College of Engineering
Mechanical & Aerospace Engineering Department

AE 170 A/B
Aircraft &Spacecraft Design
And
ME 195 A/B
Mechanical Engineering Senior Design Project

Edited by

Fred Barez

2004-2005

Compilation Sources

The materials presented here are compiled from a number of textbooks, trade journals, manuals, and handbooks. The following is an abbreviated list of the sources:

1. Engineering Design: A Materials and Processing Approach, by G.E.Dieter.
2. Drawing Requirements Manual, edited by J.Lieblish.
3. Engineer-in-Training Reference Manual, by M.Lindeburg.
4. American Society of Mechanical Engineers (ASME) publications.
5. Mechanical Engineering, the ASME magazine.
6. Machine Design, a trade journal.
7. Appliance Manufacturer, a trade journal.

Preface

This book is intended to provide some helpful information and reference material to students who are about to begin their senior design project course sequence.

The book starts with a presentation of the forms and samples used through out the course. This includes (1) Project Proposal and a sample, (2) Monthly Progress Report format and a sample, (3) Single-Page Project Summary and a sample, and (4) Reimbursement form.

Section 2 of the book helps to identify methods to form a successful team to carry out a project. Section 3 discusses the design process followed by Section 4 in preparing a timetable to complete the project.

Sections 5 and 6 discuss broad definitions of Product Liability and Ethics, respectively.

Section 7 provides some helpful suggestions on project presentation including preferred formats for written and oral delivery of the project contents.

The assistance of David North and Suzy Quinn in the compilation of this material is greatly acknowledged.

Table of Contents

Safety Rules

1. Students may not begin scheduled laboratory work prior to the arrival of the instructor.

2. Students may work in the laboratories at times other than regularly scheduled periods only by special arrangement, and must carry identification indicating such approval permission is granted by the instructor with the approval of the department chairman.

3. No student is permitted to work alone in a laboratory with equipment or materials when the procedures are considered to be hazardous by so doing.

4. Students must clean the equipment and areas used during laboratory periods. Equipment issued for laboratory use must be returned at the close of the laboratory period.

5. Students will be held financially responsible for breakage or damage to laboratory equipment due to their own negligence or abuse.

6. Smoking, eating food and drinking beverages, running or acting in a manner that might produce unsafe conditions, are prohibited in all laboratory and classroom areas.

7. Students must observe safety precautions governing laboratory activities as outlined by the instructor. Safety hazards should be reported to the instructor as soon as possible.

Emergency Phone Numbers

FOR ANY EMERGENCY:

Pick up the blue phone

or dial 911 on any regular phone

Nearest telephone	:	Located in lab
Nearest fire alarm box	:	Located in hall
Nearest fire extinguisher	:	Located in lab
Nearest first aid box	:	Located in lab
Safety shower and eyewash	:	Located in Room E113

Section 1

ME 195 A/B

Forms and Samples

Project Proposal

Each group in collaboration with the faculty advisor and industry sponsor, if any, is to develop a one-page proposal outlining the specific activities required including deliverable.

Be sure to follow the format and example provided over the next page, to prepare your project proposal.

Project Proposal Format

Title	**:**			
Industry Sponsor	**:**			
Address	**:**			
Industry Mentor	**:** Name and Address			
				Tel#:
				Fax#:
				E-mail:
Faculty Advisor	**:** Name			Tel#:
				Fax#:
				E-mail:
Student Team Member	**:** 1.	(Manager)	Tel#:	Email:
	2.		Tel#:	Email:
	3.		Tel#:	Email:
Project Scope	**:**			
Project Objectives	**:**			
Deliverables	**:**			
Timetable	**:**			
Available Resources (Facilities & Funding)	**:**			
Approval Signatures	**:**			Date:
Students	**:** 1.			
	2.			
	3.			
Faculty	**:**			
Industry Mentor	**:**			

Project Proposal
(Sample)

Title	:	Air-Conditioning Unit Experiment
Industry Sponsor	:	American Society of Heating, Refrigeration, & Air-conditioning Engineers, Inc. (ASHRAE)
Faculty Advisor	:	Jesse Maddren — Tel#: (408)-924-3850 Fax#: (408)-927-7133 E-mail: jmaddren@email.sjsu.edu
Student Team	:	1.Don Miller (Manager) Tel#:(408)-262-4854 2.Matt Nevins Tel#:(408)-927-7133 3.Terri Heflin Tel#:(408)-629-1391
Project Scope	:	Rework of existing air-conditioning unit by integrating a computer data acquisition system. (...computer control if time permits)
Project Objectives	:	1.Replace wet and dry bulb thermometers with electronic sensors. 2.Replace liquid manometers with electronic pressure sensor. 3.Replace mechanical pressure gauges and thermometers with electronic sensors to measure state of refrigerant in vapor-compression cycle. 4.Rework boiler to increase its efficiency. 5.Streamline experiment to enable 100% computer data acquisition. 6.Develop software for automated data acquisition. 7.Write new experimental procedures which reflect the changes made to the air-conditioning unit.
Deliverables	:	1.Fully functional data acquisition unit. 2.Fully developed data acquisition software (Labview). 3.Modified boiler (cleaned w/perhaps new parts). 4.Automated pressure transducers. 5.Automated humidity sensors. 6.Analytical write-up of revamped air-conditioning system.
Timeline	:	See attached pages.
Available Resources	:	ASHRAE and the MAE Department.
Approval Signatures	:	
Students	:	1. _______________ Date: ______________ 2. _______________ Date: ______________ 3. _______________ Date: ______________
Faculty	:	_______________ Date: ______________

Monthly Progress Report

Each group is expected to provide monthly reports informing their advisor and industry sponsor of their activities and progress though out the semester.

See the format and an example of such report over the next pages.

Monthly Progress Report Format

Course No. and Title :

Project Title :

Student Team Member: 1. (Manager) Tel#: Email:

2. Tel#: Email:

3. Tel#: Email:

etc.

Report Period :

Accomplishments :

Problems Encountered :

Solutions Implemented/Proposed:

Future Activities (next 4 wks):

Student Team Contribution:

	Student Name	Task Performed	Hours Contributed
1.	(Manager)		
2.			
3.			
etc.			

Monthly Progress Report

Course No. and Title	**:**	ME195B, Senior Design Project
Project Title	**:**	Catheter Tipping and Trimming Machine
Student Team	**:**	1. Coung Tran (Manager) Tel#: (408) 259-5426 2. Kim Lien Dang Tel#: (408) 247-2977 3. Thanh Dinh Tel#: (408) 929-1484 4. Dung Phung Tel#: (510) 429-9556
Report Period	**:**	3/15/98-4/15/98

Accomplishments **:**

- Completing PLC programming to control the electrical and pneumatic system.
- Completing the control box with its electrical and pneumatic schematics.
- Completing the combination of two mechanisms into one mechanism to perform both functions.
- Completing the tests of the catheters before making a final decision.
- Completing running tests of tipped and trimmed catheters with high yield: 95%.
- Completing the final demonstration with help of Advisor Professor Barez and Mentor President Danise.

Problems Encountered: Unsuccessful in achieving the expected result: 98% yield.

