A Self-Study Report

prepared by the faculty of the

Chemical Engineering Program

at

Yale University

New Haven, CT 06520-8286

and submitted to the

Engineering Accreditation Commission
Accreditation Board for Engineering and Technology

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Background Information

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Degree Options

Two undergraduate degrees are offered:

- B.S. in Chemical Engineering (ABET Accredited)
- B.S. in Engineering Sciences (Chemical)

Three graduate degrees are offered:

- M.S. in Engineering and Applied Science
- M.Phil. in Engineering and Applied Science
- Ph.D. in Engineering and Applied Science

ABET accreditation is sought only for the B.S. in Chemical Engineering degree.

Program Modes

The undergraduate Chemical Engineering Program is offered during the day. Many graduate courses are offered in the late afternoon to accommodate working engineers who wish to pursue a Masters degree on a full-time or part-time basis. However, most of our graduate students are enrolled full-time in the PhD Program.

Actions to Correct Previous Shortcomings

Concerns noted during previous accreditation visit

The Final Statement by the Chair of the Engineering Accreditation Commission, dated August 15, 2003, listed the following unresolved Program Concern:

> "The laboratory course offered to students in chemical engineering is adequate in its present form. However, expansion of this course or the addition of new courses to include experiments in environmental or biomedical engineering could put the laboratory in a position where there are insufficient resources to acquire, maintain, and operate facilities and equipment. The faculty is working to expand and improve the chemical engineering laboratory course. A wider variety of well-maintained experimental setups would provide the students with a stronger laboratory experience, one more commensurate with the high quality education found at Yale University. The current lab technician has a background in mechanical engineering and is shared with the Mechanical Engineering Program. Adding a lab technician with a stronger background in chemical engineering would improve support of the current chemical engineering lab course as well as enable expansion into environmental and biomedical engineering."

Specific actions taken

The lab course, CENG 412, has evolved somewhat since the ABET visit of 2002. At that time, the course had no "regular" instructor, and so a sense of "ownership" was lacking. Adjunct Professor Khalil, who works full time in industry, now regularly teaches this course. In addition to being a strong teacher, Prof. Khalil brings extensive experience as a principal researcher in the chemical engineering field to our chemical engineering lab course. Another recent change is a new experiment involving molecular beam epitaxy (MBE). Profs. Khalil and Altman have spearheaded this addition, made possible through financial support of the NSF Materials Research Science and Engineering Center (MRSEC) at Yale. We ultimately decided against adding new laboratory courses focusing on environmental or biomedical engineering. Owing to the new MBE experiment and the repeated teachings by Prof. Khalil, we now feel CENG 412 has reached a level of quality comparable to that of the many fine lecture courses taught in our department.

1. Students

1.1. Residential Colleges

The most conspicuous advantage of a university is that it presents students with a great breadth of learning and gives them access to scholars who are engaged not only in communicating knowledge but also in discovering it. But the potential disadvantages of a large university are that its size and complexity may discourage communication, and teachers and students may become less of a challenge to each other. In such an event, the discovery of new knowledge suffers as much as teaching and learning.

In order to avoid such disadvantages, Yale established residential colleges. Initially made possible through gifts from Edward Stephen Harkness, B.A. 1897, the colleges are more than living quarters; they are small communities of men and women, whose members know one another well and learn from one another. Each college has its own dining hall, where the students eat together, as well as its own library, common rooms, and athletic teams; each college offers courses for which academic credit is given; and each college celebrates the progress of the academic year with various festivities, concerts, and dramatic presentations

There are twelve colleges: Berkeley, Branford, Calhoun, Davenport, Timothy Dwight, Jonathan Edwards, Morse, Pierson, Saybrook, Silliman, Ezra Stiles, and Trumbull. At the head of each college is a resident master; and in each college a dean advises students on both academic and nonacademic matters. Associated with the master and the dean as fellows are about fifty members of the faculty drawn from different departments and schools of the University. A few fellows reside in the college; others have offices there.

Upon entrance, each freshman is assigned to one of the twelve residential colleges. All freshmen and sophomores are required to live on campus. Except for those freshmen affiliated with Timothy Dwight or Silliman Colleges, freshmen live in a quadrangle at the center of the University known as the Old Campus; those living on the Old Campus may take a limited number of meals in their college, and they participate fully in its life. After freshman year, most students live in their colleges, with about ten to fifteen percent of juniors and seniors choosing to live off campus. Whether they live on campus or off, undergraduates normally continue as members of the same college throughout their undergraduate careers.

1.2. Advising

Several kinds of advisers can help undergraduates plan their program. The freshman faculty adviser, who approves first-year student schedules, is assigned by the residential college dean, as is the freshman counselor. The responsibility for seeking these people and making use of their experience and advice is chiefly that of the student.

The freshman counselor is a student, either a senior or a graduate student, who lives with freshmen and serves as a source of information and assistance throughout the year, especially in the early weeks of the fall term. A small number of students are assigned to each freshman counselor, who gives suggestions about curricular and extracurricular options and is readily available to take an interest in students' academic or personal concerns. Since many freshman counselors are seniors or recent graduates of Yale, they can often give firsthand advice on how best to use the facilities, both academic and social, of the residential colleges and of Yale College.

A fellow of a residential college, either a member of the faculty or a fellow knowledgeable about education in Yale College, acts as the freshman faculty adviser. During the course selection period, freshmen meet with their advisers both to discuss the broad outline of their academic career and to approve the specific courses they choose for the freshman year. With a few telephone calls or referrals to the appropriate people, the adviser can often resolve special questions about particular courses or placement. No freshman faculty adviser can be expected to know everything about the curriculum, but any adviser can put a student in touch with someone who can answer a question that he or she cannot. And as a faculty contact, the adviser can also help throughout the school year with educational plans. Since the faculty adviser does not live in the college, as do the freshman counselors and the college dean, students need to go to his or her office. Most faculty members have fixed office hours for meeting with students.

Students are encouraged to discuss with their adviser not only their choices of particular courses, but also the relative merits of various options in the Yale curriculum. The signature of the faculty adviser on course schedules comes after a careful discussion of the student's course of study.

The residential college dean plays a central role in undergraduates' academic careers. As the representative of the Yale College Dean's Office in the residential college, the dean administers the academic regulations and oversees freshman counseling and faculty advising. The dean also counsels students on personal and academic matters, and gives advice about the rules of Yale College. The residential college dean's office maintains students' academic records. If a student should have a problem with a particular course, the dean can often help resolve it by discussing the problem with the instructor or the director of undergraduate studies, or by referring the student to the tutoring program administered by the Yale College Dean's Office. For these reasons and others, the dean is crucial to academic life at Yale. The dean's advice can be invaluable not just in the freshman year but throughout a student's whole career at Yale

The undergraduate program of each department is under the general supervision of a director of undergraduate studies (DUS), who is in charge of the undergraduate curriculum of the department. Directors of undergraduate studies are authorities on the nature and objectives of their disciplines and the general features of the departments' undergraduate programs. More particularly, the DUS is familiar with the range, focus, and objectives of individual courses in the department, as well as with departmental placement policies and major requirements. If a faculty adviser cannot answer a question about a particular department and a student is unable to find the answer in the YCPS, he/she should consult the appropriate DUS. In the YCPS, the name, campus address, telephone number, and sometimes an e-mail address for the director of undergraduate studies are listed at the beginning of the departmental entry. Often large departments have departmental representatives in the residential colleges; their names are listed in the YCPS.

1.3. Transfer Students

Yale University accepts a limited number of transfer students from other four year colleges or universities. The following regulations apply to students admitted to Yale College by transfer from other institutions:

1. In order to graduate from Yale College, transfer students must fulfill all the requirements for the bachelor's degree. They must thus earn a total of the equivalent of at least thirty-six course credits, that total consisting of the sum of the credits awarded to them for their work at their previous institutions with course credits subsequently earned at Yale. They must also complete the requirements of a major program in Yale College and fulfill the distributional requirements for the bachelor's degree, which includes the foreign language. Upon their arrival at Yale, transfer students should consult carefully with their residential college deans in order to ascertain their status with regard to the distributional requirements, especially the foreign language requirement.

2. Transfer students are expected to enroll in Yale College for the number of terms designated at the time of the final credit evaluation made of their work at previous institutions. Under no circumstances may a transfer student complete fewer than four terms of enrollment in Yale College. Under no circumstances may a transfer student earn fewer than eighteen course credits at Yale or accelerate by use of acceleration credits.

3. A preliminary evaluation of transferable credits is made at the time of the student's admission. Final evaluation of transfer credits is completed when all official transcripts from a student's previous institutions have been received.

4. Students who must remain at Yale beyond the terms designated in the final evaluation of transfer credits must petition the Yale College Committee on Honors and Academic Standing for permission to do so. Such a petition will be considered only if it is impossible for the student to complete the requirements for the bachelor's degree in the designated number of terms. A student thus granted permission to remain at Yale for an additional term, if the term represents more than the equivalent of eight terms of enrollment at the college level, is not eligible for scholarship assistance from Yale for the additional term, although other forms of financial aid may be available.

5. A transfer student's Yale transcript indicates the institution from which the student transferred to Yale, and the number of course credits earned there. It does not list the titles of courses taken or grades earned at the transfer student's previous college or university. A transfer student who needs a record of studies completed before admission to Yale must secure a transcript from the previous institution.

6. Transfer students may receive course credit for work completed outside Yale only for studies completed before matriculation at Yale; transfer students may not receive course credit for any outside courses taken after they have enrolled in Yale College. An exception is made for transfer students who earn credit on a Junior Year or Term Abrpad. Transfer students may attend a Junior Year or Term Abroad provided that they enroll in

Yale College proper for at least four terms, earning, by attendance at Yale, a minimum of eighteen course credits

7. Transfer students are not bound by the distributional requirement for the first two years, but they must fulfill the distributional requirements for the bachelor's degree. See paragraph 1 above. On the basis of stipulated scores earned on Advanced Placement tests taken in secondary schools, transfer students may fulfill the foreign language requirement. They are not eligible for the award of acceleration credit or for acceleration by use of acceleration credits

8. Once a student has been accepted for admission as a transfer student, the student may not attend Yale as a special student before his or her first term of enrollment at Yale.

1.4. Credit Transfer

Under the conditions described below, a student may apply as many as two course credits earned at another college or university toward the 36-course-credit requirement for graduation from Yale College. Forms on which to request the award of credit for study that has been completed elsewhere are available at the offices of the residential college deans. Before undertaking such outside study, the student should consult the residential college dean both about the institution to be attended and the course to be taken there. Courses in the Yale Summer Programs, including the Yale Summer Language Institute, are not considered outside courses, and there is no limit on the number of such courses that a student may offer toward the requirements of the bachelor's degree. Similarly, courses taken at the Yale Program at the Paul Mellon Centre in London are Yale courses and do not count as outside credit. Note that credits earned outside Yale may not be used to reduce the expected number of terms of enrollment in Yale College. In order for credit to be given for courses taken elsewhere, all of the following conditions must be met:

1. The director of undergraduate studies in the subject of a course taken elsewhere must approve the award of credit at Yale for the course.

2. A student who has studied at an American university, or abroad on a program sponsored by an American university, must provide the office of the residential college dean with an official transcript of the work completed. A student who has enrolled at a foreign university should supply an official transcript if the university issues transcripts; if it does not, then the student must furnish an official certificate of enrollment, showing if possible the course or courses completed.

3. Students seeking outside credit should be prepared to furnish a copy of the course syllabus, as well as essays and examinations written in the course. In some cases, a letter from the instructor of the course may be required, or the student may be asked to pass an examination on the material of the course. Such information may be particularly necessary in the case of study at a foreign university.

4. Study undertaken in the United States must be at a four-year accredited institution that grants a bachelor's degree in the arts and sciences. Foreign study must be completed at a university or other approved institution. Credit may be awarded only for work done while

a student was officially enrolled at such an institution, and cannot be given for any work completed independently of such formal enrollment.

5. A grade of A or B is expected; a grade of C is acceptable. Credit cannot be given for a course in which a grade of D was earned. Credit also cannot be given for a mark of Credit on a Credit/D/Fail option, nor for a grade of Pass on a Pass/Fail option, if the student had the choice of taking the course for a letter grade.

6. In order for credit to be given for a course completed at another university, the course must carry a value of at least three semester credit hours; if the course is taken at an institution on the quarter system, it must carry a value of at least four-and-one-half quarter units.

7. In order for credit to be given for a course completed at another university, the number of contact hours for the course must equal or exceed the number of contact hours for an equivalent course offered in Yale College during the fall or spring term, and the length of term (from the first to the last day of classes) must be at least four consecutive weeks.

1.5. Monitoring Student Progress

The requirements for the bachelor's degree are thirty-six course credits, the fulfillment of the distributional requirements, including the foreign language requirement, and the completion of a major program. Course credits and the distributional requirements are supervised by the Registrar's Office, the residential college deans, and the Yale College Dean's Office. The job of the DUS is to certify to the registrar that seniors have completed the requirements of the major program. In addition, the DUS forwards to the Committee on Honors and Academic Standing the nominations of the department or program for Distinction in the Major. The DUS also oversees the administration of any prizes awarded by the department or program to graduating seniors. No senior can be graduated until the DUS has certified that he or she has fulfilled the requirements of the major program. It should be noted, first of all, that the procedures for such certification are different at the end of the fall term from what they are at the end of the spring term.

Fall Certification

Seniors who complete degree requirements at the end of the fall term do not actually receive the degree until Commencement in May. They are cleared for the degree as soon as possible after the end of the fall term, however, so that their transcripts can show that they qualify for graduation in May. Such certification by the DUS that seniors have completed the requirements of the major at the end of a fall term is given on the Major Completion List (MC List). An MC List containing the names of seniors expected to complete degree requirements at the end of a fall term is sent to the DUS in January. (Departments with no seniors completing degree requirements at the end of a fall term will not receive an MC List.). Toward the end of January the academic records of these seniors, showing all their courses and grades up through the fall term just completed, are sent to the DUS. Upon receiving these academic records, the DUS fills out and returns the Major Completion List, writing "SAT" next to the name of seniors who have completed all the requirements of the major, as well as the senior requirement (departmental examination, senior essay, or project).

Spring Certification

Because of the pressures of time before graduation, this certification occurs in two steps in the spring: (1) the DUS gives the Registrar's Office provisional certification before grades are actually due; and (2) the Registrar's Office, in the absence of a subsequent negative correction from the DUS, confirms the certification when passing final course grades are received. The DUS gives this provisional advance certification on what is called the Provisional Major Completion List (Provisional MC List). A Provisional MC List is sent to each DUS toward the middle of the spring term, containing the names of all seniors in the major who are finishing their degree requirements in that term.

On the Provisional MC List the DUS is asked to supply the appropriate designation for each student enrolled in the major:

- The student has met all the requirements of the major, including the senior requirement, and is clear for graduation. The designation does not apply often.
- The student will have met all of the requirements of the major, including the senior requirement, if and when he or she successfully completes all of the courses in the major in which he or she is enrolled. For example, this designation would be used for a History major who needed to complete the History senior essay course and one other History course.
- The student will have met all of the requirements of the major if and when he or she successfully completes all of the courses in which he or she is enrolled. For example, this would be used for an American Studies major who needed one American Studies course and one English course.
- Even if the student successfully completes all of the courses in which he or she is currently enrolled, he or she will not have met all of the requirements of the major. This designation is often used by departments that have a non-credit senior requirement.
- There is no way the student can meet all of the requirements of the major at the conclusion of the term.

In addition to the Provisional MC List, the DUS is asked to complete a Major Completion form for each student. On this form, which shows all of the courses in which the student is enrolled, the DUS will be asked to circle the specific courses that the student needs to complete in order to graduate. If the student needs any one of several courses, the DUS should indicate that as well. That way the Registrar's Office can clear a student for graduation as soon as grades in the specific required courses have been recorded.

To aid the DUS in keeping track of the courses that their majors have completed, the Registrar supplies the DUS with copies of the academic records of each junior and senior in the major. These come twice: once in August, showing courses completed through the previous spring term, and again in late March in conjunction with the Provisional MC List, showing courses completed through the previous fall term as well as courses in the current spring term in which the student is enrolled.

A final task for the DUS, right after the Spring terms grades for seniors become available, is the identification of seniors warranting "Distinction in the Major." The criteria are set by Yale College regulations and involve the number of courses in the major with grades of A and A-, said number dependent on whether the Senior Project grade is A or A-, or lower.

1.6. Enrollment and Graduation Trends

In Table 1-1, we show the number of students enrolled in and graduating from the Chemical Engineering Program during the last five academic years. Enrollment includes sophomores, juniors, and seniors taking the chemical engineering course sequence. Based on these data, in an average year, we enroll 21.4 students, graduate 7.2 students, and graduate 5.4 students with ABET accredited degrees. We note that all students over this time period have been full-time enrolled. Only two students enrolled in the Program during this period have failed to earn a degree: one who studied during 2005-07 and one who studied during 2005-06. Looking ahead, there are 7 currently enrolled students expecting to graduate in 2009, and 9 in 2010.

Table 1-1. Enrollment Trends for Past Five Academic Years

	2003-04	2004-05	2005-06	2006-07	2007-08
Full-time Students	17	20	22	25	23
Part-time Students	0	0	0	0	0
Student FTE[1]	17	20	22	25	23
Graduates (Total)	8	8	3	10	7
Graduates (ABET)	5	6	3	7	6

[1] FTE = Full-Time Equivalent

In Table 1-2, we provide data on all students graduating from the Program over the period 2005-2008. The following items are of note. First, all students completing the Program have done so in four years. Of the 28 students listed, 22 earned the ABET accredited BS degree in Chemical Engineering, while 6 earned the unaccredited BS degree in Engineering Sciences (Chemical). Based on available information on these listed students, we know that upon graduation, 7 went on to graduate school, 7 went to industry, 3 went to medical school, 2 took positions in government, and 1 had not yet worked or attended further school.

Table 1-2. Program Graduates

Numerical Identifier	Year Matriculated	Year Graduated	Prior Degree(s)	Certification/ Licensure (If Applicable)	Initial or Current Employment/ Job Title/ Other Placement
1	2004	2008 BS (ABET)	--		PhD Student, Stanford
2	2004	2008 BS	--		Yale Start-up Company
3	2004	2008 BS (ABET)	--		Medical Student, U of Chicago
4	2004	2008 BS (ABET)	--		MS Student, Imperial College, London
5	2004	2008 BS (ABET)	--		Product Engineer, Shell Oil, New Orleans
6	2004	2008 BS (ABET)	--	none	PhD Student, Stanford
7	2004	2008 BS/MS (ABET)	--	none	Process Engineer, Belgium
8	2003	2007 BS (ABET)	--		PhD Student, MIT
9	2003	2007 BS (ABET)	--		Software Engineer, Microsoft, Redmond WA
10	2003	2007 BS (ABET)	--		Engineer, Archer Daniels Midland Company, Cedar Rapids IA
11	2003	2007 BS (ABET)	--	none	Patent Examiner, USPTO
12	2003	2007 BS (ABET)	--	none	PhD student, Notre Dame
13	2003	2007 BS (ABET)	--		PhD student, Yale
14	2003	2007 BS (ABET)	--		R&D Engineer, JetBoil, Manchester, NH
15	2003	2007 BS	--		
16	2003	2007 BS	--		Steve & Barry's University Sportswear, Port Washington, NY
17	2003	2007 BS	--		Patent Examiner, USPTO
18	2002	2006 BS (ABET)	--		
19	2002	2006 BS (ABET)	--	none	None
20	2002	2006 BS (ABET)	--	none	PhD student, Northwestern
21	2001	2005 BS (ABET)	--		
22	2001	2005 BS	--		
23	2001	2005 BS (ABET)	--	none	Management, Firmenich SA
24	2001	2005 BS (ABET)	--		Medical Student, Washington University, St. Louis
25	2001	2005 BS	--		
26	2001	2005 BS (ABET)	--		
27	2001	2005 BS (ABET)	--	none	Medical Student
28	2001	2005 BS (ABET)	--		

2. Program Objectives

2.1. Mission Statements

2.1.1. *Mission of the Chemical Engineering Program*

The Program's primary mission is to provide our graduates with a broad education and versatile engineering science background, suitable for a wide range of career options, and with the ability to engage in life-long learning.

2.1.2. *Mission of the Institution*

"As one of the world's leading centers for learning, Yale's primary mission is to attract, educate and motivate a diverse group of the most highly talented men and women in order to advance and disseminate knowledge and to promote the scholarship, high character, values, and leadership which can be directed toward sustaining and improving society. Intrinsic to this mission are the faculty's dual responsibilities for outstanding teaching and original research, carried out in a community comprised of Yale College, a Graduate School with broad coverage of the arts and sciences, and an array of professional schools in arts, sciences, and learned professions. This mission requires a continuing commitment to the excellence, the competitive position and the reputation for academic leadership that Yale has earned over three centuries."

2.2. Chemical Engineering Program Objectives

The objectives of the Chemical Engineering Program are listed below. The curriculum for our program, based on these objectives, is discussed in Section 5.

I. Graduates from our program will have an excellent engineering science background for graduate study in chemical, biomedical, and environmental engineering programs, as well as superior scientific and analytical preparation for medical school and law school. Specifically, our graduates will

- a) possess in-depth scientific knowledge and mathematical skills;
- b) be able to formulate and solve chemical engineering problems;
- c) be aware of chemical engineering research frontiers through course material, undergraduate research, and close interaction with the Program Faculty; and
- d) be able to enter top-ranked graduate engineering programs.

II. Graduates from our program will be well prepared for a diverse range of careers in industry or national laboratories. Specifically, our graduates will

- a) be able to design a chemical engineering process with desired specifications and constraints;
- b) have exposure to engineering economics, safety, and ethics; and
- c) be able to pursue technical careers in industry or at national labs.

III. Graduates from our program will have a broad general education including

a) strong oral and written communication skill;
b) the ability to communicate effectively to multidisciplinary audiences;
c) the ability to work effectively as a member of a team; and
d) a broad awareness of contemporary social and environmental issues.

The program objectives are published annually in the *Guide to Undergraduate Studies in Engineering and Applied Science* and the *Yale College Programs of Study*.

2.2.1. Consistency of Program Objectives with Accreditation Criteria

Consistency between our program objectives and the required outcomes for accreditation is discussed in Section 3. There, we demonstrate that our curriculum, based on our program objectives, meets the required professional component for accreditation. In Section 5, we show that our curriculum meets the specific criteria required for accredited chemical engineering programs.

2.2.2. Consistency of Chemical Engineering Program Objectives with Mission of Institution

The aims of Yale College to promote scholarship and advance knowledge (cf., Section 2.1.2) are closely aligned with program objective 1. Program objective 3 is consistent with the institutional goal of providing its students with a broad exposure to the arts and sciences. The institutional goal of promoting high character and values and applications to sustain and improve society encompass advances in engineering and engineering ethical issues, as described by program objective 2.

2.3. Constituencies

Listed below are the primary constituencies for the Chemical Engineering Program. We describe their interests and the extent of their participation in evaluating and revising our program objectives, and the relevant data to be available during the accreditation visit.

1. **Chemical Engineering Majors**

   Students are the most important constituency of our program. Over 90% of our students are enrolled in the accredited program.

   Interests: Our program must produce students that are successful in job interviews and in graduate school admissions and provide them with a broad and flexible engineering education with long-term value.
   Participation: Our students actively participate in the evaluation and revision of our program objectives through:

   - Course feedback via class web pages
   - Exit interviews

- Student Council meetings
- Meetings with the DUS
- Individual and group discussions with the DUS and/or Chair
- Student-Faculty dinners
- Discussions with the Director of Educational Affairs

2. **Chemical Engineering Alumni**

Interests: Chemical engineering alumni would like to maintain and even improve the quality of our program. For example, The Yale Science and Engineering Association (YSEA) is an alumni organization dedicated to the support of undergraduate research activities in engineering and science at Yale.
Participation: Alumni participate in the evaluation and revision of our program objectives through:

- Web surveys
- Telephone interviews
- Discussions with the DUS or other member of program faculty at professional meetings, such as the annual AIChE meeting
- YSEA survey

3. **Prospective Chemical Engineering Majors**

Interests: Prospective chemical engineering majors seek a quality engineering education that will prepare them for a wide range of career options including industry, national laboratories, and graduate engineering programs.

Participation:

a) High school students considering chemical engineering at Yale, their parents, and high school counselors evaluate our program objectives by:
    - Surveys of students during Bulldog Days (visit to Yale College for admitted students each Spring)
    - Surveys of parents during Bulldog Days
    - Interviews with the DUS during Bulldog Days, and drop-in visits
    - Discussions the DUS by telephone or email
b) Freshmen and Sophomores who are considering a major in chemical engineering participate in the evaluation and revision of our program objectives through:
    - Survey at Engineering Fair
    - Discussions with the DUS
    - Discussions with chemical engineering majors
c) Sophomores and Juniors who are considering transferring into the Chemical Engineering Program evaluate our objectives by:
    - Discussions with the DUS or program chair
    - Discussions with chemical engineering majors

4. **Recruiters**

Interests: Recruiters seek the best engineering students as permanent employees or as summer interns.
Participation: Recruiters participate in the evaluation and revision of our program objectives through:

- Surveys
- Annual interviews with the Director of Educational Affairs or DUS
- Meetings with the Dean of Engineering

5. **Graduate Engineering Programs**

Interests: Graduate engineering program seek the best engineering students for their PhD and Masters degree programs and for summer research positions (e.g., NSF Research Opportunities for Undergraduates).
Participation: Graduate schools evaluate our program objectives through discussions with our faculty at professional meetings (e.g., annual AIChE meeting), during visits to give seminars, and through e-mail or telephone discussions.

6. **Faculty of Chemical Engineering**

Interests: Our faculty strives to maintain the quality of our educational program; all are actively involved in both teaching and research, including undergraduate research.
Participation: Our faculty participates in the evaluation and revision of our program objectives through:

- Faculty meetings
- Individual discussions with the DUS or Chair

7. **School of Engineering and Applied Science**

The School of Engineering and Applied Science (SEAS) at Yale provides our students a multidisciplinary education, and provides a formal Focus Group that helps us to evaluate our program.

Interests: SEAS faculty are concerned about the overall quality of engineering at Yale.
Participation: The SEAS faculty participate in the evaluation and revision of our program objectives through:

- Meetings among the DUS from the accredited programs in chemical, mechanical, and electrical engineering
- Meetings of the SEAS Focus Group
- Dean's Committee meetings

8. **Faculty of Arts and Sciences**

Interests: Engineering and science departments at Yale have a shared interest in maintaining high-quality teaching in science and engineering courses, a broad range of useful science and engineering course offerings for our students, and attracting more students to their programs.
Participation: Engineering and science departments at Yale help us to evaluate our objectives primarily through monthly meetings of the engineering and science chairs to address issues related to science teaching, the needs of engineering and science students at Yale, and increasing the visibility of engineering and science at Yale to outstanding high school students. Program revisions resulting from these meetings include a new outreach program to involve high school science teachers in engineering and science at Yale.

9. **Peer Institutions**

Interests: Peer institutions such as Princeton, Columbia, and the University of Pennsylvania compete for the same pool of talented high school students. We learn from each others goals and experiences how to usefully differentiate our programs.
Participation: Peer institutions help us to evaluate and revise our program objectives through discussions with our faculty at professional meetings, during visits to give seminars, and by e-mail or telephone.

2.4. Process for Evaluating and Revising Program Objectives

The process for evaluating and revising our program objectives follows. An example of the process is provided in Section 6.

1. Annually, our published objectives are presented for evaluation to current, former, and prospective chemical engineering majors at Yale (constituencies 1–3) and the recruiters of our students (constituency 4). Monthly meetings of the engineering and science chairs provide continuous input from the faculty of Arts and Sciences (constituency 8). Faculty advisers of our alumni and the faculty at peer institutions (constituencies 5, 9) provide an informal evaluation of our program objectives on a continual informal basis through discussions with Program Faculty.

2. The DUS and Chair discuss the constituency evaluations. The responses of the constituencies may suggest that one or more program objectives be revised. Depending on the needs of the constituencies, program objectives can be individually revised or eliminated, or new program objectives can be introduced. The program objectives may also be collectively refocused.

3. If it seems that the program objectives could be usefully revised to better meet the interests of our constituencies, a proposal is interactively developed by the DUS and the program constituencies. The procedure follows:

- The DUS develops a proposal for revising our program objectives according to the responses of the constituencies.

  The process is constrained to ensure that our program objectives remain consistent with respect to the outcomes required for accreditation (see Section 4).

- The proposed revision of program objectives is returned to students currently in the Program, prospective students, and the Program Faculty (i.e., program constituencies 1, 3(b), and 6) for feedback.

- The proposal is modified accordingly, and the feedback loop repeated as necessary/useful.

4. The proposed revision of program objectives is discussed with the SEAS Focus Group (constituency 7).

5. The DUS and Chair discuss the proposal and consider further modification in response to criticism from the Focus Group.

6. The proposal is discussed by the chemical engineering faculty (constituency 6), and a poll is taken. The decision to implement the revised program objectives is made if a consensus is achieved. (This is usually possible given the input at step 3.)

7. The *Guide to Undergraduate Studies in Engineering and Applied Science* and the *Yale College Programs of Study* are annually updated to incorporate the revised program objectives.

3. Program Outcomes and Assessment

3.1. Program Outcomes, Assessment, and Metric Goals

Over the years, the Program has established its own set of outcomes, assessment methods, and metric goals. The relation between these program outcomes and our stated program objectives (see Section 2.2) is given in Table 3-1.

1. **Graduate School Admissions**.

   Graduate school admissions is the metric corresponding to program objective 1(d).

   Assessment: The DUS advises students concerning graduate school applications and is informed about acceptances/rejections. Surveys and interviews with alumni are a measure of how well our program prepares our students for graduate school.

   Metric goal: Students should have the opportunity to pursue a Masters degree, or receive a graduate fellowship to pursue a PhD in chemical, environmental, or biomedical engineering at one of the departments where they apply, preferably at one of the top twenty departments in the U.S. (e.g., *U.S. News and World Report* survey).

2. **Recruiter surveys, interviews**.

   Feedback from recruiters is an important measure of the extent to which our program meets program objective 2(c).

   Assessment: The Director of Educational Affairs is most actively involved with analyzing recruiter surveys and recruiter interviews. The information is shared among faculty within the School of Engineering and Applied Science.

   Metric goal: Recruiters should be enthusiastic about our students and alumni so that our students can find a position in industry or a national laboratory (which requires a BS degree in engineering).

3. **Awards**.

   Awards are given to engineering students at Yale whose academic achievements are outstanding. Our students also compete for external awards.

   Assessment: Awards from Yale are decided by a prize committee composed of faculty from each department in Engineering and Applied Science. Applications for outside awards are externally reviewed.

   Metric goal: At least one junior and two seniors should be worthy of an academic prize. Our students should be competitive candidates for external awards.

4. **Alumni surveys, interviews**.

Alumni feedback broadly reflects our program, and in principle, provides useful time history data.

Assessment: The DUS gathers the data and analyzes the results.

Metric goals: Our graduates should have successful starts to their careers e.g., admission to a highly-ranked graduate engineering program and success in graduate course work and research, or a good position in industry with the ability to earn promotions.

5. **Senior Design Project**.

Assessment: Grade assignment is based on the quality of the completed design project, including a written report and oral presentation from each student team, and individual test scores. The oral presentation (including a question and answer session) is given to an audience consisting of chemical engineering majors, program faculty, and visitors from local industries. The audience is asked to evaluate the projects based on the presentation.

Metric goal: To pass the course, each student team must complete the required design project, including a written report and an oral presentation. We aim to have all students earn a grade of B or better, and favorably impress the audience (particularly the industrial visitors) with their presentation.

6. **Undergraduate Research.**

Approximately 80% of our students participate in undergraduate research. Their performance is an important measure of their preparation for graduate school.

Assessment: Principal investigator of the laboratory.

Metric goal: All students should have the opportunity to participate in research. Particularly keen students should have the opportunity to delve more deeply into a project, develop the ability to make independent contributions to an original research problem, and present their results at a national meeting, or co-author a peer-reviewed article.

7. Design Projects.

Students must complete a design project for process control (CENG 480).

Assessment: Graded by the instructor.

Metric goal: Course grade strongly reflects the quality of work on the design project.

8. **Lab Reports**.

Assessment: Graded by the instructor.

Metric goal: Course grade is based largely on the quality of lab reports.

9. **Extracurricular Activities**.

Extracurricular activities help to broaden the education one of our students.

Assessment: Informal discussions with the DUS and other Program Faculty.

Metric goal: The Program should, within reason, accommodate students' extracurricular interests (e.g., through revised course scheduling, Section 3).

10. **Transcripts**

Course grades broadly reflect the extent to which we achieve our program objectives. The selection of courses taken for the Yale College distribution requirement is a measure of educational breadth.

Assessment: Course grades, based on tests and course work, are assigned by the course instructor. The DUS assesses student transcripts each semester and clears each student for graduation.

Metric goal: To graduate students must meet the program requirements as well as the distribution and foreign language requirements set by Yale College. Passing grades are required in each course; we aim for students to earn grades of B- or better.

11. Course Assignments

The quality of student work on problem sets and other assignments for a particular course is a more-detailed measure of the extent to which specific objectives are met.

Assessment: Course work is usually graded by the instructor.

Metric goal: Course work is reflected in course grade (pass required).

Program Outcomes			Program Objectives										
			1				2			3			
			a	b	c	d	a	b	c	a	b	c	d
1	Grad School Admissions		•	•	•	•		•	•			•	
2	Recruiter Surveys, Interviews		•	•	•	•			•				
3	Awards		•	•	•	•			•				
4	Alumni Surveys, Interviews		•	•	•	•			•				
5	Senior Design Project:	9	•	•	•	•			•				
6	Undergraduate Research		•	•	•	•	•	•	•				
7	Design Projects:	10	•	•	•			•	•	•		•	
8	Lab Reports:	8, 17		•	•		•	•	•	•	•	•	•
9	Extracurricular Activities		•	•		•	•		•	•			
10,11	Transcripts, Course Assignment:												
		1-8, 10-13, 15-17, 20	•										
		1-17, 20		•									
		1, 3-9, 12			•								
		7, 9, 10					•						
		1, 7-9, 22						•					
		8-10, 17, 22								•			
		9, 22									•		
		1, 8, 9, 22										•	
		9, 22											•

Table 3-1: Relation of program outcomes, as presented in Section 3.1, to program objectives, as presented in Section 2.2. Numbers in second column refer to courses (groups of courses) listed in Table 5-1.

3.2. ABET Outcomes

In addition to the set of outcomes described above, the Program seeks to adhere to the official ABET outcomes, as described below.

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

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

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

d) an ability to function on multi-disciplinary teams

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

f) an understanding of professional and ethical responsibility

g) an ability to communicate effectively

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

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

j) a knowledge of contemporary issues

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

In fact, the ABET outcomes are closely aligned with our program outcomes; Table 3-2 shows their relation.

Program Outcomes			ABET Outcomes										
			a	b	c	d	e	f	g	h	i	j	k
1	Grad School Admissions		•	•		•	•		•		•		•
2	Recruiter Surveys, Interviews		•	•	•	•	•	•	•	•	•		•
3	Awards		•	•	•	•	•		•		•	•	•
4	Alumni Surveys, Interviews		•	•	•	•	•	•	•	•	•	•	•
5	Senior Design Project:	9	•	•	•	•	•	•	•	•			•
6	Undergraduate Research		•	•	•	•	•		•		•		•
7	Design Projects:	10	•		•		•		•				•
8	Lab Reports:	8, 17	•	•		•	•		•		•		
9	Extracurricular Activities					•			•	•		•	
10, 11	Transcripts, Course Assignment:												
		1-13, 15-17, 20	•										
		8, 9, 17		•									
		7, 9, 10			•								
		8, 9, 22				•							
		1-17					•						
		7, 9						•					
		8-10, 17, 22							•				
		9, 22								•			
		1-8, 11-17									•		
		9, 22										•	
		1-17											•

Table 3-2: Projection of program outcomes, as described in Section 3.1, onto ABET outcomes, described in Section 3.2. Numbers in second column refer to courses (or groups of courses) listed in Table 5-1.

3.3. Relation between Program Objectives and ABET Outcomes

The information displayed in Table 3-1 shows the connection between our program objectives and our program outcomes; Table 3-2 shows the projection of our program outcomes onto the ABET outcomes. Together, these tables demonstrate that our program objectives are consistent with the ABET outcomes.

To more specifically address ABET Outcomes, we present in Table 3-3 certain Performance Criteria, with rubrics, associated with each Outcome.

Table 3-3 Performance Criteria (PC) with rubrics appropriate for each outcome.

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

Performance Criterion		**Unsatisfactory**	**Acceptable**	**Exemplary**		**Direct measure means**
Calculus (3 courses)		Evaluates simple integrals analytically, others via tables/software	Evaluates intermediate integrals analytically, others using tables/software	Evaluates most integrals analytically and understands concepts of calculus		ENAS 151 or Math 120 – Final Exam
Differential equations		Solves only simple Dif Eq, unable to set up Dif Eq	Solves most Dif Eq using more than method	Formulates and applies Dif Eq to novel systems		ENAS 194 – Final Exam CENG 480 – Final Exam
Computing		Solves only simple scientific problems via programming	Solves intermediate problems with MATLAB or Excel	Solves advanced problems using variety of programming tools		ENAS 130 – Final Exam CENG 480 – Final Exam
Chemistry (5 courses)		Solves problems of chemical equilibria, difficulties with problems in organic and physical chemistry	Solves intermediate problems in organic and physical chemistry	Solves advanced problems in organic and physical chemistry		CHEM 114 – Final Exam CHEM 220 – Final Exam CHEM 221 – Final Exam CHEM 330 – Final Exam
Physics (2 courses)		Solves only simple problems in mechanics	Solves intermediate problems in mechanics and simple problems in electromagnetism	Solves advanced problems in mechanics and intermediate problems in electromagnetism		Phys 180 – Final Exam Phys 181 – Final Exam
Engineering		Little understanding of the Engineering approach	Designs a chemical process using engineering principles	Understands tradeoffs to optimize process design		CENG 416 – Final Exam CENG 416 – Capstone Project CENG 480 – Term Project

Table 3-2 (Continued)

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

Performance Criterion		**Unsatisfactory**	**Acceptable**	**Exemplary**		**Direct measure means**
Create a hypothesis		Lacks knowledge of the experiment	Knows fundamental principles tested	Has thorough knowledge and tries novel ideas		CENG 412 – Lab Reports CENG 416 – Capstone Project
Understand problem		Distinctions are unclear	Understands distinctions clearly	Makes gradations in distinctions		CENG 412 – Lab Reports CENG 416 – Capstone Project CENG 480 – Term Project
State what is to be shown		Confused and not sure, makes repeated mistakes	Follows instructions to the letter	Tries novel approaches		CENG 412 – Lab Reports CENG 416 – Capstone Project
Use test equipment		Sufficient knowledge so as not to get hurt or cause harm	Understands how to use equipment	Can measure novel features beyond what is asked		CENG 412 – Lab Reports CENG 416 – Capstone Project

Table 3-2 (Continued)

c) an ability to design a system, component, or process to meet desired goals.

