SENIOR PROJECT GUIDELINES

OBJECTIVE

The Industrial and Manufacturing Engineering curriculum requires that every student earning a degree in Industrial Engineering (IE) or Manufacturing Engineering (MfgE) successfully complete IME 481 (2 units) and IME 482 (3 units), Senior Project Design Laboratory I and II. As stated in the ABET requirements, "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." (ABET 2000)

Objectives of the Senior Project can be broadly stated as follows:

- Execute a project that is an integrated application of coursework in IE or MFGE
- Plan and manage the project
- Do research in the area of interest
- Write a complete technical report
- Give a business presentation on the project

The senior project will be completed before a student leaves the university.

The senior project is an “academic report,” similar to a master’s thesis or doctoral dissertation. It is different than any other project you have completed in the IME department. In this context, you must perform a thorough review of literature in order to gain expert knowledge in the area. Projects that you work on in class or at work are generally for a client or for management and will be written with this audience in mind. The Senior Project report is written more closely to the form of a publishable research article.

ELIGIBILITY FOR ENROLLMENT

Industrial and Manufacturing Engineering students with senior standing may enroll in the senior project course. Students also must have the consent of the instructor (administrative advisor). Generally students who have less that 50 units or less remaining to complete the degree may enroll in IME 481.

We recommend that students take IME 481 and IME 482 in two successive quarters. It is possible with some projects to take IME 481 in the Spring and IME 482 in the Fall. This will have to be discussed with the administrative advisor prior to beginning the project.

Students will have to register for IME 481/482 during the academic school year (not summer quarter), and the student should be on campus. Students should not register for these courses when on a co-op.

A change of the project or faculty advisor will normally require the student to start the senior project sequence over by repeating IME 481.

It is possible to do a senior project as part of a team. These team senior projects must be approved by the advisors. In addition, it is often desirable to define specific areas of responsibility so that grading can be completed individually.

ADVISORS

There are two senior project advisors: an **administrative advisor** and a **technical advisor**. The administrative advisor runs the senior project class and ensures that students adhere to deadlines. In addition, the administrative advisor helps students find projects, and coordinates the senior project presentations. The technical advisor helps students with technical issues. This person gives direction on appropriate methodology and solution techniques. Both advisors jointly assign a grade in the courses.

If a student is working on a Multi-disciplinary Senior Project they must have a Technical Advisor from the IME department in addition to the advisor(s) for the team. This will insure that IME students satisfy the requirements for IE and MFGE senior projects.

COURSE DESCRIPTIONS

Below are the catalog descriptions of the senior project courses.

IME 481 Senior Project Design Laboratory I (2)
Culminating design project typical of problems faced in professional practice. Individual or group projects typically involve system design, modeling, analysis and testing. Project method includes costs, planning, scheduling, appropriate research methodology and formal reports. 2 laboratories. Prerequisite: Senior standing in major and consent of instructor.

IME 482 Senior Project Design Laboratory II (3)
Continuation of IME 481. Involves research methodology: problem statement, method, results, analysis, synthesis, project design, construction (when feasible), and evaluation/conclusions. Project results presented in thesis-like formal reports suitable for reference library and formal oral presentations. 3 laboratories. Prerequisite: IME 481.

SELECTION OF TOPIC

Selection of a suitable topic for the senior project is a critically important step for successful completion of the project. It is best to have a project decided upon before registering for IME 481. Inadequate attention to the topic selection may result in a change of topic by the student which typically leads to less than desirable results, including inadequate time for completion, poor quality project, change of faculty advisor, delay in completion of the project, and a poor grade. Therefore it is important for a student to give careful considerations in selecting a senior project topic.

Senior Project Requirements

A senior project will include the following:

- The project must require 150 to 200 hours to complete over two quarters (approximately 10 hours per week).
- The project must apply knowledge and skills acquired in earlier coursework in the major often from multiple areas of study.
- The project must incorporate design. The design process must be used to create a solution (product, process, or system) to a problem (satisfy a need).
- The project must define an initial state (before the recommended improvements) and a projected state (after implementation of the improvements). There must be a quantifiable comparison between the two states in order to calculate the value of the design.
- The project must include an economic justification.
- The report must include an analysis of the social and environmental impact of the project. This includes a systems view of our design including a thorough exploration of the consequences, both intended and unintended.

The project must be defined in terms of realistic constraints, including economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. These constraints should be made clear as to their effect on the project Design. Although it is understood that not all of these will be of significant impact on every project, each should be considered and justified in the context of the design solution, typically during the Discussion of results. Economic justification, in particular, is required for Industrial and Manufacturing Engineering projects.

