GUIDE

FOR

XYZ 487/488

"Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints." [1]

"Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs." [1]

Last Updated - Fall Term 2014

[1] www.abet.org ABET Criteria for Accrediting Engineering Programs 2014-15, criterion 5

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UNNUMBERED FORMS INCLUDED

Senior Design Pre/Co-Requisites
Waiver of Pre-Requisite or Co-Requisite for Senior Design
Project Content Approval Form
Budget Request Form
Project Plan Form
Evaluation of Project Potential Form
Student/Faculty Contact Report
Senior Design Meeting Log
Self/Peer Team Assessment
Project Lab Request
Project Lab Safety Rules
General Guidelines for Written Project Reports
Proposal Grading Considerations

XYZ 487/488
ENGINEERING DESIGN EXHIBIT I, II

Introduction: The material in this document is designed to guide you through your senior design project. Because a guide is not a comprehensive document you will almost certainly need information not provided here. In general that information will fall into one of two categories, administrative details associated with the course and technical details associated with your particular project.

1. Please consult your XYZ 487/488 instructors about administrative details. Other staff and faculty members may not have up-to-date information about this course, its specific requirements, timetable, etc.
2. Some technical information will be presented by your instructors and guest speakers during your regular attendance periods, and there will always be opportunities to ask questions at those sessions. In addition, you will meet regularly with your principal evaluator, your project's technical advisor(s), and your client. Finally, and probably most importantly, you are encouraged to use a wide variety of other resources to gather technical information pertinent to your project. These include the library, vendors, Mercer staff and faculty members, internet, WWW, experts from industry and government agencies, etc. Make appropriate reference to these sources of information in your written and oral presentations.

Engineering Design: Engineering design is the process of devising a system, component, or process to meet desired needs. The flow chart shown in Figure 1 shows one of many possible ways of viewing the elements involved. It is an iterative decision process in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective.

1. Thus, in XYZ 487 you are expected to:

    a. Identify one or more needs.
    b. Formulate a clear design problem statement.
    c. Establish objectives and criteria for meeting the identified need(s).
    d. Use a variety of resources (especially technical journals in your field, related patents) to gather information.
    e. Demonstrate creativity in generating two or more alternatives. If only one alternative is possible, then elaborate on design evolution and component alternatives.
    f. Determine the feasibility of each alternative.
    g. If applicable, conduct a merit analysis to help decide which of these alternatives warrant additional effort.
    h. Address economic, safety, reliability, maintainability, and ethical and aesthetic considerations, as well as social and environmental impact.
    i. Develop a detailed engineering solution, combining synthesis and engineering analysis to support your recommendation for construction, testing, and evaluation of a prototype.
    j. Write and present a detailed design report effectively communicating project concerns and details such as the work accomplished, final design, and recommendations. Your report should include engineering drawings/diagrams, complete with key information such as dimensions, material lists, etc.
    k. Develop a detailed plan for testing your deliverables.

2. Then, in XYZ 488 you will:

    a. Develop a time-based plan for constructing, testing, evaluating, and presenting a prototype or model of the system, component, or process proposed in XYZ 487.
    b. Construct a working model or prototype of your design.
    c. Execute your test plan.
    d. Propose and (upon approval) execute design changes to correct or improve performance.
    e. Retest (d) and redesign (e) as needed to develop a final design.

f. As in XYZ 487, address economic, safety, reliability, maintainability, ethical and aesthetic considerations, as well as social and environmental impact.

g. Write and present a design report effectively communicating the test results and an evaluation of model/prototype performance measured against the project objective, the explicit promises of the project proposal and, when appropriate, the implicit commitments of the feasibility and merit criteria used in XYZ 487. Include a final system description, and where appropriate, revised engineering drawings, complete with key dimensions, material lists, etc.

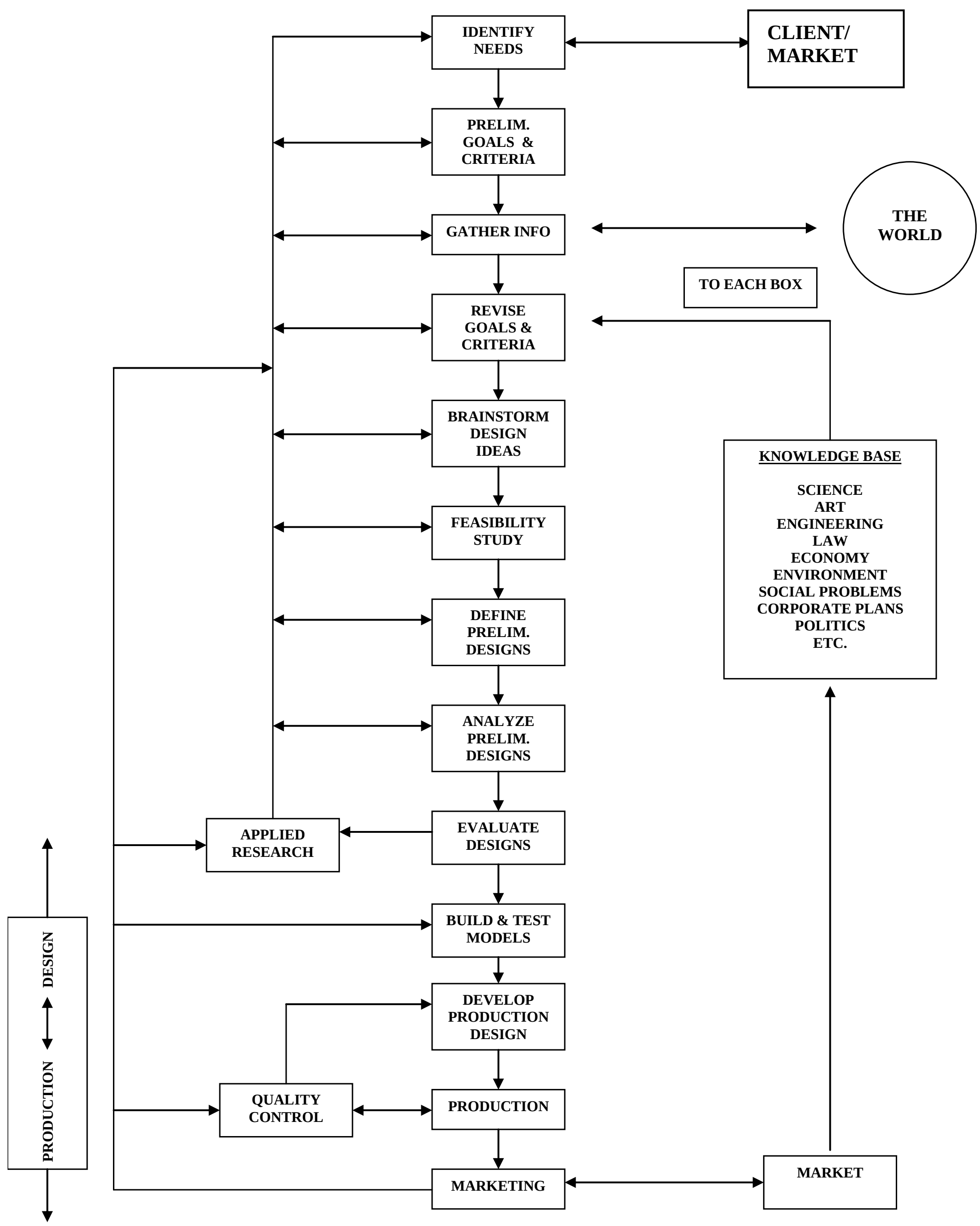


Figure 1. Flow chart of a typical engineering design process

Stakeholders: Each senior design project involves four major players:

1. Client – the person or organization for whom the hardware, software, or process is being designed and implemented.
2. Management – in this case, represented by the course instructor who oversees team efforts.
3. Project Team – group of students who will design, build, and test realistic engineering systems to satisfy both the client and management.
4. Technical advisor – faculty member(s) who provide expert advice on technical elements of the project. There must be a technical advisor from each discipline represented by your team membership.

Roles: Note that a single individual may play more than one role in the School of Engineering projects. For example, if your team undertakes to design, build, and test a new piece of laboratory equipment for Professor Smith, he will be your client. As a client, he will attempt to define his needs and provide information about his preferences and constraints (time, money, space, etc.). Under some circumstances, Professor Smith may be the only faculty member with special expertise needed by management. In those cases, he will also serve as a "consultant" to your team and to your course instructor. When he is serving in this consultant or technical advisor role, he may present advice that normally would not be available from a client. In such cases, if you have any doubt about which hat (client or advisor) is being worn, you should ask.

Resources: Keep in mind that these projects use resources – time, equipment, facilities, talent, and money. You are responsible for these resources and your project proposal must address the availability of each one. Please note in particular that you must identify the source of funding for your project. Availability of these resources should be an early matter of discussion with client, technical advisor, and team members.