Performance Criterion		**Unsatisfactory**	**Acceptable**	**Exemplary**		**Direct measure means**
Research and gather information		Does not adequately prepare	Uses obvious sources	Uses appropriate combination of library and Internet sources		CENG 412 – Lab Reports CENG 416 – Capstone Project
Identify a problem		Will do any available project	Selects project based on interests	Highly motivated to pursue desired goal		CENG 416 – Capstone Project CENG 480 – Term Project
Schedule tasks		Works on project at the end of the term	Provides a reasonable time line with milestones	Works with passion, examines alternatives		CENG 412 – Lab Reports CENG 416 – Capstone Project CENG 480 – Term Project
Completed design		Design accomplishes only portion of what is proposed	Design functions as proposed	Design optimized		CENG 412 – Lab Reports CENG 416 – Capstone Project CENG 480 – Term Project

Table 3-2 (Continued)

d) an ability to function on a multi-disciplinary team.

Performance Criterion		**Unsatisfactory**	**Acceptable**	**Exemplary**		**Direct measure means**
Research and gather information		Does not adequately prepare	Uses obvious sources	Uses appropriate combination of library and Internet sources		CENG 412 – Lab Reports CENG 416 – Capstone Project
Fulfills team role		Contributes less than average work load	Contributes average work load	Leads team in interesting directions		Observation by Instructor
Responds to others' input		Discourages conversations about alternatives	Considers options proposed by teammates	Leads discussion while being sensitive		Observation by Instructor
Safety considerations		Shows no concern for safety issues	Shows good judgment	Shows awareness of dangerous conditions and how to avoid them		Safety reports

Table 3-2 (Continued)

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

Performance Criterion		**Unsatisfactory**	**Acceptable**	**Exemplary**		**Direct measure means**
Research and gather information		Does not adequately prepare	Uses obvious sources	Uses appropriate combination of library and Internet sources		CENG 412 – Lab Reports CENG 416 – Capstone Project
Identify a problem		Will do any available project	Selects project based on interests	Highly motivated to pursue desired goal		CENG 416 – Capstone Project CENG 480 – Term Project
Schedule tasks		Works on project at the end of the term	Provides a reasonable time line with milestones	Works with passion, examines alternatives		CENG 412 – Lab Reports CENG 416 – Capstone Project
Completed design		Design accomplishes only portion of what is proposed	Design functions as proposed	Design optimized		CENG 412 – Lab Reports CENG 416 – Capstone Project
Project report		Report is limited in scope, contains typos, mostly spec sheets and program listings	Polished report describing design process and results. Addresses ethics and professionalism.	Professional report describing impact of design, its limitations, and possible future directions.		CENG 416 – Capstone Project CENG 480 – Term Project

Table 3-2 (Continued)

f) an understanding of professional and ethical responsibility.

Performance Criterion		**Unsatisfactory**	**Acceptable**	**Exemplary**		**Direct measure means**
Basic ethics		Unaware of ethical issues	Understands some ethical issues and possible resolutions	Understands and differentiates diverse ethical issues		ENAS 335 – Final Exam CENG 416 – Capstone Project
Participation in professional societies		Not a member of AIChE or related society	Active member of AIChE or related society	Officer or activity leader of AIChE or related society		Exit interview

Table 3-2 (Continued)

g) an ability to communicate effectively.

Performance Criterion		**Unsatisfactory**	**Acceptable**	**Exemplary**		**Direct measure means**
Explain experiment		Unfamiliar with fundamental terms	Uses conventional jargon	Understands audience and adjusts technical level		CENG 412 – Lab Reports
Explain design		Unsure of results and terminology	Clearly explains what was done	Describes fundamental limitations and state of the art		CENG 412 – Lab Reports CENG 416 – Capstone Project
Multi-media use		Uses only Word with limited images and Matlab/Excel plots	Uses Word and Powerpoint with Matlab/Excel plots and animations	Additionally includes video animations		CENG 416 – Capstone Project

Table 3-2 (Continued)

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

Performance Criterion		**Unsatisfactory**	**Acceptable**	**Exemplary**		**Direct measure means**
Yale's Distributional Requirements		Takes simple, non-challenging courses having little or no relationship to engineering profession	Takes more challenging courses with some significant relation to engineering	Takes challenging courses that prepares student to be a leader in technology		Transcript Exit interview – DUS

Table 3-2 (Continued)

i) a recognition of the need for, and be able to engage in, life-long learning.

Performance Criterion		**Unsatisfactory**	**Acceptable**	**Exemplary**		**Direct measure means**
Participation in professional societies		Not a member of AIChE or related society	Active member of AIChE or related society	Officer or activity leader of AIChE or related society		Exit interview
Future plan (5-year plan)		Little thought given	Ambivalent between engineering job, grad school, professional school	Is interviewing widely and has some internship experience		Exit interview Oral exam question
References current literature and device specifications		Uses only information in text	References at least one journal article or reliable Internet source	Understands relevance of new information and uses most recent reference search tools		CENG 412 – Lab Reports CENG 416 – Capstone Project
Modern software tools		Uses MS Office but little engineering software	Knows what software exists and uses in design	Uses a variety of tools and selects those best suited for the task at hand		CENG 412 – Lab Reports CENG 416 – Capstone Project CENG 480 – Term Project

Table 3-2 (Continued)

j) a knowledge of contemporary issues.

Performance Criterion		**Unsatisfactory**	**Acceptable**	**Exemplary**		**Direct measure means**
Socio-economic		Little knowledge and even less awareness	Some knowledge	In-depth knowledge		Performance in Distribution Requirement Courses Exit interview – DUS
Societal impact		Elementary understanding of issues	Understands societal impact of technology	Proposes solutions to societal problems with technology		Exit interview – DUS
Political		Elementary understanding of political aspects of engineering issues	Knowledge of political aspects of engineering issues	Strong knowledge of political aspects of engineering issues, active within political organization		Performance in Distribution Requirement Courses Exit interview – DUS
Environmental		Little knowledge of environmental issues	Knowledge of engineering impact on environment	Strong knowledge of specific cases concerning engineering impact on environment, active within environmental organization		Exit interview – DUS

Table 3-2 (Continued)

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

Performance Criterion		Unsatisfactory	Acceptable	Exemplary		Direct measure means
Modern software tools		Uses MS Office but little engineering software	Knows what software exists and uses in design	Uses a variety of tools and selects those best suited for the task at hand		CENG 412 – Lab Reports CENG 416 – Capstone Project CENG 480 – Term Project
References current literature and device specifications		Uses only information in text	References at least one journal article or reliable Internet source	Understands relevance of new information and uses most recent reference search tools		CENG 412 – Lab Reports CENG 416 – Capstone Project
Test equipment		Sufficient knowledge so as not to get hurt or cause harm	Understands how to use equipment	Can measure novel features beyond what is asked		CENG 412 – Lab Reports CENG 416 – Capstone Project

4. Continuous Improvement

4.1. Process for Revising the Program to Meet Program Objectives

Our curriculum (Section 5) is based on our program objectives (Section 2). The program outcomes, assessment means, and metric goals (Section 3) determine the extent to which we achieve our program objectives.

Here we describe the process for improving our program in response to outcomes assessment in order to better achieve our program objectives.

1. The DUS analyzes outcomes results and initiates a proposal for a program revision if a metric goal is not satisfied, or if it seems likely that a particular program revision would help to better achieve our program objectives. Program revisions may include:
   - a change in course requirements for the degree
   - introduction of a new course
   - modification of an existing course
   - introduction of auxiliary processes to better achieve a program objective (e.g., Student-Faculty dinners)
2. Alternatively, one of the constituencies may initiate a proposal for a program revision based on their perception of a program outcome not being achieved.
3. The DUS and Program Chair discuss the outcome results and proposed program revision.
4. The proposal is iteratively developed as follows:
   - The DUS forwards a summary of the outcome results and the corresponding proposal to the faculty and students (and prospective majors) in the Program to solicit feedback.
   - The DUS revises the proposal accordingly and returns it to the faculty and students. The feedback loop is repeated as necessary/useful.
   - If one of the constituencies initiates the proposal (step 2), they are also included in the feedback loop.
5. The DUS and Program Chair discuss the revised proposal further to decide whether the revised proposal still seems useful.

6. If the outcome of the previous step is positive, the proposal is discussed among the Program Faculty to achieve a consensus, and a poll is taken.

   Program revisions require approval from the Course of Studies committee, which is usually granted without further modification. Major program revisions also require a majority vote by the Yale College Faculty (e.g. Section 2).

7. The *Guide to Undergraduate Studies in Engineering and Applied Science* and the *Yale College Programs of Study* are annually updated to incorporate revisions of the program curriculum.

4.2. Examples of Process for Revising Program to Meet Program Objectives

4.2.1. Course Revisions

The process described in Section 4.1 has lead to some significant course revisions since the 2002 ABET visit.

a) CENG 210: Principles of Chemical Engineering and Process Modeling

Fall Semester 2007

Interviews and discussions with students revealed CENG 210 to be an effective and well-taught introductory course providing a broad exposure to chemical engineering science, including conservation equations, thermodynamics, and chemical kinetics. However, students felt they lacked understanding of how these calculations relate to actual chemical processes.

Discussions between the DUS and Program Chair led to the development and testing of a revised course, taught by Professor Van Tassel. The goals of the course, some of which carried over from its previous version, were

- to provide an interesting introductory course available to Freshmen chemical engineers.
- to give students a broad exposure to chemical engineering science, including conservation equations, thermodynamics, and chemical kinetics.
- to introduce students to mathematical modeling of engineering problems, dimensional analysis, and scaling arguments.
- to provide students with a broad overview of modern chemical engineering, with an emphasis on nontraditional applications and emerging technologies.
- to introduce to students how chemical processes convert raw materials into products.
- to expose students to ways in which chemical engineers make decisions and balance constraints.

Feedback solicited from students in the trial course was positive. The Program Faculty discussed the revised curriculum and agreed to implement the course revisions permanently. The Course of Studies Committee approved the revisions.

b) CENG 412: Chemical Engineering Laboratory

Spring Semester 2008

Interviews and discussions with students revealed CENG 412 to be an effective laboratory experience. However, students felt that additional experiments might improve their ability to apply their engineering expertise to practical problems. In addition, previous ABET visitors suggested improving the course through a wider variety of experimental set-ups.

Discussions between the DUS, Chair, Prof. Altman, and Prof. Khalil led to the addition of a new experiment involving the teaching molecular beam epitaxy (MBE) system that is part of Yale's NSF Materials Research Science and Engineering Center (MRSEC). One of our undergraduate students, M.R. Padmore, worked extensively on the design, construction, and testing of the system. The lab sequences involving this tool focus on two-dimensional phase equilibria, crystal diffraction, vacuum technology, etc.

The goals of the course, some of which carried over from its previous version, were to provide the students exposure to

- designing and conducting an experimental procedure in a safe, efficient and environmentally-friendly manner,
- analyzing experimental data in order to understand the fundamentals involved in a particular process,
- analyzing processes involving both traditional chemical engineering fundamentals, such as fluid mechanics and process control, as well as other, nontraditional topics, such as electrophoresis and surface tension,
- working together in small groups to analyze data and
- preparing a comprehensive laboratory report presenting and discussing experimental results.

Feedback solicited from students to the revised course was positive. The Program Faculty discussed the revised curriculum and agreed to implement the course revisions permanently. The Course of Studies Committee approved the revisions.

4.2.2. Enhanced Support of Yale AIChE Student Chapter

A group of students approached the DUS in 2006 inquiring about the possibility of enhanced support of Yale's AIChE Student Chapter. Through discussions between the DUS and Chair, and later with other members of the Program Faculty, we decided to increase funding of AIChE related events. Prof. Khalil currently serves as Chapter Advisor, and over the past two years, a number of events -- including plant tours, job fairs, dinners, and guest speakers -- have been supported by the Department.

It is important to emphasize the important leadership roles the students have played in these events, from requesting enhanced support of Student Chapter activities to suggesting and planning the events themselves. AIChE Student Chapter activities have now become an important part of the student experience here at Yale.

4.2.3. Assessment via Alumni Survey

In order to further assess the Program's objectives, and the success of meeting the objectives, in Spring 2008 we sent the following questionnaire to alumni graduating for the Program from 2002 through 2008:

1. What year did you graduate, and what degree(s) did you earn?

2. What positions have you held, and/or what graduate/professional programs have you attended, since leaving Yale?

3. On a scale of 0 (poor) to 5 (excellent), how well do you feel your Yale education prepared you for your subsequent positions/programs?

4. On a scale of 0 (poor) to 5 (excellent), how well do you feel your Yale education helped you to develop …

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

5. Did you participate in a research project as an undergraduate at Yale?

6. Have you been licensed as a professional engineer?

7. Could you very briefly list what you feel to be the key strengths and weaknesses of our program?

We received 15 responses from our 30+ inquiries. Responses to question 2 are summarized in Table 4-1. We note that our graduates go on to graduate school, professional school, and industry in roughly equal numbers. Results to questions 3 and 4, where students are asked to rate various aspects of their Yale education, are shown in Table 4-2. All items scored above 3.0, indicating no significant dissatisfaction on the part of recent graduates. Concerning questions 5 and 6, 87%

of respondents indicated that they had participated in laboratory research while at Yale, while only 7% had become licensed engineers.

Table 4-1: Summary of responses to survey question 2. (Data augmented by DUS exit interview data.)

Position following graduation	Number of Students
Graduate School	9
Medical School	5
Law School	1
Industry	7
Consulting	1
Government	2
Other	1
None	1

Table 4-2: Average responses to survey questions 3 and 4.

Survey Question	Average Response (0-5)
3	4.25
4(a)	4.07
4(b)	3.64
4(c)	3.14
4(d)	3.93
4(e)	3.71
4(f)	3.67
4(g)	4.00
4(h)	4.07
4(i)	4.43
4(j)	3.71
4(k)	3.21

Based on these responses, the DUS and Chair conclude that we currently are meeting our metric goal set at the outset of the survey, that is, that our graduates should have successful starts to their careers, e.g. admission to a highly-ranked graduate engineering program and success in graduate course work and research, or a good position in industry with the ability to earn promotions. We conclude as well that our program objectives continue to serve our students well, in particular considering that the majority of students go on to graduate or professional school.

While no glaring curricular changes appear necessary, the DUS and Chair are concerned with the somewhat low scores to questions 4(c) and 4(k). Both of these questions touch upon the practical application of engineering skills. We feel the recently (Fall 2007) remade introduction course (CENG 210), which now seeks to introduce practical chemical processing problems at an early stage, may play a positive role in improving these scores. Similarly, the recently improved lab course (CENG 412) should also help raise these scores. Changes to both these courses are discussed above in Section 4.2.1. The Program Faculty plans to discuss possible further revisions during Fall 2008.

5. Curriculum

Our curriculum is principal means by which we achieve our program objectives (Section 2). The courses in our curriculum and their contributions to our program objectives are listed in Table 5-1. Table 5-2 shows the projection of our curriculum onto the three education groups: mathematics and basic sciences, engineering science, and general education. Also indicated are courses with significant design and experimental components. Table 5-3 shows our curriculum broken down semester-by-semester, and Table 5-4 gives recent enrollment data.

A Yale Baccalaureate degree requires 36 course credits. Semester courses are given one course credit each (with two notable exceptions).[1] As shown in Table 5-3, our curriculum involves 13 semester courses of mathematics and basic science, 14 semester courses of engineering science, and 12 semester courses of general education. We note that our program exceeds the minimum values required for accreditation: 9 semester courses of mathematics and basic science and 13.5 semester courses of engineering science.

5.1. Core Courses

1. Principles of Chemical Engineering and Process Modeling (CENG 210)
Program objectives: 1(a),(b),(c),(d);2(b)(c);3(c).

This newly revised course provides a broad overview of modern chemical engineering, including nontraditional applications and emerging technologies. Topics include material and energy balances, process flow calculations, the transport and reaction of chemical species, the interpretation of laboratory experiments, mathematical modeling, and dimensional analysis. Students are required to do research into new processes and technologies and to critically evaluate their sources (e.g., internet). Students learn the core concepts underlying chemical engineering processes, including thermodynamics, conservation equations, and chemical kinetics. Interactive demonstrations are used to illustrate concepts and stimulate cooperative learning.

2. Chemical Engineering Thermodynamics (CENG 300)
Program objectives: 1(a),(b),(c),(d);2(c).

This recently redesigned course provides a rigorous introduction to equilibrium systems. Students learn to use general approaches for system analysis and problem solving. Fundamental concepts are emphasized but students are also required to solve practical engineering problems, and learn more-advanced topics such as critical phenomena and non-equilibrium thermodynamics.

[1] The two notable exceptions are: General Chemistry Laboratory (CHEM 116 L) which is ½ credit/semester, and foreign language courses which are ½ credits/semester.

Courses				Program Objectives										
				1				2			3			
Chemical Engineering Core			Credits	a	b	c	d	a	b	c	a	b	c	d
1	Princ. of Chem. Eng.	CENG 210	1	•	•	•	•		•	•			•	
2	Chem. Eng. Thermo.	CENG 300	1	•	•	•	•			•				
3	Kinetics & Reactors	CENG 301	1	•	•	•	•			•				
4	Transport Phenomena	CENG 315	1	•	•	•	•			•				
5	Fluid Mechanics	MENG 361	1	•	•	•	•			•				
6	Separation Processes	CENG 411	1	•	•	•	•	•	•	•				
7	Chem. Eng. Lab	CENG 412	1	•	•	•			•	•	•		•	
8	Process Design	CENG 416	1		•	•		•	•	•	•	•	•	•
9	Process Control	CENG 480	1	•	•		•	•		•	•			
Technical Electives														
10	Eng. Math Elective	MATH 222, others	1	•	•		•			•				
11	Eng. Electives		2	•	•	•	•			•				
Engineering Science														
12	Differential Eqs.	ENAS 194	1	•	•		•			•				
14	Organic Chem. I, II	CHEM 220 or 225, 221 or 227	2	•	•		•			•				
15	Phys. Chem. I, II	CHEM 332, 333	2	•	•		•			•				
16	Phys. Chem. Lab I	CHEM 331	1	•	•		•			•	•			
Prerequisites														
13	Intro. Computing	ENAS 130	1		•		•			•				
17	Gen. Chem. I, II	CHEM 114	2	•										
18	Gen. Chem. Lab	CHEM 116L	1	•										
19	Adv. Gen. Phys. I, II	PHYS 180, 181	2	•	•		•			•				
20	Calculus I, II, III	MATH 112, 115; Math 120 or ENAS 151	3	•										
General Education														
21	Distribution and Foreign Language		12						•	•	•	•	•	•
Miscellaneous														
Undergraduate Research				•	•	•	•	•		•	•		•	
Extracurricular Activities											•	•	•	•

Table 5-1: Program curriculum along with contributions to program objectives.

			Mathematics, Basic Science	Engineering Science	General Education	Engineering Design	Laboratory Experiments
Chemical Engineering Core							
1	Princ. of Chem. Eng.	CENG 210		1			
2	Chem. Eng. Thermo.	CENG 300		1			
3	Kinetics & Reactors	CENG 301		1			
4	Transport Phenomena	CENG 315		1			
5	Fluid Mechanics	MENG 361		1			
6	Separation Processes	CENG 411		1		•	
7	Chem. Eng. Lab	CENG 412		1			•
8	Process Design	CENG 416		1		•	
9	Process Control	CENG 480		1		•	
Technical Electives							
10	Eng. Math Elective	MATH 222, others		1			
11	Eng. Electives			2			
Engineering Science							
12	Differential Eqs.	ENAS 194		1			
14	Organic Chem. I, II	CHEM 220 or 225, 221 or 227	2				
15	Phys. Chem. I, II	CHEM 332, 333	2				
16	Phys. Chem. Lab I	CHEM 331	1				•
Prerequisites							
13	Intro. Computing	ENAS 130		1			
17	Gen. Chem. I, II	CHEM 114	2				
18	Gen. Chem Lab	CHEM 116L	1				•
19	Adv. Gen. Phys. I, II	PHYS 180, 181	2				
20	Calculus I, II, III	MATH 112, 115; MATH 120 or ENAS 151	3				
General Education							
21	Distribution and Foreign Language				12		
Total			13	14	12		

Table 5-2: Projection of curriculum onto the three educational groups. Courses with significant design and experimental components are indicated.

Table 5-3 Curriculum

Chemical Engineering (2008 – current)

Year; Semester	Course (Department, Number, Title)	Category (Courses) Math & Basic Sciences	Engineering Topics *Check if Contains Significant Design (✓)*	General Education	Other
Freshman Fall	MATH 112, Calculus I	1	( )		
	CHEM 114, General Chemistry	1	( )		
	CHEM 116L, Gen. Chemistry Lab	1/2	( )		
	Humanities/Social Science Electives		( )	2	
Freshman Spring	MATH 115, Calculus II	1	( )		
	CHEM 114, General Chemistry	1	( )		
	CHEM 116L, Gen. Chemistry Lab	1/2	( )		
	ENAS 130, Introduction to Computing		1 ( )		
	Humanities/Social Science Elective		( )	1	
Sophomore Fall	MATH 120 or ENAS 151, Multivariable Calculus	1	( )		
	CHEM 220 or 225, Organic Chemistry I	1	( )		
	PHYS 180, Advanced General Physics I	1	( )		
	CENG 210, Princ. of Chemical Engineering		1 ( )		
	Humanities/Social Science Elective		( )	1	
Sophomore Spring	ENAS 194, Differential Equations		1 ( )		
	CHEM 221 or 227, Organic Chemistry II	1	( )		
	PHYS 181, Advanced General Physics II	1			
	Humanities/Social Science Electives		( )	2	
Junior Fall	CHEM 332, Physical Chemistry I	1	( )		
	CHEM 331, Physical Chemistry Lab	1	( )		
	CENG 300, Thermodynamics		1 ( )		
	MENG 361, Fluid Mechanics		1 ( )		
	Humanities/Social Science Elective		( )	1	
Junior Spring	CHEM 333, Physical Chemistry II	1	( )		
	CENG 301, Kinetics and Reactors		1 ( )		
	CENG 315, Transport		1 ( )		
	Humanities/Social Science Electives		( )	2	
Senior Fall	Engineering Math Elective		1 ( )		
	CENG 411, Separation Processes		1 (✓)		
	CENG 480, Process Control		1 (✓)		
	Engineering Elective		1 ( )		
	Humanities/Social Science Elective		( )	1	
Senior Spring	Engineering Elective		1 ( )		
	CENG 412, Chemical Engineering Lab		1 ( )		
	CENG 416, Process Design		1 (✓)		
	Humanities/Social Science Electives		( )	2	

		Math & Basic Sciences	Engineering Topics	General Education	Other
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		13	14	12	
OVERALL TOTAL FOR DEGREE	39 courses				
PERCENT OF TOTAL		33%	36%	31%	
Totals must satisfy one set	Minimum semester courses	9	13.5		
	Minimum percentage	25%	37.5 %		

Table 5-4. Course and Section Size Summary

Department of Chemical Engineering

Course No.	Title	Responsible Faculty Member	No. of Sections Offered in Current Year	Avg. Section Enrollment (2006)	Lecture	Laboratory	Other
CENG 120	Intro. to Environmental Engineering	Jordan Peccia	1	22	100%		
CENG 210	Principles of Chemical Engineering and Process Modeling	Paul Van Tassel	1	16	100%		
CENG 300	Chemical Engineering Thermodynamics	Chinedum Osuji	1	12	100%		
CENG 301	Kinetics and Chemical Reactors	Lisa Pfefferle	1	12	100%		
CENG 315	Transport Phenomena	Michael Loewenberg	1	10	100%		
CENG 351	Biomedical Engineering I: Quantitative Physiology	Tarek Fahmy	1	24	100%		
CENG 373	Air Polution Control	Lisa Pfefferle	1	2	100%		
CENG 377	Water Quality Control	William Mitch	1	4	100%		
CENG 411	Separation and Purification Processes	Yehia Khalil	1	4	100%		
CENG 412	Chemical Engineering Laboratory	Yehia Khalil	1	4		100%	
CENG 416	Chemical Engineering Process Design	Yehia Khalil	1	4	20%		80%
CENG 480	Chemical Engineering Process Control	Eric Altman	1	4	100%		
CENG 490	Senior Research Project	Michael Loewenberg	2	0			100%

3. Chemical Kinetics and Chemical Reactors (CENG 301)
Program objectives: 1(a),(b),(c),(d);2(c).

Students learn physical-chemical principles and mathematical modeling of chemical reactors. Topics include homogeneous and heterogeneous reaction kinetics, catalytic reactions, systems of coupled reactions, selectivity and yield, chemical reactions with coupled mass transport, non-isothermal systems, and reactor design. Applications are drawn from problems in environmental, biomedical, and materials engineering.

4. Energy, Mass, and Momentum Transport (CENG 315)
Program objectives: 1(a),(b),(c),(d);2(c)..

Students learn the general form of conservation equations, constitutive equations, and boundary conditions based on conservation laws and local equilibrium. Students learn to apply scaling arguments, dimensional analysis, and a variety of advanced mathematical techniques (e.g., asymptotic analyses) to problems involving diffusive and convective transport in reacting and non-reacting systems.

5. Mechanical Engineering II: Fluid Mechanics (MENG 361)
Program objectives: 1(a),(b),(c),(d);2(c).

Students learn the fundamental equations of fluid mechanics, and how to apply them to engineering problems. Students are taught to use techniques, skills, and modern engineering tools.

6. Separation Processes (CENG 411)
Program objectives: 1(a),(b),(c)(d);2(a),(b),(c).

Students learn the theory and design of separation and purification processes for multicomponent and/or multiphase mixtures via equilibrium and rate phenomena, and how to select the most suitable separation process for a particular design application. A wide range of chemical engineering systems, as well as applications to environmental and biomedical engineering, food processing, and semiconductor processing, are included. Students learn analytical, numerical, and graphical solution techniques.

7. Chemical Engineering Laboratory (CENG 412)
Program objectives: 1(a),(b),(c);2(b),(c);3(a),(c).

Students gain experience with data acquisition and analysis of the chemical engineering systems introduced in the lecture courses of our program. Students learn how to plan and conduct experiments as part of a team in a safe and environmentally friendly manner. The connection between experimental observations and measurements and mathematical modeling is emphasized.

The newly revised course includes a new experiment involving the teaching molecular beam epitaxy (MBE) system that is part of Yale's NSF Materials Research Science and Engineering Center (MRSEC).

8. Chemical Engineering Process Design (CENG 416)
Program objectives: 1(b),(c);2(a),(b),(c);3(a),(b),(c),(d).

Students learn how to design chemical processes and plants, applying the principles of chemical engineering and economics. Emphasis is on flow-sheet development and equipment selection, cost estimation and economic analysis, design strategy and optimization, safety and hazards analysis, and environmental and ethical considerations.

Students work in teams to complete a design project, including a written report. Each team also gives a 30-45 minute presentation (with a question and answer session) on their project to an audience consisting of chemical engineering majors, program faculty, and visitors from local industries.

9. Chemical Engineering Process Control (CENG 480)
Program objectives: 1(a),(b),(d);2(a),(c);3(a).

Students learn modeling and simulations of chemical process dynamics. Students in the course are required to complete a design project.

Course		Students
Linear Algebra with Applications	MATH 222	21
Linear Algebra and Matrix Theory	MATH 225	4
Ordinary Differential Equations	MATH 246	3
Optimization I	OPRS 235	2
Introductory Data Analysis	MATH 235	1
Discrete Mathematics	MATH 244	1
Applied Numerical Methods	MENG 440	1

Table 5-5: Breakdown of mathematics electives, 2002-2008

5.2. Technical Electives

1. Mathematics elective
Program objectives: 1(a),(b),(d);2(c).

Advanced mathematics course are chosen in consultation with the DUS. The breakdown of mathematics electives taken by our students is displayed in Table 5-5.

2. Engineering Electives
Program objectives: 1(a),(b),(c),(d);2(c)

Two Engineering or Science courses are chosen in consultation with the DUS. Frequently selected courses include:

- Biomedical Engineering I: Quantitative Physiology (CENG/BENG 351)
- Air Pollution Control (CENG/ENVE 373)
- Water Quality Control (CENG/ENVE 377)
- Science and Public Policy
- Professional Ethics (ENAS 335)
- Independent Research (CENG 471)

5.3. Prerequisite Courses

Students with strong Advanced Placement Test scores in calculus or chemistry may skip prerequisite mathematics or chemistry courses by enrolling in advanced-level courses (e.g., MATH 120, ENAS 194; CHEM 220, 331, 332.

All chemical engineering majors must pass the prerequisite physics sequence (PHYS 180, 181) or a higher-level sequence.

5.4. Distribution Requirement

Program objectives: 2(b),(c);3(a),(b),(c),(d).

For the purpose of distribution in Yale College, courses are classified into four groups according to the following general scheme:

I. Language and literature, English and foreign, ancient or modern.
II. Architecture; art; classical civilization; film; history; history of art; history of science, history of medicine; humanities; music; philosophy; religious studies.
III. Anthropology; archeology; economics; linguistics; political science; psychology; sociology.
IV. Astronomy; biology; chemistry; computer science; engineering; forestry and environmental studies; geology and geophysics; mathematics; molecular biophysics and biochemistry; physics; statistics.

For a bachelor’s degree, students must complete at least 12 course credits drawn from outside the distributional group that includes the major. Thus, chemical engineering majors must complete 12 courses from Groups I, II, and III.

A diverse selection of courses in required: there can be no more than 4 course credits from a single department and no more than 6 course credits from a single distribution Group.

Aside from this constraint, chemical engineering majors may select the courses they wish according to their particular interests and goals in order to meet the distribution requirement. We monitor the courses selected and course grades earned by our chemical engineering majors in order to assess the fulfillment of our program objectives.

5.5. Foreign Language Requirement

Program objectives: 3(a),(b),(c),(d).

Students are required to demonstrate competence at the intermediate level in a foreign language before graduation, preferably by the end of the Junior year. This requirement may be met by passing intermediate courses in a foreign language at Yale or by passing an examination (see introductory statements of foreign language departments in *Yale College Programs of Study*). Languages offered at Yale include: Arabic, Chinese, Czech, ancient Egyptian, French, German, classical Greek, Hebrew, Indonesian, Italian, Japanese, Swahili, Korean, Latin, Persian, Polish, Portuguese, Russian, Spanish, Ukrainian, Vietnamese, Yoruba, and Zulu.

5.6. Undergraduate Research

Program objectives: 1(a),(b),(c),(d);2(a),(b),(c);3(a),(c).

We encourage our students to participate in research in preparation for graduate school or careers in industry (can be a design project). Approximately 80% of our students get involved in undergraduate research either for course credit (CENG 471) for their engineering electives, or for part-time employment.

Some of our students become involved in longer-term projects and contribute significantly to a research problem, and give a conference presentation at a national meeting or co-author a peer-reviewed journal article on their research. Occasionally, we provide support for seniors to attend the AIChE Annual Meeting, where they are exposed to the broad range of research activities in chemical engineering.

5.7. Extracurricular Activities

Program objectives: 3(a),(b),(c),(d).

Many of our students have well-developed interests outside of chemical engineering. We recognize the importance of these interests for the well being of our students and the contribution of extracurricular interests to program objective 3. To the extent possible, we accommodate our students' extracurricular interests through revised course scheduling, etc.

6. Faculty

The Dept. of Chemical Engineering at Yale consists of 15 full-time faculty members and 4 adjunct faculty members (see Table 6-2). We cover a broad range of expertise, including reaction engineering, catalysis, transport phenomena, colloid and interfacial phenomena, surface science, nanomaterials, biomaterials, polymers, fuel cells, and biomolecular engineering. A common thread among our research efforts is a focus on processes at interfaces.

The teaching workload for the 2007-2008 academic year is shown in Table 6-1. Most of the faculty have taught three or more of the core courses in the past, giving us considerable flexibility. Among core courses, Profs. Haller, Pfefferle, Taylor, and Van Tassel teach the introductory course; Profs. Haller, Pfefferle, and Altman teach chemical kinetics and reactions; Profs. Elimelech, Loewenberg, Pfefferle, and Rosner teach transport; Prof. Khalil teaches process design, the chemical engineering laboratory, and separations; Prof. Altman teaches control; and Profs. Loewenberg, Osuji, and Van Tassel teach thermodynamics.

Our faculty is primarily composed of experimentalists, although Loewenberg is a theoretician/numerical analyst and Profs. Wilson, Rosner, and Van Tassel combine various levels of modeling with their experimental activities. Our diversity of skills allows fruitful collaboration on course development.

Chemical Engineering majors at Yale benefit greatly from course offerings in both Biomedical Engineering (BME) and Environmental Engineering (EnvE). BME gained departmental status Fall 2003, and many of their core faculty have training in chemical engineering. BME course offerings serve to expand educational opportunities for chemical engineering students, and make them aware of important and exciting new applications of chemical engineering techniques to biomedical problems. EnvE is a program whose core faculty members -- Profs. Elimelech, Peccia, Mitch, and Zimmerman -- are housed within our department. These faculty members typically teach courses for the EnvE majors, which provide attractive electives for the chemical engineering students. In addition, Prof. Elimelech has expertise in transport phenomena in aquatic systems and occasionally teaches our core transport course.

We are fortunate to have faculty members possessing significant industrial experience (Khalil, Rosner, Pfefferle) and who actively engage in consulting (Haller). These experiences serve to keep our students in touch with “real world” chemical engineering problems. The focus of our program, however, continues to be preparing students for graduate and professional school. Our surveys and discussions with recent students suggest a large majority of Yale chemical engineers end up enrolling in graduate or professional schools. (Even those who take an industrial job immediately after graduation often leave to attend graduate school within a few years.) These results justify our practice of having nearly every student carry out research in one of our laboratories during their academic careers.

Finally, we note with sadness the passing of our dear colleague and valued friend, Csaba Horvath, in 2004. Credited as one of the pioneers of high-pressure liquid chromatography, Prof. Horvath’s scholarly legacy lives on through his many former students in industry and academia.

Table 6-1: Faculty Workload Summary
(Chemical Engineering)

Faculty Member	FT or PT	Classes Taught (Course No./Credit Hrs.) 2007-08 Academic Year	Total Activity Distribution[2]		
			Teaching	Research	Other[3**]
Eric Altman	FT	Chemical Engineering Process Control - CENG 480a	25	50	25
Menachem Elimelech	FT	EnvE courses	25	50	25
Gary Haller	FT	Master of JE College; on sabbatical leave	25	25	50
Yehia Khalil	PT	Separation and Purification Processes - CENG 411a Chemical Engineering Laboratory - CENG 412b Chemical Engineering Process Design - CENG 416b	20		80
Michael Loewenberg	FT	Transport Phenomena - CENG 315b	25	50	25
William Mitch	FT	Water Quality Control - CENG 377b	25	50	25
Chinedum Osuji	FT	Chemical Engineering Thermodynamics - CENG 300a	25	50	25
Jordan Peccia	FT	Introduction to Environmental Engineering - CENG 120a	25	50	25
Lisa Pfefferle	PT	Air Pollution Control - CENG/ENVE 373a Chemical Kinetics and Chemical Reactors - CENG 301b	25	50	25
Daniel Rosner	FT	Graduate course plus sabbatical leave	25	50	25
T. Kyle Vanderlick	FT	Dean of Engineering	0	20	80
Paul Van Tassel	FT	Principles of Chemical Engineering and Process Modeling - CENG 210a	25	50	25

1. Indicate Term and Year for which data apply.
2. Activity distribution should be in percent of effort. Members' activities should total 100%.
3. Indicate sabbatical leave, etc., under "Other." **"Other" also includes administrative duties
4. All one credit courses

Table 6-2: Faculty Analysis
(Chemical Engineering)

Name	Rank	FT or PT	Highest Degree	Institution/Year of Highest Degree	Years of Experience			Professional Registration	Level of Activity (high, med, low, none) in:		
					Govt./Ind Practice	Total Faculty	This Institution		Professional Society	Research	Consulting/ Summer Work in Industry
Eric Altman	Prof.	FT	Ph.D.	University of Pennsylvania, 1988	5	14	14		Medium	High	Low
Menachem Elimelech Dept. Chair	Prof.	FT	Ph.D.	The Johns Hopkins University, 1989	0	19	10		High	High	Low
Abbas Firoozabadi	Adj. Prof.	PT	Ph.D.	Illinois Institute of Technology, 1974	28	23	7		Medium	High	High
Gary Haller	Prof.	FT	Ph.D.	Northwestern University, 1963	0	40	40		Medium	High	Low
Yehia Khalil	Adj. Prof.	PT	Ph.D.	University of Conneecticut, 1992	22	16	16		Medium	Low	High
Michael Loewenberg	Prof.	FT	Ph.D.	California Institute of Technology, 1988	0	14	14		Medium	High	Low
Jodie Lutkenhaus	Assist. Prof.	FT	Ph.D.	MIT, 2007	0	0	0		Medium	High	Low
Robert McGraw	Adj. Prof.	PT	Ph.D.	University of Chicago, 1979	17	3	3		Medium	High	Low
William Mitch	Assoc. Prof.	FT	Ph.D.	U California at Berkeley, 2003	4	5	5		Medium	High	Low
Chinedum Osuji	Assist. Prof.	FT	Ph.D.	MIT, 2003	3	1	1		Medium	High	Low
Jordan Peccia	Assoc. Prof.	FT	Ph.D.	University of Colorado, 2000	3	7	3	P.E.	Medium	High	Low
Lisa Pfefferle	Prof.	FT	Ph.D.	University of Pennsylvania, 1984	3	24	24		Medium	High	Medium
Joseph Pignatello	Adj. Prof.	PT	Ph.D.	U California at Berkeley, 1977	24	13	9		Medium	High	Low
Daniel Rosner	Prof.	FT	Ph.D.	Princeton University, 1961	11	39	39		Medium	High	High
Andre Taylor	Assist. Prof.	FT	Ph.D.	University of Michigan, 2005	4	1	0		Medium	High	Low
T. Kyle Vanderlick Dean of Engineering	Prof.	FT	Ph.D.	University of Minnesota, 1988	1	19	1		Low	Medium	Low
Paul Van Tassel	Prof.	FT	Ph.D.	University of Minnesota, 1993	0	12	6		Medium	High	Low
Corey Wilson	Assist. Prof.	FT	Ph.D.	Rice University, 2005	0	0	0		Medium	High	Low
Julie Zimmerman	Assist. Prof.	FT	Ph.D.	University of Michigan, 2003	3	3	2		Medium	High	Low

6.1. Educational Background

The educational backgrounds of our faculty are summarized in Table 6-2 and detailed via individual CV (Appendix B). All of the faculty members hold PhD degrees.

