SELF-STUDY REPORT FOR REVIEW
OF
ENGINEERING PROGRAMS

2007-2008 Edition

Submitted by

MECHANICAL ENGINEERING PROGRAM
POLYTECHNIC UNIVERSITY OF PUERTO RICO

JUNE 2007

to the

Engineering Accreditation Commission
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A. Background Information

1. Degree Titles

The Department of Mechanical Engineering offers a program of study that leads to the degree of Bachelor of Science in Mechanical Engineering.

2. Program Modes

The Mechanical Engineering Program is a day-and-evening, on-campus program. Courses are offered from 8:00 a.m. to 10:30 p.m. from Monday to Thursday, as well as Friday and Saturday from 8:00 a.m. to 5:00 p.m.

3. Actions to Correct Previous Concerns

The 2001 accreditation decision regarding this program was to be accredited for six years. There were previous shortcomings of concern to be addressed at the institutional level and at the program level. This section is subdivided two parts, namely, the institutional concerns and the program concerns.

3.1 Actions to Correct Previous Institutional Concerns

There was only one concern in 2001 at the institutional level (Criterion 7 – Institutional Support and Financial Resources). Below you will find the EAC comment and the PUPR actions to correct the concern.

EAC Concern – Criterion 7: “The economy of Puerto Rico is such that faculty salaries tend to be low. Increases in salary are across the board based on rank and seniority. While the teaching loads of 36 hours per year adhere to, members of the faculty can reduce the teaching load by advising or other assigned administrative duties. Conversely, a faculty member can augment his/her salary by opting to teach additional courses. Augmenting salaries by consulting is common among the members of faculty. While interaction with industry potentially provides benefits to faculty members including compensation through consulting, class projects, and development contracts, existing incentives basically serve to increase teaching load or administrative assignments with little incentive for intellectual activities or professional development. To meet the goals stated for increased scholarly activity on campus, the incentives available need to be revisited to include appropriate recognition for all desired outcomes.”

PUPR response: The workload of a full-time faculty member is of 36 credit hours per academic year. Faculty members may be awarded six (6) credits of release time out of the 36 credit hours to perform different tasks such as: administrative work, intellectual activities, professional development, etc. The administrative work consists of student mentoring, counseling, or other services to the university such as curriculum review, laboratory development, paper publishing, proposal preparation, research, etc. Other activities are based in the professors’ needs, interests,
and/or department necessities. Any workload assigned above the 36 credit hours per academic year is compensated proportionately and is optional. In addition, faculty members currently have two (2) months of vacation, during the summer. At this time, some faculty members decide to be involved in summer research, consulting, teaching, and other intellectual activities.

Regarding the salary scale and promotion, there have been salary increases since the last ABET visit of about 7.5% one in 2002-2003 of 4% and the other in 2004-05 of 3%. The increase in salary is dependent also, on evaluation of professor performance. A multi-annual contract is signed with the professor and a complete process to evaluate the professor is in place.

3.2 Actions to Correct Previous Mechanical Engineering Program Concern

There were three shortcomings of concern in 2001 at the program level. These were in Criterion 1, Criterion 3, and Criterion 5. Below you will find the EAC comment and the PUPR actions to correct the concern.

**EAC concern – Criterion 1**: “Numerous pre-requisites problems were found in the 10 transcripts provided for pre-visit review. Faculty advisors and the chair have recently started to check prerequisites more rigorously. This was verified by student comments. A new College-level plan has been designed to enforce prerequisites. It is urged that the new plan be fully implemented.”

**PUPR response**: PUPR has a multi-component approach for advising students. The system is designed to assist students with personal, vocational, and academic orientation. The students are advised, prior to and during registration, in the selection and sequence of the required and elective courses.

The first component of the advising system is the Retention Management and Guidance Office. It advises students with up to 72 credit-hours approved in the adequate selection of the courses at the time of pre-registration and registration.

The second component of the advising system is the faculty mentoring program done at the academic department level. Currently, the Assistant to the Department Head in Academic Affairs and a group of six faculty mentors assist all students with 73 credit-hours or more approved during the pre-registration and registration processes. A comprehensive record analysis is carried out in order to assure full curricular compliance regarding to the completion of the program requirements. The process is speeded-up by means of a direct access to the students’ academic records using the computer program CAMS Enterprise, although is still done in a case by case basis and not an automatically assisted by the program.

The process described above has been used since the 2001 visit. The current system can be characterized as decentralized where the students may enroll with institutional counselors that do not necessarily report to the department head, but they assist in the tedious manual process of enrollment. At the present, the student can enroll with just the approval signature of either the institutional counselor or mentor. If a student enrolls into a course without the prerequisites there is a system in place to correct the problem. First, the student lists show an RQ, which
represents that the student needs pre-requisites. The professor of the course reports the problem to the student and the student must find an approval signature from the person (institutional academic counselor or mentor) that prepared his pre-enrollment sheet. If the permission is not approved the professor can decide not to accept the student in the course and the student must drop the course. If the permission is approved the mentor or authorized personnel writes an explanation for the acceptance.

In the near future, a new centralized system will be fully implemented in WT-08. In this new system, the Department Head and the Assistant to the Department Head in Academic Affairs have complete control of the enrollment process. The computer program to be used will be Jenzabar. The department directors are preparing the master catalogue database to include a degree audit into the system to prevent the pre-requisites problem and automate the process.

**EAC concern – Criterion 3:** “Some examples of curriculum changes as a result of assessment were shown, but little follow up assessment of the effect of these changes has yet been demonstrated. The mechanical engineering faculty is encouraged to continue implementing the assessment plan using all planned constituents and outcomes measures to determine the effects of changes made.”


The outcomes assessment process has been consistently performed after the 2001 ABET visit.

Table A.1 shows the plan of when and how (assessment tools) the outcomes are measured either by the Outcomes Assessment Faculty Committee and/or the Faculty. The outcome assessment results for the last cycle 2005-2007 of evaluation with direct measurements is shown in Figure A.1 (outcomes assessment results for cycle 2001-2003 and 2003-2005 are available in Appendix I-E).

Table A.2 summarizes the actions performed per assessment cycle since the last ABET visit. As can be seen the improvement of the mechanical engineering program has be possible due to the implementation of this process. More information about outcomes assessment is discussed in later sections.
Table A.1 Relation between outcome, assessment tool and when it is measure in the cycle

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Assessment Tool</th>
<th>First Academic Year</th>
<th>Second Academic Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fall</td>
<td>Winter</td>
</tr>
<tr>
<td>Local Exams</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Simulations</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Perform Appraisals</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Oral Examinations</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Behavioral Observ.</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Course Portfolio</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Capstone Survey</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Senior Exit Survey</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Fundamental Exam</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>i Fundamental Exam</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Figure A.1 Outcomes Assessment Results Cycle 2005-2007

Table A.2 Demonstration of Action of Steps Application

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 4</th>
<th>Step 5</th>
<th>Step 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-2003</td>
<td>No changes</td>
<td>No changes</td>
<td>No changes</td>
<td>Indirect Measures only</td>
<td>Performed by OAFC</td>
<td>Rec. Curr. Change</td>
</tr>
<tr>
<td>2003-2005</td>
<td>No changes</td>
<td>No changes</td>
<td>Curr. Change</td>
<td>Indirect Measures only</td>
<td>Performed by OAFC</td>
<td>Implement Curr. Change</td>
</tr>
<tr>
<td>2005-2007</td>
<td>No changes</td>
<td>No changes</td>
<td>No changes</td>
<td>Direct and Indirect Measures</td>
<td>Performed by Faculty &amp; OAFC</td>
<td>Syllabus Changes</td>
</tr>
</tbody>
</table>
**EAC concern – Criterion 5:** “There is a concern about the professional development of faculty when a planned graduate program is implemented. The institution is recommended for its policies to help young faculty earn doctorates. There appears to be an over reliance by the faculty on industrial consulting for professional development needs. The department needs to assess its current resources for faculty development to maximize the impact as the unit moves to the next academic level. More involvement in the technical professional societies is encouraged. A future emphasis on developing applied research is suggested in order to meet the dean’s stated future goals of increasing applied research and the initiation of a master’s program in the department.”

**PUPR response:** Faculty development has been priorities in our department since the last ABET visit. In 2001, 11% (1/9) faculty members had a Ph.D. In the present, 33% (6/18), have PhD as compared to 2001. Now that the department has enough Ph.D. resources the Master’s program in Mechanical Engineering is scheduled to start in winter 2007. In addition, two of our faculty members are conducting their Ph.D. studies where the institution is sponsoring the tuition, fees, and a monthly stipend.

**4. Contact Information**

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B. Accreditation Summary

1. Students

1.1 Admissions Policy

1.1.1 Acceptance of Freshmen Applicants

The Polytechnic University of Puerto Rico (PUPR) provides the opportunity to high school graduates or individuals who have passed a state high school equivalency examination to enroll in university programs, through a flexible admission policy. Until the end of academic year 2001-2002 the applicants to all of the PUPR Engineering Programs were admitted with a minimum High School Grade Point Average (GPA) Index of 2.50 (out of a maximum of 4.00) and a minimum Puerto Rico College Entrance Examination Board Achievement Test score of 1,300 (out of a maximum of 2,400). Since the beginning of academic year 2002-2003 the applicants must obtain a PUPR Admission Index (IGS) of at least 245 (out of a maximum of 400; formula = [GPA High School x 200 + verbal + math] / 6). The IGS is obtained taking into consideration the applicant High School GPA Index and the Puerto Rico College Entrance Examination Board Aptitude Test scores. Applicants who do not meet minimum requirements can request special consideration by the Director of Admissions.

1.1.2 Acceptance of Transfer Applicants

An applicant who has studied at a recognized institution of higher education may apply for admission as a transfer student. Transfer applicants must have passed no fewer than nine transferable college credit-hours. They will be favorably considered for all academic work completed with a C or higher grade at each prior institution. Transfer credit-hours are limited to work satisfactorily completed at an accredited college or university within a five year period immediately preceding application for admission. A transfer applicant will not be considered if he/she is on academic probation, suspension, or dismissal from the previous institution; if he/she would be on academic probation upon return to the previous institution; or if on disciplinary probation during or following the last term at the previous institution; or within one year after dismissal.

1.2 Validation of Transfer Credits

The validation process for transfer students starts with a preliminary limited validation that is performed by the PUPR Admissions Office. This validation is mostly limited to socio-humanistic, language, mathematics and science courses from accredited higher education institutions. They are performed based on written policies and procedures of the Admissions Office developed in consultation with the directors of the non-engineering academic departments. The general engineering courses considered for validation are submitted to the corresponding engineering academic department that offers the course, while the mechanical engineering (ME) courses considered for validation are submitted to the ME Department. These courses are evaluated by the Department Head, the Associate Department Head, or the Assistant to the Department Head in Academic Affairs, who may consult with other members of the
faculty for their approval. All validations are logged on the students’ records at the Registrar Office.

1.2.1 Readmission

Students who are not active during two or more consecutive terms, or who are under suspension for disciplinary or academic reasons, and wish to continue their studies, must apply for readmission to the Institution. Regular students who have discontinued their studies for one year or more will be readmitted under the institutional procedure in effect at the time of readmission, and the applicable curriculum will be the one outlined in the Catalog in force at that time. The Registrar Office will apply the following criteria to evaluate the readmission application: a) study any evidence of disciplinary measures taken or non-compliance with University regulations and any stipulations made, b) verify that the student complies with the minimum GPA, and c) confirm that the student complies with the required suspension time limit.

1.2.2 Preparatory Program

The flexible admission policy of PUPR requires a program to overcome students’ educational deficiencies from high school. Specific deficiencies are identified using the results of the Puerto Rico College Entrance Examination Board tests. Those students that do not demonstrate the academic abilities and skills that are necessary to succeed at the university academic level will be required to take preparatory courses. These courses, listed in Table B.1, are designed to help the students to overcome deficiencies in languages, mathematics, and science.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit-Hours</th>
<th>PR College Entrance Examination Board Achievement Test score on subject section (out of a maximum of 800)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 0102</td>
<td>Preparatory Mathematics</td>
<td>3</td>
<td>200 to 549 (Mathematics section)</td>
</tr>
<tr>
<td>MATH 0106</td>
<td>Elementary Algebra</td>
<td>3</td>
<td>550 to 649 (Mathematics section)</td>
</tr>
<tr>
<td>MATH 0110</td>
<td>Intermediate Algebra</td>
<td>3</td>
<td>650 to 699 (Mathematics section)</td>
</tr>
<tr>
<td>ENGL 0100</td>
<td>Preparatory English</td>
<td>3</td>
<td>200 to 599 (English section)</td>
</tr>
<tr>
<td>ENGL 0110</td>
<td>English Grammar</td>
<td>3</td>
<td>600 to 749 (English section)</td>
</tr>
<tr>
<td>SPAN 0100</td>
<td>Preparatory Spanish</td>
<td>3</td>
<td>200 to 549 (Spanish section)</td>
</tr>
<tr>
<td>SPAN 0110</td>
<td>Spanish Grammar</td>
<td>3</td>
<td>550 to 749 (Spanish section)</td>
</tr>
</tbody>
</table>

All engineering freshman students are required to take the Adjustment to University Life course (ATUL 0100), offered by institutional professional counselors, and Introduction to Physics (SCIE 0110)
1.3 Evaluation and Retention

The performance of the engineering students is evaluated at the course level by means of examinations, assignments, design projects, site visits, publication reviews, portfolios, and/or oral presentations in compliance with the respective course syllabus. Students are authorized to take the next courses in curriculum sequence only after the completion of the pre-requisite courses. PUPR utilizes an alphanumeric grading system. The grades are as stated in Table B.2

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Excellent (4 honor points per credit-hour)</td>
</tr>
<tr>
<td>B</td>
<td>Good (3 honor points per credit-hour)</td>
</tr>
<tr>
<td>C</td>
<td>Satisfactory (2 honor points per credit-hour)</td>
</tr>
<tr>
<td>D</td>
<td>Deficient (1 honor points per credit-hour)</td>
</tr>
<tr>
<td>F</td>
<td>Failure (0 honor points per credit-hour)</td>
</tr>
<tr>
<td>P</td>
<td>Pass (Grading for 0 credit-hour courses)</td>
</tr>
<tr>
<td>NP</td>
<td>Not Passed (Grading for 0 credit-hour courses)</td>
</tr>
<tr>
<td>I</td>
<td>Incomplete</td>
</tr>
<tr>
<td>W</td>
<td>Withdrawal</td>
</tr>
</tbody>
</table>

Note: One credit-hour corresponds to 15 contact hours per term for a lecture course, and 30 to 45 contact hours per term for a laboratory course.

The grade point average index (GPA) of a student is the measure of his/her academic achievement. It is computed as follows:

- The total number of credit-hours corresponding to all courses taken, counted once, and having a grade of A, B, C, D, or F, are obtained (T).
- The credit-hours of each course is multiplied by 4, 3, 2, 1, or 0 according to grades A, B, C, D or F, respectively. For repeated courses, only the highest grade obtained is used. The transferred credit-hours from other institutions are not used in the computation.
- These products are added (S).
- S is divided by T to obtain the GPA.

The policy and procedures for student retention, probationary status, suspension, and permanent dismissal are established mechanisms that allow for the evaluation of the students’ achievement. PUPR requires every student to demonstrate academic progress in the number of academic credit-hours completed and the GPA that the student maintains. Academic progress is defined as the measure that shows whether the student passes sixty six percent (66%) of the attempted credit-hours with a GPA equal to, or higher than, the retention index. Table B.3 shows the Retention Index that applies to students without federal financial aid and Table B.4 shows the Retention Index for students with federal financial aid.
<table>
<thead>
<tr>
<th>Total Accumulated Credit-Hours</th>
<th>Minimum Grade Point Average (GPA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 36</td>
<td>1.50</td>
</tr>
<tr>
<td>37 to 72</td>
<td>1.65</td>
</tr>
<tr>
<td>73 to 108</td>
<td>1.80</td>
</tr>
<tr>
<td>109 or more</td>
<td>2.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Accumulated Credit-Hours</th>
<th>Minimum Grade Point Average (GPA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 36</td>
<td>1.60</td>
</tr>
<tr>
<td>37 to 72</td>
<td>1.80</td>
</tr>
<tr>
<td>73 or more</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Students whose academic progress does not satisfy the retention index requirement begin a probationary period that does not exceed two consecutive academic years, before being suspended for one academic year. After suspension is effective, the student may return under a probationary status for a maximum period of one additional academic year, at the end of which he/she may be suspended for a period of three academic years. The student can be admitted once again under a probationary status for one academic year. In the event that the student does not succeed, he/she will be permanently dismissed.

1.4 Advising

PUPR has a multi-component approach for advising students. The system is designed to assist students with personal, vocational, and academic orientation. The students are advised, prior to and during registration, in the selection and sequence of the required and elective courses.

The first component of the advising system is the Retention Management and Guidance Office. It advises students with up to 72 credit-hours approved in the adequate selection of the courses at the time of pre-registration and registration. This office also provides to all of the university students with professional counseling and psychological services, and coordinates the institutional services for handicapped students.

The second component of the advising system is the faculty mentoring program done at the academic department level. Currently, the Assistant to the Department Head in Academic Affairs and a group of six faculty mentors assist all students with 73 credit-hours or more approved during the pre-registration and registration processes. A comprehensive record analysis is carried out in order to assure full curricular compliance regarding to the completion of the program requirements. The process is speeded-up by means of a direct access to the students’ academic records using the computer program CAMS Enterprise. The students also have the opportunity
to discuss specific career matters, such as elective courses selection, graduate school options, employment possibilities, and other professional issues with their faculty mentors. This component of advising provides a general exposure to the profession and to future academic opportunities to all students.

1.5 Monitoring

The monitoring of students’ progress to foster their success in achieving program outcomes is addressed at three stages. At the first stage, the counselors of the Retention Management and Guidance Office monitor the academic achievement of the students with up to 72 credit-hours approved. Those students with academic deficiencies or disadvantages are referred to either the Student Support Services Program or the University Progress Center. The personnel at the Student Support Services Program provide counseling and tutorial services in the preparatory courses listed in to low income, first generation with university level studies and/or physically handicapped students. Meanwhile, the tutors of the University Progress Center provide academic support to the rest of the students on the languages, mathematics, science, and general engineering courses reinforcing their academic skills to achieve their academic program outcomes.

At the second stage, the academic progress of the students with more than 72 credits-hours approved is monitored by the Assistant to the Department Head in Academic Affairs and the faculty mentors of the Department of Mechanical Engineering. The mentors perform a comprehensive analysis of the students’ records to monitor student compliance and performance as he/she advances through the curriculum. Every term, faculty mentors monitor the students programs and authorize the pre-registration and registration in courses that complies with the pre-requisites and/or co-requisites based on the courses that the students are taking or have already approved. The faculty mentors also monitor the students’ academic records to verify the completion of the program requirements for graduation.

In order to enable the students as graduates to attain program objectives the Department of Mechanical Engineering has a comprehensive objectives and outcomes assessment program in place. Examples and results of several assessment tools at the program, area of specialty and course levels are presented in detail in Chapters 2 and 3 of this Self-Study Report.

At the third stage, the student transcript is analyzed by the Registrar Office to verify the completion of every course in the student program and the satisfaction of the GPA requirements. In order to graduate from PUPR engineering programs the students must attain a minimum cumulative GPA of 2.00, as well as a minimum GPA of 2.00 in general engineering and mechanical engineering courses.

Once the students complete eighty percent (80%) or more of the required credit-hours, they are entitled to apply for graduation by filing an application form at the Registrar Office. After this is done, the Office sends to the students an analysis of their records showing the courses already taken and the courses that need to be taken to complete the program requirements. At the time of graduation, the Registrar Office is responsible for confirming that all requirements have been met.

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1.6 Enrollment and Graduation Data

Since ABET’s reaccreditation visit of 2001 the number of active students enrolled in the undergraduate Mechanical Engineering program has been increasing from 588 to 755, as presented in Table B.5.

Table B.5 Students Enrolled in PUPR Mechanical Engineering Program

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>Number of Female Students</th>
<th>Number of Male Students</th>
<th>Total Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-2002</td>
<td>55</td>
<td>533</td>
<td>588</td>
</tr>
<tr>
<td>2002-2003</td>
<td>55</td>
<td>539</td>
<td>594</td>
</tr>
<tr>
<td>2003-2004</td>
<td>63</td>
<td>605</td>
<td>668</td>
</tr>
<tr>
<td>2004-2005</td>
<td>53</td>
<td>663</td>
<td>716</td>
</tr>
<tr>
<td>2005-2006</td>
<td>50</td>
<td>670</td>
<td>720</td>
</tr>
<tr>
<td>2006-2007</td>
<td>43</td>
<td>712</td>
<td>755</td>
</tr>
</tbody>
</table>

Meanwhile, the number of students that have graduated from the Program has oscillated between 27 and 67 since ABET’s reaccreditation visit of 2001, as presented in Table B.6.

Table B.6 Graduates from PUPR Mechanical Engineering Program

<table>
<thead>
<tr>
<th>Graduation Year</th>
<th>Total Number of Graduates</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>53</td>
</tr>
<tr>
<td>2002</td>
<td>27</td>
</tr>
<tr>
<td>2003</td>
<td>36</td>
</tr>
<tr>
<td>2004</td>
<td>40</td>
</tr>
<tr>
<td>2005</td>
<td>67</td>
</tr>
<tr>
<td>2006</td>
<td>46</td>
</tr>
</tbody>
</table>

According to the latest publications by the Profiles of Engineering and Engineering Technological Colleges published by American Society of Engineering Education 2005 Edition, our number of graduates compares as follows:

✓ % of Hispanic Graduates in ME from PUPR to total Hispanics = 67 / (175+744) = 7.3%
✓ % of Graduates in ME from PUPR to total in US = 67 / 14,947 = 0.45%

1.7 Student Profile

This section contains important information of the student profile including the student status (part time <12 crds. or full time, >=12 crds.) and employment responsibilities, and the student marital status. The university mission includes the admission of people with different backgrounds and societal status that will have an impact to the educational strategies to achieve program objectives. A survey (available in Appendix I-D) was conducted to measure the student
profile. The population surveyed is shown in Figure B.1 where it is divided in the student placement in the curriculum. The number of students surveyed was 215.

Figure B.2 shows the academic and employment load of students. Only 41% of the students surveyed dedicate themselves to full time or part time studies. The other 59% dedicate to both academic load and employment in a part time or full time basis. In addition, Figure B. shows the marital status of the students surveyed. It shows that about 75% are single. 5% are married with no children. The other 20% is either married or not married, both with children. This fact further compromises the time of the students to dedicate to the university.

**Figure B.1 Surveyed Population. 215 Students Surveyed.**
The average number of credit hours in SP-07 was 11.

Figure B.2 Student Load

Figure B.3. Students Marital Status
2. **Program Educational Objectives**

Our current program educational objectives states that graduates from Polytechnic University of Puerto Rico in mechanical engineering will be able to:

1. work effectively in the mechanical engineering profession in both thermal and mechanical systems areas or successfully pursue graduate studies as appropriate to individual career goals.
2. apply the fundamentals of mathematics, sciences, and engineering and use modem techniques and tools to solve mechanical engineering problems.
3. design and develop useful products, processes, or systems that benefit society and design and conduct experiments and analyze and interpret data.
4. participate as team members in projects that may involve multi-disciplinary activities, communicate their ideas verbally, graphically, and in writing so that they can perform engineering functions effectively.
5. conduct their engineering work professionally, aware of related ethical and contemporary issues, and continually improve their capabilities through life-long learning.

These educational objectives are published in the Polytechnic University Undergraduate Catalog as well as in the world-wide-web (http://www.pupr.edu). They are also posted on the departmental bulletin boards and brochures.

The next sub-sections are organized as follows: Section 2.1 describes the relation of program educational objectives to the university mission. Section 2.2 contains the constituents that review and implement program objectives and their level of involvement. Section 2.3 describes the assessment tools to establish program objectives. Section 2.4 describes the process to establish program educational objectives. Section 2.5 has the relationship between curriculum and processes to achieve program educational objectives. Section 2.6 describes the relationship between curriculum and program educational objectives. Section 2.7 contains the process to achieve program educational objectives. Section 2.8 has the level of achievement of program educational objectives. Section 2.9 contains the recommendations of cycle 2005-2007. Information about previous cycle is in Appendix I-E.

2.1 **Relation of Program Educational Objectives to University Mission**

This section presents the institutional mission and shows its relationship to the Program Educational Objectives. The mission of Polytechnic University of Puerto Rico as published in our undergraduate catalog is the following:

“As an institution of higher education, Polytechnic University of Puerto Rico provides opportunities for individuals from diverse backgrounds in different locations using multiple methods of delivery to cultivate their potential for leadership, productivity and competitiveness with the purpose of providing greater social responsibility toward their communities, through exposure to intellectual, humanistic and technological advancement.”

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The mission of Polytechnic University of Puerto Rico is to be implemented through the following goals:

1. To contribute to the socioeconomic development of Puerto Rico through the formation of well rounded educated engineers, architects, surveyors, and industrial business and construction managers.
2. To provide access to higher education to additional segments of our population other than traditional high school graduates.
3. To provide students, with, the capability to continue graduate programs that will enable them to became managers in public or private enterprises.
4. To foster the linkage between industry, government, commerce, professional associations and engineering education in particularly through the continuous education program.
5. To keep our students abreast of modern technological advancements.
6. To develop qualified professionals with mastery in their specialized fields and an adequate general culture.
7. To develop in the students a profound ethical commitment and a sense of social responsibility.
8. To promote the linkage among the university, its immediate community, the metropolitan area and Puerto Rican society at large.
9. To develop research skills in its students and to promote scientific research within the academic community.
10. To develop critical thinking and a scientific approach in the analysis and solutions of professional and social problems.
11. To promote the dissemination of knowledge through publications both in engineering and on general education.

Table B.7 shows the relationship of the Program Educational Objectives to the mission of Polytechnic University of Puerto Rico.
### Table B.7 Relationship of Program Educational Objectives to the Mission of the Institution

<table>
<thead>
<tr>
<th>Accreditation Criteria</th>
<th>Program Educational Objective</th>
<th>Institutional Mission</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Work effectively in mechanical engineering profession in both thermal and mechanical systems areas or successfully pursue graduate studies as appropriate individual career goals</td>
<td>To provide opportunities for individuals from diverse backgrounds to cultivate their potential for leadership, productivity and competitiveness.</td>
</tr>
<tr>
<td></td>
<td>Apply the fundamentals of mathematics, sciences and engineering and use modern techniques and tools to solve mechanical engineering problems</td>
<td>To provide greater social responsibility through exposure to intellectual, humanistic and technological advancement</td>
</tr>
<tr>
<td></td>
<td>Design and develop useful products, process, or system that benefit society and design and conduct experiments and analyze and interpret data.</td>
<td>To contribute to the economic development of Puerto Rico through the formation of well-rounded educated engineers</td>
</tr>
<tr>
<td></td>
<td>Participate as team members in projects that may involve multidisciplinary activities, communicate their ideas verbally, graphically, and in writing so that they can perform engineering functions effectively.</td>
<td>To provide students with the capacity to continue graduate programs</td>
</tr>
<tr>
<td></td>
<td>Conduct their engineering work professionally, aware of related ethical and contemporary issues, and continually improve their capacities through lifelong learning.</td>
<td>To foster the linkage between industry, government, commerce, professional associations and engineering education</td>
</tr>
<tr>
<td></td>
<td>To keep our students abreast of modern technological advancements</td>
<td>To develop qualified professionals with mastery in their specialized fields and an adequate general culture</td>
</tr>
<tr>
<td></td>
<td>To develop critical research skills in our students and to promote scientific research within the academic community</td>
<td>To develop in the students a profound ethical commitment and a sense of social responsibility</td>
</tr>
<tr>
<td></td>
<td>To develop critical thinking and scientific approach in the analysis and solutions of professional and social problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>To promote the dissemination of knowledge through publications both in engineering and on general education</td>
<td></td>
</tr>
</tbody>
</table>

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2.2 Program Constituencies

Polytechnic University of Puerto Rico (PUPR) has customarily promoted activities leading to the integration of Academia, Industry, Professional Societies, and Government. Meetings between representatives from these four sectors have been used in the past by PUPR to define the strategy of the institution as well as the characteristics of the engineering programs offered. Hence, PUPR institutionalized an Industrial Advisory Board that has been active since 1995. This board has been performing meetings to advise PUPR President, the Dean of the School of Engineering and the Department Heads on industry requirements.

In addition to the input from PUPR Industrial Advisory Board, the Department of Mechanical Engineering (ME) has obtained feedback from constituents including the Mechanical Engineering Advisory Board (MEAB), alumni, employers, professional societies, and faculty. The Outcome Assessment Faculty Committee (OAFC) is responsible to carry out the assessment process. Table B.8 shows a brief description and the rationale for the program’s constituencies.

The involvement of the MEAB is of outmost importance to both the ME Program and their members. Members include representatives from industry, academia, professional societies, and alumni. The interaction between the ME Program and the advisory board is performed through focus groups meetings to determine if program educational objectives must be redefined, revise, and/or recommend any changes. The advisory board provides information of how the ME program must evolve to achieve program educational objectives that will serve industry and alumni to satisfy their needs.

The alumni and employer feedback is used to determine if program educational objectives have been achieved. The interaction between the ME Program and alumni is performed through focus groups meetings and/or surveys to determine if the program objectives must be revised and whether they were achieved.

Professional societies, especially related to mechanical engineering, understand the future trends and the evolution of the mechanical engineer of tomorrow. Some of these societies are the American Society of Mechanical Engineers (ASME), Engineering Accreditation Commission (EAC), National Council of Examiners for Engineering and Surveying (NCEES), “Colegio the Ingenieros y Agrimensores de Puerto Rico” (CIAPR) and their Institute of Mechanical Engineering (IIM), Society of Automotive Engineers (SAE), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Society of Manufacturing Engineers (SME), and Society of Plastics Engineers (SPE). Table B.9 shows the contribution and the interaction with the ME Program of each of these societies to improve the ME offerings and to revisit the program objectives.
### Table B.8 Mechanical Engineering Program Constituents

<table>
<thead>
<tr>
<th>CONSTITUENTS</th>
<th>DESCRIPTION</th>
<th>RATIONALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advisory Committee</td>
<td>Members from industry, academia, professional societies, and alumni help in redefining, revising, and/or recommend any changes to program educational objectives.</td>
<td>Know industry needs and current standards required for ME graduates.</td>
</tr>
<tr>
<td>Employers</td>
<td>Distinguished leaders of Puerto Rico’s Industrial sector that represent actual and potential employers of program graduates. Areas such as manufacturing, air conditioning, instrumentation, mechanical contractors, and mechanical design are represented. Members are identified through PUPR COOP Office and Department Records.</td>
<td>Recruit program students. Know industry needs and current standards required to ME graduates.</td>
</tr>
<tr>
<td>Alumni</td>
<td>Distinguished professionals from different industrial sectors graduated from our program within a period of three to five years.</td>
<td>Received and education from our program. Able to compare work demands to aptitudes and skills obtained through the program.</td>
</tr>
<tr>
<td>Professional Societies</td>
<td>Members of active chapters of professional societies provide input through meeting conferences and special activities particular to each society. (ASME, SAE, ASHRAE, CIAPR)</td>
<td>Represent high standards of engineering practice. Provide up-to-date trends in technology and industry requirements.</td>
</tr>
<tr>
<td>Faculty</td>
<td>ME Program full-time and part-time faculty</td>
<td>Instrumental in the development, implementation and evaluation of the program</td>
</tr>
<tr>
<td>Outcomes Assessment Faculty Committee (OAFC)</td>
<td>3 faculty full time and/or part time members.</td>
<td>Conduct the program assessment process</td>
</tr>
<tr>
<td>Department Head</td>
<td>Full time faculty member</td>
<td>Appoints OAFC members, involved, involved in the self-study write-up, and other assessment duties.</td>
</tr>
</tbody>
</table>

### Table B.9 Professional Societies contribution to Establish and Achieve Program Educational Objectives and Outcomes Assessment

<table>
<thead>
<tr>
<th>Society</th>
<th>Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAC</td>
<td>Establishes guides to obtain ABET accreditation; engineering education knowledge to recommend, establish, review, and/or obtain program educational objectives and outcomes assessment.</td>
</tr>
<tr>
<td>ASME</td>
<td>Establishes program criteria for ME, including curriculum and faculty. In addition, student chapters can participate in competitions.</td>
</tr>
<tr>
<td>NCEES</td>
<td>Prepares Fundamental of Engineering Exam and Professional Engineering Exam in Mechanical Engineering. Serves outside metric to assess skills of our graduates as compared to other institutions.</td>
</tr>
<tr>
<td>CIAPR-IIM</td>
<td>State representatives for engineers in Puerto Rico. Constituents work in industry and assist licensed engineers, government, and educational programs in engineering</td>
</tr>
</tbody>
</table>
| SAE/ASHRAE/SME/SPE | Student Societies participate in competitions were students used their learned skills. In addition, standards and articles are established by these societies.
Faculty members impart the instruction and the necessary skills to our graduates. Their involvement results in the definition and achievement of program objectives.

An Outcome Assessment Faculty Committee (OAFC) has been established to conduct the program assessment process. The committee is composed of three faculty members at this time. The Committee advises the Head of the Department on matters pertinent to the program’s success in achieving its outcomes and program objectives. Its meetings are held once a month, although it frequently meets twice. Other faculty members are welcome into its meetings. In fact, input comes mostly from the faculty. The Head of the Department appoints the Committee’s members. Even though, membership is on a voluntary basis. The committee also functions as a Curriculum Committee in the approval of new courses, reviewing the curriculum and changing academic policies. However, prerogatives on these areas are shared with the Head of the Department.

2.3 Assessment Tools for Program Educational Objectives

Our Program Educational Objectives have evolved as a result of the input from our constituents. An intensive process has been undertaken during three assessment cycles 2001-2003, 2003-2005, and 2005-2007 for receiving feedback from employers, alumni, professional societies, students, and faculty to set and evaluate our objectives. This report includes cycle 2005-2007 results in the body of the document since it contains the most recent changes in the assessment process. Other cycles reports are available in Appendix I-E. The input from our constituents is channeled through focus group meetings, and surveys as follows:

Focus Group Meetings: Focus Group Meetings are held with advisory board, employers, alumni, and faculty at least once every two years. From these meetings, the Outcomes Assessment Faculty Committee (OAFC) is able to obtain input as to industry’s current needs both from employers and employees point of view. This input is used to reevaluate the program educational objectives. The Outcomes Assessment Faculty Committee gathers information from these sources for subsequent actions.

Alumni and Employer Surveys: Information to evaluate our program is collected in an ongoing basis through alumni and employers surveys performed at least once every three years. The Outcome Assessment Faculty Committee performs a subsequent analysis of the surveys. Results and conclusions are documented and filed in the departmental records. These conclusions are used for a reevaluation of the program educational objectives. The surveys are available in Appendix I-D.

Collection of Published Job Descriptions: Sample of published job descriptions focused on requirements for entry-level mechanical engineers. These requirements are compared with the attributes of graduates from the Mechanical Engineering Program at Polytechnic University of Puerto Rico. The information is used to complement data from the constituencies during reevaluation of objectives.
Table B.10 illustrates how assessment methods used are related to our program educational objectives. The following sections give more details as to the procedure by which objectives are evaluated.

### 2.4 Program Objective Assessment Criteria

The program objective criterion for success is summarized in Table B.11. Most of the assessment tools require 70% or more answering either agree or strongly agree with the achievement of Program Objective. Others, like the Portfolio, Focus Groups, Senior Exit Survey, and Entry Level Job Descriptions give us information to evaluate our offerings and take action to satisfy the needs of students and industry.

#### Table B.10 Relationship of Program Educational Objectives to Assessment Methods

<table>
<thead>
<tr>
<th>Program Educational Objective</th>
<th>Assessment Methods</th>
<th>1. Work effectively in mechanical engineering profession in both thermal and mechanical systems areas or successfully pursue graduate studies as appropriate individual career goals</th>
<th>2. Apply the fundamentals of mathematics, sciences and engineering and use modern techniques and tools to solve mechanical engineering problems</th>
<th>3. Design and develop useful products, process, or system that benefits society and design and conduct experiments and analyze and interpret data.</th>
<th>4. Participate as team members in projects that may involve multidisciplinary activities, communicate their ideas verbally, graphically, and in writing so that they can perform engineering functions effectively.</th>
<th>5. Conduct their engineering work professionally, aware of related ethical and contemporary issues, and continually improve their capacities through life-long learning.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alumni Survey</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Employer Survey</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Alumni Focus Group</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Employer Focus Group</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Entry-level Job Descriptions</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment Tool</td>
<td>Outcome Criteria</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alumni Survey</td>
<td>70% or more of alumni answering must respond either agree or</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>strongly agree with the achievement of Program Objective.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employer Survey</td>
<td>70% or more of employers answering must respond either agree or</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>strongly agree with the achievement of Program Objective.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus Group Meetings (Advisory</td>
<td>Comments are taken into consideration and an action is associated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Board, Employers, and Professional Societies)</td>
<td>to them.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entry-level Job Descriptions</td>
<td>Comments are taken into consideration and an action is associated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>to them.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.5 Assessment Process of Program Educational Objectives

The assessment process of program educational objectives is summarized in the following steps:

1. Meeting OAFC and Advisory Board - OAFC meets with Advisory Board (composed of professionals in Mechanical Engineer that work in industry, academia, and selected professional societies) to discuss skills needed for the mechanical engineer and redefine, revise, and/or recommend changes to program educational objectives. In the meeting, the results of program educational objectives (from step 5) are presented for the analysis of the Advisory Board. Assessment tool is a focus group meeting performed once every two to three years.

2. Meeting OAFC & Alumni - OAFC meets with alumni to discuss skills needed for the mechanical engineer and determine if program educational objectives have been achieved. In addition, the alumni can suggest necessary skills that would have been good to acquire during their studies. Assessment tool is a focus group meeting with the alumni performed once every two to three years.

3. Program Objectives Evaluation - OAFC present suggested definitions, revisions, and/or changes in program educational objectives proposed in step 1 and 2 to faculty members. Decision regards to program educational objectives are made. OAFC can add additional information, i.e. a collection of published job descriptions, etc.

4. Program Improvement and Implementation - The OAFC implements any changes such as redefinition of program educational objectives (if any) or other changes to improve the achievement of program educational objectives (i.e. curriculum changes, course objectives, syllabus changes, suggest necessary instructional tools, human resources, measurable outcomes, etc.). All of these suggestions must be approved by the Department Head.

5. Data Collection - OAFC evaluates if the program educational objectives are achieved as supportive information for steps 1 and 2. Some of the tools available are alumni and industrial surveys.

6. Go back to step 1. The cycle is completed in two years. If there are no improvements in program educational objectives in over five years they will be changed.

Figure B.4 shows the process pictorially. It shows the program objective assessment process. Later on the complete assessment process which includes program objectives (Criterion 2) and outcomes assessment (Criteria 3) will be presented.
Figure B.4  Program Objective Cycle Criteria 2
2.6 Relationship between Curriculum and Program Educational Objectives.

Special attention has been devoted to the curriculum development in order to accomplish our Program Educational Objectives. Integration of design and usage of computer tools throughout the curriculum, development of teamwork skills, and refining of oral and written communication abilities through design projects are strengths of our program curriculum. Course syllabi for the ME courses and the general science courses taught by our department are presented in Appendix I-B. These syllabi include the specific course objectives and their relation to the Program Educational Objectives. This information is summarized in Table B.12 for all required courses.

2.7 Process to achieve Program Educational Objectives

The general process to measure program educational objectives in two year cycle with assessment tools is summarized in Table B.13. It shows when in the academic year the process takes place.

Table B.14 summarizes the number of times, since the last ABET visit, that the process has been performed to demonstrate that the process is working in the two year cycle. As you can see most the step were performed. The assessment processes help us to implement curriculum changes and the addition or subtraction of course topics. The results for cycles 2001-2003 and 2003-2005 are available in the OAFC report available in Appendix I-E. Cycle 2005-2007 data is presented in the body of this document.

2.8 Level of achievement of Program Educational Objectives.

This section shows the performance of each program objective, suggestions made by the constituents to further achieve the program objectives. Figure B.5 shows results of surveys evaluations filled by alumni and employers. Achievement of the program educational objectives is defined for a score of 70% or more. It can be seen that the program educational objectives based on our assessment tool have been achieved to an acceptable level.

The suggestions made by the constituents are obtained by Focus Groups. A focus group with the advisory board was conducted in Cycle 2005-2007. The following suggestions were made:

- Add Design of Experiments to Curriculum should be included in labs.
- Add more chemistry related to industrial applications
- Why teach Pro-E, instead of what is seen in industry, mostly AutoCAD
- Good curriculum because is tuned with Puerto Rico’s necessities
- Good curriculum because it has a high percentage of ME courses
- Add more about project management

The information presented is summarized in this section. Further information with more details is available in Appendix I-F in Figures F.31 to F.34.
### Table B.12 Course Objectives for ME Courses related to Program Educational Objectives

<table>
<thead>
<tr>
<th>Course</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGI 3410 Engineering Mechanics, Dynamics</td>
<td>X</td>
<td>X</td>
<td></td>
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<td>ME 5240 Design of Machine Elements II</td>
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<td>X</td>
<td>X</td>
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</tr>
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</table>

Work effectively in mechanical engineering profession in both thermal and mechanical systems areas or successfully pursue graduate studies as appropriate individual career goals.

Apply the fundamentals of mathematics, sciences and engineering and use modern techniques and tools to solve mechanical engineering problems.

Design and develop useful products, process, or system that benefit society and design and conduct experiments and analyze and interpret data.

Participate as team members in projects that may involve multidisciplinary activities, communicate their ideas verbally, graphically, and in writing so that they can perform engineering functions effectively.

Conduct their engineering work professionally, aware of related ethical and contemporary issues, and continually improve their capacities through life-long learning.
Table B.13 Measures of Program Education Objectives

<table>
<thead>
<tr>
<th>Process</th>
<th>First Academic Year</th>
<th>Second Academic Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fall</td>
<td>Winter</td>
</tr>
<tr>
<td>Step 1 – Define, Revise, and/or Recommend Changes to Prog. Ed. Obj. with industry</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Step 2 – Define, Revise, and/or Recommend Changes to Prog. Ed. Obj. with alumni</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Step 3 – Define, Revise, and/or Recommend Changes to Prog. Ed. Obj. with faculty</td>
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<td></td>
</tr>
<tr>
<td>Step 4 – OAFC Implements</td>
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<td></td>
</tr>
<tr>
<td>Step 5 – Collect data of achievement of Program Educational Objectives.</td>
<td>X</td>
<td>X</td>
</tr>
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</table>

Table B.14 Demonstration of Action of Steps Application

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Step 1 - Industry</th>
<th>Step 2 - Alumni</th>
<th>Step 3 - Faculty</th>
<th>Step 4 - Cur</th>
<th>Step 5 - Eval</th>
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</thead>
<tbody>
<tr>
<td>2001-2003</td>
<td>None</td>
<td>Focus Group/</td>
<td>Meeting</td>
<td>No changes</td>
<td>Passed all PEO’s OAFC</td>
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<tr>
<td></td>
<td></td>
<td>Survey</td>
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<tr>
<td>2003-2005</td>
<td>Survey</td>
<td>Survey</td>
<td>Meeting</td>
<td>Curr. Change</td>
<td>Passed all PEO’s OAFC</td>
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<tr>
<td></td>
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</tr>
<tr>
<td>2005-2007</td>
<td>Focus Group/</td>
<td>Survey</td>
<td>Meeting</td>
<td>Number of</td>
<td>Passed all PEO’s OAFC</td>
</tr>
<tr>
<td></td>
<td>Survey</td>
<td></td>
<td></td>
<td>Topics Req. Min.</td>
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</table>

Figure B.5 Program Objective Cycle 2005-2007

<table>
<thead>
<tr>
<th>Program Objectives</th>
<th>Mean of Score</th>
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</thead>
<tbody>
<tr>
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<tr>
<td>2</td>
<td>82</td>
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<tr>
<td>9</td>
<td>87</td>
</tr>
<tr>
<td>10</td>
<td>88</td>
</tr>
</tbody>
</table>

Alumni Survey  
Employers Survey
2.9 Recommendations and Actions Cycle 2005-2007

The program educational objectives are revisited once every three to five years in a faculty meeting with the given feedback from the advisory board, alumni and employers. The faculty can make suggestions about re-defining, revising, and recommend changes to program objectives or changing educational strategies to achieve the objectives. Since 1995 the program educational objectives have not been changed, since all the program educational objectives have been achieved according to the evaluation tools used.

When reviewing the program educational objectives in the last assessment cycle (2005-2007) it came to our attention that our program educational objectives are similar to our program outcomes. In the next cycle changes to the statement in program educational objectives will be performed.

Another suggestion is to change the two year cycle to a three year cycle, since achievement of program educational objectives should be measured three to five years after graduation.

Other recommendations to further improve the program educational objectives and/or the measurement of achievement made by the faculty are:

Program Objective 1

✓ Add an additional goal to train the students in softer skills such as management and business incubation so that they can start their own business or manage engineering projects. Can be implemented using current pre-requisites in curriculum.
✓ Focus more in undergraduate research to promote student to continue graduate studies.
✓ Master’s Program in Mechanical Engineering is been developed as an additional opportunity for our students and from other institutions.

Program Objective 2

✓ Take the E.I.T. examination in the last trimester and if the students fail they cannot graduate until the exam is passed or use the PPI examination in the capstone course.
✓ Ask for more work from students.

Program Objective 3

✓ A product realization laboratory is being constructed were students will have an additional laboratory to manufacture rapid prototypes.
✓ Laboratories will be revisited to remake laboratory manuals. These manuals will help the plan to train Teaching Assistants to teach laboratories in combination to the start up of a master’s degree.

Program Objective 4
✓ Make interdisciplinary projects with other departments to have real multi-disciplinary projects.
✓ Ask capstone students to present their final project to a thesis committee that shows formal written projects and oral presentations.
✓ Assist students to express themselves more frequently to promote their oral presentation skills.

Program Objective 5

✓ Motivate students to participate in continuing education.

Actions:

The previous suggestions were analyzed and corresponding changes were made.

✓ Students will have an opportunity to take courses in business management within the free elective credits have additional management skills at the time of graduation. Two recommended courses are Management 1010-Introduction to Management and Management 4660 – Entrepreneurship.
✓ Assessment cycle will be performed every three years.
✓ Based in the information about the Student Profile. The use of the Problem based learning and Format in the Classroom will be presented to professors to be incorporated into their teaching strategies.
✓ PPI examination will be held in capstone course, mostly to evaluate outcomes assessment.
✓ Capstone students to present their final project to a thesis an evaluation committee will revise formal written projects and oral presentations.
✓ An additional type of Capstone project may be in starting own engineering business for those students who have taken courses in management.
✓ Student projects as extra-curricular activities will be encouraged, as well as engineering practice.
3. **Program Outcomes and Assessment**

Considering the requirements of the Engineering Accreditation Criteria 2006, the faculty with the input from the constituents has convened to the following Program Outcomes for the undergraduate program in Mechanical Engineering at Polytechnic University of Puerto Rico:

Every graduating mechanical engineer from our program shall be able to:

a. apply knowledge of mathematics, science, and engineering
b. design and conduct experiments, as well as to analyze and interpret data
c. design a system, component, or process to meet desired needs
d. function on multi-disciplinary teams
e. identify, formulate, and solve engineering problems
f. understand professional and ethical responsibilities
g. communicate effectively
h. understand the impact of engineering solutions in a global and societal context
i. recognize the need for, and engage in life-long learning
j. understand contemporary engineering issues
k. use the techniques, skills, and modern engineering tools necessary for engineering practice
l. apply knowledge of chemistry and calculus-based physics with depth in at least one of them
m. apply statistics, linear algebra, and advanced mathematics through multivariate calculus and differential equations
n. work professionally in both thermal and mechanical systems areas including the design and realization of such systems
o. apply knowledge of contemporary analytical, computational, and experimental practices

Outcomes a through k are the required outcomes for the EAC2006 criteria while outcomes i through o are the program specific outcomes to accomplish ASME curriculum and faculty suggestions.

The next sub-sections are organized as follows: Section 3.1 definition of program outcomes. Section 3.2 contains the relationship between program outcomes and program educational objectives. Section 3.3 describes the assessment tools for program outcomes of curriculum. Section 3.4 describes the assessment process of program outcomes. Section 3.5 has the relationship between curriculum and program outcomes. Section 3.6 describes outcomes assessment criteria. Section 3.7 contains process to achieve program outcomes. Section 3.8 has the level of achievement of program outcomes. Section 3.9 contains the extra-curricular activities. Finally 3.10 have the recommendations and actions for cycle 2005-2007. Recommendations and actions of cycles 2001-2003 and 2003-2005 are in Appendix I-E.
3.1 Definition of Program Outcomes

In order to assess the program outcomes, the program has adopted specific definitions for each one of them. The outcomes are divided in different performance criteria or indicators that represent specific measures for the outcome. The application of the performance criteria may vary from course to course, in other words, not all of the performance criteria apply for a course. The professor of the course may add different performance criteria to the course given the approval of the Outcome Assessment Faculty Committee (OAFC). Outcomes are understood as defined below.

(a) To demonstrate that graduates have an ability to apply knowledge of mathematics, science, and engineering, they should:

- Use of concepts, principles and/or equations - Student can easily convert word problems to a sequence of interconnected mathematical equations. All the concepts, principles, and equations are correctly identified and applied with little or no extraneous efforts. Combines mathematical and/or scientific principles to formulate models of chemical and/or physical processes.
- Formulates appropriate strategies of solution - Student uses a very efficient and sophisticated strategy leading directly to a solution. He/She sees what must be done clearly. He/She shows all the steps used to solve the problem. All mathematical relations and principles are applied logically in sequence.
- Execution of solution strategies - Student applies procedures accurately to correctly solve the problem and verify the results. There are no errors by hand or by mathematical software.
- Use of engineering judgments - Student employs refined and complex reasoning to make relevant observations and/or connections. He/She verifies answers and/or evaluates the reasonableness of the answer.

(b) To demonstrate that graduates have an ability to design and conduct experiments as well as analyze and interpret data, they should:

- Design experiments - Students very clearly identify main objectives to be achieved in the experiment. They clearly identify variables to measure and to calculate. They formulate an experimental plan of gathering data with many logical workable ideas/steps. Experimental plan consider statistics for sample size, intervals of confidence, accuracy-precision, etc.
- Conduct experiments - Students follow good laboratory safety procedures. They are able to operate instrumentation and process equipment without supervision. Students implement logical experimental procedures with precision. They correct rapidly and successfully any ineffective procedure step. They carefully document gathered data.
- Analyze data - Data analysis is performed using appropriate charts, graphs, tables, equations and/or any other tool. Students link theory analysis with experimental results logically and accurately. Students fully identify major sources of errors and uncertainties in the data/method of analysis.
Interpret data - Students quantify errors and uncertainty propagation in results using adequate statistical techniques. They weight data by uncertainty and see how this affects results. They develop clear and understandable conclusions.

(c) To demonstrate that graduates have an ability to design a system, component, or process to meet desired needs, they should:

- Characterizing the design need - Students recognize the existence of a design problem. They can define clearly and concisely the problem. They are able to delineate what is needed and/or wanted by the professor, customer, or any other stakeholder of the design. They are able to define technical and realistic constraints of the problem clearly.
- Attributes of an ideal solution - Students clearly identify most critical outcomes by which success is achieved. They develop specific metrics and target values for these outcomes.
- Sources of information - Students show a deep search into the engineering knowledge, existence design alternatives and potential technologies by using databases of scientific literature, patents, and other archival sources (of the library).
- Potential solutions - Students show the use of brainstorm techniques to find potential solutions. All potential solutions are well reasonable in satisfying the needs of the design. They might use benchmarking techniques to compare existing solutions to new ideas in a systematic manner.
- Prototyping of design concepts - Students develop prototypes (computer simulations and cardboard muck-up) of their design concepts. They develop an effective strategy for the iterative process of testing each idea. They select the best alternative of solution.
- Evaluations of design solution - Students develop a strategy to evaluate the solution, which include the design of suitable experiments, the selection of customer surveys, and actual testing (or more sophisticate and rigorous simulations).
- Technical communication of both solution and decision process - From problem definition to evaluation of solution, students show fluent communication (oral and written) with customers, supervisors. Their reports are well documented.
- Project management - Students show the ability to work as part of a team, to manage a budget, and to prepare and follow a schedule to complete the design

(d) To demonstrate that graduates have an ability to function on multi-disciplinary teams, they should:

- Behavior among teammates - Student is a polite group member. He is open to listen to ideas/opinions from people of different background. He remains non-judgmental when disagreeing with others/seeks conflict resolution; does not "point fingers" or blame others when things go wrong.
- Availability for the team - He never misses a scheduled meeting. He almost always arrives on time. He is available for re-scheduling a meeting. He demonstrates the ability to assume a designated role in the group.
Attitude for work - Student is prepared for group meeting with clearly formulated ideas. He shares information with others and provide assistance to others. He cooperates with other (outside of the discipline)

Workload - Student contributes a fair share to the project workload. He verbally contributes to the organizational development of the task. He evaluates group’s progress toward task accomplishment.

Group dynamics - Student builds cohesion in group through verbal and non-verbal behavior. He takes an active roll to encourage participation of all team members.

(e) **To demonstrate that graduates have an ability to identify, formulate, and solve engineering problems, they should:**

- Identifying an engineering problem - Student identifies the problem by describing clearly in his own words what happens and by recognizing what needs to be done and why.
- Formulating an engineering problem - Student formulates the problem by stating clearly all important data that is known, by establishing all physical and technological constrains, by writing what needs to be find, by drawing or sketching his/her understanding of the problem.
- Analyzing an engineering problem - Student develops a clear and concise plan of solution (the execution of the plan is flawless). He/She states clearly the approximations for his/her approach, writes down the main principles that govern the problem. He/She relates written statements with mathematical equations or quantitative indicators. The analysis is deep.
- Interpreting finding and solving the problem - Student provides a logical interpretation of the finding and clearly solves the problem. He/She offers comments and/or alternative solutions.

