union. Representatives from each department's external advisory board judge these presentations. Teams give another poster presentation to the dean's Engineering Advisory

Board, as well as a formal project presentation to their entire home department faculty and other capstone teams.

Students are also required to present their project to an audience outside the university. Often this is satisfied by presenting to the project sponsor. If the project is internally-sponsored, the team must find another appropriate audience such as a regional ASEE or IEEE conference.

Documentation: A project proposal is developed during the fall semester. An initial proposal is due mid-semester, comprising several major portions of the final report. The final proposal is due at the end of fall semester. The final report summarizes the project in the spring. Details of all these reports are in the syllabus.

An electronic archive including all of the team's reports, PowerPoint files, drawings, videos, and poster files must be turned in at the end of spring semester. Some advisors, reflecting prior practice on the department capstone course, add a documentation requirement such as the creation of a project website (ECCS). The advisor-generated documentation grade is based on all of these items plus the timely completion of weekly email reports and the project notebook.

Results

As a work in progress, this course is still in transition, but the fundamental goal has been achieved. Multidisciplinary groups – indeed all groups – now have a common schedule and a common set of requirements.

The new process represents a relatively minor adjustment for the ME and ECCS departments, but a major one for the CEE department. In fact, the ME and ECCS department chairs had already worked for several years to synchronize their schedules and, to some extent, team deliverables.² The CEE department did not formerly assign projects until the fall semester; now this schedule is pushed to the spring of the junior year. The one-hour CEE Design Seminar course has been temporarily suspended to make space in the curriculum for the new experiential course in the fall (due to a credit hour cap). Thus, until a curriculum revision can again make space for this course, fall semester instruction on the design process falls to the individual faculty advisors.

Another result of the unified capstone experience is that a more-uniform language and design process is possible throughout the college curriculum. There are many ongoing efforts at ONU and elsewhere in engineering education to reinforce the design process throughout the curriculum. Consistent expectations in capstone can help make this easier in earlier courses, witnessed by a recent discussion initiated by the coordinators of the Introduction to Engineering first-year courses common to all engineering majors.²⁵

These coordinators were concerned that the concepts of project “constraints” and “criteria” taught in the Intro class were not consistent with how the terms were being applied in capstone.

A CEE faculty member was further concerned that the term “criteria” was now used in that discipline in two entirely different and conflicting ways – one for the regulatory codes to which all designs *must* adhere, and one for a set of metrics by which different designs may be evaluated against one another. Representatives from all departments agreed on a consistent definition of “constraints” and replaced the word criteria with “evaluation metrics,” both terms and concepts which can now be uniform throughout the college.

Several challenges remain. Further reconciliation of the course documents is necessary to meet the needs of both prototype and system design projects. Rubrics must be generated to ensure consistent evaluation of teams’ written reports by faculty advisors. There must also be an accountability mechanism created for the individual advisors. The online student course evaluation questions are not well-suited for a project course, and all of the feedback comes back to the coordinator. Comments meant for a particular advisor are often not accompanied by the advisor’s name, and are thus ineffective. The coordinator and Capstone Committee must also work to educate faculty on the new capstone expectations, and should generate grading rubrics to ensure consistent evaluation of written reports by the faculty advisors.

Communication is always a challenge, especially during the transition to the new course format. Since this project course has no common meeting time, students must pay attention to the requirements outlined in the syllabus and the reminder emails from the course coordinator. Twenty-four different faculty advise the teams, and many of them are not yet familiar with the details in the 13-page syllabus. The Capstone Coordinator makes some announcements in the college faculty meeting, and copies advisors on all capstone-related emails, but it is not uncommon for the students to be more familiar with the schedule or requirements than their advisors.

In the first year under the new format, five out of 26 projects have members from multiple departments. This is one fewer than the previous year, but this is chiefly attributed to the relatively low enrollment in the electrical and computer engineering majors in these classes. A number of electrical-, electronic-, or programming-intensive projects have recently been completed by teams with only mechanical engineers, though these students were begging for (and sometimes paying for) help from their ECCS colleagues. It is anticipated that the rebounding enrollment in the ECCS disciplines will enable more of these projects to benefit from a multidisciplinary team. The common course will certainly facilitate increased collaboration with the civil engineering students, also; two joint CEE/ME projects are already proposed for next year.

