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APPENDIX I – Mechanical Engineering Student Resource Page

To provide students with a common reference source for various Student Outcomes, we created the Mechanical Engineering Student Reference Materials web page. The web page includes resources for engineering problem solving, design work, project management, team work, laboratory work, and communication (writing, speaking, graphical). The following is the text version of the web page (de-activated links), http://faculty.up.edu/lulay/MEStudentPage/ME-Student-Page.htm

Relevant Pedagogy:

- **Pedagogy for Student Outcome a**, an ability to apply knowledge of mathematics, science, and engineering
- **Pedagogy for Student Outcome b**, An ability to design and conduct experiments, as well as to analyze and interpret data
- **Pedagogy for Student Outcome c**, An ability to design a system, component, or process to meet desired needs
- **Pedagogy for Student Outcome d**, An ability to function on multi-disciplinary teams
- **Pedagogy for Student Outcome e**, an ability to identify, formulate, and solve engineering problems.
- **Pedagogy for Student Outcome g**, an ability to communicate effectively

**Mechanical Engineering Student Reference Materials**

This page is meant to provide a source for documents utilized by students. Most, if not all, of these documents are provided to students in various courses.

**MISCELLANEOUS LINKS**

- How to avoid procrastination - the number 1 killer of projects
- Standard problem solving format (must be applied for all analysis, homework problems and especially design problems)
- Significant figures (don't abuse numbers - take care of them, treat them with respect)
- Cartoon on Sig Figs. When was the last time your doctor used more than 2 significant figures in writing a prescription?
- Top "10" most important things for ME’s to know (actually, there are 13 - but Top 10 sounds better).
- What you really need to know!

**DESIGN PROCESS, PROJECT MANAGEMENT, TEAM WORK**

- Design? (author unknown)
- ABET Definition of Design
- Standard problem solving format (must be applied for all analysis, homework problems)
problems and especially design analysis problems)

Design Decision Documentation

Engineering Design Process
Project Planning using Key Characteristics
Design Considerations (from which criteria may be developed)
Concurrent design evaluation
Evaluating alternatives, developing criteria
Fail safe and safe life design philosophy
Scheduling (making schedules)
MS Project Basics (how to)
Example of a Schedule (Gantt Chart format)

What are Action Item Logs and Decision Logs

Action Item Logs
Decision Log
Meetings - how to run and manage them effectively
Concisely: meetings, agenda, minutes
Agenda example
How to manage a dysfunctional team
How to avoid procrastination - the number 1 killer of projects
Peer evaluations

Codes and Standards

Human Factor Design (60 Minutes clip - but 10 minutes to watch) --- keep this in mind - what you design will be manufactured by someone and maintained by someone - make their life easier.

GENERAL LABORATORY

Mechanical Engineering Laboratory Handbook
Codes and Standards
ASME Codes and Standards

GRAPHING, ENGINEERING DRAWINGS, PHOTOGRAPHY

Graphing of Engineering Data
Graphing/Figure Standards
Graph formatting
Engineering Drawing Standard
Example of a detailed drawing
Example of an assembly drawing
Photography for Engineering Reports

WRITING and SPEAKING

Writing for Engineers (booklet)
Memos and Letters
Memo and letter content
Proposals
Laboratory Reports
Design/Project Reports
Technical Presentations
Common writing mistakes that students make; Part I
Common writing mistakes that students make; Part II
Columnist Advice

WRITING and SPEAKING EXAMPLES
Well written letter
Poorly written letter
Memo - good example
Well produced oral presentation
Poorly produced oral presentation
Proposal memo example
"Grade sheet" used by ME faculty for technical presentations

Spelling:

I halve a spelling checker,
It came with my pea see.
It plainly marks four my revue
Mistakes I dew knot sea.

Eye strike a key and type a word
And weight four it two say
Weather eye am wrong oar write
It shows me strait aweigh.

As soon as a mist ache is maid
It nose bee four two long
And eye can put the era rite
Its rarely ever wrong.