(f) **To demonstrate that graduates have an understanding of professional and ethical responsibility, they should:**

- Professional registration - Student knows about professional registration, and plans to be certified as E.I.T. and later on as P.E.
- Ethical Codes - Student knows and applies the code of Professional Engineers, and PUPR students’ rights and responsibilities. He/she acts according to them.
- Ethical behavior among Peer and Faculty - Student demonstrates ethical behavior among peers and faculty.
- Responsibility - Student takes personal responsibility for his/her actions.
- Professional behavior among peer and faculty - Student is punctual, professional, and collegial. He/she attends almost all classes.
- Evaluation and Judgment - Student evaluates and judges a situation in practice or as a case study using facts and a professional code of ethics.

(g) **To show that graduate have an ability to communicate effectively, they should:**

**Written Reports**
✓ Content and concatenation of ideas of the written report - Written text shows coherent ideas clearly and concisely.
✓ Mechanical organization of the written report - Report organizes written materials in a logic sequence to enhance the reader’s comprehension (headings, subheadings, sections, paragraphs, etc)
✓ Presentation of results - Report uses graphs, tables, and diagrams to support points to explain, interpret, and assess information.
✓ Format and grammar - Written work is presented neatly and professionally: grammar and spelling are correct, figures are in proper format; writing style is good and conforming to the prescribed format (if any)

Oral Presentations

✓ Organization of an oral presentation - Oral presentation is well planed and organized. He/she reserves accommodations with anticipation, uses visual aid, starts on time, delivers creative handouts for guidance
✓ Content of oral presentation - Presentation has enough appropriate technical content for the time constraint and the type of audience
✓ Mechanical execution of oral presentation - Presentation is performed well mechanically: makes eye contact, can easily be heard, speaks comfortably with minimal aids (note cards), do not block screen, do not have distracting nervous habits
✓ Appearance for presentation - Student has a professional appearance for presentation, dressing correctly for the occasion
✓ Oral communication - Student communicates with proper language during presentation. He/she uses technical and non-technical terms as needed to deliver the message
✓ Use of visual aids - Student uses visual aides effectively, e.g., he/she uses power point with meaningful and adequate number of slides (~ one slide/minute)
✓ Listening and responsiveness - Student listens carefully and responds to questions appropriately; he/she is able to explain and interpret results for various audiences and purposes

(h) To demonstrate that graduates have the broad education to understand the impact of engineering solutions in a global and societal context, they should:

✓ Values of humankind to understand impact of engineering solutions - Student knows and practices the values to the betterment of humankind, such as: dignity of human life, respect and consideration of others, preservation of earth, integrity and service, and quest of peace
✓ Awareness of engineering impact - Student reads and is familiar with the content of periodicals or any other source that are relevant to understanding how engineering has a global and societal impact. He/she engages in related conversations
✓ Environmental impact of engineering - Student considers the environmental impact of engineering projects. Identify projects that reflect “Green” engineering. All negative environmental impacts are minimized and fully disclosed
✓ Importance of engineering - He/she has a personal perspective on the importance of engineering in the world of today. He/she wants to use engineering to change for better a little bit (or to preserve at least) his/her community, region, or environment

(i) To demonstrate that graduates recognize the need for and possess the ability to engage in life-long learning, they should:

✓ Independent learning - Student demonstrates ability to learn independently. He/she goes beyond what is required in completing an assignment and brings information from outside sources into assignments
✓ Self-awareness of learning - Student learns from mistakes. He/she continuously improves with practice
✓ Learning’s responsibility - Student demonstrates responsibility for creating one’s own learning opportunities. He/she attends seminars, participates in fieldtrips, engages in technical talks via the www, etc.
✓ Recognition of learned material - Student is able to understand, interpret, and apply learned materials and concepts in a format different that were taught in class, e.g., he/she differentiates the Bernoulli’s equation from the energy equation, and that either equation can be written in different forms (energy terms or linear terms).
✓ Network learning - He/she participates and takes leadership role in professional and technical societies available to the student body such as ASME, ASHRAE, SAE, CIAPR, etc.

(j) To demonstrate that graduates possess knowledge of contemporary issues, they should:

✓ Knowledge of current events - Student has knowledge of current events in his society and the world. He/She understands and is able to connect those events with his society
✓ Job market - Student has a clear perspective on the current job market. He/she monitors the job market regularly. He/She can guess what job-market situation would be in the future. He prepares for that situation.
✓ Political issues - Student is able to discuss in-depth major political issues (world-wide, national, and local) at appropriate levels. He/she takes and defends a position on them. He/she is able to evaluate political, economical, and technical solutions.

(k) To demonstrate an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice, they should:

✓ Acquiring data - Student identifies and uses relevant data with little or no extraneous efforts. He makes reasonable estimates when necessary.
✓ Mathematical skills to solve engineering problems - Student use sufficient mathematical skills to solve engineering problems. He readily applies algebra, calculus, and/or differential equations to solve problems.
✓ Utilizing engineering principles (mass, momentum, and energy balances) - Student consistently and efficiently applies engineering principles. No conceptual errors and few if any procedural errors exist. Student appears to be proficient in all areas.
✓ Using word processors - Student shows high proficiency in using word processors. Word processed document are clear and contain useful figures and illustrations that enhance comprehension.
✓ Using spreadsheets - Repetitive calculations are performed on spreadsheets and neatly summarized. Graphs are clear, clean, well-labeled informative, and thoroughly integrated in the text.
✓ Using CAD software, such as AutoCAD - Drawings are neatly presented. Student shows accurate drawing views (frontal, top, side, and isometric) of the task. Dimensions of drawings are well displayed and according to conventions. [Student does not require much of the assistance of the instructor to accomplish the task.
✓ Using computer programming tools such as MathCAD, MatLab - Student performs calculations and/or simulations using computer programming tools. He clearly and understandable presents his algorithm of calculations. His results are fully analyzed and also presented as Graphs which are clear, clean, and well-labeled informative.

(l) To demonstrate that ME graduates apply knowledge of chemistry and calculus-based physics with depth in at least one, they should:

✓ Use of concepts, principles and/or equations - Student can easily convert word problems to a sequence of interconnected mathematical equations. All the concepts, principles, and equations are correctly identified and applied with little or no extraneous efforts. Combines mathematical and/or scientific principles to formulate models of chemical and/or physical processes.
✓ Formulates appropriate strategies of solution - Student uses a very efficient and sophisticated strategy leading directly to a solution. He/She sees what must be done clearly. He/She shows all the steps used to solve the problem. All mathematical relations and principles are applied logically in sequence.
✓ Execution of solution strategies - Student applies procedures accurately to correctly solve the problem and verify the results. There are no errors by hand or by mathematical software.
✓ Use of engineering judgments - Student employs refined and complex reasoning to make relevant observations and/or connections. He/She verifies answers and/or evaluates the reasonableness of the answer.

(m) To demonstrate that ME graduates have an ability to apply knowledge of statistics, linear algebra, and advanced mathematics through multivariate calculus and differential equations. they should:

✓ Use of concepts, principles and/or equations - Student can easily convert word problems to a sequence of interconnected mathematical equations. All the concepts, principles, and equations are correctly identified and applied with little or no extraneous efforts. Combines mathematical and/or scientific principles to formulate models of chemical and/or physical processes.
✓ Formulates appropriate strategies of solution - Student uses a very efficient and sophisticated strategy leading directly to a solution. He/She sees what must be done
clearly. He/She shows all the steps used to solve the problem. All mathematical relations and principles are applied logically in sequence.

✓ Execution of solution strategies - Student applies procedures accurately to correctly solve the problem and verify the results. There are no errors by hand or by mathematical software.

✓ Use of engineering judgments - Student employs refined and complex reasoning to make relevant observations and/or connections. He/She verifies answers and/or evaluates the reasonableness of the answer.

(n) To show that ME graduates have an ability to work professionally in both thermal and mechanical systems areas including the design and realization of such systems, they should:

✓ Characterizing the design need - Students recognize the existence of a design problem. They can define clearly and concisely the problem. They are able to delineate what is needed and/or wanted by the professor, customer, or any other stakeholder of the design. They are able to define technical and realistic constraints of the problem clearly.

✓ Attributes of an ideal solution - Students clearly identify most critical outcomes by which success is achieved. They develop specific metrics and target values for these outcomes.

✓ Sources of information - Students show a deep search into the engineering knowledge, existence design alternatives and potential technologies by using databases of scientific literature, patents, and other archival sources (of the library).

✓ Potential solutions - Students show the use of brainstorm techniques to find potential solutions. All potential solutions are well reasonable in satisfying the needs of the design. They might use benchmarking techniques to compare existing solutions to new ideas in a systematic manner.

✓ Prototyping of design concepts - Students develop prototypes (computer simulations and cardboard muck-up) of their design concepts. They develop an effective strategy for the iterative process of testing each idea. They select the best alternative of solution.

✓ Evaluations of design solution - Students develop a strategy to evaluate the solution, which include the design of suitable experiments, the selection of costumer surveys, and actual testing (or more sophisticate and rigorous simulations).

✓ Technical communication of both solution and decision process - From problem definition to evaluation of solution, students show fluent communication (oral and written) with customers, supervisors. Their reports are well documented.

✓ Project management - Students show the ability to work as part of a team, to manage a budget, and to prepare and follow a schedule to complete the design

(o) To show that ME graduates apply knowledge of contemporary analytical, computational, and experimental practices, they should:

✓ Acquiring data - Student identifies and uses relevant data with little or no extraneous efforts. He makes reasonable estimates when necessary.
✓ Mathematical skills to solve engineering problems - Student use sufficient mathematical skills to solve engineering problems. He readily applies algebra, calculus, and/or differential equations to solve problems.

✓ Utilizing engineering principles (mass, momentum, and energy balances) - Student consistently and efficiently applies engineering principles. No conceptual errors and few if any procedural errors exist. Student appears to be proficient in all areas.

✓ Using word processors - Student shows high proficiency in using word processors. Word processed document are clear and contain useful figures and illustrations that enhance comprehension.

✓ Using spreadsheets - Repetitive calculations are performed on spreadsheets and neatly summarized. Graphs are clear, clean, well-labeled informative, and thoroughly integrated in the text.

✓ Using CAD software, such as AutoCAD - Drawings are neatly presented. Student shows accurate drawing views (frontal, top, side, and isometric) of the task. Dimensions of drawings are well displayed and according to conventions. [Student does not require much of the assistance of the instructor to accomplish the task.

✓ Using computer programming tools such as MathCAD, MatLab - Student performs calculations and/or simulations using computer programming tools. He clearly and understandable presents his algorithm of calculations. His results are fully analyzed and also presented as Graphs which are clear, clean, and well-labeled informative.

Scoring rubrics were defined to determine the level of achievement (presented in later sections) and are available in Appendix I-G.

3.2 Relation between Program Outcomes and Program Educational Objectives

The program outcomes must foster attainment of the program objectives. Table B.15 shows the relationship between the program outcomes and program objectives. This relation demonstrates that in order to achieve the program objectives the students must acquire the skills enunciated in the outcomes definition.

3.3 Assessment Tools for Program Outcomes of Curriculum

An assessment program has been developed to measure performance, document results, and take appropriate actions if needed. The assessment tools can be classified in two main categories, direct and indirect measurements of outcomes. Direct measures provide for the direct examination or observation of student knowledge or skills against measurable learning objectives. Indirect measures are those that ascertain the opinion or self-report of the extent or value of learning experiences. The difference between the two can simply be defined as non-opinioned tools for direct measures (i.e. exams) and opinioned tools for indirect (i.e. surveys).
<table>
<thead>
<tr>
<th>Program Educational Objective</th>
<th>Program Outcomes</th>
<th>a. apply knowledge of mathematics, science, and engineering</th>
<th>b. design and conduct experiments, as well as to analyze and interpret data</th>
<th>c. design a system, component, or process to meet desired needs</th>
<th>d. function on multi-disciplinary teams</th>
<th>e. identify, formulate, and solve engineering problems</th>
<th>f. understand professional and ethical responsibilities</th>
<th>g. communicate effectively</th>
<th>h. understand the impact of engineering solutions in a global and societal context</th>
<th>i. recognize the need for, and engage in life-long learning</th>
<th>j. understand contemporary engineering issues</th>
<th>k. use the techniques, skills, and modern engineering tools necessary for engineering practice</th>
<th>l. apply knowledge of chemistry and calculus-based physics with depth in at least one of them</th>
<th>m. apply statistics, linear algebra, and advanced mathematics through multivariate calculus and differential equations</th>
<th>n. work professionally in both thermal and mechanical systems areas including the design and realization of such systems</th>
<th>o. apply knowledge of contemporary analytical, computational, and experimental practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Work effectively in mechanical engineering profession in both thermal and mechanical systems areas or successfully pursue graduate studies as appropriate individual career goals</td>
<td>2. Apply the fundamentals of mathematics, sciences and engineering and use modern techniques and tools to solve mechanical engineering problems</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>3. Design and develop useful products, process, or system that benefit society and design and conduct experiments and analyze and interpret data.</td>
<td>4. Participate as team members in projects that may involve multidisciplinary activities, communicate their ideas verbally, graphically, and in writing so that they can perform engineering functions effectively.</td>
<td>5. Conduct their engineering work professionally, aware of related ethical and contemporary issues, and continually improve their capacities through life-long learning.</td>
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</table>

Table B.15 Relationship of Program Educational Objectives to Program Outcomes
The assessment tools selected according to the following criteria.

- **Relevance** - the assessment option measures the educational outcome as directly as possible. The measure is performed using scoring rubrics, which will be presented in later sections.
- **Accuracy** - the option measures the educational outcome as precisely as possible (i.e. appropriate sample size representative of all students, validation techniques, etc.)
- **Utility** - the option provides formative and summative results with clear implications for educational program evaluation and improvement

The direct measurement tools selected in our program are locally developed exams, simulations, oral examinations, portfolios, performance appraisals, and behavioral observations. The indirect measurement tools are surveys and externally developed exams. The assessment tools are defined in detail below:

### 3.3.1 Direct Assessment Tools

**Locally developed exams** – these can be defined as objective and subjective tests designed by faculty of the program or course sequence being evaluated. This is the most useful for individual coursework or program evaluation, with careful adherence to measurement principles. It must be supplemented with external validity (i.e. triangulation). These locally developed exams are given to students as an evaluation strategy in their courses as Exams and Quizzes.

**Simulations** – can be defined as a competency based measure where a person’s abilities are measured in a situation that approximates a real world setting. Simulation is primarily used when it is impractical to observe a person performing a task in a real world situation. This assessment tool is an excellent way to increase the external and internal validity of skills assessment at minimal long-term costs. These simulations are given to students as an evaluation strategy in their courses as Projects.

**Oral examinations** – can be defined as the assessment of student knowledge levels through a face to face dialogue between the student and examiner (usually faculty). Oral exams can provide excellent results, but usually only with significant additional costs. This tool is definitely worth to utilize in group presentations, because it reduces evaluation costs. These oral examinations are given to students as an evaluation strategy in their courses as Presentations.

**Performance appraisals** – it can be defined as a competency-based method whereby abilities are measured in most direct, real world approach. It is the systematic demonstration of acquired skills. This is generally the most highly valued measure of skill development, but costly form of student outcome assessment. The performance appraisals are given to students as an evaluation strategy in their Laboratories and/or Workshops.

**Behavioral observations** – it can be defined as the measurement of frequency, duration, topology, etc. of student actions, usually in a natural setting with non-interactive methods. This is the best way to know what students actually do, how they manifest their motives, attitudes and
values. This tool has high validity when carefully planned. The behavioral observations are given to students as an evaluation strategy in their Laboratories and/or Workshops.

**Portfolios** – it can be defined as the collections of multiple student work samples usually compiled over time and rated using rubrics. Portfolios are a valuable option that adds important longitudinal and qualitative data for multiple objective assessments. The use of this evaluation tool has evolved in our program for the previous assessment cycle. In the past, Student Portfolios were collected, but most of its information was used to evaluate effective communication of the students. The portfolio used as of today is the Course Portfolio which is prepared by the professor that teaches the course in a trimester. The Course Portfolio contains the course syllabus, the outcomes that were evaluated for a particular course, the outcome assessment plan sheet filled by the professor (which contains the evaluation tools planned used to assess outcomes, see Table B.16), the rubrics used to assess the outcomes, results of the outcomes assessment process, a locally developed exam to evaluates performance course objectives to program objectives, sample examinations, projects, etc. given in class, and the recommendations of the professor to improve the performance of students in the course.

### 3.3.2 Indirect Assessment Tools

Most of the indirect measurements of outcomes are written surveys/questionnaires, which are use for triangulation and/or outcomes performance. The other indirect measures are an externally developed examination and a transcript analysis, and pre-tests (locally developed exam).

**Written Surveys/Questionnaires** – it can be defined as asking individuals to share their perceptions about their own or others skills, attitudes, behavior, or program/course qualities and attributes. It is a relatively inexpensive way to collect data on important evaluative topics from a large number of respondents. Sample of survey forms are presented in Appendix I-D. In our program many surveys are conducted to measure outcome assessment these are:

- **Senior Exit Survey.** Documentation of seniors exiting assessment of EAC2006 criteria: strength and weakness of the program
- **Capstone Surveys.** Assessment of capstone students as a group to evaluate outcomes assessment.
- **Alumni Survey.** Assessment of alumni as a group within the context of EAC2006: specific concerns of employers. Used only for outcome i.

**External Examination, FE Exam Results** – This tool is the best supplement to our own or locally developed assessment for external validity. In our case, the external examination is the Fundamental of Engineering Examination which documents knowledge of mathematics, science, engineering fundamentals, and engineering core, and ability to solve problems. This exam is created for student assessment at the national level. It is labeled as an indirect measure of outcomes assessment since the scoring rubrics cannot be applied to this tool. In addition, this tools serves as an indirect measure of outcome i, since it is the first step to become collegiate.
### Table B.16 Outcome Assessment Plan for Professor

#### Professor: ________________________

#### Course: __________________

#### Trimester: _________

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Final Exam</th>
<th>Assign.</th>
<th>Quizzes</th>
<th>Project</th>
<th>Presentation</th>
<th>Portfolio</th>
<th>Lab/workshop</th>
<th>Details</th>
</tr>
</thead>
</table>

Every graduating mechanical engineer from our program shall be able to:

a) Apply knowledge of mathematics, science and engineering.

b) Design and conduct experiments, as well as analyze and interpret data.

c) Design a system, component, or process to meet desired needs.

d) Function on multi-disciplinary teams.

e) Identify, formulate and solve engineering problems.

f) Understand professional and ethical responsibilities.

g) Communicate effectively.

h) Understand the impact of engineering solutions in a global and societal context

i) Recognize the need for and an ability to engage in lifelong learning.

j) Understand contemporary issues.

k) Use techniques, skills and modern engineering tools necessary for engineering practice.

l) Apply knowledge of chemistry and calculus-based physics with depth in at least one of them.

m) Apply statistics, linear algebra and advanced mathematics through multivariate calculus and differential equations.

n) Work professionally in both thermal and mechanical systems areas including the design and realization of such systems.

o) Apply knowledge of contemporary analytical computational and experimental practice.

Professor Signature: _________________________

Evaluation Tool not to be used to assess outcome

Outcome Assessment Coordinator Approval: _______________

Assessment Methods According to ABET:

- Exams and Quizzes = 4. Locally Developed Examinations
- Project = 8. Simulation
- Presentation = 11. Oral Examinations
- Portfolios = 7. Portfolios
Transcripts – Transcripts from graduating students are selected to assess the outcomes achievement.

Local Examination Pre-tests – This tool assists us in assessing service courses to the mechanical engineering program. Pre-Tests were prepared for selected courses, such as Dynamics, Computer Aided Drafting and Design, Computer Programming for Mechanical Engineering, among, others. Results are submitted to corresponding departments, so that they can take corrective actions.

A matrix that relates the program outcomes to the assessment tools is presented in Table B.17.

<table>
<thead>
<tr>
<th>Program Outcomes</th>
<th>Assessment Tools</th>
<th>Transcript</th>
<th>FE Exam</th>
<th>Course Portfolio Contents</th>
<th>Alumni Survey</th>
<th>Capstone Survey</th>
<th>Senior Exit Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. apply knowledge of mathematics, science, and engineering</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>b. design and conduct experiments, as well as to analyze and interpret data</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>c. design a system, component, or process to meet desired needs</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>d. function on multi-disciplinary teams</td>
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<td>X</td>
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<td>X</td>
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<tr>
<td>e. identify, formulate, and solve engineering problems</td>
<td></td>
<td>X</td>
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<td>X</td>
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<tr>
<td>f. understand professional and ethical responsibilities</td>
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<td>X</td>
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<td>X</td>
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<td></td>
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<tr>
<td>g. communicate effectively</td>
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<td>X</td>
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<tr>
<td>h. understand the impact of engineering solutions in a global and societal context</td>
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<tr>
<td>i. recognize the need for, and engage in life-long learning</td>
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<td>X</td>
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<td>X</td>
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<tr>
<td>j. understand contemporary engineering issues</td>
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<td>X</td>
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<td>X</td>
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<tr>
<td>k. use the techniques, skills, and modern engineering tools necessary for engineering practice</td>
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<td>X</td>
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<tr>
<td>l. apply knowledge of chemistry and calculus-based physics with depth in at least one of them</td>
<td></td>
<td>X</td>
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<tr>
<td>m. apply statistics, linear algebra, and advanced mathematics through multivariate calculus and differential equations</td>
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<td>X</td>
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<td>X</td>
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<tr>
<td>n. work professionally in both thermal and mechanical systems areas including the design and realization of such systems</td>
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<td>X</td>
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<tr>
<td>o. apply knowledge of contemporary analytical, computational, and experimental practices</td>
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<td>X</td>
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</tbody>
</table>
3.4 Assessment Process of Program Outcomes

The assessment process of program outcomes assessment is summarized in the following steps:

1. Define Outcomes - the OAFC and Department Head meet to define the program outcomes as to relate to the achievement of program objectives using EAC guidelines. Changes are presented to the faculty for their input and approval. OAFC implements changes to program outcomes and their definitions, if any.

2. Measurable Performance Criteria - OAFC and Department Head establish the performance criteria of an acceptable outcome achievement.

3. Educational Practices/ Strategies - There are three principal educational strategies to instruct students to achieve the desired outcomes. These are: 1) Curriculum Offering - OAFC and Department Head establish relation between curriculum and outcomes assessments (Curriculum Map), which enables students to acquire the necessary skills to achieve program objectives. 2) Extracurricular Activities - students are encouraged to participate in Professional Student Societies such as ASME, SAE, ASHRAE, among others. Their involvement includes participation in student competitions, leadership positions, industry contacts and visits, etc. Professors interested become mentors of the students. 3) Engineering Experience - there are courses and/or programs developed for students to acquire experience before graduation. These are the COOP program (ME 5970), Mechanical Engineering Practice (ME 5970), and Undergraduate Research (ME 5980).

4. Assessment: Data collection, Analysis of Evidence - The assessment process takes place by the faculty at the course level and OAFC at program level. Figure B.7 shows when the data is collected per outcome, the assessment tool, and the responsible to perform the collection. Graphs that show outcomes performance are made. General graphs included are Level of Achievement vs. Performance Criteria for an outcome, Level of Achievement vs. Performance Criteria Distribution (i.e. Unsatisfactory to Exemplary) for an outcome, among others.

5. Evaluation: Interpretation of Evidence and Design improvements - Each faculty member and the OAFC after the completion of their assessment makes recommendations for actions to improve the level of achievement of outcomes. The OAFC, Department Head, and Faculty meet to determine course of action.

6. Implement Improvements and Data Collection - OAFC at the program level and Faculty at the course level implement changes agreed from the previous step.

7. Go back to step a.

Figure B.6 shows the process pictorially. It shows the outcomes assessment process. Figure B.7 shows the complete assessment process which includes program objectives (Criterion 2) and outcomes assessment (Criteria 3).
Figure B.7 Complete Assessment Process Criteria 2 and 3
3.5 Relationship between Curriculum and Program Outcomes.

Special attention has been devoted to the curriculum development in order to accomplish our Program Outcomes. Integration of design and usage of computer tools throughout the curriculum, development of teamwork skills and refining of oral and written communication abilities through design projects are strengths of our program. Table B.18 shows outcomes required in each one of the core courses along with some general engineering courses that are of fundamental importance. This outcome-course relationship is important for defining outcome criteria and performing the analysis of the assessment process. Table B.18 also indicates whether the outcome covered in a course is evaluated (number 1) or not (number 2).

Course syllabi for the ME courses and the general science courses taught by our department are presented in Appendix I-A include the relation between a specific course the Program Outcomes. This information is summarized in Table B.18 for all required courses of the curriculum.

3.6 Outcome Assessment Criteria

The metric goals for each outcome influences in the achievement of program educational objectives of our graduates. The acceptable achievement for direct measurement of outcomes is summarized in Table B.19. Performance Criteria is measured using rubrics developed by the OAFC available in Appendix I-G. If professor of a course wants to add additional performance criteria to his specific course, he/she may do so with the performance criteria approval of the OAFC. Not all the outcomes for a specific course are measured (see details in previous section).

The acceptable achievement for direct measurement of outcomes is summarized in Table B.19.

3.7 Process to achieve Program Outcomes

This section shows how the assessment process relates to the academic year and the two year assessment cycle. Table B.21 shows the relation of the assessment steps (assessment steps available in section 3.4) and when they are performed in the two year cycle. Table B.22 shows which assessment tools are used to evaluate outcomes and how they relate to the academic year and/or two year assessment cycle.

Finally, Table B.23, summarizes the number of times, since the last ABET visit, that the process has been performed to demonstrate that the process is working in the two year cycle. In addition, this table shows the most important changes made in the cycle, which are presented in detail in the final reports for the corresponding cycles (see Appendix I-E). Cycle 2005-2007 results are the ones presented in this report.
<table>
<thead>
<tr>
<th>Course</th>
<th>a</th>
<th>b</th>
<th>c</th>
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<tbody>
<tr>
<td>ENGI 3410 Engineering Mechanics, Dynamics</td>
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<td>ENGI 3420 Fluid Mechanics</td>
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<td>ENGI 3421 Fluid Mechanics Laboratory</td>
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<td>ME 1210 Computer Aided Drafting and Design</td>
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<td>ME 1230 Introduction to Mechanical Engineering</td>
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<td>ME 2010 Computer Programming for Mechanical Eng.</td>
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<td>ME 3010 Applied Numerical Analysis</td>
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<td>ME 4140 Heat Transfer II</td>
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<tr>
<td>ME 4210 Solid Mechanics I</td>
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<td>ME 4220 Solid Mechanics II</td>
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<tr>
<td>ME 4230 Design of Machine Elements I</td>
<td>2</td>
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<tr>
<td>ME 5240 Design of Machine Elements II</td>
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<tr>
<td>ME 4240 Manufacturing Engineering</td>
<td>1</td>
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<tr>
<td>ME 4241 Manufacturing Engineering Laboratory</td>
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<tr>
<td>ME 4261 Computer Aided Engineering Laboratory</td>
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<td>ME 5050 System Dynamics and Controls</td>
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<tr>
<td>ME 5150 Design of Thermal Systems</td>
<td>2</td>
<td>1</td>
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<td>ME 5151 Thermal Engineering Laboratory</td>
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<tr>
<td>ME 5250 Mechatronics</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
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<tr>
<td>ME 5251 Mechatronics Laboratory</td>
<td>2</td>
<td>1</td>
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<tr>
<td>ME 5992 Mechanical Engineering Capstone Design I</td>
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<td>2</td>
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</tr>
<tr>
<td>ME 5994 Mechanical Engineering Capstone Design II</td>
<td>2</td>
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<td>2</td>
<td>1</td>
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<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

(*) 1. Explicit Outcome to demonstrate competence and give formal feedback. 2. Secondary Outcome not to be evaluated in this course.
### Table B.19 Direct Tools for Outcome Assessment Criteria

<table>
<thead>
<tr>
<th>Direct Assessment Tool</th>
<th>Outcome Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locally Developed Exams [Exams and Quizzes]</td>
<td>70% or more of students achieve the outcome.</td>
</tr>
<tr>
<td>Simulations [Project]</td>
<td>70% or more of students achieve the outcome.</td>
</tr>
<tr>
<td>Performance Appraisals [Laboratory/Workshop]</td>
<td>70% or more of students achieve the outcome.</td>
</tr>
<tr>
<td>Oral Examinations [Presentation]</td>
<td>70% or more of students achieve the outcome.</td>
</tr>
<tr>
<td>Behavioral Observations [Laboratory/Workshop]</td>
<td>70% or more of students achieve the outcome.</td>
</tr>
<tr>
<td>Portfolio [Course Portfolio]</td>
<td>Has necessary evidence for evaluators to demonstrate that outcomes are being achieved.</td>
</tr>
</tbody>
</table>

### Table B.20 Indirect Tools for Outcome Assessment Criteria

<table>
<thead>
<tr>
<th>Indirect Assessment Tool</th>
<th>Outcome Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capstone Survey</td>
<td>70% or more of students answering must respond that they either agree or strongly agree with this outcome.</td>
</tr>
<tr>
<td>Senior Exit Survey</td>
<td>70% or more of students answering must respond that they either agree or strongly agree with this outcome.</td>
</tr>
<tr>
<td>Alumni Survey</td>
<td>70% or more of students answering must respond that they either agree or strongly agree with this outcome.</td>
</tr>
<tr>
<td>Fundamental Exam</td>
<td>70% or more of students pass the exam.</td>
</tr>
</tbody>
</table>

### Table B.21 General process with time to measure outcomes in two year cycle with tools

<table>
<thead>
<tr>
<th>Process</th>
<th>First Academic Year</th>
<th>Second Academic Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fall</td>
<td>Winter</td>
</tr>
<tr>
<td>Step 1 – Define Outcomes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 2 – Measurable Performance Criteria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 3 – Educational Practices/ Strategies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 4 – Assessment: Collection, Analysis</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Step 5 – Evaluation Interpretation of Evidence</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Step 6 – Implementation</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Table B.22 Relation between outcome, assessment tool and when it is measure in the cycle

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Assessment Tool</th>
<th>First Academic Year</th>
<th>Second Academic Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fall</td>
<td>Winter</td>
</tr>
<tr>
<td>a, b, c, d, e, f, g, h</td>
<td>Local Exams</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Simulations</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Perform Appraisals</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Oral Examinations</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Behavioral Observ.</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Course Portfolio</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Capstone Survey</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Senior Exit Survey</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fundamental Exam</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>i</td>
<td>Alumni Survey</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table B.23 Demonstration of Action of Steps Application

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 4</th>
<th>Step 5</th>
<th>Step 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-2003</td>
<td>No changes</td>
<td>No changes</td>
<td>No changes</td>
<td>Indirect Measures only</td>
<td>Performed by OAFC</td>
<td>Rec. Curr. Change</td>
</tr>
<tr>
<td>2003-2005</td>
<td>No changes</td>
<td>No changes</td>
<td>Curr. Change</td>
<td>Indirect Measures only</td>
<td>Performed by OAFC</td>
<td>Implement Curr. Change</td>
</tr>
<tr>
<td>2005-2007</td>
<td>No changes</td>
<td>No changes</td>
<td>No changes</td>
<td>Direct and Indirect Measures</td>
<td>Performed by Faculty &amp; OAFC</td>
<td>Syllabus Changes</td>
</tr>
<tr>
<td>Current</td>
<td>No changes</td>
<td>No changes</td>
<td>No changes</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
3.8 Level of achievement of Program Outcomes

This section shows the performance of each outcome. The most direct assessment methods were made by the faculty summarized in Course Portfolios that include the use of Locally Developed Exams, Simulations, Performance Appraisals, Oral Examinations, and Behavioral Observations. Figure B.8 summarizes the mean performance per outcome for cycle 2005-2007 (evaluations of cycles 2001-2003 and 2003-2005 are available in Appendix I-E) of the above evaluation tools. In this graph, all outcomes achieved a 70% or more of the mean score and only outcomes e and h are the only ones below 70%. Figure B.9 shows the achievement of outcomes for the cycle 2005-2007. In this figure outcomes b, d, f, g, and j are achieved above the 70% threshold; other outcomes are below this level. Table B.24 shows how the assessment of outcome a was performed including the performance criteria (from the rubrics in Appendix I-G), strategies (courses were outcome is instructed), assessment method(s), context for assessment (courses where outcomes were measured), time of data collection, the assessment coordinator, and evaluation of results. The achievement of the outcome per trimester is available at the Table B.24 footnote. Appendix I-H has this information for the other outcomes.

In addition, Figure B.10 and Figure B.11 show the mean and the achievement of outcomes per trimester of evaluation, respectively. The importance of these graphs is to show the fluctuations of the mean and achievement of outcomes per trimester. It can be seen that all the outcomes in mean and achievement are met at least once in each trimester.

Figure B.12 to Figure B.26 summarize the level of achievement of each individual outcome as it was evaluated per course. This information is useful since the level of difficulty of the courses might be an important variable to consider when evaluating outcomes level of achievement.

At the end of each trimester the professors evaluated the achievement of outcomes and integrated changes to the course in order to adapt his teaching strategies to improve their achievement. Appendix I-F contains figures were the level of achievement of each individual outcome evaluated per trimester and course.

Other assessment tools were used including the FE Exam, Transcript Analysis, and Pre-Tests. The Fundamental Exam (FE) is used in outcomes assessment evaluation to assess two outcomes, namely a and i. For outcome a, passing the FE proves that the student has the fundamental knowledge of mathematics, science, and engineering necessary for today’s engineers. In addition, for outcome i, this is the 1st step in achieving life-long learning, because it is required to become collegiate and practice as a professional engineer. To remain collegiate is required to have credit hours in continuing education. Figure B.27 shows that 63% of our graduate took the FE Exam in 2005. Out of the students that took the exam, 67% passed the test, see Figure B.28.

Transcript analysis relates grades in transcript to outcome assessment achievement indirectly see Figure B.30.
Figure B.8 Outcomes Assessment Results, Cycle 2005-2007

Figure B.9 Outcomes Assessment Achievement Cycle 2005-2007
<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Use of concepts, principles and/or equations: Concepts, principles, equations, and data (components) are identified as needed for the problem (or task), including the connections between them.</td>
<td>All except ME 1230 ME 4261 ME 5251</td>
<td>Locally developed Exam, Project and/or quizzes</td>
<td>ENGI 3410 ENGI 3420 ENGI 3421 ME 1210 ME 1230 ME 3110 ME 3410 ME 3421 ME 4120 ME 4140 ME 4210 ME 4241 ME 5050 ME 5250 ME 5992/94</td>
<td>WT-05 SP-06 FA-06 WT-06</td>
<td>Professors: Alvarado, Bardalez, Cabrera, Clavell, Carrera, Lebrón, Ordoñez,, Restrepo.</td>
<td>Assigned Professor, OAFC and Faculty Head</td>
</tr>
<tr>
<td>2 Formulates appropriate strategies of solution: A logic plan to solve the problem is proposed.</td>
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<tr>
<td>3 Execution of solution strategies: A procedure must flow free of errors. All calculations are executed without any error by hand or using calculator or any software.</td>
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<tr>
<td>4 Use of engineering judgments: Engineering judgments must be applied to evaluate the answer of a problem.</td>
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</tbody>
</table>

Results: WT-05 = 54%, SP-06 = 65%, FA-06 = 79%, WT-06 = 61%
Outcomes for Cycle WT-05-WT-06 Course Portfolio

Program Outcomes

Figure B.10 Outcomes Evaluations Results by Faculty

Figure B.11 Success of Outcomes Evaluations by Faculty
Figure B.12 Results for Outcome a

Figure B.13 Results for Outcome b
Figure B.14 Results for Outcome c

Figure B.15 Results of Outcome d
Figure B.16 Results of Outcome e

Success of Outcome e vs Course

Figure B.17 Results of Outcomes f

Success of Outcome f vs Course
Figure B.18 Results of Outcome g

Figure B.19 Results of Outcome h
Success of Outcome i vs Course or Tool

Figure B.20 Results of Outcome i

Success of Outcome j vs Course

Figure B.21 Results of Outcome j
Figure B.22 Results of Outcome k

Figure B.23 Results of Outcome l
Figure B.24  Results of Outcome m

Figure B.25  Results of Outcome n
Figure B.26 Results of Outcome o

Figure B.27 Alumni Take Fundamental Exam Cycle 2005
Fundamental Exam Results

No Pass FE Exam, 4, 33%
Pass FE Exam, 8, 67%

Figure B.28  Fundamental Exam Cycle 2005

Outcome Achievement
Transcript Analysis 2006

Figure B.29  Transcript Analysis 2006
Finally, pre-tests give us information about the service courses for the ME program. These courses include mathematics, science, and general engineering courses not taught by the mechanical engineering department. The mathematics knowledge evaluated is of high school level, imparted in Computer Aided Drafting and Design course (ME 1210) course. It evaluates simple high school mathematics in Algebra, Geometry (Angles, Coordinates, and Cartesian Planes), and Dimensioning.

The college level mathematics and physics pre-tests are given in ME third year courses, imparted at Dynamics (ENGI 3410) and Fluid Mechanics (ENGI 3420). The engineering course evaluated with pre-tests is Statics. The pre-test is administered in the Solids I course.

The results are presented in Figure B.28 to Figure B.30. Figure B.30 shows that only four areas of the pre-tests were achieved including Geometry, Trigonometry, Coordinates, and Angles. Other areas were deficient.
Figure B.30 Mathematics Pretest Results
Mathematics Pretest vs Course by Trimester

Pretest = Static

Mathematics Pretest vs Course by Trimester

Pretest = Physics

Figure B.31 Statics & Physics Pretest Results
Pretest Results Cycle FA-05 - SP-07

[Bar chart showing mean scores for various topics]

Pretest Topics

Figure B.32 Pretest Results Cycle FA-05 – SP-07
3.9 Extra-Curricular Activities

In addition to curricular activities, extra-curricular activities are encouraged to students for their participation. These include student competitions and work-study programs. These activities are held, but no specific data is collected to assess the outcomes.

In the past years, our students have participated in several student competitions. These include:


There are three ways that students may involve in work-study. These are COOP students, Mechanical Engineering Practice, and Undergraduate Research. Many of our students have enrolled to these programs to acquire experience before graduation and have a clearer idea of how to achieve their career goals.


The outcomes performance is measured many times in the two year assessment cycle. At the faculty meeting at the end of the two year cycle changes in the outcomes definition, educational strategies and other outcome assessment steps are revisited. The faculty has the available data to make suggestions to achieve program outcomes. Appendix I-H has the tables of Student Learning Outcome assessment at the program level. These tables include the performance criteria of the outcomes, assessment methods, context of for assessment, time of data collection, assessment coordinator, and evaluation of results.

Recommendations and Actions based in Course Portfolio Results:

Based in the previous information gathered in the course portfolios the professors gave the following recommendations:

WT-05

✓ The outcome assessments for ME 5251 MECHATRONICS LABORATORY course were in general acceptable to a 74% achievement. The only outcomes with deficiencies were outcomes c & n, which are related to characterize the design need (defining technical and realistic constraints of the problem clearly). To improve the deficiencies in these outcomes more design laboratory practices will be implemented by the professor.

✓ The outcome assessments for ME 5050 SYSTEM DYNAMICS AND CONTROLS course were in general acceptable to a 70% achievement. The only outcomes with deficiencies were outcomes a, e, which are related to mathematics (to convert word problems to mathematical equations). To improve the deficiencies in these outcomes more emphasis in mathematics and text interpretation will be done by the professor, including the recommendation to students to attend to available mathematics tutoring.
addition, a recommendation outside the course is to establish a measure of the mathematic skills of students prior to taking mechanical engineering courses.

✓ The outcome assessments for ME 1210 CADD course were in general acceptable to a 86% achievement. The only outcome with deficiency is outcomes a related to mathematics. In order to improve their math skills I recommend the students to attend to available mathematics tutoring.
In addition, the course should have mathematics prerequisites which it does not have any at the moment.

SP-06

✓ The outcome assessments for ME 5251 MECHATRONIC LABORATORY SP-06 course were acceptable except for course objectives 1.1 and 1.3. To improve the deficiencies in these outcomes more emphasis in the use of design and selection of the right components will be done by the professor during the laboratory practices.

✓ The outcome assessments for ME 5260 CAD/CAM course were in general acceptable to a 70% achievement. The only outcomes with deficiencies were outcomes a, l, and m, which are related to mathematics. To improve the deficiencies in these outcomes more emphasis in mathematics will be done by the professor, including the recommendation to students to attend to available mathematics tutoring.
In addition, a recommendation outside the course is to establish a measure of the mathematic skills of students prior to taking mechanical engineering courses.

FA-06

✓ The course of ME- 2010 Computer Programming for Mechanical Engineers had an acceptable achievement of 75% on the analysis of outcome Other outcomes concerning to this course will be evaluated in future terms. The evaluation of the course objectives reveals some deficiencies, such as objective 1.2 (ability to understand how the commands work and how they may fail), 1.4 (apply MatLab in solving linear algebra problems), 1.5 (present mathematical and scientific material using graphics) and 2.2 (set goal, stay on task toward a timely completion of goal and apply a systematic approach to solve a thermal problem) which represent a score below of 70%. In general, this deficiencies are associated to the lack of computer versus the amount of enroll students and the need of laboratory upgrades. A recommendation for this course is to increase the number of computers and equal the number of enrolled students. This will help to reach a better percentage of achievement by acquiring fundamental practices and skills associated to the course.

✓ The outcome k and o need to be improved. There were two criteria evaluated for this class criteria 3 (engineering judgment) and 6 (use of CAB software). Criteria 3 is the one that needs improvement. Student has to have a good judgment of the results he/she acquires from the software. Next trimester I will emphasize on this criteria.
ME 4260 - The outcome k and o need to be improved. The teaching technique will be revised to further explain the use of engineering tools, which in this course is specifically the use of ANSYS. Outcome m was achieved successfully. The only change will be to cover more topics related to Linear Algebra.

The outcome assessment for ENGI 3410, Engineering Mechanic Dynamic course had 68% of achievement. This outcome a is much related to mathematical and student ability to convert word problems to a sequence of mathematical equations. In order to improve the deficiencies, the professor will increase the emphasis in the mathematical strategies and the logical verification on the obtained result, including recommendation for student to attend mathematics and dynamic tutoring at the university.

The outcome assessments for ME 5050 SYSTEM DYNAMICS AND CONTROLS FA-06 course were in general acceptable according to the Blackboard exam results were different course objectives were evaluated. However, objective 2.1 and 2.2 were not accomplished according to those results. The result for the outcome N, was acceptable (more than the 70%). To improve the deficiencies in these outcomes more emphasis in design of mechanical, electrical, thermal and fluid systems will be done by the professor using more assignments and quizzes in addition to the course project.

The outcome assessments for ENGI 3410-08 ENGINEERING MECHANICS, DYNAMICS course were in general good to an 83.7% achievement. To improve this achievement rating the professor will increase the number of homeworks and quizzes assigned during the next trimester. In addition, a recommendation that could be made in order to improve the outcomes achievement by the students, and that is beyond the professor’s control in the classroom, is related to the need to increase the level of the student knowledge of Physics and Differential Equations.

The outcome assessment for ENGI 3420 Fluid Mechanics (Section 06 for FA 06) course was in general acceptable to a 73% achievement. Some deficiencies were encountered related to the use of units and interpretation of data. To improve the deficiencies in these outcomes more emphasis in the use of the unit systems will be done by the professor, including the recommendation to students to attend available tutoring programs. In addition, a recommendation outside the ME Department is to establish a program directed to ensure skills in unit systems and interpretation of data for proper solution of problems; this should be prior to taking mechanical engineering courses.

The outcome assessments for ME 5250 MECHATRONICS FA-06 course were not acceptable according to the Blackboard exam results were different course objectives were evaluated. Objectives 1.4, 1.7 and 2.3 were not accomplished according to those results. The result for the outcome c, was acceptable (more than the 70%). To improve the deficiencies in these outcomes more emphasis in the use of computer software for simulation as trilogy and simulink will be done by the professor using more assignments and quizzes in addition to the course project. Those evaluation tools will include also more design problems.
The outcome assessments for ME 3110-08 THERMODYNAMICS I course were in general good to an 87.5% achievement. The professor’s perception is that this very good achievement rating could still be improved by increasing the student work through assignments of different authors from the textbook’s authors; the number of quizzes might be increased as well.

The outcomes assessments for ME 4210 SOLID MECHANICS I course were in general very good to a 90% achievement. The professor’s perception is that this very good achievement rating could still be improved by increasing the student work through assignments with problems of diversified authors; the number of quizzes might be increased as well.

The outcome assessment for ENGI 3420, Fluid Mechanic course had an acceptable 77% of achievement. This outcome is much related to mathematical and student ability to convert word problems to a sequence of mathematical equations. In order to improve the deficiencies, the professor will increase the emphasis in the mathematical strategies and the logical verification on the obtained result, including recommendation for student to attend mathematics tutoring at the university.

Having carried out this assessment of outcomes during the quarter Fall 2006 to the students of the course ME 1210 section 03 and 08. Rubrics to evaluate outcomes g, k, and o; and the different indicators established in them were used in order to measure the ability of the students to understand the concepts impart in class, we can infer the following:.

General:
1. The students showed ability to handle the programs and to present the results of use of the same of a mild and understandable form.
2. Most of the students they showed interest in the class, showing assets participation and they did not miss to classes.
3. The students understood the importance to know to represent drawing pieces, models, and to plot as middle of communication and explanation compose and characteristics of the same of them.
4. The students related tool of work, with objective of the class and with applications you practice and they saw the relation among them.
5. In writing communication, the most of the students they know to handle the programs, but they have some difficulty to concatenate ideas, to be orderly in their documents writings and to edit effective and clear.

Specific:
Outcome g
1. At the first exam, the students had problems to imagine and in logic sequence create a 3-D solid feature.
2. During the quarter the students were progressing in the use of the tools of drawing, the change among the regular notes of the first exams is noted in the performance of the project. A
3. Finally, 77.75% is a good index if we think that they don’t have any mathematical background and they are beginning their career.
Outcome k,o
1. The students have ability to handle Word, AutoCAD, and ProEngineer.
2. This outcome was accomplished better than outcome g, the students achieve an 80.75% average, this is a good result, but this can be better.

WT-06

✓ ME 1210 - The outcome g, k, and o need to be improved. Outcome g was achieved successfully. For outcomes k and o, criteria k-6 (use of CAD software) is the one that needs improvement. Next trimester, I will emphasize on this criteria using more CAD examples. In addition, the students do not have any pre-requisite for this course. I recommend that they must have at least Pre-Calculus to have a math background.

✓ The outcome assessments for ME 3110-20 THERMODYNAMICS I course were in general acceptable to a 77.575% achievement. This rate of achievement may be considered almost normal taking into account the fact that this WT-O6 quarter is broken by the three-week-Christmas’ and New Year’s break. This type of break influences negatively on the students’ level of academic achievement.

✓ The outcome assessment for ENGI 3420 Fluid Mechanics (section 06 for WTO6) course was in general not acceptable to a 57% achievement. Many deficiencies were encounter related to the interpretation of data and the use of units systems. To improve in these deficiencies more emphasis in the use of units systems will be done by the professor. A recommendation will be given to students to attend available tutoring programs to improve in these areas. In addition, a recommendation outside the ME Department is to establish a program directed to ensure skills in interpretation of data and in unit systems for proper solutions of problems, this should be prior to taking mechanical engineering courses.

✓ The outcome assessments for ENGI 3410-08 ENGINEERING MECHANICS, DYNAMICS course were in general acceptable to a 70.5% achievement. The only outcomes with deficiencies were outcomes a, 1, and m, which are related to mathematics. To improve the deficiencies in these outcomes more emphasis in mathematics will be done by the professor, including the recommendation to students to attend to available mathematics tutoring. - In addition, a recommendation outside the course is to establish a measure of the mathematic skills of students prior to taking mechanical engineering courses. Emphasis should be exercised on measures of student’s skills on differentiation, integration, vector operations, and moments of inertia of rigid bodies.

✓ The outcomes assessment for ME 4140-23 HEAT TRANSFER II course were in general acceptable to a 76.75% achievement for the outcome “a”. This level of achievement may still be increased by motivating the students to solve increased number of home assignments. In general, the levels of academic achievement of the students for the WT quarters are lower than those for FA and SP quarters, because winter quarters have a three-week break due to end-of-year’s holidays.
The outcomes assessment for ME 4120-21 THERMODYNAMICS II course was in general acceptable to an 80.4125% achievement for the outcome “a” and an 88.555% achievement for the outcome “j”. These good levels of achievement may still be increased by motivating the students to solve increased number of home assignments.

**Recommendations and Actions in Faculty Meeting:**

The following recommendations were made in the faculty meeting:

- Given the student profile it was suggested to reduce the number of topics covered in a trimester, to dedicate more time to most important course topics.
- The use new educational strategies to let student do most of their work at the course time. In addition, trainings to professors about new educational tools such as Problem Based Learning, and Format in the Classroom will be taught.
- Take the PPI examination in the last trimester and if the students fail they cannot graduate until the exam is passed.
- Laboratories will be revisited to remake laboratory manuals. These manuals will help the plan to train Teaching Assistants to teach laboratories in combination to the start up of a master’s degree.
- Make interdisciplinary projects with other departments to have real multi-disciplinary projects.
- Ask capstone students to present their final project to a thesis committee that shows formal written projects and oral presentations.
- Assist students to express themselves more frequently to promote their oral presentation skills.

The previous suggestions were analyzed and corresponding changes were made.

- In the syllabus, topics will be labeled to show which topics are of most importance and will be covered using more time on class.
- The use of the Singapore’s Educational will be presented to professors to determine if it can be applied in engineering courses.
- Fundamental Exam importance will be further shown to students.
- Capstone students to present their final project to a thesis an evaluation committee will revise formal written projects and oral presentations.
- Student projects as extra-curricular activities will be encouraged, as well as engineering practice.
4. Professional Component

Our curriculum given in Table I-1 of Appendix I-A meets the ABET Program Requirements. A total of 167 credit hours are required for the degree, including 34 credit hours (20.4%) of math and basic sciences, 100 credit hours (59.9%) of engineering topics, 24 credit hours (14.4%) of general education, and 9 credit hours (5.4%) of other subjects.

The curriculum allows the students to freely choose 5 elective courses (15 credit hours). These electives can be chosen from several departments as follows: one elective from the Socio-Humanistic Department, three electives from the Mechanical Engineering Program, and one elective freely chosen from other departments according to the student’s interest. The electives in the Mechanical Engineering Program are listed in the Undergraduate Catalog.

The objectives of each mechanical engineering course are related to the Program Educational Objectives in the individual course syllabi. Syllabi for courses taught by the Mechanical Engineering Program are presented in Appendix I-B. Each mechanical engineering course has a number of objectives, and each course objective may relate to one or more Program Educational Objectives as shown in Table B.12. The course syllabi for the courses taught in mechanical engineering also contain the performance criteria for each course objective and a relation to the outcomes that are satisfied.

Table I-1 of Appendix I-A specifies courses that based on their content have significant design. Here are brief descriptions of selected design courses.

- **ME1210 - Computer Aided Drafting and Design** the students learn how to use parametric software to design parts and make detail drawings.
- **ME 1230 - Introduction to Mechanical Engineering** course students are introduced to the design process without the requirements of establishing complex formulations. It includes the use of PLC’s and numerical control programming.
- **ME 4230 - Design of Machine Elements I and ME 5240 - Design of Machine Elements II** focus on the design of components and simple mechanical systems.
- **ME 5150 - Design of Thermal Systems** focus on the integrated design, analysis, and optimization of thermal systems.
- **ME 4240 and ME 4241 - Manufacturing Course and Laboratory** the students get to realize (or build a prototype) of assigned parts.
- **ME 4260 Finite Element Analysis** students get experience on the use of current commercial computer tools for drafting (Pro/Engineer), finite elements (ANSYS), and numerical control programming.
- **ME 4261 - Computer Aided Engineering Laboratory** students learn the role of computers and software as tools in the design process. It includes the use of Pro-Engineering Design Modules that involves engineering design tools such as: Pro-Mechanica, Mechanism Kinematics and Dynamics, Sheet Metal Module, Animation Module, Surfacing, CNC Milling and Lathe, Advanced Part Modeling, among others.

As listed in Table I-1 of Appendix I-A, there are other courses not mentioned above wherein students are also faced to design experiences. All these cumulative design experiences and
knowledge acquired in earlier courses culminates in a sequence of two major design courses. ME 5992 - Mechanical Engineering Capstone Design I and ME 5994 - Mechanical Engineering Capstone Design II. In these courses, students have the opportunity in a teamwork environment, to proceed through the entire design process from problem formulation to prototype fabrication. The design problems are usually drawn from industry, students competitions, and community projects in either thermal and/or mechanical systems areas. It is a requirement in the Capstone courses to include in the Product/Process Design Specifications. Most of the following considerations but not limited to: economics, environmental, engineering standards, sustainability, manufacturability, ethical, health and safety, social and political. In these courses, it is emphasized the responsibility and impact of a designer to his customer, employer, and society. It is also an objective to create the student’s awareness that failure of a design may lead to loss of property and/or human life. There are two types of capstone projects where students are faced with a major design experience; these are industry projects, competitions of student societies, and community projects. Here we mention just a few recent projects.

**Industry Projects**

**I - Project**

**Title:** Piping system design for AEE (Electrical Power Authority) boilers start up. (WT-06)

**Team:** Elías Vega, José Escalera, Angel Sierra

**Abstract:**

Light oil has been used as start up fuel for boilers at the Puerto Rico Electric Power Authority following a legal decision. Prior to this decision it was used just in case of emergency, at Palo Seco Power Station this system develops a low pressure problem for the farthest two boilers. In this project we analyze and design a solution for the low pressure problem with the light oil start up system at the Palo Seco Power Station boilers #3 and #4. A new piping system will be installed at the side of boiler #4. This new system will deliver 107 psi to boiler #4 and 106 psi to boiler #3 with a maximum of 50 gpm, thus exceeding the minimum requirements of 80 psi and 40 gpm for each boiler. A complete analysis for all alternative and final decision is presented in this document. In addition, a scale system is designed to test the mathematical model. This scaled design obtained a theoretical pressure of 95 psi for boiler #3 and 94 psi for boiler #4, and an experimental value of 94 psi for boiler #3 and 93 psi for boiler #4, with a difference and error of 1.1% for boiler #3 and 1.3% for boiler #4.
II - Project

Title: CASE PACKER MACHINE MODIFICATION (Pfizer; WT 05)

Team: Alexis Abrams, Jaime Villamil, Raynel Medina, Ricardo Rosich

Abstract:
The project scope consists to improve the packing process at line six (6) in Pfizer Pharmaceuticals at Barceloneta site. The HIS-2400 case Packer Machine was shattering the cases due of a change in cases dimensions. A mechanism had to be design and built to HIS-2400 Case Packer Machine to prevent the Case Shattering. After the installation of the mechanism the machine improved drastically, the shattering stopped approximated 93.2 and the cases start closing the way they should be.