Finding a topic

Each student is responsible for deciding on their own topic. Often an area of interest can turn into a really good project topic. **A suitable problem** for an IE or MfgE Senior Design Project is one that requires an IE or MfgE education to solve and produce a good solution. If anyone without an IE or MfgE education could produce a good solution to the problem, then the problem is not a good topic for an IE or MfgE Senior Design Project.
IE Technical Areas include: OR, simulation, facilities, ergonomics, human factors, work measurement, statistics, quality, DOE, data management, information system design, supply chain management, inventory control systems.
MfgE Technical Areas include: manufacturing processes design, CAD/CAM, automation, facilities, ergonomics, work measurement, statistics, quality, DOE, reliability, metrology, data management, information system design, design for manufacturability, production planning and control, supply chain management, and manufacturing simulation.
All projects must include: an economic justification.
The report must include the social and environmental impact of the project. This includes a systems view of our design including a thorough exploration of the consequences, both intended and unintended.

Provided the objectives above (i.e., design, economics, etc.) are addressed in the project, there are many options available to a student in order to find a topic for a senior project. Listed below are a few of the methods students have used in the past.

Industry Generated Projects. Faculty or Industry representatives may often have project ideas that are available to students to work on. These projects require a different level of commitment and students must apply and be accepted by the coordinating faculty to work on these projects. It is important when dealing with an outside agency that the quality of project deliverables is very high. Thus the requirements for these types of projects are more strenuous. At a minimum there will be an additional report out session with the client. This must be arranged by the students taking into account the schedules of all involved. Usually these reports outs will consist of a formal presentation and report delivery. This should be done during the ninth or tenth week of the second quarter of senior project. The Administrative advisor should have a list of these industry projects**.**

Co-op Program or Summer Internship. Students working on a co-op program or a summer internship often work on a project that can be used as a senior project. These company-defined projects are often excellent in that they satisfy all the project requirements listed above and they provide the company with a good solution to a real problem. A student should remember that the deliverable for the senior project must be the "design" of something: a product, process or system. If a student works on implementing a previous designed solution or performing data collection, this may not qualify as a senior project. If a student is working at a company and they find a project that they believe satisfies the requirements for a senior project, the student should contact a faculty member with a project description. The faculty member can help to define the project and possibly give solution technique advice. See Appendix I for details.

Multi-Disciplinary Projects. Sometimes students will work on teams with other non-IME students. These projects will be available at the beginning of Fall quarter only. Please see the special requirements of these projects in a separate section.

Senior Electives. In most senior elective courses, instructors discuss possible areas for senior projects. Students must be aware that these projects will focus to a great extent on the subject matter of the course.

Course Projects. Frequently, students are required to do practical group projects or literature reviews as part of the requirements in the courses. These efforts, may lead to a senior project topic.

Industrial & Manufacturing Engineering Laboratories. The IME Department is engaged continuously in modernizing and expanding its laboratories. Senior projects involving the modernization of these facilities allows the student to work closely with a faculty member and through expanded expertise enhance the student's job opportunities.

Faculty Research Projects. Department faculty may be involved in sponsored or individual research activities. Students with research aptitude may have an opportunity to work in these projects as research assistants. Part of such research can form excellent topics for a senior project.

Current Journals. Students can also develop senior project topics by regularly reading the current issues of journals related to the industrial or manufacturing engineering discipline. This

approach, not only helps in the selection of a good senior project, but also makes a student aware of the wide range of developments taking place in the industrial or manufacturing engineering.

Currently relevant topics. Current meaningful "hot topic" may be suitable senior project topics. Global warming, sustainability, community and service learning project may provide opportunities for a good senior project.

Local companies or non-profits. Sometimes local companies or non-profits have engineering projects that can lead to a senior project. Students can contact them directly. They may have worked with the company or non-profit in other classes and thus have established a working relationship. These companies are a good source for projects.

COURSE STRUCTURE

Students will meet with the administrative advisor in a classroom setting at least five times a quarter. During these meeting, the administrative advisor will discuss topics such as project deadlines, literature reviews and research, methodology, and technical report writing. Several class meeting will also be spent with students giving presentations on their progress.

In addition, students will be expected to meet with their technical advisor at least five times a quarter. This will vary from advisor to advisor and project to project, but in general the student must keep their technical advisor updated on technical issues and progress. Students should be spending approximately 10 hours per week on the project.

Class meetings

The administrative advisors coordinate the senior project lab classes each quarter. A series of deliverables are scheduled throughout the quarter to help students make progress. The IME 481 and 482 covers two quarters and thus the schedule below is for the 20 weeks of the two quarters. **Please refer to IME481/482 course syllabus for exact due dates of deliverables.**

IME481 schedule:

Week 1:

Objective: Define Projects

Students must, by the end of the first week, have a topic for their senior project. See the "Finding a topic" section for aid in this.

Week 2

Objective: Technical Advisor

Students need to meet and discuss their topic with an appropriate technical advisor. The topic and the name of the technical advisor must be reported to the administrative advisor by the end of this week. See above for technical advisor information.

Week 3

Objective: Project Proposal

Students will turn in a project proposal to both the administrative and the technical advisor.

