OAKLAND UNIVERSITY

School of Engineering and Computer Science

Winter 2018

ECE 4999 - Senior Design
ISE 4491 - Senior Design
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ME 4999 - Senior Mechanical Engineering Design Project
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Course (Catalog) Descriptions

ECE 4999 Senior Design (4)
Capstone design projects selected from a wide variety of areas related to electrical and computer engineering. Develops system approach to design: preparation of specifications, scheduling, modeling, simulations, and technological, financial and environmental aspects. Multi-disciplinary teamwork is emphasized. Prototyping, testing and completion of the project are required. Presentation of results required. (Formerly ECE 491). *Satisfies the university general education requirement for a capstone experience. Satisfies the university general education requirement for a writing intensive course in the major. Prerequisite for writing intensive: completion of the university writing foundation requirement*.
Prerequisite(s): for Computer Engineering majors: (ECE 327 or ECE 3100), (ECE 378 or ECE 3710) and (ECE 470 or ECE 4720)

Prerequisite(s): for Electrical Engineering majors: (ECE 423 or ECE 4500) or (ECE 429 or ECE 4610) or (ECE 431 or ECE 4400) or (ECE 437 or ECE 4210) or (ECE 443 or ECE 4410) or (ECE 470 or ECE 4720) or (ECE 485 or ECE 4132)

ISE 4491 Senior Design (4)
Capstone design project selected from manufacturing systems, automotive or industrial systems, instrumentation and measurement, and control systems. Develops system approach to design; preparation of specifications, scheduling, modeling, simulation, and technological, financial environmental aspects. Teamwork is emphasized. *Satisfies the university general education requirement for the capstone experience. Satisfies the university general education requirement for a writing intensive course in the major. Prerequisite for writing intensive: completion of the university writing foundation requirement*. (Formerly ISE 491)
Prerequisite(s): (ISE 318 or ISE 3318), (ISE 330 or 3330), (ISE 341 or ISE 3341) and major standing.
Prerequisite(s) with concurrency: (ISE 483 or ISE 4483) or (ISE 484 or ISE 4484)

ME 4999 Senior Mechanical Engineering Design Project (4)
Multi-disciplinary team experience in engineering design, emphasizing realistic constraints such as safety, economic factors, reliability, aesthetics, ethics and societal impact. Projects will be supervised by engineering faculty. Generally offered fall, winter. *Satisfies the university general education requirement for the capstone experience. Satisfies the university general education requirement for a writing intensive course in the major. Prerequisite for writing intensive: completion of the university writing foundation requirement*. (Formerly ME 492)
Prerequisite(s): (ME 308 or ME 3300), (ME 331 or ME 3500), (ME 361 or ME 3250), (ME 372 or ME 3700) and major standing.

General Education

These classes satisfy the General Education requirements for a Capstone Experience.
The student will demonstrate General Education Learning Outcome:

> *Capstone Experience*
> The student will demonstrate:
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> - appropriate uses of a variety of methods of inquiry and a recognition of ethical considerations that arise
> - the ability to integrate the knowledge learned in general education and its relevance to the student's life and career

The student will integrate knowledge from Natural Science and Technology Knowledge Exploration Area of General Education as well as demonstrate the General Education Cross-Cutting Capacities:

- **Effective communication** - Exhibited through extensive written and oral communication exercises and assignments
- **Critical thinking** - Developing novel and innovative solutions to technological problems
- **Social awareness** - Considering and allowing for multicultural aspects of the global marketplace as technical solutions are sought that are socially responsible and culturally appropriate
- **Information literacy** - Finding, evaluating and utilizing information to assess and develop innovative and creative solutions to technical solutions that are socially responsible and culturally appropriate

Course Objectives

The successful student will demonstrate, and exhibit proficiency in, all of the SECS Engineering Student Outcomes. In particular, students will be required to gather, investigate, evaluate and assess information to successfully achieve a technological solution to an engineering problem, including realistic constraints such as safety, economic factors, reliability, aesthetics, ethical considerations and societal impact. In addition, students will have to draw on their prior knowledge, including and especially that obtained in general education coursework, to develop appropriate, sensitive and successful engineering designs.