Project Notebook: Each team must maintain a loose-leaf notebook which, by the end of XYZ 488, will contain a complete record of the team's efforts on this project. This record will be brought to each class attendance, each meeting with course instructors, and each meeting with the team's technical advisor or client. As a minimum, it will contain tabbed sections as follows:

Administrative Details (this guide, etc.)	Proposal
Ideas/Sketches/Engineering Drawings	Cost Analysis/Cost Records
Engineering Analysis	Preliminary Design Review
Timetable (PERT/CPM, Gantt, etc.)	Progress Reports
Test Plan/Test Results	Project Notes
References	Activities Logs

Proposal: The first written requirement in XYZ 487 is the development of a proposal. You are encouraged to review your TCO 341 text and notes concerning this subject. Recall that a proposal is a written offer to solve a problem or provide a service by following a specified procedure, using identified resources, and adhering to a published timetable and budget. It establishes the overall goal of your project and, as a minimum, it must answer the questions shown on page 8 of this guidebook. While your proposal may be submitted earlier, it is due at the start of your second attendance in XYZ 487. A completed Budget Request Form should be submitted with your proposal. While preparing your proposal keep in mind what you are trying to accomplish. Your senior design experience must be a "major design experience

- Based on the knowledge and skills acquired in earlier course work and
- Incorporating appropriate
  - Engineering standards and
  - Multiple realistic constraints"[2]

Brainstorming/Feasibility Study/Merit Analysis: Following acceptance of your proposal, you are free to begin the creative portion of the project. Brainstorming should produce a substantial number of alternatives for accomplishing the overall design goal. Once these ideas have been cataloged, you must

[2] www.abet.org ABET Criteria for Accrediting Engineering Programs 2012-13, criterion 5.

identify those factors that limit your design and those factors that allow discrimination between design alternatives. The former is known as feasibility criteria and the latter as merit criteria. A careful feasibility study (measuring each alternative against the feasibility criteria) will not only eliminate some of your concepts, it will also reveal ways that other alternatives may overcome their limitations. This process must leave your group with at least two feasible alternatives (preferably more). The subsequent merit analysis applies the merit criteria to each feasible concept in order to identify the best choice to pursue into the build-and –test phase. A sample merit analysis spreadsheet is shown on page 7 below. Your instructor will discuss this topic in greater detail. Please note that it is virtually impossible to conduct a feasibility study or a merit analysis without engaging in sensitivity analysis, engineering analysis, and cost analysis as discussed below.

Sensitivity Analysis: The eventual selection of a "best choice" from among your design alternatives may be very sensitive to the factors defined in your feasibility and merit criteria. The weights assigned to the factors included in your merit analysis are especially important. You are required to examine this sensitivity and to communicate both your analysis process and the range of possible results to your audience. You must take steps to eliminate ambiguous results where possible (add new criteria, revise existing criteria, reassess merit assignments, etc.). In those cases where two or more alternatives are still "close" in terms of their respective merit totals, you must present a clear and supportable rationale for your final selection. Clients, technical advisors, and instructors should be consulted and agree to such choices.

Engineering Analysis: While trial-and-error has its place in the engineering design process, the associated costs rarely justify this approach in any but the most elementary projects. In XYZ 487/488 you are expected to use appropriate engineering analysis techniques to predict the behavior of individual and combined components of the system which you are designing (both feasibility and performance analyses). In short, you are required to experiment on paper long before you undertake the construction of a prototype. You are expected to apply the knowledge that you gained from earlier courses; and, in those cases where you need information or techniques not studied to date, you are expected to consult appropriate resources in order to gather and use associated data and principles. A major portion of your grade will depend on the thoroughness, accuracy, and presentation of this analysis at your PDR. Later, during the build-and-test phase of XYZ 488, you will be expected to verify the behavior predicted by your engineering analysis and explain any anomalies.

Cost Analysis/Cost Records: Predicting the cost of your deliverables is an essential part of this project. This cost analysis should begin during the development of the proposal and details should be added (note that this does not mean that the overall estimated cost should be increased) throughout the stages leading to the Preliminary Design Review. Each team should arrange to record and preserve all cost-related information accumulated during both terms. These records are required even when members of a team spend personal funds on the project. If the School of Engineering agrees to fund the project, any associated purchase must be approved by the faculty member serving as the team's technical advisor. This approval must be obtained before the purchase is made! When seeking approval, the design group representative should show the faculty member a complete list of purchases to date so that the group's total expenditures may be checked. Records MUST include all quotes received from vendors, copies of any associated purchase orders, and all subsequent invoices, receipts, and other documents showing cost-related data.

Engineering Sketches/Working Drawings: Both the written and oral presentation associated with this course must be accompanied by appropriate graphical illustrations. Keep in mind that engineering sketches and formal working drawings are used to present information to a wide spectrum of people such as clients, engineers, technicians, investors, managers, manufacturers, installers, maintenance and repair personnel, etc. The primary purpose of these graphics is to document and communicate details concerning shape, size, layout, location, materials, assembly, etc. of components associated with a given design. They should be professional in appearance and should include sufficient printed notation to stand on their own without the need for someone to explain them. This means that a shop technician should be able to use your working drawings to build the associated hardware without seeking additional information. Even when design efforts focus on processes or software there are graphics involved (flow charts, decision diagrams, etc.). In each case the result is a set of documents that change as the design is revised, new materials are selected, and new components become available from vendors. Consequently, your drawings must be made with change in mind; and they must be kept current as you proceed through both terms of XYZ 487/488. Note that all drawings/sketches should be oriented so they can be read from either the bottom or the right side edge of single-sided paper.

Planning/Timetable: A plan is a detailed scheme for the accomplishment of a goal. It is laid out in advance, specifying what is to be done, when it will be done, how the goal will be accomplished, and what resources are needed. Good planning is an essential element in any engineering design project. Your team is expected to identify all activities needed in order to achieve successful completion of your design goal in the time allocated and within the proposed budget. You must then use either PERT or CPM to determine the critical path through the activities and a Gantt chart to schedule the activities and record the team's progress. These documents must be kept current and should be available in your notebook at each meeting with your instructor, technical advisor, and client.

Reports/Presentations: All written reports must be typed, or prepared on a word processor, and each student should contribute to his/her group's reports.

1. **Formal Written Reports:** The Preliminary Design Review in XYZ 487 and the Critical Design Review in XYZ 488 should be complete, formal reports with covers. Both written reviews, to the extent practical, should follow the format provided below in this guide. **Copies of these written reports must be submitted to your 487/488 instructors, your clients if they are MUSE faculty, and to each of your technical advisors at least 72 working hours prior to the associated oral presentation. This is a firm deadline. If your written documentation is not available within 72 hours of the scheduled oral presentation, you must reschedule because you will not be allowed to present. A copy of all CDR and PDR reports must be submitted on CDrom to the administrative assistant in the Associate Dean's Office at the same time the report is due**. These materials will be retained by the School of Engineering for use in subsequent accreditation exhibits.
2. **Oral Reviews:** Once you and your instructor have agreed on a date/time/location for your oral review, your team is responsible for coordinating the attendance of the client and the technical advisor(s). Unless you make closed invitation arrangements at the beginning of the term (complete with non-disclosure forms), your oral review will be an open invitation presentation attended by a variety of students and faculty. They will participate in question/answer sessions and will be asked to evaluate your group and individual performances. Each student in your group must present a significant part of each oral review. You are responsible for obtaining all audio-visual resources, duplicating and distributing appropriate handout materials, and returning the presentation room to an acceptable condition following your oral report.
3. **Progress Reports:** Throughout this project, you will be expected to present both written and oral reports that communicate the work accomplished to date, work remaining to be done, the status of project resources (time, talent, money, equipment, and facilities), and any problems encountered. Guidance concerning these reports can be found below in this guide, and additional information will be presented by your instructor. As scheduled by your instructor, team progress reports will be presented orally to the class and individual progress reports are to be written.
4. **Technology Review Reports:** Current technologies and the state of the field can profoundly influence a design and design ideas and should not be overlooked. During XYZ 487, each team member may be required to conduct a literature review associated with some aspect of their project. This review would preferably be associated with your specific engineering discipline of study. As specified by your instructor, you will find a number of appropriate, referenced journal articles, patents and/or trade journal articles and write a one-page summary of each.

Test Plan/Test Results: During XYZ 488, you must not only construct a model or prototype, you must also prove the validity of your design. This involves a series of tests (performance, endurance, environmental, human acceptance, etc.) following plans developed in XYZ 487. Because provisions for at least some of these tests may need to be incorporated into the design, you should develop a preliminary test plan early in XYZ 487. This will be followed by a more detailed plan that must be presented and executed in XYZ 488 with results reported at the Critical Design Review. Keep in mind that these tests should do much more than verify accomplishment of the explicit promises of the project proposal. They must also offer proof that the implicit assumptions and commitments of the feasibility and merit criteria have been met. When design deficiencies are revealed, redesign and retesting are almost always required. Because these activities take time, your original planning should allow for such contingencies.

Meetings: You are expected to meet frequently (at least bi-weekly) with both your principal evaluator and your technical advisor. You are also expected to keep your client informed about key details of the project. Make appointments for these sessions, prepare and present a brief oral progress report at each, and use the time profitably to ask questions, discuss alternatives, etc. Bring your project notebook to these meetings and be prepared to use the included materials.