6.2. Experience: Teaching, Engineering

Our faculty is highly experienced with significant teaching experience as summarized in Table 6-2. Most have taught at least three of the core undergraduate courses, providing needed flexibility given Yale's triennial and junior faculty leave policies, and serving to keep a fresh teaching perspective. With a few exceptions, courses are rotated among faculty at least every three years.

6.3. Diversity of Background

Our faculty comes from a variety of educational backgrounds including training in chemistry, chemical engineering, environmental engineering, mathematics, and mechanical engineering. Training includes work in industrial settings, academic and governmental research laboratories, and medical (hospital) research settings. Our diverse backgrounds serve us well in bringing different perspectives and problem solving tools.

6.3.1. Faculty Interaction with Students

Our small student to faculty ratio provides the opportunity for significant interaction with undergraduate students. For example, nearly all of the undergraduates carry out research projects in faculty laboratories. Some do this as a formal course elective but others work in labs for up to three years as part of their work-study program.

We also have frequent informal contacts with the students as a group. For example, about once per semester, we host a dinner for all chemical engineering majors. Typically, about 3 to 4 faculty attend these dinners. In addition, the New Haven AIChE Student Section also hosts a dinner every year or so. These meetings are invaluable for providing feedback on courses, graduate teaching assistants, and general questions about chemical engineering as a career.

Prof. Loewenberg has been very effective and innovative in his role as the Director of Undergraduate Studies (DUS) in Chemical Engineering over the period 1996-2008. He has taken the initiative and made considerable effort to improve our educational program to better meet the needs of our students. He has interacted closely with our students, actively engaging them in the process of assessing and revising our program. His accomplishments include restructuring our curriculum by revising our courses and introducing new courses, revising our degree requirements, and identifying educational objectives for the department that closely reflect the goals of our students. Prof. Van Tassel seeks to build on this legacy as he begins his tenure as DUS in Fall 2008.

6.3.2. Academic Advising

Our academic advising is coordinated by the DUS. He actively promotes our students and effectively coaches them with graduate school preparation: the majority of our graduates pursue a PhD at a top-10-ranked graduate school, and perform very competitively once in graduate school.

To further expose our students at the national level, the department typically provides funds to send all seniors to the AIChE Annual Meeting. Undergraduate students typically attend research group meetings and give presentations.

Our informal advising has been greatly enhanced through the department dinners. A typical dinner will involve over half of the chemical engineering majors, giving students the chance to chat with faculty and classmates about our program, career goals, and other interests.

Freshman advising is organized by the residential colleges. Nearly the entire faculty participates by meeting students and approving their schedules.

6.4. Individual Competencies

Given below are examples of the work of individual faculty members in achieving our student teaching and advising goals.

6.4.1. Ability to interact with students

Our faculty are all actively involved in undergraduate research. A large fraction (over 75%) of our students do at least one project with our faculty. Several examples of current projects and the faculty involved are discussed here. Further documentation and project reports are available with the course folders.

- Chris VanLang, a 2008 graduate, worked with Prof. Van Tassel on the interfacial adsorption kinetics of charged polymers under an applied electric potential. Together they have discovered a mechanism of polymer-polymer binding plus charge regulation to account for unusually rapid long-time kinetics. Chris will enroll at Stanford University in Fall 2008 to pursue a PhD in chemical engineering.

- Diana Liao, a 2007 graduate, worked with Prof. Altman on designing a new thermal desorption system as well as on a project focused on determining if surface chemical properties of ferroelectric materials could be switched by reversing the polarization. She did much of the early experimental work on this project and showed that there is a substantial effect and for her efforts was credited as co-author of two papers - Y. Yun, L. Kampschulte, D. Liao, M. Li and E.I. Altman, "Journal of Physical Chemistry C **111** (2007) 13951; Y. Yun, M. Li, D. Liao, L. Kampschulte and E.I. Altman, Surface Science **601** (2007) 4636.

- Dorrell McCallman, a 2007 graduate, worked with Prof. Loewenberg on numerical analyses of the capture of rods by rising bubbles. Together, they developed a computational formalism, based on conservation equations, for predicting the trajectories of rods in the presence of a rising bubble or drop.

- Andrew Brannon, who will graduate in 2009, conducted research with Prof. Osuji to design microfluidic devices for use in characterizing the mechanical properties of vesicles. Liposomes subjected to osmotic pressure shocks dilate or contract in a manner that is dependent on their membrane rigidity and their internal salt concentration, spurring the development of a microfluidic assay. Andrew is currently pursuing an internship with BASF in the summer and will return to Yale in Fall 2008 for his senior year.

Prof. Haller continues to serve as Master of Jonathan Edwards College. In this capacity, he is social host for the students and organizes many fun and intellectually stimulating activities. He is a role model for our students in being able to juggle many roles and having broad ranging interests.

6.4.2 Enthusiasm for developing a more effective program

Our department is continually striving to improve the effectiveness of our undergraduate program. As discussed earlier, we have made significant changes to our undergraduate curriculum based on discussions with the students.

Prof. Rosner has recently contributed two articles to Chemical Engineering Education based on course development work. The subject was "Combustion Synthesis and Materials Processing." A follow-up article focused on problems for undergraduates.

Prof. Haller, as Master of Jonathan Edwards College, uses this venue to expose undergraduates in all departments to engineering sensibilities. He has hosted several events with topics of Chemical Engineering interest (Sylvia Ceyers was a recent guest) but even non-science guests provide opportunities for "engineering attitude" education. It should be noted that although eligible for relief from undergraduate teaching, he chooses to teach.

6.4.3. Level of scholarship, development participation in professional societies, registration/licensure as professional engineers

We maintain a high level of scholarship in our academic research. A recent ISI study named Yale Engineering first in their citation impact category. Two of our faculty members were recently elected to the National Academy of Engineering (Horvath in 2004, Elimelech in 2006). Detailed information is given in the faculty CVs.

The opportunities for faculty development at Yale are abundant. Every 6^{th} term, faculty members are allowed a one-semester academic leave, often used to develop new skills and courses.

Our faculty members are active in various professional societies. Prof. Loewenberg served as Chair of AIChE Fluid Mechanics Programming Committee from 2002-2004, and has chaired session at the AIChE Annual Meeting during most years. Prof. Altman has been serving as Secretary of the New England Catalysis Society for the last year, and for the last two years, has been on the executive committee of the Nanoscale Science and Technology Division of AVS. He has have chaired sessions at recent AVS, ACS and North American Catalysis Society Conferences. Prof. Khalil serves as faculty advisor for Yale AIChE Student Chapter and has been active in inviting speakers and taking students on field trips and to seminars on. He is also the Chairman of the American Nuclear Society (ANS), CT Section, serves as a Technical Expert on the Hydrogen Technology Committee of the National Fire Protection Association (NFPA), and is Chairman of the Technical Committee on Safety and Security for the American Society of Mechanical Engineers (ASME). Prof. Van Tassel serves on the Executive Committee of the American Chemical Society Division of Colloid and Surface Chemistry, and typically chairs at least one session at the AIChE Annual Meeting.

7. Facilities

In this section we describe the facilities that support our undergraduate engineering program. Our undergraduates are expected to use most of the facilities described below in meeting the requirements of the Program.

7.1. Classrooms

Yale College maintains classrooms throughout the campus to which the School of Engineering and Applied Science has access as needed. Classrooms in which the Engineering has direct control include two 20-seat classrooms (Becton 408 and 508) and one 20-seat seminar room (Mason 107). Classrooms located in Engineering Buildings include a 260-seat auditorium (Davies Auditorium), two 50-seat rooms (Mason 211 and Dunham 220), and four 20-seat classrooms (Becton 102 and 104, Mason 104 and Dunham 102). Several of these classrooms are permanently equipped with audio/visual equipment (*i.e.*, computer projectors), however portable equipment can also be obtained from the Engineering offices.

7.2. Laboratory Facilities

Chemical Engineering maintains a dedicated 1,000 sq. ft. undergraduate teaching laboratory in the 1st floor of Mason Laboratory (9 Hillhouse Avenue). The laboratory has five functional experiments, including a fluid mechanics experiment analyzing jet flows and vortices, a heat transfer experiment on radial and unsteady heat conduction, a packed bed experiment analyzing ammonia absorption, a heterogeneous catalysis experiment on acid-catalyzed hydrolysis of ethyl acetate, and a molecular beam epitaxy experiment on the growth of $SrTiO_3$ on a Si substrate. In the packed bed experiment, the cooling water flow rate is controlled by a PI controller to illustrate the fundamentals of process control. Further details on lab equipment can be found in Appendix C.

7.3. Machine Shop Facilities

The Engineering Machine Shop, located in the basement of Mason Laboratory, is accessible to undergraduate students. The shop contains Bridgeport milling machines with numerical readouts, lathes, band saws, and drills. The shop is staffed full-time by a trained machinist to help students with their designs and with the use of the machines.

7.4. Computer Facilities

The computing resources are adequate to support the Program. In addition to computers located in Engineering's Dunham Laboratory building, maintained computer clusters are located throughout the campus, at central locations and in residential colleges. A local computer cluster contains software packages that support engineering education. Faculty who teach a course requiring specific software need only request a license from Information Technology Services (ITS) and it will be obtained. More students are using their own laptops, and to accommodate these students, wireless networks are almost universally accessible throughout Yale.

One challenge for our computer systems is to provide a diverse collection of Engineering-relevant computers and software at a reasonable cost and with reasonable support demands. There is a tension between fully capable "professional" software and simplified student-friendly "consumer" software. On one hand, students should graduate with exposure to professional tools, but they should not spend excessive time mastering software details at the expense of fundamental education. We steer a middle course.

Most of our facilities are operated on a "do-it-yourself" basis, with only occasional staff assistance. Staff members are generally not able to provide higher level applications assistance. Either faculty or teaching assistants now must fill this role, despite the fact that many would-be faculty and TA's do not have full proficiency with the tools. We continue to look for ways to increase the available expertise to support teaching applications, both for students who are trying to learn and for faculty who are developing new curricula or demonstrations.

7.5. Library

The Engineering & Applied Science Library is a full service facility located within Yale's Engineering community. Engineering students and faculty also may take advantage of a wide range of library resources and services provided by the 22 campus libraries and 600 staff comprising one of the largest library collections in the world.

The Engineering Library is a dynamic collection supporting research and teaching in engineering and computer science. However, nn recent years, student and faculty library use has tended to be done over the internet. The library now provides online access to thousands of databases and full text journals.

The librarian consults with faculty and students about collection resources and provides the opportunity for input concerning the development of the collection. Materials are purchased based on profiles of program interests, faculty and student requests, and objective criteria including circulation statistics for similar items already in the collection. Journal subscriptions are added according to faculty research and teaching requirements, and canceled based on consultation.

8. Institutional Support and Financial Resources

8.1. Level and Adequacy of Institutional Support

Yale University provides information systems, facilities and financial support. Information systems include the campus computer network and computer support (email, backup, student clusters throughout campus). Facilities include classrooms, library and other study spaces, as well as space for student organizations, and residential colleges. We believe this support to be sufficient to accomplish the program objectives and assure continuity of the Programs. Office of Career Services maintains contact with recruiters and provides career counseling and assists students with establishing contacts with potential employers.

8.2. Level and Adequacy of Financial Resources

Yale University provides a general appropriation funds for our operations. During the year 2007-08, the School of Engineering and Applied Science received $918,336 for operations, $82,356 for travel, $483,946 for equipment, and $405,587 for teaching assistants. These funds are then apportioned based on the needs of the individual programs. Additional funds are made available from discretionary funds from within each department. Further details can be found in Table D-3. We believe the financial resources to be sufficient to accomplish the program objectives and assure continuity of the Programs.

8.3. Constructive Leadership

Yale University has shown strong and increasing support of its Engineering Programs. In the late 1990's, the position of Dean of the Faculty of Engineering was created and in 2000, a $500 million commitment to support science and engineering was announced. In 2008, we became the School of Engineering and Applied Science. The Engineering Programs have improved the relationship with Yale Admissions Office in order to balance our needs for recruiting qualified engineering students with those of Yale College.

8.4. Faculty Professional Development

Each new faculty is provided with a start-up package from the Office of the Provost sufficient to allow them establish their laboratory and research program. Faculty members are also provided with cost-matching support that can be used to purchase additional major equipment through such programs as the NSF Major Research Instrumentation Program. Funds for travel assistance for the faculty and graduate students can also be obtained through the Office of the Provost or the Yale Graduate School.

All incoming chemical engineering graduate students receive a university fellowship during their first year that covers their tuition, stipend, and health care. Additional student support beyond this period can be obtained from the Engineering and Applied Science Director of Graduate Studies on an as-needed basis.

Beginning faculty members are typically provided either a complete or partial release form teaching duties during their first semester to allow them to develop their research program. The typical teaching load after that period is one course per semester.

Ample sabbatical leaves are provided. Full professors are eligible for triennial, one-semester leaves at full salary. Through the new Tenure and Appointments Policy effective July 1, 2007, assistant professors are eligible a one-year paid leave during years 2-4 of their initial appointment, and associate professor are eligible for a one-year paid leave in years 1-2 following their promotion.

Yale University has substantial resources available to assist faculty in teaching and course development. For example, the Paul Moore Memorial Fund provides grants ranging from $1,000 to $6,000 to support the development of new methods and materials for the reorganization of important basic courses or the development of new approaches for the effective use of teaching assistants. The Information and Technology Services (ITS) program at Yale provides support to faculty interested in using advanced computer technologies in their courses, as might could include posting assignments on web sites, developing electronic discussion groups, or using computer-based video projections during lectures. Finally, the Yale Center for Media Initiatives (CMI) funds and develops substantial faculty-based media projects toward the goal of improving teaching and learning. Funding for CMI projects consists of grants worth up to $50,000 in direct expense support.

8.5. Support Personnel

Support personnel include

- Technical support:
  - Director of Information Technology Services (Philip Long)
  - Computer support specialist (Lieyang Xhou)
  - Student computing assistants
  - Morse Teaching Lab (Edward Jackson)
  - Engineering Design Advisor (Glen Weston-Murphy)
  - Student Machine Shop Manager (Nick Burnardo)
  - Systems Programmer (Brian Dobbins)
- Administrative personnel who conduct the business activities supporting our programs:
  - Dean of Faculty of Engineering (T. Kyle Vanderlick)
  - Director of Educational Affairs (Roman Kuc)
  - Coordinator of Educational Affairs and the Select Program (Jane Boone).
  - Director of Undergraduate Programs (SEAS, Chem Eng, Elect Eng, Mech Eng)
  - Communications and Publications Director (Steven Geringer)
  - Senior Administrator (Harley Pretty)
  - Facilities Operations (Andrew Morcus and Christopher Doyle)
  - Accounting Operations (Marian Frasier).
  - Financial management for faculty accounts (Susan Johns, Julie Murphy, and Robert Antunez).
  - Chairs of Departments offering ABET programs

- Administrative Associates to Program Chairs (Ben McManus (ChE), Pat Kakalow (EE), Mary MacNicholl (ME)).
- Administrative Assistants to DUS (Barbara Skolones (ChE), Vivian Smart (EE), Lorraine Ragusa (ME)).

9. Program Criteria for Chemical Engineering

Table 9-1 shows how our curriculum meets the specific criteria required of accredited chemical engineering programs.

Criteria		Course		Credits
Basic Chemistry	17 18	Gen. Chem. I & II Gen. Chem. Lab	CHEM 114 CHEM 116L	2 1
Advanced Chemistry	14 15 16	Organic Chem. I & II Phys. Chem. I & II Phys. Chem. Lab I	CHEM 220, 221 CHEM 332, 333 CHEM 331L	2 2 1
Material and Energy Balances	1	Princ. Of Chem. Eng.	CENG 210	1
Thermodynamics of Physical and Chemical Equilibria	2	Chem. Eng. Thermo.	CENG 300	1
Heat, Mass, and Momentum Transport	4 5	Transport Phenomena Fluid Mechanics	CENG 315 MENG 361	1 1
Chemical Reaction Engineering	3	Kinetics & Reactors	CENG 301	1
Continuous and Stage-wise Separation Operations	6	Separation Processes	CENG 411	1
Process Dynamics and Control	9	Process Control	CENG 480	1
Process Design	8	Process Design	CENG 416	1
Experimental Techniques	18 16 7	Gen. Chem. Lab Phys. Chem. Lab I Chem. Eng. Lab	CHEM 116L CHEM 331L CENG 412	1 1 1
Computing Techniques	13	Intro. Computing	ENAS 130	1

Table 9-1: Projection of curriculum onto specific program criteria for accredited chemical engineering programs. Numbers in second column correspond to those used in Table 5-1.

APPENDIX A: COURSE SYLLABI

Below we show course syllabi from CENG, CHEM, and PHYS courses taken by students seeking the ABET accredited B.S. in Chemical Engineering. MATH syllabi appear in Appendix D.

CENG 120A - Introduction to Environmental Engineering

Designation: Elective

2007-2008 Catalog Data: CENG 120a/ENVE 120a/ENAS120a, Introduction to Environmental Engineering. Jordan Peccia TTH 1-2.15, F 1 HTBA IV

Introduction to engineering principles related to the environment, with emphasis on causes of problems and technologies for abatement. Topics include air and water pollution, global climate change, hazardous chemical and radioactive waste, and green technology.

Prerequisites: High school calculus and chemistry or CHEM 114 (may be taken concurrently)

Text Book: Nazaroff, W. and L. Alvarez-Cohen. *Environmental Engineering Science*. John Wiley and Sons Inc., New York, 2001.

Course Objectives:

1. Demonstrate a familiarity with the scope and purpose of environmental engineering;
2. demonstrate a knowledge of water and air quality parameters, and an understanding of the associated chemistry and biology;
3. apply mass balances, reactor theory, and transport theory to solve quantitative water and air quality problems and design environmental reactors;
4. critically evaluate and discuss contemporary environmental contaminant issues that are of concern as an environmental engineer and as a citizen.

Topics Covered:

- units of measure in environmental systems
- water impurities and water quality parameters
- metal-ligand solubility and equilibrium
- acid/base reactions
- carbonate system and alkalinity
- biochemical oxygen demand
- gas-liquid partitioning
- solubility of organic compounds and sorption
- mass balance equations
- Streeter-Phelps dissolved oxygen modeling
- drinking water treatment
- wastewater treatment
- air quality parameters
- air quality modeling

Schedule: Two 75 minute lecture sessions per week plus three, one hour labs per semester

Relevance to Program Objectives: 1, 3

Relevance to Outcome Criteria: a, b, e, g, h, j, k

Prepared by Jordan Peccia, April 2008

CENG 210a - Principles of Chemical Engineering and Process Modeling

Designation: Required

2007-08 Catalog Data: CENG 210a, Principles of Chemical Engineering and Process Modeling. Paul Van Tassel

MW 1:00-2:15 IV; Not CR/D/F QR, SC Meets RP (36)

Analysis of transport and reactions of chemical species as applied to problems of chemical, biochemical, and environmental systems. Emphasis is placed on the interpretation of laboratory experiments, mathematical modeling, and dimensional analysis.

Prerequisites: MATH 120a *or* b *or* ENAS 151a or *permission of instructor.*

Textbook: Murphy, Regina M. *Introduction to Chemical Processes: Principles, Analysis, Synthesis* 1st Edition, McGraw-Hill

Course Objectives: The goal is to introduce students to chemical processes, and for students to develop the necessary skills to solve elementary problems in chemical engineering processing.

Topics Covered:

- Stoichiometry
- Material balances
- Process flow calculations
- Degree of freedom analysis
- Material balance equations
- Chemical reactors
- Chemical separators
- Phase equilibrium
- Energy balances
- Process energy calculations

Schedule: Two 75-minute sessions per week

Relevance to Program Objectives: 1a, 1b, 2a, 2b

Relevance to Outcome Criteria: a, b, c, e

Prepared by Paul Van Tassel, September 2007

CENG 300a - Chemical Engineering Thermodynamics

Designation: Required

2007-08 Catalog Data: CENG 300a, Chemical Engineering Thermodynamics. Chinedum Osuji

MW 11:35-12:50 IV; Not CR/D/F QR, SC Meets RP (34)

Analysis of equilibrium systems. Topics include energy conservation, entropy, heat engines, Legendre transforms, derived thermodynamic potentials and equilibrium criteria, multicomponent systems, chemical reaction and phase equilibria, systematic derivation of thermodynamic identities, criteria for thermodynamic stability, and introduction to statistical thermodynamics.

Prerequisites: MATH 120a *or* b *or* ENAS 151a or *permission of instructor*.

Textbook: Callen, Herbert B. *Thermodynamics and an Introduction to Thermostatics,* 2nd Edition, Wiley

Denbigh, Kenneth *The Principles of Chemical Equilibrium* Fourth Edition, Cambridge University Press

Course Objectives: The goal of this course is for students to obtain the necessary qualitative knowledge and quantitative skills for solving chemical engineering and engineering science problems involving thermodynamics.

Topics Covered:

- Internal energy, entropy
- Intensive properties, equations of state, temperature, mechanical equilibrium, chemical equilibrium
- Euler equation, Gibbs-Duhem relation, simple ideal gases; Van der Waals fluid, virial expansion, corresponding states; other systems: rubber bands, electromagnetic systems, heat capacity and other derivatives
- Maximum work, feasible processes, reversible/irreversible processes; cyclic processes: heat engines, Carnot cycle, efficiency
- Legendre transformations; the Helmholtz, enthalpy, Gibbs, and Massieu functions
- Extremum principle; Chemical reactions in ideal gases
- Maxwell relations
- Stability of thermodynamics systems
- First-order phase transitions, Latent heat, Clapeyron equation
- Introduction to statistical thermodynamics: microcanonical ensemble
- Statistical thermodynamics: canonical formalism

Schedule: Two 75-minute sessions per week

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a, e, i

Prepared by Chinedum Osuji, September 2007

CENG 301b-Chemical Kinetics and Chemical Reactors

Designation: Required

2007-08 Catalog Data: CENG 301b, Chemical Kinetics and Chemical Reactors.
Lisa Pfefferle
MW 11:35-12:50 IV; Not CR/D/F QR, Sc Meets RP (34)
Physical-chemical principles and mathematical modeling of chemical reactors. Topics include homogeneous and heterogeneous reaction kinetics, catalytic reactions, systems of coupled reactions, selectivity and yield, chemical reactions with coupled mass transport, nonisothermal systems, and reactor design. Applications from problems in environmental, biomedical, and materials engineering.

Prerequisites*:* ENAS 194a *or* b *or permission of instructor*.

Textbook: *Chemical Reaction Engineering, 3rd Ed*, Octave Levenspiel, John Wiley & Sons, 1999

Reference Text: *Reaction Kinetics and Reactor Design, Second Edition*, John B. Butt, Marcel Dekker, 2000 (on reserve Becton Library)

Web reactor lab: http://www-mae.ucsd.edu/research/herz/reactorlab

This is a useful simulation of reactors, which you are encouraged to use. See also the web site web at http://www.engin.umich.edu/~cre

Course Objectives: The core objectives have to do with understanding the development of the kinetics of chemical reactions and mass balances on ideal reactors that lead to design and performance equations. We strive to develop both an intuition for the effect of reaction parameters that effect fixed costs (reactor volume) and operating costs (reactant recycle, steady state versus batch reaction) and ability to formulate and solve reaction engineering problems quantitatively. Non- ideal flow and heterogeneous reactions are dealt with in the same way, with examples of practical industrial reactions, but not at the same level of detail as are ideal reactors that are the basis for thinking about all real reactors.

Topics Covered:

- Kinetics of Homogeneous Reactions
- Interpretation of Batch Reactor Data
- Reactor Design
- Ideal Reactors for a Single Reaction
- Design for Single Reactions
- Design for Parallel Reactions
- Potpourri of Multiple Reactions
- Temperature and Pressure Effects
- Choosing the Right Kind of Reactor
- Basics of Non-Ideal Flow
- Compartment Models
- Dispersion Model

- Solid Catalyzed Reactions

Schedule: Two 75-minute classes per week

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a, b, c, e

Prepared by Lisa Pfefferle, January 2008

CENG 315b/MENG 315b – Transport Phenomena

Designation: Required

2007-08 Catalog Data: CENG 315b/MENG 315b, Transport Phenomena.
Michael Loewenberg
MW 1-2:15 IV; Not CR/D/F QR, Sc Meets RP (36)

Unified treatment of momentum, energy, and chemical species transport including conservation laws, flux relations, and boundary conditions. Topics include convective and diffusive transport, transport with homogeneous and heterogeneous chemical reactions and phase change, and interfacial transport phenomena. Emphasis on problem analysis and mathematical modeling, including problem formulation, scaling arguments, analytical methods, approximation techniques, and numerical solutions.

Prerequisites: ENAS 194a *or* b, *or permission of the instructor*.

Textbook: *Analysis of Transport Phenomena*, W. M. Deen, Oxford.

Course Objectives: This course provides a rigorous introduction to convective and diffusive transport of heat, mass, and momentum.

Topics covered:

- Diffusive fluxes
- Conservation equations, boundary conditions
- Scaling and approximation techniques
- Analysis of conduction and diffusion problems
- Unidirectional flow, lubrication theory
- Theory for Low-Reynolds-number flow
- Convective heat and mass transport
- Boundary layer transport

Course work will primarily involve weekly problem sets and careful study of assigned reading.

Schedule: Three 50-minutes sessions per week plus one hour individually scheduled small group meetings.

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a, e, I, k

Prepared by Michael Loewenberg, January 2008

CENG 351a/BENG 351a - Biomedical Engineering I: Quantitative Physiology

Designation: Elective

2007-08 Catalog Data: CENG 351a/BENG 351a. Biomedical Engineering I: Quantitative Physiology Tarek Fahmy
TTh 11:35-12:50 IV; Not CR/D/F QR, Sc (24)

Together with the companion course BENG 352b, a yearlong presentation of the fundamentals of biomedical engineering. Demonstration of the use of engineering analysis and synthesis in problems in the life sciences and medicine; focus on modeling of molecular physiological processes and design of artificial organs. Lectures are coordinated with BENG 350a to illustrate how engineering analysis can be used to understand physiological processes. Additional topics include pharmacokinetics, heat and mass transfer in physiological systems, hemodialysis, drug delivery, and tissue engineering. *Concurrently with* BENG 350a,

Prerequisite: MCDB 120a, the first term of CHEM 113 or 114, or 118a; PHYS 180a, 181b; MATH 115a or b; ENAS 194 a or b.

Textbook: Transport Phenomena in Biological Systems (Truskey, Yan and Katz)

Drug Delivery, Mark Saltzman (Oxford University Press, 2001)

Additional readings:
Medical Physiology: Walter Boron and Emile Boulpaep

Introduction to Biomedical Engineering. Enderle et al (ed.) Academic Press (This book will be required for BENG 352b)

Notes covering certain topics in the course as well as pertinent reading material will be supplied.

Course Objectives: The course introduces the fundamentals of chemical engineering science and relates them to the life sciences with emphasis on biomedical applications.

Topics Covered:

- Random Walks and Diffusivity
- Flux and the diffusion equation
- Diffusion in Biological Systems
- Diffusion and Elimination
- Diffusion and Reaction
- Diffusion with Convection
- Mass transfer: Application to Dialysis
- Renal Physiology: Transport in the Kidney
- Respiratory Physiology: Transport in the lungs
- Biophysics of Receptor-Ligand Interactions (I)
- Biophysics of Receptor-Ligand Interactions (II)
- Biophysics of Receptor-Ligand Interactions (III)
- Momentum Balances
- Fluid flow and circulation (I)
- Fluid flow and circulation (II)

- Pharmacokinetics (I)
- Pharmacokinetics (II)
- Biological thermodynamics (I)
- Biological thermodynamics (II)
- Biological thermodynamics (III)
- Drug Delivery Systems
- Oral presentations
- Integration of course material and final review

Schedule: Two 75-minute sessions per week

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a, c, e, g-k

Prepared by Tarek Fahmy, September 2007

CENG 373a/ENVE 373a - Air Pollution Control

Designation: Elective

2007-08 Catalog Data: CENG 373a/ENVE 373a, Air Pollution Control. Lisa Pfefferle
TTH 4-5:15 IV; Not CR/D/F QR, Sc Meets RP (27)
Kinetics, thermodynamics, and transport of chemical reactions of common air pollutants including suspended particulate matter. The role of surface chemistry and transport phenomena in air pollution. Pollutant dispersion modeling. Technology available to prevent or control air pollutants.

Prerequisites: ENEV 210a *or permission of instructor*.

Textbook: DeNevers, Noel, *Air Pollution Control Engineering, 2nd Edition,* McGraw Hill 2000

Additional readings:
Cooper, C.D. and Alley, F.C.; *Air Pollution Control: A Design Appproach; 2nd Edition*, Waveland Press, 1994

Wark, Warner and Davis: *Air Pollution Its Origin and Control*, 3rd Edition, Addison-Wesley, 1998

Heinsohn and Kabel: *Sources and Control of Air Pollution;* Prentice Hall, 1999

Course Objectives: To introduce the student to the sources of air pollution, current legal status of air pollution control and its impacts on humans and property both locally and globally. To have the student understand the engineering principles used for modeling, control and prevention of air pollution with emphasis on the chemical and physical phenomena involved and mathematical models. To let the student become familiar with some of the aspects of air pollution engineering project management including information on equipment specifications, cost estimating, and governmental regulations.

Topics covered:

- Common Units & Values
- Typical Air Pollutants, Effects on Human Health & Property
- Air Pollution Regulations, Air Pollution Measurements
- Introduction to Meteorology, Ideal Gas Law
- Sources of Pollutants, Review of effects
- Volatile Organic Carbon(VOC)s, HCs,Troposphere Ozone
- Control of VOCs, Combustion/Catalysts
- Automobile Emissions, BTEX, MV & Fuels Alternatives
- What is Process Design?, Air Pollution Conc. Models
- Plumes, Dispersion, Ideas to Improve Dispersion & Major Concepts in
- APC
- Particulates, Control of Primary Particulates
- Sulfur Oxides, Nitrogen Oxides, Mercury
- Air Pollutants & Global Climate, Ozone Hole, Acid Rain

- Other Toxics, Indoor Air Pollution
- Other Carbon Sources(Wetlands), Forest Fires, Agricultural Burning

Schedule: Two 75-minute sessions per week

Relevance to Program Objectives: 1, 2, 3

Relevance to Outcome Criteria: a – k

Prepared by Lisa Pfefferle, September 2007

CENG 377b/ENVE 377b - Water Quality Control

Designation: Elective

2007-08 Catalog Data: CENG 377b/ENVE 377b, Water Quality Control.
William Mitch
TTh 2:30-3:45 IV; Not CR/D/F Sc Meets RP (27)

Study of the preparation of water for domestic and other uses and treatment of waste water for recycling or discharge to the environment. Topics include processes for removal of organics and inorganics, regulation of dissolved oxygen, and techniques such as ion exchange, electrodialysis, reverse osmosis, activated carbon absorption, and biological methods.

Prerequisite: ENVE 210a *or permission of instructor.*

Textbook: *Theory and Practice of Water and Wastewater Treatment*, Ronald L. Droste, Wiley & Sons, 1997.

Course Objectives:

1. Design of processes used for water and wastewater treatment.
2. Use of team-based problem solving.

Topics Covered:

1. Intro/Regulatory Framework/Trends
2. Master Plans/Hydraulics
3. Screens
4. Reactor Models
5. Air stripping/Aeration
6. Coagulation/Flocculation
7. Sedimentation
8. Filtration
9. Precipitation/Lime Softening
10. Carbon Adsorption
11. Ion Exchange
12. Reverse Osmosis
13. Disinfection: Bugs
14. Disinfection: Chemicals
15. Microorganism Behavior
16. Activated Sludge Equation Derivation
17. Activated Sludge Discussion
18. Activated Sludge Design

19, Other Aerated Biological Treatments

20. Anaerobic Digestion
21. Solids Handling
22. Wastewater Recycling
Field trip: New Haven and WWTP

Schedule: Two 75-minute sessions per week

Relevance to Program Objectives: 1, 2

Relevance to Outcome Criteria: a - e, g, k

Prepared by William Mitch, January 2008

CENG 411a - Separation and Purification Processes

Designation: Required

2007-08 Catalog Data: CENG 411a^G, Separation and Purification Processes.
Yehia Khalil
MW 2:30-3:45 IV; Not CR/D/F QR, Sc Meets RP (37)

Theory and deisgn of separation processes for multicomponent and/or multiphase mixtures via equilibrium and rate phenomena. Topics include single-stage and cascaded absorption, adsorption, extraction, distillation, partial condensation, filtration, and srystallization processes. Applications to environmental engineering (air and water pollution control), biomedical-chemical engineering (artificial organs, drug purification), food processing,and semiconductor processing.

Prerequisites: CENG 300a, 315b *or permission of instructor.*

Textbook: Seader,W. and Henley,E., *Separation Process Principles*, J.Wiley& Sons, (1998)

Additional readings:

King, C.J., *Separation Processes*, McGraw-Hill (2d ed. 1980)

Treybal, R.E., *Mass Transfer Operations McGraw-Hill* (3d ed., 1980)

Rosner, D.E., *Transport Processes in Chemically Reacting Flow Systems*, DOVER Paperback (2000) (Supplementary reference for energy- and mass- balance equations, and transport-controlled separations)

Course Objectives: To convey the underlying physicochemical theory and useful design techniques for a wide variety of both industrial and laboratory scale separation/purification processes. Non-ideal multi-component and/or multi-phase mixtures are included, as are processes that depend on multi-stage equilibrium- and/or 'rate'- (eg., transport-) phenomena. These principles and techniques are illustrated in the context of environmental engineering (air and water pollution control), resource recovery (petroleum processing, geothermal 'steam',...), biomedical/chemical engineering (eg., artificial organs, chirally specific drugs), food processing, semi-conductor processing, as well as commodity/specialty chemical synthesis. The student is expected to come away with both quantitative and heuristic principles for the economic selection and sequencing of alternative separation processes, as well as an understanding of current advances being made across the rather broad separations 'frontier'.

Topics Covered:

1. Introduction to Separation/Purification Processes in Research and in Industry; Important Historical Precedents, Analytical vs. Preparative

   Separations, Product Purity Requirements and Cost, Separation schemes",

Separating Fundamentals:

a. Non-ideal Solution Thermodynamics and Phase Equilibria; Absorption vs. Adsorption; "Dew" Points and "Bubble" Points; Equibrium

Phase Diagrams, Application of Thermodynamics to Single-stage Equilibrium Separation Processes; Maximum Achievable Separation Factors

b. Mass Transfer Balance Equations (Total Mass, Species Mass and Chemical Element Mass) and Rate Laws (Concentration Diffusion and "2 Film (Lewis-Whitman)Theory")

c. Implications of Energy- and Entropy- Balances (DER Chs. 2,3); Separation Work and Separator Efficiency

2. Comparison of Algebraic and Graphical Solution Methods: Performance of Single-Stage Solvent Extraction Separator Accounting for Thermo-dynamic Non-idealities; Multi-component Generalizations; Numerical methods
3. Real vs. Ideal Separation Factors; Transport Phenomena in Single-Stage Separator Modules
4. Contacting Patterns, Staging and Recycle: Effects on Product Purity and Separating Agent Requirements; Heat "Integration"

6. Steady-Flow Multi-stage Counter-current Distillation; Binary, Multi-component, "non-azeotropic" Systems

7. Steady-Flow Liquid (Solvent-) Extraction Systems; Supercritical Solvents (Relation to "Stripping"); Parallels with Leaching of Granular Solids

8. Absorption and 'Stripping': Irrigated Packed Columns (Differential Contacting); "Complexing"

9. Adsorption and Ion-Exchange Systems; Fixed-bed Adsorbers and available adsorbents; Gas / Liquid "Chromatography", Gas "Masks", Moving beds, Fluidized beds, and Adsorbent "wheels"

10. Crystallization, Precipitation, "Zone-Refining"; Control of crystal size distribution and morphology ("habit")

11. Barrier ("Membrane") Separations: Selective Permeation and "Filtration" Mechanisms /Performance; Artificial Organs; VOC recovery from air

12. Fluid/Solid Phase Separations based on Suspended Particle Inertia: Impactors, Cyclones and Centrifuges; Dry Dust Collection (Air Pollution Control); Notion of "aerodynamic" diameter

13. Separation System Selection and Sequencing; 'Heuristics' and Computer-Aided Design; "Why NOT Distillation?"

14. Conclusions, Trends, Reactor-Separator Combinations, Emerging Techniques

Schedule: Two 75-minute sessions per week

Relevance to Program Objectives: 1,2

Relevance to Outcome Criteria: a, c, e-k

Prepared by Yehia Khalil, September 2007

CENG 412b-Chemical Engineering Laboratory

Designation: Required

2007-08 Catalog Data: CENG 412b, Chemical Engineering Laboratory Yehia Khalil
W 12-4 IV; Not CR/D/F Sc Meets RP (34)

Basic experiments in chemical engineering science, including interpretation, analysis, and modeling of experimental results. Typical experiments include liquid level control, convective heat transfer, electrophoresis of colloidal particles, surface tension, surface wettability measurements, particle sedimentation, microfiltration, and flow in porous media.

Prerequisites: CENG 301b, 411a.

Textbook: There will be no specific text for the course. A lecture will be given prior to each experiment in which the physical fundamentals will be reviewed. Appropriate references and reading material will be provided during this lecturein the form of handouts.