Week 4 and 5

Objective: Work on research and make progress on the project
Students should begin research in the library for their review of literature. Students should also begin work on the project such as data collection or methodology exploration. The exact steps should be discussed with your technical advisor and should have been included in the project proposal above. Project progress report is due in Week 5.

Week 6 and 7

Objective: To complete Introduction Background and Literature Review
Students will complete their literature review and submit Introduction Background and Literature Review sections of their senior project report to both advisors.

Week 8 , 9, and 10

Objective: To make progress on design, and methodology.
Submit IME481 final reports
Students will turn in two separate files at the end of the quarter:
1) Turn in IME481 final report which includes: "Introduction, Background and Lit Review, Proposed Methodology to include specific steps to solve the problem, and plan to complete project" to both advisors for grading.
2) The second deliverable is a presentation in the form of inside-out video recording. This video recording will be evaluated by advisory board members. Please see the evaluation criteria provided in Appendix II. The purpose of this step is to receive constructive feedback from the advisory board members.

In addition, IME 481 students will be invited to observe and evaluate IME 482 students' presentations. Active critique and evaluation of senior project final presentations will help IME 481 students.

IME482 schedule:

Week 1 of second quarter

IME 482 students will give a presentation in class to be evaluated by their peers and IME 481 students.

Weeks 2-4 of second quarter

Objective: To make progress on the project
Students should progress on their project. Each individual should be spending approximately 10 hours per week on the project. The students seek feedback on their progress from the technical advisors.

Week 5 of second quarter

Project Status Report is due.

Weeks 6 and 7 of second quarter

Objective: To make progress on the project

Week 8 of second quarter

Objective: Video recording of presentations will be sent to reviewers
The links of approved inside-out recordings of senior project presentations will be released to IAB members, faculty, and peers.

Week 9 of second quarter

Objective: To submit draft project report, and to present results to IME's constituencies.
Students should submit a complete draft of their senior project to their technical advisor.

This is not a rough draft, but a complete draft with charts and figures and formatted correctly. See writing guidelines below.

In addition, students will participate in a Q&A session. Students will present to a group of either Industrial Advisory board (IAB) members of a group of faculty a presentation outlining the work they did on the senior project. This should be a final presentation of problem, methodology and results.

Week 10 of second quarter

Objective: Submission of IME482 final project report

Students should submit a final copy of the project to their technical advisor for signature and submit to the library. See Senior Project submission guidelines for final submission requirements posted at http://ime.calpoly.edu/media/uploads/IME_Guide_Sr_Prjt_Submit_Prcess_Rev.pdf

Project Proposal. All students registering for IME 481 must prepare a project proposal and submit it to both the administrative advisor and the technical advisor. The senior project proposal must include the following:

1. **Project title and technical advisor's name**
2. **Problem Statement**: A brief description of the problem to be solved or issue to be addressed.
3. **Expected Deliverables**: A brief description of the deliverables for the project.
4. **Technical Approach**: Brief description of the problem solving methodology.
5. **Industrial or Manufacturing Engineering Orientation**: Description explaining the relationship of the project to Industrial or Manufacturing Engineering, including applicable courses and topics and techniques.
6. **Project Outline and Schedule**
    1. Work breakdown structure
    2. Time estimates and milestone dates for proposed work.
    3. Gantt chart

IME 481 Project Status Report:

This report should include technical work accomplished to date. The students might want to add a section on the scope (what you will do and what you won't), and review information submitted in the proposal (above). It is a good idea to start building the project report by adding new sections each time a status report is submitted. Students are encouraged to start writing about the Proposed Methodology that includes specific steps to solve the problem.

IME481 Final Reports

Students will turn in two separate files at the end of the first quarter: Turn in "Introduction, Background and Lit Review, Proposed Methodology to include specific steps to solve the problem, and Plan to complete project" to both advisors.

The second deliverable is an inside-out video recording of PowerPoint presentation to be evaluated by advisory board members. The Industrial Advisor Board members will review your presentation for technical content and provide feedback.

IME 482 Project Status Report

This report should include technical work accomplished to date. This is the last report before the final draft. Try to include as much information as possible to receive meaningful feedback from your technical advisor. It is a good idea to start using the template (see PolyLearn site for the template).

IAB Presentations (both IME 481 and 482)

The Industrial Advisor Board reviews our senior project for technical content and oral presentation ability. Listed below are the basic requirements. Please see Appendix II for evaluation criteria.

- Student has identified and defined a suitable problem
- Student has solved the problem using an appropriate strategy (i.e., the engineering design process)
- Student has used appropriate techniques, skills, or tools for the project (i.e., based on knowledge and skills acquired in course work)
- Student has assessed the economics of the project
- Student shows an ability to communicate effectively.