Solutions Implemented/Proposed:

- Modify mechanism linkage length (Tran 20APR98)
- Re-run yield tests (Dinh 22APR98)

Future Activities (next 4 wks):

- Finish drawings, schematics and documents (Phung 25APR98)
- Prepare for the final presentation (all 05MAY98).
- Finishing the final report (all 05MAY98).
- Etc., etc… **(Owner *date_task_complete*)**

Student Team Contribution:

<u>Students name</u>	<u>Task Performed</u>	<u>Hours Contributed</u>
1. Cuong Tran (Manager)	Test of catheters/control box design (Provide some details)	24hrs
2. Kim Lien Dang	PLC programming	22hrs
3. Thanh Diah	Combined 2 mechanisms into one (Provide some details)	23hrs
4. Dung Phung	Ran tests of tipped and trimmed catheters. (Provide some details)	25hrs

Single-Page Project Summary

Each group is required to prepare a one-page summary of their project. This summary includes:

Title
Project Scope and Objective
Project Results
Sponsor
Faculty Advisor
Student Team Members

Be sure to include a 'clear' photo or drawing of your project to fit in a "3x3" space in the lower right hand side of the page as shown on the following page.

This summary is required and due to your advisor by May 1 for inclusion in the 'Senior Design Project Summary ' booklet available on the 'Engineering Conference Day'.

Single-Page Project Summary Format

Title:

Project Scope and Objectives:

Project Results:

Sponsor:

Faculty Advisor:

Student Team Members:

3" x 3" Space for a photo or a drawing of the final project

Inverted Pendulum Project Summary

Title: Fuzzy Logic Control of an Inverted Pendulum/Crane System

Project Scope and Objectives:

1. Design and fabricate system components for sustaining of an inverted pendulum. This includes designing for cost and minimization of friction within the system for ease for pendulum motion.
2. Design an algorithm that is capable of sustaining the pendulum in the upright position.
3. To maintain pendulum in the inverted position with minimum oscillation.

Project Results:

1. All hardware components have been designed, fabricated, and assembled.
2. Computer simulation to test system dynamics and controller algorithm is completed.
3. Controller algorithm and state variables defining system behavior has been created.
4. Testing and implementation of Analog/Digital converter communication card has been completed.
5. Program interface between hardware feed back and controller has been completed.

Sponsor: Mechanical & Aerospace Engineering Department, San Jose State University

Faculty Advisor: Dr. Addisu Tesfaye

Student Team Members:

1. Mike Lau
2. Clayton Young
3. Alan Yu

Senior Design Project Expense Reimbursement

Projects not supported by industry are eligible for some reimbursement of expense incurred related to their activity.

This amount is limited to $50 per student in each group and to be paid for materials purchased only.

The form on the next page may be copied for reimbursement purpose.

Fill out the form completely and submit along with all original receipt. Receipts are to be attached to an 81/2"x11" sheet of paper.

ME 195A/B Senior Design Project Expense Reimbursement Form

Semester : ____

Project Title : ____

Faculty Advisor : ____

Student Member : ____________________ ____________________
____________________ ____________________

Project Start Date : ____________________

Please answer questions in one area A, B, or C below:

A-Project Sponsored by Industry: Yes ____________, No _____________
Industry/Company Name: _________________________________
Amount Contributed by Company: __________________________

B-Project Sponsored by ME faculty: Yes __________, No _____________
Is this project a laboratory hardware: Yes ________, No __________
Which laboratory will be located at: _________________________

C-Project is of own personal interest: Yes __________, No ____________
Who sponsored this project? _______________________________
Amount of financial support provided? _______________________

Amount Spent: ____

Amount Requested: ____

Requester's Name: ______________, Social Security No:_______________
Address: ____
____

Requester's Signature: ____

Faculty Approval: ____

Sr. Project Director Approval: __________________________________

Amount Requested may not exceed no. of students x $ 50.00

Reimbursement Amount Authorized: ______________________________

Section 2

Team Building

Building A Winning Team

2.1 Getting started

Because of the different personalities and disciplines coming together, conflict and confrontation are to be expected in the early stages before standard operating procedures are in place. Allow a trial period of at least three to four weeks before expecting a work group to become a full-fledged team.

The fruit of teamwork is the synergy that results. Members should trust and enjoy working with one another, and they should be proud of what they accomplish.

2.2 The ideal leader

In general, a team leader is the liaison between the team and the faculty advisor or industry sponsor. In a team's early stages, the leader is generally a manager or supervisor. When the team has its objectives in place, it will elect a leader, who is in agreement with the team as well as the faculty advisor or industry sponsor.

Leadership embodies the ability to inspire and organize others to work together to achieve a goal. An ideal leader is a role model, leading by example and exhibiting these characteristics:

- Highly developed interpersonal skills-He or she is flexible and displays empathy for other.
- Organizational effectiveness-An effective leader is attuned to the needs of the group and recognizes team members' strengths and capabilities.
- Communication skills- Clarifying what needs to be done is vital in working with team members as well as faculty advisor or industry sponsor.
- Ability to deal with problem team members-The ideal leader first diagnoses the problem, then becomes involved or takes ownership of it, suggests corrective behavior, gets agreement on the facts and a plan of action, reinforces the plan, and if all else fails, takes the final step, which is to get rid of the problem member.

2.3 Communicating

The next major step in team building involves communicating with team members.

2.4 Motivation

The key to success is to get people to like working hard. In this fifth step in team building, There are five reasons why people don't do what they're supposed to do:

- They don't know what they're supposed to do.
- They don't know how to do it.

- They don't have sufficient information and resources.
- They refuse to do it.
- They were never given a reason why they should do it.

2.5 Evaluation

Member contributions are to be evaluated and recognized. This reinforces a team's success, creates camaraderie, and leads to higher level of performance.

Section 3

Design Process

3.1 Introduction

What is design? If you search the literature for an answer to that question, you will find about as many definitions as there are designs. Perhaps the reason is that the process of design is such a common human experience. Webster's dictionary says that to design is " to fashion after a plan," but that leaves out the essential fact that to design is to create something that has never been.

Thus, although engineers are not the only people who design things, it is true that the professional practice of engineering is largely concerned with design; it is frequently said that design is the essence of engineering. To design is to pull together something new or arrange existing things in a new way to satisfy a recognized need of society. An elegant word for "pulling together" is synthesis. We shall adopt the following formal definition of design: [1] "Design establishes and defines solutions to problems which have previously been solved in a different way."

Good design requires both analysis and synthesis. In order to design something we must be able to calculate as much as about the thing's behavior as possible by using the appropriate disciplines of science or engineering science and the necessary computational tools. Analysis usually involves the simplification of the real world through models. It is concerned with the separation of the problem into manageable parts, whereas synthesis is concerned with assembling the elements into a workable whole.

3.2 The Design Process

We frequently talk about "designing a system." By a system we mean the entire combination of hardware, information, and people necessary to accomplish some specified mission. A system may be an electric power distribution network for a region of the nation, a procedure for detecting flaws in welded pressure vessels, or a combination of production steps to produce automobile parts. A large system usually is divided into subsystems, which in turn are made up of components.

Examples of the operations might be 1) exploring the alternative systems that could satisfy the specified need, 2) formulating a mathematical model of the best system concept, 3) specifying specific parts to construct a component of a subsystem, and 4) selecting a material from which to manufacture a part. Each information that is expected of the trained professional and some of it very specific information that is needed to produce a successful outcome.

3.3 A Simplified Design Process

Once armed with the necessary information, the design engineer (or design team) carries out the design operation by using the appropriate technical knowledge and computational and/or experimental tools. At this stage it may be necessary to construct a mathematical model and conduct a simulation of the component's performance on a digital computer. Or it may be necessary to construct a full-size prototype model and test it to destruction at a proving ground. Whatever it is, the operation produces a design outcome that, again, may take many forms. It can be a ream of computer printout, a rough sketch with critical dimensions established, or a complete set of engineering drawings ready to go to the manufacturing department. At this stage the design outcome must be evaluated, often by a team of impartial experts, to decide whether it is adequate to meet the need. If so, the designer may of on to the next step. If the evaluation uncovers deficiencies, then the design operation must be repeated. The information from the first design is fed as input, together with new information that has been developed as a result of questions raised at the evaluation step. Each objective requires an evaluation, and it is common for the decision-making phase to involve repeated trials or iterations. The need to go back and try again should not be considered a personal failure or weakness. Design is a creative process, and all new creations of the mind are the result of trial and error. In fact, if it were possible to work a design straight through without iteration, the design would indeed be very routine. This iterative aspect of design may take some getting used to. You will have to persevere and work the problem out one way or the other.