Additional reference material:
Software: Some of the experiments will use a software package called LabView. LabView is a graphical programming language developed for data collection and analysis and laboratory simulation. LabView allows creation of sophisticated data collection and simulation programs without requiring time consuming coding. During the first laboratory period there will be a short tutorial that covers the basics of the program

Course Objectives: The Chemical Engineering laboratory course is an essential part of our ABET accredited curriculum. The objectives of the course are to provide the students exposure to (1) designing and conducting an experimental procedure in a safe, efficient and environmentally-friendly manner, (2) analyzing experimental data in order to understand the fundamentals involved in a particular process, (3) analyzing processes involving both traditional chemical engineering fundamentals, such as fluid mechanics and process control, as well as other, nontraditional topics, such as electrophoresis and surface tension, (4) working together in small groups to analyze data and (5) preparing a comprehensive laboratory report presenting and discussing experimental results.

Topics covered: Experiments will be conducted in the areas of fluid mechanics, electrophoresis, process control, membrane separation processes, and surface tension/contact angle. Each group will perform 4 or 5 experiments, depending on the time available in the laboratory. Some of the experiments will be performed in the undergraduate laboratory while others will use equipment in individual research laboratories.

Schedule: One four-hour meeting per week

Relevance to Program Objectives: 1, 2

Relevance to Outcome Criteria: a, b, d, e, f, g, k

Prepared by Yehia Khalil, January 2008

CENG 416b/ENVE 416b - Chemical Engineering Process Design

Designation: Required

2007-08 Catalog Data: CENG 416b/ENVE 416b Chemical Engineering Process Design. Yehia Khalil
TTH 7-8:15 P.M. IV; Not CR/D/F QR, Sc Meets RP (0)
Study of the techniques for and the design of chemical processes and plants, applying the principles of chemical engineering and economics. Emphasis on flowsheet development and equipment selection, cost estimation and economic analysis, design strategy and optimization, safety and hazards analysis, and environmental and ethical considerations.

Prerequisites: CENG 301b, *and* 411a.

Textbook: *Plant Design and Economics for Chemical Engineers; 4th Edition.* Peters and Timmerhaus, McGraw-Hill, 1991.

References: *Perry's Chemical Engineering Handbook, 6th Edition*. McGraw-Hill, 1984.

Course Objectives: Process Design is the capstone design course in the ABET accredited undergraduate chemical engineering curriculum. It involves the application of all prior coursework to the design of chemical process systems. Integration of the knowledge and skills acquired in prior courses will provide the student with a foundation to better address the conceptual, analytical and decision aspects of open-ended design situations. Students will gain an appreciation for determining the optimum process design, selecting equipment, laying out a process plant, analyzing costs, evaluating hazards and assessing environmental concerns for the production of an industrial chemical. Experience will be gained with working in small student groups in addition to individualized effort. The students will also be required to present their final project in a written report and oral presentation.

Topics Covered:

- Flowsheet development
- Equipment selection
- Process operating conditions
- Cost estimation
- Economic analysis
- Design strategy and optimization
- Safety and hazards analysis
- Environmental constraints.

Schedule: Two 75-minute sessions per week

Relevance to Program Objectives: 2

Relevance to Outcome Criteria: a, b, c, d, e, f, g, h, I, j, k

Prepared by Yehia Khalil, January 2008

CENG471a *and* 472b-Independent Research

Designation: Elective

2007-08 Catalog Data: CENG 471a *and* 472b, Chemical Engineering Projects. Consult the director of undergraduate studies
HTBA IV; Not CR/D/F (0)

Faculty-supervised individual student research and design projects. Emphasis on the integration of mathematics with basic and engineering sciences in the solution of a theoretical, experimental, and/or design problem. *May be taken more than once for credit.*

Prerequisites: None

Course objectives: The purpose of this course is to engage students in original research in close collaboration with individual Chemical Engineering Program faculty. Students are involved in the design of a research problem including a literature search, and learn about research methods including experimental techniques, and/or numerical and analytical modeling methods. The aim is to prepare students for independent research in graduate school or in industry.

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a, b, e, g, I, j, k

Prepared by Michael Loewenberg, September 2007

CENG 480a — Chemical Engineering Process Control

Designation: Required

2007-08 Catalog Data: CENG 480a, Chemical Engineering Process Control Eric Altman
MW 9-10:15 IV; Not CR/D/F QR, Sc Meets RP (32)

Transient regime modeling and stimulations of chemical processes. Conventional and state-space methods of analysis and control design. Applications of modern control methods in chemical engineering. Course work includes a design project.

Prerequisites: ENAS 194a *or* b *or permission of instructor*.

Textbook: Seborg,D., Edgar, T., and Mellichamp, D., *Process Dynamics andControl*, John Wiley & Sons, New York, 1989.
Software: Matlab with Simulink and Control System Toolbox
Additional Reference:
www.techteach.no/publications/control_toolbox_matlab/cst4.htm

Course Objectives: Develop transient modeling skills, develop ability to analyze the stability and performance of control systems and to design control systems for unit operations.

Topics Covered:

1. Essential Background Material
   a. Introduction to Control Concepts
   b. Unsteady-State Process Modeling
   c. Laplace Transforms
   d. Transfer Functions
2. Classical Feedback Control
   a. Control Algorithms
   b. Closed-Loop Block Diagrams
   c. Dynamical Response of Open-Loop Systems
   d. Dynamical Response of Closed-Loop Systems
   e. Simulation with Simulink and Analysis with Matlab
3. Stability of Control Systems
   a. General Stability Criterion
   b. Frequency Response Analysis
   c. Selection of Control Parameters
4 Real Systems
   a. Lags and Noise
   b. Multiple Inputs and Multiple Outputs
5. Advanced Control Methods
   a. Feedforward Control
   b. Digital Control

Schedule: Two 75-minute sessions per week

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a, c, e, g, k

Prepared by Eric Altman, September 2007

CENG 490a *or* b-Senior Research Project

Designation: Elective

2007-08 Catalog Data: CENG 490a *or* b, Senior Research Project. Consult the director of undergraduate studies.
HTBA IV; Not CR/D/F (0)

Individual research and/or design project supervised by a faculty member in Chemical Engineering, or in a related field with permission of the director of undergraduate studies.

Prerequisites: None

Course Objectives: The purpose of this course is to engage students in original research in close collaboration with individual Chemical Engineering Program faculty. Students are involved in the design of a research problem including a literature search, and learn about research methods including experimental techniques, and/or numerical and analytical modeling methods. The aim is to prepare students for independent research in graduate school or in industry.

This course ulfills the Senior Requirement for the (unaccredited) BS in Engineering Sciences (Chemical).

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a, b, e, g, I, j, k

Prepared by Michael Loewenberg, September 2007

CHEM 114a-Comprehensive General Chemistry

Designation: Required

2007-08 Catalog Data: Chemistry 114, Comprehensive General Chemistry.
R. James Cross, Jr.
Lect. MWF 10:30-11:20 Not CR/D/F Meet RP IV (33)
Disc. MTW or Th 11:35-12:25 or 1:30-2:20 or 2:30-3:20

A comprehensive survey of modern descriptive, inorganic, and physical chemistry for students with a good secondary school exposure to general chemistry. Fulfills the prerequisites for medical school and for all majors requiring a year of general chemistry as well as the general chemistry prerequisite for CHEM 220a or 225b. *Attendance at a discussion section required. May not be taken after* CHEM 113, 118a, 125, 220a, 221b, or 225b. *Normally to be accompanied by* CHEM 116L. Enrollment by placement only. For placement information see "Placement in introductory courses" in the text above.

Textbook: *Chemistry* by S. S. Zumdahl and S. A. Zumdahl, Houghton Mifflin, 7th edition
The text includes a student solution manual (for odd numbered problems) and one CD's.

Topics in the Fall Semester:

Chemical Foundations
Thermochemistry
Atoms, Molecules, and Ions
Atomic Structure and Periodicity
Types of Chemical Reactions and Solution Stoichiometry
Bonding: General Concepts
Covalent Bonding: Orbitals
Liquids and Solids
Gases
Properties of Solutions

Schedule: Three 50-minute lectures per week plus one 50-minute discussion per week

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a

Prepared by R. James Cross, Jr., September 2007

CHEM 114b-Comprehensive General Chemistry

Designation: Required

2007-08 Catalog Data: Chemistry 114, Comprehensive General Chemistry. Kurt Zilm
Lect. MWF 10:30-11:20 Not CR/D/F Meet RP IV (33)
Disc. MTW or Th 11:30-12:20 or 1:30-2:20 or 2:30-3:20

A comprehensive survey of modern descriptive, inorganic, and physical chemistry for students with a good secondary school exposure to general chemistry. Fulfills the prerequisites for medical school and for all majors requiring a year of general chemistry as well as the general chemistry prerequisite for CHEM 220a or 225a. *Attendance at a discussion section required. May not be taken after* CHEM 113, 118a, 125, 220a, 221b, *or* 225b. *To be accompanied by* CHEM 116L. Enrollment by placement only. For placement information see “Placement in introductory courses” in course book.

Textbook: *Chemistry* by S. S. Zumdahl and S. A. Zumdahl, Houghton Mifflin, 7th edition
The text includes a student solution manual (for odd numbered problems) and one CD.

Topics in the Spring Semester:
This course continues where CHEM 114a left off:
Osmotic Pressure
Chemical Kinetics.

Schedule: Three 50-minute lectures per week plus one 50-minute discussion per week

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a

Prepared by Kurt Zilm, September 2007

CHEM 116La - General Chemistry Laboratory

Designation: Required

2007-08 Catalog Data: Chemistry 116L, General Chemistry Laboratory.
Narasimhan Ganapathi
Not CR/D/F ½ C Credit per term Meet RP IV
MTWTh or F 12-3 or 1-4 IV; Not CR/D/F Sc ½ C Credit per term Meets RP (0)

In the fall term, laboratory techniques required for quantitative analysis, thermodynamics, and properties of gases. In the spring term, rate and equilibrium measurement, acid-base chemistry, synthesis of inorganic compounds, and qualitative and quantitative analysis.
CHEM 116L *must accompany or follow* CHEM 113 *or* 114. *May not be taken after a higher-numbered laboratory.*

Textbook: For reference: *Chemistry* by S. S. Zumdahl and S. A. Zumdahl, Houghton Mifflin, 5th edition

Topic Covered:

1. Basics: Measurements and Chemical Reactions
2. Density of aquarium water
3. The Briggs-Rausher oscillating reaction
4. Stoichiometry of a chemical reaction
5. Empirical Formula of a Binary Inorganic Salt Hydrate
6. Hardness of aquarium water
7. Oxidation States of Vanadium
8. Calorimetry & Hess Law
9. Evaluation of the value of the Gas Constant R
10. Electrolysis
11. Rydberg's Constant

Schedule: One three-hour class per week

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a, b

Prepared by Narasimhan Ganapathi, September, 2007

CHEM 116Lb - General Chemistry Laboratory

Designation: Required

2007-08 Catalog Data: Chemistry 116L, General Chemistry Laboratory.
Narasimhan Ganapathi
Not CR/D/F ½ C Credit per term Meet RP IV
MTWTh or F 12-3 or 1-4 IV; Not CR/D/F Sc ½ C Credit per term Meets RP (0)

In the fall term, laboratory techniques required for quantitative analysis, thermodynamics, and properties of gases. In the spring term, rate and equilibrium measurement, acid-base chemistry, synthesis of inorganic compounds, and qualitative and quantitative analysis.
CHEM 116L *must accompany or follow* CHEM 113 *or* 114. *May not be taken after a higher-numbered laboratory.*

Textbook: For reference: *Chemistry* by S. S. Zumdahl and S. A. Zumdahl, Houghton Mifflin, 5th edition

Topic Covered:

1. Basics: Measurements and Chemical Reactions
2. Density of aquarium water
3. The Briggs-Rausher oscillating reaction
4. Stoichiometry of a chemical reaction
5. Empirical Formula of a Binary Inorganic Salt Hydrate
6. Hardness of aquarium water
7. Oxidation States of Vanadium
8. Calorimetry & Hess Law
9. Evaluation of the value of the Gas Constant R
10. Electrolysis
11. Rydberg's Constant

Schedule: One three-hour class per week

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a, b

Prepared by Narasimhan Ganapathi, September, 2007

CHEM 220a - Organic Chemistry

Designation: Required

2007-08 Catalog Data: Chemistry 220a, Organic Chemistry. Scott Miller
Lect. MWF 9:25-10:15 Meets RP IV (32)
Disc. MTW or Th 12:30-1:20 or 1:30-2:20 or 2:30-3:20

An introductory course covering the fundamental principles of organic chemistry. The laboratory for this course is CHEM 222La. After CHEM 113, 114, 118a, or 333b. *Students who have earned a grade of less than C in one of the general chemistry courses are cautioned that they may not be sufficiently prepared for this course. Usually followed by* CHEM 221b.

Textbook: *Organic Chemistry* (6^{th} Edition) by L.G. Wade, Jr. (Published by Pearson)

Solutions Manual for *Organic Chemistry* by J.L. Simek

Darling Molecular Models (Absolutely indispensable)

All items are available in the bookstore.

Topics Covered:

1. Structure and Bonding of Organic Molecules
2. Introduction to Hydrocarbons and Sterochemistry
3. Introduction to Organic Reactions
4. Aspects of Stereochemistry
5. Functionalized Molecules - Alkyl Halides
6. Nucleophilic Substitution and Elimination
7. Unsaturated Molecules – Their Structure and Reactivity
8. Alkynes
9. Functionalized Molecules - Alcohols
10. the Workshorse Spectroscopies of Organic Chemistry

Schedule: Three 50-minute lectures plus one 50-minute discussion session per week.

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a

Prepared by Scott Miller, September, 2007

CHEM 221b - The Organic Chemistry of Life Processes

Designation: Required

2007-08 Catalog Data: Chemistry 221b, The Organic Chemistry of Life Processes. Andrew D. Hamilton
Lect. MWF 9:25-10:15 Meets RP IV (32)
Disc. MTW or Th 12:30-1:20 or 1:30-2:20 or 2:30-3:20

The principles of organic reactivity and how they form the basis for biological processes. The laboratory for this course is CHEM 223Lb. *After* CHEM 220a. *Students who have earned a grade of less than C in one of the general chemistry courses are cautioned that they may not be sufficiently prepared for this course.*

Textbook: L.G. Wade, Jr., *Organic Chemistry,* Sixth Edition, Prentice Hall, 2006

Study guide: J.W. Simek, *Solutions Manual* for L.G. Wade, 3rd Edition, Prentice Hall, 1995

Also suggested: Molecular Models

Topics Covered:

1. Conjugated Systems
2. Aromatic Compounds
3. Aromatic Reactions
4. Ketones & Aldehydes
5. Amines
6. Carboxylic Acids Derivatives
7. Enols and Enolates
8. Ethers, Epoxides, Sulfides
9. Amino Acids, etc.
10. Carbohydrates

Schedule: Three 50-minute lectures and one 50-minute discussion per week.

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a

Prepared by Alanna Schepartz, January, 2008

CHEM 332a - Physical Chemistry with Applications in the Biological Sciences

Designation: Required

2007-08 Catalog Data: Chemistry 330, Physical Chemistry with Applications in the Biological Science. Elsa Yan
Lect. TTh 9-10:15; *disc.* 1 HTBA IV QR, Sc Meets RP (22)

Physical chemical principles and their application to the chemical and life sciences. Topics include thermodynamics, chemical and biochemical kinetics, solution physicalchemistry, electrochemistry, and membrane equilibria. CHEM 332a *is preferred for Chemistry majors.*

Prerequisites: PHYS 180a, 181b, *or* 200a, 201b *preferred;* PHYS 150a, 151b *acceptable;* MATH 112a or b *and* 115a *or* b required; MATH 120a *or* b *suggested;* CHEM 113, 114, 118a *or* 125; or *permission of instructor. May not be taken after* CHEM 332a.

Textbook: *Physical Chemistry with Applications to the Life Sciences,* D. Eisenberg & D. Crothers, Benjamin/Cummings, 1979.

Thermodynamics and Kinetics for the Biological Sciences, Gordon G. Hammes, John Wiley & Sons, 2000

Additional Reading: Other physical chemistry texts have been placed on reserve in Kline Science Library. Also, note that multivariable calculus will be used extensively in this course. Difficulties in physical chemistry often arise because of insufficient background in math. Review sections 1.6-1.7 in Eisenberg & Crothers (E&C). If you are not comfortable with this material, get an applied math textbook to review.

Topics Covered:

1. Description of Macroscopic Systems
2. Energy and the first Law
3. Entropy and the Second Law
4. Free Energy and Equilibrium
5. Chemical and Biochemical Kinetics
6. Solutions
7. Electrolyte Solutions
8. Electrochemical Equilibria

Schedule: Two 75-minute lectures and one 60-minute discussion each week.

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a

Prepared by Elsa Yan, September 2007

CHEM 333b - Physical Chemistry with Applications in the Biological Sciences

Designation: Required

2007-08 Catalog Data: Chemistry 330, Physical Chemistry with Applications in the Biological Science. Elsa Yan
Lect. TTh 9-10:15; *disc.* 1 HTBA IV QR, Sc Meets RP (22)

Physical chemical principles and their application to the chemical and life sciences. Topics include thermodynamics, chemical and biochemical kinetics, solution physicalchemistry, electrochemistry, and membrane equilibria. CHEM 332a *is preferred for Chemistry majors.*

Prerequisites: PHYS 180a, 181b, *or* 200a, 201b *preferred;* PHYS 150a, 151b *acceptable;* MATH 112a or b *and* 115a *or* b required; MATH 120a *or* b *suggested;* CHEM 113, 114, 118a *or* 125; or *permission of instructor. May not be taken after* CHEM *332a.*

Textbook: *Physical Chemistry with Applications to the Life Sciences,* D. Eisenberg & D. Crothers, Benjamin/Cummings, 1979.

Topics Covered:

1. Quantum Mechanics
2. Atoms & Molecules
3. Spectroscopy
6. NMR
7. Crystallography
8. Statistical Mechanics
9. Transport

Schedule: Two 75-minute lectures and one 60-minute discussion each week.

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a

Prepared by Elsa Yan, January 2008

CHEM 331La – Laboratory for Physical Chemistry

Designation: Required

2007-08 Catalog Data: Chem 331L, Laboratory for Physical Chemistry. Patrick Vaccaro.
Lect. F 1.30-2.20; *lab* MTW or Th 1-5 Meets RP IV (0)
Laboratory course introducing physical chemical techniques and emphasizing quantitative analysis of experimental data. *After or concurrently with* CHEM 328a *or* 332a *and* CHEM 333b. *Prerequisites*: PHYS 18a, 181b, *or* 200a, 201b *preferred*; PHYS 150a, 151b *acceptable*; MATH 112a *or* b *and* 115a *or* b. *Successful completion of the first term of* CHEM 331L *required before enrollment in the second term. Advanced Chemistry majors may wish to enroll in the graduate laboratory* CHEM 560L *as an alternative course; permission of the instructor and the director of graduate studies is required. Meets on Wednesday, Thursday, and Friday from* 1:30 to 2:30 *for the first week of the term.*

Prerequisites: PHYS 180a, 181b *or* 200a, 201b *preferred;* PHYS 150a, 151b *acceptable*; MATH 112a *or* b *and* 115a *or* b.

Textbook: *Principles of Instrumental Analysis* by Skoog, D.A., Holler, F.J. and Nieman, T.A., 5th Edition, Saunders College Publishing

Reserved texts:
Brophy, J.J., *Basic Electronics for Scientists,* 1983
Oldham, W.G. and Schwartz, S.E., *An Introduction to Electronics,* 1972
Farrar, T.C. *Pulse & Fourier Transform NMR: Introduction,* 1971
Malmstadt, H.V. *Electronics for Scientists: Principles*, 1963
Shoemaker, D.P. & Garland, B., *Experiments in Physical Chemistry,* 3rd rev. ed., 1974
Skoog, D.A., *Principles of Instrumental Analysis*, 3rd ed. 1985
Strobel, H.A., *Chemical Instrumentation*, 2nd ed. 1989
White, J.M., *Physical Chemistry Laboratory Experiments*, 1975
Monro, D.M., *BASIC and Introduction to Programming*, 1978
Hubin, W.N., *BASIC Programming for Scientists and Engineers*, 1978

Course Objective: As Chemistry is central to all disciplines of science, physical chemistry is central to all branches of chemistry. Trying to understand various physical and chemical phenomena in nature and determining the chemical properties of materials & systems are the primary activities of most experimental physical chemists. To an increasing extent, these studies are made nowadays with the aid of sophisticated instrumentation. Physical Chemistry Laboratory is, therefore, intended to provide not only an illustration of the basic principles associated with various physical and chemical phenomena, but also to provide an introduction to the methods and instrumentation for making the measurements on which these chemical principles are based.

Topics Covered:

1. Electronics
2. Liquid-Gas & Solid-Gas Phase Equilibria
3. Heat Capacity Ratio of Gases
4. Laser Induced Fluorescence

5. NMR Spectroscopy

Schedule: One four-hour laboratory session and one 50-minute lecture per week

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a, b

Prepared by Patrick Vaccaro, September, 2007

PHYS 180a and 181b – Advanced General Physics

Designation: **Prerequisite**

2001-2002 Catalog Data: PHYS 180a and 181b. Advanced General Physics. (IV)34. A broad introduction to classical and modern physics for students who have some previous preparation in physics and mathematics. Physics 180a covers Newtonian mechanics, gravitation, waves, and thermodynamics. Physics 181b covers electromagnetism, optics, special relativity, and quantum physics. Corequisites: Math 115 and Math 120. May not be elected for credit after Physics 150a, 151b.

Text book: Halliday, Resnick and Walker, *Fundamentals of Physics*, Sixth Edition, 2001. Volumes 1,2.

Coordinator: [F] Megan Ury, Professor of Physics
[Sp] Robert Grober, Professor of Physics

Goals: To provide a basic introduction to physics for students studying classical physics as well as special relativity and quantum physics.

Prerequisites by topic:
1. Calculus of functions with one variable
2. Calculus of functions with several variables

Topics:
Fall:
1. Motion along a straight line
2. Vectors
3. Motion in two and three dimensions
4. Force and motion
5. Work and kinetic energy
6. Conservation of energy
7. Systems of particles
8. Collisions
9. Rotation
10. Rolling, torque and angular momentum
11. Oscillations
12. Gravitation
13. Waves
14. Temperature
15. Heat and the first law of thermodynamics
16. Kinetic theory of gases
17. Entropy and the second law of thermodynamics

Spring:

1. Electric Charge
2. Electric Field
3. Gauss' Law
4. Electric Potential
5. Capacitance
6. Current and Resistance
7. Circuits
8. Magnetic Field
9. Ampere's Law
10. Faraday's Law of Induction
11. Inductance
12. Magnetism and Matter
13. Electromagnetic Oscillations
14. Alternating Currents
15. Maxwell's Equations
16. Electromagnetic Waves
17. Geometrical Optics
18. Interference
19. Diffraction
20. Relativity
21. Quantum Physics

Computer Usage: N/A

Laboratory projects (including major items of equipment and instrumentation used): N/A

Relevance to Program Objectives: 1

Relevance to Outcome Criteria: a, e, i

APPENDIX B – FACULTY RESUMES

Below we show resumes of Program Faculty.

Eric I. Altman

1. Academic Rank: Professor

2. Degrees: Ph.D. 1988 University of Pennsylvania (Chemical Engineering)
B.S. 1983 Cornell University (Chemical Engineering)

3. Years of service on this faculty: 14
July 2002 – present Professor
Nov. 1997 – June 2002 Associate Professor
Jan. 1994 – Oct. 1997 Assistant Professor

4. Other related experience:
1990-1993 Chemistry Division, Naval Research Laboratory, Washington, DC
1989 Eos Technologies, Inc., Arlington, VA

5. Consulting – None

6. Not a professional engineer

7. Principal publications of last five years:

Y. Yun, J. Wang and E.I. Altman, "Comparison of the Reactivity of Bulk and Surface Oxides on Pd(100)," Journal of Catalysis, **253** (2007) 295.

Y. Yun and E.I. Altman, "Using Ferroelectric Poling to Change Adsorption on Oxide Surfaces," Journal of the American Chemical Society, **129** (2007) 15684.

Y. Yun, L. Kampschulte, D. Liao, M. Li and E.I. Altman, "Effect of Ferroelectric Poling on the Adsorption of 2-Propanol on $LiNbO_3$(0001)," Journal of Physical Chemistry C **111** (2007) 13951.

W. Gao, M. Li, R. Klie and E.I. Altman, "Growth and Characterization of Model Oxide Catalysts," Journal of Electron Spectroscopy and Related Phenomena, **150** (2006) 136.

J. Wang, M. Li and E.I. Altman, "Scanning Tunneling Microscopy Study of Self-Organized Au Atomic Chain Growth on Ge(001)," Physical Review B **70** (2004) 233312.

8. Scientific and professional societies of which a member:
American Institute of Chemical Engineers
American Vacuum Society
American Chemical Society

9. Honors and awards:
Presidential Early Career Award in Science and Engineering

10. Courses taught last two academic years:
Process Control, CENG 480a
Surfaces and Surface Processes, EAS 608b

Surface and Thin Film Chararacterization, EAS 614b

11. Other assigned duties:
Director of Graduate Studies, Engineering and Applied Science 2005-
Director of Graduate Admissons, Engineering and Applied Science 2006
Term Appointments Committee, Faculty of Arts and Sciences 2007-

12. Self-improvement:

Attendance/presentations at national meetings (AIChE, Am. Vacuum Soc., N. Am. Catal. Soc., Am. Chem. Soc.) Gordon Conferences

AVS Nanoscale Science and Technology Division Executive Committee 2006-

Menachem Elimelech

1. Academic Rank: Professor
2, Degrees:
   1989 Ph.D. Environmental Engineering, The Johns Hopkins University
   1985 M.Sc. Environmental Science & Technology, The Hebrew University
   1983 B.Sc. Soil and Water Sciences, The Hebrew University, Jerusalem, Israel
3. Years of service on this faculty: 9
   1998-present Roberto Goizueta Professor, Dept. of Chemical Engineering, Yale University
   1998-present Director, Environmental Engineering Program, Yale University
   2005-present Chair, Department of Chemical Engineering
4. Other Related Experience:
   2001 (summer) Visiting Professor, Department of Civil Eng., National University of Singapore
   1997-1998 Professor, Dept. of Civil & Environmental Engineering, UCLA
   1996 Visiting Associate, Environmental Engineering Science, California Institute of Technology (Fall Quarter)
   1994-1997 Associate Professor, Dept. of Civil & Environmental Engineering, UCLA
   1989-1994 Assistant Professor, Dept. of Civil & Environmental Engineering, UCLA
5. Consulting: Nestle
6. Is not a professional engineer
7. Principal Publications of the Last Five Years

McCutcheon, J.R., and Elimelech, M. "Influence of Membrane Support Layer Hydrophobicity on Water Flux in Osmotically Driven Membrane Processes", Journal of Membrane Science, 318, 2008, 458-466.

Huertas, H, Herzberg, M., Oron, G. Elimelech, M, "Influence of Biofouling on Boron Removal by Nanofiltration and Reverse Osmosis Membranes", Journal of Membrane Science, 318, 2008, 264-270.

Shannon, M.A., Bohn, P.W., Elimelech, M., Georgiadis, J.G., Mariñas, B.J. and Mayes, A.M. "Science and Technology for Water Purification in the Coming Decades", Nature, 452, March 2008, 301-310.

Brady-Estévez, A.S., Kang, S., and Elimelech, M. "A Single-Walled Carbon Nanotube Filter for Removal of Viral and Bacterial Pathogens", Small, 4, 2008, 481-484.

de Kerchove, A.J. and Elimelech, M. "Adhesion of Non-Motile Pseudomonas aeruginosa on "Soft" Polyelectrolyte Layer in a Radial Stagnation Point Flow System: Measurements and Model Prediction", Langmuir, 23, 2007, 12301-12308.

McGinnis, R.L., McCutcheon, J.R., and Elimelech, M. "A Novel Ammonia - Carbon Dioxide Osmotic Heat Engine for Power Generation", Journal of Membrane Science, 305, 2007, 13-19.

Kang, S., Pinault, M., Pfefferle, L.D., and Elimelech, M. "Single-Walled Carbon Nanotubes Exhibit Strong Antimicrobial Activity", Langmuir, 23, 2007, 8670-8673.

de Kerchove, A.J. and Elimelech, M. "Impact of Alginate Conditioning Film on Deposition Kinetics of Motile and Nonmotile Pseudomonas aeruginosa Strains", Applied & Environmental Microbiology, 73, 2007, 5227-5234.

McCutcheon, J.R., and Elimelech, M. "Modeling Water Flux in Forward Osmosis: Implications for Improved Membrane Design", AIChE Journal, 53, June 2007, 1736-1744.

Asatekin, A., Kang, S, Elimelech, M., and Mayes, A.M. "Anti-fouling Ultrafiltration Membranes Containing Polyacrylonitrile-Graft-Poly(Ethylene Oxide) Comb Copolymer Additives" , Journal of Membrane Science, 298, 2007, 136-146.

8. Scientific and Professional Societies of Which a Member

American Chemical Society, Association of Environmental Engineering Science Professors, American Institute of Chemical Engineers, American Society of Civil Engineers, American Water Works Association, International Association of Colloid and Interface Scientists, North American Membrane Society

9. Honors and Awards

2007	Connecticut Academy of Science and Engineering
2006	National Academy of Engineering
2006	AEESP Frontier of Research Award
2005	Clarke Prize, National Water Research Institute
2005	Trendsetter, Public Work Magazine
2004	Excellence in Review Award, Environmental Science & Technology
2004	Yale University Graduate Mentor Award
1996	American Society of Civil Engineers, Walter L. Huber Civil Engineering Research Prize
1994	W.M. Keck Foundation, Engineering Teaching Excellence Award
1990	National Science Foundation, Research Initiation Award

10. Courses Taught the Past Academic Year
Environmental Transport Processes (**ENVE 444a**)
Physical and Chemical Processes in Environmental Engineering (**ENAS 642b**)

11. Other Duties
Advisory Committee, Center for Industrial Ecology, School of Forestry & Environmental Studies; Yale College Course of Study Committee; Studies in the Environment Committee; Standing Advisory and Appointments Committee for the School of Forestry and Environmental Studies

12 Self Improvement:
Attended conferences: AIChE, ACS, AGU, NAMS, ASCE
Organized Sessions at: AIChE, ACS, and NAMS Annual Meetings`

Gary L. Haller

1. Academic rank: Professor, Chemical Engineering and Chemistry
2. Degrees: Ph.D. Northwestern University, Chemistry, 1966
   B.S. University of Nebraska at Kearney, Mathematics, 1962
3. Years of service on this faculty: 41

July 1967	Assistant Professor, Department of Engineering and Applied Science
July 1972	Associate Professor, Department of Engineering and Applied Science
July 1980	Professor, Department of Engineering and Applied Science
July 1981	Professor, Department of Chemical Engineering
July 1985	Professor, Department of Chemical Engineering and Chemistry

4. Other related experience:

Sept. 1966- Sept. 1967	NATO Postdoctoral Fellow, Oxford University
Dec. 1971- July 1972	Universite Catholique de Louvain, Belgium
Summer 1974	U. N. Ind. Dev. Org., Consultant, Bahia Blanca, Argentina
Summer 1975	Chair, Gordon Research Conference on Catalysis
Jan. 1977- Dec. 1979	Council of the Gordon Research Conferences
Jan. 1989- Dec. 1991	Council of the Gordon Research Conferences
Sept. 1977- Sept. 1981	Intern. Union of Pure and Applied Chemistry, Associate Member, Commission on Colloid and Surface Chemistry
Mar. 1978 - Aug. 1978	Sci. Res. Council, Sen. Visiting Fellow, Univ. of Edinburgh
Jan. 1982 - Dec. 1982	Chair, Div. of Colloid and Surface Chem., Am. Chem. Soc.
July 1981 - Dec. 1981	Visiting Scholar, National Bureau of Standards
Aug. 1986 - present	Member, CT Academy of Science and Engineering
July 1992 -July 1996	General Chairman, 11th Intern. Congr. on Catalysis

5. Consulting: Jan. 1986 - present Engelhard Corp.
6. Not a professional engineer
7. Principal publications of last five years:

X-ray Absorption Spectroscopic Investigation of Partially Reduced Cobalt Species in Co-MCM-41 Catalysts during Synthesis of Single-Wall Carbon Nanotubes, Dragos Ciuparu, P. Haider, Y.Chen, Steven S Lim, Gary L Haller, Lisa D Pfefferle, 2005, Journal of Physical Chemistry B, 109(34), 16332-39.

Pore Curvature Effect on the Stability of Co-MCM-41 and the Formation of Size-Controllable Subnanometer Co Clusters, Steven S Lim, Dragos Ciuparu, Yuan Chen, Yanhui Yang, Lisa D Pfefferle, Gary L Haller, 2005, Journal of Physical Chemistry B, 109(6), 2285-229.

Uniform-Diameter Single-Walled Carbon Nanotubes Catalytically Grown in Cobalt-Incorporated MCM-41, Dragos Ciuparu, Y. Chen, Steven S Lim, Gary L Haller, Lisa D Pfefferle, 2004, Journal of Physical Chemistry B, 108(2), 503-507.

Synthesis of Uniform Diameter Single-wall Carbon Nanotubes in Co-MCM-41: Effects of the Catalyst Prereduction and Nanotube Growth Temperatures , Y. Chen, D. Ciuparu, Steven S Lim, Y. Yang, Gary L Haller, Lisa D Pfefferle, 2004, J. Catal., 225, 453.

Multivariate Correlation and Prediction of the Synthesis of Vanadium Substituted Mesoporous Molecular Sieves , Y. Yang, Steven S Lim, C. Wang, D. Harding, Gary L Haller, 2004, Micropor. Mesopor. Mater., 67, 245.

Synthesis and Characterization of Highly Ordered Co-MCM-41 for Production of Aligned Single Walled Carbon Nanotubes (SWNT) , Steven S Lim, D. Ciuparu, C. Pak, F. Dobek, Y. Chen, D. Harding, Lisa D Pfefferle, Gary L Haller, 2003, J. Phys. Chem. B, 107(40), 11048.

8. Scientific and Professional societies of which a member: American Association for the Advancement of Science, American Chemical Society, American Institute of Chemical Engineers, The North American Catalysis Society, Sigma XI

9. Honors and awards:

   Professeur Invité à l'Université Pierre et Marie Curie (Paris VI), 1996; NIOK (Netherlands Institute for Catalysis Research) Lecturer (Guest Teacher), 1996; Lacey Lecturer in Chemical Engineering; California Institute of Technology, 1996; Ipatieff Lectureship; Northwestern University, 1996 ; Harry Fair Lectureship; University of Oklahoma, 1995; Robert Burwell Lectureship; The Catalysis Society, sponsored by Amoco, 1995

   Yale Science and Engineering Association Meritorious Service Award, 1995; Catalysis Society of Metropolitan New York Award for Excellence in Catalysis, sponsored by Exxon Research and Engineering Company, 1993; The George C. A. Schuit Lectureship, Center for Catalytic Science and Technology; University of Delaware, October 17, 1990; Kearney State College Outstanding Alumni Award, 1988; Donald E. Fox Chemistry Lectureship; Kearney State College, NB, 1982

10. Courses taught this academic year:

    no teaching due to service as Master of Jonathon Edwards College

11. Other assigned duties:

    Master, Jonathan Edwards College

    Committees Teachers Institute Executive Committee; Honorary Degree Committee; Dean of Drama School Search Committee; Tercentennial Steering Committee; Provost's Music Advisory Committee; Council of Master's Committee on Agenda; Council of Master's Committee on Creative and Performing Arts; Council of Master's Committee on Awards

12. Self improvement:

    Annual meeting of AIChE, ACS, Gordon Conf. On Catalysis, various NSF and/or DOE workshops, i.e. NSF workshop on electrocatalysis, DOE workshop on x-ray adsorption in catalysis

Yehia F. Khalil

1. Academic Rank: Associate Professor (Adjunct)

2. Degrees: N.E., Nuclear Engineering, Massachusetts Institute of Technology (MIT), 1985
   M.S., Nuclear Engineering, Massachusetts Institute of technology (MIT), 1985
   M.S., Chemical Engineering, Massachusetts Institute of Technology (MIT), 1986
   Ph.D., Chemical Engineering, University of Connecticut at Storrs, 1992
   Sc.D., Management, University of New Haven, 1997

3. Years of service on this faculty: 16 years

4. Other related experience:
   2006-2007 MIT Sloan School of Management and School of Engineering
   Certification Program in System Engineering and Design, Cambridge, MA
   2001 National Academy for Nuclear Training, Atlanta, GA
   Engineering Supervisors Professional Certification Program
   2001 Yale School of Management (SOM), Yale University, New Haven, CT
   Executive Advanced program in Management Leadership
   2004 University of Phoenix (UOP), Phoenix, AZ
   Critical Thinking (CT) Teaching Methods Certification
   2004 School of Advanced Studies (SAS), University of Phoenix (UOP), Phoenix, AZ
   Principal Investigator Certification – Protection of Human Research subjects

5. Consulting:

6. Professional engineer?

7. Principal publications of last five years:

Authored and co-authored over 40 peer-reviewed articles and reports on nuclear safety, risk assessment, and use of PRA to support homeland security.

Technical reviewer for the Wear International Journal (an international journal on the science and technology of friction and wear, published by Elsevier Science, Oxford, England), Nuclear Technology Journal, and Journal of the American Society for Mechanical Engineers (ASME.)

