

**Executive Summary of the 2002-03 WPI ME Department Outcomes
Assessment Review**

(The numbered statements below are explained in more detail in the corresponding full report, which follows.)

1. Departmental review and updating of the definition and alignment of student learning *objectives* (longer term, post-graduation) and *outcomes* (expected to be demonstrated at graduation), using external and internal inputs.
2. Schematic illustration of the ME Assessment process, indicating how decisions are made to change 1) the assessment process or 2) the educational program or 3) the objectives.
3. Annual review of how ME students satisfied the ABET outcomes, based on assessment of projects and courses.
4. Metrics for outcomes—detailed explanation of expectations at different levels of achievement for each of the ME/ABET outcomes
5. Faculty expectations for MQP work—based on multiple reviews of MQPs, the faculty adopted this year expectations with respect to team work, understanding of professional and ethical responsibility, communications, life-long learning, understanding of contemporary issues, the use of techniques, skills and modern engineering tools, and the incorporation of design and related issues into project work.
6. Report on the 2003 ME course review, covering four core courses with respect to how students in these courses satisfy certain departmental learning outcomes.

**1. WPI Departmental Objectives And Departmental Outcomes
Review of Outcomes Assessment, 2002-03**

Objectives

	The Department of Mechanical Engineering seeks to have alumni who
1	...are successful professionals because of their mastery of the fundamental engineering sciences, and mechanical engineering and their understanding of the design process.
2	...are leaders in business and society due to a broad preparation in technology, communication, teamwork, globalization, ethics, business acumen and entrepreneurship.
3	...will use their understanding of the impact of technology on society for the betterment of humankind.

These program objectives address abilities that the faculty expects graduates of the program to exhibit after graduation and a few years of professional experience. The Departmental objectives were reviewed in the fall of 2002, leading to some revisions.

The objectives are supported by the departmental outcomes:

Outcomes

A	an ability to apply knowledge of mathematics, science, and engineering
B	an ability to design and conduct experiments, as well as to analyze and interpret data
C	an ability to design a system, component, or process to meet desired needs
D	an ability to function on multi-disciplinary teams
e	an ability to identify, formulate, and solve engineering problems
f	an understanding of professional and ethical responsibility
g	an ability to communicate effectively
h	the broad education necessary to understand the impact of engineering solutions in a global and societal context
i	A recognition of the need for, and an ability to engage in life-long learning
j	A knowledge of contemporary issues
k	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The faculty expects all students graduating from the Department to develop those abilities during their course of study at WPI and to be able to demonstrate a mastery of those abilities at graduation.

The Program Objectives are supported by the Program Outcomes. The relationship is shown in the table below.

		OBJECTIVES		
		1	2	3
O U T C O M E S	a	X		
	b	X		
	c	X		
	d		X	
	e	X	X	
	f		X	X
	g		X	
	h		X	X
	i		X	
	j		X	X
	k	X		

Relation of Program Outcomes to Program Objectives.

The outcomes are assessed in two ways:

1. By seeking input from the customers and stakeholders of the Department through alumni survey and meeting with an industrial advisory board. Our alumni survey attempts to map out how successful our graduates have been and whether they appear to be

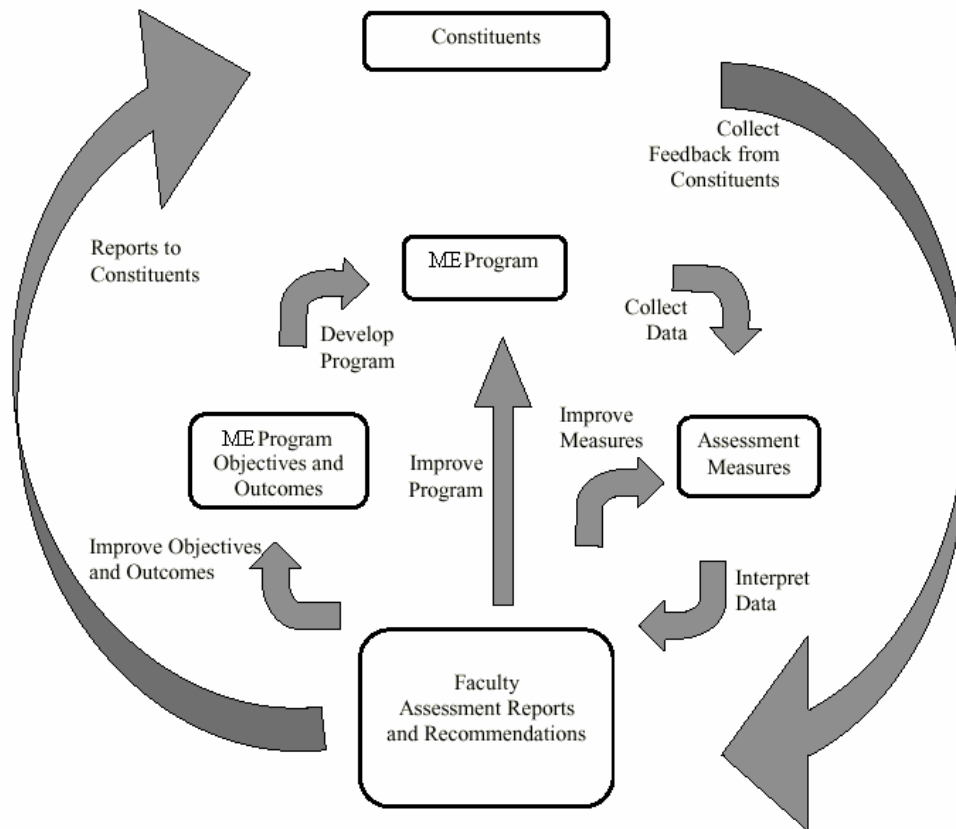
meeting the expectations stated in the objectives. The survey also attempts to assess whether the program objectives are the correct one. The last question is also addressed by reviews of the program objectives by the external advisory board.