The iterative nature of design provides an opportunity to improve the design on the basis of a preceding outcome. That, in turn, leads to the search for the best possible technical condition, e.g., maximum performance at minimum weight (or cost).

3.4 The Design Process Steps

To further illustrate the design process, we consider the process to consist of the following steps:

- Recognition of a need
- Definition of a problem
- Gathering of information
- Conceptualization
- Evaluation
- Communication of the design

The design process generally proceeds from top to bottom in the list just given, but it must be understood that in practice some of the steps will be carried out in a parallel and that feedback leading to iteration is a common fact of design.

3.5 Recognition of a Need

Needs are identified at many points in a business or agency. Most organizations have research or development components whose job it is to create ideas that are relevant to the needs of the organization. Needs may come from inputs of operating or service personnel or from customers through sales or marketing representatives. Other needs are generated by outside consultants, purchasing agents, government agencies, or trade associations or by the attitudes or decisions of the general public.

Needs usually arise from dissatisfaction with the existing situation or wanting one. They may be to reduce cost, increase reliability or performance.

3.6 Definition of a Problem

Probably the most critical step in the design process is the definition of the problem. The problem is not always what it seems to be at first glance. Because this step requires such a small part of the total time to create the final design, its importance is often overlooked.

It is advantageous to define the problem as broadly as possible. If the definition is broad, you will be less likely to overload unusual or unconventional solutions. Broad treatment of problems that previously were attacked in piecemeal fashion can have a big payoff. However, you should realize that the degree to which you can purse a broad problem formulation toward a final design will depend on factors often outside your control. Pursuit of a broad formulation may bring you into direct conflict with decisions already made by your employer or client, or it may lead you into areas of responsibility of other persons in the organization. In most cases the extent to which you are able to follow a broad problem formulation will depend on the importance of the problem, the limits on time and money that have been placed on the problem, and your own position in the organization.

One approach that you should not take is to consider the existing solution to the problem to be the problem itself. That approach immediately submerges you in the trees of the forest, and you will find yourself generating solutions to a problem that you have failed to define.

The definition of a problem should writing down a formal problem statement, which should express as specifically as possible what the design is intended to accomplish.

3.7 Gathering of Information

Perhaps the greatest frustration you will encounter when you embark n your first design problem will be due to the dearth or plethora of information. No longer will your responsibility stop with the knowledge contained in a few chapters of a text. Your assigned problem may be in a technical area in which you have no previous background, and you may not have even a single basic reference on the subject. At the other extreme you may be presented with a mountain of reports of previous work and your task will be keeping from drowning in paper. Whatever the situation, the immediate task is to identify the needed pieced of information and find or develop that information.

The following are some of the problems connected with obtaining information:

- Where can I find it?
- How can I get it?
- How credible and accurate is the information?
- How should the information be interpreted for my specific need?
- When do I have enough information?
- What decisions result from the information?

3.8 Conceptualization

The conceptualization step is to determine the elements, mechanisms, processes, or configurations that in some combination or other result in a design that satisfies the need. It is the key step for employing inventiveness and creativity.

Very often the conceptualization step involves the formulation of a model which maybe either of the two general types: analytical and experimental. In most of your engineering courses the emphasis has been on the development of analytical models based on physical principles, but experimental models are no less important.

A vital aspect of the conceptualization step is synthesis. Synthesis is the process of taking the elements of the concept and arranging them in the proper order, sized and dimensioned in the proper way. Synthesis is a creative process and is present in every design.

3.9 Evaluation

The evaluation step involves a thorough analysis of the design. The term evaluation is used more in the sense of weighing and judging than in the sense of grading. Typically the evaluation step may involve detailed calculation, often computer calculation, of the performance of the design by using an analytical model. In other cases the evaluation may involve extensive simulated service testing of an experimental model or perhaps a full-sized prototype.

An important consideration at every step in the design, but especially as the design nears completion, is checking. In general, there are two types of checks that can be made: mathematical checks and engineering-sense checks. Mathematical checks are concerned with checking the arithmetic and the equations used in the analytical model. Incidentally, the frequency of careless math errors is a good reason why you should adopt the practice of making all your design calculations in a bound notebook. In that way you won't be missing a vital calculation when you are forced by an error to go back and check things out. Just draw a line through the part in error and continue. It is of special importance to ensure that every equation is dimensionally consistent.

3.10 Communication of the Design

It must always be kept in mind that the purpose of the design is to satisfy the needs of a customer or client. Therefore, the finalized design must be properly communicated, or it may lose much of its impact or significance. The communication is usually by oral presentation to the sponsor as well as by a written design report. Detailed engineering drawings, computer programs, and working models are frequently part of the "deliverables" to the customer. It hardly needs to be emphasized that communication is not a one-time thing to be carried out at the end of the project. In a well-run design project there is continual oral and written dialog between the project manager and the customer.

3.11 Design Drawings

Engineering drawings are vital for communicating the design. Although at one time it could be assumed that most engineering graduates were proficient in engineering drawing, today the education of an engineer provides limited exposure to the subject. Clearly, the time devoted to engineering drawing in the present education of an engineer is not commensurate with the practical importance of the subject. Every engineer, who deals more than casually with design should be well grounded in the elements of orthographic projection, be able to read the language of engineering drawings fluently, and be able to produce an acceptable sketch that can be converted by a draftsman into an engineering drawing.

Engineering drawings also often contain instructions on 1) the surface roughness or surface treatment of the part, 2) the required heat treatment, and 3) the inspection or testing of the part. When the information is too detailed or voluminous, the drawing has a reference to a specification or standard that will supply the needed information.

Different kind of engineering drawings are used for various purposes. A detail drawing gives a complete description of the shape of a part using up to three orthographic views and possibly one or more section views. It provides all of the information for producing the part. The detail drawing specifies the material finished dimensions, surface finish, and any special processing (such as heating treating). Usually a separate drawing is made for each component. Such a drawing normally will include a parts list that identifies component part numbers, part names, and the required number of pieces. Schematic drawings show the manner in which components are connected together, as in a piping system or electronic control system. The components are shown in symbolic form in this type of drawing.

Three aspects of engineering drawing that are often overlooked in an introduction to the subject but are vital in design practice are dimensions, tolerance, and specification of surface finish. Careful attention to those aspects of engineering drawing can greatly improve the cost and quality of a design.

3.12 Tolerances

Tolerances must be placed on the dimensions of a part to limit the permissible variations in size because it is impossible to manufacture a part exactly to given dimensions. A small tolerance results in greater ease of interchangeability of parts, but it also greatly adds to the cost of manufacture.

Tolerances can be expressed in either of two ways. A bilateral tolerance is specified as a plus or minus deviation from a basic dimension, e.g., 2.000 ± 0.004 in. This system is being replaced by the unilateral tolerance, in which the deviation in one direction from the basic dimension is given. For example,

$$2.000\begin{smallmatrix}+0.008\\-0.000\end{smallmatrix} \quad \text{or} \quad 5.005\begin{smallmatrix}+0.000\\-0.005\end{smallmatrix}$$

In the case of bilateral tolerance, the dimension of the part would be permitted to vary between 1.996 and 2.004 in for a total tolerance of 0.008 in. If unilateral tolerances have the advantages that they are easier to check on drawings and that a change in the tolerance can be made with the least disturbance to other dimensions.

