UCR
Bourns College of Engineering

ABET
Self-Study Report

for the

Chemical Engineering program

at

University of California, Riverside

July 1, 2012

CONFIDENTIAL

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BACKGROUND INFORMATION

A. Contact Information

The Chair of the Department of Chemical and Environmental Engineering (CEE) is Prof. Nosang V. Myung. He will serve as the main point of contact for the visit. The ABET review and assessment process in the CEE Department is organized as follows. There is an ABET Accreditation and Assessment Committee, which is composed of the Undergraduate Studies Committee. The committee is chaired by the faculty representing the department in the College-wide ABET Committee. Prof. David Cocker has chaired the committee since January 2006. Dr. Cocker and the ABET Committee had the primary responsibility of preparing this Self-Study Report and planning the site visit. Contact information for these individuals is given below:

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B. Program History

The Chemical Engineering program was established in Fall 1986 with the first freshman class admitted in Fall 1990. The M.S. and Ph.D. program in Chemical and Environmental Engineering was established in Fall, 1998. A BS/MS offering was established in Fall, 2009.

C. Options

There are three concentrations within the Chemical Engineering B.S. Degree Program: Chemical Engineering (effective Fall 2001), Biochemical Engineering (effective Fall 2001), and Nanotechnology (effective Fall 2006). A fourth concentration (Bioengineering) was originally created in Fall 2003 and was discontinued effective in Summer 2011 as a result of the creation of a Department of Bioengineering and the degree offered there.

D. Organizational Structure

Figures BG-1 and BG-2 show the organizational structure of the Chemical Engineering degree program within the context of the University and the organizational process that governs academic decision-making for the undergraduate degree program.