2. By assessment of how students meet the program outcomes, using the table above to relate the success in the outcomes to the objectives. This assessment, described in Attachment B, is done by a faculty committee that reviews student work and grades how each outcome is satisfied, using the rubrics in Attachment D. Project and capstone design courses are reviewed every other year and other core courses are reviewed in the years when the projects are not reviewed. The committee members read every project report, but courses are assessed by reviewing only the work of a few students from each course.

Both processes have been in place for a few years and have resulted in action taken to improve the program, as detailed in the ABET self-study.

The overall Departmental assessment process is shown on the next page.

2. Schematic Illustration of the ME Assessment Process



The ME assessment and improvement process is summarized in the Figure above. Each box represents an object and the arrows represent actions of the faculty that connect the objects. The outer loop represents communication with our constituents. The inner loops represent development and improvement of the educational program and the assessment program. Much of the processes shown have been going on informally for years. It is the undergraduate committee's task to formalize the process and then improve on them. The outer loop is the slowest, and it is here that the process starts. With input from our constituents the faculty defines the program objectives and the resulting outcomes. From here we define the educational program. Students go through the program and along the way we gather data. The data is collected through our assessment measures and from there the department's assessment committee interprets the findings. At this point three separate paths diverge. Depending on what is found, the faculty can decide to *change the assessment measures* (for instance if a particular measure is too time consuming and there is an easier way to measure the same thing), the faculty can decide to *change the educational program* (for instance if we found that probability and statistics were only used in the required math course), or the faculty can decide to *change some of the objectives* (for instance if we decided that the objectives did not accurately describe what we wanted to). Changes to the assessment program and minor changes to the educational program will happen much more often than changes to the program objectives. To complete the outer loop, the students and the faculty will interact with our constituencies. From that interaction we will solicit and gather feedback so that we can continue the process.

3. Annual Review of How ME Students Satisfy ABET Outcomes

The departmental outcomes are satisfied in many ways by a variety of activities that students engage in during their time at WPI. Instead of attempting to assess every activity, the Department has decided to focus the assessment on a few selected parts of the curriculum. A significant fraction of our students use the senior thesis (Major Qualifying Project—MQP) to satisfy the capstone design requirement. Those who do not do so must take one or more capstone design course. The Department has conducted biennial reviews of MQP reports for the last six years. Well-defined rubrics have been used to measure a few aspects of the projects and feedback from the review has resulted in a significant increase in the number of projects done in teams and in the quality of the reports, for example. This review process has now been extended to include both Capstone Design Courses as well as a few other selected core courses. The review will now be done every year. The biennial review of MQP reports will continue but with the addition of a review of Capstone Design Courses. In alternate years other core courses will be reviewed. The table below shows what sources we will use to evaluate each Departmental Outcome.

a	an ability to apply knowledge of mathematics, science, and engineering	Core Courses
b	an ability to design and conduct experiments, as well as to analyze and interpret data	ME 3901/MQP
c	an ability to design a system, component, or process to meet desired needs	MQP/Capstone Design Courses
d	an ability to function on multi-disciplinary teams	MQP/Capstone Design Courses
e	an ability to identify, formulate, and solve engineering problems	MQP/Capstone Design Courses/Core courses
f	an understanding of professional and ethical responsibility	MQP/Capstone Design Courses
g	an ability to communicate effectively	IQP/MQP/Capstone Design Courses
h	the broad education necessary to understand the impact of engineering solutions in a global and societal context	IQP/MQP/Capstone Design Courses
i	a recognition of the need for, and an ability to engage in life-long learning	MQP/Capstone Design Courses
j	a knowledge of contemporary issues	Humanity Project, IQP, MQP and Capstone courses
k	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	MQP/Capstone Design courses. ME 3901. Core courses

Table I. The Departmental Outcomes and where the outcomes are evaluated.