The American National Standards Institute (ANSI) has established eight classed of fit that specify the amount of allowance and the tolerance on the hole size *d* is the basic dimension, because most holes are produced by using produced to a nonstandard dimension. Consider a basic hole size of 2.000 in and a class (medium) fit.

Allowance $0.009(2)^{2/3}$=0.0014 in

Tolerance $\pm 0.0008(2)^{2/3}$=0.0010 in

Hole

Maximum dimension 2.001 in

Minimum dimension 2.000 in

Shaft

Maximum dimension 2.000- 0.0014=1.9986 in

Minimum dimension 1.9986-0.001=1.9976 in

Therefore, the maximum clearance between shaft and hole is

2.0010-1.9976=0.0034 in

And the minimum clearance between shaft hole is

2.00-1.9986=0.0014 in

3.13 Dimensions

The engineering drawing provides the manufacturing department with the information necessary for producing the part. Therefore, it is important that the dimensions of the part be clear and complete. The dimensions given should be sufficient in number to make it unnecessary for shop personnel to perform involved calculations for setting up the production equipment. On the other hand, too many dimensions can cause problems by resulting in ambiguity and leaving the manufacturing department with a choice.

3.14 Computer-Aided Engineering

The advent of plentiful computing is having a major impact on how engineering is practiced. While engineers were one of the first professional groups to adapt the computer to their needs, the early applications chiefly were computational intensive ones.

The greatest impact of computer-aided engineering to date has been in engineering graphics. The automation of drafting in two dimensions (CAD) has become commonplace. Such geometric modeling capabilities tie in nicely with analysis capabilities introduced through extensive use of finite element modeling (FEM). This makes possible interactive simulations in such problems as stress analysis, kinematics of mechanical linkages, and numerically controlled tool path generation for machining operations. The computer extends the designer's capability in several ways. First, by organizing and handling time-consuming and repetitive operations, it frees the designer to concentrate on more complex design situations. Second, it allows the designer to analyze complex problems faster and more completely. Both of these factors make it possible to carry out more iterations of design. Finally, through a computer-based information system the designer can share more information sooner with people in the company, like purchasing agent, tool and die designers, manufacturing engineers, and process planners, who need the design information. The link between computer-aided design (CAD) and computer-aided manufacturing (CAM) is particularly important, and often difficult to achieve.

3.15 Computer-Aided Design

The widespread use and decreasing cost of the computer have brought about a revolution in the practice of engineering design. There are two different aspects to this fantastic change in design practice.

- Through on-line interaction with the computer in real time, the designer is able to utilize the computer and its graphics input-output devices to perform many of the routine aspects of design at far greater speed and lower cost. For example, the designer is able to draw objects on a graphics display terminal and, by utilizing computer software, portray the object in a three- dimensional view, and oblique view, or in any cross section.
- By employing computer software codes based on the finite-element method, the designers are able to perform powerful analytical procedures. The actual structural members under analysis can be displayed graphically. Graphical simulation, such as how a structure deforms under load, and be observed. The interactive mode of communication with the computer through the graphics terminal permits easy iteration procedures and design optimization.

The development of the finite-element method (FEM) coupled with computer analysis has created a new and powerful tool for the analysis of engineering problems. Now the analysis can be performed on a complex shape with the actual loads rather than use a simplified geometry and/or loads for which a solution is available.

3.16 Design Review

The design review is a vital aspect of the design process. It provides an opportunity for specialists from different disciplines to interact with generalists to ask critical questions and exchange vital information. A design review is a retrospective study of the design up to that point in time. It provides a systematic method for identifying problems with the design, aids in determining possible courses of action, and initiates action to correct the problem areas.

To accomplish these objectives the review team should consist of representatives from design, manufacturing, marketing, purchasing, quality control, reliability engineering, and field service. The chairman of the review team is normally a chief engineer of project manger with broad technical background and broad knowledge of the company’s products. In order to ensure freedom from bias the chairman of the design review team should not have direct responsibility for the design under review.

Depending on the size and criticality of the project, full-scale design reviews should be held at three or four times in the life of the project. The first review should be held when concept feasibility has been established. The problem definition and initial specifications should be critically examined with respect to the needs of the marketplace. If the feasibility study has been done by the research laboratory, them this review is especially critical to pass on information to the engineering group. Sometimes an intermediate design review is conducted before the detail drawings have been completed. This review would look critically at the interfaces between the specialty design teams, e.g. mechanical, electronics, materials, and begin to discuss tooling and packaging. A design review after the detail drawings are complete will ensure that the dis8ign is ready for prototype testing. A review after the completion of prototype testing is critical to ensure that there are no loose ends to the project. The purpose of this review is to fine-tune the design prior to authorizing full-scale production. This review focuses on achieving the performance, producibility, cost, and reliability goals. There may also need to be a final acceptance review prior to handing the project over to the customer.

It is helpful to prepare a checklist for the design review. The major headings should consist of:

1. Design requirements
2. Functional requirements
3. Environmental requirements
4. Manufacturing requirements
5. Reliability-related requirements

For each item under these headings answer yes or no as to whether the condition has been fulfilled by the design.

Section 4

Project Planning and Scheduling

Project Planing and Scheduling

4.1 Importance of Planning

It is an old business axiom that time is money. Therefore, planning future events and scheduling them, so they are accomplished with a minimum of time delay is an important part of the engineering design process. For large construction and production projects, detailed planning and scheduling is a must. Computer-based methods for handling the large volume of information have become commonplace. However, engineering design projects of all magnitudes of scale can profit greatly by applying the simple planning and scheduling techniques discussed in this chapter.

One of the most common criticisms leveled at the young graduate engineer is an overemphasis on technical perfection of the design and not enough concern for completing the design on time and below the estimated cost. Therefore, the planning and scheduling tools presented in this chapter can profitably be applied at the personal level as well as to the more complex engineering project.

In the context of engineering design, planning consists of identifying the key activities in a project and ordering them in the sequence in which they should be performed. Scheduling consists of putting the plan into the time frame of the calendar. The design process generally is divided into the following phases.

- Feasibility study
- Preliminary design-the concept phase
- Detail design
- Production phase
- Operational phase

Usually, a detailed design review is conducted at the end of each phase to establish whether the results warrant advancing into the next phase. The alternatives may be to repeat the phase or abandon the project. Frequently, well-defined decision points or milestones are established partway through a phase in order to provide a target to strive for and a way to control the project.

The major decisions that are made over the life cycle of a project fall into four areas: performance, time, cost, and risk.

- Performance-The design must possess an acceptable level of operational capability or the resources expended on it will be wasted. The design process must generate satisfactory specifications to test the performance of prototypes and production units.
- Time-In the early phases of a project the emphasis is on accurately estimating the length of time required to accomplished the various tasks and scheduling to ensure that sufficient time is available to complete those tasks. In the production phase the

time parameter becomes focused on setting and meeting production rates, and in the operational phase it focuses on reliability, maintenance, and resupply.

- Cost-The importance of cost in determining what is feasible in an engineering design has been emphasized in earlier chapters. Keeping costs and resources within approved limits is one of the chief functions of the project manager.
- Risk-Risks are inherent in anything new. Acceptable levels of risk must be established for the parameters of performance, time, and cost, and they must be monitored throughout the project.

The most crucial step for planning is the preliminary design phase. At its completion the design concept has been formulated and must be expressed in terms of performance standards, a time schedule, a cost estimate, and a risk assessment. At this stage, performance characteristics are usually the deciding factors in the tradeoff studies.

The first step in developing a plan is to identify the activities that need to be controlled. The usual way to do that is to start with the system and identify the 10 or 20 activities that are critical. Then the larger activities are broken down into subactivities, and these in turn are subdivided until you get in a hierarchical fashion from the system to the subassembly to the component to the individual part.

