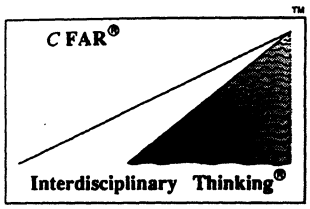

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Part Zero: Textbook Structure

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Preface

Since the publication of my textbook, *Analog and Digital Circuits Theory and Experimentation,* in 1987, I was ambitiously hoping to reach every engineering student by writing a textbook that becomes the primary source of information for years to come. I wanted to complement the previous textbook such that every student benefits from and keeps that for life. The initial idea to write this textbook came to me when I learned that there are concerns among educators about two concepts: teaching new senior design courses; and meeting the requirements for the Accreditation Board for Engineering and Technology (ABET). It was not really clear where to look for information to develop such new courses, which meet the recent recommendations of this board (ABET). Thus, to address commonalties in these design courses became the main focus of my activity and the main theme of this textbook. These materials are gathered in response to the expectations and requirements of ABET. Although this textbook is not related to or endorsed by that organization, every effort is made to meet their criteria as best as one could have understood.

In this regard a concise account of various underlying issues that comprises this course is described in Part One. Issues pertaining to the formation of the corresponding lecture notes, are described in Part Two, followed by samples of student's work in Part Three. I believe students should know various constraints associated with this course in order to plan their work accordingly and that is why Part One is included. Although this book is written to address senior students primarily, it is my sincere hope that it will help instructors of similar courses in their planning. As such I have left ample opportunities for them to revise my presentations, based on their need and experience. I am looking forward to receiving their constructive suggestions for improvement of this textbook, which I will incorporate graciously in its future editions.

Thus, based on many years of teaching experience in engineering schools, I developed this textbook, which I hope fits the bill and addresses commonalties in these design courses.

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It is my pleasure to thank all staff at the University of California at Riverside (UCR) who helped me with the creation of this series of design courses during Winter and Spring of 2001, when I was visiting the Dept. of Electrical Engineering. In particular, the initial web sites on WCB.UCR, for EE175A/B, was developed with substantial help and guidance of Dr. Leo Schouest who was constantly an inspiring colleague, and my former Teaching Assistant, Mr. Kirill Shabunov. Because of those web sites, I had to rewrite the notes into the current form to improve my earlier work. Thanks to all staff at UCR for their collective efforts to encourage me to complete this task, especially Ms. Zina Romero, Ms. Janet Harshman, and Mr. Isaac Saldana.

Most importantly, special thanks are due to my former students in EE175A/B at UCR. This book is dedicated to them for their hard work and sincerity. However, it would be out of character, if I would not thank all my former students worldwide – about 4500 strong so far. Thus, it is always a pleasure to thank them all for keeping me going all these years. They come from almost every country in the world. I have been the subject of many high-level family discussions worldwide, since many of them have a story about me to tell.

Special thanks are also due to my colleagues at the University of Illinois at Chicago for their very timely request that I finish this work and get this book ready for students in this and other universities around the country.

These days nothing can be done without extensive support of computer staff. I am grateful to my good friends currently at UIC, Ralph Orlick, Certa Nicholas, and Richard Chang. Also, I have not forgotten the help and support of my good friends and former staff at UIC, Leland Luecke, Ashish Desai, John Yancey and Clarence Murzyn, who had set up my other computer networks. I thank Barbara Sykes for her tremendous help in this project as well.

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Part One: Course Administrative Issues

1.1. Introduction

In this part, a concise account of various underlying issues that comprises this course and the formation of the corresponding lecture notes are described. These materials are gathered in response to the expectations and requirements of accreditation board for engineering and technology (ABET). Although we are not representing, nor this textbook is related to or endorsed by that organization, we have made every effort to meet their criteria as best as we have understood.

This part opens with a brief overview of ABET requirements; some general guidelines, and a typical university catalog course description for senior design. Then follows by the core of senior design courses as we have understood, and a typical senior design contract that is described subsequently. Part one ends with a procedure for students on steps to select a project.