Conclusions

The implementation of multidisciplinary capstone projects at ONU was hindered by the varying schedules and requirements of the separate departmental capstone courses. College faculty voted unanimously to drop these disparate courses in favor of a single course to govern the project-based portion of capstone design. The new course was created, enrolling 100 students in its first offering this year.

Now in the first year under the new format, five out of 26 projects have members from multiple departments. This is lower than some years in the past, but due only to a recent lower number of ECCS seniors to share with other departments. The multidisciplinary teams have enjoyed a consistent set of requirements which were more or less clear from the beginning of the year. Some work remains for the college Capstone Committee, helping departments adjust to the new system and further reconciling the requirements and arbitrating the expectations of college faculty.

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Appendix

ENGR 4011/4021 CAPSTONE DESIGN EXPERIENCE 2016-2017

- Coordinator:** Dr. David Mikesell d-mikesell@onu.edu x2386
- Meetings:** Time and place as arranged with team advisor.
- Course description:** Continuation of the experiential portion of the capstone design that is common to all majors in the college. Student teams demonstrate project management skills through use of effective communication techniques, including advisor/client meetings and written progress updates, oral presentations, and written reports. 2 hours.
- Prerequisite:** For ENGR 4011: Senior standing in the College of Engineering.
For ENGR 4021: ENGR 4011.
- Course outcomes:** Upon completion of this course, the student are expected to demonstrate:
1. an ability to apply knowledge of mathematics and science, and of their respective discipline.
 2. an ability to design a component, process, program, or system to meet desired needs within appropriate constraints.
 3. an ability to effectively function on teams where individual members focus on different aspects of a project.
 4. an ability to communicate effectively.
 5. an ability to use current techniques, skills, and discipline-specific tools necessary for practice within one's discipline.

Grading:

Fall semester

25%	Objectives completed	Project progress compared to objectives & schedule.
25%	Peer and advisor ratings	
25%	Presentations	PRB 1, PRB 2
25%	Documentation	Weekly email reports, Initial Proposal, Final Proposal, notebook.

Spring semester

25%	Objectives completed	Project completion, including testing and redesign as applicable.
25%	Peer and advisor ratings	
25%	Presentations	PRB 3, Design Showcase, Poster Presentation, Formal Presentation.
25%	Documentation	Weekly email reports, project notebook, Final Report, documentation CD.

A	90-100%	Excellent	D	60-69%	Poor
B	80-89%	Good	F	<60%	Failure
C	70-79%	Satisfactory			

Notes:

- Faculty are serving as advisors, not managers, and are not responsible for the success or failure of the project.
- Throughout this document, an asterisk* will be used to denote those items which should be completed if they are appropriate to your project. Consult with your advisor if in doubt.
- Assignments are not accepted after the due dates listed below.
- Failing to meet any milestone written in bold on the schedule below list will result in the reduction of one letter grade.
- Students are responsible for ensuring that their project is compatible with ABET requirements and to document it as such. ABET requires "an 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.”¹

- In addition, students must demonstrate that they have followed a standard problem-solving methodology. The following 5-step approach is recommended:²

1. Define the problem	2. Gather information	3. Generate alternatives
4. Evaluate alternatives	5. Communicate the results	

Fall Schedule:

Due Date	Assignments
8/26, Fri	Arrange a weekly meeting time with your faculty consultant/advisor(s). Identify an initial team leader and a budget manager (as appropriate).
9/30, Fri	-Submit Initial Proposal to advisor <i>and</i> upload to Moodle. See Appendix 6 for details. Provide a one-page executive summary to each member of your Review Board. -Complete the online Peer Evaluation.
10/6, Thu	Project Review Board (PRB) 1. See Appendix 5 for details.
11/11, Fri	-Submit Final Proposal to advisor <i>and</i> upload to Moodle. See Appendix 6 for details. -Provide a one-page executive summary to each member of your Review Board. -Complete the online Peer Evaluation. -Identify a suitable external audience for your project.
11/17, Thu	Project Review Board (PRB) 2. See Appendix 5 for details.
12/9, Fri	All major components and materials must be ordered.

