Interim Report

For the Materials Science and Engineering Program

(formerly Metallurgical and Materials Engineering)

Contents

Preface

This interim report is to document progress made in correcting weaknesses identified in the Metallurgical and Materials Engineering Program at IIT during the 2002 visit by the EAC of ABET. Weaknesses were identified in Criterion 2 and Criterion 3: specifically, that the assessment process had not been in place long enough to document refinement of program objectives and improvements to the programs as a result of applying the assessment process.

ABET does not prescribe a particular format for interim reports. This report has been structured to follow, as far as is appropriate, the standard EAC format for Criteria 2 and 3. In addition we include both in the body of the report and as appendices relevant data on the nature of the institution, the department, students and the curriculum that place the assessment process in context.

As familiarity has been gained with the assessment process, the process itself has been changed to drop features that produced little or no useful data, and to add elements that we believe are more pertinent. These are also documented in this report.

The Materials Science and Engineering Program (MSE) is one of three accredited engineering programs offered in the department of Mechanical, Materials and Aerospace Engineering (MMAE). These are: Aerospace Engineering (AE), Mechanical Engineering (ME), and Materials Science and Engineering (MSE). The three programs have a high degree of commonality, having some 80% of their coursework in common. While discipline specific faculty teach the professional component of each program, the engineering science core courses are assigned to qualified faculty regardless of his or her specific discipline. Because the programs are small and have so much in common, a common assessment process is used in order to provide better statistics.

20 June 2004

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For the Materials Science and Engineering Program

(formerly Metallurgical and Materials Engineering)

A. Background Information

1. Degree Titles

Bachelor of Science in Materials Science and Engineering. At the time of the 2002 visit the program was named "Metallurgical and Materials Engineering". See Section B.2 for details on program name change process.

2. Program Modes

Day. No alternative modes are offered. A structured co-op is available as an optional activity for students, but co-op experience does not count for academic credit in the program.

3. Contact Information

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B. Accreditation Summary

1. Students

1.1 Program Demographics

See **Table I-2**

1.2 Advising

All students are advised by full-time faculty in the department. New students are assigned to a faculty advisor on enrollment, and are advised either in person, by telephone, or by e-mail correspondence during the inter-semester break prior to matriculation. The advisor has access to the student's high school record, standardized test scores and AP or IB credit prior to the advising session. Once advised, students may immediately register for courses using "Web for Students" ™. Incoming freshmen (and transfer students with less than 30 transferable credit hours) are required to take MMAE100 (Introduction to the Profession) in the Fall semester. Section sizes in this course sequence are limited to 20 (typical size is 14 - 18) and *the course instructor is the students' academic advisor for the first year*. This course meet twice per week, ensuring excellent contact between student and advisor. Following the freshman year, students are assigned a faculty advisor who will usually stay with them for the remainder of their undergraduate career. Advisor's permission is required before a student may register for the following semester or withdraw from any course.

Faculty advisors have the following tools available to ensure that the advising process is effective:

SIS (Student Information System)™ and Web for Faculty™ : this software allows advisors to access the student's complete course schedule and official academic record from their office computer.

Mid-term grades: mid-term grades are issued for all lower division courses. Advisors have access to these grades so that intervention can occur when necessary before the course is complete.

Advising holds: students cannot register for any courses until their advisor releases a hold.

MMAE Department Advising Guidelines: a comprehensive booklet describing how the course sequence fits together, graduation requirements, etc. is provided for students and faculty advisors. These guidelines are also available on the department's web site. The booklet is updated annually.

1.3 Monitoring

Each student's progress is monitored at mid semester (1st and 2nd year courses) by the advisor, and at the end of each semester by the associate chair of the department and the associate dean of the Undergraduate College. Students whose progress is unsatisfactory due to low grades or failing to maintain 12 credit hours/semester (6 CH/semester for part time students) towards their degree are placed on academic probation and notified by letter from the dean's office. Students on probation are limited to 15 hours/semester of coursework, and may not participate in varsity sports or take office in any student organization. In severe cases, students may be asked to meet with the associate dean who will place more stringent conditions on their continued enrollment. Typical conditions may be compulsory attendance at the Academic Resource Center for tutoring, or the Student Counseling Center if learning disability or emotional problems are suspected. IIT is classified as having "selective" admissions, and student academic problems are not usually associated with insufficient ability or preparation, but more commonly with difficulty adjusting to college, inappropriate choice of major, or financial/emotional stress, and the Student Counseling Center is equipped to help is such cases.

If a student stays on academic probation for two (or more) consecutive semesters, the student may be dismissed.

1.4 Evaluation

Students are evaluated using a traditional 4-point grading scale, with grades being assigned by the course instructor. All courses have stated learning objectives and instructors are expected to assign grades based on achievement of those objectives. Specific protocols have been developed for evaluating written and oral communication skills, and team skills. *Thus a passing grade in a course implies achievement of the learning objectives at a minimum acceptable level*.

2. Program Educational Objectives

The 2002 EAC of ABET visit identified the following weakness:

"Various questionnaires have been devised, but there is no extended history of these being extensively refined. There is no mechanism that enables an evaluation on whether the stated objectives have been achieved. No feedback loops have been instituted to determine program changes systematically. This process will become viable after at least one more questionnaire cycle, presumably available in 2003, so that the effectiveness of the program objectives can be determined."

2.1 Objectives

Three engineering programs are offered in the Department of Mechanical, Materials and Aerospace Engineering; they are: Aerospace engineering (AE), Mechanical Engineering (ME) and Materials Science and Engineering (MSE). In the statement of objectives that follows, the concordance with ABET Criteria 3(a) through 3(k) or program specific criteria is indicated in **[ ]**. Please note that following the scheduled review in 2003, there have been some changes in the objectives compared to those in place at the time of the 2002 EAC of ABET visit.

The common objectives of the three programs in the department are:

To educate students for a broad range of professional careers, provide the basis for life-long learning **[3i],** and prepare students for advanced studies at the graduate level. Recognizing the changing professional environment that graduates will encounter, our programs aim to develop graduates who:

- possess a strong foundation in mathematics, science and engineering and are proficient in the engineering sciences on which the major discipline is based **[3a, 4]**
- are able to link science and engineering principles to identify, formulate and solve engineering problems in professional practice and research and development contexts **[3b, 3c, 3e, 4]**
- are able to design and conduct experiments, as well as analyze and interpret data **[3b]**

- have proficiency working in multidisciplinary and interprofessional teams **[3d]**
- utilize effective oral, written, graphical and computational communication skills **[3g, 3k]**
- understand the economic, ethical, societal, environmental and global contexts of their professional activities **[3f, 3h, 3j, 4]**
- have a recognition of the need to remain current in their chosen field and are able to engage in lifelong, independent learning and professional development **[3i]**, and
- translate knowledge of their respective disciplines to a broad spectrum of professions **[3k]**

The MSE program-specific objectives are: to develop graduates who understand the structure, properties, processing, performance, selection, and service behavior of engineering materials including metals, ceramics, polymeric and composite materials. This knowledge applies to design of new materials, improvement of existing materials, and optimization of methods of manufacture **[program criteria, materials and similarly named programs]**.

These objectives are published in the *IIT Undergraduate Bulletin*, the next edition of which will be published August 2004, and on the departmental web site http://mmae.iit.edu

The clear relationship between the program objectives and the requirements of EAC of ABET criteria 3(a) through 3(k) facilitates the determination of the achievement of objectives.

2.2 Constituencies

The faculty has determined the constituencies of the program to be: the public, students, alumni of the program, program faculty, and employers of our graduates. Formal communication with these constituencies has been established by means of:

IIT Board of Trustees: The Board of Trustees represents the public interest and establishes the mission of the university. Its members are drawn primarily from community and industry leaders in the Chicago metropolitan area. The board is responsible for setting the overall mission and goals of the university. It meets twice each year.

Armour College of Engineering and Science Board of Overseers: The College overseers are drawn from industry and academia, and provide guidance to the dean on college wide issues.

MMAE Student Advisory Board: This is a self-governing entity. It conducts its own elections of officers drawn from students enrolled in the three programs within the department, spread over all four years. Secretarial support is provided by the department. This board can act on its own initiative about any issue relevant to the undergraduate programs, or may be consulted by the department head or the department undergraduate studies committee. The student advisory board also conducts a survey of graduating seniors.

It should be emphasized that the low student/faculty ratio in the MME program also results in excellent informal lines of communication between students and faculty.

MMAE External Advisory Board: This board represents alumni, employers of our graduates, and representatives of academia and the professions of mechanical, materials and aerospace engineering. Members are appointed by the department head. This board meets annually with the department faculty, and members may be consulted as appropriate.

The current (2004) membership of the External Advisory Board follows:

Adnan Akay	Lord Professor and Head, Department of ME	Carnegie Mellon University
Ted Belytschko	Professor	Northwestern University
Richard Buckius	Professor and Head, Department of ME	U of Illinois Champaign -Urbana
Skip Fletcher	Director for Aerospace	NASA Ames Research Center
Robert Footlik	President	Footlik and Associates
Les Hardison	Senior Consultant	Wheelabrator Technologies
James Korenchan	Director, Service Delivery	General Motors
Bruce Liimatainen	President	A. Finkl & Sons Company
Robert Page	Emeritus Professor	Texas A&M University
William Rogers	Director, Business Dev & Technology Application	Alcoa Engineered Products
Sushil Sharma	Group Leader -- ME/ASD, Advanced Photon Source	Argonne National Laboratory
Herb Velazquez	Research Fellow, Aesthetics Research Center	Kimberly Clark
Richard Wlezien	Program Manager, Vehicle Systems	Office of Aerospace Technology, NASA Headquarters
Ric Woldow	Advanced Materials Technology	Caterpillar Inc.

IIT Faculty meetings and faculty committees: All new programs, as well as changes in the General Education requirements must be approved by majority vote of the full university faculty. University faculty meetings are held biannually. The *IIT Undergraduate Studies Committee* meets monthly through the academic year and is charged with reviewing programs, monitoring and recommending changes to the General Education Requirements, and approving significant changes in existing programs. The MSE program has a representative on this committee.

MMAE Faculty meetings and faculty committees: Faculty meetings are held monthly. All program changes must be approved by majority vote of the faculty. An annual 1-day retreat has been established for in-depth discussion of programmatic issues. Faculty committees are appointed for various tasks: relevant to the undergraduate program are *Undergraduate Studies Committee*: this has 7 members including the department chair *ex-officio*. It is tasked with evaluating data from the assessment process, making recommendations to the faculty concerning undergraduate program improvements, and approving student petitions for special projects, undergraduate research and course substitutions. This committee provides liaison with the Student Advisory Board. The committee meets on alternate weeks during the academic year or may be convened at any time if rapid response to an issue is required. *Laboratory Committee*: this committee is charged with maintaining the plan for upgrading and improving the departmental laboratory facilities based on needs.

2.3 Establishment and Review of Program Educational Objectives

In 1994 the *National Commission for IIT* was established by the IIT Board of Trustees to chart a course for the following decade. The commission was chaired by Robert Galvin, Chairman Emeritus of Motorola, and its members were drawn from industry and academia and included members of the National Academy of Engineering, National Academy of Science, Nobel Laureates, and leaders of industry and colleges nationwide. There was also student and faculty representation. This commission recommended, *inter alia,* significant changes in IIT's mission and objectives, including an increased emphasis on inter-professional studies, communication skills, and a more international outlook. The Board of Trustees accepted the report in 1995 and mandated its implementation. (This also coincided with the release of a draft of ABET EAC Criteria 2000, which themselves indicated significant curricular change). In order to facilitate the necessary changes the university announced a $250M development campaign. The campaign ended in 2001, having raised in excess of $258M.

Extensive discussion within the faculty took place from 1995 – 97 to establish the basic framework for the necessary programmatic changes, and in 1997 the IIT faculty approved a major revision of the General Education Requirements of the university, to take effect with the entering class of 1999. Among the changes were a requirement for 6 credit hours of work on "Interprofessional Projects" (IPRO) to develop skills working with individuals from other disciplines and professions on real-world technical projects involving economic, legal, ethical and social issues. Another new requirement was for each student to take 42 credit hours of courses designated as communications-intensive (indicated with a (**C**) in the Undergraduate Bulletin), split between courses in the major and in other areas. There must be significant writing, oral presentation or graphical components in these courses.

The MMAE Department's undergraduate studies committee then drafted a proposed set of educational objectives for the department's programs. These drafts were circulated for review and comment to the student advisory board and the external advisory board. The full MMAE faculty then considered the drafts and all comments received, before final approval of the program objectives.

The program objectives are scheduled to be reviewed every three years by the faculty, and by the two advisory boards. The last review was in progress at the time of the 2002 EAC of ABET visit and was completed in Spring 2003.

2.4 Relationship of Curriculum with Program Objectives and Learning Outcomes

The curriculum was designed by the faculty to be consistent with the program objectives. In particular, there is a major emphasis on interdisciplinary studies, team skills, and open-ended problem solving emphasizing the need for life-long learning skills, and on written, oral and graphical communications skills. In keeping with the focus on interdisciplinary studies, the first two years of the program are now common with the Aerospace Engineering and Mechanical Engineering programs. Details and analysis of the curriculum are provided in Appendix I.

The following table indicates the relationship of the required engineering and related courses in the curriculum to the ABET criteria 3(a) through 3(k). In this table, a curriculum component receives a score of 0 through 3 according to the extent to which the particular learning objective is addressed (0 = not addressed at all, 3 = major component of the course. The table indicates coverage of all required outcomes in required courses in engineering topics. *General education courses that contribute substantially to outcomes 3(g), 3(h), 3(i), and 3(j) are not included in this table.*

This table emphasizes that all objectives are addressed in a minimum of three required courses in the curriculum, and most objectives, including all technical objectives, are addressed to some extent in at least 8 required courses.

Table 2.1 ABET outcomes 3(a) - 3(k) addressed in required courses in the MME curriculum. Mathematics, basic science and general education courses *excluded*. All courses are MMAE unless otherwise specified.