1.2. ABET Requirements

Very briefly, engineering students must have a sound training in mathematics (including probability and statistics), natural sciences, computer sciences, humanities, social sciences, communicational skills, and engineering topics including engineering science and engineering design. Engineering science is incorporated by creative application of basic science skills, and engineering design focuses on the process of devising a system, or component, or process. Design element is incorporated into the program by a team of faculty and concentrates on design issues of a real system through construction and possible fabrication of a working prototype. This design element is advanced through the use of mathematics and sciences as well as the use of design tools and analytical skills during a series of project courses, which will culminate in a Capstone senior design project. In short, students will continually be informed of the ultimate goal of being an engineer through a series of design courses and working in a team. This textbook is designed to elaborate and meet various requirements pertaining to this series of courses.

1.3. General Guidelines

Objectives. The Senior Design Project is the culmination of course work in the bachelor's degree program in each field of engineering. In this comprehensive two-semester or two-quarter course, students are expected to apply the concepts and theories of their discipline to a novel research project. A written report, giving details of the project and test results, and an oral presentation giving the details of the project, will be required to complete this course satisfactorily.

Credit and Hours. Up to five semester (or up to eight quarter) units of engineering design credit will be granted for the completed project. It is expected that up to twelve hours of laboratory (or field) work will be required weekly for satisfactory completion of the project. The design value of these units has been accounted for in the total number of required science and design units necessary for graduation to meet the ABET requirements.

Project Participants. Projects may be completed individually (though not recommended), or in small teams with shared responsibility. In the team option, each student will be held responsible for a distinct component of the total team effort. Team projects are sufficiently more complex than individual projects so as to allow for an appropriate work load for all team members.

Technical Faculty Supervisors. All projects will have a technical supervisor who will serve as a resource person and sponsor, however, the instructor of the course will be responsible for approving the proposal and assuring that the project is of sufficient content and work load to satisfy the course objectives. Individuals or teams are to secure sponsorship by the beginning of the first semester or the first quarter.

Project Topics. Engineering projects will include proposal, design, development of software/hardware, and testing of the corresponding engineering devices or systems. Possible project topics may be obtained from the engineering faculty, or from cooperating industry. However, students may also propose an original project of their own.

Weekly Class Meeting. The entire class of senior design will meet once each week for one hour. These meetings are intended to provide instruction in topics common to all design projects (engineering economics, ethics, etc.). They may include brief presentations by each team, aimed at improving technical presentation skills. The class coordinator will conduct the sessions. These meetings are mandatory and are for student's benefit.

1.4. Typical Catalog Course Description

Senior Design Project (four to five semester-hour credits or up to eight quarter-hour units) with nine hours Laboratory work plus one hour consultation per week. Under the direction of a faculty member, students (individually or in small teams with shared responsibilities) propose, design, build, and test engineering devices or systems. Major design experience for senior students through projects with local industries can also be arranged. Open ended design experience requiring the application of a broad spectrum of the student's engineering knowledge to a practical design problem. A written report, giving details of the project and test results, and an oral presentation of the design aspects are required. An in progress or deferred grade will be given for the first course initially. A letter grade will be given for both courses finally. Prerequisite: Senior standing in Engineering.

1.5. The Core of Senior Design Courses

The Senior Design Projects must be administratively organized and supervised by one faculty member who also grades the entire class, while other faculty members equitably contribute to the technical supervision of students. The Senior Design Project will include the project specification, design, budget, reporting, and presentation requirements specified by the supervising faculty member and the project contract shown subsequently in this part, which must also be signed accordingly. These courses will include a lecture component of at least one hour per week in order to meet ABET requirements. Topics to be covered include project management, budgeting, scheduling, engineering economics, and engineering ethics plus similar topics as the supervising faculty deems necessary; based on the particular strength and/or needs of the underlying engineering program.

A Student Group – This may include students from other engineering disciplines. All students in a group (no more than four persons per group), however, must have a well-defined role. On such occasions when students come from different engineering programs, each department will grade its own students.