The review will follow the already established MQP review process. A committee of three faculty members is appointed by the Department Head in consultation with the Associate Provost for Academic Affairs. The institute provides partial summer support

for each of the committee members. The members of the committee read every MQP report for that academic year and determine how well each outcome is satisfied by using the rubrics listed in the attached document (Attachment D). The committee will also examine how student work in all the Capstone Design courses meet the outcomes, again using the attached rubrics. Unlike the MQP review, where every report is examined, the courses will be reviewed by looking at representative samples of student work and the related course material. The justification is that while the MQP's are individually tailored experiences, all students going through a given course are likely to have a similar experience. We note that all course outcomes are linked to Departmental outcomes and that every advisor fills out a form showing how a specific senior project (MQP) meets departmental outcomes providing a starting point for the review process. This form is currently being modified to incorporate the rubrics listed in Attachment D. The material used for course review is based on the current "ABET course folders" where all material handed in by three or more students, along with all material from the instructor are assembled. The review plan is shown in the table below.

Year	Items reviewed	Comments
2003	ES 3003, ES 2503, ME 3901, ES 2001	Using existing course folders plus new material for ME 3901
2004	MQP/IQP/Capstone Design Courses: ME 4429, ME 4320, ME 4816	
2005	ES 3004, ES 2502, ME 3901	
2006	MQP/IQP/Capstone Design Courses: ME 4770, ME 4430	
2007	ES 3001, ME 2501, ME 3901, ES 2001	
2008	MQP/IQP/ Capstone Design Courses: ME 4429, ME 4320, ME 4816	

Table II. Review Plan.

The Capstone Design Courses are:

- ME 4320. ADVANCED ENGINEERING DESIGN
- ME 4429. THERMOFLUID APPLICATION AND DESIGN
- ME 4430. INTEGRATED THERMOMECHANICAL DESIGN AND ANALYSIS
- ME 4770. AIRCRAFT DESIGN
- ME 4816. MATERIALS OPTIMIZATION FOR ENGINEERS

Three of the Capstone Design Courses will be reviewed during the first round and two during the second round. The core courses consist of three courses in thermal sciences, three courses in mechanical sciences, a materials class, and a laboratory class. These courses are:

- ES 2001. INTRODUCTION TO MATERIAL SCIENCE.
- ES 2501. INTRODUCTION TO STATIC SYSTEMS

ES 2502. STRESS ANALYSIS.
ES 2503. INTRODUCTION TO DYNAMIC SYSTEMS.
ES 3001. INTRODUCTION TO THERMODYNAMICS
ES 3003. HEAT TRANSFER.
ES 3004. FLUID MECHANICS.
ME 3901. ENGINEERING EXPERIMENTATION

One class in each area (mechanical vs. thermofluids) is reviewed in each review cycle but the experimentation class (ME3901) is reviewed in each cycle.

We note, again, that MQP reviews have been done for several years and that some aspects (teamwork, design, report quality) have been measured against specific rubrics. The information provided by the review has been evaluated by the Undergraduate Program Committee which has proposed specific actions, including changes in courses and graduation requirements, seminars and discussions to increase faculty awareness of specific issues, and certification processes where faculty must specifically check for certain content before they can declare that projects satisfy the capstone design requirement, for example. As a result of these actions, significant improvement in the quality of projects has been recorded. We therefore believe that we have in place an assessment system that works and that the addition of a review of the courses and the extension of the rubrics used to measure how well the students meet the outcomes are an extension and improvement of this process, but not a fundamentally new undertaking.

4. Metrics for Outcomes

(a) an ability to apply knowledge of mathematics, science, and engineering

a-i. Demonstrates specific engineering knowledge of subject area.	
3	Understands and applies mathematical and scientific principles toward solving engineering problems. Skilled at evaluating and analyzing process(es) and/or data.
2	Adequately understands and applies mathematical and scientific principles toward solving engineering problems. Adequately evaluates and analyzes process(es) and/or data.
1	Minimally understands and tries to apply mathematical and scientific principles toward solving engineering problems. Shows effort to evaluate and analyze process(es) and/or data.
0	Not present.

a-ii. Demonstrates analysis and judgment.	
3	Always identifies and understands issues or problems. Integrates information from many sources to determine cause and effect relationships. Effectively chooses a course of action or develops an appropriate solution.
2	Frequently identifies and understands issues or problems. Demonstrates potential to integrate information from other sources to determine cause and effect relationships. Chooses a reasonable course of action or develops an appropriate solution.
1	Tries to identify and understand issues or problems. Demonstrates deficiencies with integrating information from other sources to determine cause and effect relationships. Struggles to choose a course of action or develop an appropriate solution.
0	Not present.

a-iii. Demonstrates knowledge of mathematics.	
3	Understands and applies appropriate mathematics. Handles algebra, trigonometry and calculus with minimal errors.
2	Adequately understands and applies appropriate mathematics. Handles algebra, trigonometry and calculus with minor errors.
1	Minimally understands the mathematical and scientific principles involved.
0	Not present.