I've scent this massage threw it,
And I'm shore your pleased too no
Its letter prefect in every weigh;
My checker tolled me sew.

-Author unknown.
APPENDIX II – Standard Engineering Problem Solving Format

The following document is provided to all mechanical engineering students and they are required to follow this format on every problem on every assignment from sophomore through senior year. This helps students develop a habit of producing professional documentation. For problems that do not lend themselves well to this format (such as essay problems) the intent of the format must still be adhered to: it must be clear what the question is they are answering, and their answer must be clearly highlighted. All data or other information used to answer the question must be clearly communicated. For larger design problems, students must follow the Design Decision Document format, which is a detailed expansion of the standard homework format.

Relevant Pedagogy:

- **Pedagogy for Student Outcome a**, an ability to apply knowledge of mathematics, science, and engineering
- **Pedagogy for Student Outcome e**, an ability to identify, formulate, and solve engineering problems.
- **Pedagogy for Student Outcome g**, an ability to communicate effectively
University of Portland
Donald P. Shiley School of Engineering
Standard Engineering Problem Solving (Homework) Format

"We are what we repeatedly do. Excellence, then, is not an act, but a habit." - Aristotle

Purpose of this Format

Calculations performed by engineers become permanent records that substantiate their decisions. As such, it is essential that an engineer’s written work be clear and understandable. It is critical that engineering students develop a habit of communicating work effectively. By following the format described below in assignments, design work, and other technical works, students will learn the habit of producing professional quality documentation. It is critical that students develop a habit of always using this format; therefore, homework not following this format will be penalized appropriately.

- Homework should be on 8.5” x 11” paper. The writing should be neat and legible. All pages must be placed in order and stapled.
- If using engineering paper, write on only one side of the paper.
- Pages must be stapled together in the upper left-hand corner.
- Your name, course number, course title, assigned problem numbers, submission date, and page number must be at the top of first page. Your initials and page number must be at the top on all subsequent pages.
- Problem format: Each problem must include the following:
  1. **Purpose**: A brief sentence describing the purpose of the problem (explains why the analysis is being conducted). Example: “Determine the location and magnitude of the maximum stress in the beam to assist with material selection.”
  2. **Given**: Brief description of all information provided in problem statement. Use neat sketches, schematics and free body diagrams as appropriate.
  3. **Assumptions**: If any assumptions are made, clearly indicate them and if none are made, state so. This is your opportunity to explain the limitations of any analysis you conduct. Explain what conditions are required for the analysis to be valid. Never just plug numbers into an equation, you must understand the limitations of the equation! Stating assumptions communicates those limitations.
  4. **Solution**: Show all details of calculations including variables! Every step of the solution must include units (never numbers by themselves)! Cite equation numbers used (unless otherwise stated, it will be assumed equation numbers are from the course textbook). Example, show the equation with variables (and equation citation), then numbers with units, then the answer: \( F = m \times a = 5 \text{kg} \times 9.8 \text{m/s}^2 = 49 \text{N} \) eqn. 1-1; Hibbeler.
  5. **Final Answer**: Underline the final answer. It must include proper units, correct number of significant figures, and the quantities calculated.
  6. **Explain the answer**: a brief explanation of the significance of the answer is often appropriate. Is it reasonable? Does it answer the question posed in the purpose statement? Example: The maximum stress of 160ksi occurs at the middle of the beam. This is higher than the yield strength of many materials.
APPENDIX III – Standards for Written and Oral Communication

In order to help students more effectively learn to communicate, the mechanical engineering program has developed a number of standards. These standards are provided to the students so they can develop their communication abilities and faculty use these standards to assess student work.