Section 5

Product Liability

Product Liability

5.1 Definition and Background

Product liability is the area of law in which the liability of sellers of products falls. It is one of many kinds of torts, which are defined as injuries or wrong to a person or personal property. The number of product liability claims is increasing very rapidly because of recent changes in the interpretation of the law. Not only has the number of legal actions increased by a factor of 20 over a 15-year period but the cost of product liability insurance also has increased five-fold in ten years.

For over 100 years the legal concept of privacy restricted the widespread use of product liability actions. Privity is the relationship which exists between the buyer and the seller or two or more contracting parties. The courts held that the injured party could sue only the party in privity. Thus, if a consumer was injured by a power tool, he could sue only the retailer who sold him the tool; the retailer, in turn, could sue only the wholesaler, who in turn could sue the manufacturer. Now that the courts have abandoned the concept of privity in product liability, the injured consumer can sue all members in the manufacturing chain. From the viewpoint of recovering damages it obviously is an advantage to be able to directly sue the manufacturer, whose resources are likely to be much greater than those of the owner of the neighborhood hardware store.

A second major change in the law of product liability is the almost universal adoption by the courts of the standard of strict liability. Previously manufacturers or sellers were liable only when they could be proved negligent or unreasonably careless in what they made or how they made it. It had to be proved that a reasonable manufacturer using prudence would have exercised a higher standard of care. However, today in most states a standard of strict liability is applied. Under this theory of law the plaintiff must prove that: 1) the product was defective and unreasonably dangerous, 2) the defect existed at the time the product left the defendant's control, 3) the defect caused the harm, and 4) the harm is appropriately assignable to the identified defect. Thus, the emphasis on responsibility for product safety has shifted from the consumer to the manufacturer of products.

A related issue is the use for which the product is intended. A product intended to be used by children will be held to a stricter standard than one intended to be operated by a trained professional. Under strict liability a manufacturer may be held liable even if a well-designed and well-manufactured product injured a consumer who misused or outright abused it.

5.2 Goals of Product Liability Law

Only 100 years ago it was the practice in American and British law not to respond to accidental losses. It was generally held that the accident victim, not the manufacturer, should bear the economic burdens of injury. Starting in the mid-twentieth century the law began to assume a more active role. Product liability law evolved to serve four basic societal goals: loss spending, punishment, deterrence, and symbolic affirmation of social values. Loss spreading seeks to shift the accidental loss from the victim to other parties better able to absorb or distribute it. In a product liability suit the loss is typically shifted to the manufacturer, who theoretically passes this cost on to the consumer in the form of higher prices. Often the manufacturer has liability insurance, so the cost is spread further, but at the price of greatly increased insurance rates.

Another goal of product liability law is to punish persons or organizations responsible for causing needless loss. It is important to recognize that under liability law the designer, not just the company, may be held responsible for a design defect. In extreme cases, the punishment may take the form of criminal penalties, although this is rare. More common is the assessment of punitive damages for malicious or willful acts. A third function is to prevent similar accidents from happening in the future, i.e., deterrence. Substantial damage awards against manufacturers constitute strong incentives to produce safer products. Finally, product liability laws act as a kind of symbolic reaffirmation that society values human safety and quality in products.

5.3 Negligence

A high percentage of product litigation alleges engineering negligence. Negligence is the failure to do something that a reasonable man, guided by the considerations that ordinarily regulate human affairs, would do. In product liability law the seller id liable for negligence in the manufacture or sale of any product that may reasonably be expected to be capable of inflicting substantial harm if it is defective. Negligence in design is usually based one of three factors.

- That the manufacturer’s design has created a concealed danger.
- That the manufacturer has failed to provide needed safety devices as part of the design of the product.
- That the design called for materials of inadequate strength or failed to comply with accepted standards.

Another common area of negligence is failure to warn the user of the product concerning possible dangers involved in the product use. This should take the form of warning labels firmly affixed to the product and more detailed warnings of restrictions of use and maintenance procedures in the brochure that comes with the product.

5.4 Strict Liability

Under the theory of strict liability it is not necessary to prove negligence on the part of the manufacturer of the product. The plaintiff need only prove that 1) the product contained an unreasonably dangerous defect, 2) that the defect existed at the time the product left the defendant’s hands, and 3) the defect was the cause of the injury. The fact that the injured party acted carelessly or in bad faith is not a defense under strict liability standards. More recently the courts have acted so as to the require the manufacturer to design his product in such a way as to anticipate foreseeable use and abuse by the user.

The criteria by which the defective and unreasonably dangerous nature of any product may be tested in litigation are:

- The usefulness and desirability of the product
- The availability of other and safer products to meet the same need
- The likelihood of injury and its probable seriousness
- The obviousness of the danger
- Common knowledge and normal public expectation of the danger
- The avoidability of injury by care in use of the warnings
- The ability to eliminate the danger without seriously impairing the usefulness of the product or making the product or making the product unduly expensive

5.5 Design Aspect of Product Liability

Court decisions on product liability coupled with consumer safely legislation have placed greater responsibility on the designer for product safety. The following aspects of the design process should be emphasized to minimize potential problems from product liability.

- Take every precaution that there is strict adherence to industry and government standards. Conformance to standards does not relieve or protect the manufacturer from liability, but it certainly lessens the possibility of product defects.
- All products should be thoroughly tested before being released for sale. An attempt should be made to identify the possible ways a product can become unsafe, and tests should be devised to evaluate those aspects of the design. When failure modes are discovered, the design should be modified to remove the potential cause of failure.
- The finest quality-control techniques available will not absolve the manufacturer of a product liability if, in fact, the product being marketed is defective. However, the strong emphasis on product liability has placed renewed emphasis on quality engineering as a way to limit the incidence of product liability.
- Make a careful study of the system relations between your product and upstream and downstream components. You are required to know how malfunctions upstream and downstream of your product may cause failure to your product. You should warn users of any hazards of foreseeable misuses based on these system relationships.
- Documentation of the design, testing, and quality activities can be very important. If there is a product recall, it is necessary to be able to pinpoint products by serial or lot number. If there is a product liability suit, the existence of good, complete records will help establish an atmosphere of competent behavior. Documentation is the single most important factor in winning or losing a product liability lawsuit.
- The design of warning labels and user instruction manuals should be an integral part of the design process. The appropriate symbols, color, and size and the precise wording of the label must be developed after joint meetings of the engineering, legal, marketing, and manufacturing staffs. Use international warning symbols.

- Create a means of incorporating legal developments in product liability into the design decision process. It is particularly important to get legal advice from the product liability angle on new innovative and unfamiliar designs.

5.6 Business Procedures to Minimize Risk

In addition to careful consideration of the above design factors, there are a number of business procedures that can minimize product liability risk.

- There should be an active product liability and safety committee charged with seeing to it that the corporation has an effective product liability loss control and product safety program. This committee should have representatives from the advertising, engineering, insurance, legal, manufacturing, marketing, materials, purchasing, and quality-control departments of the corporation.
- Insurance protection for product liability suits and product recall expenses should be obtained.
- Develop a product usage and incident-reporting system just as soon as a new product moves into the marketplace. It will enable the manufacturer to establish whether the product has good customer acceptance and detect early signs of previously unsuspected product hazards or other quality deficiencies.

5.7 Problems with Product Liability Law

As product liability has grown so rapidly certain problems have developed in the implementation of the law. There has been a dramatic shift in the doctrine of the product liability law from negligence to strict liability but the law has proved incapable of defining the meaning of strict liability in a useful fashion. The incapable of defining the meaning of strict liability in a useful fashion. The rules of law are vague, which gives juries little guidance, and as a result verdicts appear capricious and without any definitive pattern. Another problem concerns the computation of damages once liability is established. There is great uncertainty and diversity in awarding damages for pain and suffering. Our adversarial legal system and the unfamiliarity of juries with even the rudiments of technical knowledge lead to high costs and much frustration.