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

b-i. Shows skill at developing experimental goals and procedures.	
3	Student is able to clearly identify and explain important analytic features of a problem to be investigated during a laboratory experiment. Student can prepare and execute a successful experimental plan.
2	Student presents a correct analysis describing the problem, and is able to use the analysis to plan an experimental procedure.
1	Theoretical approach is lacking or incorrect, test plan will yield experimental data that may or may not be useful.
0	Not present.

b-ii. Demonstrates use of judgment and insight to design (formulate) and present experimental results.	
3	Student is able to associate theoretical analysis and experimental results to develop clear and understandable conclusions. Experimental results are presented in easily understood terms using appropriate charts, graphs, or other presentation format.
2	Experimental trends are discovered and presented using charts, graphs, or other presentation format.
1	Presents data in an understandable manner, but does not explain relation to theoretical trends.
0	Not present.

(c) an ability to design a system, component, or process to meet desired needs

c-i. Identify Design Problem and Constraints	
3	Clear and complete identification of the design goal and the constraints.
2	Basically sound understanding of the problem and constraints, has missed some key points.
1	Evidence of some understanding of the problem, deficiencies will impact the quality of the solution.
0	Not present (no evidence of successful approach to identification of design problem).

c-ii. Explores Alternative Designs	
3	Reasonable alternatives explored to arrive at final design.
2	Alternative approaches explored to a limited depth.
1	Single design presented or unreasonable alternative presented.
0	Not present.

c-iii. Uses analytic tools to aid in design process and support final design.	
3	Selects appropriate tools and uses them effectively in developing design.
2	Uses some analytic tools with moderate effectiveness.
1	Minimal application and use of appropriate tools.
0	Not present.

c-iv. Documented Final Design	
3	Complete, well documented, referenced final design.
2	Incomplete-missing important documentation or calculations.
1	Missing major calculations or design justification.
0	Not present.

(d) an ability to function on multi-disciplinary teams

d-i. Communication and Interaction	
3	Solid evidence of effective technical interaction among participants, with good use of technical communication tools.
2	Useful technical communication among participants.
1	Some evidence of communication and interaction.
0	Not present.

d-ii. Initiative	
3	Uses technical strengths of each team member to full advantage. Full participation and a appropriate technical contributions of each member.
2	Contributions by all members of the team.
1	Limited contributions of team members.
0	Not present.

d-iii. Professional Traits/Skills	
3	Group work shows organization, planning, and productive interaction.
2	Some planning and interaction is evident.
1	Little evidence of leadership, cooperation, or interaction.
0	Not present.

d-iv. Use of Diverse (Multidisciplinary) Technology	
3	Aggressive investigation and use of diverse technology by team members.
2	Successful use of a variety of technologies in the project.
1	Some integration of multiple technologies.
0	Not present.

(e) an ability to identify, formulate, and solve engineering problems

e-i. Demonstrates specific engineering knowledge of subject area.	
3	Can readily apply mathematical and scientific principles to solution of open ended engineering problems. Can make appropriate assumptions and clearly identify the problem to be solved. The solution methodology is clear and correct.
2	Can apply mathematical and scientific principles to solution of open ended engineering problems. Can make assumptions and reasonably identify the problem to be solved. The solution methodology is clear with minor errors.
1	Attempts to apply mathematical and scientific principles to solution of open ended engineering problems. Assumptions are weak and the problem to be solved is poorly laid out. The solution methodology is unclear and incorrect.
0	Not present.

e-ii. Demonstrates analysis & judgment.	
3	Always identifies and understands issues, problems and opportunities. Repeatedly uses effective approaches to develop solutions. Unfailingly takes action consistent with facts, constraints and probable consequences.
2	Often identifies and understands issues, problems and opportunities. Usually uses effective approaches to develop solutions. Normally takes action consistent with facts, constraints and probably consequences.
1	Seldom identifies and understands issues, problems and opportunities. Sometimes uses effective approaches to develop solutions. Occasionally takes action inconsistent with facts, constraints or probable consequences.
0	Not present.

e-iii. Demonstrates effective communication in identifying, formulating and solving engineering problems.	
3	Always stresses major points and follows a logical sequence. Frequently makes effective use of modern presentation tools. Repeatedly uses terms, examples, and graphs that are meaningful to audience.
2	Frequently stresses major points and follows a logical sequence. Often makes effective use of modern presentation tools. Usually uses terms, examples, and graphs that are meaningful to audience.
1	Usually stresses major points and follows a logical sequence. Sometimes makes effective use of modern presentation tools. Occasionally uses terms, examples, and graphs that are not meaningful to audience.
0	Not present.