The successful student will:

- Demonstrate an ability to apply knowledge of mathematics, science, and engineering
- Demonstrate an ability to design and conduct experiments, as well as to analyze and interpret data
- Demonstrate 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
- Demonstrate an ability to function on multi-disciplinary teams
- Demonstrate an ability to identify, formulate, and solve engineering problems
- Demonstrate an understanding of professional and ethical responsibility
- Demonstrate an ability to communicate effectively
- Demonstrate the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- Demonstrate a recognition of the need for, and an ability to engage in life-long learning
- Demonstrate a knowledge of contemporary issues
- Demonstrate an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Course Procedures

Overview. The course will consist mainly of independent and group student work. Once per week, each group will meet with the instructors at a specified time in the Senior Design Lab (178 EC) to submit individual written progress reports and present an informal progress report. During the semester each student will keep a project notebook. About three weeks into the semester, each group will submit a written design proposal that will present a detailed plan to satisfy all of the aspects of the design challenge. Each group will make two formal oral presentations, one around mid-term and the other at the end of the semester. At the end of the semester, the design groups will take part in a public competition or exposition, and will submit a final written report.

Weekly progress meetings. Each week, each groups will assemble and meet with the instructors to turn in their individual progress reports to their instructor and have their project notebooks examined and signed. The project manager will deliver an informal oral progress report, concentrating on what has been accomplished in the last week; reviewing updates to models and simulations, verification tests and physical systems that have been obtained and/or constructed; and what is planned for the upcoming week. Each student must submit an individual progress report and have his/her design notebook signed each week. HINT: Download the progress report form above, enter your name at the top and the names of all your group members below yours, and print enough copies of the form to get you through the semester.

Design Project Notebooks: Each student must obtain and keep a design project notebook. Notebooks must be sewn-bound (no spiral notebooks) with consecutively numbered pages (you may have to add the page numbers yourself) and may have pages that are blank, ruled or with grids, your choice. You are to record in your notebook *anything and everything associated with your project* - ideas, thoughts, sketches, computer programs, derivations, graphs, data, website URLs, printouts - dated and thoroughly documented. In particular, computer model revisions, data, conclusions of verification tests, and any changes to the design must be documented both when they are considered and when they are implemented. One reason to follow these procedures with any engineering project is in case you decide to pursue patents based on your work. You will be showing these notebooks to your instructors each week; a portion of your grade depends on how complete and descriptive they are.

Written Design Proposals: The design proposals are an initial check to make sure that each group understands the problems to be solved and has made a concrete plan to develop a system that has the potential to solve every aspect of the design problem. This plan needs to be as complete as it can be when it is submitted and must include a time line for the remainder of the semester (in Gantt chart format) and, of course, references to outside sources of components and ideas. It is understood that these are initial proposals, that designs necessarily evolve and changes are frequently made, therefore teams are not held to the specifics of their design proposals. Proposals must adhere to the Design Proposal Outline. ***Please submit one printed copy to each instructor.*** **NOTE: Incomplete or unacceptable proposals will require resubmission, and may result in project delays.**

Project Managers: Each student group will select a project manager or team leader. The project manager will be the main contact for the group, will usually present the weekly progress reports and be responsible for the internal communications within the group. The project manager must be identified to the instructors when the design proposal is submitted, or before.

Reimbursement procedures: In the event that funds are available for reimbursement of prototype costs, each student is responsible for following the required reimbursement procedures. Each student seeking reimbursement will have to be familiar with Oakland University Policies 207 (Business Expenditure Policies), 208 (Business Meals And Hosting Expense Policy) and 1000 (Procurement Policy). In order to document that these policies have been read and will be followed, each student must submit a SECS Reimbursement Agreement Form before submitting receipts for reimbursement.

Oral Presentations: These presentations will "tell the story" of the design project.

> The **mid-term progress report** is to tell the story from the first day of class to the presentation date, describing what was considered and explored and what needs to be done in the next several weeks to complete the project and/or win the competition. Since you may be competing with the other groups, you need not reveal any secret or particularly clever ideas that you might have, but the presentation must contain significant technical substance.
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> The **final presentation** will contain complete details of each subsystem and component of your design as well as a summary cost analysis. The focus of this presentation is performance, and must answer these questions - *How* does your device work? *How well* does your device work, based on the design specifications and measured performance? For groups that are directly competing in a challenge project - *Why* is your team/device going to win the competition?
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> The overall emphasis of both of these presentations is to have your audience understand what you did, why you did it and how your device works. Each group will present for 12-15 minutes, not including questions. A crisp, excellent 12 minute presentation is far better than a disorganized, poor 15 minute presentation. You will be abruptly cut off at the 15-minute time limit, even if you are not finished. You are **not to include equations, photographs of printed circuits and/or listings of computer code**. There is no time to explain and understand equations, photographs of PC boards do not contain any useful information, and computer code is impossible to explain and understand in a brief presentation. Explain your design at a high level through drawings, photos, demonstrations, video clips, block diagrams and flowcharts, all properly referenced if the content is not your original work. The presentations must be prepared according to the specified guidelines and format; the opening slide should contain the names and photos of all group members. Introduce all group members as they begin to speak.