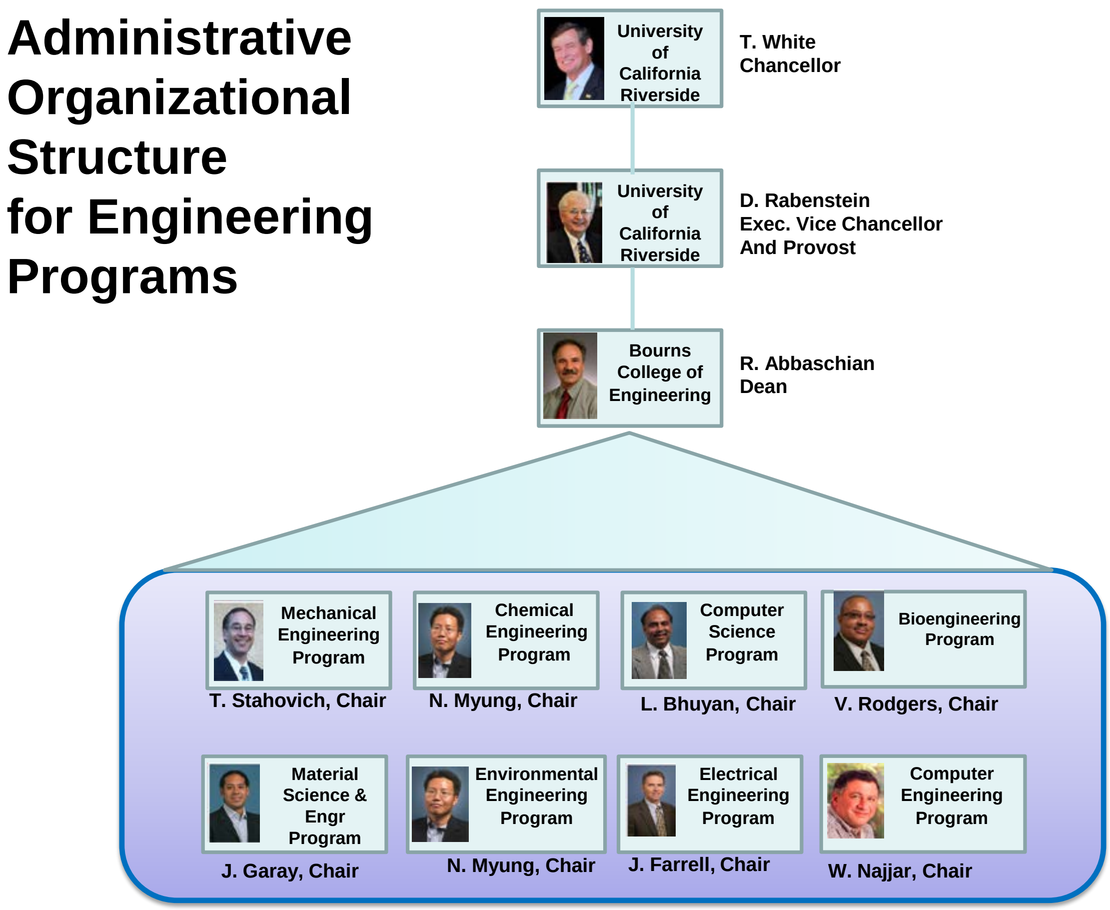

Figure BG-1: Administrative structure of the program

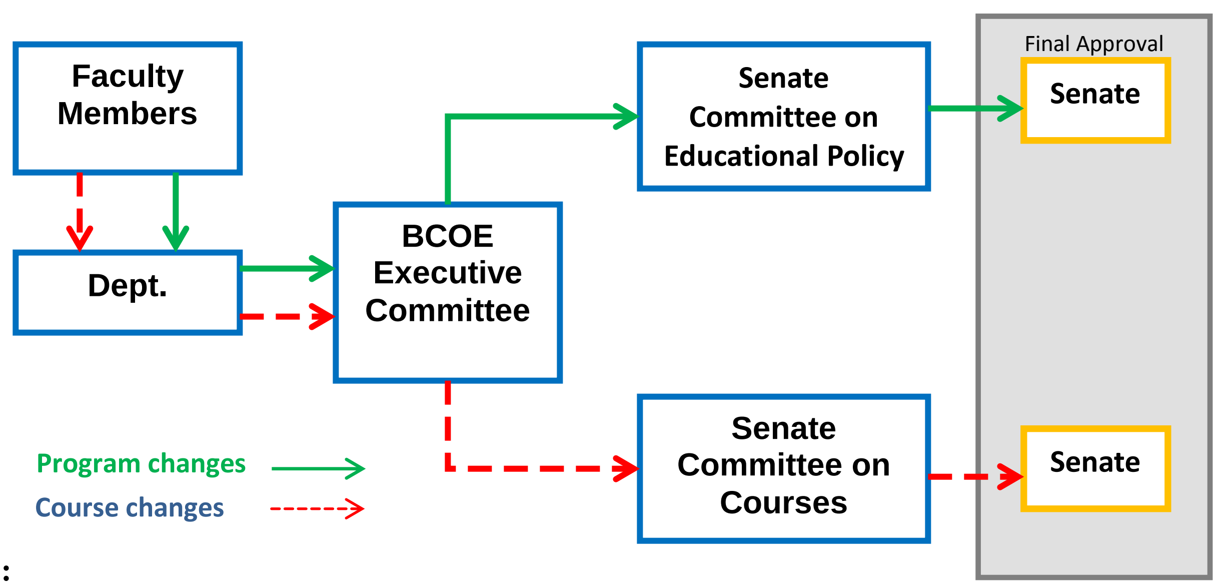

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Figure BG-2: Process for approving course and program changes.

E. Program Delivery Modes

All courses for the bachelor's degree are delivered in campus classrooms and laboratories on weekdays and weeknights. The curriculum includes no cooperative education, distance education, or web-based instruction.

F. Program Locations

The program is offered on the UC Riverside main campus. In addition, a number of undergraduate students in the chemical engineering program perform research (including independent research for unit hour credit) at the College of Engineering, Center for Environmental Research and Technology (CE-CERT), located approximately 1.5 miles away from the main UC Riverside campus.

G. Deficiencies, Weaknesses or Concerns from Previous Evaluation(s) and the Actions Taken to Address Them

A summary of the 2006 evaluation and the actions to address them are provided below:

Program Strengths

1. Faculty members are well qualified, committed, energetic, and accessible to the students.
2. The program emphasizes undergraduate research. Most students have at least one undergraduate research experience prior to graduation.

Program Weaknesses

1. Criterion 2. Program Educational Objectives Criterion 2 states, "These objectives are broad statements that describe the career and professional accomplishments that the program is preparing students to achieve." Many of the statements describe skills and knowledge that are very similar to the Program Outcomes and Assessments and are appropriate for students to achieve at graduation. The Criterion also states in 2b, "Each engineering program for which an institution seeks accreditation or re-accreditation must have in place a process based on the needs of the program's various constituencies in which the objectives are determined and periodically evaluated." Stakeholders other than faculty had extremely limited involvement in creating and validating the objectives. The Criterion also states in 2d, "Each engineering program for which an institution seeks accreditation or re-accreditation must have in place a process of ongoing evaluation of the extent to which these objectives are attained, the result of which shall be used to develop and improve the program outcomes so that graduates are better prepared to attain the objectives." There are only limited examples of use of the information to improve the attainment of objectives.

- 14-Day response: The EAC acknowledges receipt of a 14-day response pointing out that a Criterion 2d shortcoming was incorrectly identified as a 2c shortcoming and an error on the Program Audit Form relative to the past accreditation actions. These errors have been corrected in the draft statement and audit form.

- Due-process response: The EAC acknowledges the receipt of documentation that the program has rewritten and approved a set of educational objectives that define expected early career accomplishments. The documentation also provides evidence of appropriate involvement of constituents in defining the objectives and in the definition of a review process.

- The weakness is now cited as a concern pending demonstration of the robustness of the new process.

The program educational objectives (PEOs) were updated in 2007 as indicated above during the due-process period to define specific early career expectations and goals for alumni of the

Chemical Engineering program. These program educational objectives are reviewed annually by all departmental faculty during the ABET segment of the faculty retreat and every three years by our alumni through a web-based survey. Furthermore, the PEOs are reviewed by our advisory board and alumni advisory board, which most recently met in 2011 and 2012, respectively. Alumni, faculty, and the Board of Advisors all have opportunities to suggest improvements to the PEOs. Through this review process, our PEOs were updated again in the Fall of 2011. The PEOs have been updated on our departmental website (http://www.cee.ucr.edu/undergrad/abet.html) and in the UCR general catalog (2012-2013) to read:

> "Graduates will attain high levels of technical expertise to enable their achievement in diverse chemical engineering practice and research or in allied careers, prepare them for graduate level education, and enable them to be successful members of the professional community, for the benefit of our constituents" focusing on achievement of students after graduation. See also criterion 2 and 4 for more detail.

2. Criterion 8. Program Criteria Criterion 8 requires the curriculum to include "appropriate modern experimental techniques." Although many students demonstrate the ability to design experiments through the final design courses, elective courses, or participation in research projects, based on the information available at the time of the visit, it is possible for students to complete the program without fulfilling this requirement.

    - 14-Day response: The EAC acknowledges receipt of a 14-day response to Criterion 8. The information provided does not deal with matters of errors of fact but will be considered during due process.

- Due-process response: The EAC acknowledges the receipt of documentation providing additional evidence of experimental design content in the curriculum and the modification of the curriculum to further strengthen the experimental design component.

- The weakness has been resolved.

The programs have continued to increase their emphasis on design of experiments, with major updates to the senior laboratory courses continuing throughout the past six years. The last efforts included a complete update to CHE/ENVE 160A in Spring 2011 (required course for all CEE students) by rewriting the lab manual and the removal of all experimental recipes. In addition, two open-ended labs were added to CHE160C during Winter 2012 (a required course for all Chemical Engineering students).

CHE/ENVE 160A: Chemical and Environmental Engineering Laboratory

Students are provided with specific experimental goals and appropriate modern equipment and are required to design their experiment to achieve experimental goals. The CHE/ENVE 160A instructor notes in his course pre-assessment: “The lab manual has been modified to remove all protocols, and students are now required to develop all of their own protocols to achieve the specific objectives posed to them in the lab manual.” This change has in turn made the students’ preparation time for the laboratory more critical. Prelab write-ups are now a more significant fraction of the total course grade (evaluation of prelab and the lab notebook now account for 25% of the students’ grade). Specifically, the students are now expected to become acquainted with, and obtain training on, all laboratory modules prior to their arrival in lab to conduct the experiment and collect data. From this training period, they must prepare and submit a prelab report to the instructor that clearly states (i) the objective of the module, (ii) the key equations and a brief description of the relevant theory pertaining to the module, (iii) a hypothesis regarding the module to be tested during the laboratory period, (iv) a detailed description of the module/apparatus to be employed, (v) a clear, concise, step-by-step description of the experimental plan (this is the protocol that your group will follow to achieve the stated module objective), (vi) a description of the key data to be collected and a brief description of how the data will be analyzed, and (vii) a list of references used to develop the prelab.