Course	EG 105	CS105	100	MS 201	201	202	271	PHYS300
3a	1	0	2	2	2	2	3	3
3b	1	1	2	1	1	1	3	3
3c	2	0	3	0	0	3	1	3
3d	0	0	2	0	0	0	0	0
3e	1	0	2	0	3	2	3	0
3f	1	1	3	0	0	0	1	0
3g	2	0	3	0	1	0	3	0
3h	0	0	2	1	1	0	0	0
3i	1	0	2	1	2	0	0	0
3j	1	1	2	2	1	0	0	0
3k	3	0	2	0	1	3	3	3

Course	365	320	370	463	465	467/483	468	476
3a	3	3	3	3	3	3	3	3
3b	1	0	3	0	1	1	3	3
3c	0	0	0	0	1	1	1	0
3d	0	0	0	0	0	0	0	0
3e	0	0	2	3	2	3	2	2
3f	0	0	1	1	1	1	0	1
3g	1	0	3	1	2	1	3	3
3h	0	0	0	0	0	0	0	0
3i	0	0	0	0	1	0	0	0
3j	0	0	0	0	1	1	1	0
3k	1	3	3	3	1	3	2	3

ABET outcomes addressed in required courses in the MME curriculum (continued).

Course	482	485	IPRO I	IPROII	TOTALS
3a	3	3	2	2	49
3b	1	0	2	2	30
3c	0	1	3	3	21
3d	0	0	3	3	8
3e	3	2	3	3	36
3f	0	1	3	3	18
3g	2	1	3	3	32
3h	0	0	3	3	10
3i	1	1	3	3	15
3j	0	1	2	2	15
3k	2	3	2	2	43

Program objectives relating to experimental and laboratory skills

In addition to two dedicated Materials Laboratory courses (MMAE 370 and MMAE 476) and the Instrumentation course (PHYS 300), the MSE program has a strong experimental component through laboratory requirements in Chemistry, and Physics. Several project and design experiences are incorporated into MMAE 100 during the Freshman year. MMAE 271 ″Engineering Materials and Design″ has one credit hour devoted to experiments on mechanical testing methods including tension, torsion, hardness, impact, toughness, fatigue and creep. The two credit hour Engineering Graphics course includes a two-hour CAD lab per week, the Computer Science course CS105 includes a one-hour laboratory session per week and two of the basic mathematics courses include weekly one-hour long laboratory sessions to introduce symbolic mathematics software (MAPLE). These experiences introduce the student to experimental and design methods, data analysis, report writing and technical presentation techniques, and contemporary engineering tools relevant to the discipline.

2.5 Achievement of Objectives

The assessment plan calls for a review of objectives on a three-yearly cycle. The scheduled review was in progress at the time of the 2002 EAC of ABET visit.

Alumni Surveys were sent in Spring 2002 to all students who graduated from the program in 1995 and 1998 for whom addresses were known. Approximately 15% of the surveys were returned. The only stated objective in which improvement was suggested by a substantial number was *communications skills.* 100% of returned surveys indicated that the graduates of the program either had pursued an advanced degree, or had attended professional society meetings, or both, indicating a strong commitment to lifelong learning. Note: *The curriculum in place since 1999 has had an increased emphasis on communications skills.* The next survey is scheduled for Fall 2004.

Engineering Intern Exam Results from the State of Illinois for 2002 and 2003 indicate a pass rates of 89% and 100% for graduates of the AE, ME and MSE programs. This comfortably exceeds the national average, although the sample size is really too small to be statistically valid. Nevertheless, it is a strong indicator of the quality of the programs.

Employment Data are collected by the Career Development Center and made available to the department. For the years 2001 – 2003 (latest for which data are available) 100% of MSE respondents were employed in their field or enrolled in graduate school within 6 months of graduation. While employers are reluctant to provide feedback on employees, many of employers return year after year to hire our graduates, indicating a high degree of satisfaction.

Input from the Student Advisory Board and Senior Surveys with respect to objectives was perhaps the most valuable source of information. Students reported positively on all objectives except familiarity with *international issues,* and the wording of the objective relating to *lifelong learning.*

2.6 Action Taken to Remedy Weakness

At the time of the 2002 EAC of ABET visit the review of objectives was in progress. Input had been solicited from alumni by way of a survey (results of this were made available to the EAC visitor in 2002). Subsequently inputs have been obtained from the Student Advisory Board and from the External Advisory Board, and data from the EI examination and employment data were also available.

These data were analyzed by the department undergraduate studies committee and recommendations were made to the faculty at its annual retreat in May 2003. Based on the quantitative information from the EI exam and employment statistics, as well as input from the alumni survey and the advisory boards the faculty concluded that the program is highly successful, in that both pass rate in the EI exam and the rate of employment or admission to graduate school comfortably exceed the national averages.

Qualitative feedback received from both alumni and the Student Advisory Board indicated that that the wording of the objectives required reworking in order accurately to reflect the actual intent of the program. In particular the following issues were identified by the Student Advisory Board:

1. The program objectives mentioned “international contexts” of professional activities, and that this was not covered in the program. The faculty agreed with this analysis, concluding that this wording implied a political context that was not, and was not intended to be, emphasized in the program. The emphasis is intended to be on global issues such as environment, resources, sustainable growth, etc.
2. An objective was that graduates should “engage in life-long learning”. It was concluded that prescribing an activity for life was beyond the capability of any undergraduate program, and furthermore was not measurable. Revised wording was suggested.

The faculty considered these comments and agreed that the Student Advisory Board had accurately identified areas of concern.

Specific wording changes were made as follows (omitted text struck out, replacement text in italics)

> Understand the economic, ethical, societal, environmental and ~~international~~ *global* contexts of their professional activities.
>
> And
>
> ~~Engage in lifelong learning~~ Have a recognition of the need to remain current in their chosen field and are able to engage in lifelong, independent learning and professional development

The program objectives as revised May 2003 are stated in section 2.1

The revised program objectives were approved by vote of the department faculty May 9, 2003. They were presented to and endorsed by the External Advisory Board at its meeting in October 2003.

The objectives are next due for review during the 2006-2007 academic year.

2.7 Specific results

2.7.1 Engineering Intern Exam

Year	MMAE Pass rate	National Average
2001	91%	83%
2002	89%	84%
2003	100%	88%

2.7.2 Tracking Survey, AE, ME and MSE programs, 6 months after graduation

Graduation	Employed in field	Graduate school	Seeking job	Other
2001-2002	46%	43%	6%	6%
2002-2003	41%	48%	8%	4%
2003-2004*	67%	22%	0	11%

*Data for May 2004 graduating class not available. Data may not add up to 100% on account of rounding. Source, IIT Center for Career Development.

2.7.3 Responses to specific questions in 2002 Alumni Survey

Question*: Please rate your BS program's overall effectiveness in preparing you for your job or graduate study:*

Excellent	12.5%,
Good	62.5%
Fair	18.8%
Poor	6.3%

Question*: Please rate your preparation relative to that of your peers from other institutions:*

Superior to	18.8%
Somewhat better than	75%
About the same as	0%
Worse than	6.3%

2.8 Program Name Change

In Fall 2003 the materials faculty proposed changing the name of the program to "Materials Science and Engineering", as a name that more accurately reflects the nature and goals and emphasis of the program. This motion was approved unanimously by the faculty of the department, by the External Advisory Board, the Dean of Armour College of Engineering, and by the President and Board of Trustees of IIT. This change is effective from Fall 2004.

3. Program Outcomes and Assessment

The 2002 EAC of ABET visit identified the following weakness:

"*The assessment process has been in place for 18 months, and only one documented cycle has been analyzed to date. Thus the process has not attained sufficient maturity to allow feedback loops to become established. The results from questionnaires have not been applied universally across all courses to allow improvement of the overall program.*"

Program Outcomes

The general program objectives listed in section 2 are framed in terms of outcomes and are repeated here for convenience, together with their relationship to the outcomes specified in EAC Criteria 3 and 4.

Graduates of the MSE program:

- possess a strong foundation in mathematics, science and engineering and are proficient in the engineering sciences on which the major discipline is based **[3a, 4]**
- are able to link science and engineering principles to identify, formulate and solve engineering problems in professional practice and research and development contexts **[3b, 3c, 3e, 4]**
- are able to design and conduct experiments, as well as analyze and interpret data **[3b]**
- have experience working in multidisciplinary and interprofessional teams **[3d]**
- utilize effective oral, written, graphical and computational communication skills **[3g, 3k]**
- understand the economic, ethical, societal, environmental and global contexts of their professional activities **[3f, 3h, 3j, 4]**
- have a recognition of the need to remain current in their chosen field and are able to engage in lifelong, independent learning and professional development **[3i]**, and
- translate knowledge of their respective disciplines to a broad spectrum of professions **[3k]**

In addition, the program specific outcomes are:

- An ability to describe and analyze materials structure
- An ability to relate structure, processing and properties
- An ability select materials for service based on performance
- An ability to design compositions and processes to meet specifications

3.1 Relation of Curriculum to Outcomes

These outcomes are produced by a curriculum comprising:

- A required general education component emphasizing breadth of knowledge of society, human behavior and achievement.
- Required courses in mathematics, physics, chemistry and computer science laying a

sound foundation for engineering studies.

- An introductory engineering course emphasizing the nature of engineering as a profession and the role of the engineer as a professional.
- Basic engineering science courses encompassing knowledge of mechanics, thermodynamics, materials and instrumentation.
- Advanced courses in the major discipline emphasizing structure, properties and performance of modern materials in engineering applications.
- Interprofessional projects in which students work in interdisciplinary teams to design solutions to real-world, open-ended problems, subject to realistic constraints.
- Laboratory courses in which students learn to design experiments, analyze data, and use modern tools of engineering practice
- Communication intensive courses both in the major and in other areas in which writing, oral, and graphical communication skills are developed.
- Technical elective courses enabling students to pursue studies outside of their major area.

The effectiveness of the curriculum in achieving these outcomes is reinforced by well qualified faculty, academic advising conducted by full-time faculty, a low student/faculty ratio, well equipped laboratory facilities, and support services.

Section 2.4 (Table 2.1) gives a detailed correspondence between the curriculum and the learning outcomes EAC of ABET 3(a) through 3(k). Each learning outcome is addressed in a *minimum* of three required courses, and all outcomes relating to technical competence are addressed in a *minimum* of 8 courses.

3.2 Assessment of Outcomes

The various program outcomes are assessed using the following tools:

- Faculty assessment of course and program outcomes (every semester)
- Student course assessments and surveys of graduating seniors (every semester)
- Surveys of alumni (triennially)
- Interprofessional Project (IPRO) program assessments, annually
- Communications program assessments (university wide), biennially
- Student advisory board input (continuous)
- Engineering Intern exam administered by the State of Illinois
- Direct feedback from students (continuous)
- Analysis and recommendations by the IIT and departmental Undergraduate Studies Committees (scheduled meetings throughout the year).

Specific survey instruments in use are listed in Appendix 1C.

The table on the next page indicates how the specific outcomes are assessed, and the estimated utility of each assessment tool on a scale of 0 – 3. A score of zero indicates that no reliance is placed on this tool, and a score of 3 suggests that the tool is considered highly effective. These estimates are based on perceived accuracy and on response rate, and have been adjusted in the light of experience.

Changes since 2002 Visit:

1. The State of Illinois did not release details of EI examination results by topic until 2002. These data are very valuable and have been included in the process since that time.

2. The return rate on employer surveys was very poor, and this instrument has been dropped.

3. The senior survey has been revised to make it more quantitative, although open ended questions remain.

4. The faculty survey has been revised to make it quantitative.

5. The Student Advisory Board has taken over the administration of the graduating senior survey. This now has a 90% return rate.

6. The Student Advisory Board is used for rapid feedback as potential problems arise, enabling a marked improvement in departmental response to student concerns. We have found this to be the single most useful feedback mechanism.

Table 3.1 The tools used to assess program outcomes, and an estimate of their utility. Scale used: zero (no utility) through 3 (highly reliable).

Outcome/Assessment Tool	Faculty Assessment	Senior Survey	Alumni Survey At 3 and 5 years	IPRO and Communications Assessment	EI Exam
Foundation in Math/Science/ Engineering	3	2	1	0	3
Link principles with engineering problems	3	2	1	1	3
Design and conduct experiments…	3	2	1	2	0
Multidisciplinary team skills	1	2	1	3	0
Communication skills	1	2	1	3	0
Ethical, societal and professional responsibility	2	2	1	1	1
Lifelong learning	1	2	1	3	2
Translate knowledge of discipline to profession	2	2	1	2	2
Describe/analyze material structure	3	2	1	1	1
Relate structure to properties/processing	3	2	0	1	1
Selection, service, performance	3	2	0	2	0
Design to specifications	3	2	1	2	0

Metrics

Each engineering course has course-specific learning outcomes, and faculty have defined course-specific metrics for them. In addition, separate, comprehensive assessments are performed on a college-wide basis of the outcomes of the IPRO, communications, and basic mathematics programs.

Satisfactory achievement of program outcomes is defined as follows:

- possess a strong foundation in mathematics, science and engineering and are proficient in the engineering sciences on which the major discipline is based.

  Metric/target: Better than 3.5/5.0 response on returned surveys of faculty, graduating seniors. National average or better EI score.

- are able to link science and engineering principles to identify, formulate and solve engineering problems in professional practice and research and development contexts.

  Metric/target: Better than 3.5/5.0 response on returned surveys of faculty, alumni, graduating seniors. National average or better EI score.

- are able to design and conduct experiments, as well as analyze and interpret data

  Metric/target: Better than 3.5/5.0 positive response on returned surveys of faculty, alumni, graduating seniors.

- have experience working in multidisciplinary and interprofessional teams

  Metric/target: Better than 3.5/5.0 response on returned surveys of faculty, alumni, graduating seniors. College-wide IPRO assessment report considered by program faculty.

- utilize effective oral, written, graphical and computational communication skills

  Metric/target: Better than 3.5/5.0 response on returned surveys of faculty, alumni, graduating seniors. Results of college-wide IPRO program outcomes assessment report considered by program faculty.

- understand the economic, ethical, societal, environmental and international contexts of their professional activities

  Metric/target: Better than 3.5/5.0 positive response on surveys of faculty, alumni, graduating seniors. The IPRO evaluation report is considered by program faculty.

- Understand need for lifelong learning

  Metric/target: Better than 75% positive response on surveys of faculty, graduating seniors for participation in professional development or continuing education activities.