Book review editor for the Society of Risk Analysis (SRA). Recent book reviews include:

"Management of Engineering Risk," by Roger B. Keey
"The Particulate air Pollution Controversy – A case Study and Lessons Learned," by Robert F. Phalen

Technical Reviewer for the journal of environmental Management (JEM), Berkeley, CA

Newsletter editor, MIT Alumni Club of Hartford, CT

8. Scientific and professional societies of which a member:

1992 – 1993 And 1998 – Present	Chairman of the American Nuclear Society (ANS), State of Connecticut
	Chairman and faculty advisor of the American Institute of Chemical Engineers AIChE, Yale University Chapter.
1985 – Present	Member of the American Chemical Society (ACS)
1985 – Present	Member of the American Institute of Chemical Engineers (AIChE)
1985 – Present	Member of the Sigma XI society, MIT Chapter

9, Honors and Awards:

1980 – 1982	Fulbright Scholar
1980 – 1982	MIT Fellow, Advanced Engineering Studies
1982 – 1984	MIT Research Scholarship, Plasma fusion Center
1984	Bethlehem Steel Guest Fellowship
1985	General Electric (GE) Fellowship
1993	The American Nuclear Society (ANS) Best Author Recognition Award
1997	Best Technical Paper Awards (in fundamental research category) in Safety Risk Assessment, ASME International
2004	Best Technical Paper (accepted with honors) on use of PRA for security Vulnerability assessment, ASME International, Nuclear Engineering Division, (ICONE-12)
1995 and 1998	ABB Combustion Engineering (ABB-CE) Recognition Plaques
1999 and 2003	The Japan Society of Mechanical Engineers (JSME International) Recognition Plaques for Technical Leadership in Safety and Reliability Analysis, Tokyo, Japan
2001	Societe' Francaise D' Energie Nucleaire, Recognition Award for Safety and Reliability Studies, Nice, France
2003	Certificate of Recognition, U.S. Department of Energy (US DOE)
2004, 2005 and 2006	ASME International Recognition Award for Technical Leadership in the field Of Safety and Security
2005	Outstanding Achievement Award, United Technologies Research Center (UTRC)

10. Courses taught last two academic years:

CENG 412	Chemical Engineering Laboratory – Spring 2008
CENG 416	Chem Engineering Process Design – Spring 2008
CENG 411	Separation & Purification Processes – Fall 2007
CENG 416	Chem Engineering process Design – Spring 2007
CENG 412	Chemical Engineering Laboratory – Spring 2007
CENG 373	Air Pollution Control – Fall 2006
CENG 411	Separation & Purification Processes – Fall 2006

11. Other assigned duties: MIT Energy Advisory Council for Connectictut

12: Self-improvement: Attended "hydrogen technology conference" sponsored by the Department of Energy and the National Fire Protection Association at the National Renewable Energy Laboratory, 2008.

Michael Loewenberg

1. Academic rank: Professor of Chemical Engineering
2. Degrees:
    - Ph.D., (Chemical Engineering), California Institute of Technology, 1988
    - B.S., (Chemical Engineering), Purdue University, 1982
3. Years of service on this faculty: 14
    - Jan. 1995 – June 2000, Assistant Professor
    - July 2000 – June 2003, Associate Professor
    - July 2003 – Present, Professor
4. Other related experience:
    - Postdoc with Prof. John Hinch, Dept. Phys. & Appl. Math., Univ. Cambridge, UK., 1994
    - Postdoc with Prof. Rob Davis, Chemical Eng., Univ. Colorado, 1991-1994
    - Postdoc with Dr. Dick O'Brien, Dept. Appl. Math., Univ. New South Wales, 1988-1991
5. Consulting:
    - Nestle Foods (Geneva), 1998, Inhale Therapeutics, 1998
6. Is/is not a professional engineer: Is not a professional engineer
7. Principal publications of last five years:

    Nemer, M., Chen, X., Papadopoulos, D. H., Blawzdziewicz, J.& Loewenberg, M., 2004, Hindered and accelerated coalescence of drops in Stokes flow. Phys. Rev. Letters 92, 114501. [pdf]

    Ismail A.E. & Loewenberg, M. 2004 Long-time evolution of a drop size distribution by coalescence in a linear flow. Phys. Rev. E. 69 46307.

    Vlahovska, P., Blawzdziewicz, J. & Loewenberg, M., 2005, Deformation of a surfactantcovered drop in a linear flow. Phys. Fluids, bf 17, 103103.

    Nemer, M.B., Chen, X., Papadopoulos, D.H., Blawzdziewicz, J, & Loewenberg, M., 2007, Comment on ”Two touching spherical drops in uniaxial extensional flow: Analytical solution to the creeping flow problem”. J. Colloid Interface Sci., 308, 1–3.

    Hashmi, S.M., Loewenberg, M. & Dufresne, E.R., 2007, Spatially extended FCS for visualizing and quantifying high-speed multiphase flows in microchannels. Optics Express, 15 6528-6533.
8. Professional societies of which a member: AIChE and AIP
9. Honors and awards:
    - Presidential Early Career Award for Scientists and Engineers (PECASE) ``in recognition of novel research on viscous multiphase fluids leading to the development of predictive models for use in the chemical and manufacturing industries," 1999.
    - CAREER Award, National Science Foundation, 1996
    - Outstanding Paper Award ``Drop deformation and breakup in isotropic turbulence." AIChE annual meeting, 1997
    - American Physical Society, Andreas Acrivos Dissertation Prize in Fluid Dynamics awarded to Vittorio Cristini “for important theoretical and numerical contributions to the description and understanding of drop dynamics and breakup in laminar and turbulent flows," (Loewenberg, graduate advisor)

10. Courses taught this academic year:
    Fall 2007
    ENAS 603a, Energy and Mass Transport Processes
    Spring 2008
    CENG 315b/ENVE 315b, Transport Phenomena
11. Other assigned duties:
    Director of Undergraduate Studies. Chemical Engineering, 1997-present
    Chair of ABET Committee in Chemical Engineering, 2000-2002
    Faculty Advisor for Yale Science and Engineering Association, 2001-present
    Faculty Advisor for AIChE student chapter, 2001-present
12. Self Improvement:
    Attendance and presentation at annual meetings: AIChE and AIP

Jodie Lutkenhaus

1. Academic Rank: Assistant Professor starting July 2008
2. Degrees:
   2007 Ph.D. Chemical Engineering, Massachusetts Institute of Technology
   2002 B.S. Chemical Engineering, The University of Texas at Austin
3. Years of service on this faculty: less than 1
4. Other Related Experience:

   2007-2008 Post-Doctoral Fellow, Department of Polymer Science and Engineering, University of Massachusetts Amherst
5. Consulting: None
6. Is not a professional engineer
7. Principal Publications of the Last Five Years

   Lutkenhaus, J. L.; McEnnis, K.; Hammond, P. T., Structure and Ionic Conductivity of Microporous Poly(ethylene imine)/Poly(acrylic acid) Layer-by-Layer Assemblies. Accepted to *Macromolecules*.

   Lutkenhaus, J. L.; Hammond, P. T., "Electrochemically enabled polyelectrolyte multilayer devices: from fuel cells to sensors." Invited Review. *Soft Matter* 2007, 3, 804–816.

   Lutkenhaus, J. L.; McEnnis, K.; Hammond, P. T., "The Glass Transition and Ionic Conductivity of Poly(ethylene oxide)/Poly(acrylic acid) Layer-by-Layer Assemblies". *Macromolecules* 2007, 40, (23), 8367-8373.

   Lutkenhaus, J. L.; Olivetti, E. O.; Verploegen, E. A.; Cord, B.; Sadoway, D. R.; Hammond, P. T., "Anisotropic Structure and Transport in Self-Assembled Layered Polymer-Clay Nanocomposites." *Langmuir* 2007, 23, (16), 8515-8521.

   Lutkenhaus, J. L.; Hrabak, K. D.; McEnnis, K.; Hammond, P. T., "Elastomeric Flexible Free-Standing Hydrogen-Bonded Nanoscale Assemblies." *Journal of the American Chemical Society* 2005, 127, (49), 17228-17234.
8. Scientific and Professional Societies of Which a Member

   American Institute of Chemical Engineers, American Chemical Society, American Physical Society, Materials Research Society, Electrochemical Society
9. Honors and Awards

   2006 Electrochemical Society Graduate Student Travel Award
   2002-2005 National Science Foundation Graduate Research Fellowship
   2002-2003 Presidential Graduate Fellowship
   2002 Hertz Fellowship Finalist
10. Courses Taught the Past Academic Year
    No courses yet taught
11. Other Duties
    No university duties as of yet
12. Self Improvement:
    Attended conferences: AIChE, ACS, MRS, APS; Chaired Sessions: APS; Attended Path of Professorship Workshop at MIT; Attended NSF Polymers 2007 Workshop

William A. Mitch

1. Academic Rank: Associate Professor

2. Degrees: Ph.D. 2003 University of California at Berkeley (Civil/Environmental Engineering)

   M.S. 1996 University of California at Berkeley (Civil/Environmental Engineering)
   B.A. 1993 Harvard University (Anthropology)

3. Years of service on this faculty: 5
   July 2003 - December 2007 Assistant Professor
   December 2007 – present Associate Professor

4. Other related experience:
   1998-2000 Senior Staff Engineer, Kennedy/Jenks Consultants, San Francisco, CA.
   1997-1998 Assistant Engineer, Montgomery Watson, Walnut Creek, CA.
   1994-1995 Staff Analyst, Environmental Solutions for Business, Billerica, MA.

5. Consulting – occasionally

6. Professional Civil Engineer License #61429 in California

7. Principal publications of last five years:

   Mitch, W.A.; Schreiber, I.M. Degradation of tertiary alkylamines during chlorination/chloramination: implications for formation of aldehydes, nitriles, halonitroalkanes, and nitrosamines. *Environ. Sci. Technol.,* in press.

   Kemper, J.M.; Ammar, E.; Mitch, W.A. Abiotic degradation of RDX in the presence of hydrogen sulfide and black carbon. *Environ. Sci. Technol.,* **2008**, 42 *(6),* 2118-2123.

   Walse, S.S.; Mitch, W.A. Nitrosamine carcinogens also swim in pools. *Environ. Sci. Technol.,* **2008,** *42* (4), 1032 – 1037.

   Schreiber, I.M.; Mitch, W.A. Enhanced nitrogenous disinfection byproduct formation near the breakpoint: implications for nitrification control. *Environ. Sci. Technol.,* **2007**, *41 (20),* 7039-7046.

   Joo, S.-H.; Mitch, W.A. Nitrile, aldehyde and halonitroalkane formation during chlorination/chloramination of primary amines. *Environ. Sci. Technol.,* **2007,** *41 (4),* 1288-1296.

8. Scientific and professional societies of which a member:
   American Chemical Society
   American Association of Environmental Engineering Professors

9. Honors and Awards:
   2007 NSF CAREER Award
   2004 Outstanding Doctoral Dissertation Award from the Association of Environmental Engineering and Science Professors and Parsons Engineering.

10. Courses taught last two academic years:
    Water Quality Control, ENVE 377b/CENG 377b
    Environmental Organic Chemistry, ENAS 644a

Chinedum Osuji

Academic Rank: Assistant Professor of Chemical Engineering

Degrees with fields, institution, and date:
- BS, Materials Science and Engineering, Cornell University, 1996
- PhD, Materials Science and Engineering, Massachusetts Institute of Technology, 2003

Number of years service on this faculty: 1 Year
- Assistant Professor, Yale University (July 2007)

Other related experience--teaching, industrial, etc.:
- Postdoctoral associate: Harvard University (March 2005-June 2007)
- Senior Scientist, Surface Logix Inc. (September 2002-March 2005)

Consulting, patents, etc.:
- Panel reviewer for NSF

State(s) in which registered: None

Principal publications of last five years:

"Shear Thickening and Gel Elasticity in a Colloidal System with Attractive Interactions." C. O. Osuji, C. Kim, D. A. Weitz. *Phys. Rev. E.* **77** 060402 (2008)

"Highly Anisotropic Vorticity Aligned Structures in a Shear Thickening Attractive Colloidal System." C. O. Osuji and D. A. Weitz. In press, *Soft Matter* 2008, doi:10.1039/ b716324j.

"Supramolecular Microphase Separation in a Hydrogen Bonded Liquid Crystalline Comb Copolymer in the Melt State." C. O. Osuji, C. Y. Chao, C. K. Ober and E. L. Thomas. *Macromolecules* 39:3114-3117, 2006.

"Alignment of Self-Assembled Hierarchical Microstructure in Liquid Crystalline Diblock Copolymers Using High Magnetic Fields." C. O. Osuji, P. Ferreira, G. Mao, C. K. Ober, J. B. Vander Sande and E. L. Thomas. *Macromolecules* 37:9903-9908, 2004.

"Orientational switching of mesogens and microdomains in hydrogen-bonded side-chain liquid-crystalline block copolymers using AC electric fields." C-Y Chao, C. O. Osuji, X-F Li, C. K. Ober and E. L. Thomas. *Advanced Functional Materials*, 14 (4), 364-370, 2004.

Scientific and professional societies of which a member:
- American Institute of Chemical Engineers
- American Chemical Society
- American Physical Society
- Materials Research Society
- Society of Rheology

Honors and awards:
- MIT Program in Polymer Science and Technology Graduate Fellow.
- MIT: Omnova award for graduate research
- NSF Padden award symposium member

Institutional and professional service in the last five years: None

Professional development activities in the last five years: None.

Jordan Peccia

1. Academic Rank: Assistant Professor

2.. Degrees: Ph.D. 2000, University of Colorado (Environmental Engineering)
M.S. 1995, Montana State University (Environmental Engineering)
B.S. 1993, Montana State University (Mechanical Engineering)

3. Years of service on this faculty: 3
July 2005 – present, Assistant Professor

4. Other related experience:

2001-2005 Assistant Professor, Arizona State University, Department of Civil and Environmental Engineering

2000-2001 Post doctoral researcher, University of Wisconsin, Department of Civil and Environmental Engineering

5. Consulting:

1995-1996 Conoco, Inc., Houston, TX

1993 RPA Civil Engineering, Helena, MT

6. Professional engineer: License number 11642 PE. Licensed in MT

6. Principal publications of last five years:

Baertsch, C., Paez-Rubio, T., Viau, E., **Peccia, J.** (2007) "Source tracking aerosols released from land-applied class B biosolids during high wind events, *Applied and Environmental Microbiology,***73**, 4522-4531.

Paez-Rubio, T., Ramarui, A., Sommer, J., Xin, H., Anderson, J. and **Peccia, J.** (2007) "Emission Rates and Characterization of Aerosols Produced During the Spreading of Dewatered Class B Biosolids" *Environmental Science and Technology*, **41,** 3537-3544.

Rittmann, B.E., Haunser, M, Loeffler, F., Love N.G., Muyzer G., Okabe S., Oerther D.B., **Peccia J.** Raskin R., Wagner M. (2006) "A vista for microbial ecology and environmental biotechnology" *Environmental Science and Technology*, **40**:1096-1103.

Paez-Rubio, T, E. Viau, S. Romero-H., **J. Peccia** (2005). Source bioaerosol concentration and rDNA-based identification of microorganisms aerosolized during agricultural wastewater reuse." *Applied and Environmental Microbiology*: **71**: 804-810.

Boreson, J., A. M. Dillner, and **J. Peccia** (2004). "Correlating bioaerosol load with PM2.5 and PM10cf concentrations: a comparison between natural desert and urban fringe aerosols." *Atmospheric Environment.* **38**: 6029-6041.

8. Scientific and professional societies of which a member:
American Society for Microbiology
Pan American Aerobiology Association
American Association of Environmental Engineering Professors

9. Honors and awards:
ASCE-ASU Civil Engineering Instructor of the Year (2004)
Teaching Excellence Award, Fulton School of Engineering, Arizona State

CAREER Award, National Science Foundation (2004)
AEESP/CH2MHILL Outstanding Environmental Engineering Doctoral Thesis Award (2001)

10. Courses taught last two academic years:
    CENG/ENVE 120, Introduction to Environmental Engineering
    SCIE 198, Perspective on Science
    ENVE 441/641, Biological Processes in Environmental Engineering

11. Other assigned duties:
    Director of undergraduate studies, Environmental Engineering, Fall 2006
    Graduate students admission committee

12. Self -improvement
    ASCE fellow and mentor for Excellence in Civil Engineering Education program (2003, 2004)

Lisa D. Pfefferle

1. Academic Rank: Professor
2. Degrees:
   1984 PhD in Chemical Engineering, University of Pennsylvania
   BSE in Chemical Engineering, Princeton University
3. Years of service on this faculty: 18
   July 1997 - present Professor tenured, Chemical Engineering, Yale University
   July 1988-June 1997 Associate Professor, Chemical Engineering, Yale University
   July 1984-June 1988 Assistant Professor, Chemical Engineering, Yale University
4. Other experience:
   1982 Lecturer, Chemical Engineering, University of Pennsylvania
   1977-79 Technical Support/Process Supervisor, E.I. Dupont de Nemours
5. Consulting, patents, etc:

Consulting: Precision Combustion; Georgia Tech Carbon Nanotube FETs

3 Patents Granted: Carbon Nanotubes Templated Using MCM-41, Synthesis of GaN Nanotubes; Structure of Material: Boron Single-walled Nanotube and Superconductivity; 4 other patent applications and several more disclosures.

6. Is not a professional engineer
7. Selected Principal Publications of last five years:
   1. T. R. Fadel, E. R. Steenblock, E. Stern, N. Li, X. Wang, G. L. Haller, L. D. Pfefferle, "Enhanced cellular activation with single walled carbon nanotube bundles presenting antibody stimuli", *Nanoletters*, In press (online), 2008.
   2. C. S. McEnally, L. D. Pfefferle, "Decomposition and hydrocarbon growth processes for hexadiences in nonpremixed flames," *Combustion and Flame*, 152 (4): 2008, 469-481
   3. C. S. McEnally, L. D. Pfefferle, "The effects of dimethyl ether and ethanol on benzene and soot formation in ethylene nonpremixed flames," *Proceedings of the Combustion Institute*, 31: 2007, 603-610 Part 1.
   4. Y. Chen; L. Wei, B. Wang, S. Y. Lim, D. Ciuparu, M. Zheng, J. Chen, C. Zoican, Y. H. Yang, H. L. Haller, L. D. Pfefferle, "Low-defect, purified, narrowly (n.m)-dispersed single-walled carbon nanotubes grown from cobalt-incorporated MCM-41", *ACS Nano*, 1 (4): 2007, 327-336.
   5. Y. Chen, B. Wang, L. J. Li, Y. H. Yang, D. Ciuparu, S. Y. Lim, G. L. Haller, L. D. Pfefferle, "Effect of different carbon sources on the growth of single-walled carbon nanotube from MCM-41 containing nickel", *Carbon*, 45 (11): 2007, 2217-2228.
   6. G. Du, L. Lim, Y.H. Yang, C.Wang, L.D. Pfefferle, G.L. Haller, "Methanation of carbon dioxide on Ni-incorporated MCM-41 catalysts: The influence of catalyst pretreatment and study of steady-state reaction", *Journal of Catalysis*, 249(2): 2007, 370-379.
   7. S. Kang, M. Pinault, L.D. Pfefferle, M. Elimelech, "Single-walled carbon nanotubes exhibit strong antimicrobial activity", *Langmuir*, 23(17): 2007, 8670-8673.
   8. K. Persson, L.D. Pfefferle, W. Schwartz, A. Ersson, S.G. Jaras, "Stability of palladium-based catalysts during catalytic combustion of methane: The incluench of water", *Applied Catalysis B-Environmental*, 74(3-4): 2007, 242-250.
   9. S.Y. Lim, C. Wang, Y.H. Yang, D. Diuparu, L.D. Pfefferle, G.L. Haller, "Evidence for anchoring and partial occlusion of metallic clusters on the pore walls of MCM-41 and effect on the stability of the metallic clusters" *Catalysis Today*, 123(1-4): 2007, 122-132.
   10. S. Lim, D. Diuparu, Y.H. Yang, G.A. Du, L.D. Pfefferle, G.L. Haller, "Improved synthesis of highly ordered Co-MCM-41", *Microporous and Mesoporous Materials*, 101(1-2): 2007, 200-206.
   11. C. McEnally, L.D. Pfefferle, "Improved sooting tendency measurements for aromatic hydrocarbons and their implications for naphthalene formation pathways" *Combustion and Flame*, 148(4): 2007, 210-222.
   12. Z.T. Luo, L.D. Pfefferle, H.G. Haller, F. Papadimitrakopoulos, "(n,m) abundance evaluation of single-walled carbon nanotubes by fluorescence and absorption spectroscopy", *Journal of the American Chemical Society*, 128(48): 2006, 15511-15516.
   13. S. Lim, A. Ranade, G.A. Du, L.D. Pfefferle, H.L. Haller, "Pseudomorphic synthesis of large-particle Co-MCM-41" *Chemistry of Materials*, 18(23): 2006, 5584-5590.

14. G.A. Du, Y.H. Yang, W. Qiu, S. Lim, L.D. Pfefferle, H.L. Haller, "Statistical design and modeling of the process of methane partial oxidation using V-MCM-41 catalysts and the prediction of the formaldehyde production", *Applied Catalysis A-General*, 313(1): 2006, 1-13.

15. W. Schwartz, C. McEnally, L.D. Pfefferle, "Decomposition and hydrocarbon growth processes for esters in non-premixed flames", *Journal of Physical Chemistry A*, 110(21): 2006, 6643-6648.
16. G.A. Du, S.Y. Lim, Y.H. Yang, C. Wang, L.D. Pfefferle, G.L, Haller, "Catalytic performance of vanadium incorporated MCM-41 catalysts for the partial oxidation of methane to formaldehyde", *Applied Catalysis A-General*, 302(1): 2006, 48-61.
17. Y. Chen, D. Ciuparu, S. Lim, G.L. Haller, L.D. Pfefferle, "The effect of the cobalt loading on the growth of single wall carbon nanotubes by CO disproportionation on Co-MCM-41 catalysts", *Carbon*, 44(1): 2006, 67-78.
18. C. McEnally, L.D. Pfefferle, B. Atakan, K. Kohse-Hoinghaus, "Studies of aromatic hydrocarbon formation mechanisms in flames: Progress towards closing in fuel gap", *Progress in Energy and Combustion Science*, 32, 2006, 247-294.
19. J. Su, G. Cui, M. Gherasimova, H. Tsukamoto, J. Han, D. Ciuparu, S. Lim, L.D. Pfefferle, "Catalytic growth of group III-nitride nanowires and nanostructures by metalorganic chemical vapor deposition", *Applied Physics Letters*, 86, 2005, 013105.
20. C. McEnally, L.D. Pfefferle, "Fuel decomposition and hydrocarbon growth processes for oxygenated hydrocarbons: Butyl Alcohols", *30th Int'l. Symposium on Combustion*, 30, 2005, 1363-1370.
21. C. McEnally, L.D. Pfefferle, "Fuel decomposition and hydrocarbon growth processes for substituted cyclohexanes and for alkenes in nonpremixed flames*", 30th Int'l Symposium on Combustion*, 30, 2005, 1425-1432.
22. Y. Li, Y. Chen, R. Ziang, D. Ciuparu, L.D. Pfefferle, C. Horvath, J. Wilkins, "Incorporating single wall carbon nanotubes into organic polymer monolith as the stationiary phase for μ-HPLC and capillary electrochromatography, *Analytical Chemistry,* 77, 2005, 1398.
23. P. Haider, Y. Chen, L. Sangyun, G.L. Haller, L.D. Pfefferle, D. Ciuparu "Application of the generalized 2D correlation analysis to dynamic near edge X-ray absorption spectroscopy data. *J. Am. Chem. Soc*., 127, 2005, 1906
24. P. Amama, S. Lim, D. Ciuparu, L.D. Pfefferle, G.L. Haller, "Synthesis of highly ordered MCM-41: Engineering of pore size", *J. Phys. Chem*., 109, 2005, 2285.
25. C. McEnally, L.D. Pfefferle, "Decomposition and hydrocarbon growth processes for hexenes in nonpremixed flames", *Combustion and Flame*, 143, 2005, 246-263.
26. P. Amama, S. Lim, D. Diuparu, Y. Yang, L. Pfefferle, G.L. Haller, "Synthesis, Characterization, and Stability of Fe-MCM-41 for Production of Carbon Nanotubes by Acetylene Pyrolysis", *J. Phys. Chem., 109 (7*), 2005, 2645-2656.
27. P. Amama, S. Lim, D. Ciuparu, L. Pfefferle, G.L. Haller, "Hydrothermal synthesis of MCM-41 using different ratios of colloidal and soluble silica", *Microporous and Mesoporous Materials*, 81 (1-3): 2005, 191-200.

8. Professional Society Memberships: The Combustion Institute, Executive Committee Eastern States, Program Chair last Eastern States Combustion meeting

9. Honors and awards:

1997 Best Paper Award, 1996 AIChE Annual Meeting;

2005 IBM faculty Award; for carbon nanotubes advances

10. Classes taught: Fall: Undergraduate projects 2hr/week

Fall 2007: ChE 373a Air Pollution

Spring, 2008: ChE 301b Chemical Kinetics and Reactors

Also teach: ChE 210a – Introduction to Chemical and Environmental Engineering

11. Other duties:

Freshman Advisor

12. Self Improvement:

Learning biomedical engineering techniques related to protein adsorption an nanotubes for biomedical applications; coauthor antibody stimulation paper "Nanoletters"

Developed project on solar energy harvesting based on our new material GaN nanotubes

Daniel E. Rosner

1. Academic rank: Professor, Chemical Engineering
2. Degrees:

    Princeton University, Aeronautical Engineering (Chemical Propulsion), PhD 1961

    City College of New York, Mechanical Engineering, BME (summa cum laude) June 1955

    Brooklyn College, Pre-Engineering/Graphic Arts, Transfer to CCNY in 1953

3. Years of service on this faculty: 39 years

    July 1969-June 1974, Associate Professor

    July 1974, Professor

4. Other related experience

    Chairman, Yale Univ. Dept. Chemical Engineering (Guide development of curriculum and faculty ;1984-1987; 1993-1996)

    Head, Interface Kinetics and Transport Group, AeroChem Div.Sybron (Ritter-Pfaudler) Corp., Princeton NJ; 1967-1969; Research Scientist, 1958-1967

5. Consulting (Last 5 years):

    Engineering Calculations: duPont, Dresser-Rand, Columbian Carbon Co, NASA.

    Over a 30 year period, have been Engineering Consultant to ca. 12 corporations and industrial consortia (including ALCOA, Babcock & Wilcox, Columbian Chemicals, Dresser-Rand, duPont, EPRI, EXXON, GE, IFPRI, Pfaudler, Praxair, SCM-Chemicals and Union Carbide).

6. Not a Professional Engineer (took only first part of formal exam, upon graduation (1955)
7. Principal publications of last five years:

    Soret Effects in Combustion for Power Production or Chemical Synthesis, Daniel E Rosner, 2007, Progress in Energy and Combustion Science, in press.

    Soret-Modified Hydrocarbon Vapor Mass Transport Across Compressed Nonisothermal Gases, Daniel E Rosner, M. Arias-Zugasti, 2006, AIChE J, submitted.

    Soret-Shifted Dew-Point Temperatures for Surfaces Exposed to Hydrocarbon Vapors Dilute in Compressed Nitrogen, Daniel E Rosner, M. Arias-Zugasti, 2006, Chemical Engineering Science, submitted.

    Recent Progress on Improved Rate Laws and Population Simulation Methods: Applications to the Combustion Synthesis of Valuable Nano-particles, Daniel E Rosner, 2006, Int. J. Chem Reactor Engrg., 4.

    Drag on a Large Spherical Aggregate With Self-Similar Structure: An Asymptotic Analysis, P.L. Garcia-Ybarra, J.L. Castillo , Daniel E Rosner, 2006, J. Aerosol Science, 37, 413-428.

    Flame Synthesis of Nano-particles: Recent Progress/Current Needs in Areas of Rate Laws, Population Dynamics and Characterization, Daniel E Rosner, 2005, Industrial/Engineering Chem-Research, 44, 6045-6055.

    Calculation of Soret-Shifted Dew-Points by Continuous Mixture Thermodynamics, Daniel E Rosner, M. Arias-Zugasti, B. La Mantia, 2005, AIChE J, 51, 2811-2824.

8.Scientific and Professional societies of which a member:

AIChE, Combustion Inst., Chemical Heritage Soc., Amer. Chemical Soc, Amer. Assoc. Aerosol Research.

9. Honors and awards:

American Soc. Engineering Education 1988 Meriam/Wiley Engineering; Award for Textbook: Transport Processes in Chemically Reacting Flow Systems (Butterworth-Heinemann 1986,1988,1990); DOVER(2000); 1999 D. Sinclair senior scientist research award of the Amer. Assoc. Aerosol Research for sustained, outstanding contributions to aerosol science and technology; CCNY Engineering School Alumni (12,000); Career Achievement Award 1987; Guggenheim (Graduate) Fellowship(Chemical Propulsion), Princeton Univ. 1955-1957; Nominated for election to National Academy of Engineering, 2002; Nominated for R.H. Wilhelm Award (Chemical Reaction Engr.) of the AIChE, (2002);

10. Courses taught this academic year:

CENG 411 (Fall '07) Sabbatical leave

ENAS 606 (Spring '08) Topics in Advanced Multiphase Transport Processes

11. Other assigned duties:

Freshman adviser: Morse College

12. Self improvement:

Developer of new Yale/Engineering graduate courses in the areas of: Combustion Synthesis/Processing of Materials (also offered at NASA Glenn RC); Fine Particle Science and Technology; Multi-phase Chemical Reaction Engineering; Currently writing second book entitled: Combustion Synthesis/Processing of Materials

André D. Taylor

1. Academic Rank: Assistant Professor
2. Degrees:
   2005 Ph.D. Chemical Engineering, The University of Michigan
   2000 M.Sc. Chemical Engineering, Georgia Institute of Technology
   1995 B.Sc. Chemical Engineering, Missouri University of Science and Technology
3. Years of service on this faculty: 0, Start date 07/01/08
4. Other Related Experience:

   2007-8 *Research Scientist*, Department of Electrical Engineering, Optoelectronic Components and Materials Group, The University of Michigan, Ann Arbor, MI.

   2005-7 *Research Investigator*, Department of Chemical Engineering, The University of Michigan, Ann Arbor, MI.

   2001-5 *Graduate Research Assistant*, Department of Chemical Engineering, The University of Michigan, Ann Arbor, MI.

   2003-4 *Graduate Student Instructor*, Department of Chemical Engineering, The University of Michigan, Ann Arbor, MI.

   2002 *Organic Chemistry Instructor*, School of Dentistry, The University of Michigan, Ann Arbor, MI.

   2000-1 *Technology Transfer Engineer*, Intellectual Assets Business, E.I. DuPont de Nemours and Company, Wilmington, DE

   1997-9 *Graduate Research Assistant*, Department of Chemical Engineering, Georgia Institute of Technology, Atlanta, GA.

   1996 *Research Engineer*, Engineering Research Center, E.I. DuPont de Nemours and Company, Parkersburg, WV.

   1995 *Honors Intern,* Federal Bureau of Investigation, United States Department of Justice, Quantico, VA.

   1993-4 *Process Engineer***,** Corporate Engineering, Monsanto, St. Louis, MO.

   1992 *Project Engineer***,** Grey Iron Engineering Group, General Motors, Saginaw, MI.
5. Consulting:

   Inmatech (2006-8)

   E.I. DuPont de Nemors and Company (2001-2002)
6. Is not a professional engineer
7. Principal Publications of the Last Five Years

   Taylor A.D., Michel M., Sekol R., Kotov N., and Thompson L.T. (2008 – In Press). Fuel Cell MEAs (Membrane Electrode Assemblies) Created by Layer-By-Layer Electrostatic Self Assembly Techniques, *Advanced Functional Materials*.

   Taylor A.D., Sekol R., Kizuka J., and Comisar C. (2008 – In Press), Fuel Cell Performance and Characterization of 1-D Carbon Supported Pt Nanocomposites Synthesized in Supercritical Fluids, *Journal of Catalysis.*

   Michel M., **Taylor A.D.**, Sekol R., Kotov N., and Thompson L.T. (2007), High Performance, Nanostructured Membrane Electrode Assemblies for Fuel Cells Made by LBL of Carbon Nanocolloids *Advanced Materials,* 19, 3859-3864.

   Taylor A.D., Lucas B.D., Guo L.J., and Thompson L.T (2007), Nanoimprinted Electrodes for Micro Fuel Cell Applications. *Journal of Power Sources*, 171, 218-223.

Taylor A.D., Kim E., Humes V.P., Kizuka J., and Thompson L.T. (2007). Inkjet Printing of Carbon Supported Platinum 3-D Catalyst Layers for use in Fuel Cells. *Journal of Power Sources*, 171, 101-106.

Taylor A.D. and Thompson L.T. (2004). Integrated Micro Fuel Cell Power Supply. *IEEE Solid State Sensors and Actuators Workshop*, Hilton Head, South Carolina.

8. Scientific and Professional Societies of Which a Member

American Chemical Society, American Institute of Chemical Engineers, National Organization of Black Chemists and Chemical Engineers, National Society of Black Engineers, American Association for the Advancement of Science, Electrochemical Society

9. Honors and Awards

Eastman Kodak Dr. Theophilus Sorrell Fellowship Award 2003
University of Michigan Scholar Power Award Recipient 2002
NSF - University of Michigan Rackham Merit Scholar 2001-2006
GEM Fellowship Scholar 1995, 2000
Georgia Institute of Technology - Sloan Fellow 1996
National Collegiate Award Winner 1992, 1993
Who's Who Among American Colleges and Universities, '94, '95
Proclamation Recipient from the Mayor of Sedalia proclaiming "André Taylor Day"
University of Missouri - Rolla "Freshman of the Year" Award Winner 1992
African American Junior Achievement Award
Phillips Petroleum Scholar, 1993, 1994
E.R. Bryson Scholar 1993, 1994
Shelter Insurance Scholar
N.S.B.E. Academic Excellence Scholar 1992
National Merit Scholar, PSAT, Commended 1991
University of Missouri- Rolla Academic Scholarship Recipient

10. Courses Taught the Past Academic Year: none
11. Other Duties: None
12. Self Improvement:

Attended conferences: AIChE; Transducers, Actuators, and Solid State Sensors

T. Kyle Vanderlick

Academic Rank: Dean of Engineering, Thomas E. Golden Professor of Engineering

Degrees with fields, institution, and date:

Ph.D.	Chemical Engineering,	University of Minnesota	1988
M.S.	Chemical Engineering,	Rensselaer Polytechnic Institute	1983
B.S.	Chemical Engineering,	Rensselaer Polytechnic Institute	1981

Number of years service on this faculty, including date of original appointment and dates of advancement in rank: 1Year, January 2008.

- Assistant Professor, Chemical Engineering, University of Pennsylvania, 9/89 – 6/95
- Associate Professor, Chemical Engineering, University of Pennsylvania, 7/95 – 1/98
- Professor, Chemical Engineering, Princeton University, 2/98 – 12/07
- Assoc. Dean for Academic Affairs, School of Engineering & Applied Sciences, Princeton 7/03–7/04
- Chair, Department of Chemical Engineering, Princeton, 7/04 – 12/07
- Dean of Engineering and Thomas E. Golden Professor of Engineering, Yale University, 1/08 –

Other related experience--teaching, industrial, etc.:
- Visiting Scientist, Complex Fluids Laboratory, Rhone-Poulenc, NJ. 1/97 – 6/97
- NATO Postdoctoral Fellow, Universit¨at Mainz, West Germany, 9/88 – 8/89
- Industrial Trainee Fellow, Procter and Gamble, Cincinnati, OH, 6/81 9/81

Consulting, patents, etc.: None

State(s) in which registered: None

Principal publications of last five years:

1. Tanabe, H., Qu, X,Weeks, C. S., Cummings, J. E., Kolusheva, S., Walsh, K. B., Jelinek, R. , Vanderlick, T. K., Selsted, M. E., and Ouellette, A. J. Structure-Activity Determinants in Paneth Cell Defensins: Loss-of-Function in Mouse Cryptdin-4 by Charge-Reversal at Arginine Residue Positions, Journal of Biological Chemistry (2004) 279, 11976-11983.
2. Cha, P-R., Srolovitz, D. J., and Vanderlick, T. K. Molecular Dynamics Simulation of Single Asperity Contact, Acta Materialia (2004) 52, 3983-3996.
3. Frechette, J. and Vanderlick, T. K. Electrocapillary at Contact: Potential-Dependent Adhesion between a Gold Electrode and a Mica Surface, Langmuir (2005) 21, 985-991.
4. Frechette, J. and Vanderlick, T. K. Control of Adhesion and Surface Forces via Potential-Dependent Adsorption of Pyridine, Journal of Physical Chemistry B (2005) 109, 4007-4013.
5. Houston, J. E., Doelling, C. M., Vanderlick, T. K., Hu, Y., Scoles, G., Wenzl, I., and Lee, T. R. Comparative Study of the Adhesion, Friction, and Mechanical Properties CF3 and CH3-Terminated Alkanethiol Monolayers, Langmuir (2005) 21, 3926-3932.
6. Apel-Paz, M., Doncel, G. F., and Vanderlick, T. K. Impact of Membrane Cholesterol Content on the Resistance of Vesicles to Surfactant Attack, Langmuir (2005) 21, 9843-9849.
7. Davis, J.R., Piccarreta, M.V., Rauch, R.B., Vanderlick, T.K., Panagiotopoulos, A.Z. Phase behavior of rigid objects on a cubic lattice, Industrial Engineering Chemistry Research (2006) 45, 5421-5425.
8. Guo, W., Photos, P. J. and Vanderlick, T. K. Polymer Enhanced Fusion of Model Sperm Membranes as Induced by Calcium, Industrial and Engineering Chemistry Research (2006) 45, 5512-5517.

9. Troup, G.M., Wrenn, S.P., Apel-Paz, M., Doncel, G.F., and Vanderlick, T.K. A time-resolved fluorescence Diphenylhexatriene (DPH) anisotropy characterization of a series of model lipid constructs for the sperm plasma membrane, Industrial Engineering Chemistry Research (2006) 45, 6939-6945.
10. Weeks, C. S., Tanabe, H., Cummings, J. E., Crampton, S. P., Sheynis, T., Jelinek, R., Vanderlick, T. K., Cocco, M. J., and Ouellette, A. J. Matrix Metalloproteinase-7 Activation of Mouse Paneth Cell Pro-alpha-Defensins: Ser43 ↓Ile44 Proteolysis Enables Membrane-Disruptive Activity, Journal of Biological Chemistry (2006) 281, 28932-28942.
11. Cummings, J. E. and Vanderlick, T. K. Aggregation and Hemi-fusion of Anionic Vesicles Induced by the Antimicrobial Peptide Cryptdin-4, Biochimica Biophysica Acta (2007) 1768, 1796-1804.
12. Doelling, C.M., Songa, J., Srolovitz, D., and Vanderlick, T.K. Nano-spot-welding and contact evolution during cycling of a model microswitch, Journal of Applied Physics (2007) 101, 124303(1).
13. Cummings, J. E. and Vanderlick, T. K. Binding Orientation and Activity Determinants of the Antimicrobial Peptide Cryptdin-4 Revealed By Potency of Mutants, Colloids and Surfaces B: Biointerfaces (2007) 60, 236-242.
14. Cummings, J. E. and Vanderlick, T. K. Kinetics of Cryptdin-4 Translocation Coupled with Peptide-Induced Vesicle Leakage, Biochemistry (2007) 46, 11882-11891.
15. Beales, P.A. and Vanderlick, T.K. Specific binding of different vesicle populations by the hybridization of membrane-anchored DNA, Journal Physical Chemistry A (2007) 111, 12372-12380.
16. Apel-Paz, M., Doncel, G., and Vanderlick, T. K. Surfactants as Microbicidal Contraceptives: A Calorimetric Study of Partitioning and Translocatoin in Model Membrane Systems, Industrial and Engineering Chemistry Research (2008) 47, 3554-3561.