Written Design Reports: At the end of the semester, after the competition and/or exposition, each group will submit a final written report. This report is to document everything that you have done towards completeing your design project. A well-documented and maintained Design Project Notebook is an important tool in writing a complete report. Reports must adhere to the Design Report Outline. In addition, each submitted report must be accompanied by one or more clearly-labeled electronic storage devices (CD, DVD, flash drive) that contain: the Project Proposal and the Design Report (MS Word or PDF format), the PowerPoint files of both formal presentations, all computer models and code for the project, photos of your group members with your project, short video clips (MP3 format) of your project functioning. ***Submit one copy of the report + CD/DVD/flash drive to each instructor.*** **Projects with external sponsors will require one additional complete set of report and electronic files for the sponsor. NOTE: Incomplete or unacceptable reports and/or electronic files will require resubmission, and will result in delays in submitting and receiving grades.**

Schedule - Winter 2018

Semester timetable

Date	Event
January 4, 2018	Introduction, Project descriptions, Profiles collected
Janaury 9, 2018	Information sessions, Group assignments made
Weekly beginning Janaury 11, 2018	Group meetings in 178 EC Individual written progress reports Project notebooks
January 30 and February 1, 2018	Written design proposals, Identification of project managers
February 27 and March 1, 2018	Mid-term oral progress presentations
April 12 and 17, 2018	Final oral presentations, Rough draft of final written report
April 18, 2018	Public Competition/Exposition, 10 am - noon, 178 EC
Monday April 23, 2018 before noon	Final written report and electronic files due

Group meeting times (178 EC)

Group	Day	Time

1	Tuesday	10:00-10:15 am
2	Tuesday	10:15-10:30 am
3	Tuesday	10:30-10:45 am
4	Tuesday	10:45-11:00 am
5	Tuesday	11:00-11:15 am
6	Tuesday	11:15-11:30 am
7	Tuesday	11:30-11:45 am
8	Thursday	10:00-10:15 am
9	Thursday	10:15-10:30 am
10	Thursday	10:30-11:45 am
11	Thursday	10:45-11:00 am
12	Thursday	11:00-11:15 am
13	Thursday	11:15-11:30 am
14	Thursday	11:30-11:45 am

Grading

Grading: All grading in this course will be based on the quality of design work, its modelling, analysis and subsequent oral and written presentation. All of the projects in this course will be team efforts and will include the design, construction and testing of some device. Students will also be required to keep a permanently bound design log, submit detailed weekly progress reports and both written and public oral final reports. The final grade in the course will consider team participation and online peer evaluation, progress made in the projects, input from project supervisors and overall engineering practice. Particular emphasis will be placed on how well students analyse their designs through mathematical or simulation models, justify their engineering decisions, and document and present the results of their analyses and designs. If you have questions about your progress in the course, please make an appointment with your instructor to discuss your individual grades.

Weight	Component
10%	Creativity, innovation and applicability of the final product.
20%	Team and class participation. Attendance and contributions at team and class

	meetings, leadership and oral presentations.
25%	Quality of engineering design and analysis, quality of prototypes. Does the device function as intended?
10%	Results of expo/competition.
35%	Progress reports, design proposals, project logs and final written report.

Course Evaluation: Each student in the course is expected to fill out an online course evaluation; directions will be emailed to you towards the end of the semester. In addition, each student must fill out ***online*** peer team evaluations. Graduating seniors are also expected to submit an exit survey.

Academic Conduct: Students are expected to read, understand and comply with the Academic Conduct Policy of Oakland University, found in the schedule of Classes and in the Undergraduate Catalog. Suspected violations will be taken before the Academic Conduct Committee. Students found guilty of academic misconduct in the course will receive a grade of 0.0 in addition to any penalties imposed by the Academic Conduct Committee.

Add/Drops: The University add/drop policy will be explicitly followed. It is the student's responsibility to be aware of the University deadline dates for dropping the course.

Special Considerations: Students with disabilities who may require special considerations should make an appointment with campus Disability Support Services. Students should also bring their needs to the attention of the instructor as soon as possible.