Spring schedule:

Due Date	Assignments
1/20, Fri	Arrange a weekly meeting time with your faculty consultant/advisor(s).
2/16, Thu	Project Review Board (PRB) 3. See Appendix 5 for details. Provide a one-page executive summary to each member of your Review Board at least 24 hrs in advance.
2/17, Fri	-Submit draft of <i>Testing and Refinement</i> section of Final Report to advisor <i>and</i> upload to Moodle. See Appendix 6 for details. -Complete the online Peer Evaluation.
2/24, Fri	Submit draft project poster design to advisor. See Moodle for a template PPT file.
4/18, Tue	Deadline for submitting poster file to Mr. Hummel to be printed.
4/25, Tue	Design Showcase. Schedule & location TBA. Display poster and design or prototype demonstration to external judges.
4/28, Fri	-Submit a draft of the Final Report to advisor. See Appendix 6 for details. -Complete the online Peer Evaluation. -For externally-sponsored projects, demonstrate the prototype to your sponsor before the end of finals week.
<various>	Formal Presentation. See Appendix 5 for details.
5/5, Fri	-Poster Presentation to College of Engineering Advisory Board. Time TBA. -Submit the final version of the Final Report. -Return all tools and other borrowed equipment and clean up your workspaces. -Submit a finalized list of project expenditures. -Submit the documentation CD as described in Appendix 6.

¹ “Criteria for Accrediting Engineering Programs,” <http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2016-2017/>. Accessed 8/13/16.

² Dieter, *Engineering Design: A Materials and Processing Approach*, 5th ed. McGraw Hill, 2013.

Other student responsibilities:

- Teams must maintain a *project notebook*, and students must bring this notebook to each weekly meeting. These will be kept by your advisor at the end of the year.
- Submit *weekly email reports* to advisor as described in Appendix 1.
- Student work groups must keep their work areas clean. Tools and parts should be put away when not in use. Work areas are expected to be left in the same (or better) condition as they were found in the fall.
- Each student group must present its work to an external audience such as a conference, competition, or external project sponsor. The specific venue must be approved by the advisor. Participation in a competition only satisfies this requirement if the competition occurs before graduation and includes an oral report.
- All part drawings must be professional. This requires a title block and all views and dimensions required to create the part. All components not purchased as standard parts should have engineering drawings.
- It is the students' responsibility to allow sufficient time for ordering of parts. See Appendix 3 for purchasing procedures.

Academic honesty:

The University expects its students to conduct themselves in a dignified and honorable manner as mature members of the academic community and assumes that individually and collectively they will discourage acts of academic dishonesty. The University also expects cooperation among administrators, faculty, staff, and students in preventing acts of academic dishonesty, in detecting such acts, reporting them, and identifying those who commit them, and in providing appropriate punishment for offenders. The University Code of Academic Student Conduct is found in Appendix C of the Student Handbook:

http://www.onu.edu/student_life/student_conduct/student_handbook

Special accommodations policy:

Students requiring particular accommodations because of physical and/or learning disabilities should contact their Dean's office prior to or during the first week of classes. For additional information, see:

http://www.onu.edu/student_life/disability_services

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Appendix 1: Description of weekly email reports.

Weekly email updates are due to the faculty advisor by 4pm the day before your weekly meeting. An electronic template for this report will be provided. These reports shall include the following information:

- Date and time.
- 'To do' list from previous meeting.
- List of activities and accomplishments for that week for each student.
- Number of hours each team member worked that week and to-date for the term.
- Approximate overall percentage complete, for the term and for the overall project.
- Any problems encountered, along with steps being taken to address those problems.
- Compare current progress and initial Gantt chart. Explain any delays and describe the proposed solution to get back on schedule. Update Gantt chart as needed.
- Description of what will be done by each group member before the next meeting.
- Agenda for weekly meeting with faculty advisor, including time and place of next meeting.

Reports should use the template shown below, provided on Moodle under "Reference Templates and Documents."

Weekly Email Report
Project Title

Date/Time: **Date and time of meeting**
Location: **Location of meeting**

Budget and Expenditures

Total Allocated	Total Remaining

Number of Hours Worked per Person

Name	Past Week	Current Semester	Year-to-Date
Name 1			
Name 2			
Name 3			
Name 4			

Overall Progress ___ Behind ___ On Schedule ___ Ahead

Estimated Completion of Objectives
Semester: **XX%** **Overall:** **YY%**

Activities and Accomplishments of Previous Week

- Name 1:
- Name 2:
- Name 3:
- Name 4:
- All:

Problems Encountered with Proposed Countermeasures

-

Description of Activities to be Performed by Each Student during the Next Week

- Name 1:
- Name 2:
- Name 3:
- Name 4:
- All:

Agenda for Weekly Meeting

-

Appendix 2: Description of the project notebook.