Scientific and professional societies of which a member: AIChE, APS, ACS, BPS

Honors and awards:

- Ethel Z. Casassa Memorial Lecturer, Carnegie Mellon, Department of Chemical Engineering, 2006.
- Grace Hopper Lecturer, University of Pennsylvania, Department of Chemical Engineering, 2002.
- President's Award for Distinguished Teaching, Princeton University, 2002.
- Princeton Engineering Council Teaching Award, Fall 2002.
- Van Ness Lecturer, Rensselaer Polytechnic Institute, Department of Chemical Engineering, 1997.
- Philip's Lecturer, Haverford College, Department of Physics, 1996.
- Class of 1942 Endowed Term Chair, University Pennsylvania, 1995.
- S. Reid Warren, Jr. Award for Distinguished Teaching 1994.
- Christian R. and Mary F. Lindback Foundation Award for Excellence in Teaching 1993.
- David and Lucile Packard Fellowship 1991.
- Presidential Young Investigator Award 1989.
- NATO Postdoctoral Fellowship in Science and Engineering (9/88–89).

Institutional and professional service in the last five years:

- External Reviewer for the Department of Chemical Engineering, University of Buffalo, 2008.
- External Reviewer for the Department of Chemical Engineering, UC Santa Barbara, 2008.
- External Reviewer for the School of Chemical Engineering, Purdue, 2007.
- Advisory Council, Department of Chemical and Engineering, University of Delaware, 2007.
- Visiting Committee, Department of Chemical and Biomolecular Engineering, Johns Hopkins, 2007.
- Technical Advisory Panel, HelioVolt Corporation, Austin, TX, 2006.
- External Reviewer for the School of Chemical and Biomolecular Eng., Cornell University, 2003.

Paul Van Tassel

1. **Academic Rank:** Professor of Chemical Engineering

2. **Degrees with fields, institution, and date:**
- BA, Chemistry and Mathematics, Saint Olaf College, 1987
- PhD, Chemical Engineering, University of Minnesota, 1993

3. **Number of years service on this faculty:** 5 Years
- Professor, Yale University (December 2006)
- Associate Professor, Yale University (January 2003 - December 2006)

4. **Other related experience--teaching, industrial, etc.:**
- Associate Professor, Wayne State University (August 2001 - December 2002)
- Assistant Professor, Wayne State University (August 1996 - August 2001)
- Postdoctoral Fellow, Université Pierre et Marie Curie, Paris, France (September 1993 - July 1996)

5. **Consulting, patents, etc.:**
- Consultant to Tricardia, LLC
- Review panel member for NSF, NIH

6. **State(s) in which registered:** None

7. **Principal publications of last five years:**
- "Integral equation theory of adsorption in templated materials: influence of molecular attraction", L. Sarkisov and P. R. Van Tassel, **2007**, *Journal of Physical Chemistry C*, 111, 15726.
- "Continuous polyelectrolyte adsorption under an applied electric potential", A. P. Ngankam and P. R. Van Tassel, *Proceedings of the National Academy of Sciences of the USA*, **2007**, 104, 1140.
- "Fibronectin terminated multilayer films: protein adsorption and cell attachment studies", C. R. Wittmer, J. A. Phelps, W. M. Saltzman, and P. R. Van Tassel, *Biomaterials*, **2007**, 28, 851.
- "Structuring of macro-ions confined between like-charged surfaces", A. Tulpar, P. R. Van Tassel, and J. Y. Walz, **2006**, *Langmuir*, 22, 2876.
- "Replica Ornstein-Zernike theory of adsorption in a templated porous material: interaction site systems", L. Sarkisov and P. R. Van Tassel, **2005**, *Journal of Chemical Physics*, 123, 164706.
- "Adsorbed layers of oriented fibronectin: a strategy to control surface-cell interactions", C. Calonder, H. W. T. Matthew, and P. R. Van Tassel, **2005**, *Journal of Biomedical Materials Research A*, 75, 316.
- "In-situ layer-by-layer film formation kinetics under an applied voltage measured by optical waveguide lightmode spectroscopy", **2005**, A. P. Ngankam and P. R. Van Tassel, *Langmuir*, 21, 5865.
- "Probing adsorbed fibronectin layer structure by kinetic analysis of monoclonal antibody binding", C. R. Wittmer and P. R. Van Tassel, **2005**, *Colloids and Surfaces B*, 41, 103.
- "Conformational transition free energy profiles of an adsorbed, lattice model protein by multicanonical Monte Carlo simulation", V. Castells and P. R. Van Tassel, **2005**, *Journal of Chemical Physics*, 122, 084707.
- "Probing macromolecular adsorbed layer structure via the interfacial cavity function", Y. Tie, A. P. Ngankam, and P. R. Van Tassel, **2004**, *Langmuir*, 20, 10599.
- "Fibronectin adsorption onto polyelectrolyte multilayer films", A. P. Ngankam, G. Mao, and P. R. Van Tassel, **2004**, *Langmuir*, 20, 3362.

8. **Scientific and professional societies of which a member:**
- American Institute of Chemical Engineers
- American Chemical Society
- American Physical Society

9. Honors and awards:

- J. William Fulbright Scholarship, France, 2006
- John J. Lee Associate Professorship of Chemical Engineering, 2005
- National Academy of Engineering: *Frontiers of Engineering*, 1999
- National Science Foundation CAREER Award, 1998
- NATO-NSF Post-Doctoral Fellowship, 1994
- Chateaubriand Post-Doctoral Fellowship, 1994
- University of Minnesota Graduate School Doctoral Dissertation Fellowship, 1992
- Alpha Chi Sigma Award, 1992
- Phi Beta Kappa, 1987

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

- Liaison to Director of Graduate Studies, Faculty of Engineering, July 2005 - June 2008.
- Director of Undergraduate Studies, Dept. of Chemical Engineering, July 2008 - present.

11. Professional development activities in the last five years:

- Attended, presented, and chaired professional conferences.

Corey J. Wilson

1. Academic Rank: Assistant Professor, July 1, 2008
2. Degrees:

   2005 Ph.D. Molecular Biophysics, Rice University
   2002 B.Sc. Chemistry, University of Houston – Clear Lake
   2002 B.Sc. Biological Sciences, University of Houston – Clear Lake

3. Years of service on this faculty: less than 1

   July, 2008*- present Assistant Professor, Department of Chemical Engineering

4. Other Related Experience:

   2006-2008 Postdoctoral Scholar, California Institute of Technology
   2005-2006 Postdoctoral Associate, Rice University, Houston, Texas
   2006-2008 Complimentary Scholar, Rice University, Houston, Texas
   2006-2008 Complimentary Scholar, University of California, San Diego
   2000-2002 Research Assistant, University of Texas Medical Branch

5. Consulting: None
6. Not a professional engineer
7. Principal Publications of the Last Five Years:

Couñago, R., Wilson, C.J., Wittung-Stafshede, P., and Shamoo, Y. (2008 – in press). An Adaptive Mutation in Adenylate Kinase that Increases Oraganismal Fitness is Linked to Stability-Activity Trade-Offs" *in press*: Protein Engineering Design and Selection.

Zong, C. [†], Wilson, C.J. [¶,†], Shen, T., Wittung-Stafshede, P., Mayo, S.L., and Wolynes, P.G. (2007). Establishing the entatic state in folding metallated Pseudomonas aeruginosa azurin. Proceedings of the National Academy of Sciences of the United States of America *104*, 3159-3164.

[¶] Corresponding Author; [†] authors made equal contributions

Wilson, C.J., Zhan, H., Swint-Kruse, L., and Matthews, K.S. (2007). The lactose repressor system: paradigms for regulation, allosteric behavior and protein folding. Cellular and Molecular Life Sciences *64*, 3-16.

Wilson, C.J., Zhan, H., Swint-Kruse, L., and Matthews, K.S. (2007). Ligand interactions with lactose repressor protein and the repressor-operator complex: the effects of ionization and oligomerization on binding. Biophysical Chemistry *126*, 94-105.

Chen, M., Wilson, C.J., Wu, Y., Wittung-Stafshede, P., and Ma, J. (2006). Correlation between protein stability cores and protein folding kinetics: a case study on Pseudomonas aeruginosa apo-azurin. Structure *14*, 1401-1410.

Zong, C. [†], Wilson, C.J. [†], Shen, T., Wolynes, P.G., and Wittung-Stafshede, P. (2006). Phi-value analysis of apo-azurin folding: comparison between experiment and theory. Biochemistry *45*, 6458-6466.

[†] authors made equal contributions

Wilson, C.J., Apiyo, D., and Wittung-Stafshede, P. (2006). Solvation of the folding-transition state in Pseudomonas aeruginosa azurin is modulated by metal: Solvation of azurin's folding nucleus. Protein Science *15*, 843-852.

Wilson, C.J., Das, P., Clementi, C., Matthews, K.S., and Wittung-Stafshede, P. (2005). The experimental folding landscape of monomeric lactose repressor, a large two-domain protein, involves two kinetic intermediates. Proceedings of the National Academy of Sciences of the United States of America *102*, 14563-14568.

Das, P., Wilson, C.J., Fossati, G., Wittung-Stafshede, P., Matthews, K.S., and Clementi, C. (2005). Characterization of the folding landscape of monomeric lactose repressor: quantitative comparison of theory and experiment. Proceedings of the National Academy of Sciences of the United States of America *102*, 14569-14574.

Wilson, C.J., and Wittung-Stafshede, P. (2005). Role of structural determinants in folding of the sandwich-like protein Pseudomonas aeruginosa azurin. Proceedings of the National Academy of Sciences of the United States of America *102*, 3984-3987.

Wilson, C.J., and Wittung-Stafshede, P. (2005). Snapshots of a dynamic folding nucleus in zinc-substituted Pseudomonas aeruginosa azurin. Biochemistry *44*, 10054-10062.

Wilson, C.J., Apiyo, D., and Wittung-Stafshede, P. (2004). Role of cofactors in metalloprotein folding. Quarterly Reviews of Biophysics *37*, 285-314.

8. Scientific and Professional societies of which a member: American Chemical Society, Biophysics Society, American Society for Microbiology, Protein Society
9. Honors and Awards:

- Gordon Moore Postdoctoral Fellowship at Caltech (2006-Present)
- National Science Foundation Postdoctoral Fellowship (2006-Present)
- National Academy of Science Ford Foundation Fellowship (2006*)
  * awarded – *respectfully declined*
- Schroepfer Award: For Outstanding PhD Thesis in Biochemistry and Cell Biology for 2005
- Houston Area Molecular Biophysics Program, Research Fellowship (2003-2005)
- Presidential Fellow at Rice University (2002-2005)
- Schroepfer Award: For Outstanding Published Research in Biochemistry and Cell Biology for 2004-2005
- Best graduate student poster award *Eighth Annual Structural Biology Symposium,* University of Texas Medical Branch, Galveston (TX) May 2-4, 2003
- American Society for Microbiology Undergraduate Research Fellowship (2001-2002)
- Honors Graduate (Summa Cum Laude)
- Engineering Honors Society (Tau Beta Pi)
- Chemical Engineering Honors Club (Omega Chi Epsilon)
- International Honors Society (Phi Theta Kappa)
- General Awards: The Army Achievement Medal – for Meritorious Service during Tactical Deployment; Army Service Ribbon; National Defense Service Medal; Army Lapel Button; Good Conduct Medal; Army Commendation Medal (nominated)

10. Courses Taught the Past Academic Year (None)
11. Other Duties:

Graduate Student Mentor & Project Manager, Undergraduate Research Mentor, Outreach Mentor

12. Self Improvement:

UNDERREPRESENTED MINORITY RECRUITMENT & RELATED ACTIVITY:

- Workshop speaker – *invited*; NSF ADVANCE Workshop for Women in Science & Engineering - Negotiating the Ideal Faculty Position: *Getting The Most From Your Mentor & Building Your Laboratory*; Houston, TX, October 22-24, 2006
- Workshop speaker – *invited*; How to Find the Ideal Postdoctoral Appointment: Houston, TX, October 25, 2006
- Workshop speaker – *invited*; UHCL Biology Club: Why Should I Consider Graduate School?, UHCL Clear Lake, TX, 2003
- Graduate representative – *invited speaker*; UHCL Faculty Convocation, Clear Lake, TX, February, 2004

Julie B. Zimmerman

Name and Academic Rank: Assistant Professor (jointly appointed to School of Forestry and Environmental Studies)

Degrees with fields, institution, and date:
- BS, Civil Engineering, University of Virginia, 1997
- MS, Environmental and Water Resources Engineering, University of Michigan, 1999
- Cert., Industrial Ecology, University of Michigan, 1999
- PhD, Environmental Engineering and Natural Resources Policy, University of Michigan, 2003

Number of years service on this faculty: 1.5 Years
- Assistant Professor, Yale University (January 2007)

Other related experience--teaching, industrial, etc.:
- Associate Professor, Wayne State University (August 2005 – August 2006)
- Program Manager, Environmental Protection Agency (July 2003 – December 2006)

Consulting, patents, etc.:
- Principal, Sustainability A to Z, LLC
- Review panel member for NSF, EPA

State(s) in which registered: None

Principal publications of last five years:
- Barenfanger, J., Mueller, T., O'Brien, J., Drake, C., Lawhorn, J., Zimmerman, J.B., Ace, J., "Comparison of Flocked Swabs to Nasal Aspirates for Recovery of Respiratory Viruses, Cost, and Carbon Footprint", Journal of Clinical Microbiology, *submitted*.
- Eckelman, M.J.; Anastas, P.T.; Zimmerman, J.B. "Spatial assessment of net mercury emissions from the use of fluorescent bulbs", Environmental Science and Technology, *submitted*.
- Miller, S.; Fugate, E.; Craver, V.; Smith, J.A.; Zimmerman, J.B. "Toward Understanding the Efficacy and Mechanism of Opuntia spp. as a Natural Coagulant for Potential Applications in Water Treatment", Environmental Science and Technology, 2008, 42, 12, 4274-4279.
- Zimmerman, J.B.; Mihelcic, J.R.; Smith, J.A. "Global Stressors on Water Quality and Quantity" Environmental Science and Technology, 2008, 42, 12, 4247-4254.
- Eckelman, M. J.; Zimmerman, J. B.; Anastas, P.T. "Designing Safer Nanotechnology through Green Chemistry and Green Engineering", Journal of Industrial Ecology, *in press*.
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Scientific and professional societies of which a member:

- Association of Environmental Engineering and Science Professors
- American Society of Engineering Education
- American Society of Mechanical Engineers
- Society of Manufacturing Engineers
- American Chemical Society

Honors and awards:

- EPA Gold Medal for Commendable Service, 2006.
- National Academy of Engineering: *Frontiers of Engineering*, 2005.
- EPA Bronze Medal for Commendable Service, 2005.
- University of Michigan Distinguished Dissertation Award, 2004.
- Graduate Student Paper Award, Environmental Chemistry, American Chemical Society, 2003.
- Society of Tribologists and Lubrication Engineers scholarship recipient, 2002.
- Marian Sarah Parker Prize for Outstanding Woman Graduate Engineering Student, 2001.
- Graduate Student Award, Environmental Chemistry, American Chemical Society, 2000.
- United States Environmental Protection Agency STAR Fellow, 1999 – 2002.
- Alfred P. Sloan Fellowship, 1998.
- Environmental and Water Resources Departmental Fellowship, Department of Civil and Environmental Engineering, University of Michigan, 1997.

Institutional and professional service in the last five years:

- Reviewer for Environmental Science and Technology, International Journal of Sustainable Development, Journal of Surfactants and Detergents, Journal of Industrial Ecology
- Member, School of Forestry and Environmental Studies Space Committee, School of Forestry and Environmental Studies Non-Tenure Appointments Committee, Environmental Studies Advisory Committee, Yale University, January 2007 – present.
- Center for Green Chemistry and Green Engineering at Yale, Assistant Director for Research, January 2007 – present.
- Chair, Green Chemistry and Engineering Subdivision, Industrial and Engineering Chemistry Division, American Chemical Society, January 2007 – January 2008.
- Editorial Board, Sustainability: Science, Practice, and Policy, January 2007 – present.
- Editorial Board, Journal of Engineering for Sustainable Development: Energy, Environment, and Health, September 2006 – present.
- Session co-Chair, "Design and Manufacturing for Sustainability" 2006 International Symposium on Flexible Automation, Osaka, Japan, July 10-12, 2006.
- Steering Committee, US Partnership for the UN Decade for Education for Sustainable Development, 2004 – 2007.
- Programming Committee, Annual Green Chemistry and Engineering Conference, 2003-2007.
- Organizing Committee, International Green Chemistry and Engineering Conference, 2003-2004.
- Graduate Student Advisory Council to the College of Engineering, University of Michigan, member, 2002.

Professional development activities in the last five years: None.

APPENDIX C – LABORATORY EQUIPMENT

Overview of Equipment used in Chemical Engineering Laboratory (CENG 412)

1) Fluid Mechanics Experimental Unit:

The fluid mechanics component of the laboratory class consists of two separate experiments – one on orifice and free jet flows and one on free and forced vortices.
For the free jet part of the experiment, the students will perform the following:

a) Characterize the flow pattern and flow rate of fluid emerging from a tank through a small orifice.
b) Characterize the effects of pressure, fluid properties, and orifice diameter on the flow velocity and trajectory.
c) Compare the flow pattern in free and forced vortices. For both flows you will compare results for Newtonian and non-Newtonian fluids.

For the free and forced vortices, the profiles of vortices are examined as functions of orifice diameter; the profiles are determined and compared to models. For the orifice and free jet flow, the discharge coefficient for two different vortices is determined using the jet trajectory, constant head, and varying head methods.

2) **Heat Transfer Experimental Unit:**

The heat transfer component of the laboratory class consists of two separate experiments – one on unsteady heat transfer and one on radial heat conduction.

Unsteady State Heat Conduction: The effect of shape, size, and material properties are examined on unsteady heat flow.

Radial Heat Conduction: The steady state temperature distribution for a brass annulus is determined and the Fourier's heat transfer equation is used to determine the thermal conductivity.

3) **Ammonia absorber:**

Packed columns provide a medium in which counter-current two-phase flow occurs, and in which a relatively large gas-fluid interface per unit volume of column volume exists. Because of the nature of the packing material (often a ceramic) a packed column can operate using corrosive fluids.

Test Objectives:

(a) Determine the pressure drop across the column as a function of air and water flow rates and compared to predictive correlations.

(b) While the column is operated at the steady state, measure the outlet ammonia concentration and compare it to predictive models.

(c) Calibrate some of the flow meters used in the experiment.

The cooling water flow rate is controlled by a PI controller to illustrate the fundamentals of process control.

4) **Catalytic Hydrolysis of Ethyl Acetate Experimental Unit:**

The purpose of this experiment is to investigate the kinetics of acid-catalyzed hydrolysis of ethyl acetate, using an ion-exchange resin as the catalyst. The temperature and flow rate dependence of the calculated reaction rate constant, and the activation energy of the reaction will be determined. The possible existence of transport effects will be examined.

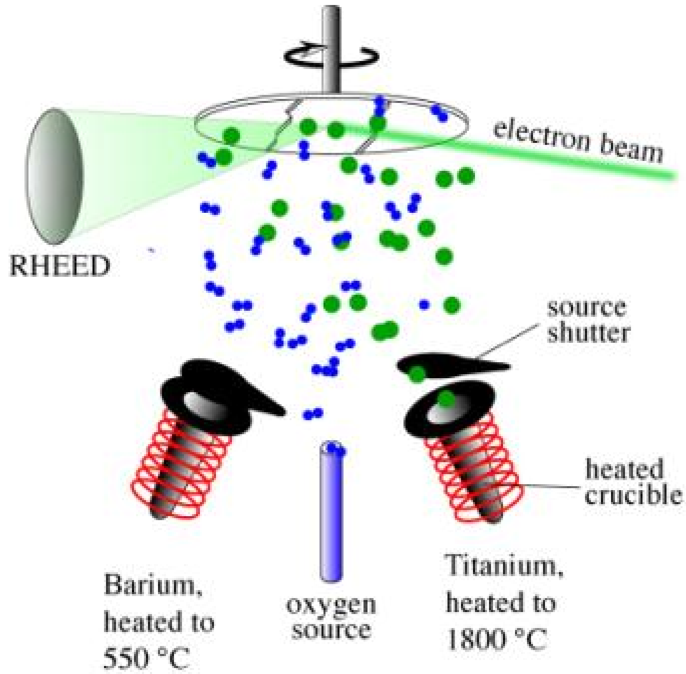
The reaction to be studied is the liquid-phase hydrolysis of ethyl acetate to ethanol and acetic acid.

By appropriate variation of the flow rates, concentrations, and temperatures, the students are expected to quantify the factors affecting the reaction rate. Under the conditions of this experiment, the reaction may be treated as first-order with respect to ethyl acetate and as essentially irreversible.

5) **Molecular Beam Epitaxy (MBE):**

Molecular Beam Epitaxy (MBE) takes place in high vacuum or ultra high vacuum (10^{-8} Pa). The most important aspect of MBE is the slow deposition rate (1 to 300 nm per minute), which allows the films to grow epitaxially. However, the slow deposition rates require proportionally better vacuum in order to achieve the same impurity levels as other deposition techniques.

In solid-source MBE, ultra-pure elements such as titanium and barium are heated in separate quasi-Knudsen effusion cells until they begin to slowly sublimate. The term "beam" comes from the fact that the evaporated atoms do not interact with each other or the chamber walls until they reach the wafer, due to the long mean free paths of the atoms. The gaseous atoms then condense on the wafer, where they may react with each other. The figure below is a schematic of the inside of an MBE chamber.



In the CENG-412 lab, the MBE system is used to investigate the growth of a layer of $SrTiO_3$ on a Si substrate. The boundaries of the two-dimensional surface phase diagram are determined by monitoring surface diffraction patterns with changes in Sr surface concentration and temperature.

APPENDIX D – INSTITUTIONAL SUMMARY

The Institution

Name and address of the institution:

Yale University
New Haven, CT

Name and title of the chief executive officer:

Richard C. Levin
President

Name and official position of the person submitting the completed questionnaire:

T. Kyle Vanderlick
Dean, School of Engineering & Applied Science

Roman Kuc
Associate Dean for Educational Affairs

Type of Control

Private, non-profit organization

History of Institution (Excerpted from www.yale.edu)

Yale's roots can be traced back to the 1640s, when colonial clergymen led an effort to establish a college in New Haven to preserve the tradition of European liberal education in the New World. This vision was fulfilled in 1701, when the charter was granted for a school "wherein Youth may be instructed in the Arts and Sciences [and] through the blessing of Almighty God may be fitted for Publick employment both in Church and Civil State." In 1718 the school was renamed "Yale College" in gratitude to the Welsh merchant Elihu Yale, who had donated the proceeds from the sale of nine bales of goods together with 417 books and a portrait of King George I.

Yale Charter

Yale College survived the American Revolutionary War (1776–1781) intact and, by the end of its first hundred years, had grown rapidly. The nineteenth and twentieth centuries brought the establishment of the graduate and professional schools that would make Yale a true university. The Yale School of Medicine was chartered in 1810, followed by the Divinity School in 1822, the Law School in 1824, and the Graduate School of Arts and Sciences in 1847 (which, in 1861, awarded the first Ph.D. in the United States), followed by the schools of Art in 1869, Music in 1894, Forestry & Environmental Studies in 1900, Nursing in 1923, Drama in 1955, Architecture in 1972, and Management in 1974.

International students have made their way to Yale since the 1830s, when the first Latin American student enrolled. The first Chinese citizen to earn a degree at a Western college or university came to Yale in 1850. Today, international students make up nearly 9 percent of the undergraduate student body, and 16 percent of all students at the University. Yale's distinguished faculty includes many who have been trained or educated abroad and many whose fields of research have a global emphasis; and international studies and exchanges play an increasingly important role in the Yale College curriculum. The University began admitting women students at the graduate level in 1869, and as undergraduates in 1969.

Yale College was transformed, beginning in the early 1930s, by the establishment of residential colleges. Taking medieval English universities such as Oxford and Cambridge as its model, this distinctive system divides the undergraduate population into twelve separate communities of approximately 450 members each, thereby enabling Yale to offer its students both the intimacy of a small college environment and the vast resources of a major research university. Each college surrounds a courtyard and occupies up to a full city block, providing a congenial community where residents live, eat, socialize, and pursue a variety of academic and extracurricular activities. Each college has a master and dean, as well as a number of resident faculty members known as fellows, and each has its own dining hall, library, seminar rooms, recreation lounges, and other facilities.

Student Body

Today, Yale has matured into one of the world's great universities. Its 11,000 students come from all fifty American states and from 108 countries. The 3,200-member faculty is a richly diverse group of men and women who are leaders in their respective fields. The central campus now covers 310 acres (125 hectares) stretching from the School of Nursing in downtown New Haven to tree-shaded residential neighborhoods around the Divinity School. Yale's 260 buildings include contributions from distinguished architects of every period in its history. Styles range from New England Colonial to High Victorian Gothic, from Moorish Revival to contemporary. Yale's buildings, towers, lawns, courtyards, walkways, gates, and arches comprise what one architecture critic has called "the most beautiful urban campus in America." The University also maintains over 600 acres (243 hectares) of athletic fields and natural preserves just a short bus ride from the center of town.

Regional or Institutional Accreditation

Yale University has been accredited by the New England Association of Schools and Colleges since 1989. Accreditation is renewed every ten years.
Yale University's engineering programs in Chemical Engineering, Electrical Engineering and Mechanical Engineering are accredited by ABET.

Personnel and Policies

On April 4, 2007, the faculty voted unanimously to accept the major recommendations of the February 5 report of the Faculty of Arts and Sciences Tenure and Appointments Policy Committee (FASTAP). These recommendations were subsequently approved by the Executive Committee of the Faculty of Arts and Sciences. As a result, a new tenure and appointments system will be initiated in the Faculty of Arts and Sciences on July 1, 2007. The Report committed the University to allowing current non-tenured faculty to choose either to follow the tenure and appointments policies currently in place and through which they were initially appointed, or to move to the new system. The Report recommended that each non-tenured faculty member make this decision some time during the fall semester of 2007. We direct this letter especially to non-tenured faculty to help each of you make an informed choice. But we also send it to department chairs and all FAS ladder faculty so everyone is well informed.

We highlight a few of the important differences between the old system and the new one to clarify options available to non-tenured faculty. Three points merit emphasis:

First, every non-tenured faculty member should meet with his or her department chair to discuss the main features of both systems and the implications for each individual of choosing one or the other. The associate and deputy provosts and the deans are available to discuss the choice as well. Second, we have set a deadline of December 1, 2007 for making this decision, and in the fall we will circulate a form that each non-tenured member of the ladder faculty will use to record his or her choice in the Provost's Office. In addition, a new *Yale University Faculty Handbook* will be issued early in the fall semester implementing the major recommendations of the FASTAP Report.
Third, each non-tenured faculty member and department chair should re-read the FASTAP Report, so that the major recommendations and the context in which they were discussed are clear to everyone. That said, we believe non-tenured faculty and their department chairs will find the following issues especially important in discussing differences between the two systems. Please also consult the chart that accompanies this letter.

"Clock" or time in faculty rank: The old system allows a non-tenured faculty member to remain on term (without tenure) for up to ten years, i.e., up to seven years as an assistant professor and up to ten if he or she has been promoted to associate professor on term. The new system reduces the total time one can be appointed in the non-tenured ranks at Yale to nine years, if one has been promoted to associate professor on term; a ladder faculty member may still serve up to seven years as an assistant professor. Extensions of time in rank on term that are provided under the Child Rearing Policies announced by the Provost in October, 2004 remain in effect under both the old and the new systems.

Leaves: In the old system, assistant professors are eligible to compete for a year's leave, fully paid, usually taken in the fourth year (as a Morse or Junior Faculty Fellowship). In addition, newly promoted associate professors on term are eligible for a one-year Senior Faculty Fellowship with salary set at the median between the base pay for the rank and the faculty member's actual salary. In the new system, assistant professors are eligible for a one-year leave at full salary that can be taken within the second through fourth years, after submitting a research plan approved by the department chair and the cognizant dean. Faculty promoted to associate professor on term are eligible for a one-year leave at full salary in the first or second year following promotion after submitting a research plan approved by the department chair and the cognizant dean. For either type of leave in the new system, the research plan would adhere to the guidelines for traditional Morse and Junior Faculty Fellowships--a five-page single-spaced explanation of the project, its potential significance, and the research methods to be used. At the same time, as part of the non-tenured faculty mentoring program being developed by each department and before approving the research plan, department chairs should gather comment and advice on the plan from senior colleagues and provide this comment to the non-tenured faculty member applying for the leave.

Promotion to Associate Professor on Term: In the old system, assistant professors are required to be reviewed for promotion to associate professor on term no later than the penultimate year of their assistant professor appointment, which typically is in their sixth year. The standard for promotion to associate professor on term is stated as follows: "Achievement and promise as a teacher and scholar or artist should be such as to qualify for tenure at a major institution within five years. To be considered for this appointment candidates must present a substantial work or body of scholarship that represents research undertaken after the dissertation and extending the scope of the dissertation." Promotions proposed by departments are reviewed by a Term Appointments Committee whose members come from all four divisions of the FAS faculty. This committee will continue to be appointed to review proposed promotions to Associate Professor on term for those non-tenured faculty who elect to remain on the old tenure and appointment system.

The FASTAP Report encourages all departments to evaluate assistant professors for promotion to associate professor on term in the new system no later than the fifth year, but the evaluation <u>must</u> be completed no later than in the sixth year. The standard for promotion is "significant published research and scholarship representing early demonstrations of disciplinary or interdisciplinary leadership; excellent teaching and mentoring of students; and engaged university citizenship." Promotions proposed by departments will be reviewed by the divisional committees that consider tenure appointments and will no longer be reviewed by the old Term Appointments Committee.
<u>Tenure process</u>: In the old system, before a department may conduct a search in which a non-tenured faculty member can be an internal candidate for appointment to tenure, the department is required to locate sufficient resources, or JFEs (Junior Faculty Equivalents, with two required for a tenured appointment) to support a tenured appointment. In the search to fill this tenured position, the internal candidate is typically considered in an international competition for the tenured appointment. The department's recommendation is then subject to approval by the divisional tenure appointments committee and then by the Joint Boards of Permanent Officers.

In the new system, each newly appointed non-tenured faculty member--and each current non-tenured faculty member who chooses the new system--will be understood to carry with his or her appointment the resources required for tenure, should tenure be warranted on the basis of merit. As a result, departments will not need to seek additional resources at the time internal candidates for tenure are evaluated. Internal candidates will be evaluated comparatively with outstanding other scholars in their field rather than standing as candidates in open searches. If the department recommends tenure, the recommendation must be approved by the relevant divisional tenure committee and by the Joint Boards of Permanent Officers. In short, the new system makes major changes in the tenure process up to the point of departmental approval but retains the extra-departmental review process of the old system.

The broad standard for tenure in the new system affirms the standard in the old system: "Professors are expected to stand in competition with the foremost leaders in their fields throughout the world." In both systems, faculty may be considered for tenure at any time.

Options: Faculty who will be in their tenth year in the non-tenured ranks at Yale in 2007-2008 are not eligible to choose the new tenure and appointments system. Faculty for whom the 2007-2008 academic year will be their ninth year in the non-tenured ranks at Yale will be eligible to choose the new system but also to remain at Yale for a tenth year. All other non-tenured faculty who choose the new system will be able to remain at Yale for a total of nine years, not ten as in the old system. In all cases, extensions granted for care giving and child care do not count toward this total.
With the exception of non-tenured faculty for whom 2007-2008 will be their ninth year at Yale, non-tenured faculty must choose either to remain entirely in the old system or to move fully to the new one. One cannot, for example, choose the new provisions for leaves and resources but remain on the old ten-year clock, or mix and match other facets of the two systems, such as being evaluated for promotion to associate professor on term within the old tenure system in the fall semester of 2007, then switching to the new tenure system if the promotion review were successful before December 1.

Department chairs and non-tenured faculty may wish to discuss subtleties and specific individual concerns distinguishing the old and new tenure systems and that might be important in a particular situation. Full discussion of these issues will help each non-tenured faculty member make the most informed decision about which tenure and appointments system to choose before the December 1, 2007 deadline.

Educational Unit

Yale's School of Engineering & Applied Science (SEAS) consists of the Departments of Biomedical Engineering, Chemical Engineering, Electrical Engineering, Mechanical Engineering, and Applied Physics, and the interdepartmental program Environmental Engineering. Chemical Engineering, Electrical Engineering, and Mechanical Engineering currently have ABET accredited curricula. There are also related programs in Applied Mathematics, Electrical Engineering and Computer Science, and Computer Science. All these departments belong to the Division of Physical Sciences and Engineering. Department Chairmen report to the Dean of SEAS on administrative and educational matters, to the Deputy Provost for most other matters, and to the Provost for major structural and budgetary decisions. The Provost makes use of an Advisory Committee for the Physical Sciences and Engineering Sciences on these matters.

The current administrative head is Kyle Vanderlick, Dean of SEAS. She was appointed on January 1, 2008. The curriculum vitae of administrators associated with ABET programs are included at the end of this report.

Engineering Mission Statement:

To promote the continued/improved quality of engineering and science (E&S) at Yale in the faculty, facilities, course of studies and undergraduate and graduate matriculants.

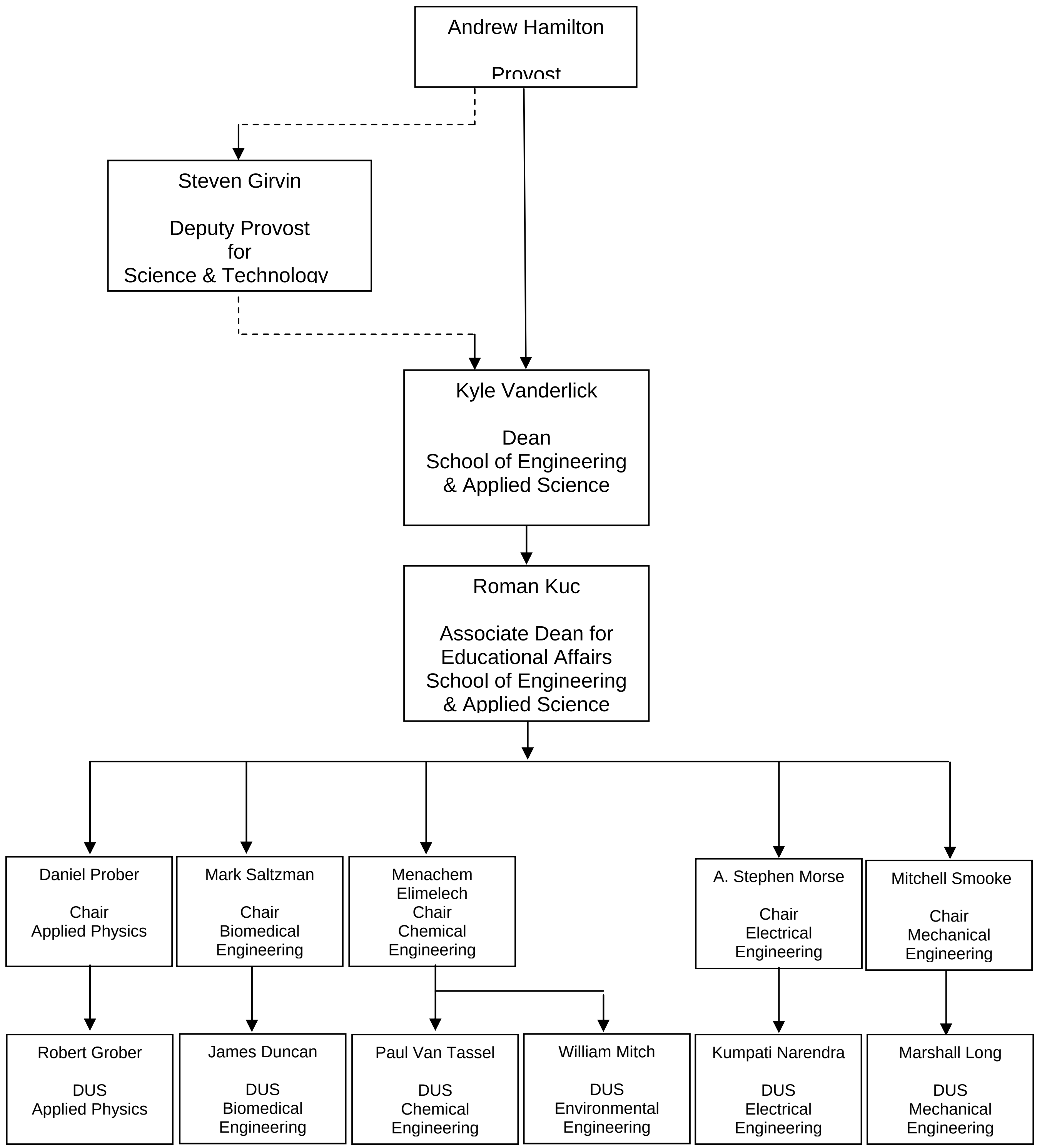
To assist students financially in the form of research grants, prizes, and scholarships.

To recognize and publicize the accomplishments of students, faculty and distinguished alumni through special awards and prizes.

To participate in any way practical in the national challenge of promoting greater number of matriculants and sustained majors in engineering and science.

To communicate with the membership in a timely and quality manner and to actively and aggressively solicit new membership for the perpetuation of the organization.