Draft Senior Project: The initial manuscript must be prepared and submitted in week 9 of IME 482. The initial manuscript represents the cumulative work of the student in the project and includes all the data, analysis and the relevant information to support the notion that the project tasks have been completed.

Final Submission: Generally after the submission of the senior project the technical advisor will fully edit the paper and return it to the student for revisions. Depending on technical advisor's teaching and project supervision load, this will take at least a week. During the last week of the quarter the student will make the revisions and then submit the final paper to the technical advisor. Details of the final submission can be found at http://ime.calpoly.edu/media/uploads/IME_Guide_Sr_Prjt_Submit_Prcess_Rev.pdf

Grading of Senior Project

Grades for the senior project are assigned by both the administrative and the technical advisor. The grading guidelines are listed below.

A All the following are true:
- All deliverables on time, professional quality and complete
- Project suitable for publication
- Topic appropriate for a senior in engineering
- Technical advisor agrees

A- Any of the above areas has slipped once during the quarter
Technical advisor agrees

B Two or more areas are not up to appropriate quality
Technical advisor agrees

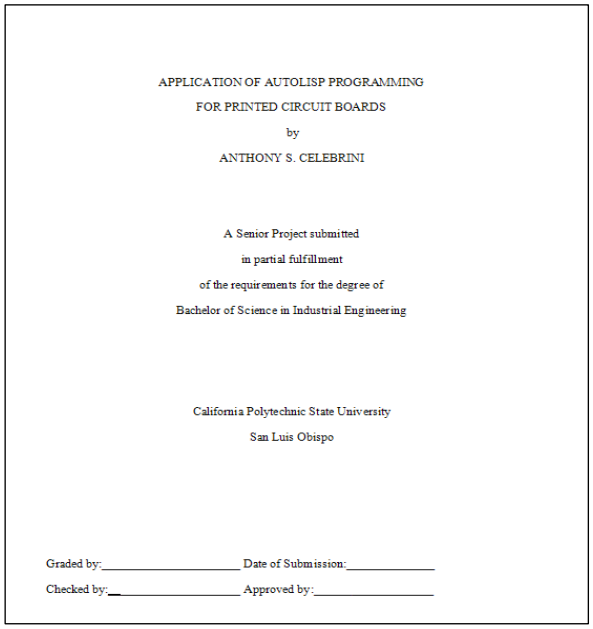
C	Report turned in too late to grade, but appears satisfactory Technical advisor agrees
D	No final report but the majority of the work has been accomplished Technical advisor agrees
D-	Significant portion of the work was accomplished, but nothing was finished Technical advisor agrees
F	Poor attempt at senior project
I	Incomplete grades are not given

WRITING THE REPORT

Organizing the report

Most reports should be organized in the following manner. Sometime there is a valid reason to include extra chapters in within the body of the report.

1. Title page
2. Executive Summary or Abstract
3. Preface and/or Acknowledgements (optional)
4. Table of Contents
5. List of Tables (if appropriate)
6. List of Figures, or illustrations (if appropriate)
7. Notation or symbols (if appropriate)
8. Chapters
    1. Introduction
    2. Background and Literature Review
    3. Design
    4. Methodology
    5. Results
    6. Conclusion
9. References/Bibliography
10. Appendices (if appropriate)



APPLICATION OF AUTOLISP PROGRAMMING
FOR PRINTED CIRCUIT BOARDS
by
ANTHONY S. CELEBRINI

A Senior Project submitted
in partial fulfillment
of the requirements for the degree of
Bachelor of Science in Industrial Engineering

California Polytechnic State University
San Luis Obispo

Graded by:_____ Date of Submission:_____
Checked by:_____ Approved by:_____

Figure 1 - Title Page

Title Page

Title page must be of the same format as shown in the sample (Figure 1). The title must be the same in all the senior project related documents i.e. title page, abstract, senior project requirement form.

Table of Contents

The table of contents should only contain the major divisions of the project, including the list of tables and list of figures, the chapters of the text and their headings exactly as in the text, the bibliography/references cited, the appendices, and their respective page numbers. See Figure 2 for a sample Table of Contents. Consider using the automatic Table of contents function within Word. It can be found under the

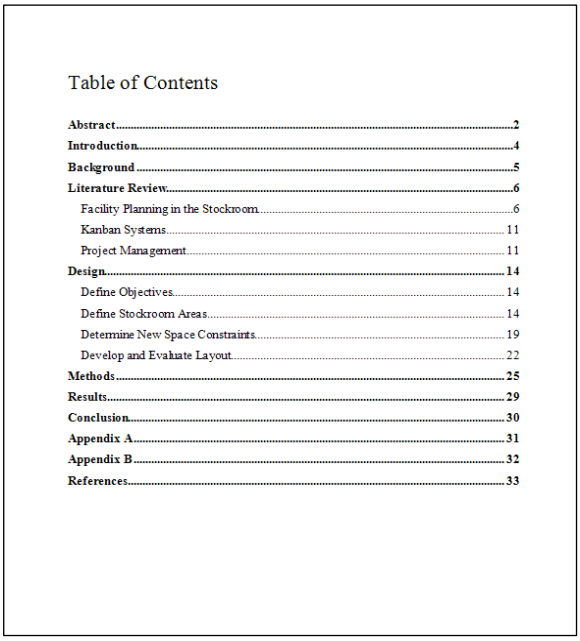


Table of Contents

Figure 2 – Example Table of Contents

"Insert" menu, "Reference" option, "Index and Tables" option, "Table of Contents" tab. This is a very useful method of organizing the document and updating tables, figure and the table of contents.

