INTRODUCTION

The ability to communicate is essential in mechanical engineering. It is not sufficient to have an idea; that idea must be communicated clearly and concisely to other members of a design team, to managers, to academic researchers, to a newspaper reporter, to the general public, or to oneself through a design notebook.

At the University of Minnesota, the Mechanical Engineering faculty recognize that students do not enter our undergraduate program as competent technical writers and that many are not proficient in the standards academic writing. Therefore, we recognize that it is the responsibility of our department to provide our undergraduate majors with an education in technical communication with the expectation that every undergraduate receiving a degree in mechanical engineering is competent in written technical communication. Because learning is the shared responsibility of faculty and students, it is the responsibility of students to know that the department has high expectations for their engineering writing, that they should strive to become better engineering writers while they are in our program and that they will experience some form of engineering writing instruction in every one of their core mechanical engineering courses.

DISCIPLINE-SPECIFIC WRITING CHARACTERISTICS

Effective writing in mechanical engineering is:

1. Pointed, concise and factual, avoiding redundancy, abstraction, and extraneous information
2. Data-driven for accuracy and credibility
3. Systematic, logical and efficient in describing and solving problems
4. Seamless in its integration of textual, numeric, and graphic information
5. Explanatory, often involving depiction of spatial objects and description of complex technical concepts and data
6. Predictable in its use of prescribed format and structure
7. Collaboratively authored when work is conducted by a distributed team
8. Presented in multiple formats, including documents, presentations, posters and web sites
9. Written and formatted in ways that are appropriate for technical or non-technical audiences depending on the purpose of the writing
10. Expressed using correct mechanics

DESIRED WRITING ABILITIES

At graduation, undergraduate students in mechanical engineering should be able to:

1. Apply knowledge of physics, mathematics, and engineering in their writing
2. Record and analyze activity related to laboratories and design projects
3. Visually represent technical concepts and designs to explain their salient features
4. Synthesize and summarize key points
5. State and explain engineering project metrics such as productivity, costs and time to completion
6. Analyze the audience and create a document that meets their needs
7. Represent themselves professionally through their writing
8. Explain, discuss, and demonstrate physical apparatus
9. Integrate visual, textual and oral explanations
10. Create team-written documents using collaborative authorship tools
11. Produce documents in the styles used by professional engineers
12. Write according to style guidelines approved by mechanical engineering faculty

INTEGRATING WRITING INTO THE MECHANICAL ENGINEERING UNDERGRADUATE CURRICULUM

Implementation of the Mechanical Engineering Writing Program starts with the following four assumptions:

1. Students do not enter the undergraduate program as competent technical writers.
2. It is the responsibility of our department to participate in writing instruction for our students.
3. Mechanical Engineering faculty generally will not spend extra time teaching or evaluating writing mechanics.
4. Problem sets, lab reports and design reports are the three most common forms of writing done by undergraduate students in mechanical engineering.

Overview of the Curriculum

Figure 1 displays the mechanical engineering undergraduate curriculum with the circles around the courses where significant writing instruction occurs. Because of the structured curriculum with strict pre-requisites in the core courses, the combination of the circled courses and the emphasis on communication in the engineering science problem set courses means that writing touches students every semester of the suggested curriculum.
Early writing instruction is covered in the service courses WRIT 1301/1401, one of which is required of all University of Minnesota students, with some students required to take WRIT 1201 in addition. Additional early instruction occurs in service courses Phys 1301W and Phys 1302W that primarily cover the writing of lab reports. The core courses offered by the department that have explicit writing instruction are ME 2011 Introduction to Engineering, ME4031W Measurements Lab and ME4054W Design Projects.

The remainder of the department core curriculum courses are engineering science courses that rely significantly on problem sets, for example, ME 3331/2/3, the three-course thermal science sequence, ME 3221/2, the two-course design and manufacturing sequence, ME 3281 System Dynamics and Control and IE 4521 Statistics, Quality and Reliability. Students also take one senior lab course from a selection of six offered within the department and four technical electives, some of which can be outside the department.

Within the core engineering science courses, the department expects certain standards for communicating technical content through the weekly problem sets delivered by students. Within the senior lab courses, the department expects certain standards in the writing of laboratory reports that builds on the lab report writing instruction and expectations introduced in ME 4031W, the pre-requisite course, and earlier in ME2011, the introductory course.