(f) an understanding of professional and ethical responsibility

f-i. The handling of proprietary information, licensed software, confidentiality, conflicts of interest, citation of sources, quotations, and copyrights. *	
3	Clearly indicates and stresses the importance of the impacts of technology on society and our need to be concerned about them or explicitly acknowledges the responsibility borne by technologies for the effect of their professional work on society.
2	Clearly indicates the importance of the impacts of technology on society.
1	Indicates that the students believe that the impacts on society are worth investigating but does not stress their importance.
0	Not present.

*Same as the IQP review that is done at the campus level except that scale was changed from 5,3,1 to 3,2,1.

f-ii. The extent to which discussion of the impact of technology on society reflected recognition of the social responsibilities of scientists and engineers. *	
3	Clearly indicates and stresses the importance of the impacts of technology on society and our need to be concerned about them or explicitly acknowledges the responsibility borne by technologies for the effect of their professional work on society.
2	Clearly indicates the importance of the impacts of technology on society.
1	Indicates that the students believe that the impacts on society are worth investigating but does not stress their importance.
0	Not present.

*Same as the IQP review that is done at the campus level except that scale was changed from 5,3,1 to 3,2,1.

f-iii. Understands and follows a professional code of ethics for engineers.	
3	Has been exposed to a code of ethics, including professional behavior for interaction with co-workers, superiors, and clients, as well as the general public. Demonstrates this understanding through exemplary conduct on a professional level activity.
2	Has been exposed to a code of ethics, including professional behavior for interaction with co-workers, superiors, and clients, as well as the general public. Demonstrates this understanding through acceptable behavior on a professional level activity.
1	Has been exposed to a code of ethics, including professional behavior for interaction with co-workers, superiors, and clients, as well as the general public.
0	Not present.

(g) an ability to communicate effectively

g-i. Effective Use of Written Communication Tools	
3	Detailed documentation. Appropriate use of computer resources. Clear, concise, organized final report.
2	Minor problems with documentation. Acceptable use of computer resources. Good final report with only minor deficiencies.
1	Little or no documentation. Limited use of computer resources. Poorly organized final report.
0	Not present.

g-ii. Effective Use of Oral/Visual Communication Tools	
3	Speaks clearly and uses appropriate technical terminology. Excellent use of props/audio-visual equipment. Responds well to questions.
2	Minor deficiencies in quality of presentation. Acceptable use of props/audio-visual equipment. Minimal difficulty in answering questions.
1	Serious deficiencies in quality of presentation. Minimal use of props/audio-visual equipment. Great difficulty in answering questions.
0	Not present.

g-iii. Shows evidence of teamwork.	
3	Actively participates and shares relevant information. Listens to and involves teammates. Attends to messages from teammates and responds appropriately. Works hard to produce a final project/product of substantial quality.
2	Significant participation but some room for improvement. Quality of final project/product is reasonable.
1	Some participation with teammates. Final project/product quality may suffer to some degree.
0	Not present.

(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context

h.i. The evaluation of the impact of engineering or technological solutions on society.*	
5	The project is focused heavily, if not entirely, on such an impact and evaluates it effectively using the most appropriate methodologies. (Implies a rating of 4 or higher on methodology and overall quality.)
3	Evaluation of such an impact is a significant component of the project and was conducted using sensible methods (if not state of the art). (Implies a rating of 3 or higher on methodology and overall quality.)
1	Evaluation of such an impact is a relatively peripheral or incidental component of the project and appropriate methodologies either were not employed or shed little light on this issue.

*Same as the IQP review that is done at the campus level.

h.ii. The extent of the student's exposure to global societal issues and/or foreign cultures, either due to project location or topic.*	
5	The project is conducted at a foreign off-campus site and dealt, in a substantive fashion, with topics that were clearly global in nature or international in scope. If conducted on campus, the project focused on and effectively analyzed topics that were clearly identified as global or international.
3	The project was conducted at a foreign off-campus site or dealt, in a substantive fashion, with topics that were clearly global in nature or international in scope.
1	The project was conducted on campus and contained only oblique indications that the students were aware that some of the problems being addressed were global or international in character.

*Same as the IQP review that is done at the campus level.

(i) a recognition of the need for, and an ability to engage in life-long learning

i-i. The extent to which the students acquired and applied knowledge not obtained from prior course work.*	
3	The project contains an extensive, critical review of the literature on a topic and/or makes extensive and effective use of recognized, respected, and appropriate methodologies not likely to have been covered in the students' coursework.
2	The project contains an acceptable review of the literature on a topic and/or makes significant use of appropriate methodologies not likely to have been covered in the students' coursework.
1	The project makes only very limited use of background knowledge or methodologies not likely to have been covered in the students' coursework.
0	Not present.

*Same as the IQP review that is done at the campus level except that scale was changed from 5,3,1 to 3,2,1.