Laboratory Safety

The safety of students, staff and faculty are of paramount importance. To this end, the following safety rules will be followed in the Senior Design Laboratory (178 EC) without exception. Violations may result in the loss of lab privileges for individuals or entire design groups, at the discretion of the instructors.

- For the personal safety of everyone, the doors of the SDL are never to be propped open. Use your student ID to swipe into the lab every time you enter.
- The SDL is to be kept clean, neat and orderly at all times.
- No food or drink is allowed in the SDL at any time. Other parts of the EC are nearby for breaks and to consume food and/or drink.
- The instructor area in the SW corner of 178 EC, near the 3D printers, is not to be entered unless specific permission is granted. The equipment and tools used in this area are expensive and specialized, and the chemicals used are dangerous. For your safety and the smooth operation of the lab, please avoid this area.
- The SDL is for design work, small-scale assembly of mechanical or electronic components, and testing. No machining or large-scale assembly will be done in the SDL. All machining and fabrication is to be done in the Machine Shop, and all safety

rules of the Machine Shop must be followed. No unauthorized chemicals are allowed in the SDL.

- Eye protection must be worn when handling tools and soldering. Heat-resistant soldering mats must be used to prevent damage to the work surfaces.
- Do not work in the SDL alone. Do not engage in horseplay. Dress properly: long-sleeve shirts and long pants; closed toe/heel shoes; no loose long hair, clothing or jewelry.
- Students must familiarize themselves with the locations and operation of fire extinguishers, fire alarms, and emergency eye wash and showers. For all emergencies: call 911 from a campus phone or 248-370-3331 from your cell phone, remain on the line to answer questions and direct responders.
- Seek immediate help for chemical spills, accidents and/or injuries. Report all incidents to the instructors and teaching assistants as soon as possible.

Design Procedures

The purpose of the Senior Design experience is to design, test, refine and present a useful product or device. Modern engineering design is much more than tinkering in build/test loops, trying to get something to work properly. Precise mathematical modelling and simulation, purposeful planning, careful selection of materials and attention to manufacturing details will help insure that parts, assemblies and components will work, and work together, as intended.

By following a modelling approach to product development, each team member will utilize the fundamental engineering skills obtained throughout the engineering degree program and apply these skills towards the successful realization of the project. In order to move from one stage to the next in the development process, your team will demonstrate through Pugh decision matrices, models, simulations, analyses and prototypes that each component, sub-system, and the overall product all function as intended.

Documentation is a major component of the design process in this course. Careful tracking of design model revisions, justifying each revision through model simulation and/or test data and use of Pugh decision matrices and performance indices to assess the improvements of each revision are crucial to the success of the final product. In addition, complete and continuous documentation of the process makes reporting progress far easier than trying to remember everything after the fact when reports are due.

Electrical and electronic modelling, components and assemblies

Modern control of electromechanical devices generally requires sensors to continually feed information to microprocessors, which in turn make decisions based on a control strategy and enable actuators to move mechanical components. Selection and placement of appropriate sensors, a precise yet robust control strategy, and careful isolation of the delicate microprocessor circuits from power intensive actuators have been the keys to successful electronic and electrical design.

Each student workstation in the Senior Design lab (178 EC) is equipped with a computer (complete with PSpice, Matlab and Simulink) and monitor. Groups can check out an oscilloscope, function generator and power supply for use during the semester. Students are to notify the instructors immediately if any of these items is not functioning properly. Students will supply their own breadboards, electronic components (solder, wire, resistors, capacitors, inductors, connectors, microprocessors, ICs, etc.) and supplies to assemble and test electric and electronic circuits. Lockable storage space is provided at every student workstation.

Student-designed components

- Electrical and electronic components that are student-designed and manufactured are highly encouraged. If the cost of available commercial components and/or the time required for design, assembly and testing of designed circuits favor the use of commercial components, detailed justification must be provided before they are ordered.
- All student-designed electric and electronic circuits must be mathematically modelled (PSpice, Matlab, Simulink, etc), and thoroughly simulated and tested before they are constructed.
- A documented plan to test each student-designed circuit must be in place before it is assembled, and its mathematical model must be updated with the results of the verification test.
- Results obtained from these models, simulations and tests must be thoroughly documented, and will be presented at the weekly group progress meetings.
- All designed electronic circuits must be produced and assembled in their final form on a printed circuit board. No breadboards will be allowed in a final project presentation. Printed-circuit CAD/CAM software to drive the SECS PC mills is available on the workstation computers.