To promote interaction between Yale and its alumni and between Yale and both private and public enterprise.


Andrew Hamilton
Provost
Steven Girvin
Deputy Provost for Science & Technology
Kyle Vanderlick
Dean School of Engineering & Applied Science
Roman Kuc
Associate Dean for Educational Affairs School of Engineering & Applied Science
Daniel Prober
Chair Applied Physics
Mark Saltzman
Chair Biomedical Engineering
Menachem Elimelech
Chair Chemical Engineering
A. Stephen Morse
Chair Electrical Engineering
Mitchell Smooke
Chair Mechanical Engineering
Robert Grober
DUS Applied Physics
James Duncan
DUS Biomedical Engineering
Paul Van Tassel
DUS Chemical Engineering
William Mitch
DUS Environmental Engineering
Kumpati Narendra
DUS Electrical Engineering
Marshall Long
DUS Mechanical Engineering

Credit Unit

One semester course normally represents three class hours (50 minutes) or three laboratory hours per week. One academic year normally represents at least 14 weeks of classes, exclusive of final examinations.

Instructional Modes

1. There are no alternate modes of instruction. For undergraduate students, all courses are given on-campus and during the day.

Grade-Point Average

1. Yale University does not have a grade point requirement for graduation. The only requirement is that a student completes 36 courses before graduation. Students who perform poorly or do not pass an appropriate number of courses in earlier years may be suspended for a year, or asked to leave. Almost all Yale students who graduate do so in four years.

Academic Supporting Units

The academic supporting units that provide required portions of the instruction for engineering students are shown in the Table below.

Supporting Academic Departments

For Academic Years 2003 – 2008

	Department or Unit	Full-time Faculty Head Count[1]	Part-time Faculty Head Count[2]	FTE Faculty[3]	Teaching Assistants Head Count	Teaching Assistants FTE
2007-2008	Chemistry	28	0	28	98	72.5
	Computer Science	22	2	22.8	35	15.4
	English	45	20	56.3	77	61.6
	Mathematics	27	3	28.6	45	30.8
	Physics	49	3	50.6	127	59.7
2006-2007	Chemistry	25	1	25.3	86	64
	Computer Science	26	3	27.3	38	18.5
	English	47	26	62.5	78	60.3
	Mathematics	28	8	32.3	46	30.8
	Physics	51	1	51.6	122	60.6
2005-2006	Chemistry	26	0	26	95	70.3
	Computer Science	24	2	25	42	18.9
	English	45	24	57.6	81	66.9
	Mathematics	29	7	32.8	41	30
	Physics	46	1	46.5	112	55.1
2004-2005	Chemistry	29	1	29.5	112	83
	Computer Science	25	4	26.8	42	20.9
	English	47	21	33.2	53	35.8
	Mathematics	30	5	33.2	53	35.8
	Physics	48	2	49.1	109	54.5
2003-2004	Chemistry	31	0	31	111	79.5
	Computer Science	25	4	26.8	38	19
	English	47	29	62.5	54	47.6
	Mathematics	34	10	39.3	44	32.4
	Physics	51	4	53.1	104	49

1. ** For student teaching assistants, 1 FTE equals 20 hours per week of work (or service). For faculty members, 1 FTE equals what your institution defines as a full-time load.

Non-Academic Supporting Units

Library

The Engineering & Applied Science Library is located in Becton Center, convenient to Engineering classroom and laboratory facilities and faculty offices. The library purchases materials to support the current and future teaching and research needs of the Engineering and Computer Science departments. As part of this mission we provide online access to thousands of databases and full text journals. Our collection has consistently received ample funding to meet the high inflation rate for engineering materials and to add new materials as needed by our users.

Engineering students and faculty also may take advantage of a wide range of research resources and services provided by the 22 campus libraries and 600 staff comprising one of the largest library collections in the world. In addition to the Engineering Library collections, related science materials are housed in the Kline Science Library, with collections in physics, biology, and chemistry; Chemistry Library; Mathematics Library; Geology Library; Forestry & Environmental Sciences Library; and the Medical Library. The Yale Library is a U.S. government and United Nations depository, and the Government Documents Center has significant holdings of technical documents produced by government agencies.

Students and faculty can access many resources from their desktop or home via the library Website. The library provides online access to thousands of databases for locating research articles, including Web of Science, Engineering Village/Compendex, Inspec, Chemical Abstracts via SciFinder Scholar, IEEE Electronic Library, ACM Electronic Library, and the SPIE Digital Library. Researchers have access to 27,000 online journals including those published by Elsevier, Wiley, Springer, IEEE, ACM, ACS, APS, and ASME. E-books are a growing part of the collection. Yale users have online access to many CRC books, including important handbooks like the *CRC Handbook of Chemistry and Physics*. Other online book subscriptions include major collections for engineering and chemical reference, computing manuals, and academic books.

The Engineering Library is a dynamic collection supporting research and teaching in engineering and computer science. In the 2007 fiscal year the library circulated 9,774 books and 690 reserve items. A full-time professional librarian and three staff members are available to assist patrons. The librarian conducted 21 orientation and instruction sessions with 119 participants. The librarian consults with faculty members to conduct course-related research education.

The library provides many services to constituents including circulation, reference, reserves/e-reserves, and interlibrary loans. Engineering Library Academic term hours are Monday-Thursday, 8:30 a.m. to 9:45 p.m.; Friday, 8:30 a.m. to 4:45 p.m.; Saturday, 1:00 p.m. to 4:45 p.m.; and Sunday 1:30 p.m. to 9:45 p.m. The library has seating for 97 people. Seven public workstations are available for accessing databases and online collections. Printers and photocopy machines are available. Instant messaging reference service is available daily until 10 p.m. Basic reference materials, computing, and study facilities are also available for extended hours until 1:45 a.m. at the newly renovated Bass Library, which is convenient to undergraduate residential colleges.

Library acquisitions and resources in the past three years, and the total number of books and periodicals are provided in the following tables.

	Acquisitions During Last Three (3) Years	Current Collection Resources	
	Books and Bound Periodicals	Books and Bound Periodicals	Current Periodical Titles
Entire Institutional Library	775,932	12,283,594	89,649
Engineering Library	7,303	48,272	872
Physics/Biology/Chemistry (Kline Science Library)	10,742	360,000	1,500
Chemistry Library	1,528	18,100	92
Mathematics Library	2,426	29,800	285

Library expenditures in the past three years

	2006-07	2005-06	2004-05
Library Total	$107,500,000	$97,600,000	$91,300,000
Engineering Library Total Expenditures	$1,232,994	$1,145,462	$1,052,589
Engineering Library Books	$95,176	$81,908	$76,481
Engineering Library Periodicals/Databases	$908,039	$841,578	$739,028

Computing Facilities

Computing facilities for engineering majors at Yale are provided by two sources:

- Yale's Information Technology Services (ITS) provides hardware and software support for academic needs, including computer clusters located throughout the campus and residential colleges for student needs, as well as classroom needs and faculty teaching needs.
- School of Engineering & Applied Science (SEAS) supports a full-time hardware/software Computer and Information Service (C&IS) Support Specialist and (Ms. Lieyang Zhou) along with part-time student assistants. This position supports computers that are used by engineering majors and graduate students. SEAS updates computer hardware every two or three years. SEAS provides academic software required for its engineering programs.

Engineering students have access to the computer cluster installations throughout Yale College. Some 127 seats are provided in "public" cluster environments (open to all students) and 72 seats among the 12 residential colleges. Hardware is upgraded typically on a 3-year cycle.

Two of the "public" clusters (58 computers) are located in Engineering's Dunham Laboratory building. These are operated in a collaborative manner between the Engineering C&IS Office and the ITS group. In addition to the standard academic software array, these machines have a number of technical software packages for the support of Engineering. These include: Matlab, Mathematica, Electronics Workbench, Simsci PRO/II (process simulation), HYSYS (process simulation), Solid Edge (Mech. CAD), Xilinx Foundation, LogicWorks 2000, Microsoft Visual Studio/J++, National Elec. Drought Analysis (NEDA), Origin, ArcView (GIS), SPSS (statistics), and Neuron.
In addition, Engineering C&IS operates a 10 computer cluster available to students in the Robert Mann Jr Engineering Student Center. Software available on these machines includes: Matlab, Mathematica, Fluent (Comp. Fluid Dymanics), Ansys Multiphysics, PGI Fortran & C Compilers, Magic & Spice.
In addition to the computer lab facilities above, there are some 30 computers distributed among the Electrical, Mechanical, and Chemical Engineering teaching laboratories, described elsewhere in this document.
All Engineering computing facilities are available 24 hours a day to authorized students.

Faculty Workload

The typical faculty teaching workload is two courses per year, usually one course at the undergraduate level and one course at the graduate level. In addition to classroom teaching, faculty members are expected to participate in some of the following activities:

- supervise undergraduates in their senior capstone project,
- be a member of the curriculum committee,
- hold office hours for student advising,
- advise student chapters of their professional societies,
- invite and host visiting researchers giving seminars,
- assess senior projects,
- attend faculty meetings to discuss curricular matters,
- serve on graduate student research committees,
- assess graduate student progress,
- act as mentors to non-tenured faculty members,
- attend conferences in their fields,
- publish scholarly articles on their research,
- submit grant proposals,
- participate in their professional societies,
- give visiting lectures at other institutions,
- attend Yale College and Yale Graduate School faculty meetings, and
- meet with the dean to discuss the future of engineering.

Tables

Table D-1. Programs Offered by the Educational Unit

Program Title[1]	Modes Offered[2]							Submitted for Evaluation[3]		Offered, Not Submitted for Evaluation[4]	
	Day	Cooperative Education	Off Campus	Alternate Mode	Nominal Years to Complete	Administrative Head	Administrative Unit or Units (e.g. Dept.) Exercising Budgetary Control	Now Accredited.	Not Now Accredited	Now Accredited	Not Now Accredited
1. Chemical Engineering, B.S.	X				4	Menachem Elimelech	CE Department	X			
2. Electrical Engineering, B.S.	X				4	A. Stephen Morse	EE Department	X			
3. Mechanical Engineering, B.S.	X				4	Michell D. Smooke	ME Department	X			
4. Applied Physics, B.S.	X				4	Daniel E. Prober	AP Department				X
5. Biomedical Engineering, B.S.	X				4	W. Mark Saltzman	BE Department				X
6. Comp. Sci./Elec. Eng., B.S.	X				4	Abraham Silberschatz/ A. Stephen Morse	CS/EE Department				X
7. Environmental Engineering, B.S.	X				4	Menachem Elimelech	CE Department				X
8. Engineering Science (Chem.), B.S.	X				4	Menachem Elimelech	CE Department				X
9. Engineering Science (Elec.), B.S.	X				4	A. Stephen Morse	EE Department				X
10. Engineering Science (Mech.), B.S.	X				4	Michell D. Smooke	ME Department				X
11. Engineering Science (Envir.), B.S.	X				4	Menachem Elimelech	CE Department				X
12. Engineering Science (Elec.), B.A.	X				4	A. Stephen Morse	EE Department				X
13. Engineering Science (Mech.), B.A.	X				4	Michell D. Smooke	ME Department				X
14. Applied Physics, B.A.	X				4	Daniel E. Prober	AP Department				X
15. Engineering Science (Envir.), B.A.	X				4	Menachem Elimelech	CE Department				X

Table D-2. Degrees Awarded and Transcript Designations by Educational Unit

Program Title[1]	Day	Modes Offered[2] Co-op	Off Campus	Alternative Mode	Name of Degree Awarded[3]	Designation on Transcript[4]
Chemical Engineering	X				Engineering Sciences (Chemical)	Engineering Sciences (Chemical)
					B.S.	B.S.
Electrical Engineering	X				Engineering Sciences (Electrical)	Engineering Sciences (Electrical)
					B.S.	B.S.
					B.A.	B.A.
Mechanical Engineering	X				Engineering Sciences (Mechanical)	Engineering Sciences (Mechanical)
					B.S.	B.S.
					B.A.	B.A.
Environmental Engineering	X				Engineering Sciences (Environmental)	Engineering Sciences (Environmental)
					B.S.	B.S.
					B.A.	B.A.
Applied Physics	X				Applied Physics, B.S. or B.A.	Applied Physics, B.S. or B.A.
Biomedical Engineering	X				Biomedical Engineering, B.S.	Biomedical Engineering, B.S.
Computer Science/Electrical Engineering	X				Computer Science/Elect. Engineering, B.S.	Computer Science/Elect. Engineering, B.S.
Environmental Engineering	X				Environmental Engineering, B.S.	Environmental Engineering, B.S.
ACCREDITED PROGRAMS						
Chemical Engineering	X				Chemical Engineering, B.S.	Chemical Engineering, B.S.
Electrical Engineering	X				Electrical Engineering, B.S.	Electrical Engineering, B.S.
Mechanical Engineering	X				Mechanical Engineering, B.S.	Mechanical Engineering, B.S.
GRADUATE PROGRAMS						
Engineering & Applied Science	X				Engineering & Applied Science, M.S.	Engineering & Applied Science, M.S.
Engineering & Applied Science	X				Engineering & Applied Science, M. Phil.	Engineering & Applied Science, M. Phil.
Engineering & Applied Science	X				Engineering & Applied Science, Ph.D.	Engineering & Applied Science, Ph.D.

Table D-3. Support Expenditures

School of Engineering & Applied Science

Fiscal Year	FY07	FY08	FY09 (Budget)
Expenditure Category			
Operations (not including staff)	824,105	918,336	945,886
Travel	81,570	82,356	86,474
Equipment	409,968	483,946	436,712
(a) Institutional Funds	409,968	483,946	436,712
(b) Grants and Gifts	0	0	0
Graduate Teaching Assistants	327,433	405,587	421,810
Part-time Assistance (other than teaching)	0	0	0
Faculty Salaries	7,224,570	7,964,960	8,703,208

Department of Chemical Engineering

Fiscal Year	FY07	FY08	FY09 (Budget)
Expenditure Category			
Operations (not including staff)	50,025	52,8465	54,431
Travel	18,326	30,020	31,521
Equipment	0	4,065	0
(a) Institutional Funds	0	4,065	0
(b) Grants and Gifts	0	0	0
Graduate Teaching Assistants	21,267	34,929	36,326
Part-time Assistance (other than teaching)	0	0	0
Faculty Salaries	1,524,279	1,603,410	1,853,581

Department of Electrical Engineering

Fiscal Year	FY07	FY08	FY09 (Budget)
Expenditure Category			
Operations (not including staff)	39,009	34,162	35,186
Travel	2,583	10,961	11,509
Equipment	53,200	90,600	112,162
(a) Institutional Funds	53,200	90,600	112,162
(b) Grants and Gifts	0	0	0
Graduate Teaching Assistants	73,700	67,796	70,508
Part-time Assistance (other than teaching)	0	0	0
Faculty Salaries	2,136,154	2,238,226	2,350,137

Department of Mechanical Engineering

Fiscal Year	FY07	FY08	FY09 (Budget)
Expenditure Category			
Operations (not including staff)	58,776	41,248	42,486
Travel	14,434	21,001	22,051
Equipment	175,000	282,840	281,673
(a) Institutional Funds	175,000	282,840	281,673
(b) Grants and Gifts	0	0	0
Graduate Teaching Assistants	63,800	64,960	67,558
Part-time Assistance (other than teaching)	0	0	0
Faculty Salaries	1,712,428	1,623,989	1,875,188

Table D-4. Personnel and Students

School of Engineering & Applied Science – Year: 2008

	HEAD COUNT FT	HEAD COUNT PT	FTE	RATIO TO FACULTY
Administrative	10	0	10	
Faculty (tenure-track)	61	4	63	
Other Faculty (excluding student Assistants)	60	0	-	
Student Teaching Assistants	43	0	14	1 / 4
Student Research Assistants	103	0	103	1.8 / 1
Technicians/Specialists	12	0	12	1 / 5
Office/Clerical Employees	23	0	23	1 / 3
Others	-	-	-	-
Undergraduate Student enrollment[6]	120*	0	120*	2 / 1*
Graduate Student enrollment	168	4	168.5	3 / 1

* Counts include only Juniors and Seniors.

Department of Chemical Engineering – Year: 2008

	HEAD COUNT FT	HEAD COUNT PT	FTE	RATIO TO FACULTY
Administrative	0	0	0	
Faculty (tenure-track)	15	0	15	
Other Faculty (excluding student Assistants)	0	0	-	
Student Teaching Assistants	9	0	3	1 / 5
Student Research Assistants	13	0	13	0.9 / 1
Technicians/Specialists	0	0	0	-
Office/Clerical Employees	3	0	3	1 / 5
Undergraduate Student enrollment	14*	0	14*	0.9 / 1
Graduate Student enrollment	18	0	18	1.2 / 1

Department of Electrical Engineering – Year: 2008

	HEAD COUNT FT	HEAD COUNT PT	FTE	RATIO TO FACULTY
Administrative	0	0	0	
Faculty (tenure-track)	16.5	0	16.5	
Other Faculty (excluding student Assistants)	0	0	-	
Student Teaching Assistants	9	0	3	1 / 5
Student Research Assistants	31	0	31	1.8 / 1
Technicians/Specialists	1	0	1	1 / 16.5
Office/Clerical Employees	4	0	4	1 / 4
Undergraduate Student enrollment	26*	0	26*	1.5 / 1
Graduate Student enrollment	45	1	45	2.7 / 1

Department of Mechanical Engineering – Year: 2008

	HEAD COUNT FT	HEAD COUNT PT	FTE	RATIO TO FACULTY
Administrative	0	0	0	
Faculty (tenure-track)	12.5	0	12.5	
Other Faculty (excluding student Assistants)	0	0	-	
Student Teaching Assistants	7	0	2	1 / 6
Student Research Assistants	18	0	18	1.4 / 1
Technicians/Specialists	3	0	3	1 / 4
Office/Clerical Employees	3	0	3	1 / 4
Undergraduate Student enrollment	33*	0	33*	2.6 / 1*
Graduate Student enrollment	27	1	27	2.2 / 1

Table D-5. Program Enrollment and Degree Data

Yale School of Engineering & Applied Sciences (all departments)

	Academic Year		Enrollment Year 1st	2nd	3rd	4th	5^{th}	Total UG	Total Grad	Degrees Conferred Bachelor	Master	Doctor	Year
CURRENT	2007-	FT	*	*	57	63		120	175	65	10	28	2008
	2008	PT											
1	2006-	FT	*	*	57	69		126	171	70	7	20	2007
	2007	PT											
2	2005-	FT	*	*	76	46		122	161	43	3	26	2006
	2006	PT											
3	2004-	FT	*	*	26	50		76	159	54	10	18	2005
	2005	PT											
4	2003-	FT	*	*	61	57		118	154	52	11	21	2004
	2004	PT											
5	2002-	FT	*	*	51	48		99	126	55	7	5	2003
	2003	PT											

FT--full time
PT--part time
* = Majors are not declared until the end of the 2^{nd} year/beginning of the 3^{rd} year

Chemical Engineering

	Academic Year		Enrollment Year 1st	2nd	3rd	4th	5^{th}	Total UG	Total Grad	Degrees Conferred Bachelor	Master	Doctor	Year
CURRENT	2007-	FT	*	*	57	63		120	175	7	-	5	2008
	2008	PT											
1	2006-	FT	*	*	57	69		126	171	70	7	20	2007
	2007	PT											
2	2005-	FT	*	*	76	46		122	161	43	3	26	2006
	2006	PT											
3	2004-	FT	*	*	26	50		76	159	54	10	18	2005
	2005	PT											
4	2003-	FT	*	*	61	57		118	154	52	11	21	2004
	2004	PT											
5	2002-	FT	*	*	51	48		99	126	55	7	5	2003
	2003	PT											

Electrical Engineering

	Academic Year		Enrollment Year					Total UG	Total Grad	Degrees Conferred			
			1st	2nd	3rd	4th	5th			Bachelor	Master	Doctor	Year
CURRENT	2007-	FT	*	*	57	63		120	175	13	-	7	2008
	2008	PT											
1	2006-	FT	*	*	57	69		126	171	70	7	20	2007
	2007	PT											
2	2005-	FT	*	*	76	46		122	161	43	3	26	2006
	2006	PT											
3	2004-	FT	*	*	26	50		76	159	54	10	18	2005
	2005	PT											
4	2003-	FT	*	*	61	57		118	154	52	11	21	2004
	2004	PT											
5	2002-	FT	*	*	51	48		99	126	55	7	5	2003
	2003	PT											

Mechanical Engineering

	Academic Year		Enrollment Year					Total UG	Total Grad	Degrees Conferred			
			1st	2nd	3rd	4th	5th			Bachelor	Master	Doctor	Year
CURRENT	2007-	FT	*	*	57	63		120	175	21	-	3	2008
	2008	PT											
1	2006-	FT	*	*	57	69		126	171	70	7	20	2007
	2007	PT											
2	2005-	FT	*	*	76	46		122	161	43	3	26	2006
	2006	PT											
3	2004-	FT	*	*	26	50		76	159	54	10	18	2005
	2005	PT											
4	2003-	FT	*	*	61	57		118	154	52	11	21	2004
	2004	PT											
5	2002-	FT	*	*	51	48		99	126	55	7	5	2003
	2003	PT											

Syllabi for Prerequisite and Common Courses

Department number: Applied Physics 322b

Title: Electromagnetic Waves and Devices

Designation: Required

Course (catalog) description:

Introduction to electrostatics and magnetostatics, time varying fields and Maxwell's equations. Applications include electromagnetic wave propagation in lossless, lossy, and metallic media and propagation through coaxial transmission lines and rectangular waveguides, as well as radiation from single and array antennas.

Prerequisite(s): PHYS 180a, 181b or 200a, 201b

Textbook(s) and/or other required material: "Field and Wave Electromagnetics", D. K. Cheng, 2nd edition (Addison-Wesley).

Course objectives: The idea of the course is to learn the applications of Maxwell's equations, especially how they lead to the propagation of electomagnetic waves, how these waves are guided and radiated, and the concepts which are important for high-frequency circuit design.

Topics covered:

- Review of electro-and magneto-statics and vector calculus.
- Current flow, time-varying fields, and induction.
- Resonant circuits, transformers, and filters.
- Transmission lines and waveguides.
- Antennas and antenna arrays.

Class/laboratory schedule, i.e., number of sessions each week and duration of each session: Two 75 minute sessions each week.

Contribution of course to meeting the professional component: Part of Math and Science component.

Relationship of course to program objectives: Required science course for ABET Electrical Engineering major.

Person(s) who prepared this description and date of preparation:

Roman Kuc, June, 2008

Department number: EAS 130

Title: Introduction to Computing for Engineers and Scientists

Designation: Elective

2007-8 Catalog Data: ENAS 130b Introduction to Computing for Engineers and Scientists
MWF 9.30-10.20 Not CR/D/F Meets RP IV(32)
An introduction to the use of the Fortran and C++ programming languages and the software packages Mathematica and MATLAB to solve a variety of problems encountered in mathematics, the natural sciences, and engineering. Topics include general problem-solving techniques, object-oriented programming, elementary numerical methods, data analysis, and a brief introduction to numerical simulations.
Prerequisite: MATH 115a or b; *some computer experience is desirable but not required. For the Class of 2008, does not count toward the natural science requirement.*

Textbook(s):

Larry Nyhoff and Sanford Leestma, *Fortran 77 for Engineers and Scientists with an Introduction to Fortran 90, 4th Edition*, Prentice Hall, 1996 (Yale Bookstore and on reserve at Engineering Library)

Gary J. Bronson, *C++ for Engineers and Scientists*", Brooks and Cole, 1999 (Yale Bookstore and on reserve at Engineering Library)

Stephen Wolfram, *The Mathematica Book*, *3rd Edition*, Cambridge University Press, 1996 (on reserve at Engineering Library)

Goals: Acquire basic tools required to numerically solve problems encountered in science and engineering. Introduction to Fortran and C++ programming languages (learn syntax, good programming practices, and debugging techniques.) Understand advantages and disadvantages of Mathematica.

Prerequisites by topic: Differential and integral calculus; *some computer experience is desirable but not required.*

Topics:
1. FORTRAN programming
2. Symbolic mathematics, numerical computations and graphics using Mathematica
3. C++ programming
4. Programming for control of instruments and experiments using LabView

Computer Usage: Weekly homework assignments require programming in FORTRAN, or C++, or use of LabView or Mathematica.

Laboratory projects: Students create a "Virtual Instrument" that simulates a computer-controlled oven. Computer facilities in the Electrical Engineering student labs are utilized for this project.

Submitted by: Marshall Long Date: September, 2007

Department number: ENAS 151

Title of course: Multivariable Calculus for Engineers

Designation: Required course

Course Description:
The course will introduce the engineering and applied science student to multivariable calculus for use in solving problems of physical interest. The course will focus on topics from three-dimensional spaces and vectors, vector-valued functions, partial derivatives, multiple integrals and vector calculus including Green's, Stokes' and the divergence theorems.

Prerequisite: Math 115.

Textbook: *Calculus (Multivariable)* 8^{th} Edition by Anton, Bivens and Davis.

Topics:
Vectors and Three-Dimensional Space **– Rectangular Coordinates in 3-space, Cylindrical Surfaces/Spheres, Vectors Dot and Cross Products, Parametric Equations of Lines, Planes, Quadric Surfaces. Examples: Lone Cypress, Valley of the Kings, Hubble Telescope, Dynamometer**

Vector-Valued Functions – **Calculus of Vector Valued Functions, Change of Parameter, Arc Length, Tangent, Normal and Binormal Vectors, Curvature, Motion Along a Curve. Examples: Slinky, Adaptive Gridding, Rock 'n' Roller Coaster, Kepler's Laws**

Partial Derivatives – **Functions of More than one Variable, Limits and Continuity, Partial Derivatives, Differentials, The Chain Rule, Directional Derivatives and Gradients, Tangent Planes and Normal Vectors, Maxima and Minima of Functions of Two Variables, Lagrange Multipliers. Examples: Laplace's Equation, Heat Equation, Wave Equation, Space Shuttle, Skiing, Sidewinder, CD cutout.**

Multiple Integrals – **Double Integrals, Double Integrals over Nonrectangular Regions, Double Integrals in Polar Coordinates, Surface Area, Triple Integrals, Centroid, Center of Gravity, Triple Integrals in Cylindrical and Spherical Coordinates, Change of Variables in Multiple Integrals, Jacobians. Examples: WGS and the Volumes of the Earth, The Titanic, Icebergs**

Topics in Vector Calculus – **Line Integrals, Path Independence and Conservative Vector Fields, Green's Theorem, Surface Integrals, Flux, Gauss's (Divergence) Theorem, Stokes' Theorem. Examples: Gravitational Law, Coulomb's Law, Potential Fluid Flow, Circulation**

Class Schedule: 75 minute lectures on Tuesday and Thursday.

Relationship of course to Program Outcomes: This course satisfies the mathematics requirements

Person who prepared this description and date of preparation:
Mitchell Smooke, May 2008

Department number: ENAS 194

Title of course: Ordinary and Partial Differential Equations with Applications

Designation: **Required**

2007-2008 Catalog Data:

EAS 194b Ordinary and Partial Differential Equations with Applications
MWF 10:30-11:20 Not CR/D/F QR Meets RP IV(33)
Basic theory of ordinary and partial differential equations useful in applications. First- and second-order equations, separation of variables, Fourier series, Laplace transforms. ***Prerequisite*: ENAS 151a or MATH 120a or b, *and knowledge of matrix-based operations*. *For the Class of 2008, does not count toward the natural science requirement.***

Textbook: *Elementary Differential Equations and Boundary Value Problems*, by W.E. Boyce and R.C. DiPrima, 8th edition (Wiley).

Coordinator: **Yvonne Moussy, Lecturer in the Department of Mechanical Engineering**

Goals: **To teach students the basic theory in solving first and second order differential equations useful in describing physical phenomena.**

Prerequisites: **MATH 120 or ENAS 151.**

Topics:

- First order ordinary diff. eq's (ODEs)
- Second order linear ODE with Constant Coefficients
- High order ODEs with Constant Coefficients
- The Laplace Transform
- Partial diff. eq's and Fourier Series
- Systems of first order linear equations
- Nonlinear equations and stability criteria
- There may also be time to include some special topics such as numerical solutions, chaos, stochastic differential equations or others.

Submitted by: Robert Schoelkopf Date: September, 2007

Department number: ENAS 335b

Title: Professional Ethics

Designation: Required

Course (catalog) description:

A theoretical and case-oriented approach to ethical decision making. Provides students with concepts, tools, and methods for constructing and justifying their own solutions to moral problems they may face as professionals.

Prerequisite(s): None

Textbook(s) and/or other required material:
- Readings and cases will be included in a packet
- Audiovisual material – presented and discussed in class

Course objectives: Theoretical and case oriented approach to ethical decision making. Designed to provide students with tools and methods to construct their own solution to moral problems they ma face as professionals.

Topic covered:

Part I:
- The nature of ethics
- Challenges to ethics
- Assumptions made in ethics
- Ethical positions on what is morally good and right
- Classification of ethical theories (specific ethical theories)

Part II:
- The ethics of capitalism
- Legitimizing capitalism
- The corporation

Part III:
- Professional ethics and personal ethics
- Codes of ethics (standards for professional community)
- Preventive ethics
- Ethical decision making
- Relevant moral issues

Class/laboratory schedule, i.e., number of sessions each week and duration of each session:
Two 75 minute sessions per week.

Person(s) who prepared this description and date of preparation:

Mercedes Carreras & Roman Kuc, June 2008

Department number: MATH 112 a or b

Title of course: Calculus of Functions of One Variable I

Designation: Prerequisite

Catalog Data:

Limits and their properties. Definitions and some techniques of differentiation and the evaluation of definite integrals, with applications. Students are instructed in use of the mathematical software package Mathematica, which is used in graphical, symbolic, and numerical methods and is required on some problem sets.

Textbook: James Stewart, *Single Variable Calculus*, Sixth Edition. Brooks/Cole, 2007.

Goals: To provide an introduction to the ideas, techniques and applications of calculus, a basic tool of quantitative reasoning

Prerequisites: No prior acquaintance with calculus or computing is assumed.

Topics:

1. Review of functions: the concept of function; algebra of numerical functions; composition; trigonometric functions.
2. Tangent and velocity problems; the limit of function values. (3 classes)
3. Algebra of limits; continuity.
4. Tangents, velocity, rates of change; algebra of derivatives. (3 classes)
5. Applications in social sciences; derivatives of trigonometric functions; derivatives of composite functions (Chain Rule).
6. Implicit differentiation; related rates; higher derivatives; tangent lines and differentials.
7. Mean Value Theorem and qualitative behavior of functions; basics of curve sketching.
8. Limits at infinity; synthesis of curve sketching; calculator-assisted graphing.
9. Optimization (maxima and minima); Newton's Method; antiderivatives.
10. Area and distance; definite integrals; summation notation.
11. Fundamental Theorem of Calculus and applications to evaluating integrals; Substitution.
12. Computing areas and volumes; work.

Computer Usage: *Mathematica* is integrated into the course and students are expected to use this software.

Laboratory Projects: N/A

Prepared by:
Yair Minsky, DUS of Mathematics, & Roman Kuc, May, 2008.

Department number: MATH 115 a or b

Title of course: Calculus of Functions of One Variable II

Designation: **Prerequisite**

Catalog Description: A continuation of Math 112a or b. Applications of integration, with some formal techniques and numerical methods. Improper integrals, approximation of functions by polynomials, infinite series. Exercises involve the mathematical software package *Mathematica*.

Text book: James Stewart, *Single Variable Calculus*, Sixth Edition. Brooks/Cole, 2007.

Goals: The objective is to introduce the notions of derivative and of definite integral for functions of one variable, with some of their physical and geometrical motivations and interpretations.

Prerequisites: Math 112a or b or equivalent; open to freshmen with some preparation in calculus.

Topics:
1. Review of 112, fundamental theorem of calculus, substitution rule
2. Areas between curves, volumes by slices, volumes by cylinders
3. Integration by parts, strategies for integration, using a table of integrals
4. Integration by computer and by tables, approximate integration
5. Improper integration, arc length, surface area
6. Probability, parametric plots
7. Polar coordinates, numerical sequences
8. Series, integral test, comparison test
9. Comparison test, alternating series, ratio and root tests
10. Strategies for testing convergence, power series
11. Representing functions by power series, Taylor and Maclaurin series
12. Taylor and Maclaurin series
13. Applications and review

Computer Usage:

1. *Mathematica* is integrated into the course and students are expected to use this software.

Laboratory Projects: N/A

Relevance to Program Objectives: Part of Mathematics and Science requirement.

Prepared by:
Yair Minsky, DUS of Mathematics, and Roman Kuc, May, 2008.

Department number: MATH 120 a and b

Title of course: Calculus of Functions of Several Variables

Designation: Prerequisite

Catalog Description:

Analytic geometry in three dimensions, using vectors. Real-valued functions of two and three variables, partial derivatives, gradient and directional derivatives, level curves and surfaces maxima and minima. Parametrized curves in space, motion in space, line integrals; applications. Multiple integrals, with applications. Divergence and curl. The theorems of Green, Stokes, and Gauss.

Prerequisite: Math 115, or permission of instructor.

Textbook: James Stewart's *Multivariable Calculus Early Transcendentals, Math 120*, sixth edition, Brooks/Cole 2007.

Topics:

1. Vectors, dot product and projections, cross product
2. Lines and planes, vector functions, derivatives and integrals of vector functions
3. Arc length, velocity and acceleration, graphs of vector functions, level curves
4. Limits and continuity, partial derivatives, tangent plane
5. The chain rule, directional derivatives and gradients
6. Maxima and minima, double integrals
7. More double integrals, vector fields
8. Line integrals, fundamental theorem of line integrals
9. Green's theorem, curl and divergence
10. Surface area, parametric surfaces, surface integrals
11. Stokes' theorem, triple integrals, triple integrals in cylindrical coordinates
12. Triple integrals in spherical coordinates, divergence theorem, applications
13. Applications and review

Class Schedule: Three 50 minute lectures or two 75 minute lectures.

Relevance to Program Objectives: Part of Mathematics and Science requirement.

Prepared by:
Yair Minsky, DUS of Mathematics, and Roman Kuc, May, 2008.

Department number: Math 222

Title of course: Linear Algebra with Applications

Designation as a "Required" or "Elective" course: Required

Course (catalog) description: Matrix representation of linear equations. Gauss elimination. Vector spaces. Linear independence, basis, and dimension. Orthogonality, projection, least squares approximation; orthogonalization and orthogonal bases. Extension to function spaces. Determinants. Eigenvalues and eigenvectors. Diagonalization. Difference equation and matrix differential equations. Symmetric and Hermitian matrices. Orthogonal and unitary transformations; similarity transformations.

Prerequisite(s): May not be taken after Math 225a or b.

Textbook(s) and/or other required material:

- Linear Algebra and its Applications, 3rd edition, by David C. Lay,Pearson Addison-Wesley, 2006

Course objectives: Provide essential analytical background with applications.

Topics covered:
- Matrix Algebra
- Vector Spaces
- Orthogonality
- Eigenvalues and Eigenvectors

Class/laboratory schedule, i.e., number of sessions each week and duration of each session:
- Three 50 minute sessions per week

Relevance to Program Objectives: Part of Mathematics and Science requirement.

Person(s) who prepared this description and date of preparation:

Roman Kuc, June, 2008

Department number: PHYS 180a and 181b

Title: Advanced General Physics

Designation: Prerequisite

2007-2008 Catalog Data: PHYS 180a and 181b. Advanced General Physics. (IV)34. A broad introduction to classical and modern physics for students who have some previous preparation in physics and mathematics. Fall-term topics include Newtonian mechanics, gravitation, waves, and thermodynamics. Spring-term topics include electromagnetism, geometrical and physical optics, and elements of quantum mechanics.

Prerequisite: *Math 115a.*

Text book: *Fundamentals of Physics*, Sixth Edition, Halliday, Resnick and Walker, 2001. Volumes 1 & 2.

Coordinator: [F] Megan Ury, Professor of Physics
[Sp] Robert Grober, Professor of Physics

Goals: To provide a basic introduction to physics for students studying classical physics as well as special relativity and quantum physics.

Prerequisites by topic:

3. Calculus of functions with one variable
4. Calculus of functions with several variables

Topics:

Fall:

18. Motion along a straight line
19. Vectors
20. Motion in two and three dimensions
21. Force and motion
22. Work and kinetic energy
23. Conservation of energy
24. Systems of particles
25. Collisions
26. Rotation
27. Rolling, torque and angular momentum

28. Oscillations
29. Gravitation
30. Waves
31. Temperature
32. Heat and the first law of thermodynamics
33. Kinetic theory of gases
34. Entropy and the second law of thermodynamics

Spring:

22. Electric Charge
23. Electric Field
24. Gauss' Law
25. Electric Potential
26. Capacitance
27. Current and Resistance
28. Circuits
29. Magnetic Field
30. Ampere's Law
31. Faraday's Law of Induction
32. Inductance
33. Magnetism and Matter
34. Electromagnetic Oscillations
35. Alternating Currents
36. Maxwell's Equations
37. Electromagnetic Waves
38. Geometrical Optics
39. Interference
40. Diffraction
41. Relativity
42. Quantum Physics

Computer Usage: N/A

Laboratory projects (including major items of equipment and instrumentation used): N/A

Prepared by: Roman Kuc, May, 2008.

Administrator Curriculum Vitae

Name and Academic Rank: T. Kyle Vanderlick,
Dean of Engineering
Thomas E. Golden Professor of Engineering

Degrees with fields, institution, and date:

Ph.D.	Chemical Engineering,	University of Minnesota	1988
M.S.	Chemical Engineering,	Rensselaer Polytechnic Institute	1983
B.S.	Chemical Engineering,	Rensselaer Polytechnic Institute	1981

Number of years service on this faculty, including date of original appointment and dates of advancement in rank: 1Year, January 2008.