The following standards are provided in this appendix:
- Concise Technical Letters and Memoranda
- Laboratory Reports
- Project and Design Reports
- Technical Oral Presentations
- Weekly Email Project Updates

Relevant Pedagogy:

**Pedagogy for Student Outcome g**, an ability to communicate effectively
Concise Technical Letters and Memoranda: Letters typically are sent outside the organization, memos typically are sent within the organization. The content of most engineering letters and memoranda can be organized into four main parts: summary, background, discussion, and conclusions. Depending on the intent and length of the letter or memo, each part can be as short as a single phrase or as long as several paragraphs or pages but most letters and memos are less than two pages. The following elements should be included. Headings are only appropriate for long letters.

Summary – Objective and overview. Within the first two sentences, the purpose of the letter or memo is clearly stated. The important recommendations or conclusions are summarized.

Background – Provides context for the discussion and educates the reader so they can understand the discussion.

Discussion – May include a brief description of methodology, relevant findings, interpretation of data, and other significant items.

Conclusions and Recommendations – Should recapitulate results and conclusions, brief explanation of significant “errors”, and recommend future work or action.

Courteous Closing (Includes your contact information) – do NOT use a heading for closings, even for long letters.

References – Should be of sufficient quantity and quality, and cited properly within the text. Bibliographic information is typically included as a footnote.

Additional information to the written text is often required. Typical attachments include:

Attachment 1* – Results (If only one or two small figures or tables are required, they may be embedded in the letter/memo, if they are large, they should be an attachment).
- Tables and figures: All figures and tables discussed in text, but self-explanatory
- Numbered and properly titled, contain units, axis labels
- Referenced (if information not created by author)
- Appropriate to communicate effectively

Attachment 2* – Test Set-up: clear and self-explanatory

Attachment 3* – Data: self-explanatory data sheet; proper symbols and units

Attachment 4* – Calculations: clear and self-explanatory, sources cited

Additional attachments as required

Writing Quality
- Single spaced, no more than 2 pages
- Properly addressed and contact information (to whom, date, etc.)
- Writing: clear, complete, and concise with proper mechanics (spelling, punctuation, grammar, and paragraph and sentence structures)
- Proper tense, semi-formal writing; avoid excessive usage of first person.
Lab Reports: This report format emphasizes laboratory methodology and the computation, presentation, and discussion of laboratory results. In some cases, the laboratory results may be used for solving a specific engineering problem posed by the instructor. The following format should be followed, use of headings is generally required.

Letter of Transmittal*, one page maximum
- Objective (purpose), procedures, results and conclusions
- Proper letter format (addressed, courteous closing, signed, etc.)

Title Page, Table of Contents*, Lists of Figures and Tables*
- All properly done with complete information

Executive Summary* half page maximum, (objective, procedures, results, conclusions)

Introduction (objective and summary)

Background

Laboratory Methodology (Equipment and Materials, Procedure)

Results and Discussion
- Interpret the results for the reader (meaning and application)
- Compare results to expectations (experimental, theoretical)
- Explain cause and magnitude of error

Tables and Figures (tables and figures should be embedded in appropriate sections such as background and discussion).
- All figures and tables discussed in text, but self-explanatory
- Numbered and properly titled, contain units, axis labels
- Referenced (if information not created by author)
- Appropriate to communicate effectively

Conclusions and Recommendations
- Conclusions (was objective met? Briefly explain.)
- Brief explanation of significant “errors”
- Recommendations for future laboratories or future action

References (not as footnotes)
- Appropriate quantity and quality
- Proper citation within text and proper reference section format at the end of the body.

Appendix I- Data

Appendix II- Calculations

Additional appendices as required

Writing Quality
Format: proper use of headings, page numbers, etc.
Writing: clear, complete, and concise with proper mechanics (spelling, punctuation, grammar, and paragraph and sentence structures)
Proper tense, third person, passive voice, formal writing
**Project and Design Reports:** This report format emphasizes communication of the design process results. The purpose of the project, current “state of affairs” relating to the project, goals and objectives of the project, criteria to define the project, evaluation of alternatives, testing and analysis, and decisions and conclusions must be clearly explained. The following format should be followed, use of headings is generally required.