Senior Design – This is a design course and students must define a *design* project, not a *research*, nor an *evaluation,* nor a *fabrication* project. It is rather a balanced approach to culminate in using the many of these ideas.

Senior Design Projects will be from one of the following categories:

(1) Faculty Specified Projects – Students can work on projects with the department faculty members to be known as a technical advisor. This requires a signed agreement by that faculty, the student(s), and the overall course supervising faculty member. The technical advisor is expected to meet with the group weekly to provide technical leadership. Faculty members outside of the department or even outside of the College of Engineering can also supervise senior design students, provided that the student group also arranges for setting up technical meetings within the College of Engineering faculty, since that may become necessary to complete the design project rigorously. Students on such projects will still be required to attend lecture and meet weekly with the supervising faculty member to report on their progress. The supervising faculty will be responsible for the final grading of all the above projects.

(2) Industrial Specified Projects – Students can work on projects in cooperation with industry, but may not be paid for the work they perform for the duration of the project. This requires a signed agreement by the industry technical supervisor, the student(s), and the supervising faculty member. The industrial technical supervisor is expected to meet with the group weekly to provide technical leadership. Students on such projects will still be required to attend lecture and meet weekly with the supervising faculty to report on their progress. Here also, the supervising faculty will be responsible for the final grading. In certain instances, the supervising faculty may require that a university faculty member serve as a consultant in such projects.

(3) Student Specified Projects – Students can propose their own projects. However, a faculty member of the university must accept to be the nominal technical advisor for the group. To propose such projects, though possible, requires extensive lobbying by students.

Each design project must include the following components:

(1) A clear technical problem statement. Before proceeding beyond this point, each group should be certain that it has affirmative answers to the following questions:

- Is the problem solvable within the allotted time, say two semester or two quarters?
- Does the group have the expertise to complete the design, prototype, and testing?
- Does the group have access to the financing for the prototype?
- Does the group have access to the required test equipment?
- Is this a design problem (not research, nor fabrication)?
- Is the project significant enough to be worthy of the earned credits (requiring up to 12 hours work per week per person)?

(2) A quantitative performance specification.

(3) Quantitative analysis for possible design solutions, from which one solution is to be further developed.

(4) Detailed quantitative design of each component for the selected solution approach.

(5) Construction of a prototype.

(6) Development of a test plan.

(7) Evaluation of the prototype solution.

Each design must consider realistic constraints on prototyping and manufacturing costs, and per item consumer cost and pricing, as well as safety, reliability, aesthetics, ethics, and other possible social impacts of the design. Generally speaking, these are categorized into two groups, namely, **design constraints,** and ***elements of design.*** These two categories together is called ***engineering constraints***.

Each project will have the following deliverables:

(1) Oral Design Review – Generally, this is at the end of the first semester or the first quarter. (We propose, however, to schedule this presentation for the beginning of the second semester or the second quarter, in order that students benefit from the extended break between two semesters.) The group presents the results of items 1-4 and a bill of materials with costs.

(2) Written final report – This is due during finals week. It should contain one section for each of the seven items listed above; a bill of materials; the realistic constraint analysis; and any schematic, block diagram, or other figure needed to describe the end product fully.

(3) Final design presentation and demonstration – The outline should be similar to that of the final report, but organized to cover the most important aspects within the time constrains.

We close this section by noting that clearly, in the forthcoming lecture notes, specific guidelines to present these deliverables are discussed, which those guidelines form the core of this course.

1.6. Senior Design Contract

A typical senior design contract is shown below, modifications are needed to use in different engineering programs.

Senior Design Contract

Senior Design I, II Student Name:_____

☐ Individual ☐ Team (members:_____

Technical Faculty Supervisor: _____Supervisor Contact:_____
(phone or e-mail)

Proposed Project Title: _____

_____

Laboratory, where the project will be performed: _____

Time and location of weekly consultation with technical supervisor:_____

Regulations

I. Meet with the technical faculty supervisor before the end of the first week of the semester to discuss the project.

II. Prepare a one-paragraph description of the project objective and expected activities, and attach that to this Contract form. Complete the Senior Design Contract, obtaining all necessary signatures, then submit the completed information to the course instructor. Note: Project teams need to submit only one contract for the whole group.