III - Project

Title: CHARACTERIZE AND MATHEMATICALLY MODEL A LIQUID SOLUTION IN ORDER TO CONTROL THE FLOW THOUGH A POROUS MEDIA USED IN A INK CARTRIDGE (Hewlett Packard, WT-05)

Team: Antonio Ramos, Ronald Pérez, Joel Caldera

Problem Description: The objective of this capstone project is to characterize the mechanical and fluidic properties of the polyurethane delivery system of a printers ink jet cartridge.

Competitions Student Societies

I - Project

Title: SAE Mini-Baja Series (SP-07)

Team: Victor A. Negrón, José A. Moraza, Walter Manrique, Fernando Sosa

Problem Description: Baja SAE consists of three regional competitions that simulate real-world engineering design projects and their related challenges. Engineering students are tasked to design and build an off-road vehicle that will survive the severe punishment of rough terrain and in the East competition water.
The object of the competition is to provide SAE student members with a challenging project that involves the planning and manufacturing tasks found when introducing a new product to the consumer industrial market. Teams compete against one another to have their design accepted for manufacture by a fictitious firm. Students must function as a team to not only design, build, test, promote, and race a vehicle within the limits of the rules, but also to generate financial support for their project and manage their educational priorities.

All vehicles are powered by a ten-horsepower Intek Model 20 engine donated by Briggs & Stratton Corporation. For over twenty-five years, the generosity of Briggs & Stratton has enabled SAE to provide each team with a dependable engine free of charge. Use of the same engine by all the teams creates a more challenging engineering design test.

II - Project

Title: Formula SAE Car (Su-06)

Team: Terimar Vázquez, Danneresis Sepúlveda, Iván Collazo, José Luis Torres, Yabriel Aguayo, Harry Lorenzo, Guillermo Ramos, Ricardo Santana, Rafael Vega

Abstract:

Formula SAE is the brand child of the Society of Automotive Engineers and is run primarily on the basis of producing graduate students with real life project experience. The Formula SAE competition is oriented for the student to conceive, design, fabricate and compete with small formula style racing car. The objective is to design and build a high performance car in terms of its acceleration, braking and handling qualities. The car must be low in cost, easy to maintain, and reliable.

The FSAE Powertrain team was responsible for the selection, design and assembly of such areas as: the engine with its components, output shaft sprocket, cooling system, fuel management system, ignition system, electrical system, shifter system, and clutch system. All the parts and elements just mentioned, were detailed designed, selected and/or manufactured by the team under the specifications and rules of the FSAE in order to construct the optimum powertrain system. Refer to the Powertrain Cycle Schematic figure below for an explanation of its basic function.

A Suzuki GSX–R 600 engine was selected based on its performance and specifications which comply with the FSAE rules; a four-stroke piston engine with a displacement not exceeding 610 cc per cycle. The turbocharger system was designed to augment the compression inside the cylinders and thus produce more power than the same engine without this system. The selected turbo-compressor is a Garret Honeywell GT12, which supports up to 130 HP and it will operate at around 12 lbs of boost. The compressed air goes into the intake system and is then distributed into the cylinders. The engine’s intake was designed and manufactured, based on the flow supplied by the turbocharger as to minimize the friction through it. The intake manifold was securely attached to the engine
block or cylinder head as specified by the FSAE rules. On the other hand the exhaust system was selected in order to comply with the FSAE noise regulations.

One of the principal challenges in the powertrain design, is to transform the 19mm air flow restrictor into a key component that contributes to the car performance by accelerating the air that goes into the turbine. The Venturi design corresponds to the ASME Torodial Throat Critical Flow Venturi as it is the standard for such small throat values.

On a final note we would like to mention that this project gave us the opportunity to implement the knowledge acquired during our engineering training as we were able to create and build a complex mechanical system for a real life competition.

III - Project

Title: DESIGN AND CONSTRUCTION OF A SUPERMILEAGE VEHICLE

Team: Javier J. Guerra Rosado, Carlos Hernández

Abstract:

Fuel efficiency and fuel consumption have become a vital buzzword in automotive Engineers (SAE) supermileage Competition. A fuel consumption of 605-miles/gallon has been obtained.

Community Projects

I - Project:

Title: Design & Development of an Automated Painting Easel for a Quadriplegic (FA-06)

Team: Hector Peña, Andres Santiago, Edwin Castro & Juliemar Meléndez

Abstract: This Project has been designed and built for a Quadriplegic Artist. Because of his multiple sclerosis, the artist has no functional movement from the neck down and therefore he paints in acrylic and watercolor using a mouth-stick to hold the paintbrush. The head-only movements results difficult motions which affects his ability to reach the different areas of the canvas, thus needing constant help from another person. In order to increase the productivity of this artist was created the Automated Painting Easel. This is able to move the canvas left, right, up & down as well as to tilt it by simply activating switches with the paint brush. This design has been successfully implemented & tested.
II - Project:

**Title:** Control Matrix for a Quadriplegic Patient (WT-06)

**Team:** Jason Calderon, Jonnasca Quevedo, Hector Alvarez & Xavier Rodríguez

**Abstract:**
The purpose of the research is to design and develop a universal control panel with which a person with quadriplegia or similar condition will have the ability to control a television set, a telephone, water supply, and a positioning bed while unassisted and by using the proposed Control Matrix (utilizing only head movements). All the proposed goals were achieved.

III - Project:

**Title:** Automation of a Wheel Chair (WT-06)

**Team:** Jorge Aponte S., Orlando Carasquillo

**Abstract**
The Capstone Design Project consists in the design and construction of an adaptable kit for a standard wheel chair. The objective is to face engineering students with a design problem which would help humanity. The movement of the wheel chair will be achieved by to electric motors which would have an axle for each wheel. The achievements of the wheel chair were to move a load of 250 pounds at 4 m.p.h. for a distance of 7 miles.

Other projects are mentioned below:

2004
- Loading System Automation - Pall Biomedical
- Human Power Vehicle, ASME
- Supermileage, SAE
- Formula, SAE
- Supermileage, SAE

2005
- Inject Foam Permeability, Hewlett Packard
- Assembly Line Yield, McNeil
- AC Design, Doral Bank
- Automation of Box Loader, Pfizer
- Automation of Clothing Management, King Uniforms

2006
- Formula, SAE
- Chill Water Re-Design, Pfizer
- Diesel Piping System Redesign; PR Power Authority
• Retractable Control Matrix for a Quadriplegic Individual, Puerto Rico Attendance Technology Program (PRATP)
• Adaptable Kit for Manual Wheel Chair, PRATP
• Formula SAE Chassis Design, SAE

2007 Current

• Parking Management System, EngiWorks
• Mini Baja 2007, SAE
• Gasoline to Ethanol Engine Modifications

In addition to the major design experience and consistent with the mission of the university and our objectives, the general education component complements the technical content of the curriculum. Students take 24 credit hours of socio-humanistic studies and languages that aim to provide the student with a wide general culture, specially in the humanistic aspects and a sense of social responsibility, and to develop the students reflective and critical thinking, basic language skills in both Spanish and English, and also to develop an attractiveness toward Universal and Hispanic literature and get acquainted with foreign languages.

As part of their general education component, students take the course PHIL 3040 - Ethics in Engineering. In this course, a study of the philosophical and legal aspects of ethics and their application to the professional responsibility in engineering is performed. Students analyze the code of ethics of different professional societies and the local board of engineers, and the professional state regulations.

5. Faculty

Presently, the Mechanical Engineering faculty includes eleven full time faculty members. Two additional full-time faculty members are studying their Ph.D. sponsored by the university. A group of seven part-time faculty members with strong links to industry and practice complements our faculty. Six of the full-time faculty members hold Ph.D. degrees, and the rest hold master degrees as described in the Faculty Analysis in Table 4 of Appendix I-A. Nine faculty members are registered professional engineers and four are engineers in training.

Each faculty member is committed to a high quality undergraduate education firmly grounded in engineering science and oriented toward engineering practice. According to the faculty competencies and interest, there is an adequate expertise among the faculty to cover all curricular areas of the program, as shown in Table B.25 and in the Faculty Workload Summary in Table 3 of Appendix I-A. The faculty strength resides in a mix of long-time experience in the areas of the curriculum, fresh enthusiasm in the areas of development, and practical experience. For additional information, faculty curriculum vitae are presented in Appendix I-C. This qualified faculty is adequate in size to cover all the areas of the curriculum and the program is not critically dependent on one individual. However, faculty search for two additional full time positions at the assistant professor level is being conducted.
Small classes permit close interaction between students and faculty. As seen in Table 2 of Appendix I-A, the average courses enrollment of 23 students and 17 students for laboratories, Design classes such as ME 3210 Mechanism Design, ME 5150 Design of Thermal Systems, ME 4260 Finite Element Analysis, and ME 5992 and ME 5994 ME Capstone Design I and II respectively, are limited to 20 students maximum.

Table B.25 Faculty Competencies and Interest

<table>
<thead>
<tr>
<th>Course</th>
<th>Professor</th>
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<tbody>
<tr>
<td></td>
<td>C. Alvarado</td>
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<tr>
<td>ENGI 3410 Dynamics</td>
<td>2 1 1 1 1 2 2 1 1 1</td>
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<tr>
<td>ENGI 3420 Fluid Mechanics</td>
<td>1 1 2 1 1 1 1 1 2 1</td>
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<tr>
<td>ENGI 3421 Fluid Mechanics Laboratory</td>
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</tr>
<tr>
<td>1210 Computer Aided Drafting &amp; Design</td>
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<td>1230 Introduction to Mechanical Engineering</td>
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<tr>
<td>2010 Computer Programming for ME</td>
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<td>2930 Introduction to Aerospace Engineering</td>
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<td>3010 Applied Numerical Analysis</td>
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<td>3140 Intermediate Fluid Mechanics</td>
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<td>3210 Mechanism Design</td>
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<td>3221 Engineering Materials Laboratory</td>
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<td>4041 Eng. Measurements Laboratory</td>
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<td>4120 Thermodynamics II</td>
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<td>4130 Heat Transfer I</td>
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<td>4140 Heat Transfer II</td>
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<tr>
<td>4210 Solid Mechanics I</td>
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<tr>
<td>4220 Solid Mechanics II</td>
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<td>4230 Design of Machine Elements I</td>
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<td>4240 Manufacturing Engineering</td>
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<td>4241 Manufacturing Engineering Laboratory</td>
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<tr>
<td>4260 Finite Element Analysis</td>
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<td>4261 Computer Aided Engineering Laboratory</td>
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<tr>
<td>5050 System Dynamics and Controls</td>
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<td>5150 Design of Thermal Systems</td>
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<td>5151 Thermal Engineering Laboratory</td>
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<td>5240 Design of Machine Elements II</td>
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<td>5251 Mechatronics Laboratory</td>
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<tr>
<td>5992 Mechanical Engineering Capstone Design I</td>
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</tr>
<tr>
<td>5994 Mechanical Engineering Capstone Design II</td>
<td>1 2 1 2 1 2 1 2 1</td>
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</tbody>
</table>

1. Primary Course & 2. Secondary Course
On the other hand, most of our faculty members are active members in professional societies of the field. Four of them serve as advisors to the student chapters of the American Society of Mechanical Engineers (ASME), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Society of Automotive Engineers (SAE), and the Board of Engineers and Land Surveyors of Puerto Rico (CIAPR).

Our faculty also keeps a close interaction with industry. As evidenced in Appendix I-C, some full-time faculty members run their own business or are active consultants in industry. In addition to this, our part-time faculty members are practicing engineers who bring all their practical and up-to-date experience to the classrooms.

The workload of a full-time faculty member is of 36 credit hours per academic year. Faculty members may be awarded six (6) credits of release time out of the 36 credit hours to perform different tasks such as: administrative work, intellectual activities, professional development, etc. The administrative work consists of student mentoring, counseling, or other services to the university such as curriculum review, laboratory development, paper publishing, proposal preparation, research, etc. Other activities are based in the professors’ needs, interests, and/or department necessities. Any workload assigned above the 36 credit hours per academic year is compensated proportionately and is optional. In addition, faculty members currently have two (2) months of vacation, during the summer. At this time, some faculty members decide to be involved in summer research, consulting, teaching, and other intellectual activities.

Thirty credits are awarded as teaching load and usually are divided into 12 credit hours during the fall term, and nine credit hours each during the winter and the spring terms, respectively. Accordingly, each full time faculty member is expected to teach a full load of four courses in the fall term and three courses in the winter and three courses in the spring term. The administrative load is split into two credits each term.

Our faculty is encouraged to engage in their own professional development. The department is supportive of any faculty initiative in this respect. There is a special fund that is used to cover costs to attend seminars, workshops, travel, etc. as requested by individual faculty and after the approval of the Department Head, Dean of the School of Engineering, and the President of the institution. Seminars on teaching methodologies or engineering education are also given at the institution as described in Appendix II. The institution is also making efforts to support faculty wishing to pursue a doctorate degree.

Regarding the salary scale and promotion, there have been salary increases since the last ABET visit of about 7.5% one in 2002-2003 of 4% and the other in 2004-05 of 3%. The increase in salary is dependent also, on evaluation of professor performance. A multi-annual contract is signed with the professor and a complete process to evaluate the professor is in place.
6. Facilities

This section contains the available facilities provided by the institution and the mechanical engineering department. The adequacy of the facilities is discussed in the next sub-sections.

6.1 Institutional Facilities

The Polytechnic University of Puerto Rico (PUPR) is located at 377 Ponce de León Avenue as a single campus, urban university in the heart of the financial district of the capital city of San Juan, comprising approximately 475,000 ft² of buildings on 10 acres of land. The campus is composed of four renovated buildings and two renovated buildings in the 10 acre setting. A parking building and a central plaza complete this campus site. Total assets for the 2002 audited figures are of $73,100,000.

6.1.1 Facilities description

Prior to year 2002, two major multi-year construction projects took place to improve two main building purposes: laboratory and classrooms, and parking facilities. Nevertheless, there are still challenges in two main areas in terms of the overall facilities’ capacity to appropriately account for the student parking space and for faculty office spaces.

Table B.26 summarizes the facilities infrastructure projects, and it also lists the classrooms and laboratory facilities per building as well. The data is organized to show recent facility improvement projects that were developed up to year 2002, focusing on the Pavilions Building and the main Parking building. In Table B.26, it can be seen that the Pavilions Building was extended in a multi-year construction project providing almost 300% additional area availability, from 16,255 ft² to around 64,000 ft². The cost of this expansion project was approximately $7,500,000.

The facilities in Table B.26 account for a total of 292,200 ft² of usable space with a total of 58 classrooms and 79 laboratory rooms. Moreover, most of the laboratory facilities listed above are enhanced with sufficient space to provide for alternate usage as teaching rooms and laboratory practices with particular laboratory equipment. PUPR has an institutional safety committee that is in charge of reviewing the laboratory facilities periodically in order to verify that no hazards are developed as a result of this alternate usage.

The main parking building is a six-story facility with a total of 170,000 ft². This building was developed in two phases. The initial phase was completed in 1995 with an 110,000 ft² facility offering 600 spaces in four levels. The second phase ended in 2002 with an additional 60,000 ft² and 275 spaces on two levels. The total investment in parking facilities for this phase was $4,500,000. Other parking facilities are distributed throughout the campus to provide parking spaces to administrative and academic personnel. These spaces comprise an additional 300 spaces.

Table B.27 offers a more detailed representation of the distribution of student services, personnel services and location of academic departments among the buildings from Table B.26. A detailed
### Table B.26 Facilities and classrooms-laboratory usage

<table>
<thead>
<tr>
<th></th>
<th>Main Building</th>
<th>Engineering Labs Building</th>
<th>Pavillions Building</th>
<th>Multi-Purpose Building</th>
<th>Library Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year Built-Completed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st phase</td>
<td>1936</td>
<td>1996</td>
<td>N/A</td>
<td>1997</td>
<td>1997</td>
</tr>
<tr>
<td>2nd phase</td>
<td>-</td>
<td>-</td>
<td>2002</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Total Sq. Ft.</td>
<td>55,000</td>
<td>60,000</td>
<td>64,000</td>
<td>70,000</td>
<td>43,200</td>
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<tr>
<td>1st phase</td>
<td>-</td>
<td>-</td>
<td>16,255</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2nd phase</td>
<td>-</td>
<td>-</td>
<td>47,662</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Number of Classroom availability</td>
<td>12</td>
<td>6</td>
<td>34</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Number of Laboratory rooms availability</td>
<td>12</td>
<td>31</td>
<td>24</td>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>
* N/A = Not available

### Table B.27 Detailed usages per facility

<table>
<thead>
<tr>
<th>BUILDING</th>
<th>Main Building</th>
<th>Engineering Labs Building</th>
<th>Pavillions Building</th>
<th>Multi-Purpose Building</th>
<th>Library Building</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Administration</td>
<td>Civil/Environmental Eng. Dept. and Labs</td>
<td>Business Adm. Dept.</td>
<td>Architecture Dept.</td>
<td>Distance Education Office</td>
</tr>
<tr>
<td></td>
<td>Student Services</td>
<td>Industrial Eng. Dept. and Labs</td>
<td>Geomatic Sciences Labs</td>
<td>Cafeteria</td>
<td>Academic Support Office</td>
</tr>
<tr>
<td></td>
<td>Language Laboratory</td>
<td>Electrical-Computer Eng./Comp. Science Dept. &amp; Labs</td>
<td>Environment Compliance</td>
<td>Theater</td>
<td>Convention Center</td>
</tr>
<tr>
<td></td>
<td>Chemical Eng. Dept.</td>
<td>Mechanical Eng. Dept. and Labs</td>
<td>Chemical Engineering Labs</td>
<td>Basket Ball Court</td>
<td>Historic Rooms</td>
</tr>
<tr>
<td></td>
<td>Computer Labs</td>
<td>Engineering Faculty Offices</td>
<td>Mechanical Engineering Labs</td>
<td>Student Center</td>
<td>Study Rooms</td>
</tr>
<tr>
<td></td>
<td>Faculty Offices</td>
<td>Environmental Engineering Labs</td>
<td>24 hr. Study Room</td>
<td>Computer Labs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Title V Office</td>
<td>Basic Sciences Labs</td>
<td>Alumni Office</td>
<td>Library</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tutoring Labs</td>
<td>Center of Excellence of Industrial Controls (CETC)</td>
<td>Honors Program Office</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Research and Development Office</td>
<td>Plasma Research Lab</td>
<td>Science and Math Dept.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Geomatic Sciences Dept.</td>
<td>Windows to the Caribbean Center</td>
<td>Socio-Humanistic Dept.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Center for Educational Technology</td>
<td>Faculty Offices</td>
<td>Faculty Offices</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sponsored Research Office</td>
<td>Security Office</td>
<td>Security Office</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Page 88 of 336
description of laboratories usage is not included in this table. One can refer to more specifics within the Department Catalog.

6.1.2 Modern Engineering Facilities, equipments and support

There is a significant support at the institutional level in terms of student exposure to modern engineering tools. Particularly, students have access to the Center for Educational Technology with three classroom settings for a total of approximately 150 desktop computers and stations. Two of these rooms have computer projectors and one of them, has a smart-board that is used as a classroom tool for the instruction of undergraduate engineering courses where students can obtain web-enabled experiences. This graphical environment allows the instructor to emulate on the projected graphics screen everything that is currently done in the classroom. This Center also has three high capacity printers and two engineering plotters, one with 24 inch sheet capacity and the other with 42 inch sheet capacity.

There are several site license agreements that contribute to the wide access and dissemination of modern engineering tools. These site-license agreements were developed and are continuously upgraded with the following software companies:

- Microsoft with the Office suite and continuous supported and updated versions of Project and Visio
- Autodesk, offering state-of-the-art 2D and 3D technologies with Autocad that let users visualize, simulate, and analyze the real-world performance of their ideas early in the design process

Other agreements with technology companies contribute to the advancement of students in the following areas:

- MathWorks, a leading global provider of software for technical computing and Model-Based Design, with the basic and extended suite of Matlab. Currently, there are 150 licenses available throughout the campus.
- Parametric Technology Corp (PTC), offering Mathcad, a software that lets students design and document engineering calculations simultaneously with comprehensive applied math functionality and dynamic, unit-aware calculations. Currently, there are 250 licenses.

Additionally, PUPR rises to the challenge posed to higher education by the revolution in information technologies through a distance learning deployment strategy. Students can access an increasing available number of online courses each trimester and have access to various delivery methods, such as hybrid courses and on-line courses. Blackboard, a well-recognized web-platform is used to manage the environment appropriately. There is an office in charge of designing, monitoring, and maintaining the strategy throughout the campus and in all programs, both at the undergraduate and graduate levels.
6.1.3 Facilities strengths and initiatives

As a result of continuous growth of the student and faculty population, facilities availability and capacity represent an invariable challenge that require constant creative thinking and monitoring in order to better serve the community as a whole, particularly the students, the faculty, and the administrative personnel. In the last two years, there are two main initiatives that are impacting the facilities management in order to enhance the usage and flexibility of the existing facilities:

- Merging of concurrent classroom sessions in the Science and Mathematics, and the Arts and Sciences academic departments. The objective of this initiative is to facilitate the planning of concurrent sessions, while maximizing the capacity usage of the classroom size and ultimately, take advantage of certain building areas such as the Theater in the Multi-Use building.

- Analysis of the overall scheduling of classrooms and laboratory sessions throughout all the pre-established hours-period offering design. In the last two years, this initiative have been organized to obtain a more balanced planning of sections, particularly in critical capacity and demand rate cycles, mainly in the evening and nights of the four-days cycle in the planning week from Monday to Thursday. This initiative is currently looking to enhance other teaching-delivery methods and to develop alternate offerings on currently low demand cycles, such as Friday and Weekends.

6.1.4 Additional Facilities

There are other separated building areas located outside the building infrastructure described above. These building areas and support services are listed in Table B.28. The total usable area for these support services buildings is 12,650 ft². There are no classroom and/or laboratory assignments within these facilities. The location of these facilities is considered along with the main campus for the total 475,000 ft². Purchasing, Communications and the Guest House are three remodeled houses acquired by PUPR as a process of improving support services throughout the campus.

<table>
<thead>
<tr>
<th>Table B.28 Additional Facilities (sq. ft. space)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Services</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>1,850</td>
</tr>
</tbody>
</table>
### 6.2 Department of Mechanical Engineering Facilities

The Mechanical Engineering Department is housed in the first and fourth floors of the Engineering Laboratory building in our campus. There are four types of rooms in the Engineering Laboratory that are used by the Mechanical Engineering Department. These are classrooms (1), laboratories (4), combined class-laboratory rooms (5), and Student Society Rooms (2).

Classroom scheduling for courses offered by other departments such as Sciences and Mathematics, General Engineering, and Humanities are scheduled centrally and usually are taught in the main building, the Pavilion Building, and the Annex Building. The classrooms and combined class-laboratory rooms are used for courses in Mechanical Engineering Department and General Engineering courses.

The Mechanical Engineering Department has nine laboratories (combined and not combined) with a total area of 11,088 ft² (previous visit was 10,314 ft²). These laboratories are entirely devoted to provide students with experiences that support theoretical courses and all of them are relatively new and in good condition. Most related theoretical courses are also offered in the laboratories such that professors can easily make use of equipment to demonstrate concepts as needed. They are furnished appropriately with overhead projectors and projector screens. There are also two LCD projectors that can be used in any classroom or laboratory upon request. A brief description of the laboratories will follow below. A laboratory development plan will be available at the time of the visit.

### 6.3 Laboratory Description

This section includes the square footage, description, expected learning experience to meet program objectives, the courses served, and the equipment (including software) available for the laboratory.

#### 6.3.1 CAE Laboratory.

This laboratory is a climate controlled area, located in the room L-404 of laboratory building. It has approximately 960 square feet. It has an installed video projector, computer, automatic projection screen, and an overhead projector.

Description: It was created to understand the impact of modern engineering tools for visualization, construction and modeling. At the same time, student has the opportunity to create, design, analysis, solve, optimize and manufacturing in a virtual environment and expose to mechanical engineering design concepts.

This laboratory serves:
ME 1210 Computer aided drafting and Design,
ME 1230 Introduction to Mechanical Engineering,
ME 4260 Finite Element Analysis
ME 4261 Computer Aided Engineering Lab.
ME 5914 Computational Fluid Dynamics.

Equipment includes: Twenty computers and an equipment of projection. This laboratory is provided with license of different programs of design as ProEngineering, Ansys, Autocad, MathCAD, MatLab, etc.

6.3.2 Fluid Mechanics Laboratory.

This laboratory is a climate controlled area, located in the room L-401 of laboratory building. It has approximately 1600 square feet.

Description: Hands on experiences on the fundamentals of fluid mechanics. Students perform and conduct simple experiments for incompressible fluids. Besides, students develop the ability to measure, analyze and interpret data.

This laboratory serves:
ENGI 3421 Fluid Mechanics Laboratory
ME 3420 Fluid Mechanic
ME 3140 Intermediate fluid Mechanics

Equipment includes: This lab is equipped with four work benches, set of different accessories and devices to measure flow, hydrostatic forces, stability of floating bodies, friction in pipes and forces of impact of jets. Other experiments included are ventury meters, weirs and orifices where students determine loss coefficient and learn some characteristics and application of them.

6.3.3 Manufacturing Laboratory.

This laboratory is located in the room L-111 of building laboratories of approximately 2100 square feet.

Description: Hands on experiences on a variety of techniques and process for the manufacturing of engineering components including, operation of machine tools and welding machines. Prototypes are designed and manufactured by teams by the guidance of the instructor

This laboratory serves:
ME 4241 Manufacturing Engineering laboratory
ME 4240 Manufacturing Engineering

Equipment Includes: This lab is equipped with CNC lathes and millings, conventional lathes, milling machines, grinder surfaces, band saws, drills, cutting saw, welding machines, oxyacetylene.
6.3.4 Materials Laboratory.

This laboratory is a climate controlled area, located in the room P-319. It has approximately 600 square feet.

Description: Hands on experience in metallographic, testing of materials, materials characterization, phase transformation and heat treatment.

This lab serves:
ME 3221 Materials Engineering Lab.
ME 3220 Materials of Engineering

Equipment includes: scales, metal grinders, hardness testers (Brinell and Rockwell units), microscopes, material sample kits, an impact test machine, heat treat furnaces, metallographic equipment, tension and compression test machine, jominy end quench testing apparatus, metrology, and computers used with materials related software.

6.3.5 Mechatronic Lab.

This laboratory is a climate controlled area, located in the room L-409 of laboratory building. It has approximately 960 square feet.

Description: Hands on experience in automation electrical, electronic, hydraulic, and pneumatic control systems. This laboratory include electronic data acquisition cards and Programmable Logic Controllers (PLC). At the same time, it is provided with computer machine and the different necessary software to accomplish this task.

This lab serves:
ME 5250 Mechatronics
ME 5251 Mechatronics Laboratory
ME 1230 Introduction to Mechanical Engineering

Equipment includes:
Hydraulics and Pneumatics Power Laboratory

The Fluid Power Laboratory is equipped with a work bench for Fluid Power and Hydraulic Motion Control Systems; Pneumatic Power and Pneumatic Motion Control Systems; equipment for Controls and Instrumentation for Automation and mechanical actuation systems.

Automation Laboratory.

This lab is equipped with sensors, transducers, actuators, Allan-Bradley and DirectLogic PLC, power supplies.
6.3.6 Measurements Lab.

This laboratory is a climate controlled area, located in the room L-409 of laboratory building. It has approximately 960 square feet.

Description: Hands on experience in instrumentation, data acquisition (using Labview), and calibration in fluid and thermal systems, heat transfer, and materials.

This Lab serves:
ME 4041 Engineering Measurement Laboratory

Equipment includes: Electronic strain gauge instrumentation, thermocouples and thermostors, pressure transducer, vibration monitoring and related instrumentation, data acquisition card and recording equipment, and supporting computers.

6.3.7 Thermal Laboratory

This laboratory is sharing between the room L-408 and L-101 of laboratory building. It has approximately 2000 square feet.

Description: The students have the opportunity of Applied knowledge of convection, radiation and conduction, laws of thermodynamics, and property relations to different thermal equipments

This laboratory serves:
ME 5051 Thermals Laboratory

Equipment includes: It is provided along with a variety of equipment for teaching lab-based undergraduate thermal, fluid science courses and turbomachinery, the facility also includes features computer controlled heating and cooling systems that mimic the types of equipment found in industry. Equipments such as compressible fluid flow, convective heat transfer, thermal radiation, air conditioning, steam boiler, cross flow heat exchanger, Tube and tube, shell and tube, and plate heat exchangers, series and parallel pumping systems, axial and centrifugal fans, hydraulics turbines, and centrifugal compressors.

6.3.8 Student Computer Center

This facility is a climate controlled area, located in the room L-406 of laboratory building with 468 ft². This laboratory has recently been updated to 24 computer machines with institutional funds.

It is provided with different licensed software as ProEngineering, SolidWorks, AutoCad, Ansys, LabView, Working Model, MathCAD, MatLab, etc. In this laboratory, the computers are connected to a main server and to the worldwide web. Students have access to the internet for communication and for information in their academic activities. The laboratory is usually open to the students whenever there is no class scheduled.
This laboratory serves:
ME 1210 Computer Aided Drafting and Design
ME 1230 Introduction to Mechanical Engineering
ME 2020 Computer Programming for Mechanical Engineering
ME 3010 Applied Numerical Analysis
ME 4140 Engineering Measurement Laboratory
ME 5250 Mechatronics
ME 5050 Systems Dynamics and Controls

6.3.9 Computer Aided Design Laboratory

This facility is a climate controlled area, located in the room L-405 of laboratory building with 286 ft². It has 10 Sun Microstation computers machines available for students and professors.

It is provided with different licensed software as Pro-Engineering, Fluent, Ansys, MatLab, etc.

The laboratory serves Capstone Design Projects (ME 5992& 94), Undergraduate Research (ME 5970) and in the future a new masters in Mechanical Engineering.

6.3.10 Future additions

Product Realization Center

This new room is under construction next to the manufacturing laboratory room of 600 squared feet. It will be provided by CNC milling and lathe machine, a rapid prototyping, a 3-D scanner, and computer machine and software for the state-of-art manufacturing technology.

Graduate Student Computing Laboratory

Room L-405 of the laboratory building with 286 ft² has 10 Sun Microstation computers machines available for students and professors. This room is expected to be used for computational analysis used primarily by graduate students. Once the master’s program begins it be used for this purpose

Thermal Science Laboratory Renovation

In the present the Thermal Sciences Laboratory is held at the L-408 and L-101 rooms. The new laboratory will be moved and re-designed in the L-101 room, with conditioned climate.

Conference Room

Room L-408 will be renovated and prepare as a Conference room to fit approximately 100 people. It will be prepared with modern teaching tools to provide the necessary infrastructure for Distance Learning.
7. Institutional Support and Financial Resources

7.1 Institutional Support and Financial Resources

Since the last ABET accreditation visit, PUPR has continued its support of the College of Engineering and Geomatic Sciences (CE&GS). PUPR has invested heavily in funds allocation for acquisition of laboratory equipment, creation of research positions with significant increase in compensation, establishment of the Office of Sponsored Research, development of new academic programs at the graduate level, faculty development through multiple initiatives, space allocation to match funds required by grant funds obtained by faculty, granting release time to faculty requested by department heads to cover departmental needs and priorities, activities that benefit the student body, and a significant number of other activities. PUPR has also increased support to a selective group of its faculty members by offering them full financing of PhD studies.

Institutional Support to the CE&GS must be viewed in the context of the development of PUPR during the past six years. The University entered a full reorganization plan in order to increase resource allocation to all student services. The plan includes the strengthening of Information Technology (IT) services. Budget allocation for this activity during the past three years has been over $5,000,000. This plan has duplicated internet accessibility from 1.5 MB to 3 MB and later in 2007 the accessibility will increase to 10 MB. About 700 computer stations were purchased over a three year span and server capability was duplicated in order to increase services in laboratories available to students and engineering classrooms. An Enterprise Resource Planning (ERP) system was purchased in mid 2006 and full implementation started in fall 2006 with a project time line of three years. This implementation will strengthen not only the back end administrative capabilities of the university, but also will expand its services in the front end improving student and academic life. PUPR will be able to offer on line registration and full payment services. ACH and EFT services will also be included to speed up loan and scholarship services to students. Furthermore, the new system will bring full portal capability to the student body and academia, offering information on all type of activities including and not limited to grades, registration, academia office hours, chat rooms and calendar information of campus wide activities. IT’s objectives also include upgrades in antivirus software, expansion of users in all licenses, new Microsoft license agreements, a new document management project (over 100 printer/copier Toshiba units will be installed and deployed throughout the University) and upgrading to CAT5e all of the network architecture. Once the last CAT5e cables are to be installed, in fall 2007, analysis of Voice over IP implementation services will start. The total investment of this allocation will be over the $12,000,000 mark (six year period) when it is fully implemented.

A plan of classroom updating has started with an objective of installing overhead projectors to all classrooms in the University. Resources for this plan were divided in three phases. The first phase was finished in 2006 and the third phase will continue until 2008. The total investment of this plan will total about $300,000 when it is completed.
While Puerto Rico is experiencing its worst economic recession in decades, PUPR strives among other strategies to maintain competitive salary scales. Furthermore, the University has started paying the principal on its $30,000,000 bond issuance of 2002. The financing increased classroom and parking facilities, as well as reconstruction of entrance and exit facilities to increase security within the institution. Since a large number of the students attend classes after working hours until late at night, PUPR decided to increase the security throughout the campus. In year 2003 a new security office was opened and all subcontracted services were reviewed. A new plan to increase security via video was implemented and since 2006 about 80% of the campus is covered. As part of this plan, a deal with a wireless communication company assured PUPR complete coverage of cellular units throughout the campus. The full investment of this project is about $1,500,000 over a period of four years.

While these projects support the student population in general, it has brought and will continue bringing engineering students an added value in its university and academic experience. The CE&GS needs the continued institutional support to maintain its role as top provider of the Nation and Puerto Rico of excellent professionals in the fields of engineering, land surveying, and computer science. This requires a clear institutional strategy to attract, develop, and retain the best faculty and students. PUPR has also increased fund allocation to both the honor and sport scholarship programs in order to provide available funds to students that cannot fully complete academic obligations with the standard federal loan and scholarship programs.

7.2 Process Used to Determine the Budget for the Program

The program’s budget is prepared on an annual basis. The balances are revised monthly and/or quarterly by the Finance Office. PUPR fiscal year begins on August 1 and ends on July 31 of the next calendar year. During the spring term a budget questionnaire is delivered to the academic department heads. The department heads submit the Budget Request along with a justification for each request to the Administration and Finances Vice-President. The Budget Request includes: salaries, operational expenses, and materials and equipment purchases among others, according to the projected needs.

The budget is evaluated and approved by the Budget and Finance committee of the Board of Trustees formed by the President of PUPR, the Vice President for Finance and Administration and three members of the Board of Trustees. Factors considered for the approval are: a) previous year’s expenditures; b) current student enrollment; c) forecasted student enrollment and incomes; d) yearly objectives for the Institution. The budget is then presented for its final approval to PUPR’s Board of Trustees.

Currently, due to the technologically limited and manual procedure followed by the budget, expenditures approval procedures are centralized. That is, in order to get approval of a purchase order the process follows a hierarchical manual approval process of: the Department Head, the Dean of the CE&GS, Budget Officer and finally the Vice-President of Administration and Finance. This procedure significantly slows down the expenditures from the departments and therefore the resource allocation is not guaranteed in a timely manner. By mid 2008, the implementation of the ERP system’s budget module will be finished. At this time, all department heads and university officers will have an electronic budget approval system.
in place that will be available for viewing through the portal capability that the ERP will furnish. The department heads will have on line budget information about balances, orders and pending orders in the system. At this point, a five year planned budget will be implemented to act in unison with the university’s strategic plan.

7.3 Institutional Support to the Mechanical Engineering Program

Institutional support for the Mechanical Engineering program is adequate for most of the fiscal years. Annual expenditures in support of the program (not including staff salaries) for the 2002-2003 to 2006-2007 academic years are shown in Appendix I-A, Table 5. The program is supported mostly with institutional funds. The only cycle were the institution did not approved any funds was in the cycle 2003-2004. In addition, the department has a grant earned in 2005 with the Department of Education that approved about $200,000.00 for equipment to develop a Product Realization Center.

There is new available infrastructure, such as the new library, laboratories, classrooms, and supporting facilities (professors’ offices, student center, athletic facilities, and auditorium) that facilitate the achievement of the program objectives. PUPR administrative and support personnel have increased substantially during the last years. New positions, such as Vice-presidents, Deans, Department Heads, Outcome Assessment Office Director, Integrated Services Center Director, and Facilities Maintenance Office Director, have been created.

The program budget is prepared on an annual basis. The balances are revised monthly and/or quarterly by the Financial Office. PUPR fiscal year begins on August 1 and ends on July 31 of the next calendar year.

A budget questionnaire is delivered to the Department Head of the program at the beginning of each calendar year. The Department Head completes the questionnaire electronically and submit it to the Financial Office during the spring term. The requested budget includes salaries (including fringe benefits), operational expenses, and materials and equipment purchases, among others, according to the projected needs.

The budget is evaluated and approved first by the Financial Office. The following items are considered for the approval: a) previous year’s expenditures, b) current student enrollment and incomes, and c) forecasted student enrollment and incomes. The budget is then presented for its final approval to PUPR’s Board of Trustees.

Currently, although the budget allocation is developed taking into consideration the departments needs, the expenditure procedure is centralized. Every purchase order has to be approved by the President of the institution after the approval of the Department Head and the Dean. This procedure slows down the expenditures from the departments and therefore the resource allocation.

In order to expedite and improve the expenditure and resource allocation process, the following procedure started in Fall 2001. Once a purchase order is generated by a department and signed by the Department Head, it will go to the dean of the corresponding school for his/her signature.
It is important to specify in the purchase order from which item of the department’s budget that expenditure will be made.

From the Dean’s Office the order will go to the Finance Department for a financial analyst to check if the department budget equals or exceeds the order amount in that corresponding category. If the analyst certifies that there is still budget available, depending on the quantity of the order requested the order will go to the Comptroller if the purchase order is below $5,000, the Vice-president of Finance if the order is between $5,000.01 and $10,000, or to the President if the order is above $10,000.01 for his/her approval.

This new expenditure procedure will accelerate the purchasing process and will assure that the resource allocation equals the budget requested by each department.

Currently, the department annual budget includes an item for faculty professional development. These funds are used as requested by the faculty members after the approval of the Department Head, the Dean of the School of Engineering, and the President of the University. It should be mentioned at this point that two faculty members of this department are pursuing doctorate under the support of the institution. It is expected that they will be finishing by Fall 2007.

Regarding the salary scale and promotion, there have been salary increases since the last ABET visit of about 7.5% one in 2002-2003 of 4% and the other in 2004-05 of 3%. The increase in salary is dependent also, on evaluation of professor performance. A multi-annual contract is signed with the professor and a complete process to evaluate the professor is in place.

The department annual budget also includes an item to acquire, maintain and operate facilities and equipment. The funds are used as requested by the Laboratory Coordinators and/or any other faculty member after the approval of the Department Head, the Dean of the School of Engineering, and the President of the University. As stated above, this procedure of approval will change starting August 2001.

In general, the current support personnel and institutional services are adequate. However, considering the number of students and faculty members presently handled by the Department, hiring one more secretary is under consideration.

8. Program Criteria

There are two program criteria, one that apply to curricula and the other to faculty. The curriculum of the Mechanical Engineering Program, as shown in Appendix I-A. Table 1 of Appendix I-A1, ensures that our graduates have knowledge of chemistry and calculus-based physics. Mechanical Engineering students are required to take 4 credits of chemistry for 2.4% of the total number of credits and 12 credits (6.9% of the total number of credits) of physics as shown in Table B.29 and Table B.30, respectively.
**Table B.29 Chemistry courses required to student in the Mechanical Engineering Program**

<table>
<thead>
<tr>
<th>Code</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCIE 1210</td>
<td>Principles of Chemistry</td>
</tr>
<tr>
<td>SCIE 1211</td>
<td>Principles of Chemistry Laboratory</td>
</tr>
</tbody>
</table>

**Table B.30 Physics courses required to student in the Mechanical Engineering Program**

<table>
<thead>
<tr>
<th>Code</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCIE 2430</td>
<td>Physics I, Mechanics</td>
</tr>
<tr>
<td>SCIE 2431</td>
<td>Physics I, Laboratory</td>
</tr>
<tr>
<td>SCIE 2440</td>
<td>Physics II, Heat, Light, and Sound</td>
</tr>
<tr>
<td>SCIE 2441</td>
<td>Physics II, Laboratory</td>
</tr>
<tr>
<td>SCIE 2450</td>
<td>Physics III, Electricity and Magnetism</td>
</tr>
<tr>
<td>SCIE 2451</td>
<td>Physics III, Laboratory</td>
</tr>
</tbody>
</table>

Our graduates also have the ability to apply advanced mathematics through multivariate calculus and differential equations. They are required to take MATH 2340 - Calculus IV and MATH 3310 - Differential Equations. In Calculus IV, they have the opportunity to study functions of several variables, partial derivatives, multiple integrals and their applications, vector analysis and surface integrals, Stoke’s, Green’s and Gauss’ Theorems, and series. In Differential equations, the students solve problems related to first-order differential equations, linear differential equations of higher order, differential equations with variable coefficients, and Laplace Transforms. The application of advanced mathematics through multivariable calculus and differential equations are also performed in core courses such as intermediate Fluid Mechanics, Heat Transfer I and II, Design of Thermal Systems, and System Dynamics and Controls among others.

Our graduates also have familiarity with statistics. Students take the course ENGI 2210 - Engineering Probability and Statistics. They also have the opportunity to apply the basics of statistics to the analysis of experimental data in some experiments of the following laboratory courses: ENGI 3421 - Fluid Mechanics Laboratory, ME 3221 - Engineering Materials Laboratory, and ME 4041 - Measurements Engineering Laboratory. Extensive use of linear algebra is required in Design of Thermal Systems. Mechanism Design, Solid Mechanics II, and Finite Element Analysis.

With the changes implemented in our curriculum in August 2003, we also ensure that our graduates have the ability to work professionally in both thermal and mechanical systems areas including the design and realization of such systems with the courses Computer Aided Drafting and Design (using Pro-Engineering at the Freshman level), Introduction to Mechanical Engineering, Finite Element Analysis, and the Computer Aided Engineering Laboratory.
In addition, our students take nine courses in the thermal sciences area and nine courses in the mechanical systems design area as listed below in Table B.31. In addition to these courses, we should mention that there are other mechanical engineering courses that do not fit exclusively into these categories but to controls and manufacturing.

The other program criterion is related to faculty. Table 4 in Appendix I-A shows that there is an adequate expertise among our faculty to cover all curricular areas of the program. Evidence of maintenance of currency in faculty professional areas is found in the faculty resumes in Appendix I-C. Most of our faculty members are also registered professional engineers and some work as consultants in industry. In addition to this, our pan-time faculty members are practitioners in industry who bring to the classroom their daily experience thus exposing the students to the most recent developments in the discipline. The mix between academic and industry-oriented faculty have created an appropriate atmosphere for the fulfillment of our program objectives. Most of our faculty participated in the development of our current program objectives, and they hold the responsibility to maintain them as well as the curriculum.

9. General Advanced-Level Program

Currently, no advanced-level or graduate program is offered by the Mechanical Engineering Program.

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Appendix I - Additional Program Information
## A. Tabular Data for Program

### Table I-1. Basic-Level Curriculum (Mechanical Engineering)

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(Mechanical Engineering)

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¹ Lecture, Laboratory, Recitation, Other

50% Workshop
75% Project
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### Table I-4. Faculty Analysis
(Mechanical Engineering Program)

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<th>Highest Degree</th>
<th>Institution from which Highest Degree Earned &amp; Year</th>
<th>Years of Experience</th>
<th>Level of Activity (high, med, low, none)</th>
<th>Professional Society (Indicate Society)</th>
<th>Consulting/Summer Work in Industry</th>
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<td>Sosa Ancajima, Ronald M.</td>
<td>Ass.</td>
<td>FT</td>
<td>M.S.</td>
<td>University of Puerto, 3 16 11</td>
<td>(Low), ASME</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
### Table I-5. Support Expenditures
(Mechanical Engineering)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations¹ (not including staff)</td>
<td>$90,000.00</td>
<td>$94,800.00</td>
<td>$81,550.00</td>
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<td>Travel²</td>
<td>$10,000.00</td>
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<td>$3,500.00</td>
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<tr>
<td>Equipment³</td>
<td></td>
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<tr>
<td>Institutional Funds</td>
<td>$256,000.00</td>
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<td>$187,752.00</td>
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<tr>
<td>Grants and Gifts⁴</td>
<td>$204,702.00</td>
<td>$22,668.88</td>
<td>$366,855.94</td>
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<tr>
<td>Graduate Teaching Assistants</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Part-time Assistance⁵ (other than teaching)</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
</tbody>
</table>
B. Course Syllabi

POLYTECHNIC UNIVERSITY OF PUERTO RICO
MECHANICAL ENGINEERING DEPARTMENT

Course Title: Engineering Mechanics, Dynamics
Course Code: ENGI 3410
Classification: Engineering Science
Credits: 3
Pre-requisite: ENGI 2110 - Engineering Mechanics, Statics
Co-requisites: ENGI 2310 – Computer Programming and Algorithms, MATH 3310 – Differential Equations
Schedule: Two two-hour lectures per week

Course Description: Kinematics and kinetics of particles and rigid bodies. Work and Energy and Impulse and Momentum methods.

Course Objectives†:
1. To develop the student ability to identify, formulate and solve problems of kinematics of particles and rigid bodies. (1, 2)
   1.1. Given the geometry of motion, the student will demonstrate the ability to identify the type of motion and select and adequate reference frame for the analysis of kinematics of particles and rigid bodies. (a, d)
   1.2. Given the geometry of motion and initial and boundary conditions, the student will demonstrate the ability to calculate the position, velocity, and acceleration of particles and rigid bodies. (a, d)
2. To develop the student ability to apply Newton’s law, work and energy, and impulse and momentum methods to solve problems of kinetics of particles and rigid bodies. (1, 2)
   2.1. The student will demonstrate the ability to determine the position, velocity and acceleration of a particle and a rigid body given the forces applied on them using the Newton’s law, conservation of energy principle, and conservation of linear and angular momentum principles. (a, d)
   2.2. The student will demonstrate the ability to determine the resultant force applied on particles and rigid bodies using the Newton’s law, conservation of energy principle, and conservation of linear and angular momentum principles. (a, d)
   2.3. The student will demonstrate the ability to analyze the dynamics of a system of particles. (a, d)
   2.4. The student will demonstrate the ability to analyze the kinematics and kinetics of rigid bodies in inertial and moving reference frames. (a, d)
   2.5. The student will demonstrate the ability to calculate moments and products of inertia. (a, d)
   2.6. The student will demonstrate the ability to analyze impact problems of particles and rigid bodies. (a, d)
3. To develop the student ability to use computational tools in solving dynamics problems of particles and rigid bodies. (1, 2)
   3.1. Student will demonstrate the ability to use computer software such as Excel, MathCad, MATLAB, and Working Model to analyze problems of kinematics and kinetics of particles and rigid bodies and to represent graphically the parameters involved in the problems. (a, d, k, l, o)
4. To develop the students’ ability to work effectively in teams and as individuals. (4)
   4.1. The student will demonstrate the necessary skills to work effectively in teams such as to reinforce and support ideas from others, to encourage open discussion of ideas, and to accept consensus or compromise. (d)
   4.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to tasks. (d)

Topics:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Kinematics of particles. Straight-line Motion. Curvilinear Motion. Polar and Cylindrical Coordinates.</td>
<td>8</td>
</tr>
</tbody>
</table>

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively


9. Exams: Two partial examinations and one comprehensive final exam. 6

Total 46

Instructional Strategies:
Conferences and problem solving sessions will be used to reinforce the learning process. A project will be assigned to groups of students to encourage them to apply the concepts in a practical application and to undergo through the different phases of design, from the conception of ideas to realization.

Required Resources:
Classroom equipped with board and overhead projector. Textbook and scientific calculator for in-class problem solving activities. Computers and computer software such as Excel, MathCad, MATLAB, and Working Model.

Evaluation Strategies:
1. Exams: 65 %. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.
2. Assignments and Quizzes: 10%. Assignments will be due to at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.
3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format. A presentation will be required.
4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

Grading Policy:
The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

Textbook:

References:

Revised by: Prof. Julio Noriega and Dr. Gilmer R. Burgos Date: 09/09/04
Course Title: Fluid Mechanics
Course Code: ENGI 3420
Classification: Engineering Science
Credits: 3
Co-requisite: None
Schedule: Two two-hour lectures per week


Course Objectives†:

1. To develop the students understanding of the fundamentals of fluids. (1, 2)
   1.1. The student will demonstrate the understanding of fluid properties such as density, viscosity and surface tension. (a, e, l, n)
   1.2. The student will demonstrate understanding of concepts of pressure and shear stress in solving fluid flow problems. (a, e, l, n)
   1.3. The student will demonstrate the ability to apply the Newton law of viscosity. (a, e, l, m, n)

2. To develop the students ability to formulate and solve problems of fluids at rest. (1,2)
   2.1. The student will demonstrate the ability to calculate the pressure distribution of fluids at rest (a, e, l, m, n)
   2.2. The student will demonstrate the ability to calculate the forces on flat and curved submerged surfaces. (a, e, l, m, n)
   2.3. The student will demonstrate the ability to calculate the buoyancy force on submerged bodies. (a, e, l, m, n)

3. To develop the students ability to formulate and solve simple fluid flow problems. (1, 2)
   3.1. The student will demonstrate the ability to describe the kinematics of a fluid flow using the concepts of streamlines, pathlines, streaklines, deformation, and vorticity. (a, e, l, m, n)
   3.2. The student will demonstrate the ability to apply Bernoulli’s equation and the limitations in its application. (a, e, l, n)

4. To develop the students ability to formulate and solve fluid flow problems using control volume analysis. (1, 2)
   4.1. The student will demonstrate the ability to obtain a mathematical model of a fluid flow problem by proper use of the conservation equations, constitutive relations, and simplifying assumptions. (a, e, l, m, n, o)
   4.2. The student will demonstrate the ability to apply the control volume formulation for mass, momentum, and energy conservation. (a, e, l, m, n, o)

5. To develop the students ability to construct dimensionless groups and predict a performance of a prototype from a model study. (1, 2)
   5.1. The student will demonstrate the ability to find the independent dimensionless groups that can be formed from a given set of physical variables that depend on each other. (a, e, k, n, o)
   5.2. The student will demonstrate an understanding of the different dimensional groups used in fluid mechanics. (a, e, k, n, o)
   5.3. The student will demonstrate the ability to find size or operating conditions for a model given the requirements for a prototype. (a, e, k, n, o)

6. To develop the students ability to solve simple piping problems. (1, 2)
   6.1. The student will be able to demonstrate the ability to calculate major and minor energy losses. (a, e, k, n, o)
   6.2. The student will be able to demonstrate the ability to solve pipe flow problems. (a, e, k, n, o)

7. To develop the students ability to solve simple fluid mechanics problems using computer software and simply numerical techniques. (1, 2)
   7.1. The student will demonstrate the ability to apply numerical techniques in the solution of fluid flow problems. (a, e, k, o)
   7.2. The student will demonstrate the ability to use computer software to visualize a fluid flow solution. (a, e, k, o)

8. To develop the student ability to work effectively as individuals and in teams. (4)

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively.
8.1. The student will demonstrate the necessary skills to work effectively in teams such as to reinforce and support ideas from others, to encourage open discussion of ideas, accept consensus or compromise. (d)

8.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to tasks. (d)

**Topics:**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Introduction. Fluids, units, fluid properties, compressibility, surface tension.</td>
<td>2</td>
</tr>
<tr>
<td>4. Fluid Kinematics. The velocity field. The acceleration field. Control volume and System representations. The Reynolds Transport Theorem.</td>
<td>4</td>
</tr>
<tr>
<td>8. Open Channel Flow: General Characteristics, Uniform Depth Channel Flow, Rapidly Varied Flow.</td>
<td>4</td>
</tr>
<tr>
<td>9. Examinations: two partial exams, one comprehensive final exam and quizzes.</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
</tr>
</tbody>
</table>

**Instructional Strategies:**

Conferences and problem solving sessions will be used to reinforce the learning process. A project will be assigned to teams of students to encourage them to apply the concepts in a practical application and to undergo through the different phases of design, from the conception of ideas to realization while acquiring team work skills.

**Required Resources:**

Classroom equipped with board and overhead projector. Textbook, scientific calculator, computer and computer software such as Excel, MATLAB, MathCad, and C++.

**Evaluation Strategies:**

1. Exams: 65 %. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.

2. Assignments and Quizzes: 10%. Assignments will be due to at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.

3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three to four students. Partial and final written reports must be submitted according to a professional format. An oral presentation will be required.