- translate knowledge of their respective disciplines to a broad spectrum of professions

  Metric/target: More than 90% of graduating seniors employed in appropriate positions or in graduate school within 6 months of graduation

Data and Process

Data are collected from the following sources:

Surveys of graduating seniors, faculty, and alumni, see Appendix 1 – (C)

Engineering Intern Examination

Very few graduates of the MSE program enter careers where PE certification is required; the faculty determined it inappropriate to *require* students to take the EI exam. However, seniors are offered the opportunity to take an EI/PE review course free of charge on the IIT campus, and IIT provides an exam registration service The State of Illinois sends exam statistics to the dean. These are made available to the departments. No information is provided on when the candidate graduated the program. Further, the size of the MSE program (average of 3 graduates/year) is such that too few graduates take the EI exam to be statistically meaningful if considered separately. However, the MSE program shares all the mathematics, basic science, engineering science and general education components with the AE and ME programs, and most MSE students take ME or AE professional courses as technical electives. Consequently we believe it valid to aggregate MSE results with AE and ME results to obtain better data. The EI examination is offered biannually.

.**Departmental External Advisory Board**

This board meets annually. A standing agenda item is discussion of students ethical responsibility, communication, knowledge of societal context, team skills, recognition of lifelong learning, and knowledge of contemporary issues.

Departmental Student Advisory Board

This is a formal and highly effective vehicle for rapid consultation and feedback.

Graduate Employment data

The IIT Career Development Center (CDC) tracks graduate employment statistics. Report issued biannually.

Interprofessional Project (IPRO) and Communications Assessment

All students are required to take a minimum of 6 credit hours of Interprofessional Projects (See **Appendix II**), and 42 credit hours of courses classified as “communications intensive”. These are part of the General Education Requirements of the university and supervised by the IIT Undergraduate Studies Committee. The learning objectives of these programs include: development of an ability to work in interdisciplinary teams, developing an awareness of professional and ethical responsibility, developing an awareness of environmental and global issues, developing an awareness of the need for lifelong learning, and developing written and oral communication skills.

Protocols have been developed for assessing the objectives of the IPRO program and the Communications Across the Curriculum program. These assessments are coordinated by the Director of Interprofessional Projects and the Director of the Writing Program, respectively. Written reports are conveyed to departments. The assessments for 2002-2003 and the preliminary assessment for 2003-2004 are attached (Appendix III).

The Department Faculty

The faculty has the primary responsibility for assessing program outcomes, and is considered to have the greatest insight. Faculty input is obtained at both the course and program level.

At the course level faculty are asked to evaluate their students' preparation in mathematics, science and engineering prerequisites, and to determine the level of achievement of the course objectives. Designing assignments and examinations to embed outcomes assessment is strongly recommended. A survey has been developed for students in the course to provide feedback to the instructor (attached), also a self-assessment that the instructor is asked to complete and return to the department chair (attached). Standard rubrics are available for assessing communications and design components of courses.

At the program level, faculty who teach senior level classes are asked to submit written comments on their perceptions of the achievement of the seniors with respect to the entire set of program objectives (attached).

Three adjunct faculty (Drs. D. Duvall, J.P. Singh and W. Warke) teach senior level professional content courses, and are local engineering practitioners (see section 4) whose input provides a large measure of objectivity to the faculty survey.

Informal communication between faculty and students

The basic MSE program graduates, on average, 3 – 4 students each year. Consequently the channels of communication between faculty and students are excellent and strongly encouraged. We find that identification and resolution of course level problems generally far more rapid by these channels of communication than by waiting for statistical analysis of data at the end of the semester or academic year.

Evaluation and Process for Corrective Action

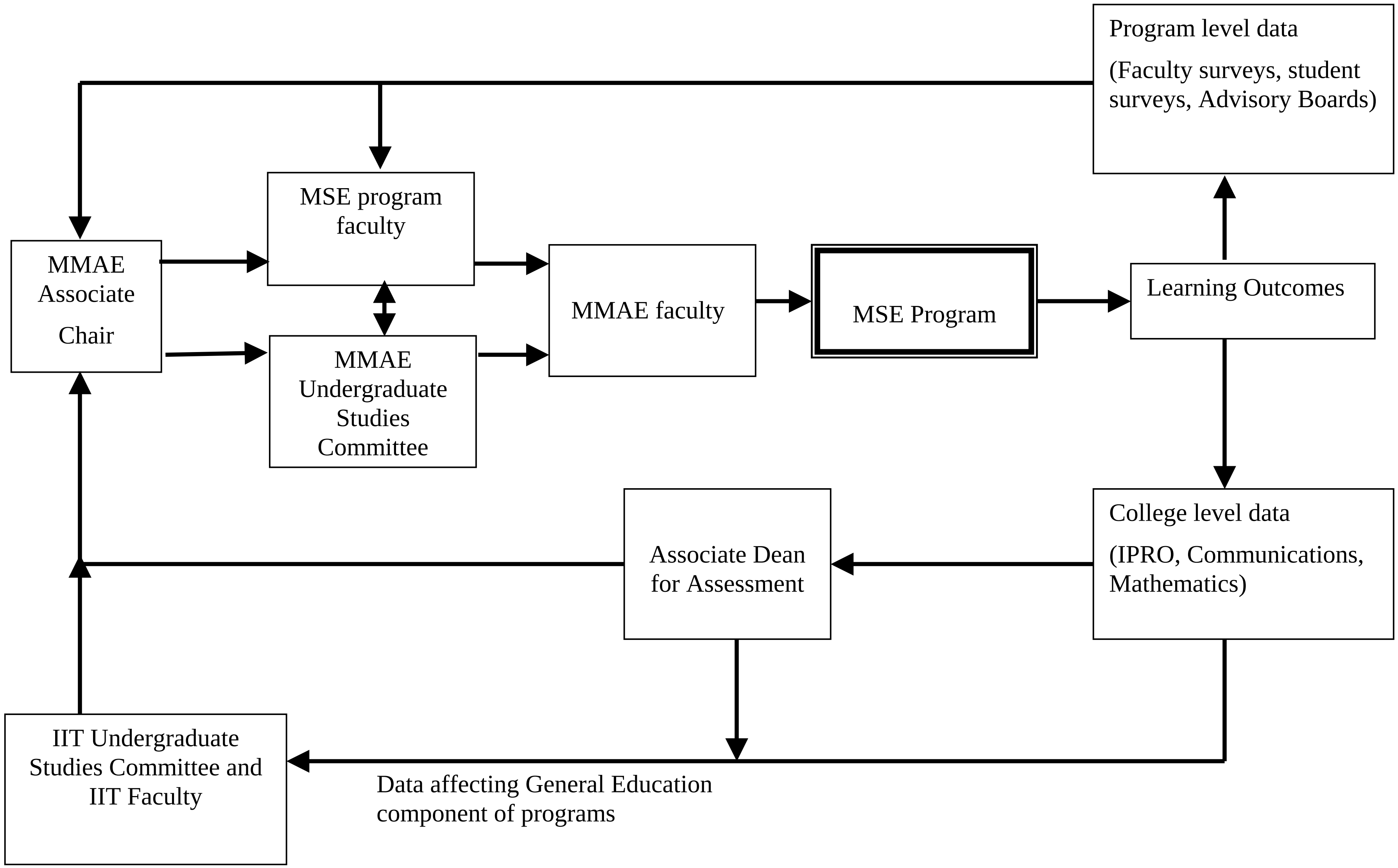
The IIT Faculty, the IIT Undergraduate Studies Committee (a subcommittee of the Faculty Council), the dean of Armour College of Engineering and Sciences, the department chair, the department Undergraduate Studies Committee, and program faculty are responsible for evaluating and analyzing data and implementing program changes.

Changes to the General Education Program must be approved by the Faculty. Detailed analysis and recommendations for proposed changes is delegated to the IIT Undergraduate Studies Committee. The IIT Undergraduate Studies Committee meets monthly throughout the academic year.

Program changes that do not affect the General Education Program must be approved by the MMAE department faculty and by the dean. Analysis of data and recommendations for program change are the responsibility of the MME program faculty, the MMAE department associate chair, and the MMAE department Undergraduate Studies Committee. The MMAE Undergraduate Studies Committee meets bimonthly throughout the academic year.

The schematic on the following page illustrates the assessment process.

Schematic Illustrating the MME Assessment Process



3.3 Survey and Engineering Intern Examination results:

Table 3.2 Average on scale from 1 (poor) to 5 (excellent) on questions pertaining to ABET criteria 3(a) through 3(k)

ABET Criterion	Faculty 2002-03	Faculty 2003-04	Graduating Seniors 2002-03	Graduating Seniors 2003-04
3a	3.8	3.8	3.8	3.9
3b	3.6	3.8	4.1	3.9
3c	3.4	3.4	3.5	3.6
3d	4.1	4.0	3.8	4.1
3e	3.8	3.8	3.7	3.9
3f	4.1	4.0	*	*
3g	3.6	4.0	3.3	3.3
3h	3.3	3.3	*	*
3i	3.7	3.7	*	*
3j	3.5	3.5	*	*
3k	3.7	3.8	3.5	3.6

*** These questions required yes/no response from students.**

Table 3.3 Percent "Yes" answers from graduating senior survey questions:

Question	% "Yes" 2002-03	% "Yes" 2003-04
Understand ethical and professional responsibility 16) Do you belong to a professional society in your field?	**25**	**29**
17) Were ethical considerations covered in any of your engineering courses?	**67**	**54**
18) Was the coverage of ethics adequate in your opinion?	**53**	**33**
Understanding of global and societal context of the engineering discipline 19) Did the IPROs make you consider the role of engineering in society?	**54**	**50**
20) Did the humanities and social sciences courses influence your thinking about the role of engineering in society?	**37**	**33**
Recognition of the need for life-long learning and knowledge of contemporary issues 21) Did the program encourage you to consider graduate school?	**82**	**79**
22) In the last year have you attended at least one lecture in the field of engineering that was not part of the curriculum?	**52**	**58**
23) Have you browsed the internet or in the library for engineering or scientific information that was not related to your classes?	**70**	**71**
24) In your engineering courses did you ever go beyond the requirements of an assignment just because it interested you?	**84**	**88**
25) Have you read a technical article just for fun..	**74**	**71**
26) Do you subscribe to any technical journals	**25**	**29**
27) Do you regularly read a newspaper or news magazine	**88**	**83**
28) Do you think that your engineering program was up-to-date	**80**	**67**

Table 3.4 Percent "Yes" responses to questions concerning prerequisites on course surveys:

Question	2002-3	2003-4
Was the preparation adequate in prerequisite math and science courses	**100**	**100**
Was the preparation adequate in pre-requisite engineering courses	**95 ****	**100**

Comments on Table 3.4: The only course generating a "No" response was MMAE350 – Computational Mechanics. A professor teaching that course for the first time expected the students to have been trained in the use of "Matlab" in a previous course. See section 3.5 for remedial action.

Table 3.5 – Summary of scores from Engineering Intern Examinations

Subject	2002 MMAE Average	2002 National Average	2002 Difference	2003 MMAE Average	2003 National Average	2003 Difference
Chemistry	51	48	3	87	76	11
Computers	76	64	12	82	65	17
Dynamics	64	53	11	72	75	-3
Electrical Circuits	54	54	0	46	56	-10
Engineering Econ	100	63	37	70	55	15
Ethics	70	68	2	90	80	10
Fluid Mechanics	50	57	-7	75	62	13
Mat Sci/Str Matter	59	63	-4	88	63	25
Mathematics	84	65	19	82	69	13
Mech of Materials	63	53	10	69	61	8
Statics	63	63	0	73	57	16
Thermodynamics	74	64	10	75	59	16

3.4 Analysis

The data presented in Tables 3.2 – 3.5 clearly indicate that the students in the program are achieving the target outcomes in those criteria relating to proficiency in mathematics, basic and engineering sciences (scores >3.5/5.0 on faculty and student surveys, technical scores exceeding the national average on the EI exam by 8 and 11 points respectively in 2002 and 2003). These are outcomes corresponding to **Criteria 3(a), 3(b), 3(e), and 3(k)**.

Results of the faculty surveys and the university wide IPRO and Communications across the Curriculum assessment (Appendix III) indicate that the students are able to communicate effectively, while the students themselves rated their abilities at 3.3/5.0, an above average score but below our target of 3.5. In this particular case, we believe that the lower student score may be a consequence of some residual insecurity particularly in terms of presenting oral reports. The IPRO presentations are evaluated by judges from outside the university, and their assessment is likely more reliable than the students' own perceptions. The faculty consider the students' communication skills to satisfy **Criterion 3(g)**.

Faculty, student and IPRO evaluations all indicate that the students' ability to work in multi-disciplinary teams is satisfactory (**Criterion 3(d)**). Student evaluations indicated variable quality in the IPRO experience. This information has been forwarded to the IPRO director, T. Jacobius.

The large fraction of the graduating seniors who enter graduate school (Table 2.7.2), combined with the number who report that they read articles or attend lectures going beyond the requirements of the program, and the faculty survey of instructors teaching senior level courses or supervising undergraduate research projects, all indicate that the graduates have a clear awareness of the need for lifelong learning (**Criterion 3(i)**).

Professional and ethical issues, including consideration of the ISPE code of ethics, are explicitly covered in MMAE100, MMAE271, and CS105. In addition all laboratory courses, IPRO and design projects implicitly involve consideration of professional and ethical issues. The faculty believes (4.1/5.0 and 4.0/5.0 in the last two years) that the graduates of the program have been made aware of and understand these issues. The EI examination results show our graduates scoring above the national average on ethics questions. However, the students' own perceptions (Table 3.3) indicate the contrary. Indeed, it seems that over 40% cannot recall ethics having been covered at all!

Our interpretation of this apparent paradox is that the explicit coverage of ethics took place in the freshman and sophomore years, and course details had been largely forgotten by the time the students graduated. The embedding of professionalism and ethical issues in the later courses is implicit, and we suspect that students simply were unaware of the presence of these components. The MMAE271 instructor wrote on his assessment *"I do talk about ethical decisions and examples where an ethical decision would be needed (from biological devices to structures to transportation). But students tend not to focus very strongly on this aspect of the course."* On balance, the data suggest that graduates of the program are aware of professional and ethical issues, **Criterion 3(f),** but that some action is needed to increase their perception (see section 3.5).

Design skills (**Criterion 3(c)**) are given similar ratings by faculty and students (3.4 – 3.6/5.0). In the MSE program the major design experience is in the senior year Interprofessional Project (IPRO) which has its own separate assessment (see Appendix III) that includes judging by practicing professionals. The IPRO assessment rates the quality of work produced by student teams to be high. We conclude that the design skills of the graduates meets expectations, but can be improved (Section 3.5).

Section 4 describes the General Education requirement in Humanities and Social Sciences, which combined with 12 hours of technical electives, 3 hours of free elective, and the availability of minors ensures that students receive a broad education necessary to understand the impact of engineering solutions in a global and societal context (**Criterion 3(h)**).