III. Prepare, in consultation with the technical faculty supervisor, a draft of the project specifications (about five pages) by the third week of the semester. Submit the draft to the course instructor for approval.

IV. Maintain weekly laboratory notes and weekly consultations with the technical faculty supervisor for the duration of the two semesters. Attend all weekly lectures delivered by the course instructor.

V. Prepare, in consultation with the technical faculty supervisor, a progress report and demonstration during the last week of the first semester. Submit laboratory notes and progress report for instructor review. A grade of in progress (or deferred) will be issued at the conclusion of the first semester indicating that the course is "In Progress" and will be issued a letter grade at a later time.

VI. Maintain weekly laboratory notes and weekly consultations with the technical faculty supervisor for the duration of the next semester (Senior Design II) as well. Attend all weekly lectures delivered by the course instructor.

VII. Make a formal presentation of the project in the last week of the second semester (Senior Design II).

VIII. Prepare, in consultation with the technical faculty supervisor, final project report and submit that to the course instructor by the end of the second semester (Senior Design II) as time and place will be announced.

IX. The final letter grade will be given to the second course (Senior Design II), and retroactively given to the first semester course (Senior Design I), replacing the in progress or deferred grade. Final grades will be based on timely submission of the abstract, the first semester progress report, the laboratory notes, the oral presentation as well as demonstration, and the final report. All endeavors will be made to achieve a **working project**.

Signatures

_____ _____

Student (Team Member 1) Student (Team Member 2)

_____ _____

Student (Team Member 3) Student (Team Member 4)

_____ _____

Technical Faculty Supervisor Course Instructor

Copies will be provided to all team members and to the instructor. Also, a copy will be filed with the Department's Office of Student Affairs

1.7. Steps to Select a Project

Step – 0: Prepare a brief academic resume, which describes your specific technical strength and general background in less than two pages. It is very important that you make a case for yourself as why you should be doing a specific project. This step is more or less like applying for a job. Therefore this resume is the first draft of your future resume that opens a door for you.

Then follow one of the following steps 1A to 1C, depending on your situation.

Step – 1A: Make an appointment to meet and talk with professors with whom you wish to work, and see whether they are willing to recommend you for their projects. At least you should talk to two (preferably three) professors. This step is the same for all faculty members of the university. Or,

Step – 1B: If you have an industrial project in mind, which meets the above requirements as stated in the core of senior design, then you still need to talk to an engineering professor in your discipline. This professor must be willing to become your Technical Advisor, in addition to your Industrial Advisor. In many cases the professor in charge of this course may serve as a Technical Advisor, but not always. Or,

Step – 1C: If none of the above projects appeals to you, but you have your own ideas, then you must lobby for that idea with a faculty member, and see whether you can find a professor who is willing to become your Technical Advisor. This approach requires extensive efforts, but cab be done if it is planned in advance.

Step – 2: Identify one or two of your classmates who have similar interest and want to work with you on the same project and have gone through the same steps as you did. Then meet again with the faculty that all of you wish to work, to see if he/she is also willing to have all of you under his/her supervision.

Step – 3: Make a brief proposal to the course instructor regarding the title of project (and the professor's name), which you want to work on. In support of this proposal include a package consisting of your resume, your classmate(s) resume(s) if applicable, the professor's consent, if any. If you have already an endorsement of the faculty member include that as well. It is also required to have at least two more projects' titles in your proposal with supporting arguments, as your second and third choices.

Step – 4: Every effort will be made to match you with your best choices, although in certain instances changes maybe required. One consideration is an equitable distribution of senior design students among faculty members. In that case you will be notified promptly. Thus, have your contract ready for signature by your faculty advisor. You are almost done.