**Letter of Transmittal** (one page maximum)
- Objective (purpose), procedures, results and conclusions
- Proper letter format (addressed, courteous closing, signed, etc.)

**Title Page, Table of Contents**, **Lists of Figures and Tables**
- All properly done with complete information

**Executive Summary** (half page maximum: objective, procedures, results, conclusions)

**Introduction** (objective/purpose and summary of the report)

**Background** (what is currently understood – state of the art, what is the context for this project, etc.)

**Discussion:**
- Clear problem definition and objectives and/or design criteria
- Thorough evaluation of alternatives
- Proper analysis and/or testing
- Decisions explained well
- Design or test details explained well

**Tables and Figures** (tables and figures should be embedded in appropriate sections such as background and discussion).
- All figures and tables discussed in text, but are self-explanatory
- Numbered and properly titled, contain units, axis labels
- Referenced (if information not created by authors)
- Appropriate and adequate to communicate effectively

**Conclusions and Recommendations**
- Conclusions (were objectives met? Briefly explain.)
- Recommendations for future work

**References**
- Appropriate quantity and quality
- Proper citation within report and proper reference section format at end of the body

**Appendices** (may include schedule, budget, meeting minutes, calculations, analysis, test data, vendor information, etc.)

**Writing Quality**
- Format: proper use of headings, page numbers, etc.
- Writing: clear, complete, and concise with proper mechanics (spelling, punctuation, grammar, and paragraph and sentence structures)
- Proper tense, third person, passive voice, formal writing

*May omit for short or less-formal reports*
### Oral Presentations:

<table>
<thead>
<tr>
<th>ORGANIZATION</th>
<th>Yes</th>
<th>Mostly</th>
<th>Lacking</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction: clear objective and presentation overview</td>
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<tr>
<td>Background: provides context, lays a foundation for the discussion</td>
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<td>Discussion (clearly presented and well organized information)</td>
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<td>Conclusions (concise, clear, appropriate)</td>
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<tr>
<td>Recommendations (if appropriate)</td>
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<tr>
<td>DELIVERY</td>
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<tr>
<td>Overheads/slides easy for audience to read, effective communication tool</td>
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<tr>
<td>Clear speech, absent of distracting phrases (ummm, you know, like, etc.)</td>
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<tr>
<td>Professional appearance, no distracting mannerisms, hands not in pockets, etc.</td>
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<td>Good eye contact with the audience, minimal use of notes, does not stand in front of screen, etc.</td>
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<td>ENGINEERING WORK</td>
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<td>Technical content was of appropriate scope and quality</td>
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<tr>
<td>WITHIN TIME LIMITS</td>
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<tr>
<td>Main strengths:</td>
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</tbody>
</table>

**Things to improve upon:**
Weekly Email Project Updates

The team leader is expected to prepare weekly updates for your faculty advisor, instructor and industrial advisor. This update is distributed via the Messages tab in Basecamp to all team members, your faculty advisor, instructor and industrial advisor (unless they request otherwise). The weekly updates are to be in plain text in the email – in other words, do not send an email with the weekly update as an attachment.

For these updates, the subject line will always be:
“Weekly Update, team (insert your concise, descriptive team name), date (insert date sent)”

The update should have the following sections with the headings as shown below. Remember, milestones are things that are to be or have been completed. Tasks are things that are done to achieve a milestone. Milestones are nouns, tasks are verbs.

Milestones Completed:
a list of milestones you completed since the last update. If there are none, state this fact.

Overdue Milestones:
a list of all not-completed milestones whose due date has passed. If there are none, state this fact.

Upcoming Milestones:
a list of milestones that must be completed before the next weekly update. If there are none, state this fact.

Recent Tasks:
the tasks you worked on this week. These are not milestones, but actual work that you did to reach towards milestone completion. This section should never be empty. Identify individuals who worked on each task.