4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

**Grading Policy:**

The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

**Textbook:**


**References:**


Revised by Prof. Edwin Ayala and Dr. Gilmer R. Burgos    Date: 09/09/04
POLYTECHNIC UNIVERSITY OF PUERTO RICO
FACULTY OF ENGINEERING
MECHANICAL ENGINEERING DEPARTMENT

Course Title: Fluid Mechanics Laboratory
Course Code: ENGI 3421
Classification: Engineering Science
Credits: 1
Pre-requisite: ENGI 2210 – Engineering Probability and Statistics
Co-requisite: ENGI 3420 – Fluid Mechanics
Schedule: One four-hour laboratory period per week

Course Objectives†:
1. To develop the student’s ability to perform simple experiments for incompressible fluids. (1, 2)
   1.1. Students will demonstrate the ability to operate simple experimental equipment to reinforce their knowledge of fluid mechanics. (a, b, f, n, o)
   1.2. Students will demonstrate the ability to calculate forces on a submerged plane surface. (a, b, n, o)
   1.3. Students will demonstrate the ability to determine the parameters involved in the stability of a floating body. (a, b, n, o)
   1.4. Students will demonstrate the ability to determine the velocity and pressure distribution in a venturi-meter. (a, b, n, o)
   1.5. Students will demonstrate the ability to apply the momentum conservation equation to determine the force exerted by a jet on a plane and a curved surface. (a, b, n, o)
   1.6. Students will demonstrate the ability to measure flow using orifice meters. (a, b, n, o)
   1.7. Students will demonstrate the ability to measure flow in open channels by using weirs of different geometries. (a, b, n, o)
   1.8. Students will demonstrate the ability to calculate the head losses in pipes and accessories. (a, b, n, o)
2. To develop the student’s ability to design and conduct simple experiments in fluid mechanics. (2, 3)
   2.1. Students will demonstrate the ability to design a fluid mechanics laboratory experiment in terms of collecting data, where to take measurements and how many measurements to take. (a, b, n, o)
   2.2. Students will demonstrate the ability to conduct fluid mechanics laboratory experiments properly and safely and describe the procedures they use to conduct those experiments so that others can understand them. (a, b, n, o)
   2.3. Students will demonstrate the ability to measure and record raw experimental data (a, b, n, o)
3. To develop the student’s ability to statistically analyze and interpret experimental data. (3)
   3.1. Students will demonstrate the ability to statistically analyze and interpret experimental data. (b)
   3.2. Students will demonstrate the ability to apply Chauvenet’s Criterion to statistically discard non-meaningful experimental data. (b)
   3.3. Students will demonstrate the ability to represent data in both verbal and visual forms (equations, tables, graphs, figures, etc.) in a way that is both an accurate and an honest reflection of the data. (b, k, o)
4. To develop the student’s ability to work effectively in teams and communicate effectively. (4)
   4.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, and accept consensus or compromise. (d)
   4.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to tasks. (d)
   4.3. Students will demonstrate their ability to make effective oral presentations and laboratory reports using appropriate computer tools. (g, k, o)
   4.4. Students will demonstrate their ability to describe the context of the experiment, describe clearly and precisely the procedures used in the experiment, report verbally and visually the findings, interpret the findings, justify the solutions persuasively, and propose recommendations for the improvement of the laboratory experiment. (g)

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
Topics:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Introduction. Accuracy and Precision. Experimental errors, error and uncertainty analysis, statistical analysis of experimental data.</td>
<td>8</td>
</tr>
<tr>
<td>2. Statistical analysis in the gravimetric flow measurement apparatus.</td>
<td>4</td>
</tr>
<tr>
<td>3. Hydrostatic thrust on a plane surface.</td>
<td>4</td>
</tr>
<tr>
<td>4. Stability of a floating body.</td>
<td>4</td>
</tr>
<tr>
<td>5. Flow through orifices and nozzles.</td>
<td>4</td>
</tr>
<tr>
<td>6. Flow through a Venturi meter.</td>
<td>4</td>
</tr>
<tr>
<td>7. Discharge over weirs.</td>
<td>4</td>
</tr>
<tr>
<td>8. Impact of a jet.</td>
<td>4</td>
</tr>
<tr>
<td>9. Friction losses in pipes and fittings.</td>
<td>4</td>
</tr>
<tr>
<td>10. Presentations</td>
<td>4</td>
</tr>
<tr>
<td>11. Examinations</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
</tr>
</tbody>
</table>

Instructional Strategies:

Students will work in groups consisting in not more than four students. At every laboratory session, students will perform the experiment and present oral and written reports of the previous laboratory experience.

Required Resources:

Laboratory equipped with Gravimetric Hydraulic Bench, Center of pressure apparatus, Stability of a Floating body apparatus, Orifice apparatus, Venturi Meter apparatus, Rectangular and V-notch Weirs, Piping and accessories test rig, Impact of a Jet apparatus. Scientific calculators, computers, and computer programs such as Excel, Word, and PowerPoint is required to perform the data analysis, written report, and presentations. A classroom equipped with board and overhead projector will be used.

Evaluation Strategies:

1. Final Exam: 20 %. A comprehensive individual in-classroom exam will be administered at the end of the term.
2. Laboratory Reports: 50%. An original group report must be submitted for each laboratory experience according to a professional format: title page, abstract, table of contents, list of figures, list of tables, introduction, theory, procedure, results and analysis of results, conclusions, recommendations, references, and appendix.
3. Oral Presentations: 15%. Oral presentations to each group at every laboratory session. A grand presentation will be also required at the end of the term.
4. Portfolio: 10%. Each group will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, lab notes, reports, examinations, presentations, and a free section as described in the Portfolio guidelines. Graded and amended laboratory reports and examinations must be included as evidence of self-improvement.
5. Attendance and participation: 5%. Students must attend all laboratory sessions. Their behavior, participation and attendance will be evaluated and considered for the individual grade of each group member.

Grading Policy:

The following grading scale will be applied: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

Textbook:


References:


Revised by Dr. Gilmer R. Burgos       Date: 09/09/04
**Course Title:** Computer Aided Drafting and Design-CADD  **Course Code:** ME 1210  
**Classification:** Engineering Design  
**Credits:** 3  
**Pre-requisites:** None  
**Co-requisite:** None  
**Schedule:** Two two-hour lecture per week

**Course Description:** Introduction to Computer Aided Drafting and Design. Engineering design process: drafting, solid modeling, dimensioning, and tolerances. Graphics communication in mechanical engineering. 2D and 3D construction, visualization, sketching and standard lettering techniques using freehand tools and CADD. Orthographic Projections. Multi-view drawings for engineering design and production. Basic Dimensioning and Tolerancing.

**Course Objectives**:

1. To develop the student understanding of the role of computer aided design in the design process. (1, 3)
   1.1. The student will demonstrate an understanding of the engineering design process and the role of computers in the design. (e)  
   1.2. The student will demonstrate an understanding of the fundamentals of engineering graphics and visualization and be able to apply them. (a, c, e, k, m, o)  
   1.3. The student will demonstrate the ability to use freehand graphics representation and techniques. (a, c, e, k, m, n, o)  
   1.4. The student will demonstrate the ability to use 2D and 3D computer-based graphics representation and techniques. (a, e, k, m, o)  
   1.5. The student will demonstrate to have a good grasp of the fundamentals of Dimensioning and Tolerancing and be able to use them to represent fairly complex parts and assemblies. (a, c, e, k, m, n, o)

2. To develop the student ability to use computers, software, and as an aid in the mechanical design and manufacture. (1, 2, 3)  
   2.1. The student will demonstrate the ability to use computer software for drafting. (k, o)  

3. To develop the student ability to communicate effectively. (4)  
   3.1. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)  
   3.2. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

**Topics:**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Introduction to Computer-Aided Drafting and Design, CADD. Definitions and Terminology.</td>
<td>2</td>
</tr>
<tr>
<td>2. 2D Sketching Techniques. Relationship Definitions and Parametric studies.</td>
<td>2</td>
</tr>
<tr>
<td>4. Isometric Sketching.</td>
<td>2</td>
</tr>
<tr>
<td>5. Orthographic Projections.</td>
<td>4</td>
</tr>
<tr>
<td>6. 3D Solid Modeling. Elements of Feature-based Modeling of Parts (Extrusions and Cuts, Revolves, Sweeps, Blends).</td>
<td>8</td>
</tr>
<tr>
<td>7. Construction of Patterns. Symmetry and Feature Incompatibility.</td>
<td>2</td>
</tr>
<tr>
<td>8. Multi-views and Auxiliary Views.</td>
<td>6</td>
</tr>
<tr>
<td>9. Assemblies.</td>
<td>6</td>
</tr>
</tbody>
</table>

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
Instructional Strategies
The professor addresses both traditional and computer-based engineering design graphics using a practical approach. Several case studies are discussed each focused on a particular topic such that students can communicate their design intentions appropriately and correctly interpret existing designs. Case studies are developed in a computer environment using the Pro/E solid modeler. Weekly assignments of 2D and 3D applications will be required to practice and excel in using Pro/E.

Several case studies are assigned to students that emphasize on computer-based 2D and 3D representation of engineering graphics concepts and visualization (multi-views, orthographic projections, and graphic communication for manufacturing). The students grouped as multi-disciplinary teams develop mini-projects. All phases of design are considered, from conception to realization, in a computer based environment. Modular design techniques are encouraged to consider.

Required Resources:
Classroom with personal computers, overhead projector, and LCD projector. Pro/E software.

Evaluation Strategies:
1. Exams: 65 %. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.
2. Assignments and Quizzes: 10 %. Assignments will be due to at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.
3. Project: 15 %. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format: title page, abstract, table of contents, list of figures, list of tables, introduction, theory, procedure, results and analysis of results, conclusions, recommendations, references, and appendix.
4. Portfolio: 10 %. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

Grading Policy:
The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).


References:

Prepared by Prof. Eduardo Veras
Revised by Prof. Hebert Jaramillo, Prof. Bernardo Restrepo, and Dr. Gilmer Burgos     Date: 09/09/2004
Course Title: Introduction to Mechanical Engineering  
Course Code: ME 1230
Classification: Engineering Design  
Credits: 3
Pre-requisites: ME 1210-Computer Aided Drafting and Design
Co-requisite: None
Schedule: Two two-hour lectures per week

Course Description: Students are exposed to mechanical engineering design concepts, methods, and techniques early in their career. This course has two main components: an introduction to manufacturing technology using Computer Numerical Controlled Machines (CNC), and an introduction to ON-OFF control using programmable logic controllers (PLC’s). CNC Manufacturing for milling and turning operations, basic operating principles of Programmable Logic Controllers, Relay Ladder Logic (RLL) Diagrams, and integration of PLC programming in the control of mechanical systems will be developed.

Course Objectives†:
1. To develop the student understanding of computer-based manufacturing and modeling techniques. (1, 3)
   1.1. The student will demonstrate the ability to generate the numerical G and M codes for simple Turning and Milling processes. (c, e, k, m, n, o)
   1.2. The student will demonstrate the ability to use a solid modeling program to generate detailed drawings of components. (k, n, o)
   1.3. The student will demonstrate the ability to apply geometric dimensioning and tolerance schemes. (k, n, o)
2. To develop the student understanding of Relay Ladder Logic Diagrams and Programmable Logic Controller programming (1,3)
   2.1. The student will demonstrate the ability to generate Relay Ladder Logic (RLL) Diagrams.
   2.2. The student will demonstrate the ability to program a PLC for controlling a mechanical system.
   2.3. The student will demonstrate the ability to generate timing, counting, and sequencing of simple operations.
3. To develop the student ability to work in teams and communicate effectively. (4)
   3.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, and accept consensus and compromise. (d)
   3.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a real-world problem. (d, e)
   3.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   3.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

Topics:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FIRST COMPONENT OF THE CLASS</strong></td>
<td></td>
</tr>
<tr>
<td>1. Introduction. Scope of Mechanical Engineering and its areas of study. Role in the society and Industry Applications.</td>
<td>2</td>
</tr>
<tr>
<td>2. Parts of a CNC Machine. Definitions and Terminology.</td>
<td>1</td>
</tr>
<tr>
<td>3. Coordinate Reference Systems: Linear and Rotational.</td>
<td>1</td>
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<tr>
<td>4. Basic Operating CNC Principles.</td>
<td>2</td>
</tr>
<tr>
<td>5. CNC Programming and G/M Coding.</td>
<td>2</td>
</tr>
<tr>
<td>6. CNC Milling Programs. G Codes. M codes.</td>
<td>2</td>
</tr>
<tr>
<td>7. CNC Turning Programs. G Codes. M codes</td>
<td>2</td>
</tr>
<tr>
<td>8. Mechanical and Structural Components Manufacturing.</td>
<td>8</td>
</tr>
</tbody>
</table>

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
SECOND COMPONENT OF THE CLASS

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>9.</td>
<td>Parts of a PLC. Definitions and Terminology.</td>
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<tr>
<td>10.</td>
<td>Methods of Control. Relay, Static Logic, Programmable.</td>
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<td>11.</td>
<td>Relay Ladder Logic Diagrams. Basic Programming Rules.</td>
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<tr>
<td>13.</td>
<td>Basic Timers, Counters.</td>
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<tr>
<td>14.</td>
<td>I/O Wiring Connections to a PLC.</td>
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<tr>
<td>15.</td>
<td>Design of PLC control.</td>
</tr>
<tr>
<td>16.</td>
<td>Integration of an Automatic System with Digital Control.</td>
</tr>
</tbody>
</table>

Instructional Strategies:

The class will be split into two multidisciplinary groups. During the first five (5) weeks of the trimester, the first group will focus on the manufacturing of a mechanical device or system using CNC Milling and CNC Turning. At the same time, the second group will focus on the control techniques using programmable logic controllers (PLC's). In the following five (5) weeks of the trimester, the groups switch roles. The last two weeks of the class are dedicated to the integration of PLC programming to control a mechanical device or system fabricated using CNC manufacturing techniques. A fully functional controlled device or system is expected from each group of students in the class. All phases of design are considered; i.e. from conceptual to realization in a computer based environment. Modular design techniques are encouraged to consider. The results of the student's work will be presented orally and using audiovisual hardware provided at the Computer Aided Engineering Laboratory (CAE LAB).

Required Resources:

Personal Computers, Pro/E and CNC Simulation Software, CNC Vertical Milling, CNC Turning Center, Programmable Logic Controllers, Sensors, Transducers and Actuators, MatLab and LabView software.

Evaluation:

5. Exams: 40 %. Two partial exams with a 20%-weight each will be administered.
6. Assignments: 20%. Assignments will be due to at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed.
7. Project: 30%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format: title page, abstract, table of contents, list of figures, list of tables, introduction, theory, procedure, results, and analysis of results, conclusions, recommendations, references, and appendix.
8. Portfolio: 10%. Each group will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

Grading Policy:

The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).


References:


Prepared by Prof. Eduardo Veras and revised by Dr. Gilmer R. Burgos Date: 01/24/2003
Course Title: Computer Programming for Mechanical Engineering  
Course Code: ME 2010  
Classification: Mechanical Engineering  
Pre-requisite: MATH 1340, Pre-Calculus II  
Co-requisite: None  
Credits: 3  
Schedule: Two two-hour lectures per week.

Course Description: This course will introduce the student to computer programming using Matlab and Visual C. Students will develop programs using basic program constructions in both programming languages and will be also able to add built in functions to create nontrivial programs. Weekly programming assignments will be furnished.

Course Objectives†:

1. To provide the students with computer programming skills using Matlab and Visual C. (1, 2, 4, 5)
   1.1. The student will demonstrate the ability to understand the logic and thought process in order to write programs. (a, k, m, o)
   1.2. The student will demonstrate an ability to understand how the commands work and how they may fail. (a, k, m, o)
   1.3. The student will demonstrate the ability to make computer programs in the Matlab and Visual C environments. (a, c, k, m, o)
   1.4. The student will demonstrate the ability to apply Matlab in solving linear algebra problems. (m)
   1.5. The student will demonstrate the ability to present mathematical and scientific material using graphics within the Matlab environment. (a, k, m, o)
   1.6. The student will demonstrate an ability to understand, investigate, and further develop his programming skills. (i)

2. To develop the student ability to work in teams and communicate effectively. (4)
   2.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, and accept consensus and compromise. (d)
   2.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a thermal problem. (d, e)
   2.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   2.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

Topics:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
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</thead>
<tbody>
<tr>
<td>1. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>2. The Matlab Environment</td>
<td>5</td>
</tr>
<tr>
<td>3. Control Flow</td>
<td>6</td>
</tr>
<tr>
<td>4. Functions</td>
<td>2</td>
</tr>
<tr>
<td>5. Structured Data Types</td>
<td>4</td>
</tr>
</tbody>
</table>

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively.
6. File Input and Output
   Opening and closing files, writing formatted output to files, reading formatted data from
   files, writing and reading binary files.

7. Plotting in Matlab
   Basic two dimensional plots; line styles, markers, and colors; plot color, plotting grid,
   the axis command, placing text on a plot, 2-D and 3-D plot types.

8. Basic Elements of Visual C
   The main function and compilation; conditionals and if statements; while, do while, and
   for statements; functions and recursive functions; arrays; pointers; file I/O; structures;
   personal headers.

9. Examinations
   6

Total hours 48

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**Instructional Strategies:**
Lectures will be given in a computer classroom such that the student will be able to practice the commands and the programming instructions in Matlab and C. Programming assignments will be given weekly to reinforce the programming skills and mechanical engineering applications. A design project is assigned to students groups. Partial written and oral reports are required to monitor the students’ progress as well as a final written and oral report.

**Required Resources:** Classroom equipped with board and overhead projector. A laptop and a digital projector are also used for oral presentations and lectures. Computers and Matlab and C software. Textbook.

**Evaluation Strategies:**
1. Exams: 65%. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.
2. Assignments and Quizzes: 10%. Assignments will be due to at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.
3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format. A presentation will be required.
4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

**Grading Policy:**
The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

**Textbook:**

**References:**

Revised by Prof. Hebert Jaramillo and Dr. Gilmer R. Burgos

Date: 09/11/04
Course Title: Applied Numerical Analysis  
Course Code: ME 3010  
Classification: Mathematics with Engineering Applications  
Credits: 3  
Pre-requisites: ENGI 2310 – Computer Programming and Algorithms, Math 3320 – Linear Algebra  
Co-requisite: MATH 3310 – Differential Equations  
Schedule: Two two-hour lectures per week  

Course Objectives†:

1. To develop the students ability to understand and apply numerical techniques to solve mechanical engineering problems. (1)
   1.1. Given different numerical methods for the solution of a problem, the student will demonstrate the ability to establish the limitations, advantages, and disadvantages of these techniques. (a, g, m)
   1.2. The student will demonstrate the ability to formulate a problem, establish the mathematical model and solve the problem using the appropriate numerical method. (a, e, k)
   1.3. Given a nonlinear equation, students will demonstrate the ability to find its roots using the Bisection Method, the False Position Method, the Newton Raphson Method and the Secant Method. (a)
   1.4. Given a set of linear algebraic equations, the student will demonstrate the ability to solve it using Gauss Elimination Method, Gauss Jordan Method, Gauss Seidel Method, LU Decomposition Methods. (a, n)
   1.5. Given a set of nonlinear equations, the student will demonstrate the ability to find the roots using the Newton’ Method. (a, m, n)
   1.6. Given a set of tabular data, the student will demonstrate the ability to calculate the polynomial curve fitting. (a, n)
   1.7. Given a function and an interval, the student will demonstrate the ability to evaluate its integral by Newton-Cotes integration formulas (trapezoid rule, Simpson’s rule), Romberg, and Gauss Quadrature Methods. (a)
   1.8. Given an ordinary differential equation, the student will demonstrate the ability to find its solution using Euler, Heun, Runge Kutta Methods for initial condition problems and using shooting and difference finite methods for boundary value problems. (a, m, n)
   1.9. Given the homogeneous second-order equation of a boundary condition problem with characteristic-values, the student will demonstrate the ability to find the eigenvalues. (a, k, m, n)

2. To develop the students ability to use computer programming to implement numerical techniques. (2, 3)
   2.1. The student will demonstrate the ability to translate a Pseudo-code in a program using C++ and MATLAB. (k)
   2.2. The student will demonstrate the ability to use existent subroutines of a program. (k)
   2.3. The student will demonstrate the ability to use computer software such as Excel to implement numerical techniques. (a, k)
   2.4. The student will demonstrate the ability to develop his own numerical methods software library and apply it in the solution of mechanical engineers problems. (k)

3. To develop the students ability to work in teams and communicate effectively. (4)
   3.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, accept consensus and compromise. (d)
   3.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a problem numerically. (d, e)
   3.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
3.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

**Topics:**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Numerical Computation. Modeling, Round-Off Error, Truncation Error, MATLAB.</td>
<td>4</td>
</tr>
<tr>
<td>4. Curve Fitting. Polynomial and Lagrange Interpolation. Polynomials Least Square Regression.</td>
<td>6</td>
</tr>
<tr>
<td>7. Eigenvalues and Eigenvectors The Characteristic Polynomial. Power Methods.</td>
<td>4</td>
</tr>
<tr>
<td>Examinations</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48</strong></td>
</tr>
</tbody>
</table>

**Instructional Strategies:**
Conference and problem solving sessions to solve mechanical engineering applications using numerical methods. Instruction on the development of computer programs using Excel, Matlab and C++ will be given during the lectures. 

**Required Resources:**
Textbook, scientific calculator, computer, and software such as Excel, C++, and MATLAB will be used. The lectures will be given in a classroom equipped with board and overhead projector as well as computers and computer software.

**Evaluation Strategies:**
1. Exams: 65 %. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.
2. Assignments and Quizzes: 10%. Assignments will be due to at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. Calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.
3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format.
4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

**Grading Policy:**
The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).
Textbook:

References:

Revised by Prof. Ronald M. Sosa, Dr. Hugo Peláez, and Dr. Gilmer Burgos

Date: 09/09/04

Page 126 of 336
Course Title: Thermodynamics I
Course Code: ME 3110
Classification: Engineering Science
Credits: 3
Pre-requisites: ENGI 3420 – Fluid Mechanics
Co-requisites: None
Schedule: Two two-hour lectures per week


Course Objectives†:
1. To develop the students ability to retrieve property data for common gases and pure substances. (1, 2)
   1.1. Students will demonstrate an ability to retrieve property for common gases and pure substances using tables, charts, and computer software. (a, k, n, o)
   1.2. Students will demonstrate an ability to apply the ideal gas model, including the determination of when the model is appropriate. (a, k, l, n)
   1.3. Students will demonstrate an understanding of the different diagrams to represent the states of a substance. (a, k, l, n)
2. To develop the student ability to identify, formulate, and solve problems in classical thermodynamics for both closed and open systems using the First Law of Thermodynamics. (1, 2)
   2.1. Students will demonstrate an understanding of the concepts of work, heat, and energy. (a, e, k, n)
   2.2. Students will demonstrate the ability to identify closed and open systems. (a, e, k, n)
   2.3. Students will demonstrate the ability to apply the conservation of energy to closed systems, appropriately modeling the case at hand, correctly observing sign conventions for work and heat, carefully applying SI and English units, and appropriately using property data. (a, e, k, n)
   2.4. Students will demonstrate the ability to apply the control volume forms of the mass and energy balances to devices at steady state, including nozzles and diffusers, turbines, compressors and pumps, heat exchangers, and other common thermal system components, using appropriate modeling and property data for the case at hand. (a, e, k, n)
   2.5. Students will be able to apply the control volume forms of the mass and energy conservation equations to systems operating under transient conditions, including elementary filling and emptying processes. (a, e, k, n)
3. To develop the student ability to apply entropy and exergy balances. (1, 2)
   3.1. Students will demonstrate an understanding of the concept of entropy, irreversibility, and exergy. (a, e, k, n)
   3.2. Students will be able to apply entropy and exergy balances to different closed systems and control volumes, appropriately modeling the case at hand, correctly observing sign conventions, and appropriately using property data. (a, e, k, n)
4. To develop the student ability to analyze systems involving psychrometric and ideal gas mixtures (1, 2)
   4.1. The student will demonstrate the ability to retrieve property data for non-reacting ideal gas mixtures and psychrometric mixtures using tables, charts, and computer software. (a, e, k, n, o)
   4.2. Students will be able to apply the first and second laws of thermodynamics together with property data to analyze system involving ideal gas mixtures and psychrometric mixtures. (a, e, k, n)
5. To develop the students ability to work in teams and communicate effectively. (4)
   5.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, accept consensus and compromise. (d)
   5.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a thermodynamics problem. (d, e)
   5.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
5.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

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<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
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<tbody>
<tr>
<td>1. Introductory concepts and definitions.</td>
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<tr>
<td>2. Energy and the first law of thermodynamics.</td>
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<tr>
<td>3. Evaluation of properties</td>
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<tr>
<td>4. Control volume energy analysis.</td>
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<tr>
<td>5. Second law of thermodynamics, entropy analysis.</td>
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<tr>
<td>6. Exergy analysis.</td>
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<tr>
<td>7. Ideal gas mixture and psychometrics</td>
<td>6</td>
</tr>
<tr>
<td>8. Examinations and Quizzes</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48</strong></td>
</tr>
</tbody>
</table>

### Instructional Strategies:

Conferences and problem solving sessions will be used to reinforce the learning process. A project will be assigned to teams of students to encourage them to apply the acquired concepts in a practical application and to undergo through the different phases of design, from the conception of ideas to realization.

### Required Resources:

Classroom equipped with board and overhead projector. Textbook, scientific calculator, computer and computer software such as Excel, Word, MathCad, MATLAB, and C++ will be used.

### Evaluation Strategies:

1. Exams: 65%. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.

2. Assignments and Quizzes: 10%. Assignments will be due at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.

3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format: title page, abstract, table of contents, list of figures, list of tables, introduction, theory, procedure, results and analysis of results, analysis of results, conclusions, recommendations, references, and appendix.

4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

### Grading Policy:

The following grading scale will be used: **A** (90-100), **B** (80-89), **C** (70-79), **D** (60-69), **F** (0-59).

### Textbook:


### References:


Revised by Prof. Jacinto L. Solano, Prof. Edwing Ayala, Dr. Hugo Peláez, and Dr. Gilmer R. Burgos Date: 09/09/04
Course Title: Thermodynamics II  
Course Code: ME 4120  
Classification: Engineering Design  
Credits: 3  
Pre-requisites: ME 3110 – Thermodynamics I and ME 3010 – Applied Numerical Analysis  
Co-requisites: None  
Schedule: Two two-hour lectures per week  
Course Description: Vapor and gas power systems. Refrigeration and heat pump systems. Thermodynamics relations. Reacting mixtures and combustion.

Course Objectives†:

1. To develop the student ability to analyze systems involving combustion of hydrocarbon fuels. (1, 2, 3, 5)
   1.1. The student will demonstrate the ability to retrieve property data necessary to apply the first and second law of thermodynamics to reacting systems. (a, e, k, l)
   1.2. The student will demonstrate the ability to apply the first and second law of thermodynamics to reacting systems. (a, e, k, l)
   1.3. The student will demonstrate an awareness of how engineering decisions regarding combustion processes may affect the environment. (a, f, h, j)

2. To develop the student ability to analyze common power cycles. (1, 2, 3, 5)
   2.1. The student will demonstrate the ability to apply the first and second law of thermodynamics to vapor and gas power cycles to determine the power and efficiency. (a, e, k)
   2.2. The student will demonstrate the ability to sketch the vapor and gas power cycles in the different property diagrams. (a, e, k, l)
   2.3. The student will demonstrate an understanding of the different components in a vapor and gas power cycles. (a, e, k)
   2.4. The student will demonstrate an awareness of how engineering decisions regarding power plants may affect the environment. (a, f, h, j)

3. To develop the student ability to analyze refrigeration cycles. (1, 2, 3)
   3.1. The student will demonstrate the ability to apply the first and second law of thermodynamics to refrigeration and heat pump cycles to determine the power required and coefficient of performance. (a, e, k)
   3.2. The student will demonstrate the ability to sketch the refrigeration and heat pump cycles in different property diagrams. (a, e, k, l)
   3.3. The student will demonstrate an understanding of the different components in a refrigeration and heat pump systems. (a, e, k, l)
   3.4. To develop the student ability to apply thermodynamics relations (1, 2, 3)
   3.5. The student will demonstrate the ability to apply equations of state, fundamental thermodynamic functions, the Clapeyron equation, and the Maxwell equations to evaluate thermodynamic properties. (a, e, k, l)

4. To develop the student ability to work in teams, communicate effectively, and apply engineering thermodynamics in a project setting. (1, 4)
   4.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, accept consensus and compromise. (d)
   4.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a thermal system problem. (d, e)
   4.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   4.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

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<thead>
<tr>
<th>Subject</th>
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<tbody>
<tr>
<td>Reacting mixture and combustion.</td>
<td>8</td>
</tr>
<tr>
<td>Vapor power systems.</td>
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<tr>
<td>Gas power systems.</td>
<td>9</td>
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<tr>
<td>Refrigeration systems.</td>
<td>6</td>
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<tr>
<td>Heat pump systems.</td>
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</tr>
<tr>
<td>Thermodynamic Relations</td>
<td>4</td>
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<tr>
<td>Examinations</td>
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<tr>
<td>Quizzes</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48</strong></td>
</tr>
</tbody>
</table>

Instructional Strategies:
Conferences and problem solving sessions will be used to reinforce the learning process. A project will be assigned to teams of students to encourage them to apply the acquired concepts in a practical application while attaining teamwork skills.

Required Resources:
Classroom equipped with board and overhead projector. Textbook, scientific calculator, computer and computer software such as Excel, Word, MathCad, MATLAB, and C++ will be used.

Evaluation Strategies:
1. Exams: 65%. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.
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Grading Policy:
The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

Textbook:

References:

Revised by Prof. Jacinto L. Solano, Prof. Fernando Sulsona, and Dr. Gilmer Burgos Date: 9/11/04
**Course Title:** Intermediate Fluid Mechanics  
**Course Code:** ME 3140  
**Classification:** Engineering Design  
**Credits:** Three (3)  
**Pre-requisite:** ENGI 3420 – Fluid Mechanics, ENGI 3421 – Fluid Mechanics Laboratory, and ME 3010 – Applied Numerical Analysis  
**Co-requisites:** None  
**Schedule:** Two two-hours lectures per week

**Course Description:** Differential analysis of fluid flow. Boundary layer theory. Compressible fluid flow. Turbomachines.

**Course Objectives:**

1. To develop the student ability to apply the conservation equations in differential form to both viscous and non-viscous situations. (1)
   1.1. The student will demonstrate the ability to analyze fluid flow from a differential element or differential control volume perspective both for viscous and non-viscous flows. (a, l, m)
   1.2. The student will demonstrate the ability to work with Reynolds Transport Theorem, Euler’s Equations of Motion and Navier-Stokes Equations. (a, l, m)
   1.3. The student will show the ability to perform hydrodynamic analysis of the boundary layer present in viscous flow. (a, l, m)

2. To develop students ability to apply general engineering knowledge upon design and modeling of compressible and incompressible flow. (1, 2, 3)
   2.1. The student will demonstrate the ability to understand the concepts of Mach number and speed of sound. (a, l, m)
   2.2. The student will demonstrate the ability to analyze the isentropic flow through a variable cross-section area duct. (a, l, m)
   2.3. The student will demonstrate the ability to analyze the non-isentropic adiabatic flow in a constant area duct with friction (Fanno Flow) and the non-isentropic frictionless flow in a constant area duct with heat transfer. (a, l, m)
   2.4. The student will demonstrate the ability to use computer tools as an aid to analyze fluid flow problems. (a, d, e, k, l, n, o)

3. To develop the students ability to understand the principles of turbomachines. (1)
   3.1. The student will demonstrate the ability to perform basic analysis of centrifugal pumps, hydraulic turbines, and compressible flow turbomachines. (a, d, g, n)
   3.2. The student will demonstrate the ability to analyze the system and pump characteristics for proper pump selection. (a, d, g, n)

4. To develop the students ability to work effectively as individuals and in teams and to communicate effectively. (4)
   4.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, accept consensus and compromise. (d)
   4.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a fluid flow problem. (d, e)
   4.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   4.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

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1 Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
Topics:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Differential Analysis of Fluid Flow.</td>
<td>14</td>
</tr>
<tr>
<td>Review of control volume analysis and Reynolds transport theorem; Differential Fluid Element Kinematics; Conservation of Mass from a Differential Control Volume Basis; Conservation of Momentum from a Differential Element Analysis; Inviscid Flow and Euler’s Equations of Motion; Irrotational Flow; Stream Functions and Velocity Potentials; Viscous Flow and Navier-Stokes Equations; Simple Solutions for Viscous, Incompressible Fluids.</td>
<td></td>
</tr>
<tr>
<td>2. Flow Over Immersed Bodies.</td>
<td>8</td>
</tr>
<tr>
<td>General External Flow Characteristics such as Lift and Drag Concepts; Boundary Layers; Drag; Lift.</td>
<td></td>
</tr>
<tr>
<td>3. Compressible Flow.</td>
<td>10</td>
</tr>
<tr>
<td>Ideal Gas Relationships; Mach Number and Speed of Sound; Isentropic Flow of an Ideal Gas; Non-isentropic Flow of an Ideal Gas; Analogy Between Compressible and Open-Channel Flows; Two-Dimensional Compressible Flow.</td>
<td></td>
</tr>
<tr>
<td>4. Turbomachines.</td>
<td>10</td>
</tr>
<tr>
<td>5. Examinations</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
</tr>
</tbody>
</table>

Instructional Strategies:
Conferences and problem solving sessions will be used to reinforce the learning process. A project will be assigned to teams of students to encourage them to apply the concepts in a practical application and to undergo through the different phases of design, from the conception of ideas to realization.

Required Resources:
Classroom equipped with board and overhead projector. Textbook, scientific calculator, computer and computer software such as Excel, MATLAB, and MathCad.

Evaluation Strategies:
1. Exams: 65 %. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.
2. Assignments and Quizzes: 10%. Assignments will be due to at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.
3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format.
4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

Grading Policy:
The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

Textbook:

References:

Revised by: Prof. Jacinto Solano, Prof. Ronald Sosa, and Dr. Gilmer R. Burgos  Date: 9/11/04
Course Title: Mechanism Design
Course Code: ME 3210
Classification: Engineering Design
Credits: 3
Pre-requisites: ENGI 3410 – Engineering, Mechanics, Dynamics, ME 3010-Applied Numerical Analysis
Co-requisites: None
Schedule: Two two-hour lectures per week


Course Objectives†:

1. To develop the student ability to recognize different types of mechanisms such as slider crank mechanisms, four and six bar linkage, cam-follower systems, and spur gear trains. (1)
   1.1. Given a linkage, the student will demonstrate the ability to identify the type of mechanisms and sketch the kinematics diagram. (d, e, g, k)
   1.2. Given a kinematics diagram, the student will demonstrate the ability to determine the mobility of the mechanism. (e, g, k)
2. To develop the student ability to analyze the kinematics and kinetic behavior of mechanisms using graphical and analytical methods. (1, 2)
   2.1. Given a mechanism, the student will demonstrate an ability to calculate the position, velocity, acceleration, and forces of any point on the linkage, applying graphical method. (a, d, l, m, n)
   2.2. Given a mechanism, the student will demonstrate an ability to calculate the position, velocity, acceleration, and forces of any point on the linkage by the analytical method using complex numbers. (a, d, l, m, n)
   2.3. Given the follower position diagram, the student will demonstrate the ability to design a cam mechanism for translating followers. (a, d, l, m, n)
   2.4. Given a gear’s diagram, the student will demonstrate the ability to analyze the kinematics behavior of stationary and planetary gear trains. (a, d, l, m, n)
3. To develop the student ability to use computer tools in mechanism analysis. (1, 2)
   3.1. Given a mechanism diagram, student will demonstrate an ability to build kinematics models of mechanisms using Working Model 2D. (a, g, k)
   3.2. Given a mechanism diagram, student will demonstrate an ability to use computer software such as Design View or AutoCAD to analyze graphically the position, velocity, acceleration, and forces in linkages. (a, g, k, l, n, o)
   3.3. Given a mechanism diagram, student will demonstrate an ability to use computer programs in C++, Excel, or MATLAB to solve the algebraic equations resulting from the analytical method. (a, g, k, l, m, n, o)
4. To improve the student ability to work in teams and communicate effectively. (4)
   4.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, accept consensus and compromise. (d)
   4.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a mechanism problem. (d, e)
   4.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   4.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

Topics:

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<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Graphical Linkage Synthesis. Dimensional Synthesis. Quick Return Mechanisms.</td>
<td>4</td>
</tr>
<tr>
<td>5. Acceleration Analysis. Graphical Acceleration Analysis. Analytical Solutions for Acceleration Analysis.</td>
<td>8</td>
</tr>
<tr>
<td>7. Cam Design. Cam Terminology. Analysis of Cam Follower Motion. Analytical Cam Design.</td>
<td>4</td>
</tr>
<tr>
<td>9. Examinations</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48</strong></td>
</tr>
</tbody>
</table>

**Instructional Strategies:**
Conferences and problem solving sessions will be conducted to reinforce the learning process. A project will be assigned to group of students to encourage them to apply the concepts in a practical application and to undergo through the different phases of design, from the conception of ideas to realization.

**Required Resources:**
Classroom equipped with board and overhead projector. Textbook, scientific calculator, computers, and computer software such as Excel, MATLAB, AutoCAD, and Working Model will be used. Although the listed software is readily available at the department, it is highly suggested that the students get their own licenses.

**Evaluation Strategies:**
1. Exams: 65%. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.
2. Assignments and Quizzes: 10%. Assignments will be due to at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.
3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format: title page, abstract, table of contents, list of figures, list of tables, introduction, theory, procedure, results and analysis of results, conclusions, recommendations, references, and appendix.
4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

**Grading Policy:**
The following grading scale will be used: **A** (90-100), **B** (80-89), **C** (70-79), **D** (60-69), **F** (0-59).

**Textbook:**

**References:**

Revised by Prof. Ronald M. Sosa and Dr. Gilmer R. Burgos Date: 9/11/04
Course Title: Engineering Materials

Course Code: ME 3220

Classification: Engineering Science

Credits: 3

Pre-requisites: SCIE 1220 – General Chemistry II, SCIE 1221- General Chemistry II Laboratory

Co-requisite: None

Schedule: Two two-hour lecture periods per week


Course Objectives†:

1. To develop the students understanding of atomic structure and properties of solid crystalline, non-crystalline, semi-crystalline materials. (1, 2, 3)
   1.1. Students will demonstrate an understanding of atomic structure, bonding, and crystalline structure. (a, l)
   1.2. Students will demonstrate an ability to establish the relations among atomic structure, atomic bonding, and the characteristics of solids materials. (a, e, l)

2. To develop the students ability to compare the behavior of crystalline solids (point, linear, planar, and volume defect) with non-crystalline solids. (1, 2, 3)
   2.1. Students will demonstrate an understanding of the diffusion mechanism and linear, planar, and volume defects in solids. (a, l)
   2.2. Students will demonstrate an ability to identify mechanisms to strengthen metals. (a, e, l)
   2.3. Students will demonstrate an ability to identify the influence of structural defects on alloys formation and mechanical properties. (a, e, l)

3. To develop the students’ understanding of phase diagrams and phase transformation diagrams. (1, 2, 3)
   3.1. Students will demonstrate an understanding of phase diagrams and the ability to predict the thermodynamics composition. (a, e, l)
   3.2. Students will demonstrate the ability to predict the microstructure at different conditions of composition and temperature. (a, e, l)
   3.3. Students will demonstrate the ability to predict the material microstructure and properties by kinetics of transformation. (a, e, l)
   3.4. Students will demonstrate the ability to use the appropriate phase diagram and determine the state, microstructure, and mechanical properties of an alloy. (a, e, l)

4. To develop the student ability to select a material for a specific application based on the structure, mechanical behavior. (1, 2, 3)
   4.1. Students will demonstrate an understanding of the mechanical properties of solid materials. (a, e, k)
   4.2. Students will demonstrate the ability to predict the failure of solids based on the stresses and cracking development. (a, e, l)
   4.3. The student will demonstrate the ability to analyze the reasons for failure of mechanical elements and to propose improved designs. (a, e, l)

5. To develop the student interest in life-long learning. (5)
   5.1. The student will demonstrate an ability to search for information on new and improved materials for engineering applications and to have an awareness of the developments in the field. (i)

6. To develop the students ability to work effectively as individuals and in teams and to communicate effectively. (4)
   6.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, and accept consensus and compromise. (d)
   6.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve an engineering materials problem. (d, e)
   6.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
6.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

**Topics:**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atomic structures</td>
<td>2</td>
</tr>
<tr>
<td>Crystal structure</td>
<td>4</td>
</tr>
<tr>
<td>Imperfections in solids and diffusion</td>
<td>3</td>
</tr>
<tr>
<td>Mechanical properties of metals</td>
<td>3</td>
</tr>
<tr>
<td>Dislocations and strengthening mechanisms</td>
<td>3</td>
</tr>
<tr>
<td>Failure</td>
<td>6</td>
</tr>
<tr>
<td>Phase diagrams</td>
<td>3</td>
</tr>
<tr>
<td>Phase transformation in metals and thermal processing</td>
<td>6</td>
</tr>
<tr>
<td>Structures and properties of ceramics</td>
<td>6</td>
</tr>
<tr>
<td>Polymers and composites</td>
<td>4</td>
</tr>
<tr>
<td>Materials-environment interactions</td>
<td>2</td>
</tr>
<tr>
<td>Examinations</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48</strong></td>
</tr>
</tbody>
</table>

**Instructional Strategies:**

Course lectures and discussion with the students. Current computer software related to the topics will be presented in the lectures. Actual corroded and failed mechanical elements will be analyzed in class and as part of an assigned project. Internet search about materials properties and new materials will be required.

**Required Resources:**

Classroom equipped with board, overhead projector, computer, and LCD projector. The Engineering Materials Laboratory will be used to determine the properties of actual materials. Students are required to use computers for Internet search and the textbook software as a multimedia aid in the learning process.

**Evaluation Strategies:**

1. Exams: 65 %. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.
2. Assignments and Quizzes: 10%. Assignments will be due at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.
3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format: title page, abstract, table of contents, list of figures, list of tables, introduction, theory, procedure, results and analysis of results, conclusions, recommendations, references, and appendix.
4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

**Grading Policy:**

The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

**Textbook:**


**References:**

3. Mary Anne White, Properties of Materials, Oxford University Press, 1999

Revised by Prof. Julio Noriega and Dr. Gilmer R. Burgos Date: 10/31/03
Course Title: Engineering Materials Laboratory  
Course Code: ME 3221  
Classification: Engineering Science  
Credits: 1  
Pre-requisite: ENGI 2210 – Engineering Probability and Statistics  
Co-requisite: ME 3220 – Engineering Materials  
Schedule: One-four hours session per week

Course Description: Hands on experience in metallography, testing of materials, materials characterization, phase diagrams and heat treatment.

Course Objectives:

1. To develop the students’ ability to perform engineering materials experiments. (1,2,3)
   1.1. The student will demonstrate the ability to use the appropriate ASTM Standards in each experiment. (a, b, k, n, o)
   1.2. The student will demonstrate the ability to determine experimentally the yield point, yield strength, tensile strength, resilience modulus, and toughness modulus for metals, polymers, and composites using a universal testing machine. (a, b, k)
   1.3. The student will demonstrate the ability to determine the hardness of a metal using Brinell and Rockwell hardness tester. (b, k, o)
   1.4. The student will demonstrate the ability to evaluate experimentally the influence of the stress concentration factor on the mechanical behavior of a specimen. (a, b, k)
   1.5. The student will demonstrate the ability to operate an impact machine and interpret the materials properties such as resilience and toughness modules for ferrous materials. (a, b, k)
   1.6. The student will demonstrate the ability to determine experimentally the grain size, grain geometry, and phases. (a, b, k)
   1.7. The student will demonstrate the ability to use grinding, polishing and microscopes for specimen preparation. (b, k, o)
   1.8. The student will demonstrate the ability to predict the mechanical properties and microstructure of metals after a heat treatment process using different cooling media, temperatures, and time to promote phase change. (a, b, k, o)

2. To develop the student’s ability to design and conduct simple experiments in engineering materials. (2, 3)
   2.1. The student will demonstrate the ability to design an engineering materials laboratory experiment in terms of collecting data, where to take measurements and how many measurements to take. (a, b, n, o)
   2.2. The student will demonstrate the ability to conduct engineering materials laboratory experiments properly and safely and describe the procedures used to conduct those experiments so that others can understand them. (a, b, n, o, k)
   2.3. The student will demonstrate the ability to measure and record raw experimental data. (a, b, n, o)

3. To develop the student’s ability to statistically analyze and interpret experimental data. (3)
   3.1. Students will demonstrate the ability to statistically analyze and interpret experimental data. (b)
   3.2. Students will demonstrate the ability to apply Chauvenet’s Criterion to statistically discard non-meaningful experimental data. (b)
   3.3. Students will demonstrate the ability to represent data in both verbal and visual forms (equations, tables, graphs, figures, etc.) in a way that is both an accurate and an honest reflection of the data. (b, k, o)

4. To develop the student’s ability to work effectively in teams and communicate effectively. (4)
   4.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, and accept consensus or compromise. (d)
   4.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to tasks. (d)
   4.3. Students will demonstrate their ability to make effective oral presentations and laboratory reports using appropriate computer tools. (g, k, o)
   4.4. Students will demonstrate their ability to describe the context of the experiment, describe clearly and precisely the procedures used in the experiment, report verbally and visually the findings, interpret the findings, justify the solutions persuasively, and propose recommendations for the improvement of the laboratory experiment. (g)

Topics:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tension test</td>
<td>4</td>
</tr>
</tbody>
</table>

Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively.

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2. Hardness test 4
3. Stress concentration factors 4
4. Impact test 4
5. Microstructure 4
6. Heat treatment of steels 12
7. Phase transformations 4
8. Jominy test 4
9. Examinations and presentations 8
Total 48

**Instructional Strategies:**
At every laboratory session, the instructor will conduct a half-hour lecture then a group of students will present the laboratory experience to be performed during that session. PowerPoint presentation is required. Students will perform the laboratory experiments and submit a written and oral report the session after the experiment was carried out. Students groups will consist of four members as a maximum.

**Required Resources:**
Classroom equipped with board, overhead projector, computer, and LCD projector. Laboratory equipped with Universal testing machine, Brinell and Rockwell hardness test machines, impact test machine, low velocity saw, specimen mounting equipment, grinding and polishing workstations, metallographic microscopes, data acquisition systems, and safety equipment. Laboratory manual is required for brief instructions and data collection. Scientific calculator and/or computer with PowerPoint and Word, and Excel are necessary for oral presentations, report writing, and analysis.

**Evaluation Strategies:**
1. Final Exam: 20 %. A comprehensive and individual in-classroom exam will be administered at the end of the term.
2. Laboratory Reports: 50%. An original group report must be submitted for each laboratory experience according to a professional format: title page, abstract, table of contents, list of figures, list of tables, introduction, theory, procedure, results and analysis of results, conclusions, recommendations, references, and appendix.
3. Oral Presentations: 15%. Oral presentations will be prepared by each group and presented at the beginning of each lab session. A grand presentation will be also required at the end of the term.
4. Portfolio: 10%. Each group will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, lab notes, reports, examinations, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected lab reports and examinations must be included as evidence of self-improvement.
5. Attendance and participation: 5%. Students must attend all laboratory sessions. Their behavior, participation and attendance will be evaluated and considered for the individual grade of each group member.

**Grading Policy:**
The following grading scale will be applied: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

**Textbook:**

**References:**

Revised by Prof. Julio Noriega and Dr. Gilmer R. Burgos Date: 9/11/04
Course Title: Engineering Measurements Laboratory  
Course Code: ME 4041  
Classification: Engineering Design  
Credits: 1  
Pre-requisites: ME 3110 – Thermodynamics I, ME 3140 – Intermediate Fluid Mechanics, EE 3020 – Circuit Analysis II  
Co-requisites: None  
Schedule: One four-hour laboratory period per week.

Course Description: Hand on experience in instrumentation, data acquisition, and calibration in fluid and thermal systems, heat transfer, and materials. Emphasis on errors and statistical analysis and team work. Oral and written reports are required.

Course Objectives†:

1. To develop the students’ ability to perform engineering measurements experiments. (1, 2)
   1.1. The student will demonstrate the ability to assemble and calibrate the equipment to perform experiments to measure temperature, pressure, velocity, flow, strain, and vibrations. (a, b, f, k, l, m, n, o)
   1.2. The student will demonstrate the ability to use Lab View software. (k, o)
2. To develop the student’s ability to design and conduct simple experiments in engineering measurements. (2, 3)
   2.1. The student will demonstrate the ability to design engineering measurement laboratory experiments in terms of collecting data, where to take measurements and how many measurements to take. (a, b, n, o)
   2.2. The student will demonstrate the ability to conduct engineering measurements laboratory experiments properly and safely and describe the procedures used to conduct those experiments so that others can understand them. (a, b, n, o)
   2.3. The student will demonstrate the ability to measure and record experimental data using data acquisition systems. (a, b, n, o)
3. To develop the student’s ability to statistically analyze and interpret experimental data. (3)
   3.1. The student will demonstrate the ability to quantify errors in measurements. (b)
   3.2. Students will demonstrate the ability to statistically analyze and interpret experimental data. (b)
   3.3. Students will demonstrate the ability to apply Chauvenet’s Criterion to statistically discard non-meaningful experimental data. (b)
   3.4. Student will demonstrate the ability to represent data in both verbal and visual forms (equations, tables, graphs, figures, etc.) in a way that is both an accurate and an honest reflection of the data. (b, k, o)
4. To develop the student’s ability to work effectively in teams and communicate effectively. (4)
   4.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, and accept consensus or compromise. (d)
   4.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to tasks. (d)
   4.3. Students will demonstrate their ability to make effective oral presentations and laboratory reports using appropriate computer tools. (g, k, o)
   4.4. Students will demonstrate their ability to describe the context of the experiment, describe clearly and precisely the procedures used in the experiment, report verbally and visually the findings, interpret the findings, justify the solutions persuasively, and propose recommendations for the improvement of the laboratory experiment. (g)

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively

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<thead>
<tr>
<th>Subject</th>
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</thead>
<tbody>
<tr>
<td>1. Fundamentals of Mechanical Measurement.</td>
<td>4</td>
</tr>
<tr>
<td>2. Data Acquisition and Processing.</td>
<td>4</td>
</tr>
</tbody>
</table>

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3. Introduction to Lab View. 8
4. Measurements of Temperature. 4
5. Flow Measurements. 4
6. Pressure Measurements. 4
7. Stress - Strain Measurements. 4
8. Vibration Measurements. 4
8. Presentations and discussion of results of laboratories. 8
9. Examinations. 4
10. Total 48

**Instructional Strategies:**
The students will work in groups of not more than four members. Each group is required to perform a weekly presentation of the results of the last laboratory experience. Also each team is required to present the theory, procedure, and calculation of at least two laboratory experiences.

**Required Resources:**
Laboratory equipped with National Instruments data acquisition systems, thermocouples, strain gages, calorimeter equipment, boiler, heat exchanger, and cooling tower, and equipment manuals. Software such as LabView, Mathcad, Excel, PowerPoint, and Word will be used. Classroom equipped with board and overhead projector is also used for presentations.

**Evaluation Strategies:**
1. Exam: 30%. Two exams in classroom of equal weight for 30% of the final grade will be administered. The final exam will cover all the material related to the experiments.
2. Report of Experiments: 40% Experiments will be done in groups. Groups will be composed of four or five students and assistance will be compulsory. There will be no make up experiments. A written report of the experiments with emphasis in statistical analysis of data acquisition must be submitted. The report will be written according to the professional format. An oral presentation is required. Groups will work individually, cheating and or plagiarism is an unethical conduct that will not be tolerated.
3. Task Discussion: 10%. Theory and procedure to perform the experiment. Safety considerations. Data acquisition and equipment to be used. A report that includes objectives of the experiment, experimental setup, procedure, brief theory, and example of calculations must be submitted. A short presentation is also required.
4. Quizzes and laboratory work: 5% Random quizzes will be administered to ensure a continuous learning process. Student participation and good behavior in the laboratory session is highly encouraged.
5. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of four or five students. Partial and final written reports must be submitted according to the professional format.

**Grading Policy:**
The following grade scale: A (90 – 100), B (80 - 89), C (70 – 79), D (60 – 69), F (0 – 59).

**Textbook:**

**References:**

Revised by Prof. Ronald M. Sosa and Dr. Gilmer R. Burgos Date: 9/11/04
Course Title: Heat Transfer I  
Course Code: ME 4130  
Classification: Engineering Design  
Credits: 3  
Pre-requisites: ME 3140 - Intermediate Fluid Mechanics and ME 4120 - Thermodynamics II  
Co-requisites: None  
Schedule: Two two-hour lectures per week


Course Objectives†:

1. To develop the student understanding of the principles of heat transfer. (1, 2)
   1.1. The student will demonstrate the ability to identify the modes of heat transfer: conduction, convection, and radiation. (a, e)
   1.2. The student will demonstrate the ability to identify conductive and radiative properties of materials. (a, e)

2. To develop the student ability to formulate and solve engineering problems involving conduction and radiation heat transfer. (1,2)
   2.1. The student will demonstrate the ability to establish the governing equations for a physical problem involving conduction and radiation heat transfer. (a, e, k, m, n)
   2.2. The student will demonstrate the ability to make appropriate assumptions and select appropriate solution techniques to solve a conduction and radiation heat transfer problem. (a, e, k, m, n)

3. To develop the student ability to use contemporary computer tools to analyze engineering problems involving conduction and radiation heat transfer. (1,2)
   3.1. The student will demonstrate the ability to apply appropriate numerical techniques to solve conduction heat transfer problems. (a, e, k, n, o)
   3.2. The student will demonstrate the ability to use appropriate computer software to analyze conduction and radiation heat transfer problems. (a, e, k, n, o)

4. To develop the student ability to work in teams, communicate effectively, and apply knowledge of heat transfer in a project setting. (1, 4)
   4.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, accept consensus and compromise. (d)
   4.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a heat transfer problem. (d, e)
   4.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   4.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

Topics:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Modes of heat transfer.</td>
<td>2</td>
</tr>
<tr>
<td>2. Introduction to conduction.</td>
<td>5</td>
</tr>
<tr>
<td>3. One-dimensional steady-state conduction.</td>
<td>4</td>
</tr>
<tr>
<td>4. Heat transfer from extended surfaces.</td>
<td>6</td>
</tr>
</tbody>
</table>

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
5. Two-dimensional steady-state conduction. 6  
6. Transient conduction. 6  
7. Radiation: Processes and properties. 6  
8. Radiation exchange between surfaces. 6  
9. Examinations 6  
10. Quizzes 1  
Total  48 

**Instructional Strategies:**  
Conferences and problem solving sessions will be used as a formative learning process. A project will be assigned to teams of students to encourage the application of concepts in a practical problem while acquiring team working skills.