(j) a knowledge of contemporary issues

j. The extent to which the project indicated an understanding or appreciation of contemporary issues.*	
3	The project dealt with an aspect of an issue that is contemporary or aids in understanding contemporary issues. The report, most likely the introduction and/or the literature review, indicated that the students understood clearly the detailed scope and character of the larger societal issue within which their specific topic was imbedded and appreciated its significance.
2	The project dealt with an aspect of an issue that is contemporary or aids in understanding contemporary issues. The report, most likely the introduction and/or the literature review, indicated that the students understood and appreciated the basic societal issue(s) within which their specific topic was imbedded.
1	The project dealt with an aspect of an issue that is contemporary or aids in understanding contemporary issues, but the report says little about the basic societal issue(s) within the specific topic was imbedded.
0	Not present.

*Same as the IQP review that is done at the campus level except that scale was changed from 5,3,1 to 3,2,1.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

k-i. Chooses appropriate analytic and design tools for an engineering problem.	
3	Analysis and design tools used in the problem are well-suited for the problem and show knowledge of available tools and techniques.
2	Shows reasonable familiarity and use of analytic tools.
1	Some evidence of use of modern tools for the problem.
0	Not present.

k-ii. Demonstrates effective practical and analytic techniques in solving engineering problems.	
3	Excellent ability to mix solid engineering analysis with practical design and implementation considerations.
2	Good use of engineering skills to analyze and design a solution to the problem.
1	Uses some engineering skills to determine problem solution.
0	Not present.

k-iii. Shows depth of knowledge in using fundamental and advanced engineering approaches to problems.	
3	Demonstrates clear, sound reasoning in identifying the underlying engineering issues and formulating a plan for solution. Uses the appropriate level of engineering analysis for each part of the problem.
2	Good ability to isolate the problem and formulate a solution. Uses engineering approach to solve problems.
1	Identifies most of the major issues and attempts to solve in an analytic manner.
0	Not present.

5. Faculty Expectations for Major Qualifying Projects Conducted in the Mechanical Engineering Department

The Faculty of the Mechanical Engineering Department endorses the following expectations for Major Qualifying Projects conducted under the auspices of the Department.

1. Students are expected to work in teams of at least 2 persons.

In rare instances where logistics or extenuating circumstances result in the student working alone, the student will demonstrate that he/she has participated as a member of a technical team in either course format or other project based activities.

2. Students will receive instruction in and have demonstrated an understanding of professional and ethical responsibility during the completion of their MQP.

The Project Advisor will insure that appropriate discussions of profession and ethical responsibility take place during the execution of the project. The project report should reflect the discussion as appropriate.

3. Students completing their MQP will have demonstrated the ability to communicate effectively.

WPI requires that a project report be submitted through the Registrar's Office as part of meeting the MQP degree requirement. The Mechanical Engineering Faculty has responsibility for insuring the quality of that report. In addition the Faculty Advisor assumes the responsibility insuring that the project team orally presents the results of their project in an appropriate venue. Usually this venue is participation in the WPI Project Presentation Day in April. In other cases the students may give a formal oral presentation to a project sponsor.

4. Students completing their MQP will have demonstrated the need for and the ability to engage in life-long learning.

Appropriate topics for a Major Qualifying Project will require that the students research and develop technical background that was not directly presented in their prior educational program.

5. Students completing their MQP will have demonstrated a knowledge of contemporary issues.

The Project Advisor will insure that during the conduct of the project the students demonstrate an understanding of the relationship between their project and contemporary engineering literature and issues.

6. Students completing their MQP will have demonstrated the ability to use techniques, skills and modern engineering tools typical of current engineering practice.

An appropriate MQP topic will require students to use techniques, skills and engineering tools that are typical of their first employment as a professional.

Use of the MQP to Satisfy the Capstone Design Requirement

In many cases the Major Qualifying Project may be used to satisfy the capstone design requirement. The Project Advisor may indicate that the student has met the capstone design requirement by checking the appropriate box on the MQP Completion of Degree Requirement form. If this box is checked, the Project Advisor certifies that the student has completed a major design project based upon knowledge and skills acquired in earlier course and project work and incorporating engineering standards and realistic constraints that include most of the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political. Furthermore the Project Advisor certifies that in the process of completing this project, the student has demonstrated the ability to design a system, component, or process to meet desired needs. Reports for MQP projects satisfying a Capstone Design requirement must include evidence that professional and ethical responsibilities have been addressed in the course of the work.

6. Report on the WPI-ME Course Review for Summer 2003

WPI-ME Course Review—Summer 2003

Reviewers: Professors Zhikun Hou and Brian Savilonis

Courses Reviewed: ES 2001 Introduction to Material Science
ME 3901 Engineering Experimentation
ES 2503 Introduction to Dynamic Systems
ES 3003 Heat Transfer

The four core courses were reviewed in June 2003. This was a trial use of rubrics for outcomes assessment and serves as a needed addition to the review work done with MQPs. The ME Review Plan is attached as Attachment B.