Executive Summary (or Abstract)

The executive summary is usually less than 500 words. It summarizes all the important points of the study: context, problem, objective, approach, conclusions, and recommendations. When writing this section, imagine that the reader is incredibly simple-minded, or has so little time to think about the report that only the most simple and direct statements are appropriate. Avoid technical vocabulary. Be sure to include the most important findings in your study, but be careful not to promise more than you actually found. Express results in quantifiable financial terms. Note an Executive Summary self-contained and is a substitute for the report itself. The executive summary will fulfill the Library's need for an abstract. An abstract is also usually less than 500 words, is a guide to the report, but does not summarize the report content.

Introduction

This section should present the background/problem addressed by the study. The background/problem tells the reader WHY you performed the study, i.e., what problem you are attempting to solve. The progression is often from a very general background statement to a very specific and concise "problem statement." Though much background may be needed to get the reader ready for the report, only a summary is presented here in the introduction. The rest is placed in the next section (see below).

State the objectives or purpose of the study, i.e., what you hope to accomplish with the project or hope to convey with the report. A set of two to eight objectives is often appropriate and should be listed with bullets. These objectives should clearly define the scope of the project so that the reader is not surprised later by information or is not expecting something that isn't there. Any bulleted list of objectives (or any other list) must have 'parallel' structure; e.g., all starting with action verbs – study, design, investigate, select, etc.

Summarize the solution approach you will take to reach your objectives. If you will experiment, say so, and say why. List the key tasks you will accomplish as you solve the problem. At least some of these tasks must be related to engineering content found in your coursework or related activities and should be generally aligned with your major.

Regardless of the organization of the introduction section, it should answer the following questions:

- What is this report about?
- How did the idea for this project originate?
- What is the problem that needs to be solved?
- What needs to be accomplished to solve this problem?
- What do you intend to complete as part of this project?

- What deliverables will result from your work? Prototype, product design, process design, recommendations, etc.
- How will you meet each of your objectives?
- What will not be included in the scope of the project?
- What main tasks will you perform on the way to completing the project?

Make sure you include a few sentences telling the reader how the rest of the report is organized.

Background (includes Literature Review)

The background should provide a context for the project and should describe any important information the reader needs to know in order to understand what you've done. This may include information concerning existing products, processes, systems, or organizations. Company literature, catalogue or manual information, advertising material, or other literature may be referenced here.

The background may also include important theory that has been developed by others (literature review). This is information the reader should know (or be reminded of) before reading the rest of the report. The theory is what is known (or believed) about the important concepts under study. It may describe a link between process/system inputs and outputs or define how quality, productivity, or cost is related to design decisions. The theory can usually be found in textbooks or landmark articles about the subject. Include references to give credit to the originators of the theory.

The background should also indicate what has been completed or attempted with regards to solving this or similar problems in the past (literature review). The published literature may include those that have attempted to solve the same problem as you, similar problems related to your work, or simply problems related to some of the methods you will use. References to recent works may include journal or magazine articles, theses or previous senior projects, conference proceedings, or other sources. Explain why your project is still necessary in the face of this prior work.

Literature Review

Many students commit themselves to work on their senior project before they have done sufficient background reading on the topic, dismissing the literature search as completed after a few books and articles have been reviewed. Wide reading in the topic is strongly recommended as a means of discovering a suitable project and/or an appropriate approach to analyzing the selected problem. Often as result of such reading, an already selected senior project may be modified extensively or redefined.

A review of the related literature is an essential part of a senior project. The topic must relate to existing knowledge on the subject and must demonstrate an ability to locate, organize, and use the literature in the field. The literature search should be almost complete before proceeding with the project. This literature review will help in defining the problem, and provide insight into the methods and approaches used by others.

The review of the related literature involves locating, reading, and evaluating materials in your area of interest in the library and online. The library is, therefore, an indispensable resource for those engaged in project writing. The efficiency with which materials relevant to problem are located depends considerably on students' knowledge of the University Library and its various resources.

Generally you will need to have at least fifteen references; at least ten of them should be non-internet sources. There is much information online, but you must be diligent in evaluating the sources of the material. Cited material must be pear reviewed and published by a reputable source. Wikipedia is not an acceptable source in a literature review.