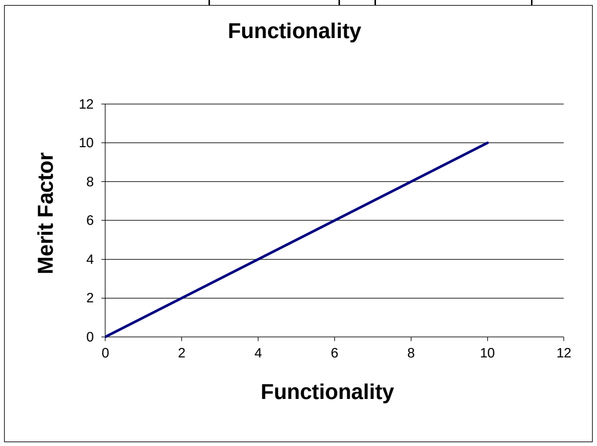
Attendance: Attendance at the lectures, laboratories, and other scheduled meetings is expected; and chronic absence may result in a student's being dropped from the class with a grade of F. After the lecture and discussion portion of each regularly scheduled attendance, design teams are expected to use the remainder of the period to work on the project. You are also required to attend and evaluate at least two PDRs and two CDRs presented by others enrolled in XYZ 487/488.

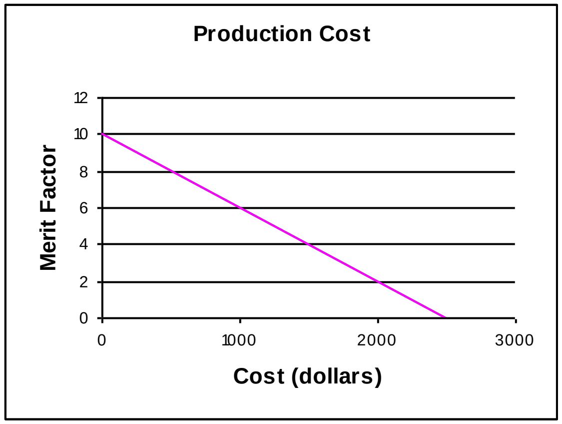
At the End: At the end of XYZ 487, each group must have a completed design or plan supported by appropriate analyses. That design or plan will be complete enough that it could be executed by anyone skilled in the appropriate technology. For example, the design of an artifact must include a **complete** set of drawings to include working drawings of all parts to be made, assembly drawings explaining how the parts go together, and a bill of materials describing what items to purchase before the parts can be made and assembled. If no such design or plan exists, the XYZ 487 effort is unsatisfactory.

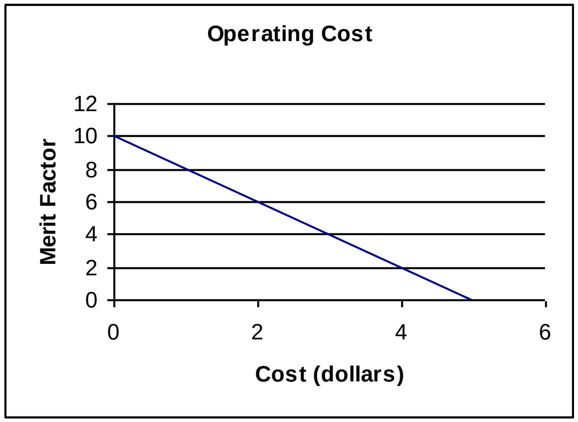
At the end of XYZ 488, each group must have executed the plan completed during XYZ 487. There may be modifications to the plan suggested by the results of prototype tests; however, the final result must come from executing the plan. Failure to do so makes the XYZ 488 effort unsatisfactory.

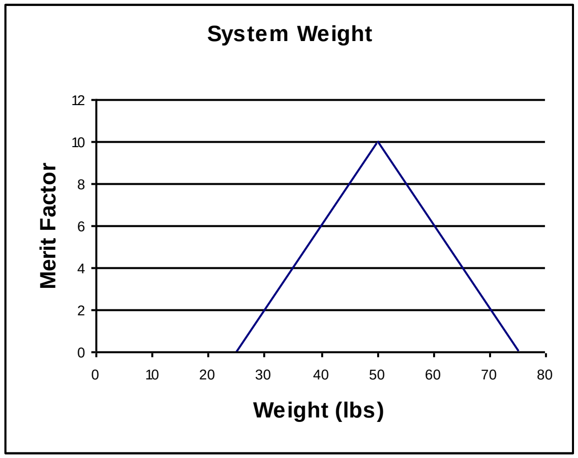
SAMPLE MERIT ANALYSIS RESULTS

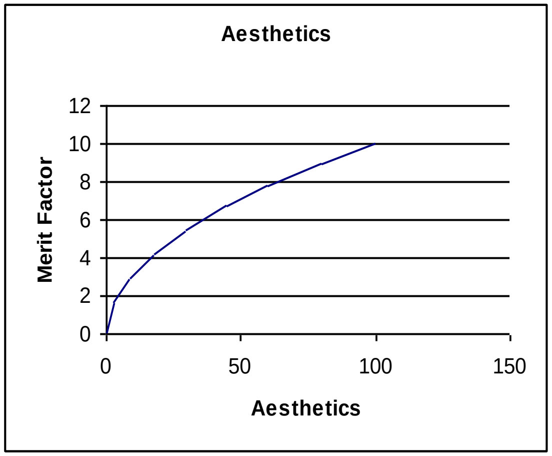
	Weight (%)	Alt #1 Features	Alt #1 Merit Factor	Alt #1 Total Merit	Alt #2 Features	Alt #2 Merit Factor	Alt #2 Total Merit	Alt #3 Features	Alt #3 Merit Factor	Alt #3 Total Merit
Functionality	40	7	7	280	9	9	360	8	8	320
Production cost	30	$1000/unit	6	180	$500/unit	8	240	$750/unit	7	210
Operating cost	15	$2.00/hr	6	90	$4.00/hr	2	30	$3.00/hr	4	60
System weight	10	60 lbs	6	60	70 lbs	2	20	50 lbs	10	100
Aesthetics	5	10	3	15	50	7	35	25	5	25
Total	100			625			685			715

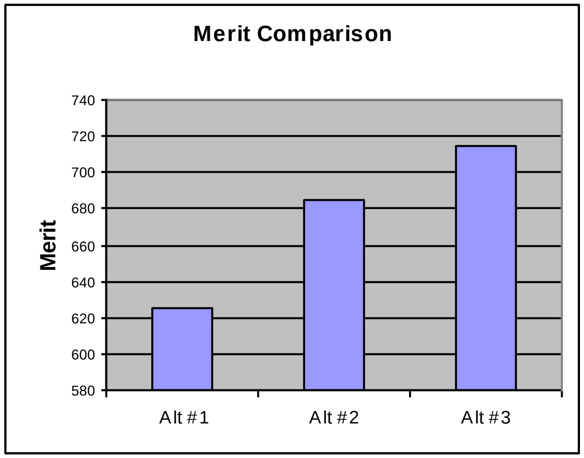












XYZ 487/488
SENIOR DESIGN PROPOSAL

The first written requirement in your XYZ 487 course is the development of a proposal. Proposal writing has been covered in your TCO 341 course and, therefore, will not be presented in detail here. You are encouraged to review your technical communication text and notes. Recall that a proposal is a written offer to solve a problem or provide a service by following a specified procedure, using identified resources, and adhering to a published timetable and budget. (Note that a budget is much more than the total dollar amount requested or allocated for the project. It is a systematic plan for meeting expenses.) Proposals answer the following:

What is the problem or need being addressed?
What is the proposed product, service, etc.? (i.e. identify all "deliverables")
How will you accomplish the work being proposed?

> Note that this is not to be a list of the engineering design process steps presented in your course notes. This is your opportunity to explain the method(s) you intend to use to achieve the design goal. In particular, by the time you write the proposal you should have at least some specific ideas that you expect to investigate. These should be described and illustrated with appropriate drawings.

What is your timetable for doing the work?
What resources will be needed (money, equipment, etc.)?
What is your plan for acquiring/using these resources?
How will you measure the effectiveness of your work?

For the purposes of this course, your proposal must also identify the specialty (EVE, ISE, etc.) of each member of your design team and you must indicate in specific terms how each of these specialties will be used in the project.

Once you have generated a document that addresses the above, you should examine it with a view toward clear communications. Consider (but do not limit yourself to) the following:

Is the audience obvious? Who is the "client"?
Does the document communicate clearly?
Is there a clear problem definition or statement of needs?
Is there a clearly proposed procedure for solution?
Is the procedure objective clear? Are "deliverables" clearly identified?
Are procedure steps presented in sufficient detail?
Does the author make a convincing case for the solution process?
Are the criteria for "success" identified?
Are resource needs addressed?

> Identified people? Specific talents?
> Equipment?
> Space/location?
> Time? Timetable?
> Budget? (A systematic plan for meeting expenses)

Is the document well organized?
Is the document free of spelling and grammatical errors?
Does the document make appropriate use of graphics, tables, etc.?

> Is there a request for approval? (Once the proposal is accepted, it may be changed only with the written approval of the client, the principal evaluator, and the technical advisor(s).