Missed Tasks:
note any tasks that had planned to do during the last week but did not complete. If there are none, state this fact

Plans:
the tasks you expect to complete next week and an estimate of how many hours it will take to complete them. These plans should be consistent with upcoming milestones (and missed tasks). Identify individuals expected to work on each task.

Concerns:
your top concerns about the project and what your options are for resolving them. Do not leave this blank. You should always have concerns.
The Recent Tasks and Missed Tasks portion of the weekly update should be consistent with the Plans section of the previous update. Everything that was planned for the last week should be listed as accomplished or missed. You should continually update Basecamp as specific tasks are identified or defined.

Your task list in Basecamp should be consistent with the Plans section of your update. For example, if your update states that you plan to “complete the budget proposal” this week then “budget proposal” should be a Basecamp task and assigned to the proper people on the team.

The milestones and due dates you include in these updates should match those in your most recent project plan. If you revise your milestones, you must submit to the instructor and advisors an updated plan including a concise explanation as to the need for revision.

Good tasks and milestones should be easy to measure or define. An observer should easily be able to tell when it is done.

- Bad Task: “Design the wing spars”
- Good Task: “Select material for wing spars.”
- Bad Task: “Begin writing design report”
- Good Task: “Complete writing the background section of the design report.”
- Bad milestone: “Oral presentation 50% completed”
- Good milestone: “Oral presentation PowerPoint slides completed”

Tasks should be small; usually less than 8 hours. Any task that you estimate will take longer than 12 hours is too long and needs to be broken up into subtasks.

**Grading**
Grading will be based upon the following criteria:
- Was your update turned in on time and sent to the appropriate people?
- Are you defining good tasks?
- Are your milestones and tasks consistent with Basecamp?
- Are your updates consistent with each other?

You will be graded strictly on the quality and timeliness of your weekly updates. How well you are staying on schedule will not affect this aspect of grading (although it certainly will affect the quality of your final project).
APPENDIX IV – Design Decision Documentation

Relevant Pedagogy:

Pedagogy for Student Outcome c, an ability to design a system, component, or process to meet desired needs

Pedagogy for Student Outcome g, an ability to communicate effectively

The following document titled Design Decision Documentation is provided to all students in ME401 Machine Design. Its purpose is to help students produce professional-quality design documentation for specific design problems. The so-called DDD’s are intended to be stand-alone documents meant to communicate design work that was conducted to make a design decision. The DDD would appropriately be included in the appendix of a design report or be submitted as an attachment to a memo or letter. Several DDD’s are required as part of capstone design project reporting.

Design Decision Documentation

Background Information
Throughout the design process, engineers must make numerous decisions which eventually lead to a completed design or other engineered work. It is important for engineers to properly document their decisions; explaining or providing justification for them. Typical mechanical engineering decisions may involve any of the following:

- determining the overall concept of a product (for example “the airplane should have wings mounted below the fuselage”)
- selecting or specifying an existing product to be used in a design (such as a specific engine to be used in a vehicle or air conditioning unit to be used in a building)
- defining the form (geometry) and specific material of a component
- determining how parts should be manufactured or assembled
- etcetera

In order to make good decisions, engineers must rely on facts and data. Facts and data may be obtained from personal experience, experience of colleagues, literature search (journals, textbooks, handbooks, company reports, etc.), analysis, and experimentation or testing. Engineers should remember that expert opinion, analysis or even testing do not provide the answer to a design question. They merely provide data to help you make a decision. Decisions require judgment and are based on the available data.

The purpose of this document is to provide a guideline for students in regards to communication of incremental activities that assist with design decisions (such as Mechanical Engineering Pedagogical Plan, Appendices
analysis or testing). Such communication will be referred to as a “Design Decision Documentation.” These may be stand-alone documents, part of a technical letter, an appendix in a design report, etc. Upper-division students should already be familiar with the spirit of a Design Decision Documentation, as it closely mirrors the standard problem solving format (given, find, etc.). However, Design Decision Documentation often requires even more detailed explanations. It is important that design decisions are properly documented in order to communicate with others as well as to serve as a record for future needs.