To accommodate this change, several procedural aspects of the class have changed. First, the prelab must be submitted to the instructor in advance of the students conducting the laboratory work, and the instructor must return these prelab reports with appropriate edits/corrections by their laboratory period. For example, with the current Monday/Wednesday scheduling of the class, the students must submit prelabs the week prior to their laboratory period on either Wednesday (for the Monday lab groups) or Friday (for the Wednesday lab groups). This schedule allows sufficient time for the instructor to evaluate, edit and return the prelabs. In future offerings, it is recommended that the review of prelabs be integrated into the responsibilities of the TAs for the course.

Further, the instructor notates on the course: “It should also be noted that based on the first few weeks of this model, the students’ performance and preparation for the laboratory modules far exceeds previous years. The requirement that students conduct the prelab activities has considerably improved their preparation and familiarity with the laboratory equipment and the data they need to collect to achieve stated laboratory objectives. In turn, this has actually diminished the workload of the instructor, lab technician and TAs during the M/W 8-11 am laboratory sessions. Thus, in future offerings, it may also be feasible to lower the total number of TAs assigned to this course, at least until increasing class sizes demand weekly laboratory sessions.”

CHE 160B: Chemical Engineering Laboratory

Several changes have been made to the CHE 160B to continue the success of prior laboratory experiences. An emphasis has been placed on oral and written communication skills. Students are asked to turn in individual lab reports and each student is assessed on his or her ability to compile all sections of a formal lab report. Students work in two different teams and present twice during the quarter. Previous pre-lab and lab report techniques are also re-enforced. Students are also quizzed on a regular basis on the content of the labs.

Significant modifications were made to CHE 160B in Fall 2009 to address specific outcomes. An emphasis was placed on objectives that enhance the student's ability to design and meet desired needs within realistic scenarios and understand contemporary issues in a broader context. The objectives of the class were reformulated to a) challenge students in planning, conducting, and designing experiments to obtain relevant data needed for proper design and operation of heat transfer, and kinetics and reactor systems; b) provide student opportunities to practice and improve technical writing and oral presentation skills, and c) provide students with collaborative experiences in team-building and leadership.

An open-ended design component was added to the class. Students were asked to apply CHE 160B knowledge and techniques to the real world and commonly used devices. Students then designed and executed experiments to generate data. For their group oral presentation, students characterized a commonly used heat transfer or reactor. They showed how they could devise simple experiments to safely measure heat transfer or reactor parameters; compared experimental measurements to theory, evaluated the efficiency/effectiveness of the device, included a cost analysis, and suggested measures to improve design parameters. For a specific example of this, one group in 2010 applied the measurement techniques from a pinned and finned convective heat exchanger technique to understand the differences in bevel shape used in different makes of waffle irons. The same theoretical heat transfer systems could be used, but students were often challenged with real-life experimental obstacles and were asked to address and report cases and causes of experimental error.

CHE160C: Chemical Engineering Laboratory

Two open-ended labs were added into the CHE 160C syllabus in Winter 2012. There was no lab manual for these open-ended labs, but certain experimental objectives were given: to find alternative solvent(s) replacing environment-harmful ethylene chloride for (1) the extraction of acetic acid from aqueous solutions (open-ended lab 1) and (2) regeneration of the solvent by distillation (open-ended lab 2). Students needed to understand that the new solvent should be environmentally friendly with high capacity for extraction, and should be easily separated from the product by distillation for reuse. Therefore, an integrated process with extraction and distillation steps was designed and evaluated by the students.

Before the lab started, students were asked to (1) search the literature and find the suitable solvents, (2) meet with the instructor to present literature search results and discuss their experimental plans; and (3) prepare detailed experiential plans on how to obtain the best operation parameters. Characteristics like distribution coefficient, Vapor-Liquid Equilibrium data of solvent/acetic-acid, solubility in water, absorption capacity, composition of the azeotrope, price, availability, and potential environmental and health problem must be taken into account for the purpose of this selection. Based on the student survey, 96.3% (2.89/3) of the students agreed that they were able to develop pre-lab write-ups to link the specific experimental objectives with the relevant theory in mass transfer and separation processes.

During the lab, students performed their labs using the solvent(s) they chose and followed their designed procedure to find the best operation parameters. Since there was no lab manual, the students learned how to operate the unit operation apparatus and designed sample collection protocols. According to student survey results, 89.7% (2.69/3) of the students agreed they conducted the laboratory efficiently and were able to explain experimental phenomena. Further, 92.6% (2.78/3) of the students agreed they performed data analysis well – extracted the key results from experimental data and demonstrated them clearly in graphical and tabular forms.

After the experiment, students wrote their lab reports, which emphasize the "open-ended part" – i.e., explaining the objective, describing how to design the lab to meet the objective, justifying their design decisions, presenting the results and analysis, reporting on whether the results match with the expectation/theory, and concluding on whether the experiments accomplished the lab objective. Also, 92.6% (2.78/3) of the students agreed they successfully wrote the technical reports in format of journal papers, and 90.7% (2.72/3) effectively presented and discussed their experiment results.

In summary, the open-ended labs (CHE160C) were successfully completed in the winter quarter of 2012. The overall results of ABET student evaluation indicates 94.4% (2.83/3) of the students agreed that they learned to (i) design an environmentally benign process, (ii) plan and conduct experiments to evaluate the process, and (iii) optimize the operation parameters.

Program Concern

1. Criterion 3. Program Outcomes and Assessment Criterion 3 states that programs must demonstrate that program outcomes "... are being measured and indicates the degree to which the outcomes are achieved." It further states, "There must be evidence that the results of this assessment process are applied to the further development of the program." The program has an outcomes assessment process. However, the process in place for assessment of program outcomes seems not to be capable of distinguishing the performance of one program outcome from another. The grade for each piece of student work is mapped to multiple course objectives, and each course objective is mapped to multiple program outcomes. Therefore, the result for a particular program outcome is essentially a weighted average of a weighted average of individual grades that each reflects multiple program outcomes. The effect is similar to the use of course grades to assess program outcomes, a practice that is discouraged because of the lack of specificity that would result. The assessment process should establish a unique or nearly unique association between a program outcome and student work.