XYZ 487
ENGINEERING DESIGN REVIEWS

At key points in the design process, a project is reviewed by clients, management, investors, and others who might appropriately influence the course of events. These design reviews normally involve both an oral presentation and a written report. Frequently, the timing of these reviews is such that it is appropriate to report progress to date, present the alternatives for future work, make a specific recommendation, and seek a decision. For example, the Preliminary Design Review (PDR) might report on work accomplished through the initial evaluation of design alternatives, recommend one or more designs to be built and tested, and seek approval to proceed with prototype construction. At the Critical Design Review (CDR), the entire project to date might be presented, to include the results of building and testing prototypes. If the test results warrant, a recommendation for actions to be taken in order to move the production phase might be made.

The formats for such reports vary widely, but it is quite common for the engineering element in an organization to adopt a specific structure as its "standard." In the XYZ 487/488 sequence, you will submit a written report at both the PDR and the CDR and these reports will follow the formats outlined below. You will also make oral presentations. Both the written and oral work should review the key steps leading from project initiation to the date of the presentation and should conclude with a specific recommendation for future action(s). **Briefings should make use of appropriate audio and visual aids, and written reports must include complete working drawings with labels, notations, key dimensions, etc.** (Recall that working drawings contain both isometric and dimensioned orthographic views keyed to a detailed parts list.)

FORMAT FOR WRITTEN PORTIONS OF XYZ 487 DESIGN REVIEWS

1. Title Page: A title page provides identifying material and helps orient readers to report contents. It should be neat and free from clutter. Balance and symmetry are also important. As a minimum, the title page should include the project title, the names of key members of the design team, and the date. The title itself should reflect the specific nature of the project.

2. Executive Summary: Approximately a one-page summary of the entire report, suitable for either an engineering or business executive to understand and evaluate your work and results. The executive summary is the most crucial section in your document, and should be written last after the entire report with conclusions is completed.

3. Table of Contents: The Table of Contents includes the specific titles and initial page numbers of all the major report sections specified below.

4. List of Illustrations: List figure numbers, titles, and page numbers in order. Figures include drawings, sketches, graphs, flowcharts, and other graphical information. Each illustration should have a neatly lettered title.

5. List of Tables: List the numbers and titles of all tables and their page numbers in order. Include spreadsheet presentation of expenditures, time tables, experimental results, and other tabular information in this section.

6. Symbol List: Define each symbol used in your report in one or two lines. Give units for all symbols. Put the basic symbols in alphabetical order – English alphabet first; Greek alphabet second. Place subscripts in a separate section after the basic symbols in the same alphabetical sequence under the heading "Subscripts." Numerical subscripts follow any alphabetical subscripts.

7. Glossary: Short definitions of unusual technical terms used in your report. If there are only two or three such words, they are probably best explained in the body of the text. As the number increases, it becomes more reasonable to gather the definitions under a single heading.

8. Introduction: The Introduction provides appropriate background information, citing references as appropriate. Among other things, it should establish the motivation for the project, and it should provide a smooth transition into the Project Description.

9. Project Description:

   A. Project Goal: This goal should be more specific than the goal defined at the outset of the project; however, for the PDR, it should still be defined by operational requirements as opposed to pointing toward the design of a specific device or process. All preliminary design alternatives should be presented as attempts to satisfy these requirements. In the CDR, the goal should be more focused on the design, construction, and testing of a specific device or process which meets the needs defined in earlier phases of the project.

   B. Feasibility Criteria: These are factors which limit the scope of a project. They are normally expressed as constraints. For example:

      (1) Unit must weight less than 100 lbs.
      (2) Unit production cost must be less than $50.
      (3) Unit volume cannot exceed 2 cubic feet.
      (4) Must not degrade when exposed to weather or sunlight for design life of device.

   C. Merit Criteria: These are the standards or measures which promote discrimination between design alternatives. In the PDR they provide a yardstick for selecting the "best" choice(s) to pursue into the prototype modeling phase. As they are refined, these criteria continue to provide a basis for judging the design, particularly as it is being constructed and tested. In the CDR additional merit criteria may be used to facilitate decisions concerning commitment to production. Merit criteria should be as specific as possible while still providing a basis for choosing between alternatives. It is usually better to reduce a general criterion to more detailed sub-elements. For example, instead of "low cost" the following might be listed:

      (1) Low unit production cost.
      (2) Low shipping cost.
      (3) Low storage cost.
      (4) Low assembly/installation costs.
      (5) Low operation costs.
      (6) Low maintenance costs.
      (7) Low disposal costs.

10. Work Accomplished: Describe the work leading up to the date of the report. This summary of what has taken place should provide the reader with information about key activities and decisions from project inception to the present. This means that readers of any given report should not have to review previous reports in order to have a clear picture of the project.

   A. This "work accomplished" section should include a detailed presentation of several design alternatives. **Use of appropriate engineering sketches/drawings with accompanying written explanations is mandatory. With few exceptions, these illustrations should appear in the body of your report.** (In those rare cases where pictures are shown in a separate location, such as an appendix, the reader should be given clear instructions on how to find the graphic, i.e. "see Figure 5 on page 3 of appendix B.") Discuss your evaluation of each of these preliminary designs against the detailed design criteria. This discussion should lead to conclusions concerning the best alternative. **Pay particular attention to predicting and presenting both prototype and production costs.** Note that in the "Recommendations" section shown below, you may choose to propose the construction of a device that is different from your "best" preliminary alternative in that it combines the outstanding features from several of the other designs.

B. **Use of appropriate Codes and Standards for engineering design is mandatory**. See pages 13 of this guide for details.

C. **Use of appropriate engineering analysis to predict the performance of your design is mandatory.** Presentation of this analysis should receive the same careful attention accorded the selection of your best alternative. List all "given" information and indicate its source. List and justify all assumptions. Present each equation to be used, indicate its source, and present sufficient detail and discussion to show that the use of this "theory" is appropriate. Finally, show calculations using well-documented theory, your assumptions, pertinent data, and correct/consistent units leading to a clear "conclusion." These calculations must provide the reader a step-by-step picture of how results were achieved. Present all of this in a logical, well-organized, and legible format.

11. Final Design Specifications: This section should reference a complete and exclusive set of specifications for all components of the final design(s) to include drawings, plans, and/or procedures. Similar to the requirements of a US patent, these specifications should communicate sufficient information to support the construction/implementation phase of the project without further engineering decisions. Ideally, technicians trained in the appropriate field should be able to construct the device (or implement the plan) independently. Avoid discussion of other design alternatives.

Also provide recommendations addressing actions to be taken as the final design(s) moves into the construction and test phase.

12. Conclusions: This is an itemized account stating the main results and findings of your work. In the PDR, you should select the best design alternative and explain why it is best. All conclusions should be supported by appropriate details elsewhere in the report. Keep in mind the appropriate use of appendices and annexes as presented in paragraph 15 below

13. References: Documentation meets your moral obligation to give credit where credit is due. It lets your reader know who was the originator of an idea or expression and where his or her work can be found. Also, systematic documentation makes it easy for your reader to research your subject further. **It is virtually inconceivable that an engineering design review can be presented without a substantial number of references to material, which was originated by others.** Starting in the Introduction, material from other sources should be identified by placing a reference number in parentheses after that material. Reference numbers should run consecutively through the entire report, and each should have a corresponding source citation in the References section. Consult an appropriate style manual or technical report handbook concerning formats for constructing these citations. References typically include technical journals, books, patents, websites, or other documented sources of information used in the report.

14. Appendices and Annexes: Appendices and Annexes have become increasingly important in modern report practices. The primary concern in shifting some material out of the body of the document is "reader ease." Readers frequently want to extract the principal points of a report with a minimum expenditure of time and energy. Appending some materials that might otherwise overburden the body of a report becomes an increasingly important consideration as document size grows. Candidates for the shift to appendices or annexes include:

A. Supporting calculations.

B. Sets of working drawings.
C. Samples, exhibits, photographs, and supplementary tables.
D. Extended analyses.
E. Lists (material, personnel, sites, equipment. etc.).
F. Anything else that is not essential to a first-pass understanding of the main body of the report.
G. Data sets, as appropriate.
H. Computer programs written.

Keep in mind that "reader ease" is not enhanced by frequent requirements to flip back and forth between the main report and appendices. Furthermore, appendices should be tabbed (A,B, C, etc.), and pages should be numbered (restarting at 1 for each appendix) to facilitate references to materials in these portions of the overall document. The reader should be given clear instructions on how to find this supplemental material, i.e. "see Table 2 on page 4 of appendix A").

Codes and Standards for Engineering Design

As one of the many requirements for Senior Design, all design work is expected to address professional engineering codes and standards. Teams are required to seek out appropriate codes and standards and report on their investigation and findings. Projects lacking applicable codes or standards should provide explanation and find other ways to address public welfare and device (or system) compatibility.
Codes, standards, and even regulations offer valuable resources and guidance for engineering design. Although these may seem to prohibit the creative process of original design, engineering design work is often repetitive and thus very similar to work done by others in the past. Codes and standards are developed from a consensus-based process to represent the "best practice" developed from a vast history of the engineering profession granting knowledge, skills, techniques and wisdom. Following codes and standards helps to ensure functionality, reliability, and safety for engineered products and can contribute to improve accessibility (reducing cost), maintainability (requiring interchangeability and compatibility), and effectiveness. Most importantly, such guidance and rules assist professional societies and governmental agencies to fulfill their obligation to protect public health, safety, and general welfare. Virtually all commercially available devices involve engineering codes and standards in their design, manufacture, and/or distribution.