Faculty surveys rate students' knowledge of contemporary issues at 3.5/5.0. Over 80% of the students report that they regularly read a newspaper or journal, over 70% report reading engineering or scientific material not related to their classes and reading a technical article "just for fun". Over 25% subscribe to at least one technical journal and participate in professional society activities. Some 40% of the IPRO projects originate with companies, hospitals, not-for-profits, etc., while most of the rest are connected in some way with faculty research programs. We conclude that **Criterion 3(j)** is satisfied, although a greater participation in professional society activities should be encouraged. (Section 3.5)

3.5 Program Improvement

The data in section 3.3 are *lagging indicators* of the state of the program and the issues highlighted had, in most cases, already been identified by feedback from the Student Advisory Board or the faculty. We have found this to be such an effective mechanism that potential problems at the course level were identified and rectified before they become actual problems. The surveys also ask open ended questions whose responses cannot be counted and tabulated but nevertheless provide useful information and recommendations. Thus, most of the issues raised in Section 3.4 have already resulted in remedial action.

3.5.1 Program changes since the 2002 visit

1. Based on recommendations from the faculty and Student Advisory Board, the semester 2 course MMAE111 (Introduction to Design) has been replaced with a *free elective*. This course was a follow-on to MMAE100 Introduction to the Profession. The reason for the change was (a) second semester students did not have sufficient engineering background for realistic design problems at a level beyond the projects already undertaken in MMAE100, and (b) the free elective allows students to pursue interests beyond the purely technical, thus contributing to the achievement of Criterion 3(h) and 3(j). This change was made effective Spring 2003.
2. Materials Science (MS201) has been moved to semester 2. This is a basic science, and fits better in this position in the curriculum. It also serves to introduce materials majors to their discipline at the earliest opportunity. This change was made effective Fall 2003
3. MMAE271 (Engineering Materials and Design) has been moved from the second year to 5^{th} semester. It is now taken after MMAE202 (Mechanics of Solids II – Strength of Materials). This is the first materials design course and presenting it after MMAE202 removes the need for much duplication of content. It also moves a course with explicit ethics content into the junior year, helping address the issue raised in Section 3.4. This

change was made effective Fall 2003.

4. Both senior surveys and alumni surveys indicated a desire for more manufacturing content. The department has responded by offering at least one elective in this area each semester, starting Fall 2002. The courses are: CAD/CAM and Numerical Control, Design for Manufacture, and Design for Safety in Machines.

3.5.2 Course improvements.

At the end of each semester faculty are asked to complete a form documenting the extent to which course objectives were achieved, and recommending changes (if any) to the way the course is taught. The form also tracks from semester to semester whether these recommendations have been implemented. Among the improvements made since 2002 are:

MS202 Materials Science. Section on crystal systems and space lattices has been shortened to reflect only those found in common materials. More classes devoted to electronic materials. Change made Summer 2003.

MMAE100 Introduction to the Profession. First homework assignment is to locate the ISPE Code of Ethics. Third and fourth classes in the course are ethics case studies. Partially addresses ethics issue identified in Section 3.4. Change made Fall 2002. **MATLAB** software package to be introduced. This accommodates the needs of MMAE350 (Computational Mechanics, a popular elective). Change effective Fall 2004.

MMAE201 and MMAE202 (Mechanics of Solids I and II) – content distribution between these two courses adjusted. Change effective Spring 2003.

MMAE470 Materials Lab II. One 3-week lab requires the students to design their own experiment. Contributes to Criterion 3(b). Change effective Spring 2003

MMAE365 and MMAE463 (Structure and Properties I and II) content adjusted between courses to distribute content more evenly. Change effective Spring 2004.

IPRO. Faculty member added with specific responsibility for core content and educational outcomes. See Appendix III.

3.5.3 Other changes

Student Chapter of ASM International chartered Spring 2004. All juniors and seniors in the MSE program have joined this professional society. Chapter advisor is Prof. John Kallend.

First Student Poster Competition held 4/9/2004. Chicago Chapter of ASM International sponsored cash prizes.

MMAE department has allocated a budget of $1,500 to promote student chapter activities (ASM International, ASME, AIAA, SAE) for 2004-5 academic year.

Annual $5,000 Ralph L. Barnett Excellence in Teaching Award. Students nominate faculty for the award. This award promotes teaching excellence.

Student Advisory Board solicits input from students and advises the department on the selection of elective courses for the following year.

New Undergraduate Advising Guidelines developed. This 15 page booklet, revised annually, provides guidance on course selection, a tool for assisting students meet pre-requisite requirements, information on how to complete a minor or double major, and more. It is given to all faculty advisors and all students at the beginning of the academic year, and is available on the internet at http://mmae.iit.edu/downloads/undergrad_guidelines.pdf

These actions are designed to promote increased awareness of professional responsibilities and knowledge of contemporary issues in engineering, and generally improve the teaching program of the department.

3.5.4 Example of the Use of Student Advisory Board to Help Resolve Student concerns in a Timely Manner

Five weeks into Fall semester 2002 the Student Advisory Board brought to the attention of the Undergraduate Studies Committee a developing problem in MMAE350 (Computational Mechanics) – an elective course in the MSE program. The instructor, who was experienced but had previously taught only graduate level courses, was teaching the course at too high a level and incorrectly assumed pre-requisite experience with MATLAB. The Chair met with the instructor to discuss the level at which the course was taught. To assist students who had fallen behind an additional teaching assistant was assigned to MMAE350 to run a workshop on MATLAB. The time required for remedy to be implemented was less than 1 week.

4. Professional Component

In recognition of the professional environment in which IIT's graduates will work, and in line with a revision of the mission and goals of the university by the Board of Trustees, the program was modified in 1999 with the objective of placing more emphasis on

- Teaching students to understand the economic, ethical, societal, environmental and international context of their professional activities.
- Improving oral and written communication skills
- Training students to work in multidisciplinary teams
- Preparing students for the interprofessional work force of the 21st century

The curriculum includes an introductory course in the freshman year (MMAE 100). This course includes the following:

- Introduction to engineering and design through case studies;; hands-on sessions; simple design projects; etc.
- Familiarization with IIT facilities such as the Galvin library, Career Development Center, Academic Resource Center
- Horizontal connection with the first year mathematics and science courses
- Emphasis on written and oral communication skills
- Exposure to the interdisciplinary and interprofessional nature of engineering
- Introduction to engineering ethics
- Hands-on experience with computers and software packages

IIT's General Education requirement specifies two three credit-hour ***Interprofessional Project*** (IPRO) courses. The two IPRO courses are taken in the Junior and Senior years. These projects involve teams of (nominally) 10 students drawn from two or more different disciplines who work under faculty guidance on open ended projects created by the faculty or submitted by external organizations (companies, National Laboratories, hospitals, not-for-profit organizations, etc.). Projects must include a technical component and real-world constraints (economic, ethical, environmental) before being approved. The IPRO program is coordinated by a full-time professional staff member, Thomas Jacobius. Details of the services performed by his office may be found in Appendix II. In the MSE program there is no constraint on project choice for the first IPRO experience, but the second (senior year) IPRO must be confirmed by the student's academic advisor as qualifying as ***a major design experience*** for the student.

In addition to the General Education Requirements and MSE requirements, there are Special Academic Requirements concerning Writing and Communications. These requirements are the following:

"Students must satisfy the Basic Writing Proficiency Requirements as set forth in the General Education Requirements. Students much complete a minimum of 42 credit hours of courses with a significant written and oral communication component, identified with a (**C)** in the catalog, with a minimum distribution as follows:

- 15 hours in major courses
- 15 hours in non-major courses"

To obtain the BS in Materials Science and Engineering at IIT a student must satisfactorily complete 127 credit hours. The courses can be broken down into the categories: basic math and science, engineering topics, humanities and social or behavioral sciences, Interprofessional Projects, and technical electives. More details of these courses and of the program requirements can be found in Table I-1.

In the following descriptions, 32 credits is equivalent to 1 year of study.

Basic Math and Science (35 credits):

4 (18 credits) calculus courses including one course each in "multivariate and vector calculus" and "differential equations"
1 (4 credits) Chemistry course which includes a laboratory
3 (11 credits) Physics courses, two of which include a laboratory
1 (2 credits) course in Computer Science, including laboratory

This meets the requirement of Criterion 4

Humanities and Social Science (21 credits)

7 (21 credits) courses in the humanities and social or behavioral sciences (with a minimum of nine credit hours in each) are required provided the student takes and satisfies the IIT English Proficiency exam. Courses satisfying the 21 credit hours are listed in the bulletin with either an (H) or (S) for humanities and social sciences

respectively. Two courses at the 300 level or above are required in both humanities and social science. In addition, two but not all of the courses a student takes in social science must be in the same field. Students who do not satisfy the IIT English proficiency exam must take an English composition course at IIT in addition to the 21 credit hours in humanities and social sciences.

This meets the requirement of Criterion 4 and contributes substantially to the outcomes 3(g), 3(h), 3(i), and 3(j).

Engineering Topics (51 credits)

1 (3 credits) introductory engineering courses: MMAE 100
1 (3 credits) course in Materials Science
1 (3 credits) course in Statics
1 (3 credits) course in Strength of Materials
1 (3 credits) courses in Thermodynamics
1 (2 credits) course in Engineering Graphics
1 (3 credits) courses in Engineering Materials and Design with a laboratory
2 (6 credits) courses in Materials Laboratory
2 (6 credits) courses in Structure and Properties of Materials
1 (3 credits) course in Ceramics
1 (3 credits) course in Polymers
1 (3 credits) course in Composite Materials
1 (3 credits) course in Electrical, Magnetic and Optical Materials
1 (3 credits) course in Manufacturing Processes
1 (3 credits) course in Instrumentation, with a laboratory
1 (3 credits) IPRO course must be selected to satisfy the major design experience requirement (see next section).

This meets the requirement of EAC of ABET Criterion 4

Interprofessional Projects (IPRO's) (6 credits)*

2 (6 credits) IPRO courses are required. Students work in small multidisciplinary groups. Often the students take one of their IPRO's outside of the Department where the faculty member in charge is from outside of the Department. The selection of the second IPRO must guarantee ***a major design experience*** for the student unless such an experience has been or will be obtained in an alternative elective course. Projects submitted for consideration for IPROs typically include most of the following considerations in addition to technical content: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political. IPRO selections must be approved by the student's academic advisor to ensure compliance with the design requirement. IPROs also strongly emphasize the need for lifelong learning. The IPRO support infrastructure is described in Appendix II.

* Completion of the 8 semester ROTC program that includes leadership laboratories,

command experience and summer camp in a branch of the US military service is considered equivalent in experience to one IPRO course for the purposes of team skills, ethics awareness, professional development and lifelong learning. It does not substitute for the design experience requirement of the second IPRO.

This meets the requirement of Criterion 4

Technical and Free Electives (15 credits)

4 (12 credits) Technical Elective courses. These courses are any 300 level or greater, math, physics, computer science, or engineering course approved by the advisor. In addition, ECON 423 (Economic Analysis) and Electrical and Computer Engineering 218 are permitted, as is undergraduate research (MMAE497 Undergraduate Special Topics). Technical electives partially satisfy the objectives of ABET Criteria 3(h), 3(i) and 3(j).

Communications Intensive (C) Courses

The fifteen credit hour minimum of communications intensive (C) courses in the major is achieved through required courses as follows: MMAE100 (3), MMAE271 (3), MMAE370 (3), MMAE 365 (3) and MMAE465 (3). Additional (C) courses in the major may be taken as electives. Courses outside the major that qualify as (C) courses include most humanities, social and behavioral science electives, IPRO courses, and the required courses CHEM124, PHYS123, PHYS221 and PHYS300.

Minors

Minors are available to MME majors who wish to broaden their knowledge. A minimum of five courses is required for a minor and there are several minors approved and listed in the undergraduate bulletin. Those students wishing to minor in a different area can do so with the approval of the MMAE department undergraduate studies committee and the Department through which the minor is offered. Two of the required minor courses will substitute for the two required technical electives and therefore additional courses beyond the 127 credit hours will be required. In the event a required course for the minor is also required for the major, an approved substitution must be made. The Air Force, Army and Navy ROTC programs qualify as minors.

5. Faculty

There are four full-time faculty designated as “materials” faculty (Kallend, Mostovoy, Nash, Tszeng) whose expertise covers the following areas: metallurgy and metals/materials processing, ceramics, composite materials, and materials testing and performance. These faculty are responsible for advising students in the MSE program. There are three adjuncts who teach materials courses on a regular basis (Duvall, Singh, Warke). Their expertise covers polymers, ceramics, and materials performance. A full-time Senior Research Associate, Dr. Dajun Chen, teaches the electon microscopy components of the two Materials Laboratory courses

The Department of Mechanical, Materials and Aerospace Engineering is organized to be truly interdisciplinary, and substantial additional materials expertise is available through professors Gosz (solid mechanics), Nair (solid mechanics), Yagoobi (heat and mass transfer, paper technology), and Ruiz (thermodynamics). .

The first two years of the Mechanical Engineering, Aerospace Engineering, and Materials Science and Engineering programs form a common core, and consequently the required courses in engineering science may be taught by faculty with primary affiliation to any of these programs. In general, the materials faculty concentrate on the professional component of the MSE curriculum.

The size of the total student body in the undergraduate and graduate materials programs is typically fewer than 30. This results in an excellent faculty/student ratio, allowing the faculty ample opportunity to advise and mentor students.

All materials faculty are active in professional societies, and our students are invited to attend local chapter meetings (and generally entertained to a free dinner). We sponsor an student chapter of ASM International and an annual student poster competition. Chicago is the heart of one of the largest concentrations of metals and materials industry in the world: our faculty are actively engaged with local metals, materials and manufacturing companies and with Argonne National Laboratory, resulting in excellent opportunities for establishing student summer internships and co-ops.

Program Faculty

There are 4 full-time faculty in the MMAE department designated as “Materials” faculty. Their areas of expertise are:

Dr. John Kallend – polycrystalline materials. Professor Kallend’s research has been in the areas of polycrystal characterization, structure/property/processing relationships for metals and ceramics, magnetic materials, and ceramic superconductors.

Dr. Sheldon Mostovoy – mechanical behavior and failure of materials, materials testing and design. Professor Mostovoy’s research has emphasized development of mechanical testing methodologies for many types of materials applications.

Dr. Philip Nash – alloy design and materials processing. Professor Nash has conducted extensive research on the design of nickel-based alloys, powder processing, and has established the Thermal Processing Technology Center.