**Required Resources:**  
Classroom equipped with board and overhead projector. Textbook, scientific calculator, computer and computer software such as Excel, MATLAB, MathCad, and C++.

**Evaluation Strategies:**  
1. Exams: 65 %. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom. No make-up exams will be honored.  
2. Assignments and Quizzes: 10%. Assignments will be due at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.  
3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format: title page, abstract, table of contents, list of figures, list of tables, introduction, theory, procedure, results and analysis of results, conclusions, recommendations, references, and appendix.  
4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

**Grading Policy:**  
The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

**Textbook:**  

**References:**  

Revised by Prof. Jacinto L. Solano and Dr. Gilmer R. Burgos Date: 10/31/03
Course Title: Heat Transfer II
Course Code: ME 4140
Classification: Engineering Design
Credits: 3
Pre-requisite: ME 4130 – Heat Transfer I
Co-requisite: None
Schedule: Two two-hour lectures per week


Course Objectives†:

1. To develop the student ability to analyze convection heat transfer problems in internal and external flows. (1, 2)
   1.1. The student will demonstrate the ability to perform an energy balance on a convection heat transfer problem. (a, e)
   1.2. Student will demonstrate the ability to identify the proper form of the convection heat transfer equation. (a, e, m)
   1.3. The student will demonstrate the ability to calculate the heat transfer on a flat plate, a cylinder in cross flow, and across a bank of tubes. (a, e, k)
   1.4. The student will demonstrate the ability to calculate the heat transfer on circular and noncircular tubes. (a, e, k)
   1.5. The student will demonstrate the ability to solve free convection problems. (a, e, m, k)
   1.6. The student will demonstrate understanding of the boiling and condensation problems. (a, e)
   1.7. The student will demonstrate understanding of the diffusion process. (a, e)
2. To develop the student ability to analyze heat exchangers. (1, 2, 3)
   2.1. The student will demonstrate the ability to analyze a heat exchanger using the NTU-effectiveness method. (a, e, k)
   2.2. The student will demonstrate the ability to analyze a heat exchanger using the LMTD method. (a, e, k)
   2.3. The student will demonstrate the ability to design double pipe and shell and tube heat exchangers given data on temperatures and flow rates. (a, c, e, k, n, o)
   2.4. The student will demonstrate the ability to design heat exchanger for use as air coolers, condensers, and evaporators. (a, c, e, k, n, o)
3. To develop the student ability to work in teams, communicate effectively, and apply knowledge of heat transfer in a project setting. (1, 4)
   3.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, accept consensus and compromise. (d)
   3.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a heat transfer problem. (d, e)
   3.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   3.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

Topics:

<table>
<thead>
<tr>
<th>Subject</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1. Introduction to convection</td>
<td>2</td>
</tr>
</tbody>
</table>

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
2. Convection heat transfer equations 5
3. External Flow 6
4. Internal Flow 6
5. Free Convection 6
6. Boiling and condensation 6
7. Heat Exchangers 6
8. Diffusion Mass Transfer 4
9. Examinations and Quizzes 7

Total 48

**Instructional Strategies:**
Conferences and problem solving sessions will be used to reinforce the learning process. A project will be assigned to teams of students to encourage them to apply the concepts in a practical application.

**Required Resources:**
Classroom equipped with board and overhead projector. Textbook, scientific calculator, computer and computer software such as Excel, MATLAB, MathCad, and C++.

**Evaluation:**
1. Exams: 65%. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom. No make-up exams will be honored.
2. Assignments and Quizzes: 10%. Assignments will be due at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.
3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three to four students. Partial and final written reports must be submitted according to a professional format: title page, abstract, table of contents, list of figures, list of tables, introduction, theory, procedure, results and analysis of results, conclusions, recommendations, references, and appendix.
4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

**Grading Policy:**
The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

**Textbook:**

**References:**

Revised by Prof. Jacinto L. Solano and Dr. Gilmer R. Burgos  Date: 10/31/03
Course Title: Solids Mechanics I  
Course Code: ME 4210  
Classification: Engineering Science  
Credits: 3  
Co-requisite: None  
Schedule: Two two-hour lectures per week.


Course Objectives†:
1. To develop the students ability to apply engineering fundamentals to solve solid mechanics problems. (1, 2)
   1.1. The student will demonstrate the ability to determine the stress, strain, and their relations due to bending, torsion, and axial loading over statically determinate systems and statically indeterminate systems. (a, c, e, n)
2. To develop the students ability to use computer tools for calculating stress, strain, and their relations due to bending, torsion, and axial loading over statically determinate systems and statically indeterminate systems. (1, 2, 3, 4)
   2.1. The student will demonstrate the ability to use computer software to calculate stress, strain, and their relations due to bending, torsion, and axial loading over statically determinate systems and statically indeterminate systems. (a, k, o)  
   2.2. The Student will demonstrate the ability to develop computer programs using numerical techniques to calculate stress, strain, and their relations due to bending, torsion, and axial loading over statically determinate systems and statically indeterminate systems. (k, o)
3. To develop the student ability to work in teams, communicate effectively, and apply knowledge of solid mechanics in a project setting. (1, 4)
   3.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, accept consensus and compromise. (d)
   3.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a solid mechanics problem. (d, e)
   3.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   3.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

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<tr>
<th>Subject</th>
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<tbody>
<tr>
<td>2. Axially loaded members. Introduction, Changes in lengths of axially loaded members and nonuniforms bars, Statically indeterminate structures, Thermal effects, misfits and prestrains. Stress concentration.</td>
<td>6</td>
</tr>
<tr>
<td>3. Torsion. Introduction, Torsional deformation of a circular bar, circular torsion of linearly elastic materials, nonuniform torsion, stresses and strain in pure shear, relation between E and G, Transmission of power, Statically indeterminate torsional members, strain energy and torsion in pure shear. Thin walled tubes, stress concentration in torsion.</td>
<td>6</td>
</tr>
<tr>
<td>4. Shear forces and bending moments. Introduction, Types of beam loads, and reactions, shear force and bending moments, Relations between loads, shear forces and bending moments, Shear-force and bending-moment diagrams.</td>
<td>4</td>
</tr>
<tr>
<td>5. Stresses in beams, Introduction, Pure bending and non-uniform bending, Curvature of a beam, Longitudinal strains in beams, Normal stresses in beams, Design of beams for bending stresses, Non-prismatic beams, shear stresses in beams of rectangular and circular cross sections, Shear stresses in the webs of beams with flanges. Built-Up Beams and shear flow, beams with axial loads, Stress concentration in bending.</td>
<td>6</td>
</tr>
</tbody>
</table>

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively

7. Deflections of beams, Differential equations of the deflection curve, Deflection by integration of the bending-moment equation and the shear force and load equations, Method of superposition, Moment-area method, Non-prismatic beams, Strain energy of bending, Castigliano theorem.

8. Columns, Buckling Instability: columns with pinned ends and other support conditions, Eccentric loading, The secant formula for columns, design formulas for columns.

9. Examinations

Total 48

Instructional Strategies:
Conferences and problem solving sessions will be used to reinforce the learning process. A project will be assigned to teams of students to encourage them to apply the concepts in a practical application.

Required Resources:
Classroom equipped with board, overhead projector, computer, and LCD projector. Textbook, scientific calculator, computer and computer software such as Excel, MATLAB, and MathCad.

Evaluation Strategies:
5. Exams: 65 %. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.

6. Assignments and Quizzes: 10%. Assignments will be due at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.

7. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format: title page, abstract, table of contents, list of figures, list of tables, introduction, theory, procedure, results and analysis of results, conclusions, recommendations, references, and appendix.

8. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

Grading Policy:
The following grading scale will be applied: A (90-100), B (80-89), C (70-79), D (60-60), and F (0-59).

Textbook:

References:

Revised by Prof. Hebert Jaramillo, Prof. Julio Noriega, and Dr. Gilmer R. Burgos Date: 9/11/04
Course Title: Solids Mechanics II
Course Code: ME 4220
Classification: Engineering Design
Pre-requisite: ME 4210 – Solid Mechanics I
Course Objectives†:
1. To develop the student ability to apply engineering fundamentals for determining stress-strain. (1,2)
   1.1. The student will be able to demonstrate the ability to evaluate stress and strain for various types of loading. (a, c)
   1.2. The student will be able to demonstrate the ability to calculate principal stresses and safety factors using failures theories. (a, c)
   1.3. The student will be able to solve simple solid mechanics problems using finite elements. (a, c)
   1.4. To develop the student ability to use computer tools for calculating the effects of loads over structures. (1,2,3,4)
   1.5. The student will be able to demonstrate the ability to use computer software as an aid in designing simple elements (k, o)
2. To develop the student ability to work in teams, communicate effectively, and apply knowledge of solid mechanics in a project setting. (1, 4)
   2.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, accept consensus and compromise. (d)
   2.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve solid mechanics problem. (d, e)
   2.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   2.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

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<th>Subject</th>
<th>Time (hours)</th>
</tr>
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<tbody>
<tr>
<td>Analysis of Stress and Strain</td>
<td>10</td>
</tr>
<tr>
<td>Introduction, Plane stress, Principal stresses and Maximum shear stress, Mohr’s circle for plane stress, Hook’s Law for Plane stress, Tri-axial stress, Plane strain.</td>
<td></td>
</tr>
<tr>
<td>Applications of Plane Stress (Pressure Vessels, Beams), and Combined Loading.</td>
<td>8</td>
</tr>
<tr>
<td>Spherical Pressure Vessels, Cylindrical Pressure Vessels, Maximum stresses in Beams, Combined Loadings.</td>
<td></td>
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<tr>
<td>Statically Indeterminate Beams</td>
<td>6</td>
</tr>
<tr>
<td>Finite Element Method</td>
<td>6</td>
</tr>
<tr>
<td>Addressing Uncertainty</td>
<td>4</td>
</tr>
<tr>
<td>Failure Resulting from Static Loading.</td>
<td>8</td>
</tr>
</tbody>
</table>

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively.
**Instructional Strategies:** Conferences and problem solving sessions will be used to reinforce the learning process. Students use computer software to implement and apply the techniques learnt in class. A design project is assigned to students groups. Partial written and oral reports are required to monitor the students’ progress as well as a final written and oral report.

**Required Resources:** Classroom equipped with board and overhead projector. A laptop and a digital projector will also be used for oral presentations and lectures.

**Evaluation Strategies**
1. Exams: 65 %. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.
2. Assignments and Quizzes: 10%. Assignments will be due to at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.
3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format. A presentation will be required.
4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

**Grading Policy:**
The following grading scale will be used: **A** (90-100), **B** (80-89), **C** (70-79), **D** (60-69), **F** (0-59).

**Textbook:**

**References:**

Revised by: Prof. Hebert Jaramillo and Dr. Gilmer R. Burgos    Date: 09/11/04
Course Title: Design of Machine Elements I
Course Code: ME 4230
Classification: Engineering Design
Pre-requisite: ME 4220 – Solid Mechanics II
Co-requisite: None
Schedule: Two two-hour lectures per week.


Course Objectives†:
1. To develop the student ability to apply engineering fundamentals to analyze and design mechanical components to meet desired requirements. (1, 2)
   1.1. The student will demonstrate the ability to determine failures due to static loading while considering stress concentrations. (a, c)
   1.2. The student will demonstrate the ability to determine failure for cyclic loading while considering the fatigue strength and the logarithm of the number of cycles to failure. (a, c)
   1.3. The student will demonstrate the ability to analyze the forces and torques of a power screw to raise and lower a load. (a, c)
   1.4. The student will demonstrate the ability to determine the load and stiffness of a bolt and joint for both static and dynamic conditions. (a, c)
   1.5. The student will demonstrate the ability to analyze riveted and threaded fasteners in shear. (a, c)
   1.6. The student will demonstrate the ability to design welded fasteners using various types of loading conditions. (a, c)
   1.7. The student will demonstrate the ability to understand the hydrodynamic lubrication theory and to apply it in bearing design. (a, c)
   1.8. The student will demonstrate the ability to select appropriately rolling-element bearings upon the loading conditions. (a, c)
2. To develop the student ability to select, configure, and synthesize mechanical components into a complete system. (1, 2, 3, 4)
   2.1. The student will demonstrate the ability to apply the fundamentals of machine design to design a system to meet desired needs. (c)
   2.2. To develop the student creativity to devise useful machines components in an economical way while considering the impacts on society. (h)
   2.3. To develop the student ability to use modern computer tools in the analysis and design of machine elements. (k, o)
3. To develop the student ability to work in teams, communicate effectively, and apply knowledge of machine design in a project setting. (1, 4)
   3.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, accept consensus and compromise. (d)
   3.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a machine design problem. (d, e)
   3.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   3.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

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<tr>
<td>1. Failure resulting from Variable Loading.</td>
<td>10</td>
</tr>
<tr>
<td>2. Screw, Fasteners, and the Design of Nonpermanent Joints.</td>
<td>8</td>
</tr>
</tbody>
</table>

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively


7. Examinations

| Instructional Strategies: |
| Conference and problem solving sessions. Use of computers and computer software to implement the concepts in the solution of engineering applications. A design project is assigned to students groups. Partial written and oral reports are required to monitor the students’ progress as well as a final written and oral report. |

| Required Resources: |
| Classroom equipped with board and projector. A laptop and a digital projector are also used for oral presentations and as needed for lectures. |

| Evaluation Strategies: |
| Exams: 65 %. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom. |

| Assignments and Quizzes: 10%. Assignments will be due to at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process. |

| Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format. A presentation will be required. |

| Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement. |

| Grading Policy: |
| The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59). |

| Textbook: |

| References: |


Revised by Prof. Hebert Jaramillo, Prof. Julio Noriega, and Dr. Gilmer R. Burgos Date: 09/11/04
Course Title: Machine Design Elements II
Classification: Engineering Design
Pre-requisite: ME 4230 – Design of Machine Elements I
Course Description: Design of machine elements: Spur, helical, bevel, and worm gears; shafts, clutches and brakes, belts, chains, hydrodynamic drives. Static and dynamic loading conditions, application of failure theories, selection of flexible power transmission elements.

Course Objectives†:
1. To develop the student ability to apply engineering fundamentals to analyze and design mechanical components to meet desired requirements. (1, 2, 3)
   1.1. The student will demonstrate the ability to design spur and helical gears while considering kinematics, loads, and stresses. (a, c, e)
   1.2. The student will demonstrate the ability to determine when and where failure will occur in gears. (a, c, e)
   1.3. The student will demonstrate the ability to analyze the loading on a shaft while considering various combinations of bending, torsion, and axial or transverse shear. (a, c, e)
   1.4. The student will demonstrate the ability to analyze shaft dynamics and first critical speed and determine resonance. (a, c, e)
   1.5. The student will demonstrate the ability to design clutches and brakes that have the common feature of storing and/or transferring rotating energy. (a, c, e)
   1.6. The student will demonstrate the ability to determine torque transmitted relative to the actuating force, coefficient of friction, and the geometry of the clutch or brake. (a, c, e)
   1.7. The student will demonstrate the ability to design belts and chains such that they provide a convenient means of transferring required length, power from one shaft to another. (a, c, e)

2. To develop the student ability to select, configure, and synthesize mechanical components into a complete system. (1, 2, 3, 4)
   2.1. The student will demonstrate the ability to apply the fundamentals of machine design to design a system to meet desired needs. (c)
   2.2. To develop the student creativity to devise useful machines components in an economical way while considering the impacts on society. (h)
   2.3. To develop the student ability to use modern computer tools in the analysis and design of machine elements. (k, o)

3. To develop the student ability to work in teams, communicate effectively, and apply knowledge of machine design in a project setting. (1, 4)
   3.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, accept consensus and compromise. (d)
   3.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a machine design problem. (d, e)
   3.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   3.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

Topics:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gearing-General.</td>
<td>4</td>
</tr>
<tr>
<td>2. Spur and Helical gears.</td>
<td>10</td>
</tr>
</tbody>
</table>

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively

3. Bevel and Worm Gears.

4. Clutches, Brakes, Couplings and Flywheels

5. Flexible mechanical elements


7. Examinations
   Total 48

Instructional Strategies:
Conference and problem solving sessions. Analysis of the kinematics and dynamics of actual mechanical elements will be performed in class. Computer software for kinematics and dynamics analysis of elements will be used. Selection of various elements using Catalogs from different manufacturers.

Required Resources:

Evaluation Strategies:
1. Exams: 65 %. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.
2. Assignments and Quizzes: 10%. Assignments will be due at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.
3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format. A presentation will be required.
4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

Grading Policy:
The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

Textbook:

References:
POLYTECHNIC UNIVERSITY OF PUERTO RICO
FACULTY OF ENGINEERING
MECHANICAL ENGINEERING DEPARTMENT

Course Title: Manufacturing Engineering  
Course Code: ME 4240
Classification: Engineering Design  
Credits: 3
Pre-requisite: ME 4220 – Solid Mechanics II  
Co-requisite: None
Schedule: Two-two hour lecture periods per week


Course Objectives†:

1. To develop the student understanding of manufacturing processes and their impact on society and the environment. (1, 3, 5)
   1.1. Students will demonstrate an understanding of the different manufacturing methods, as well as their limitations, advantages and their impact on society and the environment. (a, h, l, n)
   1.2. Students will demonstrate ability to search for new information on manufacturing processes. (i)

2. To develop the student ability to select a manufacturing process based on materials properties, mechanical behavior, reliability, and cost. (1, 3)
   2.1. Students will demonstrate the ability to select the most appropriate manufacturing method based on the specific application. (a, c, e, j, k, n)
   2.2. Students will demonstrate the ability to design a manufacturing process, calculate process parameters, and select appropriate tools. (a, c, e, j, k, n)
   2.3. Students will demonstrate the ability to calculate manufacturing costs. (a, k, n)

3. To develop the student ability to calculate parameters for metal cutting, casting, forming, and shaping processes. (1, 2, 3)
   3.1. Students will demonstrate the ability to formulate mathematical models for metal cutting, casting, forming, and shaping processes. (a, e, l, m, n, o)
   3.2. Students will demonstrate the ability to make appropriate assumptions to simplify the mathematical models and obtain analytical solutions. (a, e, l, m, n, o)
   3.3. Students will demonstrate ability to use computers and software as an aid to solve manufacturing problems. (k, o)

4. To develop the student ability to work in teams, communicate effectively, and apply knowledge of manufacturing engineering in a project setting. (1, 4)
   4.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, accept consensus and compromise. (d)
   4.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a manufacturing problem. (d, e)
   4.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   4.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

Topics: Subject Time (hours)

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
1. Introduction. Fundamentals of casting 4
2. Metal-casting processes, design, materials and economics 4
3. Rolling, forging, extrusion, drawing of metals, sheet metal forming 6
4. Forming and shaping plastics and composite materials 2
6. Welding processes, metallurgy of welding 4
7. Brazing, soldering, adhesive bonding and mechanical fastening 2
8. Surface technology. Cleaning, coating, treatments 2
9. Engineering Metrology and instrumentation 1
10. Quality assurance, testing and inspection 2
11. Human factors, safety, and product liability 1
12. Examinations 6

Total 48

Instructional Strategies:
Conference, Discussion, Working Groups, Special Project, Homework, Quizzes and Presentations

Required Resources:
Classroom equipped with board and overhead projector. Computer, Calculators, and computer software such as PowerPoint, Excel, Word, Mathcad will be used.

Evaluation Strategies:
1. Exams: 65 %. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.
2. Assignments and Quizzes: 10%. Assignments will be due to at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.
3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of two to four students. Partial and final written reports must be submitted according to a professional format. A presentation will be required.
4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

Grading Policy:
The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

Textbook:
ISBN 0201361310.

References:

Revised by: Prof. Carlos Miró and Dr. Gilmer Burgos
Date: 09/11/04
Course Title: Manufacturing Engineering Laboratory  
Course Code: ME 4241  
Classification: Engineering Design  
Credits: 1

Pre-requisite: ME 4220 – Solid Mechanics I  
Co-requisite: ME 4240 – Manufacturing Engineering  
Schedule: One four-hour laboratory period per week.

Course Description: Hands on experiences on a variety of techniques and processes for the manufacturing of engineering components including, operation of machine tools and welding machines. Prototypes are designed and manufactured by teams under the guidance of the instructor.

Course Objectives†:
1. To develop the student understanding of the fundamentals of manufacturing processes for engineering materials. (1,2,3)
   1.1. The student will demonstrate an understanding of the fundamentals of manufacturing processes. (a, h, l, n)
   1.2. The student will demonstrate the ability to design appropriate manufacturing processes for prototyping design and fabrication. (a, c, e, k, o)
   1.3. Students will demonstrate the ability to prepare, read, and interpret mechanical drawings. (a, c, k, n, o)
   1.4. The student will demonstrate the ability to operate safely a lathe, milling and welding machines. (k, n)
2. To develop the student’s ability to statistically analyze and identify errors in mechanical measurements. (3)
   2.1. The student will demonstrate the ability to perform mechanical measurements with precision. (k, n)
   2.2. The student will demonstrate the ability to statistically analyze mechanical measurement data and to interpret the results. (b)
3. To develop the student’s ability to work effectively as individuals and in teams and to communicate effectively. (4)
   3.1. The student will demonstrate the ability to work effectively as individuals and in teams to accomplish assigned goals. (d)
   3.2. The student will demonstrate the ability to make oral presentations and to write effective technical reports using appropriate computer tools. (g)

Topics:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Introduction to safety rules and regulations: OSHA, MSDS, and Machine Shop general safety rules.</td>
<td>4</td>
</tr>
<tr>
<td>3. Blue Printing readings: Surface Finishing Dimensioning and Tolerances.</td>
<td>4</td>
</tr>
<tr>
<td>4. Cutting Tool Selection: Tool Materials, Cutting Angles, Tool Life, Chip Formation.</td>
<td>4</td>
</tr>
<tr>
<td>5. Lathe Operations: Orthogonal Cutting, Lathe Process, Operation Forces, Speed and Feeds.</td>
<td>8</td>
</tr>
<tr>
<td>7. Welding Procedures: Gas Welding, Arc Welding, Soldering and Brazing.</td>
<td>8</td>
</tr>
<tr>
<td>8. Final examination</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
</tr>
</tbody>
</table>

Instructional Strategies:
Conference, discussion, hands on practice, teamwork. A special project will be assigned.

Required Resources:

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
Evaluation Strategies:
1. Exams: 60%. Four-partial exams with a 10% - weight each and a comprehensive final exam with a 20 % - weight. Exams will be administered individually and in-classroom.
2. Design Project: 15%. An original group report must be submitted for the prototyping design project according to a professional format.
3. Oral Presentation: 10%. An oral presentation will be prepared by each group and presented at the end of the term.
4. Portfolio: 10%. Each student’s group will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, laboratory notes reports, examinations, presentations, and a free section as describe in the in the portfolio guide lines.
5. Attendance and Participation: 5%. Student must attend all laboratory sessions. Their behavior, participation and attendance will be evaluated and considered for the individual grade of each group member.

Grading Policy:
The following grading scale will be applied: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59)

Textbook: None

References:

Revised by Prof. Angel L. Carreras and Dr. Gilmer R. Burgos

Date: 09/11/04
Course Title: System Dynamics and Controls  
Course Code: ME 5050  
Classification: Engineering Design  
Credits: 3  
Pre-requisites: ME 4041 – Engineering Measurements Laboratory, ME 4140 – Heat Transfer II, ME 4220 – Solid Mechanics II  
Co-requisite: None  
Schedule: Two two-hours lectures per week.

Course Description: Laplace transforms. Mathematical modeling of mechanical, electrical, thermal, and fluid systems. Linear system analysis. Stability.

Course Objectives†:
1. To develop the student ability to model, analyze and predict the dynamic behavior of mechanical, electrical, fluid and thermal systems. (1, 2, 3)
   1.1. The student will demonstrate the ability to determine the mathematical relationship between force and motion, derive the transfer function and frequency response, and establish the governing differential equations given schematics of spring, mass, and damper elements. (a, e)
   1.2. The student will demonstrate the ability to determine the mathematical relationship between current and voltage, derive the transfer function and frequency response, and establish the governing differential equations given schematics of resistor, inductor, capacitor, and operational amplifier elements. (a, e)
   1.3. The student will demonstrate the ability to determine the mathematical relationship between flow and pressure, derive the transfer function and frequency response, and establish the governing differential equations given schematics of fluid flow and heat transfer problems. (a, c)
2. To develop the student ability to design simple mechanical, electrical, fluid and thermal systems to meet specified dynamic performance criteria. (1, 2, 3)
   2.1. The student will demonstrate the ability to use Matlab/Simulink to simulate the dynamic system behavior of first and second order systems. (a, c, k, n, o)
   2.2. The student will demonstrate the ability to design a second-order system that meets the performance requirements and satisfies the design constraints. (a, c, e, k, n, o)
3. To develop the student ability to formulate and manipulate control system block diagrams. (1, 2, 3)
   3.1. The student will demonstrate the ability to formulate closed and open loop block diagrams for a system. (a, c)
   3.2. The student will demonstrate the ability to determine reference input transfer functions and disturbance input transfer functions given a system block diagram. (a, c)
   3.3. The student will demonstrate the ability to determine the transfer function of a PID-type of cascade controller. (a, c)
4. To develop the student ability to analyze the steady and transient performance of feedback control systems. (1, 2, 3)
   4.1. The student will demonstrate the ability to describe control system performance in terms of its time domain response to standard inputs such as step, ramp, and impulse. (a, c)
   4.2. The student will demonstrate the ability to determine open loop and closed loop frequency responses for control systems. (a, c)
   4.3. The student will demonstrate the ability to relate open loop frequency response measures to system performance characteristics such as stability and speed of response. (a, c)
   4.4. The student will demonstrate the ability to relate closed loop frequency response measures to system performance characteristics. (a, c)
5. To develop the student ability to understand the characteristics of different control modes. (1, 2, 3)
   5.1. The student will demonstrate the understanding of the tradeoffs in using the proportional-integral, and derivative control modes. (a, c)
   5.2. The student will demonstrate the ability to tune PID controllers. (a, c)
6. To develop the student ability to use both graphical and analytical approaches to control system analysis. (1, 3)
   6.1. The student will demonstrate the ability to analyze the stability of closed loop systems using the root locus and Routh’s stability criterion. (a, c)
   6.2. The student will demonstrate the ability to sketch the root locus, Nyquist, and Bode plots by hand as well as to plot them using Matlab and to analyze the stability of closed loop systems using the Nyquist and Bode plots. (a, c, k, o)
   6.3. The student will demonstrate the ability to design control systems using the Root Locus, Nyquist, and Bode Plots.
7. To develop the student ability to work in teams and communicate effectively. (4)
   7.1. The student will demonstrate the necessary skills to work effectively in teams. (d)
   7.2. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
### Topics:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The Laplace Transform: Introduction, Complex numbers, Complex Variables, and Complex Functions, Laplace Transformation, Inverse Laplace Transformation, Partial-Fraction Expansion with MATLAB, Solving Linear, Time-Invariant, Differential Equations.</td>
<td>4</td>
</tr>
<tr>
<td>7. PID Controls. Tuning Rules for PID Controllers. Computational Approach to Obtain Optimal Sets of Parameter Values. Modifications of PID Control Schemes.</td>
<td>6</td>
</tr>
<tr>
<td>8. Examinations</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48</strong></td>
</tr>
</tbody>
</table>

### Instructional Strategies:
Conference and problem solving sessions. Computer based modeling using Matlab/Simulink is emphasized. A design project is assigned to students groups. Partial written and oral reports are required to monitor the students’ progress as well as a final written and oral report.

### Required Resources:
Classroom equipped with board and overhead projector. A laptop and a digital projector will be also used for student oral presentations and as needed for lectures. Personal Computers and Matlab/Simulink software are available at the institution; however, it is highly suggested that the students acquire their own as well as the textbook and a graphics calculator.

### Evaluation Strategies:
9. **Exams:** 65%. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered.
10. **Assignments and Quizzes:** 10%. Assignments will be due to at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.
11. **Project:** 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format.
12. **Portfolio:** 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

### Grading Policy:
The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

### Textbook:

### References:

Revised by: Prof. Hebert Jaramillo, and Dr. Gilmer R. Burgos

Date: 09/13/04

Page 159 of 336
Course Title: Design of Thermal Systems  
Course Code: ME 5150  
Classification: Engineering Design  
Credits: 3  
Pre-requisites: ME 4140 – Heat Transfer II, ENGI 4210 – Engineering Economics  
Co-requisite: None  
Schedule: Two two-hour lectures per week  

Course Description: Integrated concepts to analyze, simulate, and design energy systems. System economics, and design optimization are covered. A design project is required.

Course Objectives†:

1. To develop a student’s ability to analyze, design, and optimize thermal systems. (1, 2, 3)
   1.1. The student will demonstrate the ability to analyze piping networks that includes accessories, pumps, and heat exchangers. (a, e, k, n, o)
   1.2. The student will demonstrate the ability to analyze appropriately heat exchangers and power and refrigeration cycles. (a, e, k, n, o)
   1.3. The student will demonstrate the ability to represent mathematically property and performance data represented in tables and graphics. (a, e, k, m, o)
   1.4. The student will demonstrate the ability to establish a mathematical model to simulate a thermal system. (a, e, k, n, m, o)
   1.5. The student will demonstrate the ability to formulate appropriately a thermal optimization problem by defining the objective function and the constraint(s) based on the physics of the problem. (a, e, k, n, o)
   1.6. The student will demonstrate the ability to apply analytical and numerical techniques to solve a thermal optimization problem. (a, c, e, k, m, n, o)
   1.7. The student will demonstrate the ability to apply economic considerations on thermal design. (a, c, e)
   1.8. The student will demonstrate the ability to design a thermal system in a project setting. (a, c, e, h, i, j, k, n, o)

2. To develop a student’s ability to write efficient computer programs to simulate and optimize thermal systems (2, 3)
   2.1. The student will demonstrate the ability to write efficient computer programs to analyze, simulate, and optimize thermal systems using algebraic programs such as Mathcad and Matlab. (k, o)

3. To develop the student ability to work in teams and communicate effectively. (4)
   3.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, and accept consensus and compromise. (d)
   3.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a thermal problem. (d, e)
   3.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   3.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
Topics:

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<tr>
<th>Subject</th>
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</tr>
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<tbody>
<tr>
<td>1. Introduction.</td>
<td>2</td>
</tr>
<tr>
<td>2. Head-loss representation. Friction Factor and minor losses. Piping networks</td>
<td>4</td>
</tr>
<tr>
<td>3. Hardy-Cross Method. Generalized Hardy-Cross Analysis. Hardy-Cross Programs using MathCad.</td>
<td>8</td>
</tr>
<tr>
<td>4. Heat exchangers</td>
<td>6</td>
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<tr>
<td>5. Pumps</td>
<td>6</td>
</tr>
<tr>
<td>6. Steady state simulations</td>
<td>8</td>
</tr>
<tr>
<td>7. Optimization. Lagrange multiplier method.</td>
<td>8</td>
</tr>
<tr>
<td>8. Examinations</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48</strong></td>
</tr>
</tbody>
</table>

Instructional Strategies:
Conference and problem solving sessions will be used. The course will emphasize on modeling thermal systems using conservation equations and constitutive equations that represent the actual behavior of equipment and accessories. Computers and computer software such as Excel, MathCad, and Matlab will be used as an aid in simulating and optimizing thermal systems. This course is the umbrella of several other courses that include Fluid Mechanics, Intermediate Fluid Mechanics, Thermodynamics I, Thermodynamics II, Heat Transfer I, Heat transfer II as well as Applied Numerical Analysis and all the mathematics courses in the curriculum, it is highly recommended that the student revisit the appropriate material when needed.

Required Resources:
Textbook, scientific calculator, computer, and computer software such as Excel, MathCad and Matlab. Although computers and software are readily available at the school, it is highly suggested that the students get a computer and the appropriate software licenses.

Evaluation Strategies:
1. Exams: 65 %. Two partial exams with a 20%-weight each and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each student. Therefore, they will be administered individually and in-classroom.
2. Assignments and Quizzes: 10%. Assignments will be due at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.
3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format: title page, abstract, table of contents, list of figures, list of tables, introduction, theory, procedure, results and analysis of results, conclusions, recommendations, references, and appendix.
4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement.

Grading Policy:
The following grading scale will be used: **A** (90-100), **B** (80-89), **C** (70-79), **D** (60-69), **F** (0-59).

Textbook:

References:

Revised by Dr. Gilmer R. Burgos       Date: 09/13/04
Course Title: Thermal Engineering Laboratory  
Course Code: ME 5151  
Classification: Engineering Design  
Credits: 1  
Pre-requisites: ME 4041 – Engineering Measurements Laboratory, ME 4140-Heat Transfer II  
Co-requisite: None  
Schedule: One four-hour laboratory period per week.

Course Description: Experimental analysis of fluid and thermal systems such as heat exchanger, steam generators, cooling towers, refrigeration and air conditioning systems, wind tunnel, compressible fluid flow and turbomachinery. Oral and written reports are required.

Course Objectives†:

1. To develop the student’s ability to design and conduct experiments with thermal equipment. (1, 2, 3)
   1.1. The student will demonstrate an ability to establish a mathematical model for the experiment at hand and relate the experimental data to the model. (a, e, k, n, o)
   1.2. The student will demonstrate an ability to describe the equipment and perform the installation by following the manufacturer instruction manual. (b, n)
   1.3. The student will demonstrate an ability to correlate the experiments with other applications in industry. (n)
   1.4. The student will demonstrate the ability to design a thermal laboratory experiment in terms of performing the experimental setup, specify the equipment and instruments, collecting data, and how and where to take measurements. (a, b, n, o)
   1.5. The student will demonstrate the ability to conduct thermal laboratory experiments properly and safely and describe the procedures they use to conduct those experiments so that others can understand them. (a, b, n, o)
   1.6. The student will demonstrate the ability to measure and record raw experimental data (a, b, n, o)
   1.7. The student will demonstrate a better understanding of the thermo fluid processes in heat transfer, heat exchangers, and turbomachinery.

2. To develop the student’s ability to statistically analyze and interpret experimental data. (3)
   2.1. Students will demonstrate the ability to statistically analyze and interpret experimental data. (b)
   2.2. Students will demonstrate the ability to represent data in both verbal and visual forms (equations, tables, graphs, figures, etc.) in a way that is both an accurate and an honest reflection of the data. (b, k, o)

3. To develop the student’s ability to work effectively in teams and communicate effectively. (4)
   3.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, and accept consensus or compromise. (d)
   3.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to tasks. (d)
   3.3. Students will demonstrate their ability to make effective oral presentations and laboratory reports using appropriate computer tools. (g, k, o)
   3.4. Students will demonstrate their ability to describe the context of the experiment, describe clearly and precisely the procedures used in the experiment, report verbally and visually the findings, interpret the findings, justify the solutions persuasively, and propose recommendations for the improvement of the laboratory experiment. (g)

Topics:

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively.


<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Compressible Fluid Flow Experimentation</td>
<td>4</td>
</tr>
<tr>
<td>10. Convective Heat Transfer in Pipes</td>
<td>4</td>
</tr>
<tr>
<td>11. Thermal Radiation</td>
<td>4</td>
</tr>
<tr>
<td>12. Air Conditioning Simulation</td>
<td>4</td>
</tr>
<tr>
<td>13. Steam Boiler Performance</td>
<td>4</td>
</tr>
<tr>
<td>14. Cross Flow Heat Exchanger</td>
<td>4</td>
</tr>
<tr>
<td>15. Tube and Tube, Shell and Tube, and Plate Heat Exchangers</td>
<td>4</td>
</tr>
<tr>
<td>17. Hydraulic Turbines</td>
<td>4</td>
</tr>
<tr>
<td>18. Centrifugal Compressor</td>
<td>4</td>
</tr>
<tr>
<td>19. Presentations and laboratory discussions</td>
<td>4</td>
</tr>
<tr>
<td>20. Examinations and Quizzes</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
</tr>
</tbody>
</table>

**Instructional Strategies:**

Students are divided in groups of 4 members. Each group is required to perform a weekly presentation of the last laboratory experience. Each team is also required to present the theory, procedure, and calculation of at least two laboratory experiences.

**Required Resources:**

Laboratory equipment with heat radiation unit, air conditioning equipment, convective heat transfer equipment, boiler, heat exchanger, and cooling tower system, heat exchanger test unit with tube and tube, shell and tube, and plate heat exchangers, centrifugal pumps test rig, axial and centrifugal fans, hydraulic turbines, and centrifugal compressor. Classroom with board and overhead projector. Scientific calculator and software such as Excel, Power Point, Mathcad, and Word.

**Evaluation Strategies:**

1. Exam: 15%. A final exam in classroom will be administered. The final exam will cover all the material related with the experiments.
2. Report of Experiments: 60% Experiments will be performed in groups. Groups will be composed of three students and assistance will be compulsory. There will be no make up experiments. A written report of the experiments with emphasis in statistical analysis of experimental data must be submitted. The report will be written according to a professional format. An oral presentation is required. Groups will work individually, cheating and or plagiarism is an unethical conduct that will not be tolerated.
3. Oral Presentation: 10%.
4. Portfolio: 15%.

**Grading Policy:**

There will be no make up exam. The following grade scale will be honored: **A** (90 – 100), **B** (80 - 89), **C** (70 – 79), **D** (60 – 69), **F** (0 – 59).

**Textbook:** None.

**References:**


Revised by Prof. Jacinto Solano and Dr. Gilmer R. Burgos Date: 09/13/04
POLYTECHNIC UNIVERSITY OF PUERTO RICO  
FACULTY OF ENGINEERING  
MECHANICAL ENGINEERING DEPARTMENT

Course Title: Mechatronics Laboratory  
Course Code: ME 5251  
Classification: Engineering Design  
Credits: 1  
Pre-requisites: ME 5050 - System Dynamics and Controls, EE 4802 - Industrial Electronics, EE 4803 - Industrial Electronics Laboratory  
Co-requisites: None  
Schedule: One-four hours session per week

Course description: Hands on experience in automation and electrical, electronic, hydraulic, and pneumatic control systems. Topics in this course include selection and implementation of sensors, transducers, and actuators (mechanical, pneumatics and hydraulics), calculus of transfer functions of existing closed-loop pressure control and flow control accessories. Electronic data acquisition cards and Programmable Logic Controllers (PLC’s) are used as input and output interfaces to personal computers. Emphasis is placed on the applications of these topics to real-world situations.

Course Objectives†:

1. To develop the student understanding of automation and electrical, electronic, hydraulic, and pneumatic control systems and the ability to apply this knowledge to real situations (1,2,3)
   1.1. The student will demonstrate the ability to use and select appropriately sensors and transducers. (b, c, k, n)
   1.2. The student will demonstrate the ability to implement and control pneumatic, hydraulic, and mechanical actuation systems. (b,c,k,n)
   1.3. The student will demonstrate the ability to implement closed-loop controls. (b, c, k, n)
   1.4. The student will demonstrate an understanding of digital logic. (b, c, k, n)
   1.5. The student will demonstrate the ability to program PLC’s. (b, c, k, n)

2. To develop the student ability to communicate efficiently and work effectively as individuals and in teams (4)
   2.1. The student will demonstrate the ability to prepare and deliver effective oral presentations. (g)
   2.2. The student will demonstrate the ability to write outstanding technical reports. (g)
   2.3. Students will demonstrate the ability to work effectively individually and in teams. (d)

Topics:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sensors and transducers</td>
<td>4</td>
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<tr>
<td>2. Pneumatic and hydraulic systems</td>
<td>4</td>
</tr>
<tr>
<td>3. Mechanical actuation systems</td>
<td>4</td>
</tr>
<tr>
<td>4. Electrical actuation systems</td>
<td>4</td>
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<tr>
<td>5. Closed-loop controllers</td>
<td>10</td>
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<tr>
<td>6. Digital logic</td>
<td>8</td>
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<tr>
<td>7. Programmable logical controllers</td>
<td>8</td>
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<tr>
<td>8. Presentations</td>
<td>4</td>
</tr>
<tr>
<td>9. Final Examination</td>
<td>2</td>
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<tr>
<td>Total</td>
<td>48</td>
</tr>
</tbody>
</table>

Instructional Strategies:

Several experiments are assigned to the students that emphasize automatic data acquisition of different variables such as pressure, temperature, level, flow, position and speed using ADC cards. Students perform error estimation using the Hysteresis concept to record data and linear and nonlinear regression models to analyze data. Students perform experiments to demonstrate the characteristics of different process controllers: P, PI, PD, and PID. Experiments are conducted to record the response of the controller to changes in set point or disturbances of the process. ADC and DAC cards are interfaced with PCs for controlling position and speed of DC motors.

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
The students grouped as multi-disciplinary teams develop the experiments. Modular design techniques are encouraged to consider. The results of the students work are presented orally and using audiovisual hardware provided at the Mechatronics Laboratory.

**Required Resources:**
1. Personal Computers
2. Data Acquisition Cards and Software
3. Pressure Control Accessories
4. Flow Control Accessories
5. Programmable Logic Controllers
6. Sensors and Actuators
7. LabView Software

**Evaluation Strategies:**
1. Final Exam: 20 %. A comprehensive and individual in-classroom exam will be administered at the end of the term.
2. Laboratory Reports: 50%. An original group report must be submitted for each laboratory experience according to a professional format: title page, abstract, table of contents, list of figures, list of tables, introduction, theory, procedure, results, and analysis of results, conclusions, recommendations, references, and appendix.
3. Oral Presentations: 15%. Oral presentations will be prepared by each group and presented at the beginning of each lab session. A grand presentation will be also required at the end of the term.
4. Portfolio: 10%. Each group will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, lab notes, reports, examinations, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected lab reports and examinations must be included as evidence of self-improvement.
5. Attendance and participation: 5%. Students must attend all laboratory sessions. Their behavior, participation and attendance will be evaluated and considered for the individual grade of each group member.

**Grading Policy:**
The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

**Textbook:** None

**References:**

Prepared by Prof. Eduardo Veras and Revised by Dr. Gilmer R. Burgos Date: 11/06/2003
Course Title: Finite Element Analysis
Classification: Engineering Design
Pre-requisites: ME 4220- Solid Mechanics II
Co-requisite: ME 4261
Schedule: Two two-hour lectures per week

Course Description: Introduction to the fundament of the Finite Element Method (FEM) and its applications. Review of Matrix Algebra. FEM Formulations. Analysis of trusses, beams and frames. One-, two-, and three-dimensional elements. Applications using MATLAB and ANSYS

Course Objectives†:

1. To develop the students understanding of finite element analysis and its applications in mechanical engineering design. (1, 3)
   1.1. The student will demonstrate the ability to apply matrix linear Algebra to the solution of finite element problems. (a, c, k)
   1.2. The student will demonstrate the understanding of the finite element formulation including direct formulation, the minimum potential energy theorem, and the weighted residual methods. (a, c, k)
   1.3. The student will demonstrate the ability to apply finite element concepts to solve problems of trusses, members under axial loading, beams, and frames. (a, c, k)
   1.4. The student will demonstrate the ability to perform the finite element formulation using 1D, 2D, and 3D elements and different shape functions. (a, c, k)
   1.5. The student will demonstrate the ability to carry out the transformation of the stiffness matrix from local to global coordinates. (a, c, k)
   1.6. The student will demonstrate the ability to perform the data structure representation of the stiffness matrices, coordinate transformations, matrix assembly, and solution of the system of equations using MATLAB. (k)
   1.7. The student will demonstrate the ability to use ANSYS to analyze mechanical engineering design problems using finite elements including the meshing of solid models. (e, k)
   1.8. The student will demonstrate the ability to analyze from moderate to complex mechanical engineering design problems using Finite Elements. (a, c, e, k)

2. To develop the student ability to work in teams and communicate effectively. (4)
   2.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, and accept consensus and compromise. (d)
   2.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a CAE problem. (d, e)
   2.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   2.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

Topics:

<table>
<thead>
<tr>
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<th>Time (hours)</th>
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</thead>
<tbody>
<tr>
<td>1. Introduction. Basic steps in Finite Element Methods. Direct Formulation. Minimum Total Potential Energy Formulation. Weighted Residual Formulations.</td>
<td>4</td>
</tr>
</tbody>
</table>

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively


9. Examination, 

Total 48

Instructional Strategies:

Conference and problem solving sessions will by used. Matlab and ANSYS computer software will be used to implement and apply the Finite Element Methods. A design project is assigned to students groups. Partial written and oral reports are required to monitor the students' progress as well as a final written and oral report.

Required Resources:

Classroom equipped with board and overhead projector. A laptop and digital projector will also be used for presentations. Personal Computers. MATLAB and ANSYS computer programs.

Evaluation Strategies:

1. Exams: 65%. Two partial exam with 20%-weight and a comprehensive final exam with a 25%-weight will be administered. Exams are instruments to measure the individual scholastic work of each Student. Therefore, they will be administered individually and in-classroom.

2. Assignments and Quizzes: 10%. Assignments will be due to at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed. Random quizzes will be also administered to ensure a continuous learning process.

3. Project: 15%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format. A presentation will be required.

4. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents (properly made with page numbers, topics, and identification of outcomes), course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement. In addition a course survey must be filled out and included in the portfolio, if not the portfolio will not be collected. A label in the side of the portfolio that identifies the course numbers, course name, and trimester must be added as well.

Grading Policy:

The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).

References:

Revised by: Dr. Gilmer Burgos Date: 10/27/04
Course Title: Computer Aided Engineering Laboratory
Course Code: ME 4261
Classification: Engineering Design
Credits: 3
Pre-requisites: ME 4220
Co-requisite: ME 4260
Schedule: Two two-hour lectures per week

Course Description: Computer implementation of finite element methods for the analysis of structural and heat transfer problems. Computer programming in MATLAB or any other programming language and mastering in the use of commercial software for finite element analysis will be required.

Course Objectives:

3. To develop the student understanding of computer modeling techniques used for design. (1, 3)
   3.1. The student will demonstrate the ability to use an available solid modeling program to generate a solid representation of a part conceptual design. (k, n, o)
   3.2. The student will demonstrate the ability to use a solid model to visualize a part, parametrically change dimensions, and create an assembly. (k, n, o)
   3.3. The student will demonstrate the ability to use a solid modeling program to generate detailed drawings of components of parts. (k, n, o)
   3.4. The student will demonstrate the ability to apply geometric dimensioning and tolerance schemes. (k, n, o)
   3.5. The student will demonstrate an understanding of the fundamentals of geometric modeling and be able to apply them. (a, c, e, k, m, n, o)
   3.6. The student will demonstrate the ability to create a two-dimensional finite element model to solve simple structural problems and post-process the results. (k, n, o)
   3.7. The student will demonstrate the ability to apply analytical and numerical techniques to solve an optimization problem. (a, c, e, k, m, n, o)
   3.8. The student will demonstrate the ability to analyze simple problems using Finite Elements. (a, c, e, k, m, n, o)
   3.9. The student will demonstrate the ability to generate the numerical codes for simple turning and milling processes. (c, e, k, m, n, o)

4. To develop the student ability to work in teams and communicate effectively. (4)
   4.1. The student will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, and accept consensus and compromise. (d)
   4.2. The student will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a CAE problem. (d, e)
   4.3. The student will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools. (g, k, o)
   4.4. The student will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)

Topics:

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<tr>
<th>Subject</th>
<th>Time (hours)</th>
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<tbody>
<tr>
<td>10. Structural Analysis 2D Truss, Beams, Plane Frames, Constant-Strain Plane Solids</td>
<td>6</td>
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<tr>
<td>11. Heat Transfer Analysis</td>
<td>6</td>
</tr>
</tbody>
</table>

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
13. Pro/E Solid Modeling Techniques. 6
14. FEA using Pro/Mechanical software 6
15. Analysis of 3D Mechanical Systems using FEA available software packages (Pro/E and Pro/Mechanica). 10
16. Von Mises Stresses and Stress Concentration Factors Determination using FEA. 2
6. Presentations. 2
7. Final Examination. 2
Total 48

**Instructional Strategies:**

Several case studies are assigned to students that emphasize Finite Element concepts such as selection of an appropriate element model for analysis, discretization of the domain, and numerical solution techniques of the system of equations.

Students perform calculations to find local and global stiffness matrices of all the FE models. Practical applications and assignments of computational numerical techniques using MatLab, 2D and 3D modeling using Pro/E, and Finite Element Analysis using a combination of Pro/E and Pro/Mechanica.

The students grouped as multi-disciplinary teams develop case studies. All phases of design are considered from conception to realization in a computer based environment. Modular design techniques are encouraged to consider.

The results of the student's work are presented orally and using audiovisual hardware provided at the Computer Aided Engineering Laboratory (CAE LAB).

**Required Resources:**

Personal Computers, MatLab software, Solid Modeling with Pro/E software, FE analysis with Pro/Mechanica software.

**Evaluation Strategies:**

5. Assignments: 60%. Assignments will be due at the beginning of the second meeting after they are assigned. Their submission is compulsory and no later submission is permitted. All calculations must be done clearly, stating units and showing all steps necessary to arrive to the results. Appropriate software should be used when needed.

6. Project: 30%. An open-ended design project will be assigned early in the term. Working groups will be composed of three students. Partial and final written reports must be submitted according to a professional format: title page, abstract, table of contents, list of figures, list of tables, introduction, theory, procedure, results, and analysis of results, conclusions, recommendations, references, and appendix.

7. Portfolio: 10%. Each student will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents (properly made with page numbers, topics, and identification of outcomes), course syllabus, class notes, assignments, examinations, projects, presentations, and a free section as described in the Portfolio guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement. In addition a course survey must be filled out and included in the portfolio, if not the portfolio will not be collected. A label in the side of the portfolio that identifies the course numbers, course name, and trimester must be added as well.

**Grading Policy:**

The following grading scale will be used: A (90-100), B (80-89), C (70-79), D (60-69), F (0-59).


**References:**


Revised by: Dr. J. Carranza, Prof. B. Restrepo, and Prof. C. Alvarado

Date: 10/27/04
Course Title: Mechanical Engineering Capstone Design I  
Course Code: ME 5992

Classification: Engineering Design  
Credits: 3

Pre-requisites: ME 5050-System Dynamics and Controls, ME 5150 – Design of Thermal Systems, ME 5240 – Design of Machine Elements II

Co-requisites: ME 5251-Mechatronics Laboratory and ME 4260-Finite Element

Schedule: Two two-hour lectures per week

Course Description: Teams perform a systematic design process to solve a multidisciplinary mechanical engineering problem. Weekly written and oral reports are required.

Course Objectives†:

1. To expose senior level students to a major mechanical design experience. (1, 2, 3, 5)
   1.1. Students will demonstrate the ability to take part in and conduct brainstorming sessions, generate ideas using morphological charts, create a graph of a product’s assembly structure, and identify and map out the functional systems of a product. (c, e, k, n)
   1.2. Students will demonstrate a basic understanding of the different design analysis requirements, as well as their limitations, advantages and impact on society and the environment. The design analysis/project must embrace several areas of mechanical engineering. (b, c, e, k, n)
   1.3. Students will demonstrate the ability to develop the specification and requirements for a product or process. (c, k, n)
   1.4. Students will demonstrate the ability to search for new information and/or theories on the specifics of their design. (i)
   1.5. Students will demonstrate the ability to contact vendors to acquire product information and select components. (i, n)
   1.6. Students will demonstrate the ability to calculate/estimate design costs. (a, c, n)
   1.7. Students will demonstrate the ability to apply their undergraduate course work for the analysis of their design by formulating a mathematical model, making appropriate assumptions to simplify the mathematical model, and obtain the solution. (a, c, e, k, l, m)
   1.8. Students will demonstrate the ability to use appropriately computers and software as an aid to solve their design problem. (k, o)

2. To develop the student ability to work in teams. (4)
   2.1. Students will demonstrate an understanding of the various roles that they can play in a design team environment. (d)
   2.2. Students will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, and accept consensus and compromise. (d)
   2.3. Students will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a design problem. (d, e)
   2.4. Students will demonstrate the ability to evaluate themselves and others in a variety of roles. (d)

3. To develop the student ability to communicate effectively. (4)
   3.1. Students will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools to communicate design justification and usefulness. (g, k, o)
   3.2. Students will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)
   3.3. Students will demonstrate the ability to keep a design portfolio to document a design and generate new ideas. (g)

4. To understand the responsibility and impact of a designer to his/her customer, employer, and society. (5)

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively
4.1. Students will demonstrate their awareness that failure of a design may lead to loss of property and/or human life. (f, h)

4.2. Students will demonstrate through the inclusion in the Product/Process Design Specifications most of the following considerations (when applicable) but not limited to: economics; environmental; sustainability; manufacturability; ethical; health and safety; and political. (f, h, j)

4.3. Students will demonstrate their awareness that design can be a life long skill that can continue to develop and will generate a plan for life long learning. (i)

Topics:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time (hours)</th>
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<tbody>
<tr>
<td>1. Introduction. Organization of design teams (3 to 4 members per team)</td>
<td>2</td>
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<tr>
<td>2. The design process. Definition of project goals and requirements</td>
<td>4</td>
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<tr>
<td>3. Development of design specifications</td>
<td>4</td>
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<tr>
<td>4. Development and delivery of an effective oral presentation</td>
<td>4</td>
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<tr>
<td>5. Written report requirements</td>
<td>2</td>
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<tr>
<td>6. Project Management phases</td>
<td>4</td>
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<tr>
<td>7. Development and presentation of project proposal</td>
<td>6</td>
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<tr>
<td>8. Engineering decisions in a societal context</td>
<td>2</td>
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<tr>
<td>9. Economic considerations</td>
<td>4</td>
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<tr>
<td>10. Project development</td>
<td>10</td>
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<tr>
<td>11. Project Status Presentations</td>
<td>4</td>
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<tr>
<td>12. Final Project Presentations</td>
<td>2</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>48</strong></td>
</tr>
</tbody>
</table>

Instructional Strategies:
Class will be divided in groups consisting in not more than four students per group. According to their particular interest, the groups will select their project with the aid of the instructor. The project will be such that must embrace at least three different disciplines. Partial and final written and oral reports will be required in order to assure the final quality of the project.