A standard is a sanctioned set of guidelines or technical definitions that could include procedures, criteria, specifications, material, parts, techniques, etc. Standards can declare required performance such as for seat belts, methods for testing such as measuring material properties, or "codes of practice" as instructions to working engineers. Generally standards are offered for voluntary use and developed by professional societies or other governing institutions. The American Society of Mechanical Engineers, for example, has a primary focus to globalize their codes and standards and maintains a standard for geometric dimensioning and tolerancing, a boiler and pressure vessel code, performance test codes, among many others. Just a few of the many other societies interested in codes and standards include the American Society for Testing and Materials (ASTM), the Biomedical Engineering Society (BMES), the American Institute of Chemical Engineers (AIChE), the American Society of Safety Engineers (ASSE), the Underwriter's Laboratories (UL), the Institute of Electrical and Electronic Engineers (IEEE), the Institute of Industrial Engineers (IIE), the Human Factors and Ergonomics Society (HFES) , the Society of Automotive Engineers (SAE), the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Society of Manufacturing Engineers (SME), the International Society for Measurement and Control (ISA), the Software Engineering Institute(SEI), the American Society for Healthcare Engineering (ASHE), etc. Whatever the source, the engineer is responsible to endeavor to find applicable standards for a project if he/she so chooses to consider professional guidance.

Codes refer to legally binding standards as imposed by laws or contractual agreements. Performance codes are stated in terms of design objectives and thus disregard the particular mechanisms of plans or devices. Registered professional engineers, for example, are required to follow a code of ethics as declared by their state government. Prescriptive codes present requirements in terms of specific details with the intent to leave no discretion. As a type of code, government regulations provide detail instruction for legislation and are maintained by federal agencies to address specific aspects of public safety and health. Examples of such agencies include the Occupational Safety and Health Administration (OSHA), the Consumer Product Safety Commission (CPSC), the Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC), the Federal Aviation Administration(FAA), and the National Institute of Standards and Technology (NIST). The CPSC requires engineers to design to minimize hazardous use in an unintended but foreseeable manner and when unavoidable must affix clear and precise warnings.

The engineering profession, as any other, continues to develop and aims to operate efficiently and effectively in a more and more technically advanced and complex world. The designed product of engineering typically impacts people directly as part of this world and so poses objectives and a responsibility for public wellbeing. Engineering codes, standards and regulations, contribute greatly to this goal by sharing, and enforcing when necessary, the sanctioned "best practices."

Reference:

Dieter and Schmidt, *Engineering Design*, 5th ed, McGraw-Hill, 2013.

XYZ 488
ENGINEERING DESIGN REVIEWS

At key points in the design process, a project is reviewed by clients, management, investors, and others who might appropriately influence the course of events. These design reviews normally involve both an oral presentation and a written report. Frequently, the timing of these reviews is such that it is appropriate to report progress to date, present the alternatives for future work, make a specific recommendation, and seek a decision. At the Critical Design Review (CDR), the entire project to date is presented, to include the results of building and testing prototypes. If the test results warrant, a recommendation for actions to be taken in order to move the production phase might be made.

The formats for such reports vary widely, but it is quite common for the engineering element in an organization to adopt a specific structure as its "standard." In XYZ 488, you will submit a written report of the CDR and the report will follow the format outlined below. You will also make oral presentations. Both the written and oral work should review the key steps leading from project initiation to the date of the presentation and should conclude with a specific recommendation for future action(s). **Briefings should make use of appropriate audio and visual aids, and written reports must include complete working drawings with labels, notations, key dimensions, etc.** (Recall that working drawings contain both isometric and dimensioned orthographic views keyed to a detailed parts list.)

FORMAT FOR WRITTEN PORTIONS OF XYZ 488 DESIGN REVIEWS

1. Title Page: A title page provides identifying material and helps orient readers to report contents. It should be neat and free from clutter. Balance and symmetry are also important. As a minimum, the title page should include the project title, the names of key members of the design team, and the date. The title itself should reflect the specific nature of the project.

2. Executive Summary: Approximately a one-page summary of the entire report. **Your primary audience for the summary is the general public or a non-technical manager.** A technical expert in your field is the primary audience for the remainder of the CDR document.

3. Table of Contents: The Table of Contents includes the specific titles and initial page numbers of all the major report sections specified below.

4. List of Illustrations: List figure numbers, titles, and page numbers in order. Figures include drawings, sketches, graphs, flowcharts, and other graphical information. Each illustration should have a descriptive title.

5. List of Tables: List the numbers and titles of all tables and their page numbers in order. Include spreadsheet presentation of expenditures, time tables, experimental results, and other tabular information in this section.

6. Symbol List: Define each symbol used in your report in one or two lines. Give units for all symbols. Put the basic symbols in alphabetical order – English alphabet first; Greek alphabet second. Place subscripts in a separate section after the basic symbols in the same alphabetical sequence under the heading "Subscripts." Numerical subscripts follow any alphabetical subscripts.

7. Glossary: Short definitions of unusual technical terms used in your report. If there are only two or three such words, they are probably best explained in the body of the text. As the number increases, it becomes more reasonable to gather the definitions under a single heading.

8. Introduction: The Introduction provides the problem statement and objectives. The objectives of the project are presented along with the feasibility criteria and a summary of the alternatives and

the selection process presented in the PDR. The objectives should be more focused on the design, construction, and testing of a specific device or process which meets the needs defined in earlier phases of the project. Summarize feasibility criteria from the PDR. You have been testing to ensure these goals were met.

9. Background: This section provides appropriate background information about the project. Among other things, it should establish the motivation for the project, and reference articles pertaining to the project. **The theory behind the project is summarized, presented, and referenced.**

10. Materials & Methods: Describe the work leading up to the date of the report. This includes a full description of the construction of the prototype(s) (or implementation of the plan), the materials/tools used, and the procedures used in testing. The test plans previously developed should be appropriately revised and presented in this section.

11. Results & Discussion: This section of the CDR provides the results and a discussion of the test plans that were presented in the Materials & Methods section. Figures, Tables, and supporting calculations should be presented in this section. Keep in mind the appropriate use of appendices and annexes as presented in paragraph 16 below.

   a) Specifically address how the proposal and the associated constraints of the feasibility criteria were met.
   b) Document changes to final design that differ from the design presented in the PDR.
   c) **Complete test results must be presented and appropriately interpreted.**
   d) Using your revised test plan results and/or design, a final evaluation of the project should lead you to conclusions and recommendations concerning production, including production costs.
   e) **Discuss realistic constraints including economic, environmental, social, political, ethical, health & safety, manufacturability, and sustainability that affect the design or usability of your product. If some of these constraints do not apply to your project, provide a statement describing why**.
   f) There are numerous examples of engineering design projects that have a substantial impact on society. For example, the design of a dam to provide hydroelectric power that results in no pollution or greenhouse gas emissions. An engineer should examine the greater environmental and social ramification of creating a new dam in a community. For example, people may be displaced and farmland and cultural sides flooded. Negative environmental impacts may include ponding and eutrophication, and the fish population may be adversely affected. On the other hand, the new dam my help control flooding. This example is from an paper written by Okamoto, Rhee, and Mourtos that can be found at the following URL: http://www.engr.sjsu.edu/nikos/pdf/UICEE%2005%20Jamaica-1.pdf. This manuscript provides several excellent examples. **Discuss the impact of your engineering design solution in a global, economic, environmental, and societal context. If your design solution does not have a global, economic, environmental or societal impact, provide a statement describing why**.

12. Summary and Conclusions: Briefly summarize your report and present the major conclusions or findings. This is an itemized account of the main points of the report. Your conclusion(s) should focus on the decision to proceed to the production phase. Among other things, this section of the CDR should address projected production costs. All conclusions should be supported by appropriate details elsewhere in the report.

13. Recommendations: Recommendations should focus on future actions relative to proceeding with production. This section should contain detailed and assembly drawings of the device as modified to include improvements and correct deficiencies. These drawings should communicate sufficient information to support the next phase of the project, whether that is prototype construction or full production.

15. References: Documentation meets your moral obligation to give credit where credit is due. It lets your reader know who was the originator of an idea or expression and where his or her work can be found. Also, systematic documentation makes it easy for your reader to research your subject further. **It is virtually inconceivable that an engineering design review can be presented without a substantial number of references to material, which was originated by others.** Starting in the Introduction, material from other sources should be identified by placing a reference number in parentheses after that material. Reference numbers should run consecutively through the entire report, and each should have a corresponding source citation in the References section. A parenthetical reference style is also appropriate. Consult an appropriate style manual or technical report handbook concerning formats for constructing these citations. References typically include technical journals, books, patents, websites, or other documented sources of information used in the report.