The great increases in the number of product liability claims and the dollars awarded by the courts to consumers, other companies, and government have brought a clamor to bring some restraint to the situation before we become a no-fault economy in which producers and sellers will be held responsible for all product-related injuries. Advocates of reform point to product liability insurance costs and damage awards as a significant factor in reducing American competitiveness. National product liability legislation has been introduced in the U.S. Congress to ease the situation. It aims at making tort law on product liability uniform in al the states and on speeding up product liability disputes. It proposes a limit on joint and several liability, a doctrine by which a defendant responsible for only a small portion of harm may be liable for an entire judgement award. It also calls for a limit on a product seller’s liability to cases in which the harm was proximately caused by the seller’s own lack of reasonable care or a breach of the seller’s warranty.

Probably the best thing that could happen in product liability would be the adoption of standardized liability laws on a nationwide basis. Such standardization would mean more predictability, less litigation, and lower premiums for liability insurance.

Section 6

Ethics

Ethics

6.1 Definition and Background

Ethics are the principles of conduct that govern and individual or a profession. They provide the framework of the rules of behavior that are moral, fair, and proper for a true professional. A code of ethics serves to remind individuals how important integrity is in a self-regulating profession. It lays out the issues that are deemed most important in the collective wisdom of the profession. By publishing and enforcing a code of ethics, the profession serves notice that its ethical precepts are to be taken seriously. Obviously, engineers should respect the same fundamental ethical principles in the context of the special expertise and public trust of the engineering profession.

Because engineering lacks the homogeneous character of such professions as law and medicine, it is not surprising to find that there is no widely accepted code of engineering ethics. Most professional societies have adopted their own codes, and Accreditation Board for Engineering and Technology (ABET) and National Society of Professional Engineers (NSPE) have adopted broader-based but not universally accepted ethical codes. Again, because engineers who are employees of either business or government are in the great majority, they face ethical problems that self-employed professionals avoid. These arise from the employer (and this achieve recognition and promotion) and the desire to adhere to a standard of ethics that places the public welfare ahead of corporate profit. For example, what can an employed engineer do to expose and correct the corrupt practices of an employer? What should an engineer do if employed in a business atmosphere in which kickbacks and bribes are an accepted practice?

Ethics can be learned like any other subject. Ethics is based on moral philosophy. While it is not possible to develop a single comprehensive moral principle that can provide guidance in solving all ethical dilemmas, it is possible to lay a set of moral values for personal behavior:

- Respect the right of others
- Be fair
- Do not lie or cheat
- Keep promises and contracts
- Avoid harming others
- Prevent harm coming to others
- Help others in need
- Obey all laws

An engineer in a design situation potentially can be faced with a miriad of ethical situations. Consider the following short list:

- Specification of components or materials can lead to conflict of interest for certain suppliers
- Authorizing the release of production parts that are only marginally out of specification
- Condoning the use of pirated design software
- Firing a hardworking veteran employee to make room for a star who suddenly becomes available

Ethical situations in engineering generally fall within the following general situations:

- Loyalties between two groups
- Duty to general public versus right of employer
- Issues of recognition for performance
- Falsification of experimental data
- Issue of differing standards of morals in different parts of the world

Consider the following example. A newly graduated engineer is working for a consulting firm that is engaged in research for the Department of Defense (DOD). The company is preparing a proposal to DOD and will use his resume as part of the proposal. The engineer is in the room where report copying is done and happens to look at his resume as the proposal is being assembled. To his surprise he observes that someone has grossly modified his resume, listing professional experience that he does not have. What should he do?

He immediately tells his superior about the “mistakes” in his resume, believing at the time that it was an error. The superior states that he will take care of it, but a week later the young engineer finds out that the falsified resume had been included in the proposal. He talks again with his superior but receives an evasive answer. What should he do? Should he resign immediately, or stick around and hope this was an isolated incident? Should he find other employment and then report the situation to the DOD agency that received the proposal, or should he just forget about it and get on with his career with a new employer?

An important ethical situation which periodically attracts wide attention is whistleblowing. Whistleblowing refers to making a public accusation about misconduct within an organization. In the usual case the charges are made by an employee or former employee who has been unable to obtain the attention of the organization’s management to the problem. Sometimes whistleblowing is confined to within the organization where the whistleblower’s supervision is bypassed in an appeal to higher management. An important issue is to determine the conditions under which engineers are justified in blowing the whistle. Generally, it is morally permissible for engineers to engage in whistleblowing when the following conditions are met.

- The harm that will be done by the product to the public is considerable and serious.
- Concerns have been made known to their superior, and getting no satisfaction from their immediate superior, all channels have been exhausted within the corporation, including the board of directors.

- The whistleblower must have documented evidence that would convince a reasonable impartial observer that his or her view of the situation is correct and the company position is wrong.
- There must be strong evidence that releasing the information to the public would prevent the projected serious harm.

Clearly a person engaging in whistleblowing runs considerable risk of being labeled a nut or of being charged with disloyalty, and possibly being dismissed. The decision to blow the whistle requires great moral courage. Federal government employees have won protection under the Civil Service Reform Act of 1978, but protection under state laws or active support from the engineering professional societies is still spotty. Some far-sighted companies have established the office of ombudsman or an ethics review committee to head off and solve these problems internally before they reach the whistleblowing stage.

6.2 Codes of Ethics of Engineers

It is generally conceded that an individual acting on his or her own cannot be counted on to always act in a proper and moral manner. Creeds, statutes, rules, and codes all attempt to complete the guidance needed for an engineer to do the correct thing. A creed is a statement or oath, usually religious in nature, taken or assented to by an individual.

The fundamental principles are:

Engineers uphold and advance the integrity, honor, and dignity of the Engineering profession by:

- using their knowledge and skill for the enhancement of human welfare;
- being honest and impartial, and serving with fidelity the public, their employers and clients, and
- striving to increase the competence and prestige of the engineering profession.

A code is a system of non-statutory, non-mandatory canons of personal conduct. A canon is a fundamental belief that usually encompasses several rules. For example, the code of ethics of the American Society of Mechanical Engineers (ASME) contains the following fundamental canons:

- Engineers shall hold paramount the safety, health, and welfare of the public in the performance of their professional duties.
- Engineers shall perform services only in areas of their competence.
- Engineers shall continue their professional development through their careers and shall provide opportunities for the professional and ethical development of those engineers under their supervision.
- Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest or the appearance of conflicts of interest.

- Engineers shall build their professional reputation on the merit of their service and shall not compete unfairly with others.
- Engineers shall associate only with reputable persons or organizations.
- Engineers shall issue public statements only in an objective and truthful manner

A rule is a guide (principle, standard, or norm) for conduct and action in a certain situation. A statutory rule is enacted by the legislative branch of state or federal government and carries the weight of law. Some U.S. engineering registration boards have statutory rules of professional conduct.

6.3 Purpose of A Code of Ethics

Many different sets of codes of ethics (canons of ethics, rules of professional conduct, etc.) have been produced by various engineering societies, registration boards, and other organizations. The purpose of these ethical guidelines is to guide the conduct and decision making of engineers. Most codes are primarily educational. Nevertheless, they have been used by the societies and regulatory agencies as the basis for disciplinary actions.

Fundamental to ethical codes is the requirement that engineers render faithful, honest, professional service. In providing such service, an engineer must represent the interests of his employer or client and, at the same time, protect public health, safety, and welfare.