Design Decision Documentation
The engineer should keep in mind that Design Decision Documentation should be created to function as a “stand alone” document. It must be clear to anyone reading it what its purpose is, what data was created and how it was created, what data was obtained from other sources (including proper citation of those source), and what conclusions or decisions were reached based on the data. It must be clear that the design decisions are based on proper and thorough analysis of facts and data. Often, analysis must be explained. It may also require discussing what alternatives were considered but not selected.

It cannot be over emphasized that expert opinion, analysis nor even testing will provide the answer to a design question. They merely provide data to help the engineer (you) make a decision. Decisions require judgment and are based on the available data.

- Please, never justify a design decision by saying “I selected this option because Joe says it the best, and Joe knows!” You may use expert Joe’s advice, but you must understand why it is best and are convinced yourself it is the correct decision. It is your decision – even if Joe is your boss.

- Please, never justify a design decision based on blind faith in analysis or test data. You must be convinced that the analysis or test data is correct and that you are interpreting it correctly. There is an example of a large corporation basing a significant decision on finite element modeling. The modeling was not properly validated through testing. It led engineers to an incorrect design which failed at just over half the expected load. This was a hundreds of multimillion dollar mistake that was caused by blind faith in analysis!

In general, Design Decisions Documentation should have the following format:

- Header identification information (name of individuals, team name, date, who’s it for, and any other such information)
- Statement of purpose (what are you trying to determine and/or why are you trying to determine it)
- Declaration of information you are working with (criteria, given information, etc.)
- Assumptions being made (may be stated at the beginning of the document, or embedded in the document as assumptions are being utilized)
- Clear and logically organized work using the “given” information and assumptions. It must be clear where data being utilized comes from including equations and formulae (cite references).
• Conclusion stating what you conclude and why. In many cases, you should discuss any caveats of your conclusion. For example, you may include a discussion of assumptions – if they are not perfectly valid, would that change or affect your conclusion, and if so, how?

The following may serve as “check lists” or guidelines to help you create appropriate documentation:

For analysis based decisions
• Analysis is clear and easy to follow: purpose or objective clearly stated (may even be a restatement of a specific criterion), assumptions defined, “given” information provided, sketches (including FBD’s, control volumes, etc.) are included, solution is clear, answer is underlined (or similar) with appropriate significant figures, sources of equations are cited, proper and consistent units are shown throughout the analyses, not just in the answer.
• For more extensive analysis, explanation (such as newly stated “objective, given, find,” etc.) is provided at various steps where helpful so reader can follow your thoughts.
• Correct analysis is done, and done correctly.
• Sample calculations and/or explanation provided for spreadsheet or program-based calculations.
• Results (such as graphs) show parametric design “tradeoffs” if appropriate (ex. Stress vs. diameter, thickness…).
• Clear definition of final design and show that it satisfies the established design criteria.
• Proper organization: starts with criteria, which leads to clear analysis (or analyses), followed by results (such as graphs), and conclusion (answer(s)). May be iterative.
• **Bottom line: clear that design decisions are based on proper and thorough analysis of alternatives.**

For finite element method (or similar)
• Purpose or objective clearly stated (may even be a restatement of a specific criterion), assumptions defined, “given” information provided, sketches (including FBD’s) are included.
• Assumptions must include such things as linear or nonlinear, small deformation or large deformation, etc.
• Software and version information provided for both the finite element model and the CAD solid model
• A description of the constraints or boundary conditions and a sketch or printout showing the constraints or boundary conditions is provided.
• Include an explanation of how the mesh was generated, and a printout showing the mesh.
• Include proper (meaningful, useful) printouts of the results.
• Provide an explanation regarding the significance of the analysis. May also explain what the analysis does not tell you.
• Clear definition of final design and show that it satisfies the established design criteria.
• **Bottom line: clear that design decisions are based on proper and thorough analysis of alternatives.**

For experimental or test based decisions

Most (hopefully, all) students are familiar with laboratory reports. Such reports, if done properly, serve as design decision documentation. It is appropriate to explain the significance of the testing and how it supports your design decisions.