14. Appendices and Annexes: Appendices and Annexes have become increasingly important in modern report practices. The primary concern in shifting some material out of the body of the document is "reader ease." Readers frequently want to extract the principal points of a report with a minimum expenditure of time and energy. Appending some materials that might otherwise overburden the body of a report becomes an increasingly important consideration as document size grows. Candidates for the shift to appendices or annexes include:

A. Supporting calculations.
B. Sets of working drawings.
C. Samples, exhibits, photographs, and supplementary tables.
D. Extended analyses.
E. Lists (material, personnel, sites, equipment. etc.).
F. Anything else that is not essential to a first-pass understanding of the main body of the report.
G. Data sets, as appropriate.
H. Computer programs written.

Keep in mind that "reader ease" is not enhanced by frequent requirements to flip back and forth between the main report and appendices. Furthermore, appendices should be tabbed (A, B, C, etc.), and pages should be numbered (restarting at 1 for each appendix) to facilitate references to materials in these portions of the overall document. The reader should be given clear instructions on how to find this supplemental material, i.e. "see Table 2 on page 4 of appendix A"). Appendix A should be called first in the text followed by Appendix B, etc.

XYZ 487/488
ENGINEERING PROGRESS REPORTS

Engineers are frequently required to report the progress (or lack of progress) being made toward completion of projects on which they are working. These "progress reports" may be required in either oral or written form, and the lead time for preparation of such reports range from "adequate" to "no notice." Although some companies may provide specific guidelines, there is rarely a fixed format for such reports. In any case, a number of factors will influence your approach. Consider the following questions:

> Who is my audience?
> What are the needs of this audience?
> What is my communication goal?
> Under what constraints am I operating?
>> Time? (mine and/or that of my audience…)
>> Knowledge? (mine and/or that of my audience…)
>> Language? (terminology, security requirements…)
>> Media? (written, oral, graphical, etc…)
>> Environment? (Where will the communication take place?)

With the answers to these questions in hand, you have some chance to communicate; without them you are in trouble!

Once you have addressed the above questions, consider a format that will include the following:

Introduction: Identify yourself and your team. Communicate your project goal. Provide appropriate background to include the motivation for this project (Why is it being pursued?). Make a smooth transition into communication of "work accomplished to date."

Work Accomplished to Date: As needed for a given audience, provide information about key activities and decisions from project inception to the present. Then, give an appropriate account of the work accomplished since the last report. Use audio/visual aids whenever possible. In particular, include sketches, flow charts, tables, graphs, etc. to enhance your communication.

Work Remaining to be Accomplished: Highlight key actions which are needed to complete the project and tie these to a time line by listing milestone dates, using a Gantt chart, etc. Pay particular attention to activities planned for the near future.

Use/Availability of Resources: Address the status of resources, paying particular attention to the "bit five," money, time, talent, facilities, and equipment. Use this section to highlight any problems as appropriate for the audience.

Summary/Questions: Conclude with a summary of the progress, then ask for questions.

Note: Additional information, specific requirements, and schedule will be provided your instructor.

XYZ 487/488
ENGINEERING TEST PLANS

A plan is a detailed scheme for the accomplishment of a goal. It is laid out in advance, specifying what is to be done and how the goal will be accomplished. In addition, **an engineering test plan** indicates why each task is to be undertaken and it attempts to anticipate the use of resources like time, money, equipment, facilities, and people.

Please note that a list is not a plan. A simple tabulation of what is to be accomplished, without explicit elaboration of why the tests are being performed, how the tests are to be conducted, and a careful assessment of the resources needed, cannot be considered to be an engineering test plan. Refer to the explicit promises of the project proposal and the implicit commitments of the feasibility and merit criteria presented in the preliminary design phase.

For the purposes of this project, the submission of your test plan must include a copy of your graded project proposal, plus copies of any approved changes. In addition, you must list your project goal, feasibility criteria, and merit criteria as they appeared in your PDR. Make sure that your test plan addresses each of these elements and, ultimately, that the test results presented in your CDR support all the associated promises, claims and assumptions.

Please note the following when formulating your tests:

1. Tests require (1) a model, (2) a testing facility, (3) an arrangement of instruments suitable for measuring what occurs during the test, and (4) a test plan.

2. Some tests do not require construction of the entire prototype. Only those portions important to the evaluation of particular assumptions or claims are needed for many tests.

3. As a minimum, development of an engineering test plan should consider the following types of tests:

    a. **Performance tests:** These tests show whether a design does what it is supposed to do. They prove the validity of the design. Pay particular attention to the design goal as defined in the project proposal and modified in subsequent documents.

    b. **Quality assurance tests (materials – subassemblies):**

        (1) Validate that the design will perform with the least desirable (weakest) material or sub-assembly or…
        (2) Insure that only premium material or sub-assemblies are used.

    c. **Life, endurance, and safety tests:** Investigate behavior over time or repeated loadings. Keep in mind that two combined loads may have a much more serious effect on the part than the arithmetic sum of the separate effects of the two loads (synergistic behavior). For example, consider a combination of pressure, temperature, and vibration.

    d. **Human acceptance tests:** Does the design meet the physical, mental and emotional requirements of the user? Anthropometrics…Audio vs. visual…Colors

    e. **Environmental tests:**

        (1) How is the design influenced by its environment? (dust, temperature, pressure, salt air, etc.) Again, note the synergistic phenomena.
        (2) How does the design influence its environment? (pollution, noise, vibration, etc.)

4. Note that you and any readers of your test plan should have a clear understanding of the pass/fail criteria for each test. Provide specific measures/standards for success.

The format shown below may not lend itself to all tests appropriate to your project; however, please use this outline as a point of departure both for developing your plan and reporting the results.

Type of Test: (performance, environmental, etc.)
Equipment Needed:
Location(s):
Date(s)/total time:
Personnel:

Test Objective:
Criteria for success:
Procedure:

This same format may be augmented with a "Results" paragraph after tests have been completed and the findings are being reported.

UNNUMBERED FORMS INCLUDED

Senior Design Pre/Co-Requisites
Waiver of Pre-Requisite or Co-Requisite for Senior Design
Project Content Approval Form
Budget Request Form
Project Plan Form
Evaluation of Project Potential Form
Student/Faculty Contact Report
Senior Design Meeting Log
Self/Peer Team Assessment
Project Lab Request
Project Lab Safety Rules
General Guidelines for Written Project Reports
Proposal Grading Considerations

SENIOR DESIGN PRE/CO-REQUISITES

For all specialties, students must have completed all required 100- and 200- level engineering, mathematics, and science courses.

Course		Prerequisites		Corequisites
BME 487				
	EGR 312	Engineering Economy	BME 445L	Senior Biomedical Engineering Lab
	TCO 341	Technical Communication		
	BME 402	Biomedical Instrumentation		
	BME 425	Basic Transport Phenomena		
	BME 480	Introduction to Senior Design		
ECE 485				
	TCO 341	Technical Communication		
	ECE 202	Signals and Systems		
	ECE 323	Microcomputer Fundamentals		
	ECE 481	Introduction to Senior Design		
	EGR 386	Feedback Control and Modeling		
	CSC 205	Structural Programming II		
ECE 487				
	TCO 341	Technical Communication		
	ECE 311	Electronics I		
	ECE 323	Microcomputer Fundamentals		
	ECE 480	Introduction to Senior Design		
	EGR 386	Feedback Control and Modeling		
EVE 487				
	TCO 341	Technical Communication		
	EVE 384	Engineering Hydraulics		
	EVE 405	Design and Analysis of Wastewater Systems		
	EVE 480	Introduction to Senior Design		
ISE 487				
	TCO 341	Technical Communication		
	ISE 302	Management Science/Operations Research		
	ISE 311	Ergonomics and Work Measurement		
	ISE 327	Statistical Process and Quality Control		
	ISE 370	Manufacturing Processes		
	ISE 480	Introduction to Senior Design		
IDM 487				
	TCO 341	Technical Communication		
	IDM 355	Quality Management		
	IDM 480	Introduction to Senior Design		
	ISE 302	Management Science/Operations Research		
	ISE 370	Manufacturing Processes I		
MAE 487				
	TCO 341	Technical Communication	MAE 302	Experimental Methods for Mechanical Engineers
	MAE 305L	Manufacturing Practices		
	MAE 310	Numerical Methods for Mechanical Engineers	MAE 430	Heat Transfer
	MAE 322	Machine Design		
	MAE 330	Fluid Mechanics		
	MAE 362	Structure and Properties of Materials		
	MAE 480	Introduction to Senior Design		

WAIVER OF PRE-REQUISITE OR CO-REQUISITE FOR SENIOR DESIGN

I request a waiver of the following pre-requisite(s) or co-requisite(s):

____

____

____

My reasons (justifications) for requesting the waiver are:

____

____

____

____

____

Signed: ____________________________________ Date: __________________
(Student)

****

I approve the request for waiver:

Signed: ____________________________________ Date: __________________
(Program Director/Department Chair)

Comments by program director or department chair:

____

____

____

____

Program Director/Department Chair will place the original in the student's file, and the student will return a copy to the XYZ 487 instructor at the beginning of the term.