Required Resources:
Classroom with board, overhead, and LCD projector. CAD and Finite Element software, MathCad, MATLAB, MS Office, Publisher, MS Project.

Evaluation Strategies:
1. Industrial Coach or Project Contact Survey and/or Project Prototype: 20%. Its submission is compulsory and no later submission is permitted.
2. Student Peer Survey: 10%. The surveys will be due at the specified time given by the professor. Their submission is compulsory.
3. Portfolio: 10%. Each group will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and free section as described in the Portfolio Guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement. Identification of the degree of achievement of each outcome should be also submitted.
4. Written Reports: 5% (midterm) and 25% (final) for a total of 30%. A Final report will be due on the scheduled date and it will follow the Thesis/Design Project Writing Procedures established by the institution. The report must be written in English. The content of the report as well as the style will be evaluated.
5. Technical Poster: 10%. A technical poster has become an increasingly accepted method of presenting the results of work performed. We hope the practice in using this medium will help you with your reporting during your career. Use graphics design software and English language. Be creative.
6. Oral Presentations: 5% (midterm) and 15% (final) for a total of 20%. Oral presentations in English will be performed by each group.

Grading Policy: Each student's course grade will be based on the following scale: A (90 to 100), B (80 to 89), C (70 to 79), D (60 to 69), F (0-59).

Textbook: None

References:
5. Other textbooks and references required in previous courses.

Revised by Prof. Carlos Miró and Dr. Gilmer R. Burgos

Date: 11/07/03
Course Title: Mechanical Engineering Capstone Design II  
Course Code: ME 5994  
Classification: Engineering Design  
Credits: 3  
Pre-requisites: ME 5992 Capstone Design I  
Co-requisites: ME 5251-Mechatronics Laboratory and ME 4260-Finite Element  
Schedule: Two two-hour lectures per week  

Course Description: Teams perform a systematic design process to solve a multidisciplinary mechanical engineering problem. Weekly written and oral reports are required.

Course Description: An extension of ME 5992. The design process is usually completed with a prototype. Weekly written and oral reports are required.

Course Objectives†:

1. To expose senior level students to a major mechanical design experience. (1, 2, 3, 5)
   1.1. Students will demonstrate the ability to take part in and conduct brainstorming sessions, generate ideas using morphological charts, create a graph of a product’s assembly structure, and identify and map out the functional systems of a product. (c, e, k, n)
   1.2. Students will demonstrate a basic understanding of the different design analysis requirements, as well as their limitations, advantages and impact on society and the environment. The design analysis/project must embrace several areas of mechanical engineering. (b, c, e, k, n)
   1.3. Students will demonstrate the ability to develop the specification and requirements for a product or process. (c, k, n)
   1.4. Students will demonstrate the ability to search for new information and/or theories on the specifics of their design. (i)
   1.5. Students will demonstrate the ability to contact vendors to acquire product information and select components. (i, n)
   1.6. Students will demonstrate the ability to calculate/estimate design costs. (a, c, n)
   1.7. Students will demonstrate the ability to apply their undergraduate course work for the analysis of their design by formulating a mathematical model, making appropriate assumptions to simplify the mathematical model, and obtaining the solution. (a, c, e, k, l, m)
   1.8. Students will demonstrate the ability to use appropriately computers and software as an aid to solve their design problem. (k, o)

2. To develop the student ability to work in teams. (4)
   2.1. Students will demonstrate an understanding of the various roles that they can play in a design team environment. (d)
   2.2. Students will demonstrate the necessary skills to work effectively in teams such as to share ideas with others, reinforce and support ideas from others, encourage open discussion of ideas, and accept consensus and compromise. (d)
   2.3. Students will demonstrate the ability to set goals, to stay on task toward a timely completion of goals, and apply a systematic approach to solve a design problem. (d, e)
   2.4. Students will demonstrate the ability to evaluate themselves and others in a variety of roles. (d)

3. To develop the student ability to communicate effectively. (4)
   3.1. Students will demonstrate the ability to make effective oral presentations and written reports using appropriate computer tools to communicate design justification and usefulness. (g, k, o)
   3.2. Students will demonstrate the ability to describe the context of the report (introduction), describe clearly and precisely the procedures used (methodology), report verbally and visually the findings (results), interpret the findings (analysis of results), justify the solutions persuasively (conclusions), and propose recommendations. (g)
   3.3. Students will demonstrate the ability to keep a design portfolio to document a design and generate new ideas. (g)

† Numbers and letters in parenthesis refer to the Program Educational Objectives and Program Outcomes, respectively.
4. To understand the responsibility and impact of a designer to his customer, employer, and society. (5)
   4.1. Students will demonstrate their awareness that failure of a design may lead to loss of property and/or human life. (f, h)
   4.2. Students will demonstrate through the inclusion in the Product/Process Design Specifications most of the following considerations (when applicable) but not limited to: economics; environmental; sustainability; manufacturability; ethical; health and safety; and political. (f, h, j)
   4.3. Students will demonstrate their awareness that design can be a life long skill that can continue to develop and will generate a plan for life long learning. (i)

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<td>3. Engineering decisions in a societal context</td>
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<td>5. Project development</td>
<td>10</td>
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<tr>
<td>6. Project Status Presentation</td>
<td>8</td>
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<tr>
<td>7. Project implementation and/or prototyping</td>
<td>20</td>
</tr>
<tr>
<td>8. Final Project Presentation</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48</strong></td>
</tr>
</tbody>
</table>

**Instructional Strategies:**
Groups will continue with the development of their projects. Construction of prototypes and/or project implementation will be required. Partial and final written and oral reports will be required in order to assure the final quality of the project.

**Required Resources:**
Classroom with board, overhead, and LCD projector. CAD and Finite Element software, MathCad, MATLAB, and word processor and presentation software.

**Evaluation Strategies:**
7. **Industrial Coach or Project Contact Survey and/or Project Prototype:** 20%. Its submission is compulsory and no later submission is permitted.
8. **Student Peer Survey:** 10%. The surveys will be due at the specified time given by the professor. Their submission is compulsory.
9. **Portfolio:** 10%. Each group will prepare and submit a portfolio that must include a cover sheet, abstract, table of contents, course syllabus, class notes, assignments, examinations, projects, presentations, and free section as described in the Portfolio Guidelines. Graded and corrected assignments and examinations must be included as evidence of self-improvement. Identification of the degree of achievement of each outcome should be also submitted.
10. **Written Reports:** 5% (midterm) and 25% (final) for a total of 30%. A Final report will be due on the scheduled date and it will follow the Thesis/Design Project Writing Procedures established by the institution. The report must be written in English. The content of the report as well as the style will be evaluated.
11. **Technical Poster:** 10%. A technical poster has become an increasingly accepted method of presenting the results of work performed. We hope the practice in using this medium will help you with your reporting during your career. Use graphics design software and English language. Be creative.
12. **Oral Presentations:** 5% (midterm) and 15% (final) for a total of 20%. Oral presentations in English will be performed by each group.

**Grading Policy:**
Each student's course grade will be based on the following scale: A (90 to 100), B (80 to 89), C (70 to 79), D (60 to 69), F (0-59).

**Textbook:** None

**References:**
5. Other textbooks and references required in previous courses.

Revised by Prof. Carlos Miró and Dr. Gilmer R. Burgos Date: 11/07/03
C. Faculty Resumes

1.- Name and academic rank:
- Carlos Alvarado, Associate Professor and Department Head

2.- Degrees with field, institution, and date:
- Ph.D. Biomedical Engineering University of Connecticut 2005
- M.S. Mechanical Engineering The Ohio State University 1997
- B.S. Mechanical Engineering University of Puerto Rico 1995

3.- Institutional academic experience:
- Years of service on program faculty: 4
- Date of original appointment: August 2003
- Date(s) of advancement in rank: Associate Professor 2003

4.- Other related experience - teaching, industrial, research, grants, proposals, etc.:

<table>
<thead>
<tr>
<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professor</td>
<td>University of Connecticut</td>
<td>Aug. 2000</td>
<td>May 2002</td>
</tr>
<tr>
<td>Research Associate</td>
<td>University of Connecticut</td>
<td>Aug. 2000</td>
<td>May 2003</td>
</tr>
<tr>
<td>Instructor</td>
<td>University of Puerto Rico</td>
<td>Aug 1999</td>
<td>May 2000</td>
</tr>
<tr>
<td>Manufacturing Specialist</td>
<td>General Electric</td>
<td>March 1997</td>
<td>July 1999</td>
</tr>
<tr>
<td>Research Assistant</td>
<td>The Ohio State University</td>
<td>Aug 1995</td>
<td>March 1997</td>
</tr>
</tbody>
</table>

5.- Consulting, patents, etc.:
- Orthopeadics Design Products (2003-present)

6.- State(s) in which registered:
- Professional Licensed Engineer in Puerto Rico

7.- Principal publications of last five years:

- Alvarado, C., Kazerounian (2003) “Redundancy Resolution Model of The Human Lower Limb” Accepted by the International Congress on Sports Dynamics, September 1-3 2003, Melbourne, Australia


8.- Scientific and professional societies of which a member:

- American Society of Mechanical Engineers
- Colegio de Ingenieros y Agrimensores de Puerto Rico
- Society of Automotive Engineers

9.- Honors and awards:

- Recipient of Government Scholarship to study Ph.D. (Summer 2000)
- Recipient of Government Scholarship to study M.S. (Summer 1995)

10.- Institutional and professional service in the last five years:

- Department Head Director, Polytechnic University of Puerto Rico (March 19, 2007)
- Coordinator of Outcome Assessments Committee, Polytechnic University (2004-present)

11.- Professional development activities in the last five years:

1.- Name and academic rank:

- Edwin A. Ayala, Associate Professor

2.- Degrees with field, institution, and date:

- PhD Candidate Chemical Engineering Virginia Tech 2001
- MS Chemical Engineering Virginia Tech 1996
- BS Chemical Engineering Virginia Tech 1994

3.- Institutional academic experience:

- Years of service on program faculty: 10
- Date of original appointment: March 2005
- Date(s) of advancement in rank: Associate Professor – March 2003

4.- Other related experience - teaching, industrial, research, grants, proposals, etc.:

<table>
<thead>
<tr>
<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor</td>
<td>Clarkson University</td>
<td>June 1980</td>
<td>June 1982</td>
</tr>
<tr>
<td>Project Engineer</td>
<td>Barton &amp; Loguidice, P.C.</td>
<td>July 1978</td>
<td>June 1979</td>
</tr>
</tbody>
</table>

5.- Consulting, patents, etc.:

Occasional consulting with:
- Environmental Research Management, ERM-PR, Guaynabo (2001-present)
- Engineering Solution Firm, ESF, Caguas, PR (2004 to present)

6.- State(s) in which registered:

- Registered Professional Engineer, PR - Number 16316

7.- Principal publications of last five years:

- Colucci Jose, Ayala Edwin, Amador Carlos, Acosta Angel, Biodiesel Processes Development, AIDIS Symposium 2002
- Colucci Jose, Ayala Edwin y Nelson Reyes, Biodiesel, un diesel mas limpio, Revista Tecnomoundo, CIAPR, April 2002

8.- Scientific and professional societies of which a member:

- American Institute of Chemical Engineering (AICHE)
- Colegio y Agrimensores de PR (CIAPR)
9. **Honors and awards:**

10. **Institutional and professional service in the last five years:**

    - Asbestos and Lead Based Paint Seminar at ASCE Students, 2004-2005
    - Biodiesel PR, Seminar, Induniv, 2003
    - Biodiesel Emissions, Seminar, UPADI, 2003
    - Biofiltration Seminar at ASCE Students, 2003
    - Energy NSEF Proposal Submission, 2003
    - Biodiesel SBIR Proposal, Submission 2004
    - Judge Scientific Fair, 2003-2005
    - Reviewer of Fluid Mechanics Curriculum, 2003
    - Faculty Advisor to PUPR Master Student, 2003-2005

11. **Professional development activities in the last five years:**

    2. Environmental Regulations, Environmental Quality Board, EQB, 2007
    5. Asbestos and Lead Based Paint Seminar, 2003 to present
    6. CAMEO EPA Seminar, 2003
1.- Name and academic rank:

- Manuel Bardález Alvarado, Professor

2.- Degrees with field, institution, and date:

- MSME University of Puerto Rico Mayagüez, PR 1992
- BSME The National University of Engineering Lima, Perú 1973

3.- Institutional academic experience:

- Promoted to Professor August 1998
- Promoted to Associate Professor January 1991
- Appointed Assistant Professor August 1989

4.- Other related experience - teaching, industrial, research, grants, proposals, etc.:

<table>
<thead>
<tr>
<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Investigator, Research Project, Dept. of Nature and Environment Resources</td>
<td></td>
<td>July 1996</td>
<td></td>
</tr>
<tr>
<td>Research Assistant</td>
<td>University of PR, Mayaguez</td>
<td>Aug. 1988</td>
<td>May 1989</td>
</tr>
<tr>
<td>Director of Univ. Ext. and Social Projection, National Univ., Perú</td>
<td></td>
<td>1982</td>
<td>1987</td>
</tr>
</tbody>
</table>

5.- Consulting, patents, etc.:

- Consulting Engineer of PRIMET Engineers S.A. Lima, Perú (1980-1987)

6.- State(s) in which registered:

- Puerto Rico, PE - Lic. Number 12299
- Lima, Perú - Lic. Number 19549

7.- Principal publications of last five years:

None

8.- Scientific and professional societies of which a member:

- American Society of Engineers Education (ASEE)
- Association Society of Mechanical Engineers (ASME)
9.- Honors and awards:

- Recipient of the “Outstanding Teacher Award” from the 2005 Graduation Class Association of
  The Polytechnic University of Puerto Rico, June 2005.

- Selected by honor students as one of the Best Teachers in America and published in

- Granted a teaching and research assistantship from the University of Puerto Rico, Mayagüez to pursue graduate studies leading to a Master of Sciences in Mechanical Engineering, August 1987.

- Re-elected as an Associate Professor Representative to the Government Board of the
  National University of Engineering, Lima - Peru, April 1987.

- Appointed as Director of the Office of Social Projection and Community Diffusion of the
  National University of Engineering, Lima - Peru, September 1984.

- Elected as an Associate Professor Representative to the Government Board of the
  National University of Engineering, Lima - Peru, April 1984.

10.- Institutional and professional service in the last five years:

- 

11.- Professional development activities in the last five years:

1. Center for Professional Education and Training, PUPR Courses Taught:
   i. Elevators and Escalators Inspection (Oct. 2003)
   ii. Boilers and Pressure Vessels Inspection (May 2004)
1.- Name and academic rank:

- Gilmer R. Burgos Saldaña, Associate Professor

2.- Degrees with field, institution, and date:

- PhD  Mechanical Engineering  Worcester Polytechnic Univ. Institute  1999
- MS  Mechanical Engineering  University of PR, Mayagüez  1993
- BS  Mechanical Engineering  National Univ. of Trujillo, Perú  1986

3.- Institutional academic experience:

- Years of service on program faculty:  13
- Date of original appointment:  June 1994
- Date(s) of advancement in rank:  Associate Professor – Spring 2000

4.- Other related experience - teaching, industrial, research, grants, proposals, etc.:

-Postdoctoral Fellow. Semisolid Metal Processing Laboratory, Metal Processing Institute, Worcester Polytechnic Institute. January - July 1999

-Assistant Professor and Laboratory Coordinator, Polytechnic University of Puerto Rico, Department of Mechanical Engineering. June 1994 - June 1996

-Instructor, University of Puerto Rico at Mayagüez, Department of General Engineering Taught Dynamics. Fluid Mechanics Laboratory. Thermodynamics II. August 1993 - May 1994


-Assistant Professor, Los Angeles University, Chimbote-Perú. Part time, Assistant Professor. Taught Engineering Graphics and Descriptive Geometry. August 1986 - June 1987


5. **Consulting, patents, etc.:**

    - Semisolid Processing Laboratory, Metal Processing Institute, Worcester Polytechnic Institute. (Aug. 1999- Present)

6. **State(s) in which registered:**

    - Registered E.I.T, PR - Number 22121

7. **Principal publications of last five years:**


8.- **Scientific and professional societies of which a member:**

- American Society of Mechanical Engineers (ASME)
- American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
- American Society of Engineers Education

9.- **Honors and awards:**

- Phi Kappa Phi Honor Society.
- Granted a research assistantship from Metal Processing Institute, August 1997-February 1999.
- Granted a teaching and research assistantship from the University of Puerto Rico, Mayagüez.
- Campus to pursue graduate studies ending a Master of Sciences Degree in Mechanical Engineering, August 1991-May 1993.
- Ranked in the first place in a class of 77 students at The National University of Trujillo; Department of Mechanical Engineering, Trujillo-Perú, August 1979-August 1986.

10.- **Institutional and professional service in the last five years:**

- Directing and organizing the Mechanical Engineering Department.
- Member of the Polytechnic University of Puerto Rico Academic Council.
- Promoting student participation in student section chapters of ASME, SAE, ASHRAE. Student Advisor for ASME and ASHRAE Chapters.
- Advising students and evaluating COOP student reports.

11.- **Professional development activities in the last five years:**


- Assessment for Institutional Effectiveness, Polytechnic University of Puerto Rico, San Juan, Puerto Rico, January 2004.
1.- Name and academic rank:

- Eduardo Cabrera Ruiz, Lecturer II

2.- Degrees with field, institution, and date:

- MS Mechanical Engineering University of Puerto Rico 2001
- BS Mechanical Engineering University of Guanajuato 1997

3.- Institutional academic experience:

- Years of service on program faculty: 2
- Date of original appointment: August 2005
- Date(s) of advancement in rank: Part time Professor 2005

4.- Other related experience - teaching, industrial, research, grants, proposals, etc.:

<table>
<thead>
<tr>
<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professor</td>
<td>Interamerican University of PR.</td>
<td>Aug. 2003</td>
<td></td>
</tr>
<tr>
<td>Scientific Research</td>
<td>Servicios Científicos y Técnicos Inc.</td>
<td>Jan. 2002</td>
<td>May 2005</td>
</tr>
<tr>
<td>Research Associate</td>
<td>Caribbean Thermal Technologies</td>
<td>Aug 2000</td>
<td>Aug 2001</td>
</tr>
<tr>
<td>Instructor</td>
<td>University of Puerto Rico</td>
<td>Aug 1999</td>
<td>May 2000</td>
</tr>
<tr>
<td>Graduate Research</td>
<td>University of Puerto Rico</td>
<td>Jan 1998</td>
<td>May 2000</td>
</tr>
<tr>
<td>Undergraduate Research</td>
<td>University of Guanajuato</td>
<td>Aug 1995</td>
<td>Dec 1997</td>
</tr>
</tbody>
</table>

5.- Consulting, patents, etc.:

Occasional consulting with:
- Servicios Científicos y Técnicos Inc., San Juan, PR (2004- )

6.- State(s) in which registered:

- Registered Professional Engineer in Process

7.- Principal publications of last five years:


Rodríguez, J. M., Cabrera, D., Cabrera, E., 1993 “Modelo Matemático Parametrizado para Obtener Temperaturas Horarias” XVII Semana de Energía Solar, Colima Mex., October 4-8, pag. 143-145

8.- Scientific and professional societies of which a member:

- American Society of Mechanical Engineers
- Concejo de Ciencia y Tecnología (México)
- Asociación Nacional de Energía Solar (México)

9.-Honors and awards:

- BS Honor Student – University of Guanajuato - CONCYTEG (1995)

10.- Institutional and professional service in the last five years:

- Coordinator Assistant of Outcome Assessments Committee, Polytechnic University (2007)

11.- Professional development activities in the last five years:

2. Member of “Spray Cooling” National Science Foundation, CTS-9703062 (1998-2001)
1.- **Name and academic rank:**

- Jorge E Carranza, Associate Professor

2.- **Degrees with field, institution, and date:**

- PhD Mechanical Engineering University of Florida 2002
- MS Mechanical Engineering University of Puerto Rico 1998
- BS Mechanical Engineering National University of Trujillo 1989

3.- **Institutional academic experience:**

- Years of service on program faculty: 4
- Date of original appointment: March 2003
- Date(s) of advancement in rank: March 2003

4.- **Other related experience - teaching, industrial, research, grants, proposals, etc.:**

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<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
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<tr>
<td>Associate Researcher</td>
<td>University of Florida</td>
<td>Sept. 2002</td>
<td>March 2003</td>
</tr>
<tr>
<td>Instructor</td>
<td>University of Puerto Rico</td>
<td>Jan. 1998</td>
<td>Dic. 1998</td>
</tr>
<tr>
<td>Instructor</td>
<td>National University of Trujillo</td>
<td>Ago 1991</td>
<td>July 1995</td>
</tr>
</tbody>
</table>

5.- **State(s) in which registered:**

- Registered Professional Engineer, Puerto Rico - Number 2186

6.- **Principal publications of last five years:**


7.- Scientific and professional societies of which a member:
   - American Society of Mechanical Engineers
   - American Society for Engineering Education
   - Colegio de Ingenieros y Agrimensores de Puerto Rico

8.- Honors and awards:
   - Distinguished Professor (advisory) – ASHRAE Student Chapter, PUPR (2003)

9.- Institutional and professional service in the last five years:
   - Coordinator for Departmental Exams ENGI 3410, ENGI 3420 (2004-2007)
   - Member of the Research and Development Council (2005-2007)
   - Faculty Representative at the Institutional Outcome Assessment Committee (2003-2005)
   - Member of the Editing Board of the Polytechné Journal (2004-2007)
   - Co-organizer of Mechanical Engineering display on PUPR Open Houses (2004-2007)
   - Reviewer for the DOE Grants (2004-2005)
   - Speaker for the Mechanical engineering profession at secondary schools (2004-2005)

10.- Professional development activities in the last five years:
1. Name and academic rank:

- Orlando Clavell Pumarejo, Lecturer III

2. Degrees with field, institution, and date:

- MS Civil Engineering  University of Michigan  1966
- BS Civil Engineering  CAAM PR  1959

3. Institutional academic experience:

- Years of service on program faculty: 19
- Date of original appointment: September 1972
- Date of original appointment at the Dept: August 1988
- Date(s) of advancement in rank: Lecturer III- May 1993

4. Other related experience - teaching, industrial, research, grants, proposals, etc.:

<table>
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<tr>
<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Teaching)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Staff and faculty battery</td>
<td>Fort Sill Okla</td>
<td>1960</td>
<td>1961</td>
</tr>
<tr>
<td>-Continuous Education</td>
<td>Engineers College</td>
<td>1970</td>
<td>1972</td>
</tr>
<tr>
<td>(Industry)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Engineer in charge of Revisions of Aqueduct and sewer projects submitted for approval to PRASA</td>
<td>1959</td>
<td>1963</td>
<td></td>
</tr>
<tr>
<td>-Engineer in charge of water distribution operations in PRASA</td>
<td>1963</td>
<td>1968</td>
<td></td>
</tr>
<tr>
<td>-Engineer in design of sanitary projects at PRASA</td>
<td>1965</td>
<td>1968</td>
<td></td>
</tr>
<tr>
<td>-Chief of Sanitary Design Division at PRASA in charge of eighteen (18)</td>
<td>1969</td>
<td>1976</td>
<td></td>
</tr>
</tbody>
</table>

5. Consulting, patents, etc.:

- Consulting for private and public entities on sewer and sanitary projects. Have design several storm and sanitary sewers actually in use. Also design and construct several sewage treatment plants actually in use. (1976-2007)
- Research to determine design parameters for sanitary and hydraulics projects in Puerto Rico to revise PRASA design guidelines. (1975)

6. State(s) in which registered:

- Registered Professional Engineer, PR - Number 3616

7. Principal publications of last five years:

- None in the last five years.
- While working at PRASA a series of articles were published in the Dominical Newspaper on ways to control water pollution.

8. **Scientific and professional societies of which a member:**
   - Puerto Rico Engineers College
   - Puerto Rico Society of Engineers
   - A.I.D.I.S
   - A.W.P.C.F.

9. **Honors and awards:**
   - Candidate for Manuel A. Pérez Award while working for the Government

10. **Institutional and professional service in the last five years:**
    - Design and construction of three major waste collection systems.
    - Design and construction of two major sewage treatment plants.

11. **Professional development activities in the last five years:**
    7. Cost effective analysis in sanitary project seminar.
    8. Value engineering seminar.
1.- Name and academic rank:

- Jorge E. Collazo, Lecturer II Part-time Professor

2.- Degrees with field, institution, and date:

- MS Mechanical Engineering Oakland University 2003
- BS Mechanical Engineering University of Puerto Rico 2001

3.- Institutional academic experience:

- Years of service on program faculty: 1
- Date of original appointment: November 2006
- Date(s) of advancement in rank:

4.- Other related experience - teaching, industrial, research, grants, proposals, etc.:

<table>
<thead>
<tr>
<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
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</thead>
<tbody>
<tr>
<td>Manufacturing Engineer</td>
<td>Boston Scientific Corp.</td>
<td>May 2006</td>
<td>Present</td>
</tr>
<tr>
<td>Project and Quality Engineer</td>
<td>Vassallo Industries</td>
<td>January 2004</td>
<td>April 2006</td>
</tr>
<tr>
<td>CIE Engineer</td>
<td>DaimlerChrysler Corp.</td>
<td>August 2001</td>
<td>August 2003</td>
</tr>
</tbody>
</table>

5.- Consulting, patents, etc.:

6.- State(s) in which registered:

- Registered Professional Engineer, Puerto Rico - Number 20696

7.- Principal publications of last five years:

8.- Scientific and professional societies of which a member:

- CIAPR

9.- Honors and awards:

10.- Institutional and professional service in the last five years:

11.- Professional development activities in the last five years:

1.- Name and academic rank:
- Juan C. García, Lecturer II

2.- Degrees with field, institution, and date:
- MS Mechanical Engineering Univ. of Puerto Rico, Mayagüez 1979
- BS Mechanical Engineering Univ. of Trujillo, Perú 1991

3.- Institutional academic experience:
- Years of service on program faculty: 3
- Date of original appointment: November 2004
- Date(s) of advancement in rank: Lecturer II – November 2004

4.- Other related experience - teaching, industrial, research, grants, proposals, etc.:

<table>
<thead>
<tr>
<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
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</thead>
<tbody>
<tr>
<td>Instructor</td>
<td>Inter American University of PR</td>
<td>2001</td>
<td>Present</td>
</tr>
<tr>
<td>Instructor</td>
<td>Univ. of Puerto Rico, Mayagüez</td>
<td>1998</td>
<td>2000</td>
</tr>
<tr>
<td>Research Assistant</td>
<td>Univ. of Puerto Rico, Mayagüez</td>
<td>1997</td>
<td>1997</td>
</tr>
</tbody>
</table>

5.- Consulting, patents, etc.:
- None

6.- State(s) in which registered:
- Registered Professional Engineer, PR- Number 20911

7.- Principal publications of last five years:
None

8.- Scientific and professional societies of which a member:
- CIAPR 2004- present
- ASME 2004- present
- ASM 2002- present

9.- Honors and awards:
- College Recognition for Outstanding Academic Performance, UPR, Mayagüez (1998)

10.- Institutional and professional service in the last five years:
11.- Professional development activities in the last five years:

10. None
1. **Name and academic rank:**

   - Luis González, Jr., Profesor (Lecturer IV)

2. **Degrees with field, institution, and date:**

   - MS Mechanical Engineering Georgia Tech, Atlanta, Ga. 1980
   - B Mechanical Engineering Georgia Tech, Atlanta, Ga. 1975

3. **Institutional academic experience:**

   - Years of service on program faculty: 17 years
   - Date of original appointment: September 1990
   - Date(s) of advancement in rank: Professor – November 2000
     - Associate Professor – September 1998
     - Assistant Professor – September 1990

4. **Other related experience - teaching, industrial, research, grants, proposals, etc.:**

<table>
<thead>
<tr>
<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner/Principal</td>
<td><a href="http://www.MechanicalEngineeringPR.com">www.MechanicalEngineeringPR.com</a></td>
<td>Sept. 1981</td>
<td>Present</td>
</tr>
<tr>
<td>Associate Professor</td>
<td>University of PR, Architecture</td>
<td>Aug. 2003</td>
<td>Dec. 2003</td>
</tr>
<tr>
<td>Senior Mech. Engineer</td>
<td>CMA, Architects &amp; Engineers</td>
<td>July 1977</td>
<td>Dec. 1979</td>
</tr>
<tr>
<td>Summer &amp; Part-time Jobs</td>
<td>Various Companies</td>
<td>June 1972</td>
<td>July 1977</td>
</tr>
</tbody>
</table>

5. **Consulting, patents, etc.:**

   Occasional engineering consulting with:
   - Jaime Zeno & Associates (RIP), San Juan, PR (1976-1977)
   - CSA, Engineers & Architects, San Juan, PR (1981-1982)
   - Department of Health, Gov. of Puerto Rico (1985-2001)
   - UPR, Humacao Campus, Gov. of Puerto Rico (2005- Present)

6. **State(s) in which registered:**

   - Registered Professional Engineer, Puerto Rico - Number 7485 (1981)
   - Registered EIT, Georgia - Number 5556 (1975)

7. **Published Articles of last five years:**
“Cooling Caguas Hospital; Regional Facility Installs one of Island’s most energy-efficient systems for $2.5 Millions”, by Carmen T. Casellas; CRIBBEAN BUSINESS, Thursday, February 6, 1997.


8. Scientific and professional societies of which a member:

- College of Engineers and Surveyors of Puerto Rico (CIAPR)
- American Society of mechanical Engineers (ASME)
- American Society of Plumbing Engineers (ASPE)
- National Society of Professional Engineers (NFPE)
- American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
- Society of Automotive Engineers (SAE)
- Construction Specification Institute (CSI)
- National Fire Protection Association (NFPA)
- National Space Society (NSS)
- The Planetary Society (TPS)

9. Honors and awards:

- Scholarship from the Economic Development Administration of PR (FOMENTO) (1979)
- Deans List-Georgia Tech and Scholarship from the Georgia Tech Alumni Club of PR (1972)

10. Continued Education Courses & Lectures Offered and Professional Service in the last five years:

- Instructor for PE Examination Engineering Review; Session on Air Conditioning, July 2001
- Evaluation of Air Conditioning Selection Programs, PUPR, Oct 2004 and Jan. 2006
- Applied Psychrometrics, CIAPR, Nov. 2006
- A/C, Plumbing & Fire Protection Design, One Plaza Office Building, Road 14, Ponce, PR
- Plumbing & Sanitary Risers Design, San Juan Marriott Hotel, Condado, PR
- Plumbing Design, Condo. Aqua - High Rise Luxury Apartments Bldg., Isla Verde, PR
- A/C, Plumbing & Fire Protection Design, Municipal Public Library, Ponce, PR
- A/C, Plumbing & Fire Protection Design, El Tuque High School, Ponce, PR
- Evaluation & Inspection services for 2000 Tons DX & CHW A/C Systems, UPR, Humacao
- A/C System Design for Plant 1 (140 Tons) & Plant 2 (120 Tons), Lutron, SM, Inc., Humacao
- Leak testing & Evaluation of Ammonia Refrigeration Plant, Pollos Canto Alegre, Salinas, PR
- Fire Pump & 150,000 Gals. Storage Fire Protection Systems, PR-53 Tunnels, Naguabo, PR

11. Professional development activities in the last ten years:

- VAV for Indoor Air Quality, ASHRAE, Jan. 1999
- IAQ & Sick Building Syndrome, CIAPR, Nov. 2000
- Hoffman Steam Seminar CIAPR, Aug. 2001
- Variable Refrigerant Volume (VRV) Systems, Daikin, Sept. 2002
- Humidity Control II-Applications, Control Level and Mold Avoidance, ASHRAE, Jan. 2006
- Mold in the Building Environment, Satellite Broadcast/Webcast, ASHRAE, April 2005
- Engineering Economy-Part II, CIAPR, May 2005
- Elevators Inspection, CIAPR, July 2005
- Integration of Construction Material and Thermal Systems in Commercial Buildings, CIAPR,
  Sept. 2005
- Expert Witness Seminar (Peritaje), CIAPR, Oct. 2005
- SEMINAR 37: Basis for the Ventilation Rates in ANSI/ASHRAE Standard 52.1-2004,
  ASHRAE, Jan. 2006
- Educational Models: Analysis and Practical Discuss on of the Academic Foundations,
- HETS/PUPR, Feb. 2006
- Variable Speed Applications in Chillers, Air Handling Units & Pumps, CIAPR, May 2006
- Kitchen Ventilation, CIAPR/AHRAE PR Chapter, July 2006
- Introduction to Automatic Fire Sprinkler Design, CIAPR, April 2007

For more detailed information about our experience and credentials, please, visit our Web Site at: www.mechanicalengineeringpr.com
1.- Name and academic rank:

- Ivelysse Lebrón, Lecturer II Part-time Professor

2.- Degrees with field, institution, and date:

- MS Mechanical Engineering University of Puerto Rico 2003
- BS Mechanical Engineering University of Puerto Rico 2000

3.- Institutional academic experience:

- Years of service on program faculty: 2
- Date of original appointment: November 2004
- Date(s) of advancement in rank:

4.- Other related experience - teaching, industrial, research, grants, proposals, etc.:

<table>
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<tr>
<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part-time Professor</td>
<td>Caribbean University</td>
<td>August 2005</td>
<td>December 2005</td>
</tr>
<tr>
<td>Research Assistant</td>
<td>University of Michigan</td>
<td>January 2003</td>
<td>December 2003</td>
</tr>
</tbody>
</table>

5.- Consulting, patents, etc.:

6.- State(s) in which registered:

- Registered Engineer in Training, Puerto Rico - Number 20703

7.- Principal publications of last five years:

- Master’s Thesis: “Use of Life-Cycle Assessment in the Decision Making Process of Transportation Infrastructure Projects”

8.- Scientific and professional societies of which a member:

- CIAPR
- IMEPR

9.- Honors and awards:

- Rackham Graduate Engineering Award Fellowship
- MIT/UPR/ Tren Urbano Professional Development Fellowship

10.- Institutional and professional service in the last five years:
11.- Professional development activities in the last five years:

1.- Name and academic rank:
- Julio Amilcar Noriega Motta, Associate Professor

2.- Degrees with field, institution, and date:
- PhD Mechanical Engineering West Virginia University Sept. 2006
- MS Mechanical Engineering Univ. of PR, Mayagüez July 1993
- BS Mechanical Engineering Univ. of San Carlos, Guatemala 1983

3.- Institutional academic experience:
- Years of service on program faculty: 12
- Date of original appointment: 1995
- Date(s) of advancement in rank: Associate Professor – 2001

4.- Other related experience - teaching, industrial, research, grants, proposals, etc.:

<table>
<thead>
<tr>
<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structures Sup., Eng. Dept.</td>
<td>AVIATECA S.A. Airlines</td>
<td>1993</td>
<td>1995</td>
</tr>
<tr>
<td>Section Chief, Geophysical Sec.</td>
<td>Mines Department</td>
<td>1985</td>
<td>1987</td>
</tr>
</tbody>
</table>

5.- Consulting, patents, etc.:
- One pending

6.- State(s) in which registered:
- Guatemala, - Number 2276

7.- Principal publications of last five years:
- Crack detection on aging Fleet Boeing 737 Aircraft
- Latin America Conference on 737 operators

8.- Scientific and professional societies of which a member:
- American Society of Mechanical Engineers (ASME)
- Colegio de Ingenieros de Guatemala

9.- Honors and awards:
- Mechanical and Industrial Dept. – Univ. of San Carlos, Guatemala (1983)
Honor Thesis.

10. *Institutional and professional service in the last five years:*

- Baxter Pharmaceutical, materials characterization
- Refrigeration systems, Mechanical integrity programs

11. *Professional development activities in the last five years:*

11. PhD grade
1.- Name and academic rank:
   - Ordóñez Estévez Sandra L., Lecturer II

2.- Degrees with field, institution, and date:
   - MS Electrical Engineering  Univ. of Puerto Rico (Mayagüez)  2005
   - BS Electrical Engineering  Pontificial Bolivarian Univ. (B/ga, COL)  2000

3.- Institutional academic experience:
   - Years of service on program faculty:  1.5
   - Date of original appointment:  August 2005
   - Date(s) of advancement in rank:  Academic Assistant – March 2007

4.- Other related experience - teaching, industrial, research, grants, proposals, etc.:

<table>
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<tr>
<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor</td>
<td>Univ. of Puerto Rico (Mayagüez)</td>
<td>Aug 2002</td>
<td>May 2005</td>
</tr>
<tr>
<td>Lecturer</td>
<td>DEI Institute (COL)</td>
<td>Aug 1997</td>
<td>Dec 1997</td>
</tr>
<tr>
<td>Instructor</td>
<td>Pontificial Bolivarian Univ. (B/ga,COL)</td>
<td>Aug 1996</td>
<td>June 1997</td>
</tr>
</tbody>
</table>

5.- Consulting, patents, etc.:
   None

6.- State(s) in which registered:
   None

7.- Principal publications of last five years:
   None

8.- Scientific and professional societies of which a member:
   - SAE – Society of Automotive Engineers

9.- Honors and awards:
   None

10.- Institutional and professional service in the last five years:
- Assistant to the Laboratory Coordinator (2006)
- Instructor/Assistant of the Instrumentation and Process Control Laboratory, and the Biomedical Laboratory (2002-2005)

11. Professional development activities in the last five years:

1. None
1.- Name and academic rank:
   - Bernardo Restrepo, Assistant Professor

2.- Degrees with field, institution, and date:
   - MS Mechanical Engineering University of Puerto Rico 2000
   - BS Mechanical Engineering Corporacion Universitaria Tecnologica de Bolivar 1977

3.- Institutional academic experience:
   - Years of service on program faculty: 6
   - Date of original appointment: June 2001

4.- Other related experience - teaching, industrial, research, grants, proposals, etc.:

<table>
<thead>
<tr>
<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor</td>
<td>UPR - Mayaguez</td>
<td>August 1998</td>
<td>December 2000</td>
</tr>
<tr>
<td>Project Engineer</td>
<td>Dinalco S.A.</td>
<td>August 1996</td>
<td>June 1998</td>
</tr>
</tbody>
</table>

5.- State(s) in which registered:
   - Registered Professional Engineer, Puerto Rico - Number 20270

6.- Scientific and professional societies of which a member:
   - American Society of Mechanical Engineers
   - American Society of Engineering Education

7.- Institutional and professional service in the last five years:
   - Instructor for Professional of Engineering Review session on Thermodynamics and Heat Transfer (2006, 2007)
   - Coordinator of Laboratories (2006, 2007)
   - Outcome assessment committee

8.- Continue Education:
   - Design and implementation of Automation control systems (2004)
   - ASME Section IX Welding and Brazing (2003)
1.- Name and academic rank:
   - Jacinto L. Solano, Associate Professor

2.- Degrees with field, institution, and date:
   - PhD Mechanical Engineering West Virginia University 2007
   - MS Mechanical Engineering University of Puerto Rico 1997
   - BS Mechanical Engineering University of Puerto Rico 1991

3.- Institutional academic experience:
   - Years of service on program faculty: 14
   - Date of original appointment: June 1993
   - Date(s) of advancement in rank: Associate Professor – August 1993
     Assistant Professor – June 1999

4.- Other related experience - teaching, industrial, research, grants, proposals, etc.:
   Position       Company or Institution                  From       To
   President      S & D Engineering Service            August 1997 May 2004
   Supervisor     Public Building Authority            May 1992 August 1992
   Instructor     University of Puerto Rico             August 1991 May 1992

5.- Consulting, patents, etc.:
   Consulting while at S & D Engineering:
   - Consulting in cooling tower design, upgrade, and rebuilt in Campo fresco, Chemtex, Hotel Grand San Juan.
   - Consulting in refrigeration and air conditioning in Ammonia refrigeration system for cooling pineapple processing room in Campo Fresco.
   - Air Conditioning Design: Ponce Bank, Walgreens, Hertz, New Hospital at Buchanan Army Base.

6.- State(s) in which registered:
   - Registered Professional Engineer, Puerto Rico - Number 14494

7.- Principal publications of last five years:
   None

8.- Scientific and professional societies of which a member:
   - American Society of Mechanical Engineers (ASME)
   - Society of Automotive Engineers (SAE)
- College of Professional Engineers and Surveyors of Puerto Rico (CIAPR)

9.- **Honors and awards:**

- Distinguished Professor (Institute of Mechanical Engineers, 1997)

10.- **Institutional and professional service in the last five years:**

- Member of Faculty Committee (August 2003 – May 2004)
- Faculty Advisor to Institute of mechanical Engineers Student Chapter (1995-2004)
- Mentoring 60 students, 4 hours per week, August 1994 – May 2004.

11.- **Professional development activities in the last five years:**

1.- Name and academic rank:
- Ronald Sosa, Associate Professor

2.- Degrees with field, institution, and date:
- MS Mechanical Engineering UPR Mayagüez PR 1996
- BS Mechanical Engineering UNT Trujillo Perú 1987

3.- Institutional academic experience:
- Years of service on program faculty: 10
- Date of original appointment: August 1996
- Date(s) of advancement in rank: Associate Professor – 2002, Assistant Professor – August 1996

4.- Other related experience - teaching, industrial, research, grants, proposals, etc.:

<table>
<thead>
<tr>
<th>Position</th>
<th>Company or Institution</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching Assistant</td>
<td>UPR Mayagüez PR</td>
<td>Aug. 1994</td>
<td>June 1996</td>
</tr>
<tr>
<td>Assistant Professor</td>
<td>UNT Trujillo Peru</td>
<td>March 1991</td>
<td>Aug. 1994</td>
</tr>
<tr>
<td>Project Engineer</td>
<td>COMECSA Trujillo Peru</td>
<td>Dec. 1988</td>
<td>June 1990</td>
</tr>
</tbody>
</table>

5.- Consulting, patents, etc.:
None

6.- State(s) in which registered:
- Registered Professional Engineer, Perú - Number 39279

7.- Principal publications of last five years:
None

8.- Scientific and professional societies of which a member:
None

9.- Honors and awards:
None

10.- Institutional and professional service in the last five years:
- Member of The Academic Council (Consejo Académico, PUPR) (2006 - present)

11.- Professional development activities in the last five years:

2. Seminar on Data acquisition by National Instrument (2005)
D. Survey

Polytechnic University of Puerto Rico - Mechanical Engineering Department
STUDENT PROFILE SURVEY

1. What is your GPA? ____________________

2. How many credit hours are you taking this trimester? ________________(crds.)

3. Please indicate which of the following statements is applicable to your situation.
   ☐ Full time student (>= 12 crds.)
   ☐ Part Time Student (< 12 crds.)

4. Please indicate which of the following statements is applicable to your situation.
   ☐ Employed full time (>30 hours a week)
   ☐ Employed part time (< 30 hours a week)

5. Please indicate which of the following statements is applicable to your situation.
   ☐ Single (Soltero)
   ☐ Married (Casado) no children. Children ages: ______________
   ☐ Married with children. Children ages: ______________
   ☐ Not married with children. Children ages: ______________

6. When did you enroll PUPR? ______________

7. In what year are you according to the curriculum? ______________

8. When do you expect to graduate? ______________

9. Which Mechanical Engineering courses are you taking now label (1); planning to take next trimester label (2)?

   ☐ ENGI 3410 Dynamics  ☐ ME 4210 Solid Mechanics I
   ☐ ENGI 3420 Fluid Mechanics  ☐ ME 4220 Solid Mechanics II
   ☐ ENGI 3421 Fluid Mechanics Laboratory  ☐ ME 4230 Design of Machine Elements I
   ☐ ME 1210 Computer Aided Drafting and Des.  ☐ ME 5240 Design of Machine Elements II
   ☐ ME 1230 Int. to Mechanical Engineering  ☐ ME 4240 Manufacturing Engineering
   ☐ ME 2010 Computer Programming for ME.  ☐ ME 4241 Manufacturing Eng. Laboratory
   ☐ ME 3010 Applied Numerical Analysis  ☐ ME 5050 System Dynamics and Controls
   ☐ ME 3110 Thermodynamics I  ☐ ME 5150 Design of Thermal Systems
   ☐ ME 4120 Thermodynamics II  ☐ ME 5151 Thermal Engineering Laboratory
   ☐ ME 3140 Intermediate Fluid Mechanics  ☐ ME 5250 Mechatronics
   ☐ ME 3210 Mechanism Design  ☐ ME 5251 Mechatronics Laboratory
   ☐ ME 3220 Engineering Materials  ☐ ME 4260 Finite Element
   ☐ ME 3221 Engineering Materials Laboratory  ☐ ME 4261 CAE Laboratory
   ☐ ME 4041/29 Eng. Measurements Laboratory  ☐ ME 5992 Capstone Design I
   ☐ ME 4130 Heat Transfer I  ☐ ME 5994 Capstone Design II
   ☐ ME 4140 Heat Transfer II
Electives

- ME 2930 Introduction To Aerospace Eng.
- ME 4930 Aerodynamics
- ME 4932 Aircraft Performance And Design
- ME 3960 Introduction To Plastics Eng.
- ME 3962 Plastics Processing
- ME 3940 Biomaterials
- ME 4940 Biofluid Mechanics
- ME 4942 Biosolid Mechanics
- ME 5910 Air Conditioning Systems Design
- ME 5912 Combustion Theory And App.
- ME 5914 Computational Fluid Dynamics
- ME 5916 Internal Combustion Engines
- ME 5918 Power Plants Engineering
- ME 5920 Refrigeration Systems Design
- ME 5922 Turbomachinery
- ME 5950 Mechanical Vibrations
- ME 5952 Dynamics Of Machinery
- ME 5958 Robotics
- ME 5956 Introduction To Design For Manuf.
- ME 5970 Mechanical Engineering Practice
- ME 5980 Undergraduate Research
- ME 5990 Special Topics In Mechanical Eng.
We appreciate your time to fill out this survey. Your responses will help us in assessing our degree of success in meeting our strategic goals. Thank you for your honest and thoughtful feedback that only you can give us.

Name: ___________________________
Year Graduated:  _______________  GPA at graduation: ________
If transfer student, from which University: _________________________

1. Please indicate which of the following statements is applicable to your situation. (Prog. Obj. 1)
   - Employed full time (>30 hours a week)
   - Employed part time (< 30 hours a week)
   - I am enrolled in graduate school
   - Not employed

2. What is the name of your position? _____________________

3. If NOT employed go to question 5, What best describes your current position?
   - Engineering Design
   - Maintenance
   - Sales
   - Manufacturing
   - HVAC Design
   - Management
   - Researcher
   - Consulting
   - Own Eng. Business
   - Other: __________________________ (specify)

4. Salary Range:
   - $20,000 or less
   - $20,001-$25,000
   - $25,001-$30,000
   - $30,001-$35,000
   - $35,001-$40,000
   - $40,001-$45,000
   - $45,001-$50,000
   - >$50,000

5. What was your first employment after graduation? ________________

6. How long after graduation did you obtain your engineering related job? ________

7. Which course(s) were most important to achieve your engineering career goals?
   ________________________________________________________________

8. Which course(s) do you recommend to help you achieve your engineering career goals?
   ________________________________________________________________

9. Did you take or plan to take the Fundamentals of Engineering Exam? (i)
   - Yes
   - No
   - Later on Date: _____________

10. Did you pass the Fundamentals of Engineering Exam? (i)
    - Yes
    - No
11. Are you colligated “colegiado con el CIAPR”? (i)
☐ Yes    ☐ No    ☐ Later on Date:_________

12. Are you planning to study in grad school? (Prog. Obj. 1, i)
☐ Yes    ☐ No    ☐ Already have graduate degree (specify) ______________
☐ Later on Date:_______

13. Have you attended any seminars, workshops, etc.?
☐ Yes    ☐ No
If yes, how many approximately per year? ________

14 If you had the opportunity and proper training, would you have started an engineering business?
☐ Yes    ☐ No

As result of my PUPR engineering education, I am well prepared to:

a. apply knowledge of mathematics, science, and engineering. (Prog. Obj. 2)
Never used? Totally Disagree Disagree Agree Totally Agree
1 2 3 4

b. design and conduct experiments as well as to analyze and interpret data (Prog. Obj. 3)
1 2 3 4

c. design a system, component or process to meet desired needs. (Prog. Obj. 3)
1 2 3 4

d. function on multi-disciplinary teams (Prog. Obj. 4)
1 2 3 4

e. identify, formulate, and solve engineering problems (Prog. Obj. 2)
1 2 3 4

f. understand professional and ethical responsibilities (Prog. Obj. 5)
1 2 3 4

g. communicate effectively (Prog. Obj. 4)
1 2 3 4

h. understand the impact of engineering solutions in a global society context (Prog. Obj. 3)
1 2 3 4

i. recognize the need for, and engage in life-long learning (Prog. Obj. 5)
1 2 3 4

j. understand contemporary issues (Prog. Obj. 5)
1 2 3 4

k. use techniques, skills and modern engineering tools necessary for engineering practice (Prog. Obj. 2)
1 2 3 4
n. apply knowledge of both thermal and mechanical systems areas including the design and realization of such systems (Prog. Obj. 1)
GRADUATING SENIOR EXIT SURVEY
Polytechnic University of Puerto Rico
Mechanical Engineering Department

Term

GRADUATING SENIORS: For multiple choice questions, please select an answer that is closest/best. For other questions, provide your answers in the space provided. Use the reverse side of the page if you need more space.

1. When do you expect to graduate? Please indicate month and year ____________________________

2. When did you enter Polytechnic University of Puerto Rico’s engineering program? Please state month and year ____________________________

3. What is your Cumulative Grade Point Average?
   a. 2.00 - 2.50   b. 2.51 - 3.00   c. 3.01 - 3.50   d. 3.51 - 4.00

4. Did you transfer to PUPR from another college of university?  a. Yes    b. No

5. If you transferred, approximately how many credit hours did you transfer into PUPR?
   a. <10   b. 11-20   c. 21-30   d. 31-40   e. 41-50   f. >50

6. What is your current age?
   a. <25   b. 25-30   c. 31-35   d. 36-40   e. 41-45   f. 46-50   g. >50

7. Do you hold any certifications of professional registration?
   a. Professional Engineer   b. Engineering in Training   c. Other (Please state) ________________

8. Do you have a job offer? If so, how many? If none, state “none” and skip the next question?
   ______________________________________________________________________________

9. If you have accepted a job offer, please provide the following information:
   i. Company name ____________________________
   ii. Salary range?
       a. $30,000 or less   b. $30,001-$40,000   c. $40,001-$50,000
       d. $50,000-$60,000   e. $60,001-$70,000   f. > $70,000
   iii. Nature of the position?
       d. Other (Please state) ____________________________
10. Are you planning to attend graduate school? If no, please skip the next question

11. If you are planning to attend graduate school, please provide the following information?

   University name                       ______________________________
   Department/Program                    ______________________________
   Degree Sought                         ______________________________
   Type and amount of financial support  ______________________________

12. Think about the best teacher you had at PUPR. What were the qualities of that teacher that you think should be emulated by other teachers?

13. Think about the worst teacher you had at PUPR. Please mention some characteristics that should be improved by this teacher and possibly by other teachers.

14. What can we improve about the facilities at the PUPR for students?
A. **Apply knowledge of mathematics, science, and engineering**; **L. Apply knowledge of chemistry and calculus-based physics with depth in at least one of them**; and **M. Apply knowledge of statistics, linear algebra and advanced mathematics through multivariate calculus and differential equations**.

1. If you are on a plain ground 30 ft away a 24-ft tree and aim a beam of light coming out the flashlight that you hold 4 ft above the ground to its top, then the most likely mathematical equation of the beam of light is:
   - (A) \( 2x + 3y - 72 = 0 \)
   - (B) \( 10x + 9y + 20 = 0 \)
   - (C) \( 9x - 10y - 240 = 0 \)
   - (D) \( 3x + 2y - 24 = 0 \)

2. A tropical storm approaches Puerto Rico describing a parabolic trajectory, the most likely equation that describes it is:
   - (A) \( x^2 + y^2 - 200 = 0 \)
   - (B) \( x^2 - 9y^2 + 200 = 0 \)
   - (C) \( 9xy - 10y - 200 = 0 \)
   - (D) \( 3x^2 + 5y - 20 = 0 \)

3. A skin diver is plunging into deep still sea water in a region in which pressure change is described by the following equation, \( \frac{dp}{dy} = 990(10 + y) \), when the diver is at a depth of 10 m, he/she experience a pressure of 148.5 kPa. What pressure will the diver be subject at a depth of 40 m?
   - (A) 188 kPa
   - (B) 218 kPa
   - (C) 1188 kPa
   - (D) 594 kPa

4. From an advance theory of flow past a sphere, the fluid velocity along an horizontal streamline in front of the sphere of radius \( a \) is given by \( V = V_o(1 + a^3/x^3) \), determine its acceleration \( \frac{DV}{Dt} = V_x \frac{\partial V}{\partial x} + V_y \frac{\partial V}{\partial y} + V_z \frac{\partial V}{\partial z} \).
   - (A) 0
   - (B) \( V_o^2(1 + a^2/x^2) \)
   - (C) \( -3V_o^2(1 + a^3/x^3) \cdot a^3/x^4 \)
   - (D) \( 3V_o^2(1 + a^3/x^3) \cdot a^2/x^3 \)

5. When a valve is opened, the velocity of water in a pipe is given by \( u = 10(1 - e^{-t}) \), where \( u \) is in ft/s and \( t \) is in seconds. Determine the maximum velocity and the maximum acceleration of the water.
   - (A) 10 ft/s, 10 ft/s^2
   - (B) 0 ft/s, 0 ft/s^2
6. The temperature distribution in a fluid is given by \( T = 5x + 10y \), where \( x \) and \( y \) are the horizontal and vertical coordinates in \( m \) and \( T \) in \(^\circ C\). Determine \( \frac{dT}{dt} \) of a fluid particle traveling horizontally with \( u = 10 \) m/s and \( v = 0 \).

(A) 50 \(^\circ C\)/s  
(B) 10 \(^\circ C\)/s  
(C) 100 \(^\circ C\)/s  
(D) 5 \(^\circ C\)/s

The following three questions are referred to the below figure in which incompressible air enter an elbow of squared-cross sectional area with a uniform speed of 6 m/s. At the exit of the elbow the velocity profile is not uniform as shown.