The following table illustrates the types of writing done in each course.
<table>
<thead>
<tr>
<th>Course</th>
<th>Types of Writing</th>
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</thead>
<tbody>
<tr>
<td>WRIT 1301/1401</td>
<td>academic writing, including reports with citations</td>
</tr>
<tr>
<td>PHYS 1301W/1302W</td>
<td>lab notebook, lab reports, problem sets</td>
</tr>
<tr>
<td>ME 2011</td>
<td>sketching, CAD, oral presentation, design notebook, short technical reports, lab reports, design report, resume, portfolio</td>
</tr>
<tr>
<td>ME 3281</td>
<td>problem sets</td>
</tr>
<tr>
<td>ME 3331/2/3</td>
<td>problem sets</td>
</tr>
<tr>
<td>ME 3221/2</td>
<td>problem sets, group authored design report</td>
</tr>
<tr>
<td>ME 4521</td>
<td>problem sets</td>
</tr>
<tr>
<td>ME 4031W</td>
<td>lab notebook, lab reports</td>
</tr>
<tr>
<td>ME 4xxx (Senior Labs)</td>
<td>lab notebook, lab reports</td>
</tr>
<tr>
<td>ME 4054W</td>
<td>design notebook, project web site, project proposal, project plan, oral presentation, poster, group-authored design report</td>
</tr>
</tbody>
</table>

The three core courses offered within the department that have significant writing instruction are listed in the following table.

<table>
<thead>
<tr>
<th>Course</th>
<th>Writing Instruction</th>
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</thead>
<tbody>
<tr>
<td>ME 2011</td>
<td>Instruction on maintaining a design notebook, writing a lab report, delivering a technical presentation, writing a resume, informal professional writing and other technical writing forms. Evaluation and critical review of student writing. Introduction to department writing standards and style guides.</td>
</tr>
<tr>
<td>ME 4031W</td>
<td>Instruction on maintaining lab notebooks and writing lab reports. Formal and informal evaluation of writing.</td>
</tr>
<tr>
<td>ME 4054W</td>
<td>Instruction on maintaining a design notebook, writing technical documents, writing a group-authored design report, team communication, communicating with project sponsors. Formal and informal evaluation of writing including review of drafts.</td>
</tr>
</tbody>
</table>

The first pillar of the writing program is that students experience discipline specific writing and receive discipline specific writing instruction in three core courses: ME 2011, ME 4031W and ME 4054W. In ME 2011 students learn a range of writing genres, including some that are covered in more detail in later courses. ME 4031W focuses on lab notebooks and lab reports while ME 4054W is concerned with writing related to design projects including notebooks, proposals, project plan and design reports.

The second pillar of the writing program takes place in the core and elective engineering science courses that are problem set based where writing is valued but less attention is paid to explicit writing instruction. Students in these courses are provided with instruction in how to write a problem set and are expected to deliver problem sets that meet department expectations for writing. While writing mechanics is not the focus of these courses, students are expected to communicate technical information clearly including problem sets, equations, graphs, tables, charts and sketches. Writing instruction is in the form of acquainting students with available resources on how to write a problem set, including the department’s problem set style guide and the instructor making clear in the syllabus and in opening lectures that quality of communication on problem sets is important for the course and important for the student’s growth as an engineer. The expectation is that in some of the courses, part of the grading for a problem set is based on quality of the writing along with quality of the technical content. The other set of courses in this category are the six senior lab courses. Here students are provided with resources on keeping lab notebooks and writing lab reports, a repetition of skills they learned in
the pre-requisite writing intensive course ME4031W. Instructors in the lab courses make it clear that excellent communication in lab reports is essential for success.

Assisting the pillars is the non-discipline specific writing instruction provided by the introductory courses taught outside the department, which includes First Year Writing and physics.

**Aligning Writing Outcomes to the Core Curriculum**

The desired writing abilities listed earlier are the expected outcomes for students graduating in Mechanical Engineering. The table below maps each outcome to one to one or more of the discipline-specific writing characteristics (also described above), to one or more engineering writing products seen in our courses and to the means of assessment that can be used to determine if our students are attaining the expected outcomes.