For each course, a notebook was assembled by a course coordinator. This included course objectives, topics, links to Mechanical Engineering program outcomes and objectives, syllabi, assignments and handouts, and sample work from A, B and C level students. The report consist of a short summary for each course and a table showing how well a few selected outcomes were met in each course.

METRICS

For outcome (a) an ability to apply knowledge of mathematics, science and engineering, three rubrics were used. They were used to evaluate:

- i. demonstrates specific knowledge of subject areas
- ii. demonstrates analysis and judgment
- iii. demonstrates knowledge of mathematics

For outcome (b) an ability to design and conduct experiments, as well as to interpret data, two rubrics were used to evaluate:

- i. shows skill at developing goal and procedures
- ii. demonstrates us of judgment to design (formulate) and present experimental results

For outcome (e) an ability to identify, formulate and solve engineering problems, three rubrics were used to evaluate:

- i. demonstrates specific engineering knowledge of subject areas
- ii. demonstrates analysis and judgment
- iii. demonstrates effective communication in identifying, formulating and solving problems

For outcome (g) an ability to communicate effectively, three rubrics were used to evaluate:

- i. effective use of written communication tools
- ii. effective use of oral communication tool
- iii. shows evidence of teamwork

Each rubric had a 0-3 scale where 3 is outstanding, 2 acceptable, 1 marginal, and 0 not present. The full set of rubrics, for all outcomes is included with this report as Attachment A.

ES 2001 Introduction to Material Science

Coordinator: Prof. R. D. Sisson, Jr. (Prof. D. Apelian prepared notebook).

Course Objectives:

1. Understand the fundamentals of interatomic bonding in ionic, covalent and metallic materials
2. Understand the fundamentals of crystal structure in metals and ceramics
3. Understand the structure of polymeric materials
4. Understand and be able to apply the fundamentals of mechanical behavior to metals, ceramics and polymers
5. Understand and be able to apply the fundamentals of phase diagrams to engineering materials

Coordinator indicated links to the following Program Outcomes: understanding of fundamental principles of mechanics and materials science, ability to apply mathematics, science and engineering to mechanical systems, written communication, demonstrated knowledge of chemistry and physics, multivariate calculus.

FINDINGS: The reviewers agreed the course presented and assessed the course objectives at a solid level. A level of Chemistry is seen, although physics is limited. The amount of calculus is very limited; the course is not a reasonable vehicle to assess math skills. No substantial writing takes place in the course, so communication cannot be assessed. Overall the course is working with the appropriate objectives and the student work shows a 2-3 level for Program Outcome **a**.

ME 3901 Engineering Experimentation

Coordinator: Prof. J. M. Sullivan, Jr.

Course Objectives:

1. Develop experimental skill in modern engineering measurement methods
2. Develop proficiency in the area of electronic instrumentation and computer-based data acquisition systems
3. Enhance concise and effective report writing and data presentation.

Coordinator indicated links to the following Program Outcomes: understanding of fundamental principles of conservation laws and constitutive relationships, ability to apply mathematics, science and engineering to thermofluid and mechanical systems, Design and conduct experiments, modern engineering tools, written communication, and multivariate calculus and differential equations.

FINDINGS: the reviewers agreed the course presented and assessed the course objectives at a solid level. The amount of calculus assessed does not allow those skills to be evaluated. Overall the course is working with the appropriate objectives. The student work shows a 2-3 level for Program Objectives **a, b, gi and giii, and k**.

Of significance, the course work does NOT demonstrate the ability to DESIGN experiments, so this needs to be assessed in another manner or the course needs to be altered.

ES 2503 Introduction to Dynamic Systems

Coordinator: Prof. E. Cobb

Course Objectives:

1. Demonstrate that they can derive and properly apply kinematic and kinetic equations for particles, rigid bodies, and connected rigid bodies
2. Demonstrate that they derive and properly apply force and moment equations for rigid bodies and for connected rigid bodies
3. Demonstrate that they can derive and apply the equations of work-energy for particles and rigid bodies in planar motion
4. Students demonstrate that they can derive and apply linear and angular impulse relations for particles and rigid bodies in planar motion.

Coordinator indicated links to the following Program Outcomes: understanding of conservation laws, ability to apply math science and engineering to mechanical systems, communication in writing, teamwork, calculus based physics, and apply advanced mathematics through multivariate calculus and differential calculus.

FINDINGS: the reviewers agreed the course presented and assessed the course objectives at a solid level. The calculus assessed is at the level of a first course, the ODEs are very simplistic, but the use of vectors and algebra is very high. Overall the course is working with the appropriate objectives. Communication and teamwork can not be assessed from the student work. The student work shows a 2-3 level for Program Objectives **a** and **e**.