   - Due-process response: The EAC acknowledges the receipt of documentation indicating an intent to review the assessment methodology but identifying no specific changes.

   - The concern remains unresolved.

After listening to ABET reviewer concerns in the 2006-2007 cycle, the CHE program completely revamped the outcome-based assessment procedure during 2007-2008. The process was developed through multiple ABET meetings, discussed and agreed to by the CEE faculty, and implemented starting in the 2008-2009 academic year. The greatly streamlined system involves faculty assessment of single outcome scores based on specific homework, quizzes, exams, laboratory reports, design projects, and/or finals. Each course is assigned four to eight outcomes that must be individually examined throughout the course. Only core curriculum classes taken by all students are used for outcome-based calculations, which are then averaged over the classes. This new evaluation system is discussed in detail as part of Criterion 4. This new method achieves the specificity for quantitative assessment of each individual outcome and is now in its fourth year of operation.

GENERAL CRITERIA

CRITERION 1. STUDENTS

A. Student Admissions

The admissions processes for all engineering degree programs conform to the UCR Academic Senate's interpretation of the admission policies of the University of California, which, in turn, interpret the mandates of the California Master Plan for Higher Education.

In broad terms, the Master Plan constrains the University of California to admitting only students ranking in the top 12.5% of the high school graduates in the State. Students in lower tiers are eligible for admission to campuses of the California State University system or to community colleges. Placement in the top 12.5% of the graduating class is determined by the UC Eligibility Index, which is computed centrally by the UC Office of the President, based on criteria defined by the UC System-Wide Academic Senate.

Figure 1-1 summarizes the freshman admissions process to the Bourns College of Engineering. Prospective students submit their applications to the Office of Admissions for the University of California, which serves all ten campuses. Applicants may apply to multiple campuses, and to multiple programs at these campuses. They may also designate primary and alternate majors. The UC Office of Admissions determines whether each applicant meets the UC Eligibility criteria (which specify GPA and coursework requirements) and forwards each eligible application to the campuses to which admission is being sought. Ineligible applicants are rejected. If a student is UC-eligible but is not selected for admission to the campus(es) that he or she applied to, admission to another UC campus is offered. It is notable that the Riverside campus switched from a referral campus to a selective campus within the past four years. That is, because of the increasing number and quality of students applying directly to UCR, we no longer offer admission to students who are UC-eligible but declined by their first-choice campuses. Nevertheless, we remain the most diverse campus of the UC system (in terms of overall numbers; on a percentage basis, UC Merced has greater diversity because of its very small student population), with a substantial number of students who are the first in their families to attend college.

Within UCR, processing of the freshman applications begins through the Campus Office of Admissions, in accordance with guidelines defined by the Undergraduate Admissions Committee (UAC) of the UCR Academic Senate. An Enrollment Management Council (EMC) also exists at the campus level to make decisions annually on the enrollment targets at the campus and college levels. These decisions are informed by the strategic planning processes at the campus and college levels.

UCR follows a multi-tier admissions process. At the first tier, an Academic Index Score (AIS) is computed for each applicant, based primarily on academic parameters such as the grade-point average (GPA), the Scholastic Aptitude Test (SAT) score, and the number of completed

Advanced Placement or International Baccalaureate courses. College-specific upper and lower AIS thresholds are determined in accordance with the planned enrollment targets. All applicants to a college whose AIS scores exceed the upper threshold are automatically admitted to their program of interest. All applicants with AIS scores below the lower threshold for each college are removed from that college's pool. The remaining applicants are forwarded to the respective colleges for further processing.

Once these forwarded applications arrive at BCOE, a, BCOE-specific Index Score (BIS) is computed for each applicant. This BIS score is a function of the applicant's grades in mathematics and science, as well as the math part of the SAT Reasoning Test (the SAT Advanced test is not required by UC). The applicants to each program are ranked by BIS score, and applicants are admitted starting at the top of the list for each program until the program's enrollment target is met. Applicants may be placed on a wait list, to be admitted if the yield rate from the admitted pool is insufficient to satisfy program targets.

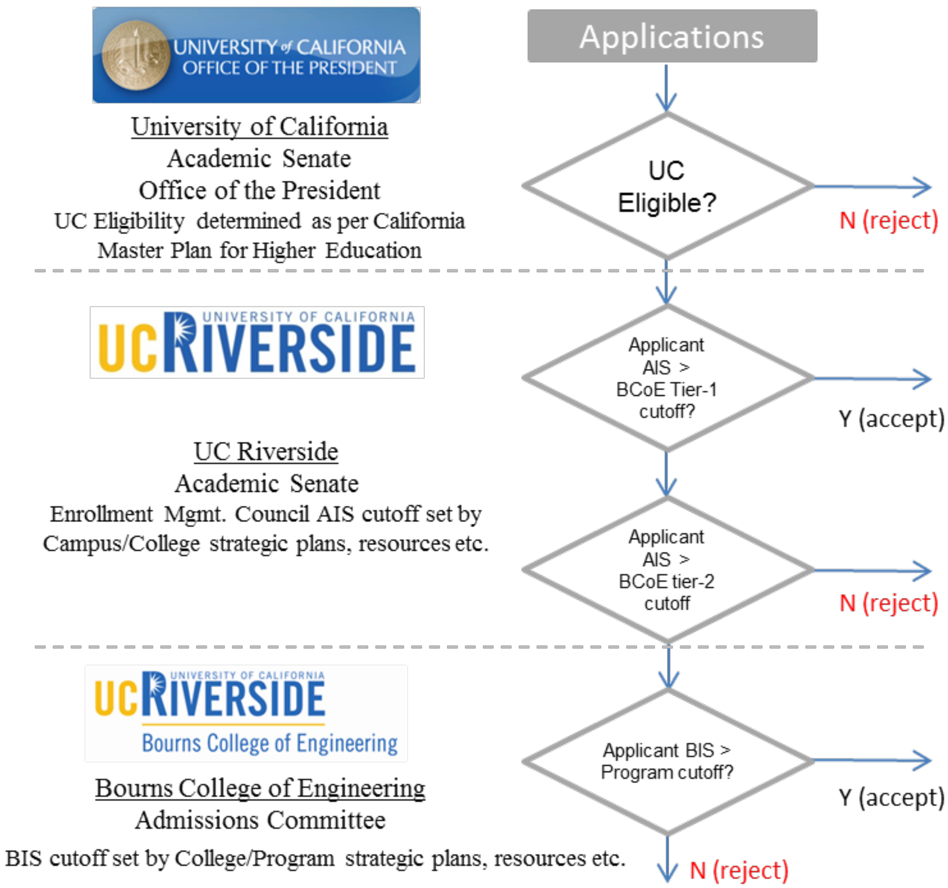


Figure 1-1: The admissions process begins with an application to the UC system, which is forwarded to the campus and then to the college for consideration.