<table>
<thead>
<tr>
<th>ABILITY</th>
<th>CHARACTERISTICS</th>
<th>PRODUCTS</th>
<th>ASSESSMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apply knowledge of physics, mathematics, and engineering in their writing</td>
<td>efficient in describing and solving problems, logical, integrates text, numbers and graphics, describes complex technical concepts</td>
<td>problem set, design report</td>
<td>sampled problem sets from selected engineering science courses, ME4054 design report, ME4xxx lab report</td>
</tr>
<tr>
<td>Record and analyze activity related to laboratories and design projects</td>
<td>data-driven, pointed and concise, prescribed format</td>
<td>lab notebook, lab report, design notebook</td>
<td>ME2011 notebook, ME2011 lab report, ME4031 lab report, ME4xxx lab report, ME4054 notebook</td>
</tr>
<tr>
<td>Visually represent technical concepts and designs to explain their salient features</td>
<td>depiction of spatial objects, describes complex technical data and concepts, integrates text, numbers and graphics</td>
<td>annotated hand sketch, CAD drawing</td>
<td>ME2011 portfolio, ME4054 report</td>
</tr>
<tr>
<td>Synthesize and summarize key points</td>
<td>pointed, concise</td>
<td>abstract, executive summary</td>
<td>ME4031 lab report, ME4054 design report</td>
</tr>
<tr>
<td>State and explain engineering project metrics such as productivity, costs and time to completion</td>
<td>systematic, credible</td>
<td>project proposal, design report</td>
<td>ME4054 statement of work, ME4054 design report</td>
</tr>
<tr>
<td>Analyze the audience and create a document that meets their needs</td>
<td>appropriate choices of evidence, appropriate use of technical information, appropriate style</td>
<td>project proposal, design report, professional correspondence</td>
<td>ME4054 statement of work, ME4054 design report</td>
</tr>
<tr>
<td>Represent themselves professionally through their writing</td>
<td>credible, clear, explanatory, correct mechanics</td>
<td>resume, cover letters, e-mail, professional correspondence</td>
<td>ME2011 resume</td>
</tr>
<tr>
<td>Explain, discuss, and demonstrate physical apparatus</td>
<td>Explains complex technical concepts, concise, integrates text and graphics</td>
<td>design report, project report</td>
<td>ME4054 design report</td>
</tr>
<tr>
<td>Integrate visual, textual, and</td>
<td>efficient</td>
<td>poster</td>
<td>ME2011 technical</td>
</tr>
</tbody>
</table>
Mechanical Engineering Style Guides

A set of discipline-specific style guides has been developed to assist students and instructors in assignments that involve writing. The guides include writing problem sets, writing lab reports, writing design reports and writing posters. The guides are non-course specific so that they can be used in any course that requires the genre covered by a guide. While much of the material in the guides can be found in numerous technical writing books, the value of creating our own guides is that they can focus on what is most important to mechanical engineers and they send the message that writing is important in mechanical engineering at the University of Minnesota.

Augmenting the guides are a set of evaluation rubrics that instructors can use for evaluating student writing and students can use to help them understand expectations for their writing.

Training Course Instructors

The writing program rests on the assumption that while the expectation for high quality writing in a course is set by the faculty member in charge, the majority of the assessment of student work is done by Teaching Assistants (TAs) who for the most part are evaluating student work for technical content. Therefore, the department provides training to all TAs so that they are aware of the department writing program, including the list of writing outcomes. Training also covers how to assess problem sets, lab reports and design reports for writing quality, as well as an introduction to the department style guides. The training occurs during the required TA orientation session that occurs at the start of every semester.

Department Writing Standards Web Site

A department Writing Standards web site has been established. From the Mechanical Engineering home page (www.me.umn.edu): Education > Undergraduate Education > Writing Standards. The web site contains a statement on writing, the department writing program (this document), style guides and instructor resources. Instructor resources include grading rubrics, sample statements about writing to include on syllabi and suggestions for assessing student writing.

University Writing Intensive Requirement

The University of Minnesota requires all students to complete four writing intensive courses (those with a W designator). Two must be taken at the advanced level, and one of those must be in the major. Mechanical engineering majors typically satisfy the writing intensive requirement by taking the two introductory physics courses and ME 4031W and ME 4054W,
both of which are advanced and within the major. There are no plans to change the W status of these two courses.