ES 3003 Heat Transfer

Coordinator: Prof. J. Hermanson (Prof. A. Esmaeeli prepared notebook)

Course Objectives:

1. To expose students to the fundamental concepts of conduction, convection, and radiant heat transfer and phase changes
2. To develop competence in calculating the heat transfer and temperature distributions in common basic structural components
3. To develop skill in modeling thermal systems

Coordinator indicated links to the following Program Outcomes: understanding fundamental conservation laws and constitutive relationships, apply math, science and engineering to thermofluid systems, knowledge of physics, multivariate calculus and differential equations.

FINDINGS: the reviewers agreed the course presented and assessed the course objectives at a solid level. The calculus assessed is at a very high level and includes

elementary differential equations. The course has chosen to focus heavily on mathematical modeling. However, this reduces the emphasis on identifying, formulating, and solving open-ended engineering problems. Overall the course is working with the appropriate objectives. The student work shows a 2-3 level for Program Objective **a**, including mathematics and **ei**. Based on the limited amount of work seen, the reviewers questioned whether course completion was strongly linked to the course Objectives. The A students were outstanding in every aspect, but the B/C student differentiation appeared blurred and one seemed able to pass the course without adequately mastering all the objectives.

SUMMARY: All four courses had solid objectives which were directly linked to Program Outcomes. In general, they show our Program meets Outcomes **a, b, e, and k**. There are three issues that should be addressed by the Curriculum Committee.

1. ME 3901 did not demonstrate the ability to design an experiment. Rather it did an excellent job in conducting experiments in both mechanical and thermofluid systems and analyzing experimental data. It uses modern tools at a high level.
2. Of the 4 courses, only ES 3003 really allows the assessment of calculus and differential equations. The work indicates that the better students have a strong mastery of mathematics; weaker students appear to have a reasonable understanding of heat transfer concepts, but they have a very poor ability to deal with higher mathematics. This is the strongest contrast seen in the course material – the ability to apply mathematics.
3. ME 2503 has sufficient open-ended problems that student work can be used to assess Outcome **e**. By contrast, ES 3003, as taught, focuses on mathematical analysis versus open-ended problems and engineering judgment.

The Reviewers also recommend that more student material be presented in the future. It would be desirable to have it randomly selected in proportion to the number of students who receive a given grade. Work that is Unacceptable should also be present, so one can better determine the minimum level that is allowed.

Table: Outcome Assessment of ME Core Courses – Year 2003

Category			ME2001 Material Sciences	ME3003 Heat Transfer	ME3901 Eng. Experimentation	ES2503 Dynamics			
a. an ability to apply knowledge of mathematics, science, and engineering	a-i	Demonstrate s specific engineering knowledge of specific area	Material sciences	3	Lower-that- expected performance in the mid-term and final exams	2		mechanics	3
	a-ii	Demonstrates analysis and judgment		3		2			3
	a-iii	Demonstrates knowledge of mathematics		2		2		Vectots Calculus Basic ODEs	2
b. an ability to design and conduct experiments, as well as to analyze and interpret data	b-i	Shows skill at developing experimental goals and procedures					Would give a factor of 3 in implementation and presentation of these well designed labs. No clear evidence as how students to develop goals and procedures and design an experiment. An open-end lab assignment is suggested.	2	
	b-ii	Demonstrates use of judgment and insight to design (formulate) and present experimental results						2	
e. an ability to identify, formulate, and solve engineering problems	e-1	Demonstrates specific engineering knowledge of subject area		3		2		Dynamics	3
	e-ii	Demonstrates analysis and judgment		2		2		Application to real- word problems	3
	e-iii	Demonstrates effective communication in identifying, formulating and solving engineering problems		2		2			2
k. an ability to use the technologies, skills, and modern engineering tools necessary for engineering practice	k-i	Choose appropriate analytic and design tools for an engineering problem		0		0	labView	3	0
	k-ii	Demonstrates effective practical and analytic techniques in solving engineering problems		1		1	MS Office DAQ Strain gauge Pressure gage	3	1
	k-iii	Shows depth of knowledge in using fundamental and advanced engineering approaches to problems		1		1	Level of analysis is appropriate but not advanced,	3	1

Comments:

1. The above table is for assessment of ME outcomes using three ME core courses and ME3901. Only relevant items, as described in Attachment B, are listed. Shaded areas indicate the associated items are not required by the ME review plan for a particular course.
2. Some description of relationship of course to program outcomes may need to be re-examined and modified if necessary. For example, there is no evidence for factor of 3 assigned for (c) design system and a factor of 3 for (g) teams (in old scales). Also, factors of 3 for mathematics (calculus and DEQs) is not justified from the students' work.
3. It is suggested the following quantitative index is used for the outcome assessment:

$$I = \frac{f_A N_A + f_B N_B + f_C N_C}{N}$$

where f_A , f_B , f_C are factors assigned A-, B-, C-student, respectively, and N_A , N_B , N_C are the numbers of A-, B-, C-students in the class. N is the total population of the class. Each factor can be selected between 0-3, say 2.5 and the assessments from different committee members should be averaged.