The project notebook is the evidence of your work. Each group should keep a 3-ring binder or electronic notebook (at the discretion of your advisor) for this purpose. Regardless of the format chosen, the notebook *must* be (1) organized into the sections listed below (plus any others deemed relevant) and (2) easily transferrable to the advisor and/or client. Advisors may collect and grade the notebook at any meeting. Notebooks will be graded based on neatness and completeness.

- **Schedules:** Current Gantt chart along with any updates.
- **Minutes:** Keep a chronological record of all meetings, including...
 - Date and time
 - Attendees
 - Summary
 - What will be done by next meeting, by whom
 - Time & location of next meeting
- **Drawings and Code:** All reference sketches, engineering drawings, and computer code.
- **Calculations:** Any necessary calculations.
- **Contacts:** Keep a list of all contacts, with email / phone contact information, along with notes regarding all conversations with that person / company.
- **Purchases*:** Keep the budget and a list of all items purchased. In addition, copies of all purchase orders should be included here.
- **Progress reports:** Keep a copy of all weekly emails, in chronological order.

Appendix 3: Capstone purchasing procedures.

<Not relevant for the paper.>

Appendix 4: Regulations for capstone workspaces

<Not relevant for the paper.>

Appendix 5: Project Review Board and Final Presentation

Project Review Board

The goal of these project review presentations is to provide your team with critical feedback to improve your project. Your team should prepare a presentation lasting only 10-15 minutes of the half-hour allotted time. You should expect to be interrupted with questions or suggestions during the presentation.

The board to whom you present will generally consist of the same members each time. They may be engineering faculty, your project client, and/or engineering alumni and regional professional society members. Other students will not be invited to observe or participate.

The questions for the various PRBs are provided below. Dress is business casual. All team members must take part in the presentation.

In addition to the questions below, the overall effectiveness of the presentation will be rated. An effective presentation includes, among other factors, the following:

- Engaging presentation style, well-paced and well-delivered
- Well-organized
- Slide text and figures are clear, properly formatted figures and tables

Rubrics detailing how board members will evaluate your presentation are available on Moodle.

PRB 1 (Fall)

1. Why is the project important?
2. What are the Constraints and are they justified?
3. What are the Evaluation Metrics and are they justified?
4. What is the competition / state of the art?
5. What are the different designs that were considered?
6. What design was chosen, and why?
7. What is the estimated capstone budget and why is it justified? (Cost to complete capstone, not build the dam or highway overpass. This mainly includes prototype components and travel.)
8. Is the tentative project schedule presented? (Project-specific milestones, not just course due dates.)
9. Were appropriate citations and references given?

PRB 2 (Fall)

1. Why is the project important?
2. Is the chosen design clearly described?
3. Are the design decisions convincingly presented?
4. Is the group ready to order parts?*
5. Have cost-saving measures been considered?
6. Were questions answered well (including unanswered questions from the previous PRB)?
7. Is the tentative schedule presented?
8. Were appropriate citations and references given?

PRB 3 (Spring)

Questions for prototype projects

1. Is the chosen design clearly described?
2. Is the design work complete?
3. Have all parts been ordered?
4. Is the prototype or project likely to be complete by April 1?
5. Is the project likely to stay within the capstone budget?
6. Are there serious concerns still to be addressed?
7. Were questions answered well?

Questions for engineering system projects (typically CEE):

1. Is the chosen design clearly described?
2. Is there sufficient progress toward a completed design?
3. Has the team worked on all aspect of the project?
4. Is the complete design (including drawings) likely to be finished by April 15?
5. Has the team finalized their travel plans?
6. Are there serious concerns still to be addressed?
7. Were questions answered well?

Presentation video and reflection

Each team must recruit another student to video record its PRB 3 presentation. After the PRB, each student must (1) watch the PRB recording, (2) evaluate his/her team's performance according to the appropriate PRB rubric, and (3) write a brief ½-1 page reflection on what went well and what they would like to do better the next time. See "Presentation video reflection.pdf" on Moodle (posted by Feb. 3) for more details.