7. Determine the reverse flow rate in m\(^3\)/s.

(A) 6.75 m\(^3\)/s  
(B) 3.25 m\(^3\)/s  
(C) 1.55 m\(^3\)/s  
(D) 0.75 m\(^3\)/s

8. Calculate the net flow rate at the exit.

(A) 6.0 m\(^3\)/s  
(B) 18.5 m\(^3\)/s  
(C) 3.2 m\(^3\)/s  
(D) 1.75 m\(^3\)/s

9. It it the regimen of flow steady or unsteady?

(A) Steady flow  
(B) Unsteady flow  
(C) Not enough information to figure out  
(D) None of the above

10. The temperature distribution in a fluid is given by \( T = 5x + 10y \), where \( x \) and \( y \) are the horizontal and vertical coordinates in \( m \) and \( T \) in \(^\circ C\). Determine \( \frac{dT}{dt} \) of a fluid particle traveling horizontally with \( u = 10 \) m/s and \( v = 0 \).

(A) 50 \(^\circ C\)/s  
(B) 10 \(^\circ C\)/s
11. The equation that represent a particle moving at constant acceleration is  \( v = 2.5 + 6t \), then the most likely particle acceleration after 10 min of movement is:

(A) 2.5 m/s
(B) 6 m/s²
(C) 0.25 ft/s²
(D) 6 m/s

12. The angular momentum of a projectile changes with time according to the equation \( H = 9t^2 - 54t + 81 \), where \( t \) is given in minutes. How long should it pass in order to have an angular momentum of zero for the projectile? The most like answer is

(A) 9 min
(B) 3 min
(C) 5 min
(D) 120 sec

13. The velocity distribution in a 0.5 m pipe is given by \( u = 10(1 - 4r^2) \), if the average velocity is defined as \( u_{avg} = 2\pi \int_0^R u dr \), then the most likely average velocity is

(A) \( \frac{20\pi}{3} \) m/s
(B) 30\pi m/s
(C) \( \frac{5\pi}{3} \) m/s
(D) \( \pi \) m/s

14. An ideal gas, \( pv = RT \), expands isothermally from an state described by 500 kPa of pressure and 0.1 m³/kg of specific volume to the state given by the specific volume of 0.5 m³/kg. The most likely work done, \( w = \int_{v_l}^{v_f} pdv \), is

(A) 5RT
(B) 200
(C) 20RT
(D) RT\ln5

15. Given the function \( F(s) = \frac{20}{s(s + 10)} \), rewrite this function as the sum of two fractions. The most likely partial fraction expansion is

(A) \( \frac{1}{s-1/(s+10)} \)
(B) \( \frac{1}{s-2/(s+10)} \)
(C) \( \frac{2}{s-1/(s+10)} \)
(D) \( \frac{2}{s-2/(s+10)} \)
B. Design and conduct experiments, as well as analyze and interpret data.

The following three questions are referred to the below figure in which is shown the time response of two thermocouples.

16. Referring to the previous figure, which of the following sentences is more likely true:
   (A) Thermocouple A heat faster than thermocouple B
   (B) Thermocouple B has the shorter time constant.
   (C) Thermocouple B reaches first a steady state temperature.
   (D) Thermocouple B heat faster than thermocouple A.

17. If the time constant of thermocouple B is 20 seconds, the most likely time delay for
the thermocouple display a reliable temperature is:
   (A) Less than 20 seconds
   (B) 20 second
   (C) At least 100 seconds
   (D) Not enough information to assess

18. Assuming the time constant of thermocouple A is 6 s. Which of the following
sentences is more likely true in a heating process that rises its temperature at 6°C/min:
   (A) Thermocouple A displays a temperature of 3°C behind the actual one.
   (B) Thermocouple A displays a temperature of 6°C behind the actual one.
   (C) Thermocouple A displays a temperature of 3°C ahead the actual one.
   (D) Thermocouple A displays real time temperatures.

19. You want to monitor the diameter of manufactured parts in a production line. You
take 30 sample measurements of the diameter every 4 hours. What is the best
statistical parameter that gives us an idea about the dispersion of the data?
   (A) Data range
   (B) Median
   (C) Standard deviation
   (D) Mean

20. What is the difference between accuracy and precision?
   (A) Accuracy is the repeatability of experimental results, whereas precision is the
   measurement of data unaffected by experimental error.
(B) Precision is the repeatability of experimental results, whereas accuracy is the measurement of data unaffected by experimental error.

(C) Precision is the difference between the actual value and the experimental value, whereas accuracy is the repeatability of experimental results.

(D) Accuracy is the difference between the actual value and the experimental value, whereas precision is the repeatability of experimental results.

21. You applied a linear regression to a dataset you had. You want to know if the linear regression applies to the data set, so you calculated the r-value. What value of r will represent the best fit of the linear regression?

(A) r-value between 0 to 0.15.

(B) r-value between 1.6 to 2.0

(C) r-value between 1.1 to 1.5

(D) r-value between 0.85 to 1.
C. Design a system, component, or process to meet desired needs; and N. Work professionally in both thermal and mechanical systems areas including the design and realization of such systems.

Hydraulic Design

22. A hydropower turbine fed with water from a reservoir is shown. If you were to use Bernoulli to determine the power generated which two points will you consider analyzing? (Recall Extended Bernoulli equation

\[
\frac{p_1}{\rho} + \frac{v_1^2}{2} + z_1 g + E_{\text{added}} = \frac{p_2}{\rho} + \frac{v_2^2}{2} + z_2 g + E_{\text{extracted}} + E_{\text{major loss}} + E_{\text{minor loss}}.
\]

(A) The pipe entrance and the pipe exit.  
(B) The top of the reservoir and the pipe exit.  
(C) The entrance of the turbine and the pipe exit.  
(D) The pipe entrance and the turbine entrance.

Thermal System Design

23. Need example of turbine cycle to evaluate if students know whether process is isentropic, isovolumetric, etc. 
   (A) LOG-MEAN Temperature Difference (LMTD).  
   (B) Number of Transfer Units (NTU).  
   (C) Either LMTD or NTU.  
   (D) Neither LMTD nor NTU.

24. You need to design a heat exchanger (including number of tube passes, contact area, etc.). You are given the needed inlet and outlet temperatures of the heat exchanger. What is the best method to use?  
   (A) LOG-MEAN Temperature Difference (LMTD).  
   (B) Number of Transfer Units (NTU).  
   (C) Either LMTD or NTU.  
   (D) Neither LMTD nor NTU.

Mechanism Design
25. You need to design a mechanism that converts a rotary motion to a linear motion. Which mechanism will you use?
   (A) Four bar linkage.
   (B) Crank slider.
   (C) Gears.
   (D) Six bar mechanism.

26. Which gear mechanism has the most compact configuration that can give the largest gear ratio?
   (A) Simple Gears.
   (B) Compound Gears.
   (C) Planetary Gears.
   (D) Epicycle Gears.

Machine Design

27. The failure theory for a static loading that best applies to ductile materials is:
   (A) Distortion Energy Theory.
   (B) Maximum Normal Stress Theory.
   (C) Maximum Shear Stress Theory.
   (D) All of the above.

28. For the above figure, determine what are the stress conditions that apply for element A at the top surface:
   (A) Bending Stress and Torsion Stress.
   (B) Bending Stress, Shear Stress, and Torsion Stress.
   (C) Torsion Stress and Transverse Shear.
   (D) Bending Stress, Torsion Stress and Transverse Shear.

29. For the above figure, determine what are the stress conditions that apply for element B at the right side surface:
(A) Bending Stress and Torsion Stress.
(B) Bending Stress, Shear Stress, and Torsion Stress.
(C) Torsion Stress and Transverse Shear.
(D) Bending Stress, Torsion Stress and Transverse Shear.

Automatic Controls

30. If the poles of a secondary order system are real, negative, and different the system should exhibit a time domain transitory response of the type:
   (A) Critically Damped.
   (B) Underdamped.
   (C) Undamped.
   (D) Overdamped.

Design for Manufacturing

31. You need to manufacture a metal part that withstands high stresses. Which manufacturing process will best improve the strength properties of the metal?
   (A) Forging.
   (B) Sand-Casting.
   (C) Machining.
   (D) Permanent Mold Casting.
D. Function on multi-disciplinary teams.

32. All of these are good ground rules to follow in multidisciplinary teams, except:
   (A) Be prepared and on time.
   (B) Be committed to the team purpose and listen actively.
   (C) Focus on the subject, do your fair share and help others.
   (D) Be defensive, but tolerate disagreement.

E. Identify, formulate and solve engineering problems.

33. What can best describe an open ended problem?
   (A) Can utilize appropriate resources to utilize to obtain information.
   (B) Can recognize errors when comparing the first estimate to the final calculation.
   (C) State concisely what is to be calculated
   (D) Relates social science knowledge when formulating an engineering solution.

F. Understand professional and ethical responsibilities.

34. The most important ethical priority in any conflict of a practicing engineer is with:
   (A) Society and the public.
   (B) The law.
   (C) The engineer’s firm.
   (D) The engineer personally.

35. Why is it important to register as a Professional Engineer?
   (A) To protect the public preventing unqualified individuals from offering engineering services.
   (B) In some companies, employment, advances, and managerial positions are limited to registered engineers
   (C) You have the same level of competence and knowledge of professionals graduated from different educational institutions.
   (D) All of the above.

G. Communicate effectively.

36. What is the definition of an Abstract in a report?
   (A) The main idea or the particular problem that is addressed in the report is stated.
   (B) Discuss the context and history of the project and describe what has been done in the past.
   (C) Is a brief summary of the contents of the document.
   (D) Discuss the phases of the design and implementation of your project.
H. Understand the impact of engineering solutions in a global and societal context.

37. As an engineer you want to use the best air-fuel ratio for a combustion process to reduce the emission of harmful gases. Which products of combustion have the least harmful gases?
(A) \( \text{C}_8\text{H}_{18} + 16.32(\text{O}_2 + 3.76\text{N}_2) \rightarrow 7.37\text{CO}_2 + 0.65\text{CO} + 4.13\text{O}_2 + 61.38\text{N}_2 + 9\text{H}_2\text{O} \)
(B) \( \text{C}_8\text{H}_{18} + 12.5(\text{O}_2 + 3.76\text{N}_2) \rightarrow 8\text{CO}_2 + 9\text{CO} + 47\text{N}_2 \)
(C) \( \text{C}_8\text{H}_{18} + 50(\text{O}_2 + 3.76\text{N}_2) \rightarrow 8\text{CO}_2 + 37.5\text{O}_2 + 188\text{N}_2 + 9\text{H}_2\text{O} \)
(D) \( \text{C}_8\text{H}_{18} + 11.25(\text{O}_2 + 3.76\text{N}_2) \rightarrow 5.5\text{CO}_2 + 2.5\text{CO} + 42.3\text{N}_2 + 9\text{H}_2\text{O} \)

I. Recognize the need for and have an ability to engage in lifelong learning.

38. The need to establish life long learning as a requirement to be a license engineer is mostly due to:
(A) To protect and secure the general public.
(B) To fulfill law requirements.
(C) To cooperate with the State Board of Engineers to defend the profession.
(D) To pursue graduate studies (Masters and/or PhD)

J. Possess knowledge of contemporary issues.

39. Why is there a need to find alternative energy sources other than petroleum?
(A) Petroleum is too expensive.
(B) Burning petroleum increases the global warming problem.
(C) Petroleum is scarce and non-renewable.
(D) All of the above.

40. What is the area in Mechanical Engineering that has the most growth in the present?
(A) Thermal Area.
(B) Design and Controls Area.
(C) Aerospace Area.
(D) Nanotechnology and Bioengineering Areas.

K. Use techniques, skills and modern engineering tools necessary for engineering practice.

41. For a the mechanical engineer of today the most important engineering tool for engineering practice is:
(A) The use of computers and software.
(B) The use of machine tool equipment.
(C) The use of Global Positioning Systems (GPS)
(D) An engineer’s calculator.
E. Cycles Report
OUTCOME ASSESSMENT FACULTY COMMITTEE
MECHANICAL ENGINEERING FACULTY COMMITTEE
POLYTECHNIC UNIVERSITY OF PUERTO RICO

ANNUAL REPORT
2001-2003 CYCLE REPORT

Submitted by: Herbert Jaramillo
Bernando Restrepo
Carlos Alvarado
Jacinto Solano
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1.0 Introduction

This document contains the recommendations of the Outcome Assessment Faculty Committee (OAFC) to improve the quality of the education in the Mechanical Engineering Department at the Polytechnic University of Puerto Rico. To assess the Mechanical Engineering program the “Self Study Report for review of Engineering Programs Submitted by the Mechanical Engineering Program of the Polytechnic University of Puerto Rico in July 2001” was used as a guideline. This report was presented to the Accreditation Board of Engineering Technology (ABET) to define how to assess our program. The assessment process is based in the concept Outcome Assessment. Program Outcomes (defined by ABET and the American Society of Mechanical Engineering) are used in the process of evaluation. These outcomes are postulates that assist us to determine which specific skills must be developed in the students.

The evaluation tools used to achieve the program outcomes are surveys to students, alumni, and industry; transcript analysis, fundamental exam results; focus groups; etc. Once this information is gathered recommendations to the ME department are made by the committee.

The assessment process takes place in two year cycles. This is the report for the OAFC for the 2001-2003 cycle.

2.0 Evaluation Tools Information

The evaluation tools used for the 2001-2003 cycle are the Portfolio Evaluation, Surveys, Alumni Focus Groups, and Transcript Evaluation Index. Other tools were not used because the data was not available. The recommendations on how to improve the learning process and outcome assessment will be discussed in the next section.

2.1 Portfolio Evaluation

The portfolio evaluation gives us important information for the Outcome Assessment process and to verify that the professor covers all the topics presented in the syllabus and that the student accomplishes the outcomes for the course (EC2000 criteria at the course level). To accomplish this task the committee members studied the portfolios for each course for each professor for each section for the trimester of Spring 2002. These reports are available in Appendix A, and contain the necessary comments in order for the professors to improve the achievement of outcomes and the fulfillment of the topics presented in the syllabus. These findings are submitted to each professor.
2.2 Surveys

There are several surveys that allow us to measure the accomplishment of the Outcomes. These surveys are the Capstone Student Survey, Capstone Peer Survey, Senior Exit Survey, Alumni Survey, and Employer Survey. The Capstone Student Survey provides a self-assessment feedback from students within the context of EC2000 when faced with a major design experience. The Capstone Peer Survey provides a peer-assessment feedback from students within the context of EC2000 when faced with a major design experience. The Senior Exit Survey provides feedback on courses, faculty, facilities, and EC2000 criteria achievement. The Alumni Survey gives us documentation of alumni assessment of EC2000 criteria about strengths and weaknesses of the program. The Employer Survey is an assessment of alumni as a group within the context of EC2000, specifically the concerns of employers.

The surveys performed for the 2001-2003 cycle are the Capstone Student Survey, Capstone Peer Survey, Senior Exit Survey, and Alumni Survey. Other surveys were not conducted because lack of information. The following subsections show the results for each survey.

2.2.1 Capstone Student Survey

This survey was conducted in winter 2002 (academic year 2002-2003) and spring 2003 (academic year 2002-2003) to students completing the Capstone II course. Figure 1 shows the response to each outcome for the self-assessment surpasses the 70% reference level. This means that, according to students, all of the outcomes were achieved through the ME program. More information about this survey can be found in Appendix B.

2.2.2 Capstone Peer Survey

This survey was performed in the same trimester and course as the Capstone Student Survey. Figure 2 shows the response to each outcome for the peer-assessment surpasses the 70% reference level. Again, this means that, according to students, all of the outcomes were achieved through the ME program. More information about this survey can be found in Appendix C.

2.2.3 Senior Exit Survey

This survey was conducted in Fall 2002 (academic year 2002-2003) and Spring 2003 (academic year 2002-2003) to students graduating from the ME program (results available in Appendix D). The survey aimed to assess the response of the students in order to measure the achievement of the program educational outcomes.
Figure 1. Outcome agree and Totally Agree Capstone Student Self-Assessment Survey Year 2002-2003

Figure 2. Outcome Agree and Totally Agree Capstone Student Peer survey Year 2002-2003
Results obtained by the OAFC after analysis of the surveys administrated in academic year 2002-2003 reflect the following. 25% of the students affirm they have a job offer. A 81.23% of the students expressed that they had submitted more than 10 written technical reports during their career as students. 93.8% of the students attend at least one workshop, seminar, or short course besides their regular curriculum. 75.2% of the students are members of at least one professional society. 81.4% of the students responded they agree or strongly agree in that they will be capable of practicing engineering successfully. In addition, Figure 3 shows outcomes b, d, e, f, i, and n where above the 70% as required by criteria. Outcomes a, c, k, l, m, and o, were evaluated by the students with a minimum of 3.73 and a maximum of 3.80 in a 0-5 scale. This represents a high proficiency of the students’ feeling about these outcomes. Outcome g, h, and j with a 68.8%, 65.7%, and 62.6% respectively were below the 70% required criteria. In general terms the above results show that it was a consistency in most of the outcomes.

In addition, the surveys provide information asking the students in which courses they accomplished the outcomes. Table 1 shows the courses that need to be targeted in order for the outcomes provide the necessary skills to students. Appendix D Table D.1 and Table D.2 have more information.
<table>
<thead>
<tr>
<th>Outcome \ Trimester</th>
<th>Fall 02</th>
<th>Fall 03</th>
</tr>
</thead>
</table>
| b - design and conduct experiments, as well as to analyze and interpret data | • Engineering Materials Lab.  
• Fluid Mechanics Lab. | OK  
• Solid Mechanics I & II  
• Manufacturing Engineering  
• Manufacturing Engineering Lab.  
• Automatic Control Systems |
| c - design a system, component, or process to meet desired needs | • Solid Mechanics I & II  
• Manufacturing Engineering  
• Manufacturing Engineering Lab. | • Solid Mechanics I & II  
• Manufacturing Engineering  
• Manufacturing Engineering Lab. |
| e identify, formulate, and solve engineering problems | • Applied Numerical Analysis  
• Engineering Materials  
• Engineering Materials Laboratory  
• Engineering Measurements Laboratory  
• Solid Mechanics I  
• Solids Mechanics II  
• Manufacturing Engineering  
• Manufacturing Engineering Laboratory  
• Mechatronic Laboratory  
• Mechanical Engineering Capstone Design I  
• Mechanical Engineering Capstone Design II | • Applied Numerical Analysis  
• Mechanism Design  
• Engineering Measurements Laboratory  
• Solid Mechanics I  
• Solids Mechanics II  
• Manufacturing Engineering  
• Manufacturing Engineering Laboratory  
• Mechatronic Laboratory |
| f understand professional and ethical responsibilities | • Thermodynamics II  
• Manufacturing Engineering  
• Manufacturing Engineering Laboratory | • Thermodynamics II  
• Design of Machine Elements I  
• Design of Machine Elements II  
• Manufacturing Engineering  
• Manufacturing Engineering Laboratory  
• Mechanical Engineering Capstone Design I  
• Mechanical Engineering Capstone Design II |
| h - understand the impact of engineering solutions in a global and societal context | • Engineering Materials  
• Manufacturing Engineering | • Engineering Materials |

Table 1. Courses That need to be Focus on the Outcomes according to students
2.2.4 Alumni Survey

The outcomes that were not achieved according to the Alumni are from g to o.

2.3 Alumni Focus Groups

A meeting with Alumni was conducted in Spring 2003 with an attendance of about 13 students. This discussion resulted in various recommendations from the Alumni to improve the skills of future graduates from our program. Some of these recommendations were:

- Make Turbomachinery and Power Plant elective courses to be included as mandatory the curricula, because it is important in the Professional Examination. Also, they want these courses to be more related to what they will face in the field.
- To make a new class that merges knowledge from course in Machine Design, Controls, and Circuits.
- To make seminars related to the material covered in class.
- To make a course related to Project Management and/or Business Administration.
- Make oral presentations in English in front of a panel.
- Promote industrial practice to students.
- To make more contact with pharmaceutical industry and government.
- Offer a masters degree that includes Applied Mechanics, Optimization, Maintenance and Operation Systems, Project Management, Scheduling, etc.
- Promote the use of computers and presentations in the internet.
- Make Continue Education courses.

2.4 Transcript Evaluation Index

Twenty seven transcripts from the graduating class of 2002 and thirty six transcripts from graduating class 2003 were analyzed by the OAFC. The results were compared with respect to the program outcomes criteria.

Figures 4 (tabulated in Appendix E) illustrate a recent analysis made of those outcomes for which transcripts are an assessment method. According to the analysis performed, outcomes a, b, c, e and l are achieved in average.

In outcomes a, b, c, e and l at least a 73% of students (in the critical case) have a cumulative GPA above the minimum criterion.

Furthermore, outcomes, m n, and o where also achieved. Outcome f was not achieved in graduating class of 2002, but raises to 83.3% in graduating class of 2003.
Comparing the result for these two years, those outcomes for which transcripts are an assessment method show a significant increase for class 2003. Figure 5 shows that in average ME students are graduating with GPA above 2.0 in all key areas of studies of the Mechanical Engineering program.

**Figure 4.** Transcript Data Analysis

**Figure 5.** GPA of ME Graduating Students in Specific Areas
3.0 Recommendations by the Committee to the ME Program

The suggestions presented in this section are based on the findings when using the Evaluation Assessment Tools in the previous section.

3.1 Recommendations Based in Portfolio Evaluation

As mentioned earlier, based in the Portfolio Evaluation the professors that taught the courses were informed via memo about the findings of the committee so that they as well improve their teaching strategies towards achieving the program outcomes. In addition to this action, the committee concluded that changes to the course syllabus needed to be implemented to achieve the program outcomes in each course. Below the changes to the syllabus in Course Description and Topics Covered, Instructional Strategies, Required Resources, Evaluation Strategies in courses and laboratories, Textbook changes, and Outcomes that apply to courses are presented.

a) Course Description and Topics
   - ME 4210 eliminate points 7 & 8, move them to ME4220 (Herbert)
   - ME 4220 eliminate 5 & 6 move them to ME 4230 (Herbert)
   - ME 4230 eliminate 5 & 6 move them to ME 5240 (Herbert)
   - ME 4120 eliminate thermodynamic relations Topic 6 (Bernardo)
   - ME 5050 sections 5, 6, & 7 discuss using MATLAB (Carlos)
   - ME 5251 divide lab in 3 major topics 1) Data Acquisition, 2) PLC’s, and 3) Microprocessors, unite topic in these larger topics (Carlos)
   - ME 5260 & 5261 add tolerancing topic , rearrange order of topics (Carlos)
   - ENGI 3410 Move Angular momentum form topic 5 to topic 7. eliminate moment of inertia in topic 7. (Bernardo)

b) Instructional Strategies:
   - ME 5260 & ME 5261 eliminate paragraph and the use of COSMOS (Carlos)

c) Required Resources:
   - ME 5260 & ME 5261 eliminate COSMOS add ProE (Carlos)

d) Evaluation Strategies:
   - **Courses**
     - 75% exams, 5% Assignments & Quizzes, 15% Project, 5% Portfolio
   - **Labs**
     - 30% final exam, 5% Portfolio, 50% Reports, 15% Presentation Students absent will have 0% in lab, Students arriving late will have 20% off from lab grade in the first 30min., after 1hr 0% in lab, 3 Absences will fail the student.

e) Text Books:
ENG1 3420 suggest to change book (Jacinto)

f) Outcomes:
   k & o Together for all
   ME 4021 add c, j need to show evidence (Bernardo)
   ENG1 3410 add e (Bernardo)
   ME 3210 add c eliminate l (m covers) (Bernardo)
   ENG1 3421 add d in syllabus, eliminate f, add m (Bernardo)
   ME 4241 eliminate b, eliminate h (Bernardo)
   Jacinto will revise the Outcomes for his courses. Other group members do not have any other comment.

3. 2 Recommendations based on Surveys

Here are the recommendations based in the surveys.

3.2.1 Capstone Student Survey

The recommendations from the portfolio evaluation, in which the professors were notified about their course deficiencies, satisfy most of the concerns presented in the Capstone Student Survey. Also, the changes in the syllabuses serve as a guide for the professors as to how to achieve the course outcomes.

3.2.2 Capstone Peer Survey

Same comments as in the Capstone Student Survey.

3.2.3 Senior Exit Survey

As mentioned earlier, the Senior Exit Survey assists us to obtain feedback on the courses offered, faculty, and facilities. The surveys showed us that use of computer tools needs to be improved. This might be done in several ways. First the curricula can be reviewed and courses related to computers might be implemented. For example, an Engineering Graphics course that uses Solid Modeling (Pro-Engineering, Solidworks, Auto CAD, etc.) packages early in their student curricula. The courses in Numerical Analysis can use modern tools such as MATLAB, MATCAD, among others. The integration of Controls, Machine Design, Mechanism Design, and Electronics in a Mechatronics class. To offer a Finite Element Course were students can apply their knowledge in Mechanical and Thermal Systems.
3.2.4 Alumni Survey

Most of the concerns obtain from this survey are closely related to the finding in the Senior Exit Survey. The changes suggested in the Senior Exit Survey will satisfy most of the findings of this survey.

4.0 Evaluation Tools Revisited and Self-Study Report Suggested Changes

The use of evaluation tools assists us to assess the Mechanical Engineering Program. However, some recommendations to improve the way that the information in gathered, the avoidance of repetitive information from different tools, and the effectiveness of the tools themselves needs to be addressed. These recommendations serve to amend the Self Study Report. Here are the suggested changes to change evaluation tools:

4.1 Information Gathering

a) Portfolio Evaluation

The Portfolio Evaluation is performed by the committee going through all the portfolios submitted by the professors. It takes a lot of time to go through the portfolios and sometimes items not found in the portfolio might have been covered by the professor. In the future the information might be gathered using a survey to students using an instructional tool such as Blackboard in which the information may be gathered immediately.

b) Surveys

Capstone Student Survey

The surveys are submitted to the students at the end of the trimester and the information is then graphed in a computer program, such as Excel. This information may be gathered using the Blackboard instructional tool.

Capstone Peer Survey

Same comment as in the Capstone Student Survey.

Senior Exit Survey

Same comment as in the Capstone Student Survey, except that some of the questions are formulated as a fill in the blank question. It will be better if they can be changed to a multiple choice format to gather and analyze the information easier.
Alumni Survey

The problem in gathering the information is to get the Alumni to answer the Survey. The best way will be to contact them via email and let them fill out the survey via the internet.

Employer Survey

Same comment as in the Alumni Survey.

c) Alumni Focus Groups

The problem in gathering the information is to get the Alumni to meet. In the past, about 13 students attended the meeting. Efforts such as sending Alumni newsletters of recent program changes and department information helps us to recruit more students to assist the focus group meetings.

d) Industry Focus Group

The problem in gathering the information is to get the Industry to meet. The best way could be to make a meeting in the Job Fair made by the university. This will be a good opportunity to make a Focus Group meeting.

e) Transcript Evaluation Index

This information is always available electronically in the CAMS system.

f) Fundamental Exam Index

This information is submitted to the Dean of Engineering, but no information from the Dean’s Office has been received for some years. The Committee will contact the Dean’s Office to know how frequently the information is available.

4.2 Avoidance of Repetitive Information from Different Evaluation Tools

a) Portfolio Evaluation

There is no problem with the portfolio information gathered. It gives unique information about the outcome assessment process and the topics covered in class. The exams and home works show how the students apply their learn skills that are related to the outcome.

b) Surveys

Capstone Student Survey
There are certain similarities of this survey with the Senior Exit Survey. These surveys are, in practice, given to capstone students which happen to be seniors. Most of the information collected from the students is based in the outcomes. The Senior Exit Survey is more detailed than the capstone survey when asking the students. The committee recommends integrating both surveys (Capstone Student Survey and the Senior Exit Survey) into only one survey.

**Capstone Peer Survey**

This survey has no problems. It is based in the outcome assessment, but the peers evaluate the students.

**Senior Exit Survey**

See comment on Capstone Student Survey.

**Alumni Survey**

The Alumni Survey gives us documentation of alumni assessment of EC2000 criteria about strengths and weaknesses of the program. This tool obtains similar information from the Alumni Focus meetings. Either the Survey and/or the Alumni Focus groups may be used to re-evaluate the program objectives and achieve better results in the outcome assessment process.

**Employer Surveys**

The Employer Survey gives us documentation of employers assessment feedback about strengths and weaknesses of our alumni. This tool obtains similar information from the Industry Focus meetings. Either the Survey and/or the Employer Focus groups may be used to re-evaluate the program objectives and achieve better results in the outcome assessment process.

c) Alumni Focus Groups

The focus groups help us to obtain feedback from alumni about industry’s current needs. See additional comment on Alumni Surveys.

d) Industry Focus Group

The focus groups help us to obtain feedback from industry about industry’s current needs. See additional comment on Employer Surveys.

e) Transcript Evaluation Index

This evaluation tool is not repetitive.
f) Fundamental Exam Index

This evaluation tool is not repetitive.

4.3 Effectiveness of the Tool

The evaluation tools can be characterized in two ways for the outcome assessment process. The first characterization is to obtain information that directly proves that the student is achieving the defined outcomes. The second characterization is to obtain information that indirectly tells us whether the students achieve the defined objectives. The prefer method of evaluation tools is the direct proof that the students achieve the outcomes.

<table>
<thead>
<tr>
<th>Evaluation Tool</th>
<th>Direct Evaluation Tool</th>
<th>Indirect Evaluation Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Portfolio</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Course Portfolio</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Outcome Portfolio</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Capstone Student Survey</td>
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<td>X</td>
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<tr>
<td>Capstone Peer Survey</td>
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<td>Senior Exit Survey</td>
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<td>Alumni Survey</td>
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<tr>
<td>Employer Survey</td>
<td></td>
<td>X</td>
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<tr>
<td>Alumni Focus Group</td>
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</tr>
<tr>
<td>Industry Focus Group</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Transcript Analysis Index</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>FE Exam</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Direct tools serve as a clear indicator that relates the student skills to the program outcomes. Indirect tools help us to determine if the program objectives are up to date to the needs of the modern challenges in Mechanical Engineering.
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CHAPTER 1
INTRODUCTION

This document contains the recommendations of the Outcome Assessment Faculty Committee (OAFC) to improve the quality of the education in the Mechanical Engineering Department at the Polytechnic University of Puerto Rico (ME-PUPR). To assess the Mechanical Engineering program the “Self Study Report for review of Engineering Programs Submitted by the Mechanical Engineering Program of the Polytechnic University of Puerto Rico in July 2001” was used as a guideline to achieve the Accreditation Board of Engineering Technology (ABET) requirements. The assessment process is based in the concept of Outcome Assessment and achievement of Program Objectives.

Program Outcomes (defined by ABET and the American Society of Mechanical Engineering) are used in the process of evaluation. These outcomes are postulates that assist us to determine which specific skills must be developed in the students. These outcomes are:

Every graduating mechanical engineer form our program shall be able to:

Outcome A - apply knowledge of mathematics, science and engineering.
Outcome B - design and conduct experiments, as well as analyze and interpret data.
Outcome C - design a system, component, or process to meet desired needs.
Outcome D - function on multi-disciplinary teams.
Outcome E - identify, formulate and solve engineering problems.
Outcome F - understand professional and ethical responsibilities.
Outcome G - communicate effectively.
Outcome H - understand the impact of engineering solutions in a global and societal context.
Outcome I - recognize the need for and an ability to engage in lifelong learning.
Outcome J - understand contemporary issues.
Outcome K - use techniques, skills and modern engineering tools necessary for engineering practice.
Outcome L - apply knowledge of chemistry and calculus-based physics with depth in at least one of them.
Outcome M - apply statistics, linear algebra and advanced mathematics through multivariate calculus and differential equations.
Outcome N - work professionally in both thermal and mechanical systems areas including the design and realization of such systems.
Outcome O - apply knowledge of contemporary analytical computational and experimental practice.

In addition to the Outcome Assessment process, the program educational objectives have to be achieved and revised to adapt to the ever changing educational and professional needs. The current program educational objectives as stated in the 1995 ABET report is the following:

“The Mechanical Engineering program aims to give students breadth and depth knowledge in mechanical engineering, mathematics, and social sciences. The students are prepared for entry level positions in industry and graduate studies in engineering and other professional fields.”

More specifically the students graduating from our program shall be able to:

1. work effectively in the mechanical engineering profession in both thermal and mechanical system areas or successfully pursue graduate studies as appropriate to individual career goals.
2. apply the fundamentals of mathematics, science, and engineering and use modern engineering techniques and tools to solve mechanical engineering problems.
3. design and develop useful products, processes, or systems that benefit society and design and conduct experiments and analyze and interpret data.
4. participate as team members in projects that may involve multi-disciplinary activities, communicate their ideas verbally, graphically, and in writing so that they can perform engineering functions effectively.
5. conduct their engineering work professionally, aware of related ethical and contemporary issues, and continually improve their capabilities through life long learning.

Both the program objectives and the outcomes to be achieved in each course are available to students in their syllabuses.

The assessment process in the department is performed in two year cycles. Figure 1 shows evaluation tools used in this cycle. Chapter 2 contains the results of the evaluation tools used for Outcome Assessment. Chapter 3 includes the results evaluation tools used for the program objectives assessment. Chapter 4 contains the analyses of results and the recommendations made by the professors and the committee. Chapter 5 contains the improvement of evaluations tools. This document is submitted to the Head of the Mechanical Engineering Department.
Figure 1. Program Assessment 2 Year Cycle
CHAPTER 2
RESULTS OF OUTCOME ASSESSMENT EVALUATION

The Outcome Assessment evaluation tools used for the 2003-2005 cycle are the Portfolio Evaluation, Capstone Surveys, Senior Exit Surveys, Transcript Evaluation Index, and Fundamental Exam. This chapter contains results that show the achievement of outcomes and recommendations made by the committee and the professors.

2.1 Portfolio Evaluation

The student portfolio evaluation gives us important information about the Outcome Assessment process to determine if the course objectives are achieved according to the syllabus (based in the EC2000 criteria at the course level). In the portfolio, the student demonstrates what he learned in the course. This is considered to be a direct measure of the expected outcomes. To evaluate the performance of students in each class the committee administered a course evaluation form were the students showed if the objectives of the course and thus the outcomes were achieved. These forms were administered using the Blackboard Instructional tool for each course. The average achievement for each outcome for all courses is in Figure 2. It can be seen that most outcomes are achieved to above the 70% threshold. Outcome I needs further improvement to achieve the performance expected for our program.

Figures 3 through 17 summarize the achievement of the outcomes per course. It can be seen that most courses achieve the outcomes above the 70%. Courses that still have difficulties to achieve the outcomes to an acceptable level are shown in Table 1.

More detailed graphs per course are presented in Appendix A. The achievement of a course objective is obtained when students have 70% or higher score. This evaluation is performed every trimester and the results are given to the professors for their review.
Figure 2. Average Outcome Performance for Cycle 2003-2005
Figure 3. Outcome A performance per course

Figure 4. Outcome B performance per course
Figure 5. Outcome C performance per course

Figure 6. Outcome D performance per course
Figure 7. Outcome E performance per course

Figure 8. Outcome F performance per course
Figure 9. Outcome G performance per course

Figure 10. Outcome H performance per course
Outcome I Performance

Figure 11. Outcome I performance per course

Outcome J Performance

Figure 12. Outcome J performance per course
Figure 13. Outcome K performance per course

Figure 14. Outcome L performance per course
Figure 15. Outcome M performance per course

Figure 16. Outcome N performance per course
Figure 17. Outcome O performance per course

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Courses</th>
<th>Fail %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>ENGI 3410, ENGI 3420, ME 2010, ME 3010</td>
<td>15.38</td>
</tr>
<tr>
<td>C</td>
<td>ME 3010, ME 3110, ME 4210, ME 5910</td>
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</tr>
<tr>
<td>D</td>
<td>ENGI 3410, ME 2010</td>
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<td>E</td>
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</tr>
<tr>
<td>G</td>
<td>ME 2010</td>
<td>3.85</td>
</tr>
<tr>
<td>I</td>
<td>ME 2010, ME 5240</td>
<td>40.00</td>
</tr>
<tr>
<td>J</td>
<td>ME 4240</td>
<td>25.00</td>
</tr>
<tr>
<td>K</td>
<td>ENGI 3410, ME 2010, ME 3010, ME 3140</td>
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<td>L</td>
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<td>M</td>
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<td>N</td>
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</tr>
<tr>
<td>O</td>
<td>ME 2010, ME 3140, ME 4240</td>
<td>11.54</td>
</tr>
</tbody>
</table>

Table 1. Courses to Improve achievement of Outcomes
2.2 Capstone Surveys

There are two capstone surveys that allow us to measure the accomplishment of the outcomes. These surveys are the Capstone Student Survey and Capstone Peer Survey. The Capstone Student Survey provides a self-assessment feedback from students within the context of EC2000 when faced with a major design experience. The Capstone Peer Survey provides a peer-assessment feedback from students within the context of EC2000 when faced with a major design experience.

2.2.1 Capstone Student Survey

This survey was conducted during the 2003-2005 cycle to students completing the Capstone II course. Figure 18 shows the response to each outcome for the self-assessment surpasses the 70% reference level. This means that, according to students, all of the outcomes were achieved through the ME program.

2.2.2 Capstone Peer Survey

This survey was performed in the same trimester and course as the Capstone Student Survey. Figure 19 shows the response to each outcome for the peer-assessment surpasses the 70% reference level. Again, this means that, according to students, all of the outcomes were achieved through the ME program.

2.3 Senior Exit Survey

The survey aimed to assess the response of the students in order to measure the achievement of the program educational outcomes. This survey was conducted in Winter 2003, Spring 2003, Fall 2004, Winter 2004 and Spring 2005 to students graduating from the ME program. According to the results all outcomes are achieved above a 70%. Graphs for each question are available in Appendix B.

2.4 Transcript Evaluation Index

This information is the study of academic records of graduating students to assess the outcome achievements. Figure 20 shows that for all the outcomes there has been an improvement from graduates in 2004 to graduates in 2005. There are five outcomes that are achieved above the 70% threshold. These are outcomes B, F, H, I, and J. The other outcomes still need improvement according to this evaluation tool.

The performance of each course in each outcome is presented in Figures 21 to 35.
Figure 18. Capstone Self-Assessment Summary Cycle 2003-2005

Figure 19. Capstone Peer-Assessment Summary Cycle 2003-2005
Outcome Assessment According to Transcript Analysis

![Outcome Assessment Bar Chart]

**Figure 20. Transcript Evaluation Index**

**Figure 21. Outcome A performance according to Transcript Evaluation**
Figure 22. Outcome B performance according to Transcript Evaluation

Figure 23. Outcome C performance according to Transcript Evaluation
Figure 24. Outcome D performance according to Transcript Evaluation

Figure 25. Outcome E performance according to Transcript Evaluation
Figure 26. Outcome F performance according to Transcript Evaluation

Figure 27. Outcome G performance according to Transcript Evaluation
Figure 28. Outcome H performance according to Transcript Evaluation

Figure 29. Outcome I performance according to Transcript Evaluation
Figure 30. Outcome J performance according to Transcript Evaluation

Figure 31. Outcome K performance according to Transcript Evaluation
Figure 32. Outcome L performance according to Transcript Evaluation

Figure 33. Outcome M performance according to Transcript Evaluation
Figure 34. Outcome N performance according to Transcript Evaluation

Figure 35. Outcome O performance according to Transcript Evaluation
This figures show that there are a lot of areas of improvement to achieve the outcomes, although it has been argued that grades cannot be directly related to outcome assessment. Table 2 shows the courses that need improvement according to the transcript analysis.

2.5 Fundamental Exam

The results from the fundamental exam show student knowledge of mathematics, science, engineering core, and ability to solve problems. These exams are created for student assessment at the national level at which the knowledge of students form different institutions should converge.

The report handed institutions by the examination board is divided in two parts, Report 5 and Report 6. Report 5 gives the information about seniors taking the exam. Report 6 includes all other students taking the exam.

Unfortunately the data obtained has certain flaws. Report 5 is the only report that demonstrates the student knowledge comes from this institution and not due to industry practice. The senior students taking this exam are very small. Most students take the exam after they graduate. Report 6 does not include results based in graduating class making it impossible to argue that students obtained their engineering knowledge mostly from our institution.

The obtained data for this cycle is summarized in Table 3.
<table>
<thead>
<tr>
<th>Outcome</th>
<th>Courses that need to improve outcomes</th>
<th>Fail %</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>ENGI 3410, ENGI 3420, ME 3010, ME 3110, ME 4120, ME 3140, ME 3210, ME 3220, ME 4130, ME 4140, ME 4210, ME 4220, ME 5050, ME 5150, ME 5151</td>
<td>57.69</td>
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<td>B</td>
<td>ME 5151</td>
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<tr>
<td>C</td>
<td>ME 4140, ME 4210, ME 4220, ME 5050, ME 5150</td>
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<tr>
<td>E</td>
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<tr>
<td>G</td>
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<td>52.00</td>
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<tr>
<td>H</td>
<td>ME 4120, ME 5150</td>
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</tr>
<tr>
<td>I</td>
<td>ENGI 3420, ME 3220, ME 5151</td>
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<td>52.38</td>
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<tr>
<td>O</td>
<td>ENGI 3410, ENGI 3420, ME 3010, ME 3110, ME 4120, ME 3140, ME 3210, ME 3220, ME 4130, ME 4140, ME 4210, ME 4220, ME 5050, ME 5150</td>
<td>53.85</td>
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</table>

Table 2. Courses to Improve Outcomes according to Transcript Analysis
<table>
<thead>
<tr>
<th>Exam Date</th>
<th>Number of Students Taking Exam</th>
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</thead>
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<td>October 2003</td>
<td>2</td>
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<tr>
<td>April 2004</td>
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</tr>
<tr>
<td>October 2004</td>
<td>3</td>
</tr>
<tr>
<td>April 2005</td>
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</tbody>
</table>

Table 3. Fundamental Exam Data for Report 5
CHAPTER 3

RESULTS OF PROGRAM OBJECTIVES EVALUATION TOOLS

The objectives of the mechanical engineering program are revised once in every two year cycle. The objectives are presented in five points (available in the introduction). The evaluation tools to assess the program objectives are the Alumni Survey, Employer Surveys, and Faculty Meetings.

3.1 Alumni Survey

The alumni survey was conducted in Fall 04. These surveys are correlated to the achievement of the five program objectives. Figure 36 shows the performance for each question in the survey. Figure 37 shows the objectives performance. According to this evaluation tool all the program objectives are met.

3.2 Employer Survey

The employer survey was conducted in the Job Fair to employers that have graduates from the mechanical engineering program. These surveys give us important information about the needs of industry and whether the program is fulfilling those needs. Appendix C has a summary of the survey results. Figure 38 has the performance of the program objectives according to the employers.
Alumni Survey FA/04
Professional Accomplishments

Figure 36. Alumni Survey Results Cycle 2003-2005

Program Objectives Performance Alumni Survey Cycle 2003-2005

Figure 37. Program Objective Performance according to Alumni Survey
Figure 38. Program Objective Performance Cycle 2003-2005 Employer Survey.
The tools used to assess the mechanical engineering program give us the necessary information to analyze and conclude if the outcomes and program objectives are achieved. In the outcome assessment evaluation, the portfolio evaluation and the transcript evaluation are the most interesting tools in the results. The portfolio evaluation is a direct evaluation of the program outcomes. The transcript analysis, although is an indirect way to measure outcomes, gives information that is not the opinion of the students, but how they perform in the course. The other outcome assessment tools, such as the Capstone Surveys and Senior Exit Surveys are based in the student opinion the obtained information does not seem to be useful since most of the students characterize themselves as achieving all the outcomes, but at compared to direct tools of evaluation there is a discrepancy. In the next section, the portfolio evaluation and transcript analysis results are analyzed in detail.

The program objectives tools used are the Alumni Survey and the Employer survey. Analyses of the results are presented in section 4.2.

4.1 Portfolio Evaluation and Transcript Evaluation

The improvement of outcome achievement is significantly influenced by the changes that professors have made to their courses. These are some of the changes and suggestions made by the professors based in the portfolio evaluation and transcript evaluation:

Dr. Carlos Alvarado

Changes at Course Level

ME 1210, ME 5260, and ME 5261 – “The use of visual aids (i.e. electronic presentations) and the use of the Blackboard Instructional tool help me to provide students with more detailed information about the course. In addition, students are able to prepare themselves prior to the class meeting resulting in an improvement of the learning process in class."

Changes at Program Level

ME 1210 – “Outcome N asks the students for more than the scope and intent of the course, since this is a freshman course. Consider eliminating this outcome from the syllabus.”
Prof. Edwin Ayala

Prof. Manuel Bardález

1. In relation to the results of the Blackboard Survey 2003-2005 submitted to me by Dr. Carlos Alvarado on October 11, 2005 and November 16, 2004, a thorough analysis has been made, and as a consequence, some corrective teaching/learning methodologies have been implemented in order to improve the achievement of the outcomes by the students. These include the following:

(a) Substantial increase (50%) in short tests or quizzes administered to the students, that is, two quizzes before each monthly exam.
(b) At the beginning of the discussion of each one of the chapters of the course program, I emphasize on the type of outcome that corresponds to the chapter under discussion, this will make the students be aware of the part of the course objective, which is sought with that expected outcome.
(c) Increase in the number of individual assignments dealing with the computational solutions of open-ended problems; this will motivate the students to use extensively computer software or even write computer programs in order to attain tabulated, numerical, and graphical results.
(d) I am assigning the working teams some theoretical topics of the course program, which are related to the design projects, as part of the theory section of the projects, as a consequence, more topics will be covered in class.

2. A recommendation that I could make in order to improve outcomes achievement by the students, and that is beyond my control in the classroom, is related to the increase in the level of the student knowledge of physics and differential equations.

Dr. Gilmer Burgos

Dr. Jorge Carranza
En un intento de elevar cumplimiento del “Outcome D” (the student should be able to function on multidisciplinary teams), en la clase ME 2010, se dividió la clase en grupos de 3 estudiantes. Estos grupos se organizaron de forma que pudieran reunirse y discutir las dudas previo a cada examen. Para fomentar que esto ocurriera se estableció premiar a los grupos que en promedio obtuvieran mejor calificación en las pruebas parciales. Los mismos grupos trabajan los proyectos de diseño final del curso.

De forma que se pudiera elevar el cumplimiento del “Outcome G” (able to communicate effectively), se les pide a los estudiantes que generen una propuesta del proyecto final del curso, se solicita un reporte escrito final y de fomenta la forma correcta de realizar presentaciones orales.

El “outcome K” (able to use techniques, skills and modern engineering tools necessary for engineering practice), se refuerza realizando programación desde la primera reunión y se requiere que los estudiantes utilicen programación en la solución de ejemplos de física básica, solución de sistema de ecuaciones, manipulación de matrices, etc.

Le “Outcome O” (applied Knowledge of contemporary analytical computational and experimental practice), debe ser revisado pues es muy difícil cumplir con el mismo al nivel en el cual se encuentran los estudiantes en este curso.

De forma que se pueda elevar el “Outcome A” (able to apply knowledge of math, science and engineering), se revisaron los ejemplos que se presentan en clase de forma que los mismos contengan demostraciones de diversas situaciones en las cuales se traten los temas concernientes a este “Outcome”.

En un intento de elevar cumplimiento del “Outcome D” (the student should be able to function on multidisciplinary teams), en la clase ENGI 3410, se dividió la clase en grupos de 4 estudiantes. Estos grupos se organizaron de forma que pudieran reunirse, realizar las asignaciones y discutir las dudas previo a cada examen.
examen. Para fomentar que esto ocurriera se estableció premiar a los grupos que en promedio obtuvieran mejor calificación en las pruebas parciales. Los mismos grupos trabajan los proyectos de diseño final del curso.

Prof. Orlando Clavell

Prof. Pedro Dones

Prof. Daniel Fleming

Prof. Juan García

Prof. Luis González Jr.

Dr. Hugo Peláez

Prof. Bernardo Restrepo

Dr. Antoni Skrzypinski
4.2 Alumni Surveys and Employer Surveys

The results obtained from these evaluation tools show that the program objectives are accomplished. The committee has revised the statements in the five objectives to improve and expand them. The use of modern engineering tools covers a broad spectrum of tools. In the department, one tool which has contributed enormously is the use of computer software including Pro-Engineering, MATLAB, Fluent, AutoCAD, Working Model, MathCAD, CNC Simulators, among others. The committee feels that the engineering tools should be classified as to broaden the definition of this objective.
CHAPTER 5
EVALUATION TOOLS REVISITED

The use of evaluation tools assists us to assess the Mechanical Engineering Program. ABET released a document named “Criteria for Accrediting Engineering Programs” in November 2004 applicable to the 2005-2006 cycle. In this document, ABET is clearer in terms of the acceptable evaluation tools that demonstrate that the program outcomes are achieved. The outcome assessment tools that need improvement based in this new information are the Portfolio Evaluation, Capstone Surveys, Senior Exit Surveys and Fundamental Exam.

In addition, the Fundamental Exam (outcome assessment tool) and the Industry Focus Group (a program’s objectives evaluation tool) are evaluated. Let’s examine each of the evaluations tools:

5.1 Portfolio Evaluation

The portfolio evaluation is a direct way to assess the outcomes. To improve the portfolio evaluation rubrics will be used by the professors in order to have a standard measure of the achievement of outcomes. In addition, a subject content examination will be administered using the Blackboard Instructional tool to determine whether the students achieved the course objectives and thus the outcomes. The program objectives can also be evaluated using this tool.

5.2 Capstone and Senior Exit Surveys

The capstone a senior exit surveys are based in the opinion of the students. This tool will be changed into a general test were the student will demonstrate if they reach the expected outcomes of the program.

5.3 Fundamental Exam

The fundamental exam is a measure that is uncontrollable by the committee as explained in the results chapter. The use of this tool is recommended to be eliminated.

5.4 Industry Focus Group

In the last cycle report 2001-2003, it was suggested to make an Industry Focus Group at the Universities Job Fair, since arranging such a meeting has been unsuccessful in the past. The committee tried to meet the employer at lunch time at the Job Fair, but most of
the employers were personnel from Human Resources. This kind of employees will not have the necessary knowledge about mechanical engineering to judge our program.

The way in which the committee plans to get feedback from industry is to make an advisory board. This board will evaluate the program in the long run and they can be witnesses of the progress of the program along time. The Institute of Mechanical Engineers of Puerto Rico is the top candidate to evaluate our program and to suggest ways to improve it. The constituents of this institute are people from industry that represent mechanical engineers in Puerto Rico.