The methods of conducting the literature review differ to some extent from subject to subject. However, in most fields the first step consists of locating or identifying key words related to the topic under investigation. This is usually done by checking the main reference sources and textbooks on the subject. These key words are needed to locate specific references in the indexes and abstracts.

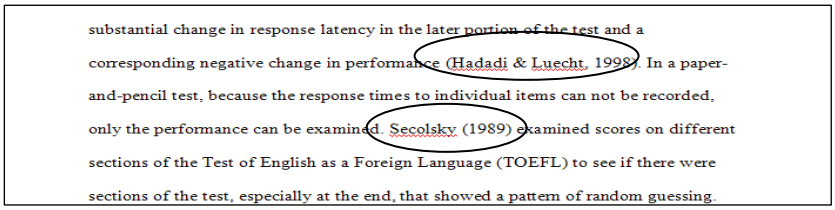
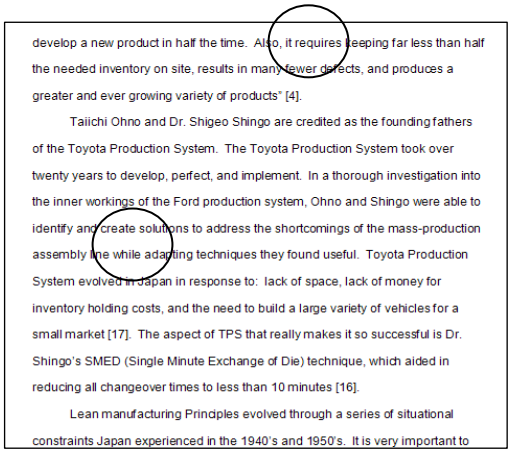

substantial change in response latency in the later portion of the test and a corresponding negative change in performance (Hadadi & Luecht, 1998). In a paper-and-pencil test, because the response times to individual items can not be recorded, only the performance can be examined. Secolsky (1989) examined scores on different sections of the Test of English as a Foreign Language (TOEFL) to see if there were sections of the test, especially at the end, that showed a pattern of random guessing.

Figure 3 - Reference by Author and Year

During the search of indexes and abstracts a bibliography card should be prepared for each book title, report or article which might contain material pertinent to the project. The bibliography card should include all the information necessary to identify the reference, such as author, title, publisher, date, periodical title, volume number, and inclusive paging. PolyCat in the Library will provide this information. Libraries will also have facilities to search for references using key word search through database of current periodicals. Some of the needed materials may not be available in the library, but may be obtained on interlibrary loan.

The review of the literature should include those articles and other references that bear a valid relationship to the problem under study. They should provide the background information that is needed to understand the project's contribution to the field and a point of reference in discussing and interpreting the conclusions in the project.


develop a new product in half the time. Also, it requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever growing variety of products" [4].

Taiichi Ohno and Dr. Shigeo Shingo are credited as the founding fathers of the Toyota Production System. The Toyota Production System took over twenty years to develop, perfect, and implement. In a thorough investigation into the inner workings of the Ford production system, Ohno and Shingo were able to identify and create solutions to address the shortcomings of the mass-production assembly line while adapting techniques they found useful. Toyota Production System evolved in Japan in response to: lack of space, lack of money for inventory holding costs, and the need to build a large variety of vehicles for a small market [17]. The aspect of TPS that really makes it so successful is Dr. Shingo's SMED (Single Minute Exchange of Die) technique, which aided in reducing all changeover times to less than 10 minutes [16].

Lean manufacturing Principles evolved through a series of situational constraints Japan experienced in the 1940's and 1950's. It is very important to

When writing the Literature Review all sources must be cited within the report and in the reference list of the bibliography. One method of citing sources includes a reference to the source by author and year. An example is included in Figure 3. Another method is to reference

the sources by number in the reference list. This is shown in figure 4. Anything reproduced from another source must be cited. Pictures taken by others or figures created by someone else must be referenced.

Design (or Theory)

This is often the longest chapter and usually has subheadings that show the steps used in the design of the solution. For a product, process, or system design, describe the overall approach and the specific steps taken (calculations, reasoning, modeling, etc) to arrive at the initial design. This includes defining requirements, constraints, or user specifications and explaining the initial concept for the design solution and any alternative concepts. Justify each major decision by describing the theory or logic used. Justify any unusual or unique aspects of the design.

Present the original design in the form of drawings, process plans, or system specifications. Your initial cost, quality, or productivity estimates should be presented here. Refer to any drawings, tables, or diagrams in your text - whether these are embedded in the text or placed in an appendix.

If you have developed new theory for this project, derive it in detail in this section. You may change the title from Design to something more appropriate.