- Assistant Professor, Chemical Engineering, University of Pennsylvania, 9/89 – 6/95
- Associate Professor, Chemical Engineering, University of Pennsylvania, 7/95 – 1/98
- Professor, Chemical Engineering, Princeton University, 2/98 – 12/07
- Assoc. Dean for Academic Affairs, School of Engineering & Applied Sciences, Princeton 7/03–7/04
- Chair, Department of Chemical Engineering, Princeton, 7/04 – 12/07
- Dean of Engineering and Thomas E. Golden Professor of Engineering, Yale University, 1/08 –

Other related experience--teaching, industrial, etc.:

- Visiting Scientist, Complex Fluids Laboratory, Rhone-Poulenc, NJ. 1/97 – 6/97
- NATO Postdoctoral Fellow, Universit¨at Mainz, West Germany, 9/88 – 8/89
- Industrial Trainee Fellow, Procter and Gamble, Cincinnati, OH, 6/81 9/81

Consulting, patents, etc.: None

State(s) in which registered: None

Principal publications of last five years:

1. Tanabe, H., Qu, X,Weeks, C. S., Cummings, J. E., Kolusheva, S., Walsh, K. B., Jelinek, R. , Vanderlick, T. K., Selsted, M. E., and Ouellette, A. J. Structure-Activity Determinants in Paneth Cell Defensins: Loss-of-Function in Mouse Cryptdin-4 by Charge-Reversal at Arginine Residue Positions, Journal of Biological Chemistry (2004) 279, 11976-11983.
2. Cha, P-R., Srolovitz, D. J., and Vanderlick, T. K. Molecular Dynamics Simulation of Single Asperity Contact, Acta Materialia (2004) 52, 3983-3996.
3. Frechette, J. and Vanderlick, T. K. Electrocapillary at Contact: Potential-Dependent Adhesion between a Gold Electrode and a Mica Surface, Langmuir (2005) 21, 985-991.
4. Frechette, J. and Vanderlick, T. K. Control of Adhesion and Surface Forces via Potential-Dependent Adsorption of Pyridine, Journal of Physical Chemistry B (2005) 109, 4007-4013.
5. Houston, J. E., Doelling, C. M., Vanderlick, T. K., Hu, Y., Scoles, G., Wenzl, I., and Lee, T. R. Comparative Study of the Adhesion, Friction, and Mechanical Properties CF3 and CH3-Terminated Alkanethiol Monolayers, Langmuir (2005) 21, 3926-3932.
6. Apel-Paz, M., Doncel, G. F., and Vanderlick, T. K. Impact of Membrane Cholesterol Content on the Resistance of Vesicles to Surfactant Attack, Langmuir (2005) 21, 9843-9849.
7. Davis, J.R., Piccarreta, M.V., Rauch, R.B., Vanderlick, T.K., Panagiotopoulos, A.Z. Phase behavior of rigid objects on a cubic lattice, Industrial Engineering Chemistry Research (2006) 45, 5421-5425.
8. Guo, W., Photos, P. J. and Vanderlick, T. K. Polymer Enhanced Fusion of Model Sperm Membranes as Induced by Calcium, Industrial and Engineering Chemistry Research (2006) 45, 5512-5517.

9. Troup, G.M., Wrenn, S.P., Apel-Paz, M., Doncel, G.F., and Vanderlick, T.K. A time-resolved fluorescence Diphenylhexatriene (DPH) anisotropy characterization of a series of model lipid constructs for the sperm plasma membrane, Industrial Engineering Chemistry Research (2006) 45, 6939-6945.
10. Weeks, C. S., Tanabe, H., Cummings, J. E., Crampton, S. P., Sheynis, T., Jelinek, R., Vanderlick, T. K., Cocco, M. J., and Ouellette, A. J. Matrix Metalloproteinase-7 Activation of Mouse Paneth Cell Pro-alpha-Defensins: Ser43 ↓Ile44 Proteolysis Enables Membrane-Disruptive Activity, Journal of Biological Chemistry (2006) 281, 28932-28942.
11. Cummings, J. E. and Vanderlick, T. K. Aggregation and Hemi-fusion of Anionic Vesicles Induced by the Antimicrobial Peptide Cryptdin-4, Biochimica Biophysica Acta (2007) 1768, 1796-1804.
12. Doelling, C.M., Songa, J., Srolovitz, D., and Vanderlick, T.K. Nano-spot-welding and contact evolution during cycling of a model microswitch, Journal of Applied Physics (2007) 101, 124303(1).
13. Cummings, J. E. and Vanderlick, T. K. Binding Orientation and Activity Determinants of the Antimicrobial Peptide Cryptdin-4 Revealed By Potency of Mutants, Colloids and Surfaces B: Biointerfaces (2007) 60, 236-242.
14. Cummings, J. E. and Vanderlick, T. K. Kinetics of Cryptdin-4 Translocation Coupled with Peptide-Induced Vesicle Leakage, Biochemistry (2007) 46, 11882-11891.
15. Beales, P.A. and Vanderlick, T.K. Specific binding of different vesicle populations by the hybridization of membrane-anchored DNA, Journal Physical Chemistry A (2007) 111, 12372-12380.
16. Apel-Paz, M., Doncel, G., and Vanderlick, T. K. Surfactants as Microbicidal Contraceptives: A Calorimetric Study of Partitioning and Translocatoin in Model Membrane Systems, Industrial and Engineering Chemistry Research (2008) 47, 3554-3561.

Scientific and professional societies of which a member: AIChE, APS, ACS, BPS

Honors and awards:

- Ethel Z. Casassa Memorial Lecturer, Carnegie Mellon, Department of Chemical Engineering, 2006.
- Grace Hopper Lecturer, University of Pennsylvania, Department of Chemical Engineering, 2002.
- President's Award for Distinguished Teaching, Princeton University, 2002.
- Princeton Engineering Council Teaching Award, Fall 2002.
- Van Ness Lecturer, Rensselaer Polytechnic Institute, Department of Chemical Engineering, 1997.
- Philip's Lecturer, Haverford College, Department of Physics, 1996.
- Class of 1942 Endowed Term Chair, University Pennsylvania, 1995.
- S. Reid Warren, Jr. Award for Distinguished Teaching 1994.
- Christian R. and Mary F. Lindback Foundation Award for Excellence in Teaching 1993.
- David and Lucile Packard Fellowship 1991.
- Presidential Young Investigator Award 1989.
- NATO Postdoctoral Fellowship in Science and Engineering (9/88–89).

Institutional and professional service in the last five years:

- External Reviewer for the Department of Chemical Engineering, University of Buffalo, 2008.
- External Reviewer for the Department of Chemical Engineering, UC Santa Barbara, 2008.
- External Reviewer for the School of Chemical Engineering, Purdue, 2007.
- Advisory Council, Department of Chemical and Engineering, University of Delaware, 2007.
- Visiting Committee, Department of Chemical and Biomolecular Engineering, Johns Hopkins, 2007.
- Technical Advisory Panel, HelioVolt Corporation, Austin, TX, 2006.
- External Reviewer for the School of Chemical and Biomolecular Eng., Cornell University, 2003.

Name and Academic Rank: Roman Kuc
Assoc. Dean for Educational Affairs
Professor of Electrical Engineering

Degrees with fields, institution, and date:

- BSEE, Electrical Engineering, Illinois Institute of Technology, 1968
- MSEE, Electrical Engineering, Columbia University, 1970
- Ph.D., Electrical Engineering, Columbia University, 1977

Number of years service on this faculty, including date of original appointment and dates of advancement in rank: 29 Years

- Professor of Electrical Engineering, Yale University (7/94)
- Tenured Associate Professor, Yale University, 7/87 – 6/94
- Associate Professor, Yale University, 7/83 – 6/87
- Assistant Professor, Yale University, 7/79 – 6/83

Other related experience--teaching, industrial, etc.:

- Member of Technical Staff, Bell Telephone Laboratories (7/68 – 1/75)
- Director of Intelligent Sensors Laboratory (7/86 – Present)

Consulting

- Rehabilitation Engineering in Veterans Administration, New York City
- Expert Witness in Telecommunications, ITC, Washington, DC
- Review panel member for NSF, NIH & NSER Canada.
- Workshop participant for DARPA and ABET.

Patents

- Adaptive Acoustic Signal Sensing Device and recognition System, U.S. Serial No. 5,577,066.
- Biomedical Magnetism Imaging Apparatus and Method, U.S. Serial No. 5,594,849.

State(s) in which registered: None

Principal publications of last five years:

- Biomimetic sonar recognizes objects from echoes. Chapter in {\it Echolocation in Bats and Dolphins}, edited by J. Thomas, C. F. Moss, and M. Vater. University of Chicago Press. 2004.
- R. Kuc. Neuro-computational processing of moving sonar echoes classifies and localizes foliage. J. Acoust. Soc. America, 116(3), 1811-1818, 2004.
- R. Kuc and S. Tully. Cybernetic model for monitoring early dementia from vehicle operation data. 7th Annual Conf. Japan Society for Early Stage of Dementia, Tokai Univ., Japan, 2005.
- R. Kuc. Biomimetic Robots: Applying Nature's Approaches to Robots, Silicon Valley Yale Club, San Jose CA, 2007.
- R. Kuc. Biomimetic sonar and neuromorphic processing eliminate reverberation artifacts. IEEE Sensors J. 7(3), pp. 361-369, 2007.
- R. Kuc. Neuromorphic processing of moving sonar data estimates passing range. IEEE Sensors J. 7(5), 851-859, 2007.
- R. Mueller and R. Kuc. Biosonar-Inspired Technology: Goals, Challenges, and Insights. Bioinspiration & Biomimetics, 2 pp. 1-16, 2007.

- R. Kuc. Generating B-scan images with a conventional sonar. IEEE Sensors Journal, 2008.
- L. Kleeman and R. Kuc. Sonar sensing. Chapter in Springer *Handbook of Robotics*, edited by B. Siciliano and O. Khatib. Springer Press. 2008.
- R. Kuc, *Introduction to Digital Signal Processing.* McGraw-Hill, 1988. Reprinted by BS Publications, India, 2007.

Scientific and professional societies of which a member:
- IEEE: 6/1989-Present (Senior Member); 3/84 – 5/89 (Member)
- Acoustical Society of America: 9/90-Present
- American Society of Engineering Education: 12//99-Present

Honors and awards:
- Phi Eta Sigma, ETA Kappa Nu, Tau Beta Pi, and Sigma Xi.
- IEEE Acoustics, Speech and Signal Processing Society Paper Award, 1983.
- Fellow, Shevchenko Scientific Society, 2001.
- Grand Order of the Golden Bulldog, Yale University, 1999.
- Academician (Hon.), Academy of Sciences of Higher Education of Ukraine, Kyiv, Ukraine, 1998.
- Sheffield Distinguished Teaching Award, 1997.

Institutional and professional service in the last five years:
- Associate Dean for Education Affairs, 5/08 - Present
- Director of Education Affairs in Engineering, 1/00 – 5/08
- Chair, Advisory Committee on Resources for Students and Employees with Disabilities, 7/00 – 6 /08.
- Member. Quantitative Reasoning Council, 7/06 – 6/08

Professional development activities in the last five years:
- ABET Workshop, 2008.
- ASEE Conference

Name and Academic Rank: Menachem Elimelech
Professor & Chair of Chemical Engineering

Degrees:

Ph.D.	Environmental Engineering, Johns Hopkins University,	1989
M.Sc.	Environmental Science & Technology, The Hebrew University,	1985
B.Sc.	Soil and Water Sciences, The Hebrew University, Jerusalem, Israel,	1983

Years of service on this faculty: 9

1998-present	Roberto Goizueta Professor, Dept. of Chemical Engineering, Yale
1998-present	Director, Environmental Engineering Program, Yale
2005-present	Chair, Department of Chemical Engineering, Yale

Other Related Experience:

2001(summer)	Visiting Professor, Department of Civil Eng., National University of Singapore
1997-1998	Professor, Dept. of Civil & Environmental Engineering, UCLA
1996	Visiting Associate, Environmental Engineering Science, California Institute of Technology (Fall Quarter)
1994-1997	Associate Professor, Dept. of Civil & Environmental Engineering, UCLA
1989-1995	Assistant Professor, Dept. of Civil & Environmental Engineering, UCLA

Consulting: Nestle

Principal Publications of the Last Five Years

McCutcheon, J.R., and Elimelech, M. "Influence of Membrane Support Layer Hydrophobicity on Water Flux in Osmotically Driven Membrane Processes", Journal of Membrane Science, 318, 2008, 458-466.

Huertas, H, Herzberg, M., Oron, G. Elimelech, M, "Influence of Biofouling on Boron Removal by Nanofiltration and Reverse Osmosis Membranes", Journal of Membrane Science, 318, 2008, 264-270.

Shannon, M.A., Bohn, P.W., Elimelech, M., Georgiadis, J.G., Mariñas, B.J. and Mayes, A.M. "Science and Technology for Water Purification in the Coming Decades", Nature, 452, March 2008, 301-310.

Brady-Estévez, A.S., Kang, S., and Elimelech, M. "A Single-Walled Carbon Nanotube Filter for Removal of Viral and Bacterial Pathogens", Small, 4, 2008, 481-484.

de Kerchove, A.J. and Elimelech, M. "Adhesion of Non-Motile Pseudomonas aeruginosa on "Soft" Polyelectrolyte Layer in a Radial Stagnation Point Flow System: Measurements and Model Prediction", Langmuir, 23, 2007, 12301-12308.

McGinnis, R.L., McCutcheon, J.R., and Elimelech, M. "A Novel Ammonia - Carbon Dioxide Osmotic Heat Engine for Power Generation", Journal of Membrane Science, 305, 2007, 13-19.

Kang, S., Pinault, M., Pfefferle, L.D., and Elimelech, M. “Single-Walled Carbon Nanotubes Exhibit Strong Antimicrobial Activity”, Langmuir, 23, 2007, 8670-8673.

de Kerchove, A.J. and Elimelech, M. “Impact of Alginate Conditioning Film on Deposition Kinetics of Motile and Nonmotile Pseudomonas aeruginosa Strains”, Applied & Environmental Microbiology, 73, 2007, 5227-5234.

McCutcheon, J.R., and Elimelech, M. “Modeling Water Flux in Forward Osmosis: Implications for Improved Membrane Design”, AIChE Journal, 53, June 2007, 1736-1744.

Asatekin, A., Kang, S, Elimelech, M., and Mayes, A.M. “Anti-fouling Ultrafiltration Membranes Containing Polyacrylonitrile-Graft-Poly(Ethylene Oxide) Comb Copolymer Additives” , Journal of Membrane Science, 298, 2007, 136-146.

Scientific and Professional Societies of Which a Member

American Chemical Society, Association of Environmental Engineering Science Professors, American Institute of Chemical Engineers, American Society of Civil Engineers, American Water Works Association, International Association of Colloid and Interface Scientists, North American Membrane Society

Honors and Awards

2007	Connecticut Academy of Science and Engineering
2006	National Academy of Engineering
2006	AEESP Frontier of Research Award
2005	Clarke Prize, National Water Research Institute
2005	Trendsetter, Public Work Magazine
2004	Excellence in Review Award, Environmental Science & Technology
2004	Yale University Graduate Mentor Award
1996	American Society of Civil Engineers, Walter L. Huber Civil Engineering Research Prize
1994	W.M. Keck Foundation, Engineering Teaching Excellence Award
1990	National Science Foundation, Research Initiation Award

Courses Taught the Past Academic Year

Environmental Transport Processes (**ENVE 444a**)
Physical and Chemical Processes in Environmental Engineering (**ENAS 642b**)

Other Duties

Advisory Committee, Center for Industrial Ecology, School of Forestry & Environmental Studies; Yale College Course of Study Committee; Studies in the Environment Committee; Standing Advisory and Appointments Committee for the School of Forestry and Environmental Studies

Self Improvement:

Attended conferences: AIChE, ACS, AGU, NAMS, ASCE
Organized Sessions at: AIChE, ACS, and NAMS Annual Meetings

Name and Academic Rank: Paul Van Tassel,
Professor & DUS of Chemical Engineering

Degrees with fields, institution, and date:
- BA, Chemistry and Mathematics, Saint Olaf College, 1987
- PhD, Chemical Engineering, University of Minnesota, 1993

Number of years service on this faculty: 5 Years
- Professor, Yale University (December 2006)
- Associate Professor, Yale University (January 2003 - December 2006)

Other related experience--teaching, industrial, etc.:
- Associate Professor, Wayne State University (August 2001 - December 2002)
- Assistant Professor, Wayne State University (August 1996 - August 2001)
- Postdoctoral Fellow, Université Pierre et Marie Curie, Paris, France (September 1993 - July 1996)

Consulting, patents, etc.:
- Consultant to Tricardia, LLC
- Review panel member for NSF, NIH

State(s) in which registered: None

Principal publications of last five years:
- "Integral equation theory of adsorption in templated materials: influence of molecular attraction", L. Sarkisov and P. R. Van Tassel, **2007**, *Journal of Physical Chemistry C*, 111, 15726.
- "Continuous polyelectrolyte adsorption under an applied electric potential", A. P. Ngankam and P. R. Van Tassel, *Proceedings of the National Academy of Sciences of the USA*, **2007**, 104, 1140.
- "Fibronectin terminated multilayer films: protein adsorption and cell attachment studies", C. R. Wittmer, J. A. Phelps, W. M. Saltzman, and P. R. Van Tassel, *Biomaterials*, **2007**, 28, 851.
- "Structuring of macro-ions confined between like-charged surfaces", A. Tulpar, P. R. Van Tassel, and J. Y. Walz, **2006**, *Langmuir*, 22, 2876.
- "Replica Ornstein-Zernike theory of adsorption in a templated porous material: interaction site systems", L. Sarkisov and P. R. Van Tassel, **2005**, *Journal of Chemical Physics*, 123, 164706.
- "Adsorbed layers of oriented fibronectin: a strategy to control surface-cell interactions", C. Calonder, H. W. T. Matthew, and P. R. Van Tassel, **2005**, *Journal of Biomedical Materials Research A*, 75, 316.
- "In-situ layer-by-layer film formation kinetics under an applied voltage measured by optical waveguide lightmode spectroscopy", **2005**, A. P. Ngankam and P. R. Van Tassel, *Langmuir*, 21, 5865.
- "Probing adsorbed fibronectin layer structure by kinetic analysis of monoclonal antibody binding", C. R. Wittmer and P. R. Van Tassel, **2005**, *Colloids and Surfaces B*, 41, 103.
- "Conformational transition free energy profiles of an adsorbed, lattice model protein by multicanonical Monte Carlo simulation", V. Castells and P. R. Van Tassel, **2005**, *Journal of Chemical Physics*, 122, 084707.
- "Probing macromolecular adsorbed layer structure via the interfacial cavity function", Y. Tie, A. P. Ngankam, and P. R. Van Tassel, **2004**, *Langmuir*, 20, 10599.
- "Fibronectin adsorption onto polyelectrolyte multilayer films", A. P. Ngankam, G. Mao, and P. R. Van Tassel, **2004**, *Langmuir*, 20, 3362.

Scientific and professional societies of which a member:
- American Institute of Chemical Engineers
- American Chemical Society
- American Physical Society

Honors and awards:
- J. William Fulbright Scholarship, France, 2006
- John J. Lee Associate Professorship of Chemical Engineering, 2005
- National Academy of Engineering: *Frontiers of Engineering*, 1999
- National Science Foundation CAREER Award, 1998
- NATO-NSF Post-Doctoral Fellowship, 1994
- Chateaubriand Post-Doctoral Fellowship, 1994
- University of Minnesota Graduate School Doctoral Dissertation Fellowship, 1992
- Alpha Chi Sigma Award, 1992
- Phi Beta Kappa, 1987

Institutional and professional service in the last five years:
- Liaison to Director of Graduate Studies, Faculty of Engineering, July 2005 - June 2008.
- Director of Undergraduate Studies, Dept. of Chemical Engineering, July 2008 - present.

Professional development activities in the last five years:
- Attended, presented, and chaired professional conferences.

Name and Academic Rank: A. Stephen Morse,
Professor & Chair of Electrical Engineering

Degrees with fields, institution, and date:
- Ph.D., Electrical Engineering, Purdue University, 1967
- M.S., Electrical Engineering, University of Arizona, 1964
- B.S., Electrical Engineering, Cornell University, 1962

Number of years service on this faculty, including date of original appointment and dates of advancement in rank: 38 Years, July 1970 (Professor)

Other related experience--teaching, industrial, etc.:
- Visiting Scientist, University of Toronto, Toronto, Canada, (Summer 1970)
- Research Scientist, Office of Control Theory and Application, NASA Electronics Research Center, Cambridge, MA, (1969-1970)
- Captain, U.S. Army, Assigned to the Office of Control Theory and Application, MASA/ERC, (1967-1969)

Consulting, patents, etc.: None

State(s) in which registered: None

Principal publications of last five years:
- W. M. Wonham and A.S. Morse, "Decoupling and Pole Assignment in Linear Multivariable Systems: A Geometric Approach", SIAM Journal on Control, 8(1):1-18, February 1970.
- A. S. Morse, "Structural Invariants of Linear Multivariable Systems", SIAM J. Control, 11(3):446-465, August 1973.
- I. Kanellakopoulos, P. V. Kokotovic, and A. S. Morse, "Systematic Design of Adaptive Controllers for Feedback Linearizable Systems", IEEE Transactions o Automatic Control,, 36(11):1241-1253, November 1991.
- R. D. Grober, J. Acimovic, J. Schuck, D. Hessman, P. Kindlmann, J. P. Hespanha, A. S. Morse, K. Karrai, Tiemann, and S. Manus, "Fundamental limits to Force Detection Using Quartz Tuning Forks, Review of Scientific Instruments, pp. 2776-2780, July 2000
- B. D. O. Anderson, T. S. Brinsmead, F. de Bruyne, J. P. Hespanha, D. >Liberzon, and A. S. Morse, "Multiple Model Adaptive Control, Part 2: Supervision", International Journal on Robust and Nonlinear Control, pp. 479-496, April 2001.
- G. Chang, J. P. Hespanha, A. S. Morse, M. Netto, and R. Ortega, "Supervisory Field-Oriented Control of Induction Motors with Uncertain Rotor Resistance", International Journal of Adaptive Control and Signal Processing, pp. 353-375, May 2001.

Scientific and professional societies of which a member:
- IEEE, Eta Kappa Nu, Sigma Xi, SIAM, NAE

Honors and awards:
- Best Technical Paper [1], 1970 Joint Automatic Control Conference, with W. M. Wonham
- Best Technical Paper [2], 1972 Joint Automatic Control Conference
- Japan Society for the Promotion of Science Fellowship, 1985

- Fellow, IEEE
- 1993 George S. Axelby Outstanding Paper Award, [3] with I. Kanelakopoulos and P. V. Kokotovic
- Distinguished Lecturer, IEEE Control Systems Society
- Recipient of the 1999 IEEE Technical Field Award for Control Systems
- Reference [1] has recently been cited by the IEEE Control Systems Society as one of the 25 most influential papers published in the field of automatic control in the twentieth century.
- Member National Academy of Engineering
- 2005 George S Axelby Outstanding Paper Award
- CT Academy of Science and Engineeering
- Automatica Theory/Methodogy Prize

Institutional and professional service in the last five years:
Physical Science Advisory Committee
Chair, Dept of Electrical Engineering

Professional development activities in the last five years:
- Past Associate Editor, IEEE Trans. Automatic Control
- Past Director of the America Automatic Control Council for SIAM
- Program Committee, JACC, International Conference on Cybernetics and Society, DCD, MTNS Hybrid Systems.
- Steering Committee, International Conference on Cybernetics and Society, MTNS
- Session Chairman: JACC, International Conference on Cybernetics and Society, IEEE Conference on Decision and Control, SIAM National Meeting, MTNS, INRIA, ACC Conferences.
- Reviewer: JACC, IEEE Trans. Auto. Control, SIAM J. Control, IFAC, Automatica, Information and Control, Applied Math and Optimization, NSF, NRC, International J. Control, Transp. Science, System and Control Letter, AFOSR.
- External Thesis Examiner: University of Toronto, Lund Institute of Technology, University of Newcastle, McGill University, University of Hamburg, University of Nante, University of Waterloo.
- NSF Research Initiation Grant and PYI Panels
- Editorial Board, European Journal of Control, Adaptive Control and Signal Processing.
- Organizer: 1994, 1997 and 2001 IEEE/CDC Short Courses on Logic Based Switching and Control, 1995 Block Island Workshop on Control Using Logic-Based Switching: 1997 Block Island Workshop on Vision and Control.
- Guest Editor, Special 1999 Issue of Automatica on Hybrid System.
- Member Peer Committee 7, NAE
- Chair, George S Axelby Awards Committee
- Chair IEEE Technical Field Award Committee for Control

Name and Academic Rank: Kumpati S. Narendra,
Professor & DUS of Electrical Engineering

Degrees with fields, institution, and date:
- Ph.D., Applied Physics, Harvard University, 1959
- MS Applied Physics, Harvard University, 1955
- Bachelor of Engineering (Honors), University of Madras, India, 1954
- Doctor of Science (Honorary), National University of Ireland, 2007
- Doctor of Science (Honorary), Anna University, India, 1995

Number of years service on this faculty, including date of original appointment and dates of advancement in rank: 43 Years, July 1965
- Associate Professor, Engineering and Applied Science, Yale University, July 1965-June 1968
- Professor, Yale University, June 1968-Present
- Chairman, Department of Electrical Engineering, Yale University, July 1984-June 1987
- Director, Neuroengineering and Neuroscience Center, Yale University, 1995-1996

Other related experience--teaching, industrial, etc.:
- Assistant Professor, Harvard University, 1961-1965
- Distinguished Visiting Scientist (JPL), 1994-1995

Consulting
16 Industrial Laboratories 1959-1999, including
- Honeywell, 1959-1961
- Sperry Rand Research Center, 1961-1964
- Bell Aero Systems, 1966
- Schlumberger, 1969-1970
- Sikorsky Aircraft, 1967-1973
- Raytheon, 1975
- AT&T Long Lines, 1975-1980
- General Motors Research Laboratories, 1984-1985
- Neural Applications Corporation , 1994-1999
- Sandia National Research Laboratories, 1996-1999.

Patents: **None**

State(s) in which registered: None

Principal publications of last five years:

1. R.N. Shorten and K.S. Narendra, "On Common Quadratic Lyapunov Functions for Paris of Stable LTI Systems Whose System Matrices Are in Companion Form", IEEE TransAutomatic Control, Vol. 48(4), 2003
2. K.S. Narendra, O.A. Driollet, M. Feiler, and K. George "Adaptive control using multiple models, switching and tuning" International Journal of Adaptive Control and Signal Processing. Vol 17(2**),** pp 87 – 102, 2003.

3. K.S. Narendra, “From Feedback Control to Complexity Management: A Personal Perspective” in Switching and Learning in Feedback Systems, Eds: R. Murry-Smith and R.N. Shorten, 2004
4. L. Chen and K.S. Narendra, “Identification and Control of a Nonlinear Discrete-Time System Based on its Liearization: A unified Framework”, IEEE Transactions on Neural Networks, Vol. 15, No. 3 2004.
5. K.S. Narendra. N. Oleng and S Mukhopadhyay, “Decentralised Adaptive Control with Partial Communication”, IEE Proc.-Control Theory Application, Vol. 153, No. 5, 2006
6. K.S. Narendra, M. Feiler and Z. Tian “Control of Complex Systems Using Neural Networks”, in Modeling and Control of Complex Systems, Eds: P. A. Ioannou and A. Pitsillides, 2007.

Scientific and professional societies of which a member:
Sigma Xi, IEE, IEEE, American Association for the Advancement of Science (AAAS), Connecticut Academy of Science and Engineering

Honors and awards:
- Franklin V. Taylor Award (IEEE SMC Society), 1972
- Fellow, IEEE, 1979
- Fellow, AAAS, 1987
- George S. Axelby Best paper Award (IEEE Control Systems Society), 1988
- John R. Ragazzini Education Award (American Automatic Control Council), 1990
- Outstanding Paper Award of the Neural Network Council, 1991
- Neural Network Leadership Award (International Neural Network Society), 1994
- The Bode Prize (Control Systems Society), 1995
- Member, Connecticut Academy of Science and Engineering, 1995
- Life Fellow, IEEE, 1997
- Distinguished speaker, Texas A& M university, 1997
- Distinguished Speaker, University of Virginia, 2001
- Harold W. Cheel Chair Professorship, 2003
- Richard E. Bellman Control Heritage Award (American Automatic control Council), 2003
- Walton Fellow, Ireland, 2007
- Pioneer Award/Medal, IEEE Computational Intelligence Society, 2008

Institutional and professional service in the last five years:
- Member of the Advisory Committee of the Institute of Advanced Engineering in Seoul, Korea
- Scientific Advisor of the Hamilton Institute in Dublin, Ireland
- Honorary (Permanent) Visiting Professor of Anna University in Madras, India
- Scientific Advisor: Center for Intelligent Systems PESIT, Bangalore, India
- Associate Editor: Neural Networks
- Associate Editor: Neural Computation
- Associate Editor: International Journal of Adaptive Control and Signal Processing
- Organizer of the 13th (2005) and 14th (2008) Yale Workshop on Adaptive and Learning Systems.
- Invited lecture at ACC, Portland, Oregon, 2005
- The Hamilton Lecture at the Hamilton Institute, The National University of Ireland at Maynooth, 2003

Professional development activities in the last five years:
Attended, presented, and chaired sessions at numerous conferences in Electrical Engineering.

Name and Academic Rank: Mitchell D. Smooke
Professor & Chair of Mechanical Engineering

Degrees:

M.B.A.	Management/Finance , University of California at Berkeley,	1983
Ph.D.	Applied Mathematics, Harvard University,	1978
M.S.	Applied Mathematics, Harvard University,	1974
B.S.	Physics, Rensselaer Polytechnic Institute,	1973

Number of years of service on this faculty:

1993-present Professor of Mechanical Engineering
1990-1993 Associate Professor with Tenure
1986-1990 Associate Professor on Term
1984-1986 Assistant Professor

Other related Experience:

1991 Associate Professor of Mechanical Engineering, Sydney, Australia
1988 Associate Professor of Mechanical Engineering, Chatenay-Malabry, France
1985 Associate Professor of Applied Mathematics, Nijmegen, Holland
1978-1984 Staff Scientist, Sandia National Laboratories, Livermore, California
1974-78 Research Assistant, Harvard University, Cambridge, Massachusetts

Consulting:

United Technologies Research Center, East Hartford, Connecticut

States in which registered: N/A

Principal Publications of the Last Five Years:

- M. Noskov, M. Benzi and M. D. Smooke, "An Implicit Compact Scheme Solver for Two-Dimensional Multicomponent Flows," *Comp. and Fluids*, **36**, (2006).
- V. Giovangigli, N. Meynet and M. D. Smooke, "Application of Continuation Techniques to Ammonium Perchlorate Plane Flames," **10**, *Comb. Theory and Modelling*, (2006).
- G. Amantini, J. H. Frank, A. Gomez and M.D. Smooke, "Computational and Experimental Study of Steady Two-Dimensional Axisymmetric Non-Premixed Methane Counterflow Flames," *Comb. Theory and Modelling*, **11**, (2007).
- G. Amantini, B. A. V. Bennett, J. H. Frank, A. Gomez and M. D. Smooke, "Comprehensive Study of Extinction, Re-ignition, and the Evolution of an Annular Edge Flame in a Counterflow Flame Perturbed by Vortices," *Comb. and Flame*, **150**, (2007).
- B. A. V. Bennett, M. D. Smooke, R. J. Osborne and R. W. Pitz, "Computational and Experimental Study of Oxy-Fuel Diffusion Flames," *Comb. Theory and Modelling*, **12**, (2008).

Scientific and Professional Societies:

The American Institute of Aeronautics and Astronautics (AIAA)
The American Society of Mechanical Engineers (ASME)
The Combustion Institute
The Institute of Physics (IOP)
Society of Industrial and Applied Mathematics (SIAM)

Honors and Awards:

Elected to the Connecticut Academy of Science and Engineering (2006)
Oppenheim Prize, Institute for the Dynamics of Explosions and Reacting Systems (2004)
The Combustion Institute Silver Medal (1994)
Fellow, Institute of Physics (1998)
Associate Fellow, AIAA (2002)
Yale University Graduate School Mentor Award (2008)
Yale College Dylan Hixon Prize for Teaching Excellence in the Natural Sciences (2006)
Yale YSEA Award for the Advancement of Basic and Applied Research (2005)
Yale Engineering Sheffield Teaching Award (2004)
Technical Achievement Award, Sandia National Laboratories (1982)
Commencement Marshall Award (highest GPA), Physics Department, RPI, (1973)

Institutional and Professional Service in the last Five Years:

Chairman, Mechanical Engineering, Yale University (2006-Present)
Director of Undergraduate Studies, Mechanical Engineering (2000-2006)
Director of Graduate Studies, Yale Engineering (2002-2003)
Yale University Tenure Committee (2005-2006)
Yale University Science Council (Member 2004-2005, Chair 2005-Present)
Yale University Budget Committee, (2005-2007)
Yale University Physical and Biological Sciences Degree Committee (2002-Present)
Yale University Scholar Awards Committee (2005-Present)
Yale University YINQE Committee (2005-Present)
Coeditor-In-Chief, Combustion Theory and Modeling (1996-Present)
Editor, Theoretical and Computational Fluid Dynamics (2001-2005)
Program Co-Chair, 32nd International Combustion Symposium (2008)
Member of the Board of Directors, The Combustion Institute, (2006-Present)
Executive Committee, Eastern States Section of the Combustion Institute (2005-2007)
Chair, Eastern States Section of the Combustion Institute (2003-2005)
Vice-Chair, Eastern States Section of the Combustion Institute (2001-2003)
Member of the Engineering Advisory Board, Fairfield University (2005-Present)
Member of the External Advisory Board, Dept. of Mech. Eng., UConn (2006-Present)
Department of Energy Workshop on Multiscale Modeling (2005)
Propellant and Combustion Technical Program Chair, ASM AIAA, Reno, (2005)
Propellant and Combustion Technical Committee, AIAA, (2001-Present)
Co-Organizer, 12th International Conference on Numerical Combustion, SIAM (2008)
Co-Organizer, 10th International Conference on Numerical Combustion, SIAM (2004)

Professional Development Activities in the Last Five Years:

Attendance as invited participant at national and international scientific conferences on combustion.

Name and Academic Rank: Marshall B. Long
Professor & DUS of Mechanical Engineering

Degrees with fields, institution, and date:

- Ph.D.Applied Physics, Yale University, 1980
- M.S. Applied Physics, Yale University, 1978
- B.A. Physics, University of Montana, 1976

Number of years service on this faculty, including date of original appointment and dates of advancement in rank: 28 Years

- Professor of Mechanical Engineering, Yale University 1990 to present
- Associate Professor, Yale University, 1984 to 1990
- Assistant Professor, Yale University, 1980 to 1984

Other related experience.:

- Summer employment at Los Alamos National Laboratory, IBM Thomas J. Watson Research Center, Sandia National Laboratory

Consulting, patents, etc.: None

State(s) in which registered: None

Principal publications of last five years:

- K.T. Walsh, J. Fielding, M.D. Smooke, M.B. Long, and A. Linan, "A Comparison of Computational and Experimental Lift-Off Heights of Coflow Laminar Diffusion Flames," *Proc. Comb. Inst.,* 30, 1555-1563 (2005).
- S.A. Kaiser and M.B. Long, "Quantitative Planar Laser-Induced Fluorescence of Naphthalenes as Fuel Tracers," *Proc. Comb. Inst.,* 30, 357-365 (2005).
- S.A. Kaiser, J.H. Frank, and M.B. Long, "Use of Rayleigh Imaging and Ray Tracing to Correct for Beam-Steering Effects in Turbulent Flames," *Appl. Opt.* 44, 6557-6564 (2005).
- J.H. Frank, S.A. Kaiser, and M.B. Long, "Multiscalar Imaging in Partially Premixed Jet Flames with Argon Dilution," *Combust. Flame* 143, 507-523 (2005).
- M.D. Smooke, M.B. Long, B.C. Connelly, M.B. Colket and R.J. Hall, "Soot Formation in Laminar Diffusion Flames," *Combust. Flame* 143, 613-628 (2005).
- R.W. Dibble and M.B. Long, "Investigation of differential diffusion in turbulent jet flows using planar laser Rayleigh scattering," *Combust. Flame* 143, 644-649 (2005).
- S.B. Dworkin, B.C. Connelly, A.M. Schaffer, M.B. Long, M.D. Smooke, M.P. Puccio, B. McAndrews and J.H. Miller, "Computational and Experimental Study of a Forced, Time-Dependent, Methane-Air Coflow Diffusion Flame," *Proc. Comb. Inst.,* 31, 971-978 (2007).
- R. Schießl, S.A. Kaiser, M.B. Long and U. Maas, "Application of Reduced State Spaces to Laser-Based Measurements in Combustion," *Proc. Comb. Inst.,* 32, in press.
- S. B. Dworkin, A. M. Schaffer, B. C. Connelly, M. B. Long and M. D. Smooke, M. A. Puccio, B. McAndrew, and J. H. Miller, "Measurements and Calculations of Formaldehyde Concentrations in a

Methane/N_2/Air, Non-Premixed Flame: Implications for Heat Release Rate," *Proc. Comb. Inst.,* 32, in press.

- B. C. Connelly, M. B. Long, M. D. Smooke, R. J. Hall, and M. B. Colket, "Computational and Experimental Investigation of the Interaction of Soot and NO_x in Coflow Diffusion Flames," *Proc. Comb. Inst.,* 32, in press.
- B. C. Connelly, B. A. V. Bennett, M. D. Smooke and M. B. Long, "A Paradigm Shift in the Interaction of Experiments and Computations in Combustion Research," *Proc. Comb. Inst.,* 32, in press.

Scientific and professional societies of which a member:

- Combustion Institute
- Optical Society of America
- Connecticut Academy of Science and Engineering
- American Society of Mechanical Engineers

Honors and awards:

- Member, Connecticut Academy of Science and Engineering
- Fellow, Optical Society of America
- Chair, Gordon Research Conference on Laser Diagnostics in Combustion
- Silver Medal, The Combustion Institute
- Lilly Endowment Teaching Fellow (1986)
- Young Alumni Award, University of Montana
- Presidential Young Investigator Award
- Northeast Association of Graduate Schools Book Award

Institutional and professional service in the last five years:

- Chairman of Department of Mechanical Engineering (two three-year terms)
- Director of Undergraduate Studies for Mechanical Engineering (2006 – present)
- Referee for numerous journals including Combustion and Flame, Applied Optics, Experiments in Fluids, Proceedings of the Combustion Institute.
- Associate Editor of Proceedings of the Combustion Institute
- Proposal Reviews for DOE, NSF, AFOSR

Professional development activities in the last five years:

- Attended, presented and chaired sessions at professional conferences.