Dr. Calvin Tszeng – composites and processing. Professor Tszeng’s research involves the processing and properties of composite materials, especially metal-matrix composites.

Other MMAE faculty and staff who participate in the materials instructional program:

Dr. Michael Gosz – associate professor, solid mechanics

Dr. Sudharkar Nair – professor, solid mechanics

Dr. Francisco Ruiz – associate professor, thermodynamics

Dr. Dajun Chen, Senior Research Associate, optical and electron microscopy and diffraction.

The following adjunct faculty teach undergraduate materials courses:

Dr. Donald Duvall – Dr. Duvall is a senior consulting engineer at Engineering Systems Inc., and is an expert in polymer processing and properties. He has been teaching since 1993

Dr. J.P. Singh – Dr. Singh is a Senior Ceramist in the Materials Components and Technology division at Argonne National Laboratory. He has been an adjunct professor since 1984.

Dr. William Warke – Dr Warke is a consultant on failure analysis. Previously he headed the failure analysis laboratories of Standard Oil of Indiana (AMOCO). Prior that he was associate professor of metallurgical engineering at IIT.

The following emeritus and research professors are also active:

Dr. Norman Breyer – Professor Emeritus. Ferrous metallurgy and metals processing

Dr. Joseph Benedyk – Research Professor. Professor Benedyk joined IIT in 2001 following a career in the aluminum industry. He is an expert on non-ferrous alloy design and processing.

Appendix I

Program and Department Specific Information

Table I-1. Basic-Level Curriculum
Materials Science and Engineering

Semester	Course (Department, Number, Title)	Category (Credit Hours)			
		Math & Basic Sciences	Engineering Topics *Check if Contains Significant Design (✓)*	General Education	Other
1	MMAE 100 Introduction to the Profession		2 ( )		1
	EG 105: Engineering Graphics and Design		2 ( )		
	Chem 124: Principles of Chemistry	4	( )		
	Math 151: Calculus I	5	( )		
	Humanities or social science elective			3	
2	MS201 Materials Science	3	( )		
	CS 105: Introduction to Computing	2	( )		
	PHYS 123: Mechanics	4	( )		
	MATH 152: Calculus II	5	( )		
	Humanities or social science elective		( )	3	
3	MMAE 201: Mechanics of Solids I		3 ( )		
	PHYS 221: Electricity and Magnetism	4	( )		
	MATH 251: Multivariate and Vector Calculus	4	( )		
	Humanities and social science electives		( )	6	
4	MMAE 202: Mechanics of Solids II		3 ( )		
	PHYS 224: Thermal and Modern Physics	3	( )		
	MATH 252: Introduction to Differential Equations	4	( )		
	Humanities and Social science elective		( )	3	
	Free elective				3

5	PHYS 300: Instrumentation Laboratory		3 ( )		
	MMAE320: Thermodynamics		3 ( )		
	MMAE365:Structure and Properties of Materials I		3 ( )		
	MMAE370 Materials Laboratory I		3 ( )		
	MMAE271 Engineering Materials and Design		3 (3)		
6	MMAE463: Structure and Properties of Materials II		3 ( )		
	MMAE465: Electrical, Magnetic and Optical Properties of Materials		3 ( )		
	Technical Elective		( )		3
	IPRO I: Interprofessional Project I		( )	3	
	Humanities or social science elective		( )	3	
7	MMAE468: Introduction to Ceramic Materials		3 ( )		
	MMAE482: Composites		3 ( )		
	MMAE 485: Manufacturing Processes		3 ( )		
	Technical elective		( )		3
	Humanities or social science elective		( )	3	
8	IPRO II		3 (√)		
	MMAE470: Materials Laboratory II		3 ( )		
	MMAE 467 or MMAE 483: Fundamentals of Polymeric Materials or Structure and Properties of Polymers		3 ( )		
	Technical Elective				3
	Technical elective		( )		3
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		38	49	24	16
OVERALL TOTAL FOR DEGREE	127				
PERCENT OF TOTAL		29.9	38.6	18.9	12.6
Totals must	Minimum semester credit hours	32 hrs	48 hrs		
satisfy one set	Minimum percentage	25%	37.5 %		

Table I-2 Program demographics in the MMAE Department

Program and Academic Year	1st year students	2nd year students	3rd year students	4th & 5th students	Number Graduated
Aerospace 2002 – 2003	31	26	20	22	12
Aerospace 2003 – 2004	47	23	20	24	16
Mechanical 2002 – 2003	30	14	23	62	37
Mechanical 2003 – 2004	30	27	17	42	33
Materials 2002 – 2003	2	2	4	6	3
Materials 2003 – 2004	2	3	5	7	3

Appendix I – (B) Course Syllabi.

Program specific courses only.

Please see following pages

PHYS 300: Instrumentation Laboratory – REQUIRED

Catalog Data: Basic electronic skills for scientific research. Electrical measurements, basic circuit analysis, diode and transistor circuits. Transistor and integrated amplifiers, filters, and power circuits. Basics of digital circuits, including Boolean algebra and design of logic circuits. Corequisite: PHYS 221

Textbooks: "Principles of Electronic Instrumentation," Third Edition, Diefenderfer and Holton

"Hands-on Electronics," First Edition, Kaplan and White

Course Objectives and Material Covered: To familiarize students with the basic principles of analog and digital electronics. This is best achieved through direct laboratory experience. Topics covered include RC networks, diodes, transistors, op-amps, comparators, timers, basic digital logic, flip-flops, counters, RAM, DAC and ADC conversions.

Schedule: PHYS 300 meets for 2 x 160-minute lab sessions per week.

Contribution to Professional Components:

PHYS 300 contributes to program outcomes by promoting a base understanding of modern electronics, experience working with electronic circuits and test equipment, lessons in trouble-shooting complex systems, as well as promoting technical writing skills. Engineering topics 100%

Relationship of Course to ABET Outcomes:

ABET Criteria	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	3
3b	Design and conduct experiments, analyze data	3
3c	Design system, component, or process to meet needs	3
3d	Function on multi-disciplinary teams	
3e	Identify, formulate, and solve engineering problems	
3f	Understand professional and ethical responsibility	
3g	Communicate effectively	
3h	Broad education	
3i	Recognize need for life-long learning	
3j	Knowledge of contemporary issues	
3k	Use techniques, skills, and tools in engineering practice	3

Prepared by: C. G. White, Instructor – PHYS 300, 5/9/02, and John Kallend

MS 201 Materials Science – REQUIRED

Catalog Data: The scientific principles determining the structure of metallic, polymeric, ceramic, semiconductor and composite materials; electronic structure, atomic bonding, atomic structure, microstructure and macrostructure. The basic principles of structure-property relationships in the context of chemical, mechanical and physical properties of materials. Prerequisite: CHEM 124. (3-0-3)

Textbook: Introduction to Materials Science for Engineers, James E. Shackelford (Prentice-Hall)

Objectives:

1. Distinguish different solid types
2. Solve elementary problems in crystal geometry
3. Relate intrinsic properties to bonding and crystal structures
4. Describe crystal defects and predict their effects on properties
5. Solve problems involving stiffness, strength, toughness
6. Solve problems involving creep and fatigue
7. Solve problems involving electrical properties of materials
8. Describe non crystalline solid structures and solve problems related to these solid types.

Prerequisite by Topic: General chemistry, elementary mechanics.

Topics:

Ionic, covalent, van der Waals and metallic bonds. Crystal structures, crystal geometry, and crystal defects. Mechanical behavior of materials: elasticity, plasticity, fracture, high temperature behavior, fatigue. Electrical behavior of materials: resistivity, conductivity, charge carriers. Qualitative band theory. Semiconductors and semiconductor devices. Phase diagrams and development of microstructures.

Schedule: Classes are 1 hr. 20 min. long, 2 sessions per week

Contribution to Professional Component: Engineering science 100%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	2
3b	Design and conduct experiments, analyze and interpret data	1
3c	Design system, component, or process to meet needs	0
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	0
3f	Understand professional and ethical responsibility	0
3g	Communicate effectively	0
3h	Broad education	1
3i	Recognize need for life-long learning	1
3j	Knowledge of contemporary issues	2
3k	Use techniques, skills, and tools in engineering practice	0

Prepared by: John S. Kallend, May 2004

MMAE 100 Introduction to the Profession – REQUIRED

Catalog Data: Introduces the student to the scope of the engineering profession and its role in society, develops a sense of professionalism in the student, confirms and reinforces the student's career choices and provides a mechanism for regular academic advising. Provides integration with other first year courses. Applications of mathematics to engineering. Emphasis is placed on development of professional communications and teamwork skills.

Textbook: none

Objectives:

After taking the course students should be able to:

1. Describe what engineering is
2. Understand the role of the engineer in society
3. Understand the code of ethics for engineers, and be aware of the responsibilities of the engineer
4. Perform bibliographic research using the IIT library facilities
5. Perform a simple design task to meet specifications, as a member of a small team
6. Apply knowledge of mathematics to simple engineering problems
7. Use Excel, Matlab, word processing, and presentation software
8. Write a short technical report
9. Make a brief technical presentation

Prerequisite by Topic: None

Topics:

Engineering Ethics, estimating, bibliographic research methods, applications of mathematics to engineering problems, rocket design project, report writing, making a presentation. Academic advising.

Schedule: Classes are 1 hr 20 min. long, 2 sessions per week

Contribution to Professional Component:

Engineering science: 30%

Engineering design: 20%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	2
3b	Design and conduct experiments	1
3b	Analyze and interpret data	2
3c	Design system, component, or process to meet needs	2
3d	Function on multi-disciplinary teams	1
3e	Identify, formulate, and solve engineering problems	2
3f	Understand professional and ethical responsibility	2
3g	Communicate effectively	3
3h	Broad education	1
3i	Recognize need for life-long learning	1
3j	Knowledge of contemporary issues	1
3k	Use techniques, skills, and tools in engineering practice	2

Prepared by: John Kallend, May 2004.

MMAE 201: Mechanics of Solids I - REQUIRED

Catalog Data: Free body diagrams. Equilibrium of a particle, a system of particles, and a rigid body. Distributed forces, centroids, centers of gravity, and moments of inertia. Analysis of structures. Friction. Internal loads in bars, shafts and beams. Stress and strain in axially loaded members. Prerequisites: CS 105, MMAE 101, PHYS 123. Corequisite: MATH 152. (3-0-3)

Textbook: R. C. Hibbeler, *Engineering Mechanics: Statics & Dynamics*, 9th Edition, Prentice Hall.

Objectives:

1. Become familiar with the basic steps in solving an engineering problem relating to equilibrium. To be able to reduce a problem from its physical description to a model (particle or a rigid body) to which equations of equilibrium can be applied. The drawing of a free body diagrams is considered essential to this procedure.
2. To be able to use equations of equilibrium relating to a particle in two and three dimensional spaces.
3. To be able to use equations of equilibrium relating to a rigid body in two and three dimensional spaces.
4. To be able to reduce system of forces acting on a rigid body to s simplest form.
5. To be able to find the resultants of an internal forces.
6. To be able to compute coordinates of a center of gravity.
7. To be able to compute moment of inertia of an area.

Topics/Course Outline:

1. Introduction of general principles. (Ch. 1,2)

   Fundamental Concepts, Scalars and Vectors, Vector Operations.

2. Equilibrium of a Particle. (Ch. 3)

   Force System, free body diagram, Equations of Equilibrium

3. Equilibrium of the force system acting on a rigid body. (Ch. 4,5)

   Moment of a Force about a point and about an axis, Couple, Resultants of the Force System, Equations of

   Equilibrium, Constraints for a rigid body.

4. Structural analysis. (Ch. 6)

   Simple tissues, Methods of Joints and Section, Frames and Machines.

5. Internal forces in structural members. (7.1, MM.-1.2)
6. Friction. (Ch. 8, Sect. 8.1-8.3)
   Dry friction, Wedges.
7. Center of Gravity and Centroid. (Ch. 9, Sect. 9.1-9.3)
8. Moments of Inertia. (Ch. 10, Sect. 10.1-10.5, 10.9)
   Moments of Inertia for Areas, Parallel-Axes Theorem, Mass Moment of Inertia.
9. Stress & Strain. Stress-stress diagram. (MM. 1.3-1.5, 2, 3.1-4, 6, 7)

Schedule: Classes are 1 hr 15 min. long, 2 sessions per week.

Contribution to Professional Component:

Engineering Science: 100%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	2
3b	Design and conduct experiments	0
3b	Analyze and interpret data	1
3c	Design system, component, or process to meet needs	1
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	3
3f	Understand professional and ethical responsibility	1
3g	Communicate effectively	1
3h	Broad education	1
3i	Recognize need for life-long learning	2
3j	Knowledge of contemporary issues	1
3k	Use techniques, skills, and tools in engineering practice	1

Prepared by: Dr. Isaac Ginsburg, Spring 2002.

MMAE 202: Mechanics of Solids II - REQUIRED

Catalog Data: Stress and strain relations, mechanical properties. Axially loaded members. Torsion of circular shafts. Plane stress and strain, Mohr's circle, stress transformation. Elementary bending theory, normal and shear stresses in beams, beam deflection. Combined loading. Prerequisite: MMAE 201. Corequisite: MMAE 271. (3-0-3)

Textbook: R. C. Hibbeler, *Mechanics of Materials*, 1999, 4th edition, Prentice Hall.

Objectives:

1. Axial Loading

- Understand the basic concepts regarding material behaviors
- Analyze statically determinate and indeterminate problems
- Analyze stresses in members subjected to temperature changes as well as applied loads.
- Understand the displacement method for systems with many elements subjected to axial loading.
- Understand the design criteria in members subjected to axial loading.

2. Torsional Loading of Circular Shafts

- Understand the basic relationships between torque, angular deflection, shear stress, shear strain, and torsional stiffness.
- Determine stresses and deflections for statically determinant and indeterminate systems.
- Use the displacement method for torsional systems.
- Understand the analysis method for thin-walled tube in torsion

3. Shear and Bending in Beams

- Develop both shear and bending moment diagrams.
- Understand and derive the differential equations relating load, shear and bending moment.
- Derive and determine shear and normal stress.
- Derive and determine shear and normal stress in composite beams.

4. Beam Flexure

- Derive and determine shear and normal stress.
- Derive and determine deflections in beams subjected to bending.
- Perform stress and deflection analyses of beams containing non-uniform cross-sections.
- Use double integration and superposition methods to obtain beam deflections.
- Solve simple statically indeterminate problems.