Literature data (journals, handbooks, etc.)

Information obtained from reliable sources may be used as data in making a decision. Sources must be properly cited. Online data is not necessarily literature, thus websites selling a particular product, Wikipedia, patents, and other sources should only be used for reference information and not for design decisions.

For “expert opinion” based decisions

No design decisions should be based strictly on “expert opinion” no matter who the expert is. Expert opinions may be used (as data), but in all cases, other data is required to justify your decision. If you are using “opinion” as data, then you must give credit where credit is due.

Revision Information:

Rev A, released October 2009
Rev B, added details to FEA requirements, February 2010
Rev C, emphasized the importance of decisions are the engineer’s responsibility, August 2010
Rev D, added requirements to include header information (name, date, etc.), January 2012
APPENDIX V – ASME’s Vision 2030 (excerpt)

The following is an excerpt from ASME’s Vision 2030 report. The pedagogical plan developed by mechanical engineering faculty at the Donald P. Shiley School of Engineering is well-aligned with this ASME report. We have in-place or developing the following attributes common with the report:

- **Rich practice-based experience**
  - Multiple hands-on laboratory and design experiences
  - Applications of engineering standards
  - Design-spine within the curriculum

- **Strong professional skills**
  - Extensive team experiences
  - Extensive emphasis on developing written and oral communication skills

- **Flexible curricula**
  - Newly revised curriculum allows students to pursue alternative areas of specialization or breadth beyond technical mechanical engineering

- **Balanced faculty skills**
  - All of the programs faculty have many years of experience working with industry and/or national labs.

- **Innovation and creativity**
  - Design-spine within the curriculum
  - Multiple hands-on laboratory and design experiences
  - Extra-curricular opportunities including study-abroad and service-learning
  - Opportunities within the University are readily available
Vision 2030 for Mechanical Engineering Education:  
An Action Agenda for Educators, Industry, and Government  
ASME Board on Education, V2030 Task Force  
September 19, 2011

What mechanical engineers do, and how they do it, constantly changes as boundaries of the discipline expand and professional expectations increase to serve an increasingly global marketplace. ASME’s Vision 2030 project (V2030) analyzed the perspectives of recent engineering graduates, their professors and their employers along with recent engineering education studies to offer recommendations on how mechanical engineers should be educated to meet the demands of their transforming profession as well as the grand societal challenges of the future.

What should Mechanical Engineering education look like in 2030? Seven aspects of the educational landscape emerge as target areas for change. They encompass a wide range, spanning the educational pathways of mechanical engineering and mechanical engineering technology to the increasingly diverse practice of mechanical engineering. To affect these changes, what specific strategies can educators, industry, and government pursue? The following actions are urged for seven major outcome areas of curricular change:

RICHER PRACTICE-BASED EXPERIENCE FOR STUDENTS

**Action:** Offer more authentic practice-based engineering experiences such as the design spine or design portfolio approach.

Among the greatest weaknesses noted among current ME and MET graduates by their employers, as well as the early career engineers themselves, are a lack of practical experience in how devices are made or work, a lack of familiarity with industry codes and standards, and a lack of a systems perspective. To address these weaknesses, an increase in and enrichment of applied engineering design-build experience throughout degree programs is urged.

STRONGER PROFESSIONAL SKILLS FOR STUDENTS

**Action:** Develop students’ professional skills to a higher standard.

Both industry supervisors and early career engineers emphasize that graduates need stronger professional skills, e.g., interpersonal skills, negotiating, conflict management, innovation, oral and written communication, and inter-disciplinary teamwork. To meet this need, a systematic focus on integration of such skills into curricula must approach the priority given to technical topics. Incorporation of a multi-year design spine, or portfolio approach, which incorporates such skills development integrated with technical competency development into curricula, is urged.
MORE FLEXIBLE CURRICULA

Action: Create curricular flexibility and efficiency with core requirements and specialization options.