Subsection C addresses the transfer admission process.

B. Evaluating Student Performance

Student performance monitoring is primarily the role of the Office of Student Affairs, under the supervision of the Associate Dean for Undergraduate Affairs, Professor C.V. Ravishankar. Each program also has a faculty member designated as the Program Faculty Adviser, who serves as the primary departmental contact for program-specific policy decisions. College-level policy is under the purview of the Associate Dean. The staff of Office of Student Affairs (OSA) supports the undergraduate programs.

Each student is assigned to a staff adviser in the OSA, and encouraged to meet with this adviser whenever the need arises, but at least once per quarter. In addition, attendance at a mandatory Annual Major Advising session is required of all undergraduates in the college. The Annual Major Advising session is conducted jointly by the OSA staff and the Program's Faculty Adviser, and provides information on a variety of topics to students, including program requirements as well as academic success strategies and professional development opportunities.

In addition to college-level advice, each CEE student is assigned a CEE faculty member and required to meet with his/her mentor each quarter. More specific advice regarding academic performance and career plans of chemical/environmental engineering are given, especially on how to choose one of the five technical concentrations within the CEE department (three for CHE and two for ENVE).

Figure 1-2 depicts the process for monitoring student progress. Students are required to maintain a GPA of 2.0 each quarter (including cumulative GPA). Students are reminded of these requirements regularly, first during the registration process in their first quarter as freshmen, and again each year during Annual Major Advising. Grades are posted by instructors each quarter to the central Student Information System (SIS) database, which tracks student performance, and provides degree audits to check for completion of degree requirements. At the end of each quarter, staff advisers in the OSA review the academic records of BCOE students and identify all whose term and cumulative GPAs are below 2.0.

A failure to meet these GPA requirements results in a student being placed on probation. The student is notified of this probationary status, and advised that a failure to obtain at least a 2.0 GPA the following term will result in dismissal. A registration hold is placed on the student's record at that point, to be released only upon the completion of Academic Success Workshops and other advising and mentoring activities through the OSA. A student who receives a dismissal notice may appeal the dismissal to the Associate Dean, who may grant or reject the appeal based on extenuating circumstances.

The primary source of information regarding student performance is the campus-wide Student Information System (SIS). SIS, which is maintained by the campus Computing and Communications office, records all student registrations and grades. All staff and faculty advisers have access to this system, either directly, or through the Student Advising System (SAS) front-end that provides access to student transcripts and degree audits. The staff of the OSA uses this system regularly to monitor student progress.

Students who are about to graduate are required to complete a graduation application. At this point, the student's academic adviser in OSA performs a detailed manual check to ensure that all degree requirements have been met. If the requirements have been met, the Office of the Registrar is notified of degree completion, so the degree may be awarded.

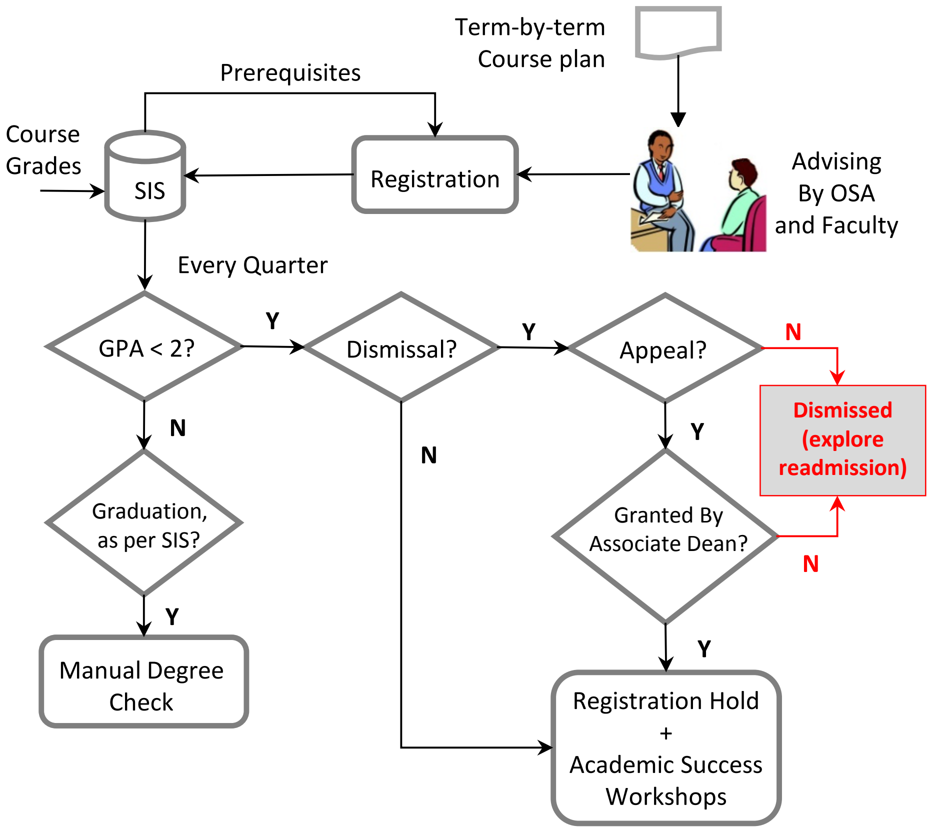


Figure 1-2: Academic advising and performance monitoring.

B.1 Enforcing Prerequisites

All students are given a term-by-term course plan that ensures timely graduation as long as courses are completed in a timely manner. This course plan incorporates prerequisites, so that students who follow the course plan automatically satisfy prerequisites.