There is an important distinction between what is legal and what is ethical. Many legal actions can be violations of codes of ethical or professional behavior.[3] For example, and engineer's contract with his client may give the engineer the right to assign his responsibilities, but doing so would be unethical without informing the client.

Ethical guidelines can be categorized on the basis of who is affected by the engineer's actions-the client, vendors and suppliers, other engineers, and the public at large.

6.4 Ethical Priorities

There are frequently conflicting demands on an engineer. While it is impossible to use a single decision-making process to solve every ethical dilemma, it is clear that ethical considerations will force an engineer to subjugate his or her dealing with others need to be considered in the following order from highest to lowest priority:

- Society and the public
- The law
- The engineering profession
- Other involved engineers
- the engineer's client
- the engineer's firm
- the engineer personally

6.5 Dealing with Client and Employers

The most common ethical guidelines affecting an engineer's interactions with his or here employer (the client) can be summarized as follows: An engineer should not accept assignments that he or she does not have the skill, knowledge, or time to complete.

- The client's interests must be protected. The extent of this protection exceeds normal business relation-ships and transcends the legal requirements of the engineer-client contract.
- The engineer must not be bound by what the client wants in instances where such desires would be unsuccessful, dishonest, or unethical.
- Confidential client information remains the property of the client and must be kept confidential.
- An engineer must avoid conflicts of interest and should inform the client of any business connections or interests that might influence his or her judgment. The engineer should also avoid the appearance of a conflict of interest when such and appearance would be detrimental to the profession, his or her client, or himself.
- An engineer must recognize his or her own limitations. He should use associates and other experts when the design requirements exceed his or her abilities.
- The engineer's sole source of income for a particular project should be the fee paid by his or her client. An engineer should not accept compensation in any form from more than one party for the same services.
- If the client rejects the engineer's recommendations, the engineer should fully explain the consequences to the client.
- The engineer must freely and openly admit to the client any errors made.

All courts of law have required an engineer to perform in a manner consistent with normal professional standards. This is not the same as saying an engineer's work must be error-free. If an engineer completes a design, has the design and calculations checked by another competent engineer, and an error is subsequently shown to have been made, the engineer may be held responsible, but he will probably not be considered negligent.

6.6 Dealing with Suppliers

Engineers routinely deal with manufacturers, contractors, and vendors (supplier). In this regard, engineers have great responsibility and influence. Such a relationship requires that engineers deal justly with both clients and suppliers.

An engineer will often have an interest in maintaining good relationships with suppliers since this often leads to future work. Nevertheless, relationships with suppliers must remain highly ethical. Suppliers should not be encouraged to feel that they have any special favors coming to them because of a long-standing relationship with the engineer.

The ethical responsibilities relating to suppliers are listed here:

- The engineer must enforce the plans and specifications (i.e., the contract documents) but must also interpret the contract documents fairly.
- Plans and specifications developed by the engineer on behalf of the client must be complete, definite, and specific.
- Suppliers should not be required to spend time or furnish materials that are not called for in the plans and contract documents.
- The engineer should not unduly delay the performance of suppliers.
- The engineer must not accept or solicit gifts or other valuable considerations from a supplier during, prior to, or after any job. An engineer should not accept discounts, allowances, commissions, or any other indirect compensation from suppliers, contractors, or other engineers in connection with any work or recommendations.

6.7 Dealing with Other Engineer

Engineers should try to protect the engineering profession as a whole, to strengthen it, and to enhance its public stature. The following ethical guidelines apply:

- An engineer should not attempt to maliciously injure the professional reputation, business practice, or employment position of another engineer. However, if there is proof that another engineer has acted unethically or illegally, the engineer should advise the proper authority.
- An engineer should not review someone else's work while the other engineer is still employed, unless the other engineer is made aware of the review.
- An engineer should not try to replace another engineer once the other engineer has received employment.
- An engineer should not use the advantage of a salaried position to compete unfairly (i.e., moonlight) with other engineers who have to charge more for the same consulting services.
- Subject to legal and proprietary restraints, an engineer should freely report, publish and distribute information that would be useful to other engineers.

6.8 Dealing with (and affecting) the Public

The relationship between an engineer and the public is essentially straightforward. Responsibilities to the public demand that the engineer place service to mankind above personal gain. Furthermore, proper ethical behavior requires that an engineer avoid association with projects that are contrary to public health and welfare or are of questionable legal character.

- An engineer must consider the safety, health, and welfare of the public in all work performed.

- An engineer must uphold the honor and dignity of his or her profession by refraining from self-laudatory advertising, explaining (when required) his or her work to the public, and by expressing opinions only in areas of knowledge.
- When an engineer issues a public statement, he or she must clearly indicate if the statement is being made on anyone's behalf (i.e., if anyone is benefiting from his or her position).
- An engineer must keep his or her skill at a state-of-the-art level.
- An engineer should develop public knowledge and appreciation of the engineering profession and its achievements.
- An engineer must notify the proper authorities when decisions adversely affecting public safety and welfare are made.

Section 7

Project Presentation

7.1 Writing the Technical Report

In no other area of professional activity will you be judged so critically as your first technical report. The quality of a report generally provides an image in the reader's mind that, in large measure, determines how you will be perceived as an engineer. A good job of report writing cannot disguise a sloppy investigation, but even excellent engineering may not receive proper attention and credit because the work was reported in a careless manner. You should be aware that written reports carry a message farther than the spoken word and have greater permanence. Therefore, technical workers often are known more widely for their writings that for their talks.

7.2 Steps in Writing a Report

The five operations involved in the writing of a high-quality report are best remembered with the acronym POWER.

P Plan the writing

O Outline the report

W Write

E Edit

R Rewrite

The planning stage of a report is concerned with assembling the data, analyzing the data, drawing conclusions from the data analysis, and organizing the report into various logical sections. The planning of a report is usually carried out by considering the various facets of the work and providing a logical blend of the material. The initial planning of a report should begin before the work is carried out. In that way the planning of the work and planning of the report are woven together, which facilitates the actual writing operation.

Outlining the report consists of actually formulating a series of headings, subheadings, sub-subheadings, etc., which encompass the various sections of the report. The outline can then be used as a guide to the writing. A complete outline can be detailed to the point at which each line consists of a single thought or point to be made and will then represent one paragraph in the report. The main headings and subheadings of the outline are usually placed in the report to guide the reader.

The writing operation should be carried out in the form of a rough draft using the maximum technical and compositional skill at the command of the writer. However, do not worry about perfection at this stage. Once you get going, don't break stride to check out fine details of punctuation or sentence structure.

Editing is the process of reading the rough draft and employing self-criticism. It consists of strengthening the rough draft by analyzing paragraph and sentence structure, economizing on words, checking spelling and punctuation, checking the line of logical thought, and, in general, asking oneself the question "Why?" Editing can be the secret of good writing. It is better for the writer to ask himself embarrassing questions than to hear them from his technical readers, his supervisor, or his instructor. In connection with editing, it has often been said that the superior writer makes good use of both ends of the pencil.

It is generally good practice to allow at least a day to elapse after writing the rough draft before editing it. That allows the writer to forget the logical pattern used in writing the report and appear more in the role of an unbiased reader when editing.

Many mistakes or weak lines of thought that would normally escape unnoticed are thereby uncovered. The rewriting operation consists of retyping or rewriting the edited rough draft to put it in a form suitable for the reader. An important tip for preparing a handwritten report draft is to use every other line on the paper. In that way you will be able to make correction in the empty lines and use part of your rough draft without doing a complete rewrite. Of course, if you are able to do your rough draft on a word processor, the revision is much less painful.

7.3 Information on Writing Project Reports

Here is a suggested outline to use in organizing and writing an engineering report.