Transfer Students
Mechanical Engineering graduates a large number of transfer students who typically enter in the second or third year. The admissions department determines whether they have satisfied first year writing and two writing intensive experience equivalent to the introductory physics courses. Once admitted, transfer students will experience almost the same writing instruction and experience as non-transfer students in the major. The only exception is that many transfer students place out of ME 2011, the only lower division course offered by the department. The writing outcomes expected of transfer students are the same as for non-transfer students.

Connecting Writing to the ABET Accreditation Process
Every six years the mechanical engineering undergraduate program goes through a comprehensive ABET accreditation process, which involves self-study, a site visit and implementing a process of continuous assessment and improvement. ABET accreditation requires that the program have a set of published educational objectives and outcomes for the program, and a documented assessment processes that demonstrates that the objectives meet the needs of stakeholders and that the objectives are being attained. Several of the ABET-required program outcomes are directly or indirectly connected to the department writing program, including objective (g), an ability to communicate effectively. For example, in a previous self-study, faculty in the department felt that objective (a), an ability to apply knowledge of mathematics, science and engineering, was not adequately achieved in the capstone design course ME 4054W as evidenced by sampling design reports. This led to an increased emphasis on analysis-driven design projects and an explicit requirement to document the design in the report. Writing ability #1 (see above), “apply knowledge of physics, mathematics, and engineering in their writing”, comes directly from ABET objective (a), and is assessed in the same way, by sampling design reports from ME 4054W. In another self-study exercise, faculty felt that several important aspects of the design process were not being communicated in the ME 4054W design reports and recommended changes that were recently implemented. Other parts of the department’s documented process of self-assessment involve sampling exams, reports, design notebooks and other student work. Evaluating the ability of students in the major to communicate is a natural part of the ABET evaluation process.

ASSESSMENT OF UNDERGRADUATE WRITING IN MECHANICAL ENGINEERING

Course-Based Assessment in Core Writing Courses
The core writing courses are ME 2011, ME 4031W and ME 4054W. Assessment is used by course instructors for course improvements to rate student writing.

Formative Assessment: Instructors review student work on assignments and use student performance to determine if writing instruction needs modification. In WI courses, instructors provide feedback for revision assignments. Instructors may choose to show exemplary examples of technical writing so that students begin to understand the quality bar. At the end of the course, one or more of the questions related to writing from the optional question bank developed for the Student Rating of Teaching (SRT) are included on the SRT form for the course and used for course improvement.
Summative Assessment: Instructors use rubrics to grade student work on writing assignments. In some cases, an explicit portion of the grade depends on the quality of the writing. Grade-norming sessions are held with instructors in multi-section courses in order to ensure that rubrics are being used similarly across sections and instructors.

Course-Based Assessment in Problem-Set and Senior Laboratory Courses

Formative Assessment: During grading for technical content, TAs examine student work on problem sets and lab reports for writing quality. If the writing quality is not meeting expected standards, TAs use recitation sections or the instructor uses whole class time to provide additional instruction to students in technical communication standards for problem sets or lab reports. Exemplary examples of technical writing may be shown so that students begin to understand the quality bar.

Summative Assessment: In some cases, graders, using a rubric, use a portion of an assignment grade to evaluate the quality of the writing.

Program-Based Assessment

The purpose of assessing the department writing program as a whole is to understand whether it is achieving the goal of students attaining the writing abilities listed in this document. Several forms of assessment are used, some of which are tied to the regular evaluation and continuous improvement done as part of the ABET assessment process. The data from program assessment is interpreted by the Mechanical Engineering Undergraduate Curriculum Committee (MEUCC) who in turn can make recommendations to the department faculty for writing program changes. The MEUCC writes a brief evaluation of the writing program for the ABET self-study report. The archived ABET reports allow evaluation of the program over a longer time window.

Writing Samples: A random set of writing samples are drawn from student work and evaluated by a group of three or four faculty members, possibly with the assistance of members of the Writing Enriched Curriculum (WEC) team. The evaluation uses a rubric with metrics based on the writing abilities listed in Section 2. Writing samples may include the following:

- From ME 2011: Portfolio
- From ME 4031: One lab report
- From ME 4054: Design report
- From one engineering science course: One problem set
- From one senior laboratory course: One lab report.

The sampling takes place on the biennial cycle that matches assessment of course material for ABET purposes.

Program Resources: At periodic intervals, the MEUCC, possibly with the assistance of members of the WEC team, reviews the department writing program resources such as the style guides, grading rubrics and instructor resources, and recommends changes.