Whether or not students follow this course plan, prerequisites are enforced by the registration system. Students register for courses through the Grades Online Web Link (GROWL) system that interfaces with SIS, and is able to enforce prerequisites. A student prevented from taking a course due to lack of prerequisites can petition the course instructor, who has the authority to grant the student a prerequisite waiver. The student may also petition the undergraduate committee, who has the authority to grant the student a prerequisite waiver. The student is not permitted to take the course without such a waiver. Such waivers are generally approved for outstanding students, transfer students, and in very special occasions.

C. Transfer Students and Transfer Courses

Transfer students apply using the same application portal that freshmen use. This portal is maintained by the System-Wide Office of Admissions, located in Oakland, CA. This office collects applications and forwards them to the UCR Office of Admissions.

In accordance with the California Master Plan for Higher Education, the University of California maintains extensive articulation agreements with community colleges in the state. Course articulations are reviewed and approved by the cognizant departments, and are tracked and maintained by the Campus Articulation Officer. All system-wide articulation agreements are available at the website http://www.assist.org, which is open access. The transfer route appears to be gaining popularity, especially given recent increases in tuition. When a transfer applicant (typically, from out of state) presents a transcript containing courses that have not already been articulated, the staff of the BCOE OSA collect the relevant course syllabi and work with the cognizant departments at UCR to determine articulations.

All BCOE programs have published detailed requirements for transfer admission. Admission to our programs requires a minimum GPA of 2.8, and the completion of coursework specific to the applied major. Incoming transfer students may transfer up to 105 quarter units (70 semester units) toward their degrees. To ease the burden of consulting for each major an applicant may be interested in, we have prepared brochures showing transfer requirements for each of our majors. We make these brochures available both in hardcopy and on the Web. Some examples appear at: http://www.engr.ucr.edu/undergrads/transferring/SpecialAgreements.html.

If the transfer applicant for a major meets all the requirements specified by that major, the UCR Office of Admissions admits that applicant. Applicants who satisfy most transfer requirements are forwarded to the College for additional review. The OSA staff reviews these applications, and in consultation with the departments and the Associate Dean, grants exceptions as warranted. Conditional admission is also sometimes granted, subject to the completion of some requirements that may not have been met at the time of application.

UCR Transfer Admission Criteria:

- Complete 60 transferable units (90 quarter units) with a minimum GPA of 2.4 for California residents and 2.8 for nonresidents
- Complete (with a grade of C or better) the following course pattern:
    - Two transferable college courses (3 semester or 4-5 quarter units) in English composition
    - One transferable college course (3 semester or 4-5 quarter units) in Mathematical concepts and Quantitative reasoning
    - Four transferable college courses (3 semester or 4-5 quarter units) chosen from two of the following subject areas: arts & humanities; social & behavioral science; physical & biological sciences

General BCOE Transfer Admission Requirements:

- A cumulative GPA of at least 2.80

- Completion of 2 major-specific sequences for your intended major with a minimum 2.50 GPA. One sequence must be single-variable calculus (MATH 9A, 9B, 9C). The second sequence may be a physics sequence such as PHYS 40A, 40B, 40C.
- Completion of one year of college level English Composition (ENGL 1A, 1B, 1C).

Chemical Engineering Major-Specific Transfer Requirements:

- The following courses must be completed at the time of application:
  - two courses in general chemistry with labs (CHEM 1A/1LA, 1B/1LB)
  - one course in calculus based physics with lab (PHYS 40A)
- A minimum of THREE (3) additional courses (shown below) must also be completed in order to form a coherent sequence. A list of potential sequences for this major is listed below.
  - one course in general chemistry with lab (CHEM 1C/1LC)
  - one course in introduction to cellular and molecular biology with lab (BIOL 5A/LA)
  - two courses in organic chemistry with labs (CHEM 112A, 112B)
  - two courses in calculus based physics with labs (PHYS 40B, 40C)
- Potential Course Sequences for Chemical Engineering: CHEM 1A/1LA, 1B/1LB, and 1C/1LC; or PHYS 40A, 40B, and 40C; or CHEM 112A, 112B and BIOL 5A/5LA

In addition to the general and major-specific requirements, applicants are strongly encouraged to complete all the recommended courses below prior to enrollment. The recommended courses are not required for Transfer Admission. Completing this coursework prior to enrollment at UCR is critical to maintaining satisfactory progress in the upper-division engineering curriculum and to finishing all degree requirements within two years of enrollment at UC Riverside, provided a full-time course load is maintained at UCR.

- Cell and Molecular Biology, BIOL 5A/LA*
- Introduction to Organismal Biology, BIOL 5B, and Introductory Evolution and Ecology BIOL 5C **
- General Chemistry sequence, CHEM 1C/LC
- Organic Chemistry sequence, CHEM 112A, 112B, 112C
- Multivariable Calculus, MATH 10A, 10B
- Differential Equations, MATH 46
- Physics sequence PHYS 40B (heat/waves/sound), 40C (electricity/magnetism)
- C++ Programming, CS 10
- 3 Humanities/Social Sciences courses to satisfy BCOE Breadth

*Required for all Chemical Engineering concentrations.
**Required for only the Bioengineering concentration within the Chemical Engineering major.

D. Advising and Career Guidance

The mechanisms by which students receive academic advice through the Office of Student Affairs have already been outlined in **Section B: Evaluating Student Performance**. Here, we will describe the mechanisms for providing Career and Professional guidance.

Professional guidance and mentoring are provided by staff (particularly, the Director of Student Professional Development), the faculty, and the Career Center. The overall college philosophy that guides all interactions with students is to ensure that they are both academically and professionally prepared to become leaders in their chosen fields. This goal is especially challenging to meet in engineering colleges.

As is typical for undergraduate programs in engineering, our students spend the first two years of their undergraduate studies completing prerequisite coursework in mathematics, sciences, and the humanities and social sciences. Unfortunately, instructors in these areas are unfamiliar with any of the engineering disciplines, and unable to motivate or mentor our students in their early years here. Consequently, our students fail to develop a clear sense of academic direction or a sense of professional pride, having no role models or mentors, either at home or on campus. Another consequence of this lack of engagement in the early years with BCOE is that it is harder for students to build effective working relationships with their peers, so they can begin to see them as technically strong, and as effective partners.