5. Stress and Strain

- Understand the general state of stress at a point on a body in two and three dimensions.
- Understand the equilibrium relationships of stress components at a point in a body in a state of plane stress or plane strain.
- Perform stress and strain transformations and determine the principal and maximum shear stresses in a body.
- Calculate the stresses in thin walled pressure vessels (cylindrical and spherical).
- Develop the relationship between strain and displacement in a body subjected to plane strain or plane stress.
- Understand the relationship between stress and strain for linear elastic materials.

6. Combined Loading

- Calculate the stresses in a body subjected to combined axial, bending shear and/or torsional loading.

Topics/Course Outline:

WEEK	TOPIC	TEXT COVERED
1	Introduction; Stress and strain	Chap. 1, 2, 3
2, 3	Axially loaded members; Statically indeterminate structures	Chap. 4
4	Thermal effects, Strain energy; Stress concentration	Chap. 4
5	Torsion of a circular bar	Chap. 5
	- Midterm Exam -	
6	Stresses and strains in pure shear; Thin-walled tube	Chap. 5
7, 8	Shear forces and bending moments	Chap. 6
9	Bending and curvature of a beams; bending stresses	Chap. 6
10	Composite beams	Chap. 7
	- Midterm Exam -	
11	Deflections of beams	Chap. 7
12	Transverse shear in beams	Chap. 9
13	Plane stress, Principal stresses; Mohr’s Circle	Chap. 9, 10
14	Triaxial stress, Plane strain	Chap. 12
	- Final Examination -	

Homework: 30% Midterms: 20% each Final Exam: 30%

Schedule: Classes are 1 hr 15 min. long, 2 sessions per week.

Contribution to Professional Component:

Engineering Science:

Engineering Design:

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	2
3b	Design and conduct experiments	0
3b	Analyze and interpret data	1
3c	Design system, component, or process to meet needs	3
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	2
3f	Understand professional and ethical responsibility	0
3g	Communicate effectively	0
3h	Broad education	0
3i	Recognize need for life-long learning	0
3j	Knowledge of contemporary issues	0
3k	Use techniques, skills, and tools in engineering practice	3

Prepared by: **T. Calvin Tszeng, Spring 2002**

MMAE 271 Engineering Materials and Design - REQUIRED

Catalog Data: Mechanical behavior of metals, polymers, ceramics and composites, laboratory testing methods including tension torsion, hardness, impact, toughness, fatigue and creep. Evaluation of structural performance in terms of material processing, service conditions and design. Prerequisites: MS 201 and MMAE 201. Corequisite MMAE 202. (2-3-3).

Textbook: Mechanical Behavior of Materials by Dowling 2nd. Edition, Prentice Hall, 1998)

References:

1. J. E. Gordon The New Science of Strong Materials Second Edition, Penguin Books, 1981.
2. J. E, Gordon Structures, Second Edition, Penguin Books, 1983.
3. G. Dieter Mechanical Metallurgy, Third Edition, McGraw Hill, 1986.
4. Ashby & Jones, Engineering Materials I 2nd Ed., Pergamon, 1996.

Objectives: This course is designed to give sophomores in Mechanical Materials and Aerospace Engineering

an introduction to material properties with respect to resistance to stress, strain, deformation and temperature.

Extensive emphasis is placed on materials testing, states of stress, and strength of materials, fatigue, creep

and fracture from the materials viewpoint.

Prerequisites by Topic: Mechanics of solids, Materials Science basics, General Chemistry, Strength of Materials Testing of Materials

Topics: Structure of materials as related to mechanical properties and structural design concepts for isotropic and anisotropic materials. Definition of "Mechanical Properties of Materials" and the conditions that constitute failure. Examination of the spectrum of materials and possible uses in service. Design criteria used to select materials. Isotropy and anisotropy in service and design of material response. Measurement of mechanical properties. Tensile and hardness tests. Determination of elastic properties, yield strength, ultimate strength, ductility, engineering stress and strain, measurement of anisotropy. Hardness-tensile property relationships as used in design. Review of strength of materials definitions for uniaxial stress and strain. Tensile test parameters for different classes of materials. Effect of isotropy and anisotropy on design. Hardness testing. Use in design. Relationship to tensile data. Elements of elasticity. Stress strain, displacement and equilibrium. Analysis of complex stress states and stress-strain relationships for isotropic and anisotropic materials. 2-D and 3-D states of stress and strain (isotropic). Effect of anisotropy. Determination of anisotropic material properties and the effect of these properties on design. Methods of experimental stress analysis. Mohr's circle Yielding and failure mechanisms. Ductile and brittle failure. Yield criteria for isotropic and anisotropic material as related to design. Design requirements to avoid fracture/failure as related to service and material properties. Yield criteria in 2-D and 3-D. Comparison of metals, polymers, ceramics and composites for selected service conditions. Structure property relationships for metals, polymers, ceramics and composites as a function of service variables. Strengthening mechanisms and manufacturing techniques needed to meet design requirements. Strengthening mechanisms in metals, polymers, ceramics and composites. Effect of service conditions and manufacturing variables on design. Fracture and failure criteria. Stress concentration, flaw sensitivity, Griffith analysis, fracture mechanics methodology, flaw tolerance, fracture toughness and composite failure criteria. Effect of service variables (e.g. strain rate and temperature) and materials/processing selection in design. Concepts of stress concentration and notch sensitivity. Griffith analysis, fracture mechanics and "classical" methodology as applied to monolithic materials. Description of composite materials and property analysis. Influence of service variables on fracture or failure by other mechanisms (e.g. stress corrosion cracking), materials selection and design. Long term failure resistance. Fatigue, creep, stress relaxation and environmental effects in the presence of flaws. Stress - life curves and the effect of complex stress states. Conventional (no-flaws) fatigue. Stress - life curves as influenced by service and material variables. Creep and stress relaxation. Effect of flaws on durability of service structures. Flaw tolerant design, the use of service failure analysis in design.

Schedule: Lecture Classes are 50 minutes long twice a week. Laboratory classes are once a week for 3 hours.

Contribution to professional component:

Engineering Topics 100%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	3
3b	Design and conduct experiments	3
3b	Analyze and interpret data	3
3c	Design system, component, or process to meet needs	1
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	3
3f	Understand professional and ethical responsibility	2
3g	Communicate effectively	3
3h	Broad education	0
3i	Recognize need for life-long learning	0
3j	Knowledge of contemporary issues	0
3k	Use techniques, skills, and tools in engineering practice	3

Prepared by: Sheldon Mostovoy, May 2004

MMAE 305: Dynamics - Elective

Catalog Data: Kinematics of particles. Kinetics of particles. Newton's Laws of motion, energy, momentum. Systems of particles. Kinematics of rigid bodies. Plane motion of rigid bodies: forces and accelerations, energy, momentum. Prerequisite: MMAE 201. Corequisite: MATH 252. (3-0-3)

Textbook: R.C. Hibbeler, Engineering Mechanics: Dynamics, 8^{th} Ed.

Objectives:

1. Become familiar with the basic steps solving engineering mechanics problems. To be able to reduce a problem from its physical description to a model (particle or rigid body) to which principles of mechanics may be applied. The drawing of free body diagrams is considered essential to this procedure.
2. To understand the meaning of the terms: displacement, velocity and acceleration of a particle. To be able to solve problems relating to the motion of a particle.
3. To understand the meaning of the terms: angular velocity and angular acceleration of a rigid body. To be bale to solve problems relating to translational, rotational motion about fixed axis and general plane motion of a rigid body.
4. To have a working knowledge of Newton's Laws and to be able to apply them in the analysis of the motion of a particle.
5. To understand the relationship between force, work, impulse of the force and to be able to apply the Three Mechanical Principles in solving problems involving motion of a particle and a system of particles.
6. To be able to apply the equation of motion of a rigid body to analyze the dynamics of translational, rotational and general plane motion of a rigid body.
7. Since mathematics provides a systematic means of applying the principles of mechanics the student is expected to have prior knowledge of algebra, geometry, trigonometry and calculus.

Prerequisites by Topic:

1. Statics
2. Mathematics through Calculus and some background in Differetial Equations.

Topics/Course Outline:

1. Introduction
2. Kinematics of a particle (Ch.12, 12.1-12.10)
3. Kinetics of a particle (Ch 13, 13.1,13.2.13.4-13.7)
4. Work and Energy (Ch 14, 14.1-14.6)
5. Impulse and Momentum (Ch 15, 15.1-15.7)
6. Planar kinematics of a Rigid Body (Ch 16, 16.1-3, 5-7)
7. Planar kinetics of a rigid Body (Ch 17, 17.1-5)

8. Work and Energy relations of a R.B. (Ch 18)
9. Linear and Angular Momentum of a R.B. (Ch 19.1)
10. Vibrations (Ch 22, 22.1,4,5)

Schedule: Classes are 1 hr 15 min. long, 2 sessions per week.

Contribution to Professional Component: Engineering Science 100%

Relationship of Course to ABET Outcomes

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	3
3b	Design and conduct experiments	0
3b	Analyze and interpret data	0
3c	Design system, component, or process to meet needs	2
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	2
3f	Understand professional and ethical responsibility	1
3g	Communicate effectively	1
3h	Broad education	1
3i	Recognize need for life-long learning	1
3j	Knowledge of contemporary issues	1
3k	Use techniques, skills, and tools in engineering practice	2

Prepared by: **Dr. Isaac Ginsburg, May 2002**

MMAE 363: Metallurgical and Materials Thermodynamics - REQUIRED

Catalog Data: The three laws of thermodynamics. Extensive problem solving in metallurgical and materials applications of heat and mass balances, free-energy criteria, and equilibrium relations. Prerequisite: MS 201. (3-0-3)

Textbook: Thermodynamics of Materials, by David V. Ragone, John Wiley & Sons, (November 1994)

Objectives:

1. Acquire and demonstrate knowledge and use of thermodynamic concepts pertaining to predicting and interpreting microstructures in simple materials at various compositions and temperatures.
2. Demonstraate familiarity with theory of and use of computational thermodynamics.
3. Reports (homework assignments) and exams shall be effectively organized and be written in proper English.
4. Demonstrate ability to communicate effectively via graphical data presentation.

Prerequisite by Topic: Crystallography, Thermodynamics, Calculus, Intro to Computer Programming.

Topics: Laws of Thermodynamics; Cyclical Relationships; Thermal Expansion; Bulk Compressibility; PVT surfaces; Work; Heat; Heat Capacity; Entropy; Helmholts Relationships; -S P T V; Thermodynamic Efficiency; Electrochemical Reactions; Nernst Equation; Gibbs Energy; Vapor Pressure; Activity; Ellingham Diagram, Construction; Calculation and Use of Phase Diagrams; Plotting Pelationships; Interpreting Plots of Relationships, Approaches for Problem Solving.

Schedule: Classes are 1 h 20 min. long, 2 sessions per week.

Contribution to professional component:

Engineering Science: 95%

Engineering Design: 5%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	3
3b	Design and conduct experiments	0
3b	Analyze and interpret data	0
3c	Design system, component, or process to meet needs	0
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	0
3f	Understand professional and ethical responsibility	0
3g	Communicate effectively	0
3h	Broad education	0
3i	Recognize need for life-long learning	0
3j	Knowledge of contemporary issues	0
3k	Use techniques, skills, and tools in engineering practice	3

Prepared by: Robert Foley, May 2002.

MMAE 365: Structure and Properties of Materials I - REQUIRED

Textbook: : Physical Metallurgy Principles by Robert E. Reed-Hill, Reza Abbaschian, PWS Publishing Co., 3rd Ed., November 1991

Objectives:

1. Solve crystal geometry problems in cubic, tetragonal and hexagonal metal and ceramic crystals
2. Determine crystal structure types from diffraction data
3. Describe and analyze the effects of point, linear and planar defects in crystals
4. Relate binary phase diagrams to thermodynamic data and equilibrium microstructures
5. Solve diffusion problems for simple structures and geometries
6. Describe nucleation and growth and solve basic problems
7. Describe non equilibrium microstructures and relate to transformation types
8. Make short oral presentations on technical topics

Prerequisite by Topic: Mechanical properties and testing, thermodynamics

Topics:

Crystal structures and crystal geometry, especially cubic, tetragonal and hexagonal metallic and ceramic structures. – 2 weeks

Experimental determination of crystal structure – 1 week

Crystal defects: Point defects – 1 week Dislocations – 2 weeks, Planar defects, twins and grain boundaries – 1 week

Extrinsic and intrinsic properties. Strength, stiffness, toughness, creep, annealing etc. – 2 week

Diffusion: Ficks laws, solutions for simple geometries, influence of structure, – 2 weeks

Kinetics of transformations: diffusionless and diffusion controlled. TTT diagrams –2 weeks

Evolution and classification of microstructures: relation with equilibrium diagrams, effect of transformation rates. – 2 weeks

Schedule: Classes are 1 hr. 20 min. long, 2 sessions per week.

Contribution to Professional Component:

Engineering science 100%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	3

3b	Design and conduct experiments	1
3b	Analyze and interpret data	2
3c	Design system, component, or process to meet needs	0
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	0
3f	Understand professional and ethical responsibility	0
3g	Communicate effectively	1
3h	Broad education	0
3i	Recognize need for life-long learning	0
3j	Knowledge of contemporary issues	0
3k	Use techniques, skills, and tools in engineering practice	2

Prepared by: **John S. Kallend, May 2002**

MMAE 370: Materials Laboratory I - REQUIRED

Catalog Data: Introduction to materials characterization techniques including specimen preparation, metallography, optical and scanning electron microscopy, temperature measurement, data acquisition and analysis and presentation. Corequisite MMAE 271.

(1-6-3).

Textbook: Metallography : Principles and Practice by George F. Vander Voort,

References:

Materials Science and Engineering Lab Manual (The Pws Series in Engineering) by Sherif D. El Wakil

Scanning Electron Microscopy and X-Ray Microanalysis" by J. I. Goldstein et. al (1984)

Omega Thermometry Catalog for year 2000

"Materials Science for Engineers" 5th Ed., ASM Metals Handbooks

Instrumentation for Engineering Measurements 2nd.Ed. by J. W. Dally et. al. Wiley 1993.

Objectives: This course is designed to give juniors in the Materials program of the Mechanical Materials and Aerospace Engineering department an introduction to the determination and measurement of material properties with respect to microstructure, crystallographic properties and temperature related phenomena.