Stake-Holder Feedback: A small sample of students in the major, department faculty and practicing engineers are interviewed through survey or in-person for comments on student writing and the department writing program. Practicing engineers are drawn from the Mechanical Engineering Advisory council. Interviewing is biennial and tied to ABET self-assessment.
Curriculum Survey: Since 1999, well before the writing program started, an opinion survey has been administered to students in ME 2011, when they are near the start of their program, and students in ME 4054, when they are near the end of their program. The survey includes a question about the importance of writing to the engineering profession. The survey continues to be administered. The data allows a longitudinal assessment to determine if the writing program has impacted student’s opinion of writing.

SUPPORT REQUIRED TO MAINTAIN THE PROGRAM

WEC Faculty Liaison: Responsible for coordinating, maintaining and improving the writing program. Serves as the connection point between the department and the university WEC program.

MEUCC: Oversight of the writing program rests with the department Undergraduate Curriculum Committee, a standing committee whose membership includes faculty, the head of Undergraduate Students Services and one undergraduate student.

Faculty Teaching Core Instruction Courses: Faculty in charge of ME 2011, ME 4031W and ME 4054W must be particularly sensitive to the responsibility for providing effective and appropriate writing instruction in the courses. Faculty teaching the two WI courses are responsible for ensuring their course meets the WI criteria.

Faculty Teaching Core Engineering Science and Senior Laboratory Courses: Faculty are encouraged to include significant writing instruction in their courses, to make use of the writing style guides, to include a statement about the importance of writing in the syllabus and to assign a small portion of the grade to quality of writing, even for problem set based courses.

Teaching Assistants: TAs are expected to attend the required training on writing instruction that occurs during TA orientation. TAs are expected to encourage students to maintain high standards for technical writing and to provide assistance in writing to students if requested. TAs in the three core writing courses will be involved in the formal assessment of writing.

University of Minnesota WEC Program: Support from the WEC program is needed to: 1. Assist with reviewing student writing samples. 2. Review and advise about our writing resources, including style guides and grading rubrics. 3. Consult with individual faculty teaching core courses on an as-needed basis. 4. Consult and assist with the “Teaching with Writing in Mechanical Engineering” workshop for department TAs, delivered twice each year in conjunction with TA orientation
### CONNECTION TO STUDENT LEARNING OUTCOMES

The University of Minnesota Student Learning Outcomes define what undergraduate students can do upon graduation. The learning outcomes state that students:

1. Can identify, define, and solve problems
2. Can locate and critically evaluate information
3. Have mastered a body of knowledge and a mode of inquiry
4. Understand diverse philosophies and cultures within and across societies
5. Can communicate effectively
6. Understand the role of creativity, innovation, discovery, and expression across disciplines
7. Have acquired skills for effective citizenship and life-long learning

The desired abilities in the Mechanical Engineering writing plan align with the SLOs as shown in the table.

<table>
<thead>
<tr>
<th>Apply knowledge of physics, mathematics, and engineering in their writing</th>
<th>Can locate and critically evaluate information</th>
<th>Can identify, define, and solve problems</th>
<th>Have mastered a body of knowledge and a mode of inquiry</th>
<th>Understand diverse philosophies and cultures within and across societies</th>
<th>Can communicate effectively</th>
<th>Understand the role of creativity, innovation, discovery, and expression across disciplines</th>
<th>Have acquired skills for effective citizenship and life-long learning</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Record and analyze activity related to laboratories and design projects</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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</tr>
<tr>
<td>Visually represent technical content and designs to explain their salient features</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Synthesize and summarize key points</td>
<td>X</td>
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<tr>
<td>State and explain engineering project metrics such as productivity, costs and time to completion</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>Analyze the audience and create a document that meets their needs</td>
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<td>X</td>
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</tr>
<tr>
<td>Represent themselves professionally through their writing</td>
<td></td>
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<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Explain, discuss, and demonstrate physical apparatus</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>Integrate visual, textual and oral explanations</td>
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<td>X</td>
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<tr>
<td>Create team-written documents using collaborative authorship tools</td>
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<td>X</td>
<td>X</td>
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<tr>
<td>Produce documents in the styles used by professional engineers</td>
<td>X</td>
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<tr>
<td>Write according to style guidelines approved by mechanical engineering faculty</td>
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<td>X</td>
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