We address these issues in several ways. The first of these is a 2-unit course (CEE 010 – Introduction to Chemical and Environmental Engineering) intended to promote engagement with BCOE in the freshman year and to help the student's professional development in later years. Activities include mini-design projects, industry overviews and interactions, involvement with professional societies and clubs, team building, career guidance, and coverage of ethics and lifelong-learning issues. The specific list of topics in these courses includes the following:

- Participate in peer-group building activity and networking exercises
- Understand Engineering as a creative process for solving real-world problems.
- Understand current and future trends in the student's major discipline
- Understand some analysis tools, and their use in design and practice.
- Understand the stages of development of an Engineer as a Professional
- Development of skills to research and review technical topics
- Development of communication skills through team oral presentations
- Participate in group design projects.
- Participate in Professional Clubs.
- Participate in the Career Path Milestones program.
- Understand the role and importance of Ethics in the Engineering profession.
- Understand the importance of engaging in life-long learning.
- Participate in Industry visits.

These topics are presented in lectures, workshops and discussion-style activities. A suite of activities supported by the college under the Professional Development Milestones program complement the program-specific content in these courses. Examples of such activities are academically-oriented workshops on time management and study-skills, as well as professionally-oriented activities such as mock interviews, resume writing, as well as research and industrial internships. Figure 1-3 summarizes these milestones.

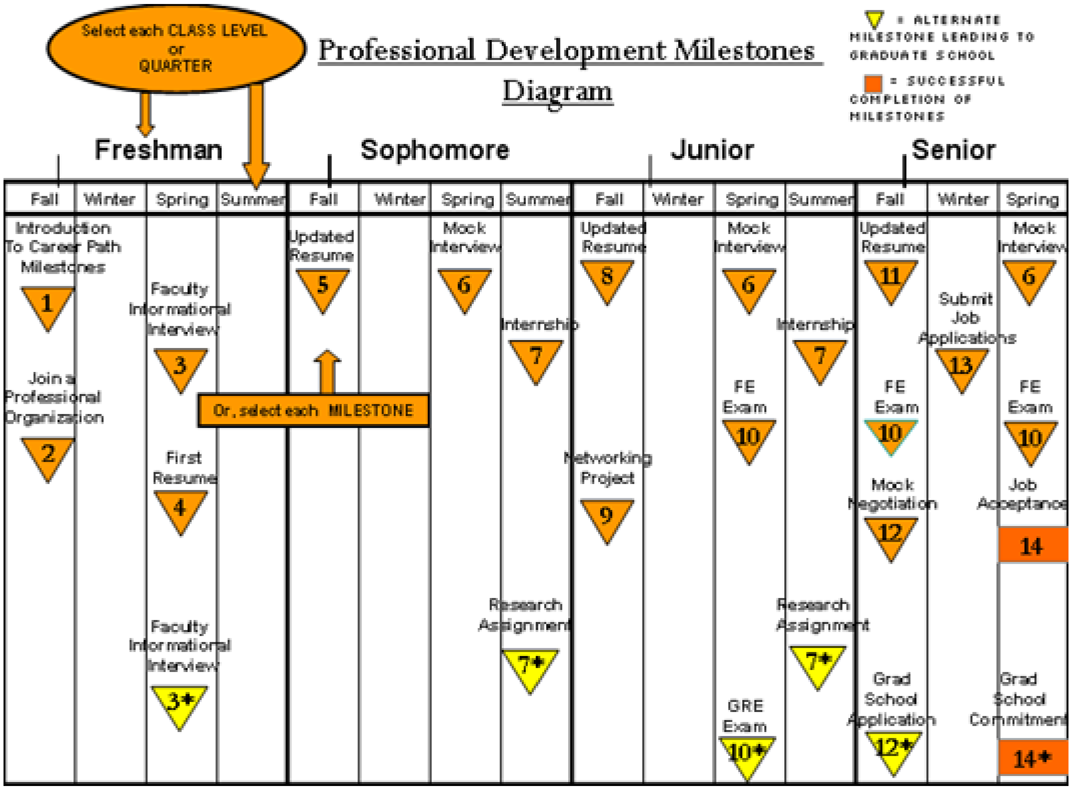


Figure 1-3: The Professional Development Milestones program guides students on key activities they should be undertaking during their undergraduate years to assure that they are ready for careers or graduate school.

This program is emphasized during the required annual advising session. The events and numerous activities listed in Table 1-1 support the program. The BCOE website provides information on the on-going program (see http://careers.ucr.edu/careerPlanningCounseling/milestones/Pages/BournsCollegeofEngineering.aspx).

A total of 18 Student Professional Organizations exist in BCOE, and are supported financially by the College. These organizations are student-led, and are very active. Just over 800 students are active members of these organizations (roughly 40% of the students in BCOE).

1. BCOE SLC (Student Leadership Council)
2. ACM (Association of Computing Machinery)
3. AIChE (American Institute of Chemical Engineers)
4. ASME (American Society of Mechanical Engineers)
5. ASQ (American Society of Quality)
6. BMES (Biomedical Engineering Society)
7. EWB (Engineers Without Borders)
8. IEEE (Institute of Electrical and Electronics Engineers)
9. IEEE EDS (Electron Devices Society)
10. ION (Institute of Navigation)
11. MRS (Material Research Society)

12. NSBE (National Society of Black Engineers)
13. OSA (Optical Society of America)
14. SACNAS (Society for Advancement of Chicanos and Native Americans in Science)
15. SHPE (Society of Hispanic Professional Engineers)
16. SAE (Society of Automotive Engineers)
17. SWE (Society of Women Engineers)
18. TBP (Tau Beta Pi) – Honors Society

These organizations, under the mentorship of the Director of Student Professional Development, Mr. Jun Wang, participate in a broad range of activities during the year. A summary for the 2011-2012 academic year appears in Table 1-1 below.

Table 1-1: Academic Year 2011-2012 activities.