To enable students to develop understanding of mechanical engineering fundamentals but also offer greater strength in context and realization of design, a better systems perspective, and the possibility of focus in an area of interest, there is a need for greater flexibility in the degree path. Thus, the model of a required ME “core” set of fundamental classes, followed by a concentration area is suggested, echoing recommendations of earlier studies.

Action: Modify ABET program criteria regarding student competencies.

To enable curriculum change and encourage more flexible curricula, modifications to program criteria for ME and MET, e.g., no longer requiring both thermal and mechanical competencies, but preparation for professional work in one or the other, with exposure to the area not emphasized, are recommended.

NEW BALANCE OF FACULTY SKILLS

Action: Increase faculty expertise in professional practice.

To produce graduates with the practical and professional skills described above, diversification of faculty capabilities is required. Employing more faculty members with significant industry experience and creating continuous faculty development opportunities for exposure to current industry practice is urged. Faculty with experience in product realization and innovation, project management and business processes, with understanding of the use of codes and standards in different contexts will impart a greater and more authentic sense of the world of practice to students.

Action: Modify ABET ME program criteria for faculty numbers and qualifications.

ABET ME Program Criteria should address metrics for minimum faculty size and student to faculty ratio to ensure program quality in design and also address measures that increase the proportion of practice-experienced faculty.

GREATER INNOVATION AND CREATIVITY

Action: Create a curriculum that inspires innovation and creativity.

The chance to produce practical and technical innovation to solve real world problems and to help people is one of the most inspiring aspects of the profession to prospective or young engineers. Developing student creativity and innovation skills, through explicit curricular components that emphasize active, discovery-based learning – such as a design spine or portfolio, or other authentic extracurricular engineering experiences -- can also enhance motivation and retention. Faculty members who can mentor and coach students through these experiences are also needed.

Mechanical Engineering Pedagogical Plan, Appendices
GREATER DIVERSITY AMONG STUDENTS AND FACULTY

Action: Implement effective strategies to attract a more diverse student body.

Diversity of thought improves engineering solutions. Thus, as the engineering discipline with one of the lowest percentages of women and underrepresented groups, mechanical engineering needs to improve recruitment of a diverse student body and faculty by all means available. Recruitment messages, mentorship, faculty diversity, and emphasizing the idea that mechanical engineering is about solving the problems that impact people lives are all important strategies. Many of the curricular changes suggested above, especially those that reinforce connection of engineering study to contextual real-world solutions that help people and society, have been shown to increase student retention and diversity.

TECHNICAL DEPTH SPECIALIZATION

Action: Focus on post graduate education for specialization

Additional technical depth and specialization in mechanical engineering topics, plus increasingly sophisticated professional skills, will be required in many aspects of industry, according to both department heads and industry managers. The availability of Professional Master’s degrees provides increased opportunity for graduates and practitioners to meet such a need. It is important to increase the number and accessibility of practice oriented masters degree programs in engineering.
Relevant Pedagogy:

**Pedagogy for Student Outcome b**, an ability to design and conduct experiments, as well as to analyze and interpret data

Students are provided a copy of the *Mechanical Engineering Laboratory Handbook* in EGR270 Materials Lab and use it in all relevant laboratory courses in the program. This handbook was written by the program’s faculty to help students see that the overall concepts discussed in labs and to appreciate the inter-connections between all labs.
APPENDIX VI – Writing for Engineers Handbook

Relevant Pedagogy:

**Pedagogy for Student Outcome g**, an ability to communicate effectively

Students are provided a copy of the *Writing for Engineers Handbook* in EGR110 Introduction to Engineering and use it in all relevant courses in the program. This handbook was developed by the School’s faculty to help students write appropriate engineering reports, letters, memos, etc.