Methods (or Experimentation)

In this section you will explain how you tested your design. If a virtual or physical prototype is produced for the product, process, or system design, explain how, including all equipment and methods. Include visual aids. If you ran experiments, indicate what you did, especially detailing your set-up. Describe all equipment and techniques used and conditions of the tests. Justify any non-standard methods. Describe any statistical tests or simulations used to evaluate the design. Include as much information as you feel is relevant. No results, however, should be included unless they are preliminary results used to justify a certain method.

Results and Discussion

In this section you will present the resulting data – whether numerical measurements or subjective observations. You should include only the important results in this section; the rest should be placed in an appendix (you should refer to them in the text). Any tables or figures should be referred to in the text.

Figure 4 - Reference by Number

Describe and explain the results. Answer the following questions:

- Were the results as expected? Why or why not?
- Did the theory hold?
- Is the design a good one?
- Were your cost, quality, or productivity estimates on track

- How should the design or theory be changed based on results? Your progression should be from facts to opinions.

Describe any problems or limitations with the methods or experiment. Answer the following questions:

- Were any unusual conditions present?
- Were any results difficult to interpret?
- Are there some questions that remain unanswered?

Interpret the results in terms of how successful you believe the actual implementation of the design will be. Answer the following:

- Based on the results, what do you predict for the future?
- Where might legitimate problems crop up?
- How should use of the design or theory be limited?

Conclusions (or Summary and Conclusions)

In this section you will summarize the project: problem, objectives, and solution approach.

List a set of conclusions as bullets. Summarize the results by answering the following:

- What were your most important results?
- What can you say about the theory or the topic in general based on your experimental results?
- Did you accomplish each objective listed in the introduction?

What did you learn in the project? How would you do the project differently next time or what would you try next? What do you recommend based on your findings?

Explicitly include the social and environmental impact of the project. This includes a systems view of our design including a thorough exploration of the consequences, both intended and unintended.

Bibliography

All published literature referred to by the student to carry out any of the project tasks must be listed in the bibliography. MLA or APA should be used to format the bibliography. There are several books and online resources that can help in this formatting. The following essential information must be included in the listing: authors, literature title, journal name or publisher's name, volume, number and year of publication, and page numbers referred.

Appendices

Appendices include materials that cannot be presented in the text (due to length, form, or complexity) without interrupting its continuity, but which are helpful in clarifying the meaning of the text. Materials that are valuable in providing supporting evidence, (i.e. summary tabulations, forms, documents, letters, manuals and questionnaires) may also be provided in the appendix.

General Writing Guidelines

Use this as a guide only. Each project has unique elements and may require a different structure or different sections for the report.

- Write the Introduction first, the Executive Summary last.
- Do not use first person in the senior project write up.
- Headings and subheadings should mean something.
- Start each major section with a short explanation of what will be covered.
- Keep in mind who you're writing for and what you want to say. Most senior projects should target a general audience (not your advisor!). Imagine that the most likely people that will read it are a future boss or a future student who wants to know what you did.
- Use headings, subheadings, bulleted lists, tables and figures whenever possible. Refer to all tables and figures in the text (same for Appendices).
- Be honest, cite others, and don't conclude more than your results tell you.
- You don't have to sound like an encyclopedia, but technical writing is meant to inform, not entertain. Shorter sentences often work better.
- Spell-check. It's easy. Consult a resource on grammar and word usage if unsure. Have a friend or colleague read over your work to catch mistakes and suggest changes.

Note: See Senior Project Template posted at PolyLearn.

Multi-Disciplinary Senior Projects

It is possible for a student to work on a project originating outside the IME department. Through the Project Based Learning Institute (PBLI) or as part of a team in another department students can work with other non-IME students to solve an engineering design problem. These projects have several aspects that require special considerations.

Extra units. These projects may be offered over three quarters and generate more than the 5 units necessary for senior project in the IME department. In this case, IME students should enroll in the course as the other students on the team. Five of the units will substitute for IME 481 and IME 482 (a substitution form is necessary) and the other units will be counted as technical elective units.

Advisor. The IME students on the multi-disciplinary team must have a technical advisor in the IME department. This will insure that IME students contribute at an appropriate level to the project team.

Report. The Senior Project report requirements will be replaced by the requirements of the multi-disciplinary team.

Appendix I: Selecting Senior Project topic from Co-op or Internship

If a student is working at a company and they find a project that they believe satisfies the requirements for a senior project, the student should contact a faculty member with a project description. The faculty member can help to define the project and possibly give solution technique advice.

Generally a student on co-op or internship should do the following while still at the company:

1) Obtain Permission from the Company. The student must obtain permission from the company in order to use the project as a senior project. The senior project is published in the library and thus the company needs to know that it will be publicly available. If the company does not want the senior project published, often changing the name of the company is enough to make them feel comfortable. In rare cases, the senior project does not have to be published in the library.
2) Collect data. The student should collect all possible information regarding the project. All computer files, data sheets, and pictures should be gathered before leaving the work site. It is very difficult to go back and collect this information.