Final Presentation

The final presentation is a formal summary presentation of your project to all departmental faculty, other capstone students, and other guests. Business professional dress is required. All team members should participate in the presentation. **Everyone** is expected to attend **all** of the presentations in their department's session, unless you have made prior arrangements with your faculty advisor. Thus an ME student on an interdisciplinary team presenting in the ECCS session, for instance, must attend the ME capstone presentations.

You will be told in advance how much time you have to present. You will not be interrupted during the presentation unless you exceed your allotted time. Several minutes will be allowed afterward for questions.

Target a general engineering audience, assuming that they know nothing of your project. Define your problem, describe your chosen design, the performance of your prototype*, and the final cost compared to the capstone budget. You may include such things as other designs considered, constraints and evaluation metrics, manufacturing details, obstacles overcome, etc., as time allows and as you think relevant, but do not overwhelm the audience with unnecessary detail. The objective is to summarize the goals, process, and ultimate performance of your project.

Depending on the venue, your group may be sharing a microphone. You should rehearse the order of your presentation, who will be advancing slides, and know when and to whom the microphone should be passed.

Do not bring your prototype or any physical samples or displays. (CEE presenters may bring a set of drawings.) Photos or videos of your project, however, are encouraged. Video playback through PowerPoint is notoriously quirky; you will want to ensure it works in your assigned venue before the presentation.

Appendix 6: Report templates

The Final Report comprises the sections listed below. Fall semester reports (Initial Proposal and Final Proposal) are draft sections of the Final Report. “Draft” here implies that the final details may not yet be certain; the proposal reports are still expected to be well-written, proofread, and thorough.

<p><u>Initial Proposal</u> The first proposal is composed of drafts of the following sections of the Final Report: <i>Problem Definition, Background, Potential Solutions, <u>Appendix – Project Management</u></i>.</p>	<p><u>Final Proposal</u> The final proposal should include drafts of the following sections of the Final Report: <i>Proposed Solution, Implementation, <u>Appendix – Engineering Drawings*</u>, <u>Appendix – Parts List*</u>, as well as a revised version of the Initial Proposal.</i></p>
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[Final Report](#)

[Cover Page](#)

- Includes the project title, team members, advisor(s), date submitted, and executive summary. The executive summary should be a concise yet comprehensive summary of your report. It should fit on the front page with the other information and give an overview of the project motivation and results.

[Table of Contents](#)

[Problem Definition](#)

- Objective: A concise statement of what you are trying to accomplish, including your customer or potential customer base.
- Motivation: What is the value of your project to a potential customer?
- Constraints: What conditions *must* a design satisfy to be a viable solution? You must include at least two of the following ABET-specified constraints: economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- Evaluation Metrics: What factors will be used to evaluate the performance of competing solutions? How will these factors be quantified?

[Background](#)

- Gathered information, including (as relevant)
 - Historical background
 - Applicable engineering standards
 - Competing products
 - Materials to consider
 - Required permits, etc.
- Tools / information you applied from previous courses.

[Potential Solutions](#)

- Descriptions and sketches of at least three viable potential solutions. A “viable” solution is one that satisfies the project constraints.
- Evaluate the alternatives by applying project evaluation metrics.

Proposed Solution and Scope of Work

- Detailed description of your design.
- Include justification for specified dimensions or performance predictions (e.g., explanations, numerical modeling, and calculations).
- Scope of work. See Appendix 7 for an example.

Implementation

- For prototype projects:
 - Describe how the prototype was manufactured.
- For engineering system projects (typically CEE):
 - Analysis and Design
 - Computational analysis required to size the system and/or its components.
 - Design system in accordance with engineering common practices and applicable codes, standards, specifications, guidelines, etc.

Testing and Refinement

- For prototype projects:
 - Describe the tests employed to evaluate the prototype.
 - Did the prototype pass the tests?
 - What redesign was required to improve the prototype or make it satisfy design evaluation metrics?
 - What have you done to respond to client feedback (incl. Design Showcase comments)?
- For engineering system projects (typically CEE):
 - Did your system design satisfy the design constraints?
 - How well does it satisfy the evaluation metrics? How could it better satisfy them?
 - What have you done to respond to client feedback (incl. Design Showcase comments)?

Cost Estimate

- For prototype projects:
 - Evaluate the market potential of your proposed solution. Questions you may consider addressing include the following:
 - What is the potential customer base and sales projections?
 - What modifications would be necessary for mass production?
 - What price point would be needed to make the project profitable?
- For engineering system projects (typically CEE):
 - Tabulate the total system cost including hardware, concrete, labor, heavy equipment usage, as well as a contingency.