PROJECT CONTENT APPROVAL FORM

Senior Design XYZ 487/488

Name: ____________________________ Engineering Specialty: _____________________

My design team partners are:

Name: ____________________________ Engineering Specialty: _____________________

Name: ____________________________ Engineering Specialty: _____________________

Name: ____________________________ Engineering Specialty: _____________________

The name of our client is ____

The goal of our project is to design, build, and test ____

____

____

____

This project requires significant use of analysis and design techniques associated with my engineering specialty. This specialty-related content is best described as follows:

____

____

____

____

In the space below, obtain the signed approval of a faculty member from your engineering specialty and return this form to your 487/488 instructor.

This project and the content described above will allow an appropriate demonstration of design and analysis capabilities associated with this student's specialty.

Faculty/Tech Advisor Member's Name ____

Signature ____

Faculty/Tech Advisor Member's Department _____________________________________

Date ____

Note: Please submit this form for each student in the group. Each discipline needs a Faculty/Tech Advisor.

EGR 487
Senior Design Exhibit I
Budget Request Form

Team Members:____

Project Title:____

<table>
<tr><th colspan="3">IDENTIFY PROJECT CLIENT</th></tr>
<tr><td>MUSE</td><td rowspan="4">OR</td><td>External</td></tr>
<tr><td>Name:</td><td>Name:</td></tr>
<tr><td rowspan="2"></td><td>Contact Person:</td></tr>
<tr><td>Phone/email:</td></tr>
</table>

Funds Requested from Client ($) ______________________
(NOTE: $300.00 limit if MUSE faculty is client)

SENIOR DESIGN
Project Plan Form

Project Team Members:

Name	Major	Signature

Project Title:

Advisor(s):

Faculty Advisor	Affiliation	Signature	Date
Co-Advisors	**Affiliation**	**Signature**	**Date**

<u>Project Description</u>:

Summarize succinctly what your project is about and what the final product (deliverable) will be. You must provide realistic design specifications.

Project Constraints:

Your project must address multiple realistic constraints. Check at least four constraints that your project design will address.

- ☐ **Economic**
- ☐ **Manufacturability**
- ☐ **Social**
- ☐ **Environmental**
- ☐ **Ethics**
- ☐ **Political**
- ☐ **Sustainability**
- ☐ **Health and Safety**
- ☐ **Other,**

Project Engineering Standards:

Your project must incorporate appropriate engineering standards. Identify any engineering standards that apply. (IEEE, EPA, ASME, ASCE, BMES, OSHA, IIE, etc.) The National Resource for Global Standards (NSSN) is a search engine for standards (http://www.nssn.org/**).**

Project Deliverable(s):

<u>Describe your plans for using engineering analysis (modeling and/or simulation) to support your design recommendation</u>:

<u>Measures for Design Evaluation</u>: Quantify levels of achievement regarding 1) proper and safe function, 2) optimum performance, 3) adequate reliability, and 4) low cost. According to Dieter and Schmidt* these are the four balancing goals of engineering design. (These measures should link directly to the project specifications provided with the project description.). *Dieter and Schmidt, *Engineering Design*, 5th ed, McGraw-Hill, 2013

Careful project selection improves performance (and grades) of senior design teams by providing better opportunities for students to demonstrate capabilities in course objectives regarding engineering design. Senior-design course objectives support ABET criteria for a capstone design experience.

> "Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints." [3]

> "Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs."[1]

Senior design problems are typically complicated and so involve many needs and performance characteristics with diverse measures of success. As design problems are open-ended, senior design projects should inherently have many (even infinite) possible feasible solutions among which some will be more successful than others. In senior design, students must apply a design process that seeks more than merely a functional solution, but an optimally (or better) performing solution. Furthermore, students must substantiate the decisions leading to this preferred solution with engineering analysis and investigations.

Three aspects of senior-design projects are critical to best serve as an open-ended engineering design problem. Figure 1.1 from Kroll, Condoor, and Jansson[2] presents the design process with these three aspects as main categories of tasks to accomplish: 1) need identification and analysis, 2) conceptual design, and 3) realization. Demonstrating capabilities attained in MUSE courses requires defining a sufficiently challenging engineering problem with multiple measureable objectives for evaluating concepts and performance. The resulting project should incorporate engineering standards and realistic constraints. Concept design includes tasks to research technology, brainstorm, and conduct merit analyses leading to the selection of a single concept to engineer. Realization then transforms a mere concept to a comprehensive set of specifications for a real prototype. The development of final specifications will inevitably require engineering analyses/simulations with appropriate calculations, results interpretation, and discussion.

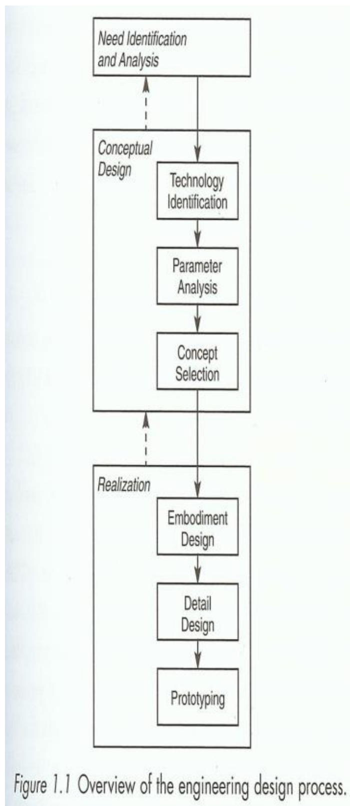


Figure 1.1 Overview of the engineering design process.

[3] www.abet.org ABET Criteria for Accrediting Engineering Programs 2012-13, criterion 5
[2] Kroll, Condoor, and Jansson, *Innovative Conceptual Design, Theory and Applications of Parameter Analysis*, Cambridge, 2001

Please estimate the potential of this project to provide opportunities for performance evaluation, innovation, and engineering analysis. For each, circle only one five options: Low-1 through High-5. Descriptions for options explain sample situations to suggest a general standard.

1) Potential for measureable functionality and performance objectives
   - Low-1 One main general objective for a functioning device
   - 2 Several objectives identified but are difficult to quantify
   - 3 Measureable functionality objectives readily available
   - 4 Measureable performance and functionality objectives readily available
   - High-5 Many performance and functionality specifications predetermined

2) Potential for innovative concept development
   - Low-1 Design components already exist (or likely best solution apparent)
   - 2 Innovation possible but not needed (may lead away from known good solution)
   - 3 Innovation will be required of some components
   - 4 Some solution concepts easily available but without clear preference
   - High-5 No examples of solutions available (or no obvious design alternatives)

3) Potential for engineering analyses (simulations, predictions, etc.) to support decisions
   - Low-1 Design process need not be complicated with analysis
   - 2 Finding aspects of project to analyze may be difficult
   - 3 Many aspects to analyze although not necessarily influential to design
   - 4 A few particular analyses likely to be crucial
   - High-5 Many or advanced analyses likely required

STUDENT/FACULTY CONTACT REPORT

DATE/STUDENT'S NAME	STUDENT'S COMMENTS	FACULTY SIGNATURE/COMMENTS

DATE/STUDENT'S NAME	STUDENT'S COMMENTS	FACULTY SIGNATURE/COMMENTS

DATE/STUDENT'S NAME	STUDENT'S COMMENTS	FACULTY SIGNATURE/COMMENTS

SENIOR DESIGN MEETING LOG

Date	Professor(s)	Members Present	Work Accomplished

XYZ 487/488 - Senior Design

Peer Rating of Team Members

Please print the names of all of your team members, INCLUDING YOURSELF, and rate the degree to which each member fulfilled his/her responsibilities in completing course assignments during the semester. The possible ratings are as follows:

Excellent	Consistently went above and beyond carried more than his/her fair share of the load.
Very Good	Consistently did what he/she was supposed to do, very well prepared and cooperative.
Satisfactory	Usually did what he/she was supposed to do, acceptably prepared and cooperative.
Ordinary	Often did what he/she was supposed to do, minimally prepared and cooperative.
Marginal	Sometimes failed to show up or complete assignments, rarely prepared.
Deficient	Often failed to show up or complete assignments, rarely prepared.
Unsatisfactory	Consistently failed to show up or complete assignments, unprepared.
Superficial	Practically no participation.
No Show	No participation at all.

These ratings should reflect each individual's level of participation and effort and sense of responsibility, not his or her academic ability.

Print Name of Team Member	**Rating**
Self:	

I understand that Mercer University has an honor code and that cheating or dishonesty of any kind is unacceptable. Furthermore, I certify that this submittal is a fair evaluation of the effort and participation of each individual team member including my own.