- Title Page
- Abstract
- Acknowledgements
- Table of Contents
- Nomenclature (if applicable)
- Executive Summary
- Introduction
- The Solution
- Analysis and Performance Results
- Discussion
- Conclusions and Recommendations for Future Work
- References
- Appendices

7.4 Amplification on Component of the Report

- Title page

  The title page clearly identifies the following elements:

  -Title of the project

  -Author(s)

  -Entity for which the project was done (e.g., San José State Univ., Department of

Mechanical & Aerospace Engineering, ME 195, etc.)

-Date

- Abstract

The abstract provides the following information (ASME Manual, MS-4):

-A clear indication of the objective, scope, and results of the paper so that readers may determine whether the full text will be of particular interest to them.

-Key words and phrases for indexing, abstracting, and retrieval purposes.

- Acknowledgements

It is very important to recognize the contribution of others to the success of your work. Design is never done in a vacuum! Be thoughtful of how others helped you achieve success. Common areas are:

-Project sponsorship or financial support

-Donations of equipment, supplies, etc.

-Technical help

-Other help of a significant nature

- Nomenclature

The nomenclature section lists any symbols, variable names, etc. and shows what they stand for Lettered symbols come first, in alphabetical order. Greek symbols come next, in alphabetical order.

- Executive Summary

The executive summary is a brief, concise summary of important information, intended for specific readers who want to know, but don't have the time, patience, or energy to slog through a rambling, obscure report.

The executive summary answers the following questions:

- What is the problem?
- What is the solution of the problem?
- What actions are recommended or have been taken?

The executive summary must be:

- *Brief*: The executive summary is generally not longer than a few pages, unless figures make up a significant portion.
- *Crisp*: Words and sentences must be relevant to the subject. Avoid filler and verbiage that doesn't add important information.
- *Readable*: The executive summary should be organized and formatted so that the reader can quickly extract the essential information. Use ample headings and subheadings to form a clear outline of the subject that can be readily understood by

the reader. Multiple points or features should be tabulated or bulleted (for example, this list). All statements in a common tabulation must have the same grammatical structure.

- *Will-illustrated*: Figures must have brief, self-explanatory titles with text that explains the significance of what is shown. Figures should be integrated into the text, not grouped together at the end. If needed, full-page figures should be oriented so that the bottom is adjacent to the outer edge of the report, not adjacent to the binding.

- Introduction

The introduction presents the following information:

-*Background of the problem*: The background sets the stage, provides context, explains the need for the solution.

-*Functional specification*: The functional specification clearly spells out in quantifiable terms how the solution must perform.

-*State-of -the-art review*: The state-of-the-art review summarizes prior and related solutions to the problem. For example, patents, journal papers, reports, etc.

- The Solution

This section clearly presents the solution to the problem. It is critical that this section contains sufficient illustrations, drawings, photographs, etc., to fully communicate the solution to the problem.

- Analysis and Performance Results

This section presents *results* of testing and modeling of the solution. Graphs, charts, tables, etc., should be used and described to clearly show how the solution performs relative to the design specifications.

- Discussion

This section reflects on the performance of the solution and interprets the meaning of the information presented in the previous section. Discussion on failure models is appropriate in this section.

- Conclusions and Recommendations for Future Work

This section summarizes the meaning of your results and outlines what could be done in the future to carry on development of your work. In other words, answer the questions, “So what?”, and “What more could be done on this problem?”

- References

The references should list all literature, catalogs, interviews, etc. that have been used in the project work. You may either list references in alphabetical order (see References below) and cited as done in the section on the Abstract or Executive sections of this document, or you may number each one and cite the number in your text.

- Appendices

The appendices contain details and other relevant information that are important to the project, but would otherwise bog down the flow of the report if included in the main sections. For example:

-Alternative design approaches and evaluation

-Supporting analysis

-Detail drawings

-Materials specifications

-Details on testing procedures, apparatus, and raw test data

-Supporting information, such as catalog data, etc.

7.5 Oral Presentations

Impressions and reputations (favorable or unfavorable) are made most quickly by audience reaction to an oral presentation. There are a number of situations in which you will be called upon to give a talk. Progress reports, whether to your boss in a one-on-one situation or in a more formal setting to your customer, are common situation in which oral communication is used. Selling an idea or a proposal to your management budget committee or a sponsor is another common situation. In the more technical arena, you may be asked to present a talk to a local technical society chapter or present a paper at a national technical meeting.

Oral communication has several special characteristics: quick feedback by questions and dialogue; impact of personal enthusiasm; impact of visual aids; and the important influence of tone, emphasis, and gesture. A skilled speaker in close contact with an audience can communicate far more effectively than the cold, distant, easily evaded written word. On the other hand, the organization and logic of presentation must be of a higher order for oral than for written communication. The listener to an oral communication has no opportunity to reread a page to clarify a point. Many opportunities for noise exist in oral communication. The presentation and delivery of the speaker, the environment of the meeting room, and the quality of the visual aids all contribute to the efficiency of the oral communication process.

7.6 Developing a Presentation Outline

To organize a logical flow of ideas designed to tell a complete story it is important to develop an outline for each presentation. The outline also serves as a checklist for items that appear in the slides. This checklist prevents the presenter from omitting important ideas as he or she becomes immersed in the details of designing the slides.

To develop an outline, transform the earlier questions into headings for the outline, then follow two steps. First, construct a general outline: write the answers to the questions as the key ideas of a presentation, organized under their corresponding headings. Then expand the general outline into a detailed outline that contains all the specific items can then be placed on the slides.

The purpose of the general outline is to collect and organize the answers to the audience's questions as the key ideas of a presentation. The following headings can be used to organize the key ideas:

- Title
- Presentation Outline
- Introduction
- Goals and Objectives
- Methodology / Approach
- Analysis / Experiment
- Details of the work
- Results / Discussion
- Conclusions
- Future work

7.7 Guidelines For Making Presentation

Important note: Individual instructors may have their own specific requirements regarding the number of presentations, their format, method of delivery, and grading, so <u>check with your instructor before preparing your presentation</u>.

The following are some guidelines and general grading criteria regarding project presentations. Presentations are part of the course requirement.

- All presentations should be limited to 15 minutes followed by a 5 minute question-and-answer period.

PRESENTATION #1(15 minutes maximum including 5 minutes for questions and answers).

This presentation should include:

- Project introduction, background, and goals
- State-of-the-art review
- Functional specification
- Concepts and concept selection
- Review of schedule and milestones
- Future work to be done

PRESENTATION #2 (15 minutes maximum including 5 minutes for questions and answers).

This presentation should include:

- Project introduction (brief)
- Describe the work completed

- Review of project schedule
- Cost Analysis
- Any anticipated problems, outside contacts, etc.
- Future work to be completed

PRESENTATION #3 (15 minutes maximum including 5 minutes for questions and answers).

This presentation should include:

- Project introduction (brief)
- Describe the work completed
- Future work to be completed
- Review of project schedule (include next semester plans)

ADDITIONAL COMMENTS

- All presentations should include about 5 to 7 overhead transparencies and be prepared professionally. (The rule of thumb is approximately 2 minutes per slide).
- Ask your instructor about the format of the presentation: i.e., whether only one person in the group should make the presentation with recognition and introduction of other group members, or all group members should participate in each presentation.
- It is highly recommended that the presenter use a pointer.

In general, your presentation will be graded using the following criteria:

- Compliance with time-limit
- Compliance with all the guidelines as outlined above
- Quality of overhead transparencies and visual aids
- Quality of presentation (loud and clear, substance, interaction with audience, etc.)

Check with your instructor for more specific information on presentation grading.

HELPFUL HINT

A day or two before your presentation, go through a dry run using your group members as audience. This will give you confidence and a good estimate of the time it takes to present the material.