Ethical Issues

Describe at least two ethical implications of your project. These could be related to the use or manufacture of the product, the product design, the design process, etc. Relate each issue to a relevant code of ethics, and discuss how the issue was addressed to satisfy the ethical demands of the engineering profession.

Conclusion

Summarize your project. What would you do differently if you were doing it again? What could you have done better?

References

Include a list of all cited references, including standards, design guidelines, figures used, and competitive products referred to. Unless otherwise directed by your advisor, format your citations according to the IEEE Citation Reference available on Moodle.

Appendices

Those listed in bold are required. (Those with asterisk are only required when applicable.)

- **Project Management**
 - Team organization: list members and specific role assignments (team leader rotation, budget manager, etc.).
 - Team schedule, including Gantt chart. Describe how this compared to your initially proposed schedule and what caused any differences.
 - Budget. This concerns expenses to complete the capstone design project, including team travel and any components required to make the prototype. This is not the cost to build the highway overpass or mass produce your widget. *Initial Proposal*: tabulate the project budget request. *Final Report*: Update to reflect all expenses for the project. Describe how this compared to your initial budget in the proposal, and what caused any differences.
- **Engineering Drawings***
 - Fully-dimensioned drawings with appropriate border and title block.
- **Parts List***
 - Provide catalog information for purchased components (manufacturer, model number, price, supplier, etc.)
- Others appendices as needed, such as:
 - Tables or charts that are too large for the main body of the report.
 - Sample calculations.
 - Site investigation boring logs.

Documentation CD/DVD

Provide a CD or DVD with soft copies of documents you have created:

- PowerPoint files for all three PRBs and the Final Presentation
- Video files of prototype demonstration
- Technical drawings/codes/photographs
- Poster
- Final Report
- Any other documents you have created

Label the CD/DVD with your project name and the year. Do not include any proprietary customer drawings or anything that your non-disclosure agreement (if applicable) would prevent you from sharing.

Note: Other documentation, such as a project website, may be required by your advisor.

Appendix 7: Scope of Work – Sample

The goal of this project is to meet the National Park Service’s desire to restore in-stream flows to support Yellowstone Cutthroat Trout spawning within Reese Creek. To achieve our goal, we propose four objectives. The first objective is to develop an automated in-stream flow-monitoring system to support decision-making regarding water rights allocation. The second objective is to design an inlet structure at the uppermost diversion that includes fish and sediment control. The third objective is to evaluate diversion structure removal options and cost. The fourth and final objective is to perform a preliminary cost estimate for a proposed pump system that will provide Yellowstone River water to the irrigator. To successfully meet these objectives, the following tasks and deliverables are proposed:

Objective 1: Develop an automated in-stream flow-monitoring system

- Task 1.1 Establish locations for in-stream monitoring
- Task 1.2 Identify hardware to collect flow measurements
- Task 1.3 Identify hardware to wirelessly transmit collected data
- Task 1.4 Specify a complete system suitable for installation
- Deliverable 1. Report detailing the specs for an automated in-stream flow-monitoring system

Objective 2: Design an inlet structure at the uppermost diversion

- Task 2.1 Identify a location for the inlet structure
- Task 2.2 Design a structure to remove sediment from entering the proposed conveyance
- Task 2.3 Identify a location for a fish control fence
- Task 2.4 Design a fish fence
- Deliverable 2. Report detailing the specifications for an inlet structure at the uppermost diversion, including drawings of the sediment removal structure and fish fence

Objective 3: Evaluate diversion structure removal

- Task 3.1 Identify structures for removal
- Task 3.2 Identify removal options and methods
- Task 3.3 Identify removal costs
- Deliverable 3. Report explaining the process and cost of removing diversion structures

Objective 4: Perform a preliminary cost estimate for a proposed pump system

- Task 4.1 Specify a pump to meet flow requirements
- Task 4.2 Cost out conveyance structure system
- Task 4.3 Cost out excavation for system installation
- Task 4.4 Cost out annual operation & maintenance for the system
- Deliverable 4. Report containing a cost estimate for a proposed pump system

Deliverables not tied to an objective:

- Deliverable 5. Mid-project update presentation
- Deliverable 6. Final project presentation