Prerequisites by Topic: Mechanics of solids, Materials Science basics, General Chemistry

Topics: Temperature Measurement. Thermocouples. Furnace Calibration**,** Microscopy and Metallography (Optical and SEM), Specimen preparation techniques for each type of microscopic examination. Macro specimen preparation and examination (castings, fracture surfaces) Macroetching techniques, Recrystallization and Grain Growth

Contribution to Professional Component:

Engineering Topics 100%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	3
3b	Design and conduct experiments	3
3b	Analyze and interpret data	3
3c	Design system, component, or process to meet needs	
3d	Function on multi-disciplinary teams	
3e	Identify, formulate, and solve engineering problems	2
3f	Understand professional and ethical responsibility	1
3g	Communicate effectively	3
3h	Broad education	
3i	Recognize need for life-long learning	
3j	Knowledge of contemporary issues	
3k	Use techniques, skills, and tools in engineering practice	3

Schedule: Lecture Class is 75 minutes long once a week. Laboratory classes are twice a week for 3 hours each.

Prepared by: Sheldon Mostovoy, May 2002

MMAE463: Structure and Properties of Materials II - REQUIRED

Textbook: : Physical Metallurgy Principles by Robert E. Reed-Hill, Reza Abbaschian, PWS Publishing Co., 3rd Ed., November 1991

Objectives:

1. Make short oral presentations on technical topics
2. Use TTT and CCT curves to follow microstructural development
3. Analyze the martensitic transformation in steels and non-ferrous alloys
4. Understand and describe shape-memory and related effects
5. Be able to use hardenability curves
6. Become familiar with strengthening mechanisms in commercial alloys.

Prerequisite by Topic: Mechanical properties and testing, thermodynamics

Topics:

Rates of transformations, TTT, CCT curves

Martensite, Pearlite and Bainite

Heat treatment of steels, hardeness and hardenability. Commercial steel grades

Non-ferrous martensites

Commercial aluminum, copper and nickel alloys and their applications

Schedule: Classes are 1 hr. 20 min. long, 2 sessions per week.

Contribution to Professional Component:

Engineering science 60% Engineering design 40%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	3
3b	Design and conduct experiments	0
3b	Analyze and interpret data	2
3c	Design system, component, or process to meet needs	2
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	0

3f	Understand professional and ethical responsibility	0
3g	Communicate effectively	1
3h	Broad education	0
3i	Recognize need for life-long learning	0
3j	Knowledge of contemporary issues	0
3k	Use techniques, skills, and tools in engineering practice	2

Prepared by: **John S. Kallend, May 2004**

MMAE 465: Electrical, Magnetic and Optical Properties of Materials - REQUIRED

Catalog Data: Electronic structure of solids, semiconductor devices and their fabrication. Ferroelectric and piezoelectric materials. Magnetic properties, magnetocrystalline, anisotropy, magnetic materials and devices. Optical properties and their applications, generation and use of polarized light. Prerequisite: ECE 435 or MMAE362. (3-0-3)

Textbook: Electronic Properties of Materials – Rolf E. Hummel (Springer Verlag), 3rd Edition

Objectives:

1. Ability to describe quantitatively the properties of engineering interest relating to electrical, magnetic and optical materials
2. Ability to correlate quantitatively the properties of interest with the atomic structure, crystalline structure, and microstructure of the material
3. Ability to specify materials types, composition and processing to achieve desired properties.

Prerequisite by Topic: Crystallography, electricity and magnetism.

Topics:

1. Behavior of constrained electrons and energy quantization. Pauli principle and many electron systems. Quantum free-electron model of solids. K-space, Fermi energy, and Fermi surfaces. Brillouin zones. Band structures, effective mass, electrons and holes.
2. Theory of metals, semiconductors and insulators. Semiconductor devices.
3. Dielectric materials, piezo electricity and pyro electricity. Applications.
4. Magnetic behavior: ferromagnetic and ferrimagnetic materials. Theory of the magnetization curve; magnetocrystalline anisotropy, domains and domain boundaries. Materials for power generation and information storage.
5. Superconductors: critical temperatures, fields and currents. Meissner effect. Type I and Type II. Superconducting ceramics.
6. Optical behavior - reflection and refraction. Optical anisotropy, birefringence, applications. Fiber optics. Solid state lasers.

Schedule: Classes are 1 hr. 20 min. long, 2 sessions per week.

Contribution to Professional Component:

Engineering Science: 80%

Engineering Design: 20%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	3
3b	Design and conduct experiments	1
3b	Analyze and interpret data	1
3c	Design system, component, or process to meet needs	1
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	2
3f	Understand professional and ethical responsibility	1
3g	Communicate effectively	2
3h	Broad education	0
3i	Recognize need for life-long learning	1
3j	Knowledge of contemporary issues	1
3k	Use techniques, skills, and tools in engineering practice	1

Prepared by: John S. Kallend, May 2002

MMAE 468: Introduction to Ceramic Materials - REQUIRED

Catalog Data: The structure and structure/properties relationships of ceramic materials. Topics include: crystal structure types, crystal defects; structure of glass; phase equilibria and how these affect applications for mechanical properties; electrical properties and magnetic properties. Sintering and ceramic reactions are related to microstructure and resultant properties. Prerequisite: MS 201 (3-0-3)

Textbook: Introduction to Ceramics, Kingery, Bowen and Uhlmann

Objectives: After taking the course students should be able to:

1. Determine the type of bonding in a given material and calculate the coordination number and most likely crystal structure.
2. Collect data and determine the thermal expansion of a material and interpret thermal expansion curves for changes in crystal structure.
3. Calculate the theoretical density of materials based on crystal structure and lattice parameters.
4. Identify the types of defects and determine how these may effect the properties of the material.
5. Calculate the electronic and ionic conductivity of a given material, and know what information is needed to make these calculations.
6. Read and understand phase diagrams, draw cooling curves, identify and determine relative magnitudes of different phases evolving during heating or cooling of binary and ternary systems.
7. Identify parameters that control powder processing and green shape forming.
8. Understand sintering mechanisms and evaluate activation energy for rate controlling process during sintering.
9. Predict the effects of different processing parameters (powder particle size, temperature, time, etc.) on sintering behavior.
10. Understand microstructural evolution and its correlation with properties.
11. Design microstructure to achieve desired properties.
12. Perform a literature search and make an oral presentation to the class on a specific topic in the area of ceramics and composites.

Prerequisite by Topic: Chemical bonding, elementary crystallography, mechanical behavior

Topics:

1. Introduction to ceramics and bonding: ceramic materials, types of bonding, directionality of bonds, electronegativity, crystalline versus non-crystalline.
2. Crystal Structures: crystal systems, Bravais lattices, Miller Indices, basic ceramic crystal structures.
3. Physical properties, thermodynamics, and kinetics: density, thermal conductivity, thermal expansion, strength, deformation behavior, heat of formation and free energy.
4. Defects: types of defects, Frenkel, Schottky, point, interstitial.
5. Diffusion: basic equations, mechanisms.
6. Conductivity: ionic conductivity, electronic conductivity, superconductivity, mixed conductivity.
7. Phase Equilibria and Phase Equilibrium Diagrams: phase rule, single and multi-component phase diagrams, intermediate compounds, binary and ternary systems with congruently and non-congruently melting compounds, and cooling curves.
8. Processing of Ceramics: powder processing (powder preparation and sizing); pre-consolidation (mixing, blending, spray drying); Shape –Forming.
9. Densification: theory of sintering, stages of sintering, mechanisms of sintering (vapor-phase, solid-state, and liquid-phase sintering), effects of powder packing and sintering aids on shrinkage and densification.
10. Microstructure and its effects on mechanical properties: porosity, inclusion, grain growth, microcracking, effects of microstructural features on strength, elastic modulus and fracture toughness.

Schedule: Classes are 2 hr. 40 min. long, 1 session per week.

Contribution to Professional Component:

Engineering Science: 67%

Engineering Design: 33%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	3
3b	Design and conduct experiments	1
3b	Analyze and interpret data	1
3c	Design system, component, or process to meet needs	2
3d	Function on multi-disciplinary teams	2

3e	Identify, formulate, and solve engineering problems	3
3f	Understand professional and ethical responsibility	1
3g	Communicate effectively	3
3h	Broad education	2
3i	Recognize need for life-long learning	2
3j	Knowledge of contemporary issues	2
3k	Use techniques, skills, and tools in engineering practice	3

Prepared by: John S. Kallend and J.P. Singh, May 2002

MMAE475 Powder Metallurgy – ELECTIVE

Catalog Data: Production, pressing, and sintering of metal powders. Effects of particle size, friction and die design on pressed densities. Theories of sintering. Relation of sintering practice to physical properties. Homogenization of alloys. Industrial equipment. Applications. Laboratory simulation of a series of P/M manufacturing cycles from powder to finished product are used to reinforce the class work. Prerequisite: MMAE 361. (2-1-3)

Textbooks: "Powder Metallurgy Science", R.M. German MPIF (1998)

"Standard Test Methods for Metal Powders and Powder Metallurgy Products", (1999) edition. Available from Dr. Nash.

Objectives: This course is designed to give students an understanding of the principles of powder metallurgy and its applications.

Grading: The grading for this course will be based on 1 mid-semester test (20%), homework assignments (15%), laboratory reports (30%), and a final exam (35%).

Topics:

1. Description and rationale for the P/M process (1 class)
2. Powder Manufacture. (2 classes)
3. Powder Characteristics on processing (2 classes)
4. Effect of powder characteristics on processing (2 classes)
5. Powder compaction (4 classes)
6. Sintering (5 classes)
7. Processing after sintering (2 classes)
8. Applications and case studies (engineering and economics) (4 classes)
9. Exam periods (2 classes)

Laboratory Projects:

Required: "Standard Test Methods for Metal Powder Metallurgy Products", 1993 edition. Available from Dr. Nash.

Depending on time 2 or 3 experiments will be undertaken.

1. Characterization and consolidation of ferrous powders
2. Properties and Microstructure of ferrous compacts.
3. Production of structural bronze components.

Schedule: Classes are 1 hr 15 min. long, 2 sessions per week.

Contribution to Professional Component:

Engineering Science: 1 credits or 33%

Engineering Design: 2 credit or 67%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	2
3b	Design and conduct experiments	3
3b	Analyze and interpret data	3
3c	Design system, component, or process to meet needs	1
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	1
3f	Understand professional and ethical responsibility	1
3g	Communicate effectively	1
3h	Broad education	1
3i	Recognize need for life-long learning	0
3j	Knowledge of contemporary issues	1
3k	Use techniques, skills, and tools in engineering practice	3

Prepared by: Dr. P. Nash, January 2002.

MMAE 476: Materials Laboratory II - REQUIRED

Catalog Data: Advanced synthesis, processing and characterization of metallic, non-metallic and composite materials. Experimental investigation of the relationships between materials structures, processing routes and properties. Design of experiments/statistical data. Prerequisite: MMAE 370 or instructor's consent. (1-6-3).

Textbook: Metallography: Principles and Practice by George F. Vander Voort

References:

Materials Science and Engineering Lab Manual (The Pws Series in Engineering) by Sherif D. El Wakil

Scanning Electron Microscopy and X-Ray Microanalysis" by J. I. Goldstein et al. (1984)

Omega Thermometry Catalog for year 2000

"Materials Science for Engineers" 5th Ed., ASM Metals Handbooks

Instrumentation for Engineering Measurements, 2nd Ed., by J. W. Dally et al., Wiley 1993.

Objectives: This course is designed to give seniors in the Materials program of the Mechanical Materials and Aerospace Engineering department an advanced program dedicated to the determination and measurement of material properties with respect to microstructure, crystallographic properties and temperature related phenomena.

Prerequisites by Topic: Mechanics of solids, Materials Science basics, General Chemistry

Topics: X-ray analysis. The use of X-ray diffraction (XRD) to identify unknown crystalline materials. Use of x-rays to determine possible preferred orientation (texture). Hardening techniques – examination of microstructures before and after heat treatment. Age hardening, martensite hardening (use of hardness testers, macro and micro, to determine hardness depths), carburizing vs. Induction hardening of high strength steels (e.g., Fine Particle Strengthening in a Heat- Treatable Aluminum Alloy). Jominy hardenability tests with microhardness and sectioning to determine local microstructure and relationship to hardness. Diffusion of Carbon in Iron (Carburization). Jominy test followed by sectioning, metallography and microhardness. Determination of elastic modulus by resonance and tensile/compressive stress-strain curves in mechanical testing. Use of strain gages to determine modulus for comparison with resonance measurements. Properties of ceramics and polymers: **Ceramics**: toughness (using Vickers Hardness Indenter): Tension (using edgewise compression of a flat disk, 2" in diameter by 0.5" thick), Flexure (MOR and elastic modulus): Comparison of various ceramics (density, porosity, grain size and microstructure). **Polymers**; viscoelasticity in tension (creep, hysteresis, temp effects), Impact (comparison of various commercial polymers – e.g., PMMA, PC, PE, PP, PS). Phase Diagram Determination. To introduce the use of thermometrics and microscopy to determine parts of three phase diagrams. Introduction To Corrosion Phenomena; Electrochemical Formation of Rust, Stress Corrosion, Corrosion Inhibition, Hydrogen Embrittlement, Electrowinning of Copper, Polarization Curves

Schedule: Lecture Class is 75 minutes long once a week. Laboratory classes are twice a week for 3 hours each.

Contribution to Professional Component:

Engineering Topics 100%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	3
3b	Design and conduct experiments	3
3b	Analyze and interpret data	3
3c	Design system, component, or process to meet needs	0
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	2
3f	Understand professional and ethical responsibility	1
3g	Communicate effectively	3
3h	Broad education	0
3i	Recognize need for life-long learning	0
3j	Knowledge of contemporary issues	0
3k	Use techniques, skills, and tools in engineering practice	3

Prepared by: Sheldon Mostovoy, May 2002

MMAE 482: Composites - REQUIRED

Catalog Data: This course focuses on metal, ceramic and carbon matrix composites. Types of composite. Synthesis of precursors. Fabrication of composites. Design of composites. Mechanical properties and environmental effects. Applications. (3-0-3)

Textbook: Krishan K. Chawla, *Composite Materials*, 2nd Edition, 1998, Springer.

Major reference: Mel M. Schwartz, *Composite Materials*, Vol. I and II, 1997, Prentice-Hall PTR.