5.5 New Evaluation Tool

There is a new evaluation tools that can be added to directly assess the outcomes, which is the Intern/COOP performance in industry. This kind of measure will gives us valuable information about the application of the acquired knowledge in the practice.
APPENDIX A – Blackboard Questions for Portfolio Evaluation
APPENDIX B – Senior Exit Survey Questions

13. Indicate Proficiency in the following areas (a, c, e, l, k, m, n, o)

15. Proficiency in Analyzing and Interpreting Data (c)
24. Identifying, Formulating and Solving mechanical engineering problems 5 max (e)

26. Ability to function as a member of a team (d)
42. Proficiency in the following tools for engineering practice (k)

- Programming in FORTRAN, C, C++, Visual Basic, Matlab, Mathcad
- Computer Graphics, drafting in AUTOCAD, PRO-E or similar software
- FEM, Mechanisms Software
- Wordprocessing
- Using spreadsheets
- Electronic mail
- Internet research

47. Knowledge of contemporary issues of importance to a mechanical engineer (j)

- Very Weak
- Weak
- About Average
- Strong
- Very Strong
- No Answer
48. Confidence to practice mechanical engineering

[Chart showing confidence levels across different periods]
APPENDIX C – Employer Survey Results

1- My primary responsibility at my company is:
   a- Manager (25%)
   b- Engineer (75%)

2- The nature of my company business is:
   a- Manufacturing (25%)
   c- Government (50%)

3- In the past five years I have supervised the following graduates from Polytechnic University of Puerto Rico:
   a- 1-2 (75%)
   b- 3-5 (25%)

4- The types of functions Polytechnic University of Puerto Rico graduates perform at the companies are:
   a- Administration (16.66%)
   b- Design and analysis (33.33%)
   c- Maintenance (16.66%)
   d- Manufacturing (33.33%)

5- On the average, I have contacted the employee:
   a- Daily (75%)
   c- Several times a month (25%)

6- I have known the employee for:
   a- Less that a year (50%)
   b- 2-3 years (25%)
   d- More than five years (25%)

7- I rate Polytechnic University of Puerto Rico graduates in relation to engineers from other universities:
   a- Top 1% - 10% (50%)
   b- Top 11% - 20% (25%)
   c- Top 21% - 50% (25%)

8- Rate of strengths of a typical Polytechnic University of Puerto Rico BS graduate in each of the following abilities:
1= very weak     2= weak     3= about average     4= strong     5= very strong

a- Apply knowledge of thermal systems to solve problems at work. (1) 3.66

b- Apply knowledge of mechanical systems to solve problems at work. (1) 4

c- Apply knowledge of mathematics, science and engineering and or modern engineering techniques and tools to solve problems at work. (2) 4

d- Apply knowledge of designing and conducting experiments as well as to analyze and interpret data. (3) 3.66

e- Ability to design and develop useful products, processes, or systems that benefit society. (3) 3.5

f- Participate as a team member that may involve multi-disciplinary activities, communicate ideas verbally, graphically, and in writing to perform engineering functions effectively. (4) 4

g- Conduct engineering work professionally (5) 4

h- Aware of ethical and contemporary issues. (5) 3.75

i- Continually improves capabilities through lifelong learning. (5) 4

9- Areas of knowledge or skills that our graduates should have but currently do not posses:

More industrial practice

10- The three most important things that we look for our organization looks for when hiring new engineering graduates:

- Responsibility, good aptitude towards work and potential fill upper positions
- Proactive search of solutions, organized and methodical, good comm. skills
- Knowledge of engineering, ability to solve problems, think on their feet, desicioin makers.
F. Additional Data of Program Outcomes

![Success of Outcome a vs Course by Trimester](image)

**Figure F.1** Results for Outcome a
Figure F.2 Results for Outcome b

Figure F.3 Results for Outcome c
Achievement

Trimester

Course

WT-06
FA-06
SP-06
WT-05

ME 5992/94
ME 3421
ME 3421
ME1230
ME 5251
ME 5250
ME 5050
ME 4241
ME 1210

ENGI 3421
ENGI 3410
ME 5251
ME 5250
ME 5050
ME 3410
ME 1230
ENGI 3420
ENGI 3410

1.0
0.8
0.6
0.4
0.2
0.0

0.7

Achievement

Trimester

1.- WT-05
2.- SP-06
3.- FA-06
4.- WT-06

Success of Outcome d vs Course by Trimester

Trimester

Course

WT-05
ME 3422
ME 5930/04

WT-06

Success of Outcome e vs Course by Trimester

Trimester

Course

WT-05
ME 3420
ME 1210
ME 1220
ME 5050
ME 5230

SP-06
ME 1210
ME 4241
ME 5230
ME 1230

WT-06
ME 5992/04

Figure F.4 Results of Outcome d

Figure F.5 Results of Outcome e
Achievement Trimester Course

WT-06 FA-06 SP-06 WT-05

PHIL 3040 ME 5992/94 ME 3421 PHIL 3040

1.0 0.8 0.6 0.4 0.2 0.0

0.7

Trimester
1.- WT-05
2.- SP-06
3.- FA-06
4.- WT-06

Success of Outcome f vs Course by Trimester

Figure F.6 Results of Outcomes f

Achievement Trimester Course

WT-06 FA-06 SP-06 WT-05

PHIL 3040 ME 5992/94 ME 3421 PHIL 3040

1.0 0.8 0.6 0.4 0.2 0.0

0.7

Trimester
1.- WT-05
2.- SP-06
3.- FA-06
4.- WT-06

Success of Outcome g vs Course by Trimester

Figure F.7 Results of Outcome g
Achievement

Trimester

Course

ME 5992/94
WT-06

0.7

0.6

0.5

0.4

0.3

0.2

0.1

0.0

Figure F.8 Results of Outcome h

Success of Outcome h vs Course by Trimester

Achievement

Trimester

Course

ME 5992/94
WT-06

0.7

0.6

0.5

0.4

0.3

0.2

0.1

0.0

Figure F.9 Results of Outcome i

Success of Outcome i vs Course by Trimester

Page 296 of 336
Achievement

Trimester

Course

WT-06 WT-05

ME 5992/94 ME 4120 ME 5050

1.0

0.8

0.6

0.4

0.2

0.0

Success of Outcome j vs Course by Trimester

Trimester

1.- WT-05

4.- WT-06

Figure F.10 Results of Outcome j

Achievement

Trimester

Course

WT-06

ME 5050

WT-05

ME 4120

ME 5992/94

1.0

0.8

0.6

0.4

0.2

0.0

Success of Outcome k vs Course by Trimester

Trimester

1.- WT-05

2.- SP-06

3.- FA-06

4.- WT-06

Figure F.11 Results of Outcome k
Achievement

Trimester

Course

WT-06

FA-06

SP-06

WT-05

ME 5992/94

ENGI 3410

ME 3421

ENGI 3410

ME 3410

ME 5250

ME 4260

ME 3420

ME 5050

ME 3410

ME 3410

Figure F.12 Results of Outcome I

Success of Outcome I vs Course by Trimester

Trimester

1.- WT-05

2.- SP-06

3.- FA-06

4.- WT-06

Achievement

Course

Trimester

1.- WT-05

3.- FA-06

4.- WT-06

0.7

0.7

Figure F.13 Results of Outcome m

Success of Outcome m vs Course by Trimester

Trimester

1.- WT-05

3.- FA-06

4.- WT-06

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Figure F.14 Results of Outcome n

Figure F.15 Results of Outcome o
Figure F.16  Results for Outcome a mean score

Figure F.17 Results for Outcome b mean score
### Outcome c vs Course by Trimester

<table>
<thead>
<tr>
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<th>Course</th>
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### Outcome d vs Course by Trimester

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Figure F.18 Results for Outcome c mean score

Figure F.19 Results of Outcome d mean score
Figure F.20 Results of Outcome e mean score

Figure F.21 Results of Outcomes f mean score
Figure F.22 Results of Outcome g mean score

Figure F.23 Results of Outcome h mean score
Figure F.24 Results of Outcome i mean score

Figure F.25 Results of Outcome j mean score
Figure F.26 Results of Outcome k mean score

Figure F.27 Results of Outcome l mean score
Outcome m vs Course by Trimester

Figure F.28 Results of Outcome m mean score

Outcome n vs Course by Trimester

Figure F.29 Results of Outcome n mean score
Outcome o vs Course by Trimester

![Graph](image)

Figure F.30 Results of Outcome o mean score
Achievement of Objective 1

Objective 1 vs Course by Trimester

Figure F.31 Program Objective 1

Achievement of Objective 2

Objective 2 vs Course by Trimester

Figure F.32 Program Objective 2
Achievement of Objective 3

Objective 3 vs Course by Trimester

Figure F.33 Program Objective 3

Achievement of Objective 4

Objective 4 vs Course by Trimester

Figure F.34 Program Objective 4
G. Rubrics

**Rubric for outcome A, L, & M:**
Apply knowledge of mathematics, science, and engineering
Apply knowledge of chemistry and calculus-based physics with depth in at least one of them
Apply statistics, linear algebra and advanced mathematics through multivariate calculus & d. e.

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<th>INDICATOR</th>
<th>4 (100%)</th>
<th>3 (75%)</th>
<th>2 (50%)</th>
<th>1 (25%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Use of concepts, principles and/or equations:</strong></td>
<td>Student can easily convert word problems to a sequence of interconnected mathematical equations. All the concepts, principles, and equations are correctly identified and applied with little or no extraneous efforts. Combines mathematical and/or scientific principles to formulate models of chemical and/or physical processes.</td>
<td>Student has few troubles to translate word problem into equations or mathematical relations. He/She ultimately identifies and uses relevant components but may start with extraneous information. He/She chooses a mathematical or scientific model that applies to an engineering problem, but have trouble to develop it.</td>
<td>Student has some troubles converting word problem into mathematical relations. He/She is able to identify some principles or equations but seem to have difficulty in distinguishing what is needed. He/She can not find enough information to apply on the equations or model development.</td>
<td>Student might be unable to translate word problems into mathematical relations. Inappropriate concepts, principles or data are identified and/or applied. Mathematical terms or equations might be wrongly executed. He/She do not understand the connections between mathematical model and chemical and/or physical processes.</td>
</tr>
<tr>
<td><strong>2. Formulates appropriate strategies of solution:</strong></td>
<td>Student uses a very efficient and sophisticated strategy leading directly to a solution. He/She sees what must be done clearly. He/She shows all the steps used to solve the problem. All mathematical relations and principles are applied logically in sequence.</td>
<td>Student forms workable strategies to obtain a solution, but may not be optimal. He/She shows most of the steps used to solve the problem. The solution of the problem might rely on brute force (a lot of calculation effort).</td>
<td>Student has difficulty in planning an approach, the plan is not clear. He/She uses a strategy that is partially useful, leading some way toward a solution, but not to a full solution of the problem. He/She shows some of the steps to get a solution of the problem.</td>
<td>There is no plan of solution or the intended plan does not help to solve the problem. Student has difficulty getting beyond the given unless they are directly instructed to do something.</td>
</tr>
<tr>
<td><strong>3. Execution of solution strategies:</strong></td>
<td>Student applies procedures accurately to correctly solve the problem and verify the results. There are no errors by hand or by mathematical software.</td>
<td>Student implements well mathematical procedures. All parts are correct and a correct answer is achieved. Occasional minor errors may occur</td>
<td>Student could not completely carry out mathematical procedures. Some parts may be correct, but a correct answer is not achieved.</td>
<td>Student often is unable to solve a problem, even when all data are given (the students might not formulate a strategy of solution either). If there is a strategy of solution, there are so many errors in mathematical procedures that the problem can not be solved.</td>
</tr>
<tr>
<td><strong>4. Use of engineering judgments:</strong></td>
<td>Student employs refined and complex reasoning to make relevant observations and/or connections. He/She verifies answers and/or evaluates the reasonableness of the answer.</td>
<td>Student assesses most of his answers using effective reasoning. He/She has no more than one if any unrecognized implausible answers.</td>
<td>Student attempts to evaluate answers, but he has difficulties. He/She shows some evidence of reasoning. He/She recognizes that numbers have meaning but cannot fully relate.</td>
<td>Student makes little effort, if any, to interpret results. Numbers appear to have little meaning. There is no evidence of reasoning.</td>
</tr>
</tbody>
</table>
### Rubric for outcome B: Design and conduct experiments, as well as analyze and interpret data

<table>
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<tr>
<th>INDICATOR</th>
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<th>1 (25%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Design experiments:</td>
<td>Students very clearly identify main objectives to be achieved in the experiment. They clearly identify variables to measure and to calculate. They formulate an experimental plan of gathering data with many logical workable ideas/steps. Experimental plan consider statistics for sample size, intervals of confidence, accuracy-precision, etc.</td>
<td>Students adequately identify the main objectives to be achieved in the experiment. They have some trouble to identify variables to measure and/or to calculate. They develop a reasonable experimental plan of gathering data where not all parameters affecting the result are investigated. Experimental plan considers simple statistical models.</td>
<td>Most of the main objectives of the experiment are inadequately identified. Students are confused in identifying what variables to measure and what variables to calculate. They might not identify all the variables or parameters of the experiment. They develop a very simplistic experimental plan with no much statistics consideration.</td>
<td>Students cannot or wrongly identify the main objectives to be achieved in the experiment. They do not identify variables to measure. Experimental plan of gathering data is completely disorganized, even random, and incomplete, it considers illogical or unworkable ideas/steps.</td>
</tr>
<tr>
<td>2 Conduct experiments:</td>
<td>Students follow good laboratory safety procedures. They are able to operate instrumentation and process equipment without supervision. Students implement logical experimental procedures with precision. They correct rapidly and successfully any ineffective procedure step. They carefully document gathered data.</td>
<td>Few unsafe, risky lab procedures are observed. They need some guidance in instrumentation and equipment operation. They execute experiments with some precision. Data are not all documented, units are missing or few measurements are not recorded according to the design of the experiment.</td>
<td>Some unsafe, risky lab procedures are observed. They need frequent instruction to operate instrumentation and equipment. They carry out the experiment with few precision using a very time consuming procedure. Gathered data show frequent incongruence with the experimental design, units are missing and some data are not recorded.</td>
<td>Students practice constant unsafe, risky behavior in lab. They use little to no precision in carrying out experiments. They do not follow experimental procedures and/or they do not know what to do. Gathered data are poorly organized.</td>
</tr>
<tr>
<td>3 Analyze data:</td>
<td>Data analysis is performed using appropriate charts, graphs, tables, equations and/or any other tool. Students link theory analysis with experimental results logically and accurately. Students fully identify major sources of errors and uncertainties in the data/method of analysis.</td>
<td>Students trouble to do data analysis even though graphs or any other presentation of results or theory are fairly presented. They strive doing some connections between results and theory beyond mere descriptions of graphs. They do not identify all major sources of errors and uncertainties in the data/method of analysis.</td>
<td>Students do not associate theory with results. Their analysis relies on a mere description of the graphs without addressing their connectivity with concepts, principles, equations, etc. Graphs and tables might not be understandable. They do not address sources or errors or uncertainties.</td>
<td>Data is analyzed poorly with no use of graphs, equations and/or concepts. There is no data analysis at all.</td>
</tr>
<tr>
<td>4 Interpret data:</td>
<td>Students quantify errors and uncertainty propagation in results using adequate statistical techniques. They weight data by uncertainty and see how this affects results. They develop clear and understandable conclusions.</td>
<td>Students might quantify errors and uncertainties but they have troubles to explain clearly the effect on results. They might develop not clear conclusions.</td>
<td>Students barely use statistics to quantify errors. There is no propagation of uncertainty. Judgments of the results are inadequate.</td>
<td>Conclusions are poor or there are no conclusions at all.</td>
</tr>
</tbody>
</table>
Rubric for outcome C & N:
Design a system, component, or process to meet desired needs with app. to mech. and thermal syst.
Work prof., in both thermal and mech. syst. areas including the design and realization of such syst.

<table>
<thead>
<tr>
<th>IDENTIFIER</th>
<th>4 (100%)</th>
<th>3 (75%)</th>
<th>2 (50%)</th>
<th>1 (25%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Characterizing the design need:</td>
<td>Students recognize the existence of a design problem. They can define clearly and concisely the problem. They are able to delineate what is needed and/or wanted by the professor, customer, or any other stakeholder of the design. They are able to define technical and realistic constraints of the problem clearly.</td>
<td>Students recognize the need for a new design. They might have minor problems in defining the problem. They identify what is needed, however they need some guidance to define the constraints of the problem.</td>
<td>Students have some troubles in recognizing the existence of a design problem, and defining the problem. They have also some problems in delineating what is needed and in defining constraints. They need constant guidance to accomplish this part of the design.</td>
<td>Students do not recognize the existence of a design problem; otherwise they need a great deal of guidance to formulate it and to define constraints.</td>
</tr>
<tr>
<td>2 Attributes of an ideal solution:</td>
<td>Students clearly identify most critical outcomes by which success is achieved. They develop specific metrics and target values for these outcomes.</td>
<td>Students identify most critical outcomes by which success is achieved; however, they have some problems developing metrics and target values.</td>
<td>Students have trouble identifying most critical outcomes for success and developing their metrics and target values.</td>
<td>Students miss almost all critical outcomes, and success is wrongly defined. Metrics for the outcomes are mostly irrelevant.</td>
</tr>
<tr>
<td>3 Sources of information:</td>
<td>Students show a deep search into the engineering knowledge, existence design alternatives and potential technologies by using databases of scientific literature, patents, and other archival sources (of the library).</td>
<td>Students present background information of previous or related designs. They have trouble to relate new technologies with the design problem. They use three or more relevant sources of information.</td>
<td>Students present background information of previous design only. They do not see how potential technologies can be used in the design problem. They present at least two sources of information.</td>
<td>Students show a poor background search of previous design and technologies. They might present just one source of information. They are unable to relate prior knowledge to the design problem.</td>
</tr>
<tr>
<td>4 Potential solutions:</td>
<td>Students show the use of brainstorm techniques to find potential solutions. All potential solutions are well reasonable in satisfying the needs of the design. They might use benchmarking techniques to compare existing solutions to new ideas in a systematic manner.</td>
<td>Students identify potential solution using brainstorm techniques. Few solutions might violate minor constrains. They use adequate procedures to compare old design to new ideas.</td>
<td>Students are not aware of any technique to find potential solutions. Some solutions violate minor constrains. They use precarious schemes to compare existing solution to new ideas.</td>
<td>Students find no solution or find just one potential solution. Solution might violate major and minor constrains. They do not use any benchmarking technique.</td>
</tr>
<tr>
<td>5 Prototyping of design concepts:</td>
<td>Students develop prototypes (computer simulations and cardboard muck-up) of their design concepts. They develop an effective strategy for the iterative process of testing each idea. They select the best alternative of solution.</td>
<td>Students have some troubles developing prototypes of their design concepts (they need minor guidance). They develop a strategy of testing each idea, but it might not be optimal (long time-consuming process).</td>
<td>Students have troubles to develop prototypes and to develop a strategy of testing each idea. Guidance is required for students to accomplish this phase.</td>
<td>Students do not develop any prototype of solution, or the solution is poorly implemented. They need direct instructions constantly to accomplish this phase of design.</td>
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<tr>
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<td>1 (25%)</td>
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</tr>
<tr>
<td>6 Evaluation of design solution:</td>
<td>Students develop a strategy to evaluate the solution, which include the design of suitable experiments, the selection of costumer surveys, and actual testing (or more sophisticate and rigorous simulations).</td>
<td>Students evaluate solution using simple procedures. The optimization process is simple using minimal computer tool and engineering resources. Costumer is satisfied.</td>
<td>Students do not perform optimization of solution. Costumer is not completely satisfied and has some concerns. There is an attempt to evaluate the solution.</td>
<td>Solution has major problems in satisfying pre-defined design specifications. There is no optimization process in the solution.</td>
</tr>
<tr>
<td>7 Technical communication of both solution and decision process:</td>
<td>From problem definition to evaluation of solution, students show fluent communication (oral and written) with customers, supervisors. Their reports are well documented.</td>
<td>Oral communication is sporadic. Written communication lack of detailed explanation of decisions, procedures and used equations.</td>
<td>There is major problem in oral communication (it might not be). Design is not documented appropriately.</td>
<td>Several phases of the design are poorly documented, or not documented at all. Design might be incomplete.</td>
</tr>
<tr>
<td>8 Project management:</td>
<td>Students show the ability to work as part of a team, to manage a budget, and to prepare and follow a schedule to complete the design</td>
<td>Students have some troubles managing a budget. They barely meet the deadlines for the tasks of the project.</td>
<td>Students have some troubles working as a team. They sometimes are behind schedule.</td>
<td>Students have a lot of problems working with each other member of the team. They are always behind schedule and might not accomplish the task (or project).</td>
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### Rubric for outcome D: Function on multi-disciplinary teams.

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<tr>
<td><strong>1 Behavior among teammates</strong></td>
<td>Student is a polite group member. He is open to listen to ideas/opinions from people of different background. He remains non-judgmental when disagreeing with others/seeks conflict resolution; does not “point fingers” or blame others when things go wrong.</td>
<td>Student is sometimes non-polite toward team members. He listens to other’s ideas and opinion with some reluctance; however, he remains non-judgmental when disagreeing. He sometimes criticizes ideas of other members.</td>
<td>Student is rough to other group members. He persuades other to adopt only his ideas or grudgingly accepts the ideas of others. He blames others for errors.</td>
<td>Student is discourteous to other group members. He does not consider the ideas of others. He is openly critical of the performance of others when things went wrong even thought he was part of the decision or idea that was carried out.</td>
</tr>
<tr>
<td><strong>2 Availability for the team</strong></td>
<td>He never misses a scheduled meeting. He almost always arrives on time. He is available for re-scheduling a meeting. He demonstrates the ability to assume a designated role in the group.</td>
<td>Student misses sometimes scheduled meetings and he apologizes when arriving late. He/She assumes designated role in group with some reluctance (he accepts role after persuasive talk).</td>
<td>Student is absent in scheduled meetings more than 25% of the time or most of the time (&gt;50%) he arrives late. He takes charge when not in the position to lead</td>
<td>Student is frequently absent in scheduled meetings more than 50% of the time. He is not willingly to assume team roles.</td>
</tr>
<tr>
<td><strong>3 Attitude for work</strong></td>
<td>Student is prepared for group meeting with clearly formulated ideas. He shares information with others and provide assistance to others. He cooperates with others (outside of the discipline).</td>
<td>Student prepares somewhat for group meeting. Ideas are few and not always clearly formulated. He sometimes keeps information for himself (not very willing to share). He sometimes interacts with extra-disciplinary team members.</td>
<td>Student barely prepares for group meetings. Ideas are not clearly formulated. He occasionally shares information with others. He does not help much to other group members.</td>
<td>Student routinely fails to prepare for meetings. He hides in the background, only participate if strongly encouraged. He is always busy (with his own work) to help his teammates.</td>
</tr>
<tr>
<td><strong>4 Workload</strong></td>
<td>Student contributes a fair share to the project workload. He verbally contributes to the organizational development of the task. He evaluates group’s progress toward task accomplishment.</td>
<td>Student sometimes depends on others to complete the work. He contributes less than fair share. He sometimes has the initiative of checking group progress.</td>
<td>Student is constantly asking for help from others. He contributes much less than fair share. He is not concern with group’s progress.</td>
<td>Student does not contribute to group work at all. He might work on his own and he does not involve in organizational development of tasks and or group progress.</td>
</tr>
<tr>
<td><strong>5 Group dynamics</strong></td>
<td>Student builds cohesion in group through verbal and non-verbal behavior. He takes an active roll to encourage participation of all team members.</td>
<td>Student behavior brings sometimes cohesion in group. Sporadic horse plays and pranks encourage participation of team members.</td>
<td>Student is in horse plays and pranks. Even though this brings cohesion in the group, meetings become very time consuming.</td>
<td>Student apathy affects negatively group performance. Group cohesion is broken by non-verbal behavior especially</td>
</tr>
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</table>
### Outcome F: Understand professional and ethical responsibilities

<table>
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<th>2 (50%)</th>
<th>1 (25%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional registration</td>
<td>Student knows about professional registration, and plans to be certified as E.I.T. and later on as P.E.</td>
<td>Student knows about professional registration and he/she would seek registration only if his job requires.</td>
<td>Student does not know exactly what means to have a professional registration and he/she does not care much about it.</td>
<td>Student does not know much about professional registration, and he/she does not care at all. He/She thinks it is not worthy.</td>
</tr>
<tr>
<td>Ethical Codes</td>
<td>Student knows and applies the code of Professional Engineers, and PUPR students’ rights and responsibilities. He/she acts according to them.</td>
<td>Student is aware of the existence of the code of Professional Engineers and other ethical behavior. He/She might not know it but he behaves ethically.</td>
<td>He/she does not recognize the existence of codes, and sometimes they may break any code of ethics.</td>
<td>Student is not aware of any code for ethical behavior. He/she regularly breaks code of ethics.</td>
</tr>
<tr>
<td>Ethical behavior among Peer and Faculty</td>
<td>Student demonstrates ethical behavior among peers and faculty.</td>
<td>Student models some ethical behavior among peers and faculty.</td>
<td>Student does not model ethical behavior among peers and faculty.</td>
<td>Student has been caught cheating or plagiarizing the work of others.</td>
</tr>
<tr>
<td>Responsibility</td>
<td>Student takes personal responsibility for his/her actions.</td>
<td>Student struggles in the dilemma of taking responsibilities for his/her actions. Most of the time he/she takes responsibility of his/her actions.</td>
<td>Student does not recognize the need to take personal responsibility for his/her actions.</td>
<td>Student blames others for own issues and problems.</td>
</tr>
<tr>
<td>Professional behavior among peer and faculty</td>
<td>Student is punctual, professional, and collegial. He/she attends almost all classes.</td>
<td>Student exhibits sometimes unprofessional behavior. He/she is sometimes absent from or comes late to class without a reason.</td>
<td>Student is absent from class without a reason more than 30% of the times.</td>
<td>Student is frequently absent from class and is generally not collegial to fellow students.</td>
</tr>
<tr>
<td>Evaluation and Judgment</td>
<td>Student evaluates and judges a situation in practice or as a case study using facts and a professional code of ethics.</td>
<td>Student evaluates and judges a situation in practice or as a case study using some facts and personal understanding. He/She might apply personal value system.</td>
<td>Student evaluates and judges a situation in practice or as a case study using personal understanding. He/She uses his own code of values.</td>
<td>Student evaluates and judges a situation in practice or as a case study using a biased perspective without objectivity.</td>
</tr>
<tr>
<td>INDICATOR</td>
<td>4 (100%)</td>
<td>3 (75%)</td>
<td>2 (50%)</td>
<td>1 (25%)</td>
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</tr>
<tr>
<td>1 Content and concatenation of ideas of the written report</td>
<td>Written text shows coherent ideas clearly and concisely.</td>
<td>Written text shows coherent ideas, but it is somewhat superfluous. Reading does not flow consistently.</td>
<td>Written text shows ideas not well organized (disjoined and superfluous). Reading does not flow easily and key points are somewhat difficult to identify. Key points are immersed in too much detail or there is a gap of information.</td>
<td>Written text is unclear; ideas are only understood after repeated reading, and key points are missing or very difficult to determine.</td>
</tr>
<tr>
<td>2 Mechanical organization of the written report</td>
<td>Report organizes written materials in a logic sequence to enhance the reader’s comprehension (headings, subheadings, sections, paragraphs, etc)</td>
<td>Written report is organized well, but paragraph combines multiple ideas. There is not proper use of subheading, section, or subsection.</td>
<td>Written report is somewhat organized. Information is misplaced and the use of paragraphs, subheading, section, or subsection is confusing.</td>
<td>Do not present structure or organization, no subheading or proper paragraphs. The reader is ignored and technical level is inappropriate.</td>
</tr>
<tr>
<td>3 Presentation of results</td>
<td>Report uses graphs, tables, and diagrams to support points to explain, interpret, and assess information.</td>
<td>Graphs, tables, and diagrams are used to support, explain or interpret information in mostly instances</td>
<td>Graphs, tables, and diagrams are not clearly used to support, explain or interpret information. They might be used only in a few instances</td>
<td>Graphs, tables or diagrams are not much used, but if they are, no reference is made to them. Information is false or missing</td>
</tr>
<tr>
<td>4 Format and grammar</td>
<td>Written work is presented neatly and professionally: grammar and spelling are correct, figures are in proper format; writing style is good and conforming to the prescribed format (if any)</td>
<td>Written work is presented professionally: grammar and spelling are mostly correct (one or two spelling errors per page), few figures are improperly displayed (mislabeled axes, no data points); format and writing style is formal</td>
<td>There is no a consistently written style and format. Style is informal or inappropriate; it might also use improper voice and tense. Grammar and spelling errors are presented throughout more than 2/3 of the paper.</td>
<td>Written work is not presented neatly: grammar and spelling errors are presented throughout more than 2/3 of the paper, no figures are used at all, written style is inappropriate for reader, and the prescribed format is not followed.</td>
</tr>
<tr>
<td>5 Organization of an oral presentation</td>
<td>Oral presentation is well planned and organized. He/she reserves accommodations with anticipation, uses visual aid, starts on time, delivers creative handouts for guidance</td>
<td>There is a certain level of organization in oral presentation: He/she might look for accommodations and visual aids at last minute, but starts on time; He/she delivers handouts</td>
<td>There is no a little of organization in oral presentation: He/she might look for accommodations and visual aids at last minute. He/she might not start on time; He/she does not deliver handouts</td>
<td>Oral presentation is poorly organized, e.g. starts late, no visual aids available, no clear introduction or summary of talk is presented</td>
</tr>
<tr>
<td>6 Content of oral presentation</td>
<td>Presentation has enough appropriate technical content for the time constraint and the type of audience</td>
<td>Oral presentation contains excessive or insufficient detail for the allotted time or level of audience, however, audience is still interested. Conclusions are connected to the results</td>
<td>Presentation is too short or long, but audience finds some connection between conclusions and results</td>
<td>Presentation is too short or excessively long; omits main results and/or conclusions during presentation</td>
</tr>
<tr>
<td>7 Mechanical execution of oral presentation</td>
<td>Presentation is performed well mechanically: makes eye contact, can easily be heard, speaks comfortably with minimal aids (notecards), do not block screen, do not have distracting nervous habits</td>
<td>Student has some minor difficulties with the mechanics of the presentation. Eye contact is sporadic, occasionally it is difficult to hear or understand speaking, he/she does not use prompts enough</td>
<td>Student has some difficulties with the mechanics of the presentation. Eye contact is sporadic, it is difficult to hear or understand speaking, he/she seems to have memorized presentation, but sometimes uses notecards</td>
<td>Presentation has major difficulties with the mechanical aspects; no eye contact, difficult to hear or understand speaking, reads from prepared script or from the projected slides, blocks the screen,</td>
</tr>
<tr>
<td>INDICATOR</td>
<td>4 (100%)</td>
<td>3 (75%)</td>
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<tr>
<td></td>
<td>(seems to have memorized presentation), he/she occasionally block the screen</td>
<td>Student has a professional appearance for presentation, dressing correctly for the occasion</td>
<td>Student has a casual appearance for the presentation</td>
<td>Student has a too casual appearance for the circumstances</td>
</tr>
<tr>
<td>8</td>
<td>Appearance for presentation</td>
<td>Student communicates with proper language during presentation. He/she uses technical and non-technical terms as needed to deliver the message</td>
<td>He/she uses occasionally an inappropriate language, conversational style</td>
<td>He/she uses most of the time a conversational language throughout the whole presentation</td>
</tr>
<tr>
<td>9</td>
<td>Oral communication</td>
<td>Visual aids are not used, sloppy or ineffective. Many slides are unclear or incomprehensible: too many written lines in one slide, small letters, and graphs are copied poorly from your written report</td>
<td>Communicate ideas using a poor language (too many slang, street speech)</td>
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</tr>
<tr>
<td>10</td>
<td>Use of visual aids</td>
<td>He/she uses visual aids with minor errors. Having the right number of slides, a few of them are too loaded or graphs are unclear</td>
<td>He/she uses visual aids with some errors. Some slides are too loaded, graphs are unclear, and there is no pleasant combination of colors for the slides</td>
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</tr>
<tr>
<td>11</td>
<td>Listening and responsiveness</td>
<td>Student listens carefully and responds to questions appropriately; he/she is able to explain and interpret results for various audiences and purposes</td>
<td>Student listens carefully and responds to questions, but he/she is able to explain and interpret results only if he/she is guided</td>
<td>Student listens and responds to questions with some difficult, but he/she struggles to explain and interpret results even with guidance</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Does not listen carefully to questions, does not provide an appropriate answer, or is unable to answer questions about presentation material</td>
</tr>
</tbody>
</table>
**Outcome H:** be able to understand the impact of engineering solutions in a global and societal context.

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>4 (100%)</th>
<th>3 (75%)</th>
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<th>1 (25%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Values of humankind to understand impact of engineering solutions</td>
<td>Student knows and practices the values to the betterment of humankind, such as dignity of human life, respect and consideration of others, preservation of earth, integrity and service, and quest of peace</td>
<td>Student practices most of the time the values to the betterment of humankind. He/She believes that these values might changes from country to country.</td>
<td>Student believes that some values to the betterment of humankind may be overridden by the convenience of a situation, e.g. integrity and service by necessity of a group, and preservation of earth by comfort.</td>
<td>Student believes that all values are relative to each situation in life. He/She thinks that humankind values are overridden by personal or group needs.</td>
</tr>
<tr>
<td>2 Awareness of engineering impact</td>
<td>Student reads and is familiar with the content of periodicals or any other source that are relevant to understanding how engineering has a global and societal impact. He/she engages in related conversations</td>
<td>Student is aware of existing relevant periodical (or other sources) disclosing the impact of engineering solutions in a societal context, and sometimes he/she reads them. He/she might engage in related conversations</td>
<td>Student is aware of current events, but he/she is not of the historical effects of engineering solutions. He/she does not read or know of journals exposing the contribution of mechanical engineering (e.g., in nanotechnology or bioengineering). He/she occasionally participates in related conversations</td>
<td>Student is unaware of current events, and of the historical effects of engineering solutions, e.g. he/she does not read or know of journals exposing the contribution of mechanical engineering (e.g., in nanotechnology or bioengineering).</td>
</tr>
<tr>
<td>3 Environmental impact of engineering</td>
<td>Student considers the environmental impact of engineering projects. Identify projects that reflect “Green” engineering. All negative environmental impacts are minimized and fully disclosed</td>
<td>Student considers somewhat the environmental impact of engineering projects. Negative environmental impacts are disclosed and efforts to reduce them are evident.</td>
<td>Student recognizes that engineering projects have an impact on the environment. He/she does little to quantify or address the impacts.</td>
<td>Student does not consider the environmental impact of engineering projects. Environmental issues are disregarded and/or not disclosed.</td>
</tr>
<tr>
<td>4 Importance of engineering</td>
<td>He/she has a personal perspective on the importance of engineering in the world of today. He/she wants to use engineering to change for better a little bit (or to preserve at least) his/her community, region, or environment</td>
<td>He/she is interested in engineering because he/she likes math, physics, and/or technology. He/She likes engineering because cars and airplanes, or any other technological gadget.</td>
<td>He/she is interested in engineering because of what the discipline offers him/her personally. He/She wants to have a well paid job.</td>
<td>Student is not sure why he/she is studying engineering.</td>
</tr>
</tbody>
</table>
Outcome I: be able to recognize the need for and an ability to engage in lifelong learning.

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>4 (100%)</th>
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<th>1 (25%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Independent learning</td>
<td>Student demonstrates ability to learn independently. He/she goes beyond what is required in completing an assignment and brings information from outside sources into assignments</td>
<td>Student needs guidance to do a task or project. He/she completes only what is required</td>
<td>Student requires detailed or step-by-step instructions to complete a task</td>
<td>Student does not complete a task even given step-by-step instructions</td>
</tr>
<tr>
<td>2 Self-awareness of learning</td>
<td>Student learns from mistakes. He/she continuously improves with practice</td>
<td>Student learns from mistakes slowly. He/she avoids repeating the same mistakes</td>
<td>Student learns sometimes from mistakes</td>
<td>Student continuously makes the same mistakes. He/she has trouble completing even the minimum required tasks</td>
</tr>
<tr>
<td>3 Learning’s responsibility</td>
<td>Student demonstrates responsibility for creating one’s own learning opportunities. He/she attends seminars, participates in fieldtrips, engages in technical talks via the www, etc.</td>
<td>Student does not always take their responsibility for own learning. He/she is interested in activities offered by the academic and/or professional community</td>
<td>Student does not take their responsibility for own learning. He/she is seldom interested in activities offered by the academic and/or professional community. He/she seldom bring information from outside sources to assignments</td>
<td>Student assumes that all learning takes place within a classroom. He/she shows little or no interest in outside learning resources</td>
</tr>
<tr>
<td>4 Recognition of learned material</td>
<td>Student is able to understand, interpret, and apply learned materials and concepts in a format different that were taught in class, e.g., he/she differentiates the Bernoulli’s equation from the energy equation, and that either equation can be written in different forms (energy terms or linear terms).</td>
<td>Student has trouble using materials and concepts that are in a different format from that taught in class</td>
<td>Student has some major problems understanding and applying learned materials and concepts in a format different that were taught in class</td>
<td>He/she can not use materials outside of what is explained in class. He/she does not recognize learned material expressed in different forms</td>
</tr>
<tr>
<td>5 Network learning</td>
<td>He/she participates and takes leadership role in professional and technical societies available to the student body such as ASME, ASHRAE, SAE, CIAPR, etc.</td>
<td>Student sometimes participates in the activities of local professional and technical societies</td>
<td>Student occasionally participates in the activities of local professional and technical societies</td>
<td>He/she does not show any interest in professional and/or technical societies</td>
</tr>
</tbody>
</table>
**Outcome J:** Be able to understand contemporary issues.

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th><strong>4 (100%)</strong></th>
<th><strong>3 (75%)</strong></th>
<th><strong>2 (50%)</strong></th>
<th><strong>1 (25%)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td><strong>Knowledge of current events</strong></td>
<td>Student has knowledge of current events in his society and the world. He/She understands and is able to connect those events with his society.</td>
<td>Student has some knowledge of current events in his society and the world. However, he/she is not quite sure of understanding what is going on.</td>
<td>Student has little knowledge of current events in his society or the world. He/She is too busy with personal stuff to give much attention to what happens around him, however he has a vague idea of what is going on.</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td><strong>Job market</strong></td>
<td>Student has a clear perspective on the current job market. He/she monitors the job market regularly. He/She can guess what job-market situation would be in the future. He prepares for that situation.</td>
<td>Student has somewhat a narrow perspective on the current job market. From time to time he checks the current job market. He/She has simplistic idea of what the job market would be.</td>
<td>Student has no much interest in how the job market is evolving. He/Shethinks only in the present situation of the job market, and how to get a job in this situation.</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td><strong>Political issues</strong></td>
<td>Student is able to discuss in-depth major political issues (world-wide, national, and local) at appropriate levels. He/she takes and defends a position on them. He/she is able to evaluate political, economical, and technical solutions.</td>
<td>Student is able to comment on major political issues, but is not familiar enough with them to defend a position on them. He/she might be able to analyze political, economical, and technical solutions.</td>
<td>Student might be concerned with local and national political issues, and sometimes he/she comment on them. He/she has some problems to understand and split political, economical, and technical solutions. He/she comment on possible alternatives.</td>
</tr>
</tbody>
</table>
**Outcome K & O:** Use techniques, skills and modern engineering tools necessary for engineering practice. Apply knowledge of contemporary analytical computational and experimental practice.

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>4 (100%)</th>
<th>3 (75%)</th>
<th>2 (50%)</th>
<th>1 (25%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acquiring data</td>
<td>Student identifies and uses relevant data with little or no extraneous efforts. He makes reasonable estimates when necessary.</td>
<td>Student ultimately identifies relevant data but may start with extraneous info.</td>
<td>Student identifies some relevant data but seems to have difficulty in distinguishing what is needed.</td>
</tr>
<tr>
<td>2</td>
<td>Mathematical skills to solve engineering problems</td>
<td>Student uses sufficient mathematical skills to solve engineering problems. He readily applies algebra, calculus, and/or differential equations to solve problems.</td>
<td>Student applies algebra, calculus, and/or differential equations effectively. He may have minors errors or be challenged by higher mathematics.</td>
<td>Student has difficulty in formulating appropriate differential equations or performing calculus analysis. He has adequate mechanics in mathematics.</td>
</tr>
<tr>
<td>3</td>
<td>Utilizing engineering principles (mass, momentum, and energy balances)</td>
<td>Student consistently and efficiently applies engineering principles. No conceptual errors and few if any procedural errors exist. Student appears to be proficient in all areas.</td>
<td>Student can apply principles. Only rare and minor conceptual errors occur. Few procedural errors. He displays a working knowledge in all areas.</td>
<td>Student can apply principles but may need improvement in one or more areas. Some conceptual and procedural errors may be evident.</td>
</tr>
<tr>
<td>4</td>
<td>Using word processors</td>
<td>Student shows high proficiency in using word processors. Word processed document are clear and contain useful figures and illustrations that enhance comprehension.</td>
<td>Student shows aptitude in using word processors. Documents are used with adequate graphics. Illustrations are adequate but could be more plentiful or informative.</td>
<td>Student uses plain text only in written documents. Spell-check is not used or used ineffectively.</td>
</tr>
<tr>
<td>5</td>
<td>Using spreadsheets</td>
<td>Repetitive calculations are performed on spreadsheets and neatly summarized. Graphs are clear, clean, well-labeled informative, and thoroughly integrated in the text.</td>
<td>Repetitive calculations are performed on spreadsheets and neatly summarized. Tables and graph are clear.</td>
<td>Some spreadsheet use is evident. Functional graph are present. Finishing details were not a concern of the student.</td>
</tr>
<tr>
<td>6</td>
<td>Using CAD software, such as AutoCAD</td>
<td>Drawings are neatly presented. Student shows accurate drawing views (frontal, top, side, and isometric) of the task. Dimensions of drawings are well displayed and according to conventions. [Student does not require much of the assistance of the instructor to accomplish the task.]</td>
<td>Drawings are presented with little errors, mostly in details. Accurate of the drawings is adequate and conventions are mostly respected. Dimensions might be displayed with minor errors. [Student needs some assistance to finish the task.]</td>
<td>Drawings have some evident errors. Student did not follow convention conventions to draw and to display dimensions. [Student requires a constant assistance of the instructor to accomplish the task]</td>
</tr>
<tr>
<td>7</td>
<td>Using computer programming tools such as MathCAD, MatLab</td>
<td>Student performs calculations and/or simulations using computer programming tools. He clearly and understandable presents his algorithm of calculations. His results are fully analyzed and also presented as Graphs which are clear, clean, and well-labeled informative.</td>
<td>Calculations and/or simulation are used by computer programming. Results are reasonable and presented in tables or graphs. Algorithm of solution might not be well documented.</td>
<td>The use of computer programming tools is limited. Results of calculations and/or simulations are assumed to be correct unless they are ridiculous.</td>
</tr>
</tbody>
</table>
H. Student Learning Outcome Assessment at the Program Level

Student Learning Outcomes at the Program level
Learning Outcome A
Apply knowledge of mathematics, science, and engineering

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Use of concepts, principles and/or equations: Concepts, principles, equations, and data (components) are identified as needed for the problem (or task), including the connections between them.</td>
<td>All except ME 1230 ME 4261 ME 5251</td>
<td>Locally developed Exam, Project and/or quizzes</td>
<td>ENGI 3410 ENGI 3420 ENGI 3421 ME 1210 ME 1230 ME 3110 ME 3410 ME 3421 ME 4120 ME 4140 ME 4210 ME 4241 ME 5050 ME 5250 ME 5992/94</td>
<td>WT-05</td>
<td>Professors: Alvarado, Bardalez, Cabrera, Clavell, Carrera, Lebrón, Ordoñez, Restrepo.</td>
<td>Assigned Professor, OAFC and Faculty Head</td>
</tr>
<tr>
<td>2 Formulates appropriate strategies of solution: A logic plan to solve the problem is proposed.</td>
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<tr>
<td>3 Execution of solution strategies: A procedure must flow free of errors. All calculations are executed without any error by hand or using calculator or any software.</td>
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<tr>
<td>4 Use of engineering judgments: Engineering judgments must be applied to evaluate the answer of a problem.</td>
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</table>

Results: WT-05 = 54%, SP-06 = 65%, FA-06 = 79%, WT-06 = 61%
Student Learning Outcomes at the Program level
Learning Outcome B
Design and conduct experiments, as well as analyze and interpret data

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Design experiments:</td>
<td>ENGI-3421</td>
<td>Laboratory Report (simulation)</td>
<td>ENGI 3421</td>
<td>WT-05</td>
<td>Professors: Alvarado Cabrera Ordoñez Restrepo</td>
<td>Assigned Professor, OAFC and Faculty Head</td>
</tr>
<tr>
<td>3 Analyze data</td>
<td>Laboratory Report (simulation)</td>
<td>Laboratory Report (simulation)</td>
<td>Laboratory Report (simulation)</td>
<td>Laboratory Report (simulation)</td>
<td>Laboratory Report (simulation)</td>
<td>Laboratory Report (simulation)</td>
</tr>
</tbody>
</table>

Results: WT-05 = 88%, SP-06 = 86%, FA-06 = 100%, WT-06 = 20%
### Student Learning Outcomes at the Program level
#### Learning Outcome C
**Design a system, component, or process to meet desired needs with app. to mech. and thermal system**

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Characterizing the design need:</td>
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</tr>
<tr>
<td>2 Attributes of an ideal solution:</td>
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</tr>
<tr>
<td>3 Sources of information</td>
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<td></td>
<td>ENGI 3421 ME 1210 ME 1230 ME 4241 ME 5050 ME 5250 ME 5251 ME 5992/94</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Prototyping of design concepts</td>
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<tr>
<td>6 Evaluation of design solution:</td>
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<tr>
<td>7 Technical communication of both solution and decision process:</td>
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<tr>
<td>8 Project management:</td>
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</tbody>
</table>

**Results:** WT-05 = 78%, SP-06 = 75%, FA-06 = 59%, WT-06 = 25%

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Student Learning Outcomes at the Program level  
Learning Outcome D  
Function on multi-disciplinary teams

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Availability for the team</td>
<td></td>
<td>ENGI 3421</td>
<td></td>
<td>FA-06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Attitude for work</td>
<td></td>
<td>ME 1210</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4 Workload</td>
<td></td>
<td>ME 1230</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Group dynamics</td>
<td></td>
<td>ME 3410</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Results: WT-05 = 88%, SP-06 = 84%, FA-06 = 91%, WT-06 = 74%
## Student Learning Outcomes at the Program level

### Learning Outcome E

**Identify, formulate and solve engineering problems**

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Formulating an engineering problem</td>
<td>Project</td>
<td>ENGI 3420 ME 1230 ME 4241 ME 5050 ME 5250 ME 5992/94</td>
<td>SP-06 WT-06</td>
<td></td>
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</tr>
<tr>
<td>3</td>
<td>Analyzing an engineering problem</td>
<td></td>
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<tr>
<td>4</td>
<td>Interpreting finding an solving the problem</td>
<td></td>
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</tr>
</tbody>
</table>

**Results:** WT-05 = 65%, SP-06 = 78%
### Student Learning Outcomes at the Program level

#### Learning Outcome F
Understand professional and ethical responsibilities

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Professional registration</td>
<td>ENGI 3421 ME 4120 ME 5992 ME 5994</td>
<td></td>
<td>ME 5992/94</td>
<td>WT-06</td>
<td>Professor: Alvarado</td>
<td>Assigned Professor, OAFC and Faculty Head</td>
</tr>
<tr>
<td>2 Ethical Codes</td>
<td></td>
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<tr>
<td>3 Ethical behavior among Peer and Faculty</td>
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<tr>
<td>4 Responsibility</td>
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<tr>
<td>5 Professional behavior among peer and faculty</td>
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<tr>
<td>6 Evaluation and Judgment</td>
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</tr>
</tbody>
</table>

**Results:** WT-05 = 83%, SP-06 = 90%, FA-06 = 93%, WT-06 = 87%
**Second- Cycle Results**  
**Student Learning Outcomes at the Program level**  
**Learning Outcome G**  
Be able to communicate effectively

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Content and concatenation of ideas of the written report</td>
<td>All except ENGI 3420 ME 5050</td>
<td>Presentation, Project</td>
<td>ENGI 3421</td>
<td>ME 1210 ME 1230</td>
<td>ME 4241 ME 5050 ME 5250 ME 5251 ME 5992/94</td>
<td>WT-05 SP-06 FA-06 WT-06</td>
</tr>
<tr>
<td>2 Mechanical organization of the written report</td>
<td></td>
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<tr>
<td>3 Presentation of results</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>4 Format and grammar</td>
<td></td>
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<tr>
<td>5 Organization of an oral presentation</td>
<td></td>
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<tr>
<td>6 Content of oral presentation</td>
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<tr>
<td>7 Mechanical execution of oral presentation</td>
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<tr>
<td>8 Appearance for presentation</td>
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<tr>
<td>9 Oral communication</td>
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<tr>
<td>10 Use of visual aids</td>
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<tr>
<td>11 Listening and responsiveness</td>
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</tbody>
</table>

**Results:** WT-05 = 80%, SP-06 = 98%, FA-06 = 87%, WT-06 = 64%

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Student Learning Outcomes at the Program level
Learning Outcome H
be able to understand the impact of engineering solutions in a global and societal context

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Values of humankind to understand impact of engineering solutions</td>
<td>ME 4120 ME 4230 ME 5240 ME 5150 ME 5992 ME 5994</td>
<td>Project</td>
<td>ME 5992/94</td>
<td>WT-06</td>
<td>Professor: Alvarado</td>
<td>Assigned Professor, OAFC and Faculty Head</td>
</tr>
<tr>
<td>2 Awareness of environmental impact</td>
<td></td>
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<tr>
<td>3 Environmental impact of engineering</td>
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<tr>
<td>4 Importance of engineering</td>
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</tr>
</tbody>
</table>

Results: WT-06 = 57%
### Student Learning Outcomes at the Program level

**Learning Outcome I**
be able to recognize the need for and an ability to engage in lifelong learning

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Independent learning</td>
<td></td>
<td></td>
<td></td>
<td>WT-06</td>
<td>Professor: Alvarado</td>
<td></td>
</tr>
<tr>
<td>2 Self-awareness of learning</td>
<td>ME 5150 ME 5992 ME 5994</td>
<td>Project</td>
<td>ME 5992/94</td>
<td>WT-06</td>
<td>Professor: Alvarado</td>
<td>Assigned Professor, OAFC and Faculty Head</td>
</tr>
<tr>
<td>3 Learning’s responsibility</td>
<td></td>
<td></td>
<td></td>
<td>WT-06</td>
<td>Professor: Alvarado</td>
<td></td>
</tr>
<tr>
<td>4 Recognition of learned material</td>
<td></td>
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<tr>
<td>5 Network learning</td>
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<td></td>
<td>WT-06</td>
<td>Assessment Coordinator</td>
<td></td>
</tr>
</tbody>
</table>

**Results:** WT-06 = 57%
Student Learning Outcomes at the Program level
Learning Outcome J
Be able to understand contemporary issues

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Knowledge of current events</td>
<td>ME 4120 ME 4240 ME 5150 ME 5992 ME 5994</td>
<td>Project, Capstone Exam</td>
<td>ME 4120 ME 5992/94</td>
<td>WT-06</td>
<td>Professors: Bardalez Alvarado</td>
<td>Assigned Professor, OAFC and Faculty Head</td>
</tr>
<tr>
<td>2 Job market</td>
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<tr>
<td>3 Political issues</td>
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</tbody>
</table>

Results: WT-05 = 76%, WT-06 = 93%
## Student Learning Outcomes at the Program level

**Learning Outcome K**

Use techniques, skills and modern engineering tools necessary for engineering practice

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Acquiring data</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Mathematical skills to solve engineering problems</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3 Utilizing engineering principles (mass, momentum, and energy balances)</td>
<td></td>
<td>Exam, Project, and/or Portfolio</td>
<td></td>
<td>WT-05, SP-06, FA-06, WT-06</td>
<td>Professors: Alvarado, Cabrera, Carreras, Carreras, Carreras, Clavell, Ordoñez, Restrepo</td>
<td></td>
</tr>
<tr>
<td>4 Using word processors</td>
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<tr>
<td>5 Using spreadsheets</td>
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<tr>
<td>6 Using CAD software, such as AutoCAD</td>
<td></td>
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</tr>
<tr>
<td>7 Using computer programming tools such as MathCAD, MatLab</td>
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</tr>
</tbody>
</table>

**Results:** WT-05 = 84%, SP-06 = 70%, FA-06 = 65%, WT-06 = 42%
**Student Learning Outcomes at the Program level**

**Learning Outcome L**

Apply knowledge of chemistry and calculus-based physics with depth in at least one of them

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Use of concepts, principles and/or equations: Concepts, principles, equations, and data (components) are identified as needed for the problem (or task), including the connections between them.</td>
<td>ENGI 3420 ENGI 3421 ME 3110 ME 4120 ME 3140 ME 3210 ME 3220 ME 4130 ME 4240 ME 4241 ME 4260 ME 5992 ME 5994</td>
<td>ENGI 3410 ENGI 3420 ME 5992/94</td>
<td>Exam</td>
<td></td>
<td>WT-05</td>
<td>Alvarado Cabrera Carreras Clavell Lebrón</td>
</tr>
<tr>
<td>2 Formulates appropriate strategies of solution: A logic plan to solve the problem is proposed.</td>
<td></td>
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</tr>
<tr>
<td>3 Execution of solution strategies: A procedure must flow free of errors. All calculations are executed without any error by hand or using calculator or any software.</td>
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</tr>
<tr>
<td>4 Use of engineering judgments: Engineering judgments must be applied to evaluate the answer of a problem.</td>
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</tr>
</tbody>
</table>

**Results:** WT-05 = 65%, SP-06 = 57%, FA-06 = 45%, WT-06 = 43%
### Student Learning Outcomes at the Program level

**Learning Outcome M**

Apply knowledge of chemistry and calculus-based physics with depth in at least one of them

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Use of concepts, principles and/or equations: Concepts, principles, equations, and data (components) are identified as needed for the problem (or task), including the connections between them.</td>
<td>ENGI 3420 ENGI 3421 ME 1210 ME 1230 ME 2010 ME 3010 ME 3140 ME 3210 ME 3221 ME 4041/29 ME 4220 ME 4240 ME 4260 ME 4261 ME 5150 ME 5992</td>
<td>Exam, Project</td>
<td>ENGI 3420 ENGI 3421 ME 4260 ME 5050 ME 5992/94</td>
<td>WT-05 FA-06 WT-06</td>
<td>Professors: Alvarado Cabrera Carreras Clavell Ordoñez</td>
<td>Assigned Professor, OAFC and Faculty Head</td>
</tr>
<tr>
<td>2 Formulates appropriate strategies of solution: A logic plan to solve the problem is proposed.</td>
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</tr>
<tr>
<td>3 Execution of solution strategies: A procedure must flow free of errors. All calculations are executed without any error by hand or using calculator or any software.</td>
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</tr>
<tr>
<td>4 Use of engineering judgments: Engineering judgments must be applied to evaluate the answer of a problem.</td>
<td>ME 5994</td>
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</tbody>
</table>

**Results:** WT-05 = 65%, FA-06 = 80%, WT-06 = 52%
Student Learning Outcomes at the Program level
Learning Outcome N
Work prof. in both thermal and mech. syst. areas including the design and realization of such system

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
</table>
| 1 Characterizing the design need: | ENGI 3420  
ENGI 3421  
ME 1210 ME 1230 ME 3010  
ME 3110 ME 3140 ME 3210  
ME 3221 ME 4041/29 ME 4130 ME 4140 ME 4210 Solid | | | | | |
| 2 Attributes of an ideal solution: | | ENGI 3420  
ENGI 3421  
ME 1210 ME 1230 | | WT-05 | Professors: Alvarado Cabrera Carreras Clavell Ordoñez Restrepo | |
| 3 Sources of information | ME 3221 ME 4041/29 ME 4130 ME 4140 ME 4210 Solid | | | | | |
| 4 Potential solutions | ME 4240 ME 4241 ME 4260 ME 4261 ME 5050 ME 5150 ME 5151 ME 5250 ME 5251 ME 5992/94 | | | | | |
| 5 Prototyping of design concepts | ME 4294 | | | | | |
| 6 Evaluation of design solution: | | | | | | |
| 7 Technical communication of both solution and decision process: | | | | | | |
| 8 Project management: | | | | | | |

Results: WT-05 = 54%, SP-06 = 65%, FA-06 = 79%, WT-06 = 61%
Student Learning Outcomes at the Program level
Learning Outcome O
Apply knowledge of contemporary analytical computational and experimental practice

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Strategies</th>
<th>Assessment Method(s)</th>
<th>Context for Assessment</th>
<th>Time of Data Collection</th>
<th>Assessment Coordinator</th>
<th>Evaluation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Acquiring data</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2 Mathematical skills to solve engineering problems</td>
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</tr>
<tr>
<td>3 Utilizing engineering principles (mass, momentum, and energy balances)</td>
<td>All Courses, except ME 5251</td>
<td></td>
<td>ENGI 3410 ENGI 3420 ENGI 3421 ME 1210 ME 1230 ME 2010 ME 4241 ME 4260 ME 4261</td>
<td>WT-05 SP-06 FA-06 WT-06</td>
<td>Professors: Alvarado Cabrera Carreras Clavell Ordoñez Restrepo</td>
<td>Assigned Professor, OAFC and Faculty Head</td>
</tr>
<tr>
<td>4 Using word processors</td>
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<tr>
<td>5 Using spreadsheets</td>
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<tr>
<td>6 Using CAD software, such as AutoCAD</td>
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<tr>
<td>7 Using computer programming tools such as MathCAD, MatLab</td>
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</tbody>
</table>

Results: WT-05 = 62%, SP-06 = 54%, FA-06 = 65%, WT-06 = 42%