If a student is on co-op or internship and receives technical elective unit credit for their work experience, he/she may need to perform extra work (consistent with 150-200 hour requirement) for the senior project beyond the work credited. It is not possible to double count co-op technical elective units and senior project units.

Students who plan to find their senior project topic during summer internships or Coops should make sure they understand all of the following items.

1. It is recommended that students talk with their faculty academic advisor **before** starting their Internship or Coop to discuss senior project requirements while on an internship or Coop.

2. The project must have an **engineering design** component and its solution method follow the **engineering design process** to be a suitable Senior Project topic.

3. Students must obtain **permission** from the company in order to use the project as a senior project.

Obtain Permission from the Company. The student must obtain permission from the company in order to use the project as a senior project. The senior project is published in the library and thus the company needs to know that it will be publicly available. If the company does not want the senior project published, often changing the name of the company is enough to make them feel comfortable. In rare cases, the senior project does not have to be published in the library.

4. Students must perform a **Literature Review** while on Internship or Coop.

5. Students should collect all relevant **data** regarding the project.

All computer files, data sheets, and pictures should be gathered before leaving the work site. It is very difficult to go back and collect this information.

6. IME faculty can volunteer to serve as senior project advisors during Summer Internships or Coops. The IME Chair will serve as the **default senior project advisor** for students during their Summer Internship or Coop.

7. Students should be in **communication** with their senior project advisor during their Summer Internship or Coop.

8. Student must meet with their senior project advisor immediately upon **returning** from their Internship or Coop.

9. Students will have to **register for IME 481/482** during the academic school year (not summer quarter), and while the student is on campus. Students should not register for these courses when on a co-op.

10. There is an expectation that students will need to perform **additional work** (consistent with 150-200 hour requirement) for the senior project beyond the work performed during their Summer Internship or Coop. Some examples may include:

    - Expanding the project into a new area of interest or objectives that may have been overlooked in the original problem statement.

    - Applying the concept or methodology to a slightly different scenario, such as when relaxing some of the original assumptions in the problem.

    - Performing sensitivity analysis and "what-if" variations of the original work.

It is not possible to double count co-op technical elective units and senior project units.

Appendix II: Evaluation Criteria

	1 point	2 points	3 points	4 points	**Points**
Topic Selection	The topic is completely inappropriate for an IME senior project. Anyone without an IE of MfgE degree would be able to produce a good solution.	Topic is marginally appropriate for an IME senior project. Anyone without an IE of MfgE degree would be able to produce an acceptable solution.	Topic is appropriate for IME senior project, with small engineering/ technical content.	Topic appropriate for IME, with suitable engineering/technical content. Requires an IE or MfgE to produce a good solution.	
Problem Statement	The problem statement is too brief, too vague, lacks clarity, is not well articulated, or is extremely narrow in scope, or describes a solution method – not a problem.	The problem statement is marginally explained, or relies on a solution to explain the problem, or is very narrow in scope.	The problem statement is well explained, but includes elements of a solution in it, or is a little narrow in scope.	The problem statement is very well explained, it does not mention the solution method in its explanation, and its scope is broad.	
Report Organization, Clarity, Self-Explanatory	Audience cannot understand report/presentation because there is no sequence of information.	Audience has difficulty following report/presentation because organization is marginal.	Student presents information in logical sequence which audience can follow.	Student presents information in logical, interesting sequence which audience can follow.	
Subject Knowledge - Literature Review	Report does not show any information relevant to the problem, or information presented is irrelevant to the project.	Report shows little information relevant to the problem, or information presented is marginally relevant to the project.	Report shows reasonable amount of information relevant to the problem, or information presented is fairly relevant to the project.	Report shows a thorough amount of information which is very relevant to the problem.	

	1 point	2 points	3 points	4 points	**Points**
Proposed Solution Strategy	The proposed solution strategy/methodology is completely inappropriate for an IME senior project	The proposed solution strategy/methodology is not well thought out for an IME senior project	The proposed solution strategy/methodology is not as good as it could be for an IME senior project	The proposed solution strategy/methodology is well thought out and reflects deep understanding of IME & engineering skills	
Planned Economic Analysis	There is no evidence that an economic justification and cost/benefit analysis are being planned for the project	There is very limited information on the economic justification and cost/benefit analysis being planned for the project	There is appropriate but not convincing information on the economic justification and cost/benefit analysis being planned for the project	There is extensive and convincing information on the economic justification and cost/benefit analysis being planned for the project	
Graphics	Student uses superfluous graphics or no graphics	Report occasionally uses graphics that rarely support the project description.	Report's graphics relate and support the project description .	Report's graphics explain and reinforce the project description very well.	
Mechanics	Report has four or more spelling errors and/or grammatical errors.	Report has two or three misspellings and/or grammatical errors.	Report has no more than one misspelling and/or grammatical errors.	Presentation has no misspellings or grammatical errors.	
				Total Points	