Signed: ______________________________________

Print Name:

COMMENTS:

Rules for Student Project Labs/Rooms

- Apply for a lab by talking with your instructor about your needs. Your instructor will provide and approve a room assignment request form. See Eric Daine to complete the room assignment.
- Labs are only assigned for one semester, unless permission by the instructor is given.
- Labs must be kept clean and orderly, and are subject to inspection by MUSE faculty or staff.
- Labs must be vacated, clean, and empty by the first day of semester final exams. If this condition is not met, course grades will be withheld.
- Labs may be reassigned, depending on school needs.
- More than 1 group may be assigned to a lab.
- You are not to work alone in the lab (safety).
- University is not responsible for personal items left in the lab.
- Do not give anyone your security code for the lab.
- No dangerous materials of any type are allowed in the lab without instructor permission. If you are uncertain if a material is potentially dangerous, ask your instructor.
- No one should be in the labs between 12:00 AM and 6:00 AM, unless special permission by the instructor is given.
- No one is permitted to sleep in the lab.
- No cooking is permitted in the lab.
- No food is to be left in the lab, including trash cans.
- Only beverages in capped plastic bottles or non-spill containers may be brought into the lab.
- Violation of any rules may result in suspension your group's assigned lab use for the entire semester.
- Follow all laboratory safety rules.

The undersigned understand and agree to abide by theses rules.

List Technical or Research Advisor	Student Name	Date	Student Signature

XYZ 488 – Engineering Design Exhibit II
Undergraduate Student Project Lab/Room Request

Instructions:
Complete items 1 through 7
Instructor/Advisors will authorize and sign (item8)
Agree to and abide by Rules for Student Project Labs
(all team members must sign rules page)
XYZ 488 Instructor will authorize and sign (item 9)

Room#________
Date__________

Box Information to be completed by Mr. Jeremy Barker, School of Engineering

Name *email* *phone*

1. Students Requesting Lab:____
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2. Project Description:____
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3. Course Associated with Project :____

4. Lab Request Justification:____
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5. Wet lab required for project: (Yes/No)_____________________________________

6. Is the project proprietary or under nondisclosure agreement?: (Yes/No)___________

7. Semester Requested for Use:____

Approval/Signatures with date:
8. Course Instructor (or Research Advisor):___________________________________
Technical Advisor (Senior Design only):_____________________________________
Technical Advisor (Senior Design only):_____________________________________

9. XYZ 488 Instructor:____

Special Requirements/Notes:____
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General Guidelines
For
Written Project Reports

1. Plan content
    a. Discuss and decide with group members on the main points for each section of the report.
    b. Identify the "creators" for particular components.
    c. Meet and discuss repeatedly as necessary.
2. Generate content
    a. Create and edit exhibits: graphs, figures, tables, etc.
        i. Sufficiently large and visible
        ii. Uncluttered, intended observation clear
        iii. All exhibits cited and discussed in the text
            1. content explained,
            2. observations noted, and
            3. interpretations discussed
        iv. Descriptive titles (placed above tables, below figures)
        v. Consecutively numbered (Figure 1. Title; Table 1. Title)
    b. Compose sentences and paragraphs
        i. Organize around presenting the exhibits
        ii. Avoid sentence "fragment" and "run-on" sentences
        iii. Technical writing should be objective, impersonal and avoid/minimize the first person – often the passive voice can be used to avoid the first person
        iv. Use strong, descriptive, action verbs when possible
        v. Avoid excessive wordiness
        vi. Appropriate tense:
            1. past tense for completed actions
            2. present tense for common knowledge
        vii. Paragraphs develop one topic with three parts:
            1. introduction that presents the topic
            2. middle with substantive text developing topic
            3. ending for closure or transition
        viii. Avoid paragraph "fragments" and "run-on" paragraphs
    c. Compose equations – special exhibits as part of a sentence.
        i. Use an equation editor
        ii. Center justify equation with right justified number in parentheses
        iii. Define all variables in terms of explicit physical or mathematical realities
        iv. Use to present a relation among ideas and not as a formula
        v. Include physical interpretation/explanation in text
    d. Assemble for professional presentation
        i. Create cover page, abstract, table of contents, etc. as required
        ii. Follow recommended section organization or strongly rationalized alternative
        iii. Bind report securely and professionally **(no three-ring binders, no paperclips)**

3. Editing
    a. Modify, reorganize, rewrite to create a cohesive, readable document
    b. Check exhibits: appropriate format, units declared, all cited and discussed, descriptive titles, intended effect achieved
    c. Check equations: correct content, variable defined, numbered and referenced, explained.
    d. Check paragraphs: clear objectives addressing requirements, topic sentence, thoughtfulness - convey distinct, appropriate concepts
    e. Check sentences: impersonal – first person avoided/minimized, Active voice judiciously, no vague or subjective arguments, style – effective, concise, scientific, and efficient
    f. Check compiled report: Cover page, abstract, table of contents, complete and well organized, complete and concise closure, justified conclusions, effective communication, predefined variables/concepts, consistent definitions, exhibit numbering and referencing
4. Proofreading – grammar and spelling mistakes can be embarrassing
    a. Proofread the edited report for grammar and spelling errors
    b. Someone other than the editor should proofread
    c. Check for common errors like confusing “to, too, and two” or “its” and “it’s”
5. Final checks: Report dated and signed, securely bound

References:

Jeter and Donnell, Writing Style and Standards in Undergraduate Reports, College Publishing, VA, 2004. (ISBN: 0-9679121-7-2)

Haile, J. M., Technical Style: Technical Writing in a Digital Age, Macatea Productions, SC, 2001. (ISBN: 0-9715418-0-9) (http://www.macatea.com/)

Proposal Grading Considerations

Proposal: The first written requirement in XYZ 487 is the development of a proposal. You are encouraged to review your TCO 340 or TCO 341 text and notes concerning this subject. Recall that a proposal is a written offer to solve a problem or provide a service by following a s**pecified procedure**, using **identified resources**, and adhering to a **published timetable** and **budget**. It establishes the overall goal of your project and, as a minimum, it must answer the questions shown on page 8 of this guidebook. While your proposal may be submitted earlier, it is due at the start of your second or third attendance in XYZ 487. While preparing your proposal keep in mind what you are trying to accomplish. Your senior design experience must be a "major design experience

- Based on the knowledge and skills acquired in earlier course work and
- Incorporating appropriate
  - Engineering standards and
  - Multiple realistic constraints"[4]

Planning/Timetable: A plan is a detailed scheme for the accomplishment of a goal. It is laid out in advance, specifying what is to be done, when it will be done, how the goal will be accomplished, and what resources are needed. Good planning is an essential element in any engineering design project. **Your team is expected to identify all activities needed in order to achieve successful completion of your design goal** in the time allocated and within the proposed budget.

Key features mentioned above – 1) offer of service to solve problem, 2) specified procedure, 3) identified resources, 4) timetable, 5) budget

From page 8, minimum set of questions to answer:

1) What is the problem or need being addressed?
   a. Is there a clear problem definition or statement of needs?
   b. Multiple realistic constraints involved?
   c. Who is the "client"?
2) What is the proposed product, service, etc.? (i.e. identify all "deliverables") **(What is the offer to the client? (services and final solution)**
   a. Are "deliverables" clearly identified?
   b. Are the criteria for "success" identified?
3) How will you accomplish the work being proposed? *Note that this is not to be a list of the engineering design process steps presented in your course notes. This is your opportunity to* ***explain the method(s)*** *you intend to use to achieve the design goal.*
   a. From Planning/Timetable above: Your team is expected to identify all activities needed in order to achieve successful completion of your design goal
   b. Is there a clearly proposed procedure for solution? **Are there clearly described procedures for solution?**
   c. Is the procedure objective clear? **Are objectives for procedures clear?**
   d. Are procedure steps presented in sufficient detail?
   e. Does the author make a convincing case for the solution process?
4) What is your timetable for doing the work?
5) What resources will be needed (money, equipment, etc.)?
   a. Budget? (A systematic plan for meeting expenses)
   b. Identified people? Specific talents?
   c. Equipment?
   d. Space/location?
6) What is your plan for acquiring/using these resources?
7) How will you measure the effectiveness of your work?

[4] www.abet.org ABET Criteria for Accrediting Engineering Programs 2008-09, criterion 5.

Communication Associated Questions: Does the document communicate clearly?

Is the document well organized?

Is the document free of spelling and grammatical errors?

Does the document make appropriate use of graphics, tables, etc.?

Is there a request for approval? (Once the proposal is accepted, it may be changed only with the written approval of the client, the principal evaluator, and the technical advisor(s).

Grading Rubric:

20	Executive summary
10	Introduction/Background
20	Problem Statement
10	Deliverables
10	Proposed Possible Solutions /Methods
10	Design Plan (with Timeline and Member Responsibilities)
10	Resource Requirements (Budget, lab facilities, software, work space,..)
5	References
5	Resumes/bios of team

Self Evaluation of Proposal Content:

Overall Impression of the Offer:

Based on the proposed offer of services, what quantity and quality of engineering effort can the client expect?

Did the team demonstrate a thorough understanding of the work/tasks required and have a well-thought-out plan to complete tasks and incorporate results?

Does the team understand the details of what will be necessary for each task/service relative to a completed undergraduate engineering education?

Did the team present sufficient depth and breadth of the important technical aspects?

Did the team anticipate the critical issues and challenges?

Ultimately, how much credibility exists towards the quality and usefulness of the final product?

Professionalism:

Is the offer well communicated with clear, distinct and organized concepts?

Does the proposal provide sufficient information on all required content?

Is the document free of spelling and grammatical errors?

Does the document make appropriate use of graphics, tables, etc.?

Is all technical and background information referenced, especially any specific claims?