Topics/Course Outline:

WEEK	SUBJECT	TEXT COVERED
1	Introduction and overview	Chap. 1
2	Reinforcement in composites	Chap. 2
3	Metal matrix composites	Chap. 3, 6
4	Metal matrix composites	Chap. 6
5	Ceramic matrix composites	Chap. 3, 7
6	Ceramic matrix composites	Chap. 7, 8
	Polymer matrix composites	Chap. 3, 5
7	Polymer matrix composites	Chap. 5
8	Mechanics of unidirectional composites and laminates	Chap. 6, 7
9	Midterm exam	
	Micromechanics of unidirectional composites	Chap. 10
10	Micromechanics of unidirectional composites	Chap. 10
	Strength of unidirectional composites and laminates	Chap. 11
11	Strength of unidirectional composites and laminates	Chap. 11
12	Interfaces and Interphases	Chap. 4
13	Fracture mechanics of composites	Chap. 12

14	Fatigue and environmental effects	Chap. 13
15	Term project presentation	
16	Final examination	

Schedule: Classes are 1 hr 15 min. long, 2 sessions per week.

Contribution to Professional Component:

Engineering Science: 67%

Engineering Design: 33%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	2
3b	Design and conduct experiments	0
3b	Analyze and interpret data	1
3c	Design system, component, or process to meet needs	2
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	1
3f	Understand professional and ethical responsibility	0
3g	Communicate effectively	0
3h	Broad education	0
3i	Recognize need for life-long learning	0
3j	Knowledge of contemporary issues	2
3k	Use techniques, skills, and tools in engineering practice	2

Prepared by: **T. Calvin Tszeng**

MMAE 483 Structure/Property Relationships in Polymers - REQUIRED*

Catalog Data: Detailed study of the relationships between polymer structure, morphology and properties. Topics include theories of rubber elasticity, the glassy state, semi-crystalline structure, and polymer melts. Effects of molecular weight and different types of intermolecular interations are presented

* Students must take either MMAE467 or MMAE 483 to satisfy program content requirement.

Textbook: Physical Properties of Polymers, Mark, Eisenberg, Graessley, Mandelkern, Samulski, Koenig and Wignall, Amer. Chem. Soc.

Objectives: To describe and understand the various molecular and morphological states developed in polymeric materials. To relate polymer structures with processing, properties and performance in service.

Prerequisite by Topic: Basic introduction to structure and properties of polymers, mechanical behavior.

Topics:

1. Introduction and overview (1 week)
2. The rubber elastic state (3 weeks)
3. The glassy state and the glass transition (3 weeks)
4. The crystalline state (4 weeks)
5. Viscoelasticity asnd flow of polymers (2 weeks)
6. Special topics (crazing, two phase structures, rubber reinforced thermoplastics, interpenetrating polymer networks, liquid crystal polymers) (1 week)

Schedule: Classes are 2 hr. 30 min. long, 1 session per week.

Contribution to Professional Component:

Engineering topics 100%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	3
3b	Design and conduct experiments	1
3c	Design system, component, or process to meet needs	1
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	3
3f	Understand professional and ethical responsibility	1
3g	Communicate effectively	1
3h	Broad education	0
3i	Recognize need for life-long learning	0
3j	Knowledge of contemporary issues	1
3k	Use techniques, skills, and tools in engineering practice	3

Prepared by: John S. Kallend and Don Duvall, June 2002.

MMAE 485: Manufacturing Processes - REQUIRED

Catalog Data: Principles of material forming and removal processes and equipment. Force and power requirements, surface integrity, final properties and dimensional accuracy as influenced by material properties and process variables. Design for manufacturing. Factors influencing choice of manufacturing processes. Prerequisite: MMAE 271. (3-0-3)

Textbook: Kalpakjian, S., Manufacturing Processes for Engineering Materials, 3rd Ed., Addison Wesley (1997).

Objectives: The first objective is to teach students the fundamental mechanical behavior of materials and how it relates to the development of manufacturing processes. The second objective is for students to apply the principles of yield theories in estimating the forces, power, and understanding of manufacturing process parameters. The third objective is to develop ability to research the manufacturing processes and make a presentation. Finally, the students should be able to select appropriate manufacturing processes and engineering materials for manufacturing a component(s).

Prerequisites by Topic:

1. Mechanical behavior of materials
2. Materials testing methods.

Topics:

1. Introduction to manufacturing processes (1 class)
2. Materials Properties (2 classes)
3. Friction, wear, and lubrication in mfg processes (2 classes)
4. Primary mfg processes: extrusion, forging, rolling (7 classes)
5. Secondary manufacturing processes: Wire, rod, and tube drawing sheet metal forming, bending, deep drawing (6 classes)
6. Machining / grinding (4 classes)
7. Non-conventional manufacturing processes (1 class)
8. Term paper presentations (2 classes)
9. Examinations (3 classes)

Schedule: Classes are 1 hr 15 min. long, 2 sessions per week.

Contribution to Professional Component:

Engineering Science: 33%

Engineering Design: 67%

Relationship of Course to ABET Outcomes:

ABET Criterion	Program Outcome	Status
3a	Apply knowledge of math, engineering, science	3
3b	Design and conduct experiments	0
3b	Analyze and interpret data	3
3c	Design system, component, or process to meet needs	1
3d	Function on multi-disciplinary teams	0
3e	Identify, formulate, and solve engineering problems	2
3f	Understand professional and ethical responsibility	1
3g	Communicate effectively	1
3h	Broad education	0
3i	Recognize need for life-long learning	1
3j	Knowledge of contemporary issues	1
3k	Use techniques, skills, and tools in engineering practice	3

Prepared by: Dr. Bharat Thakkar, June 2002.

Appendix 1 - (C)   Survey Instruments

Survey Instruments are attached on the following pages, as follows:

Survey of alumni, conducted triennially

Student course assessment form, conducted biannually

Faculty course assessment form, conducted biannually

Faculty assessment of program outcomes, conducted annually

Survey of graduating seniors, conducted annually

Illinois Institute of Technology

Survey of Engineering and CS Alumni

As part of IIT's process for continuous improvement of programs, we are requesting your help as a recent graduate with a BS in engineering or computer science. Please take a few minutes to complete this survey. A reply-paid envelope is included for your convenience. If you also received an advanced degree from IIT***, please confine your answers to your BS program at IIT.*** Thank you.

John S. Kallend, Professor of Engineering, Associate Dean.

---

1. Your name (optional): ____

2. Your BS degree program: ________________ 3. Year BS awarded _________

4. Current employer or graduate school: ____________________________________

5. Your job title or position: ____

6. Type of work: (Check all that apply)

____ Graduate School ____Design ____Research ____Teaching/Training

____Manufacturing/Production ____Management ____Technical Support

____Programming ____Maintenance ____Safety

____Owner/Operator ____Sales/Marketing ____Other

7. Have you engaged in professional development by:

Attending professional seminars/professional society meetings ? **Yes / No**

Pursuing a graduate degree or professional certification? **Yes / No**

Subscribing to a technical journal **Yes / No**

8. Please rate your BS program's overall effectiveness in preparing you for your job or graduate study (please circle one word)

Excellent Good Fair Poor

9. How do you rate your preparation relative to that of your peers from other institutions (circle one response):

Superior to Somewhat better than About the same as Worse than

10. Please circle the word that best describes your program of study in the following areas:

A. How do you rate your preparation in

- Mathematics: **Good Average Poor**
- Science: **Good Average Poor**

B. Rate your preparation to perform research and/or development tasks in your area:

Good Average Poor

C. Rate your preparation for designing and/or implementing components or systems:

Good Average Poor

D. Rate your preparation to work in a team with individuals from other disciplines:

Good Average Poor

E. Rate your preparation to solve technical problems in your area:

Good Average Poor

F. Rate your preparation for handling ethical issues:

Good Average Poor

G. Rate your preparation to deal with social issues and "people problems" at work

Good Average Poor

H. Rate your ability to communicate effectively by:

- Interaction with other employees and management **Good Average Poor**
- Making oral presentations **Good Average Poor**
- Writing reports and proposals **Good Average Poor**

I. Rate your ability to use computers, computer networks and other communication and information processing tools in your work: **Good Average Poor**

11. Did your IIT education encourage you to consider the impact of your professional decisions on society? **Yes / no / not applicable**

12. Did IIT prepare you to handle issues such as pollution, safety, etc? **Yes / no / not applicable**

13. Based on your post-graduation experience, what, if any, areas of study should receive more emphasis in your IIT BS degree program:

Thank you again for your assistance.

MMAE Course Assessment

Course MMAE/MS_____________ Semester _____________

The MMAE department is committed to continuous improvement of its programs and would like to have more information than is provided by the standard IIT course evaluation form. Please take a few minutes to complete this survey. Thank you.

1. Did you understand what was expected of you in the course? Yes / No
2. Do you think that you achieved the learning objectives for the course? Yes / No
3. If you answered "No" to question 2, which objective or objectives did you not achieve (please list). Your instructor should have supplied you with a list of learning objectives for the course.

4. Were you adequately prepared to take this course by your mathematics and science background? Yes / No
5. Were you adequately prepared to take this course by prerequisite MMAE courses (if any)? Yes / No / Not applicable
6. What did you like best about this course?

7. What, if anything, would you change about this course?

Please continue on the back if necessary.

FACULTY - COURSE SELF-ASSESSMENT

Course: MMAE _______ Semester __________ Number of students______

1. How many students earned each grade? A ____ B ____ C ____ D ____ E ____ W____

2. Indicate how many, and to what extent, students met each of the course objectives you defined for the students (please attach. Note, course files are available in 207A E1)

	NEEDED IMPROVEMENT	MET EXPECTATIONS
Objective 1		
Objective 2		
Objective 3		
Objective 4		
Objective 5		
Objective 6		
Objective 7		
Objective 8		

3. In your opinion, were the students adequately prepared in mathematics? (Yes/No). If "No", what deficiencies did you identify?
____
____

4. In your opinion, were the students adequately prepared in basic science (Yes/No). If "No", what deficiencies did you identify?
____
____

5. In your opinion, were the students adequately prepared by other pre-requisite courses, if any? (Yes/No). If "No", what deficiencies did you identify?
____
____

6. If you were to teach the course again, what changes would you make? (Use additional pages if needed)
____
____

7. Did you incorporate any changes recommended in a previous assessment (Yes/No). If "Yes", did the changes result in improved outcomes (Yes/No).

Survey of Educational Outcomes for MMAE seniors.

To: Prof. __________________

This survey is being given to MMAE faculty who teach 400 level classes or supervise undergraduate research projects.

Please rate YOUR opinion of our seniors' abilities in the following areas, using a scale of 1 (poor) to 5 (excellent). If you are unable to judge in any area, leave it blank.

ability to apply knowledge of mathematics, science, and engineering 1 2 3 4 5

ability to design and conduct experiments, as well as to analyze and interpret data 1 2 3 4 5

ability to design a system, component, or process to meet desired needs 1 2 3 4 5

ability to function on multi-disciplinary teams 1 2 3 4 5

ability to identify, formulate, and solve engineering problems 1 2 3 4 5

understanding of professional and ethical responsibility 1 2 3 4 5

ability to communicate effectively 1 2 3 4 5

the broad education necessary to understand the impact of engineering 1 2 3 4 5 solutions in a global and societal context

recognition of the need for, and an ability to engage in life-long learning 1 2 3 4 5

knowledge of contemporary issues 1 2 3 4 5

ability to use the techniques, skills, and modern engineering tools necessary for 1 2 3 4 5 engineering practice.

Based on your experience teaching MMAE seniors, do you see any areas of weakness that need to be addressed in our programs? If "Yes", please elaborate.

Please return to John Kallend by ______________

MMAE Graduating Senior Exit Survey

Date:____________________ Major____________________

On a scale of 1 (poor) to 5 (excellent) please rate the following

Math/Science/Engineering Skills

1) How well were you prepared in math and science at IIT? 1 2 3 4 5

2) How well did your preparation in math/science prepare you to tackle engineering problems? 1 2 3 4 5

Design, conduct, and analyze experiments

3) Rate your ability to design experiments 1 2 3 4 5

4) Rate your ability to conduct experiments in the lab. 1 2 3 4 5

5) Rate your ability to analyze experimental data 1 2 3 4 5

Design a system or process

6) Rate your ability to engage in engineering design 1 2 3 4 5

7) To what extent did the IPRO experience prepare you for engineering design 1 2 3 4 5

Multidisciplinary teams

8) Rate your ability to work in multidisciplinary teams 1 2 3 4 5

9) Rate the IPRO experience in preparing you for working in teams 1 2 3 4 5

Ability to solve engineering problems

Rate your ability to formulate and solve engineering problems 1 2 3 4 5

Ability to communicate

11) Rate the extent to which the program helped develop your written communication skills 1 2 3 4 5

12) Rate the extent to which the program helped develop your
Oral communication skills 1 2 3 4 5

Ability to use modern skills and techniques

13) Rate your ability to use computers as tools in solving engineering problems. 1 2 3 4 5

14) Rate the effectiveness of your coursework in preparing you to use computer and communications technology 1 2 3 4 5

15) Rate your preparation to use laboratory equipment and techniques relevant to your field? 1 2 3 4 5

Please answer Yes/No to the following questions:

Understand ethical and professional responsibility

16) Do you belong to a professional society in your field? Yes No

17) Were ethical considerations covered in any of your engineering courses? Yes No

18) Was the coverage of ethics adequate in your opinion? Yes No

Understanding of global and societal context of the engineering discipline

19) Did the IPROs make you consider the role of engineering in society? Yes No

20) Did the humanities and social sciences courses influence your thinking about the role of engineering in society? Yes No

Recognition of the need for life-long learning

21) Did the program encourage you to consider graduate school? Yes No

22) In the last year have you attended at least one lecture in the field of engineering that was not part of the curriculum? Yes No

23) Have you browsed the internet or in the library for engineering or scientific information that was not related to your classes? Yes No

24) In your engineering courses did you ever go beyond the

requirements of an assignment just because it interested you? Yes No

25) Have you read a technical article just for fun.. Yes No

Knowledge of contemporary issues

26) Do you subscribe to any technical journals Yes No

27) Do you regularly read a newspaper or news magazine Yes No

28) Do you think that your engineering program was up-to-date Yes No

These are open ended questions. Feel free to write as much (or little) as you wish:

Was the academic advising in MMAE satisfactory

Which areas of the curriculum need more emphasis?

Which areas received too much emphasis?

How valuable were the IPROs?

How could the program be improved?

OPTIONAL: Your name_________________________

Name of your employer or Graduate School (if any)_____________________________

If not currently employed or in graduate school, are you seeking employment in your field

____

Please return to: Professor John Kallend, MMAE Department, IIT