Commercial components

- Before any commercial electrical and/or electronic component (sensors, motors, motor controllers, H-bridges, power supplies, microprocessors, etc.) can be ordered, a detailed set of specifications and a Pugh decision matrix for that component must be documented, as well as a detailed plan to test that component once it is received to insure its suitability to the design and to verify its proper function.
- All commercial electronic and electrical components must be modelled and simulated, using the data supplied from the manufacturer and modified by the results of verification testing.
- Results of the modelling and verification tests must be thoroughly documented, and will be presented at the weekly group progress meetings.

Mechanical modelling, components and assemblies

Modern mechanical design emphasizes the extensive use of modelling and simulation, taking advantage of materials and manufacturing techniques to efficiently produce parts that are sufficiently strong and stiff, assemble properly and work as intended. Proper and robust geometry, careful selection of materials and tolerances, planning for assembly and repair, and accommodating necessary electrical components have long been the keys to successful mechanical design.

Most of the mechanical manufacturing will take place in the SECS Machine Shop, 179 EC, which includes capabilities for 3D printing, drilling and tapping, CNC milling and turning, water jetting, laser cutting, etc. Access to the Machine Shop is limited, and access to any particular machine is further limited to those who have passed a training session and given the proper permissions, and the schedule for that machine. Access to the Machine Shop and its capabilities are the sole decision of the Machine Shop supervisors.

Each student workstation in the Senior Design lab (178 EC) is equipped with a computer (complete with SolidWorks and Catia) and monitor, oscilloscope, function generator and power supply. A small library of SolidWorks texts are available in the Senior Design lab covering basic and advanced modelling, FEA, motion, fluid and thermal simulation. Manufacturing in the Senior Design lab itself will be limited to assembly and minor fitting of parts. At the beginning of each semester, each student group will have the opportunity to pay a deposit to check out a kit of small hand tools for these assembly and fitting tasks. Students are to notify the instructors immediately if any of these items break, are missing or do not function properly. Groups that return their tool box at the end of the semester with missing and/or broken tools will forfeit their deposit. Lockable storage space is provided at every student workstation.

Student-designed components

- Mechanical components that are student-designed and manufactured are highly encouraged. If the cost of available commercial components and/or the time required for design, assembly and testing of designed components favor the use of commercial components, a Pugh decision matrix and detailed justification must be provided before they are ordered.
- All student-designed mechanical components or parts must be mathematically modelled (SolidWorks, Catia, etc), and thoroughly simulated and tested before they are constructed.
- While nearly all materials and manufacturing operations can be accommodated in the Machine Shop, it is anticipated and preferred that most student-designed mechanical parts can be produced via 3D printing using ABS or nylon-12 polymers. In the event that this material and/or process is not suitable and/or appropriate for any particular component, other materials and/or processes may be used upon prior justification and documentation.
- In order to standardize parts and assemblies, students are to use only socket-head metric threaded fasteners wherever possible. Imperial threaded fasteners, or other fastener head styles, must be justified and documented before use.

- A documented plan to test each student-designed part must be in place before it is manufactured, and its mathematical model must be updated with the results of the verification test.
- Results obtained from these models, simulations and tests must be thoroughly documented, and will be presented at the weekly group progress meetings.

Commercial components

- Before any commercial mechanical component (wheels, bearings, axles, frame materials, etc.) can be ordered, a detailed set of specifications for that component must be documented along with a Pugh decision matrix, as well as a detailed plan to test that component once it is received to insure its suitability to the design and to verify its proper function.
- All commercial mechanical components must be modelled and simulated, using the data supplied from the manufacturer and modified by the results of verification testing.
- Results of the modelling and verification tests must be thoroughly documented, and will be presented at the weekly group progress meetings.

Electromechanical system model - components and overall function

The purpose of mathematical modelling, simulation and virtual testing is to develop a design that has a high probability of success when it is finally produced and assembled. The more realistic and detailed the mathematical model of the complete system, the more potential problems can be identified and corrected before construction, resulting in less frustration, lost time and needless expense. The overall goal is to develop a complete model of the system in order to produce each physical component, and the complete physical system, only once and thus avoid multiple, costly, frustrating and wasteful physical prototypes.

An overall electromechanical system model should be developed as soon as the overall system concept starts to take shape, and must be included in the project proposal. This model is to be thoroughly documented, including Pugh decision matrices of important components, continually updated with design changes and the results of verification tests. Results and predictions obtained from this system model will be presented at the weekly group progress meetings, and will provide much of the content of both the mid-term and final presentations. The performance of the final physical system must be compared in detail to the predictions of this system model in the final written report.