Event	**Date**	**Attendees**
Student Leadership Workshop	9/25/2011	120
Information Session: Peace Corps	9/26/2011	56
Information Session: HACU National Internship Program	9/27/2011	32
Information Session: U.S. Department of State	9/27/2011	45
Information Session: U.S. Marine Corps	9/28/2011	27
Beginning Resume Writing Workshop	10/3/2011	30
Job Search 101 Workshop	10/3/2011	42
Career Presentation by Synapse	10/5/2011	65
Internships: What, Why & How?	10/6/2011	37
Now Hiring Interns!	10/11/2011	40
Beginning Resume Writing Workshop	10/11/2011	35
Preparing for the Job Fair	10/12/2011	54
Interview Skills	10/13/2011	36
The New GRE: What does it mean for grad school applicants	10/13/2011	68
Advanced Resume Writing, featuring Cal Steel Industries, Inc.	10/13/2011	70
Careers in BioTech	10/14/2011	98
Yikes! I'm Graduating!	10/14/2011	26
Resumania	10/17/2011	30
Law School Forum	10/17/2011	35
Why Can't I Find a Job?	10/17/2011	42
Google Day at BCOE	10/17/2011	135
Resumania, Featuring Sherwin Williams	10/18/2011	25
Careers at EPA Info Session	10/18/2011	67
Career Expo	10/19/2011	
Visit at NAVSEA NSWC Corona	10/20/2011	25
Guest Speakers from NASA/Carnegie Mellon Silicon Valley	10/20/2011	59
Part-Time Job Search/Beginning Resume Writing Workshop	10/20/2011	23
Information Session: USMC Aviation	10/20/2011	25
Making Professional Connections, Featuring: Target	10/24/2011	28

LinkedIn 101: Networking Professionally Online	10/26/2011	30
Graduate & Professional School Information Day	10/27/2011	
Guest Speakers from Northrop Grumman Aerospace Systems	10/27/2011	78
Interview Skills, Featuring: Aerotek	10/31/2011	35
Law School Information Day	11/1/2011	
Advanced Resume Writing, featuring Kohl’s	11/2/2011	21
Interview Skills, Featuring: Best Buy	11/7/2011	27
Part-Time Job Search/Beginning Resume Writing Workshop	11/7/2011	32
Jump Start to Grad School, Featuring: Kaplan	11/7/2011	36
Careers in Internet Retail	11/7/2011	25
SWE Female Engineers Guest Speaker Panel	11/7/2011	67
ASQ Biomedical Industrial Panel	11/7/2011	75
Information Table: Peace Corps	11/8/2011	29
Engineer Your Future: Careers in Mechanical Eng (Northrop Grumman)	11/8/2011	56
INROADS Meeting with BCOE students	11/8/2011	102
Internships: What, Why & How?	11/9/2011	23
Information Session: CIA	11/9/2011	46
Undergraduate Research Opportunities Workshop	11/14/2011	45
Yikes! I'm Graduating!	11/14/2011	19
Now Hiring Interns!	11/15/2011	23
Information Session: 50th Anniversary of Peace Corp	11/15/2011	34
Career Marathon (resume reviewing)	11/16/2011	60
AICHE Presentation/Guest Speakers from Energy Industry	11/18/2011	76
Visit at K&N Engineering	11/19/2011	25
INROADS Workshop & Interview with students	12/10/2011	32
Visit at Luxfer Cylinder Company	12/14/2011	15
Information Table: Graduate School Prep, featuring: Princeton Review	1/4/2012	36
Internships: What, Why & How?	1/17/2012	27
Part-Time Job Search Webinar	1/17/2012	33
College to Careers: BCOE Alumni Panel	1/17/2012	65
Career Station	1/18/2012	21
Beginning Resume Writing FYSS	1/18/2012	22
Prepare For Engineering & Technical Career Fair	1/19/2012	97
Interview Skills Workshop	1/24/2012	36
Career Station	1/24/2012	12
LinkedIn: Your Professional Version of Facebook	1/24/2012	47
Now Hiring Interns: WINternships Edition	1/24/2012	25
SHPE & NSBE Meeting with EPA	1/24/2012	66
Information Table: The Princeton Review	1/25/2012	23
ENGINEERING & TECHNICAL CAREER FAIR	1/25/2012	

Career Station	1/25/2012	14
Why Can't I Find a Job?	1/25/2012	29
Advanced Resume Writing	1/26/2012	38
Career Station	1/26/2012	24
How to Perfect Your 30-Second Elevator Speech	1/26/2012	50
Making Professional Connections	1/27/2012	31
Career Station	2/1/2012	12
Career Marathon (resume reviewing)	2/1/2012	36
ASQ Mock Interviews for Engineering Students	2/2/2012	87
Trip to Life Technology	2/3/2012	34
Yikes! I'm Graduating!	2/7/2012	21
Visit to Meggitt	2/8/2012	15
Information Table: The Princeton Review	2/8/2012	20
Career Station	2/8/2012	10
Undergraduate Research Opportunities Workshop	2/9/2012	42
Non-Clinical Health Profession Panel	2/9/2012	48
Google Day at BCOE	2/9/2012	111
Jump Start to Medical School, Featuring: Kaplan	2/9/2012	21
iStartStrong: Connection You to Satisfying Careers	2/13/2012	16
AICHE Guest Speakers from Fluor Corp	2/13/2012	79
Conversation Skills	2/14/2012	14
Beginning Resume Writing	2/15/2012	28
Career Station	2/15/2012	13
Visit to Circor	2/15/2012	10
Agricultural Careers Dinner & Industry Professionals Networking Event	2/15/2012	85
Internships: What, Why & How?	2/16/2012	20
GOVERNMENT AND NON-PROFIT JOB FAIR	2/16/2012	
SWE Resume Workshop	2/21/2012	45
Career Station	2/22/2012	15
Presentation Skills	2/22/2012	32
Now Hiring Part-Time Jobs	2/23/2012	22
Making Professional Connections	2/23/2012	26
Beginning Resume Writing	2/27/2012	20
Former Interns Tell All	2/28/2012	54
Interview Skills	2/28/2012	16
BCOE IMPACT Mentoring Meeting	2/28/2012	82
Information Table: The Princeton Review	2/29/2012	19
Career Station	2/29/2012	18
Advanced Resume Writing	2/29/2012	28
Are You Really Ready to Work? Workplace Etiquette	3/1/2012	46

Careers at Air Force	3/1/2012	24
BCOE IMPACT Mentoring Meeting	3/1/2012	78
ACM Guest Speaker from Western Digital	3/5/2012	56
GRADUATE VIRTUAL FAIR	3/7/2012	
Making Professional Connections	3/7/2012	26
Yikes! I'm Graduating!	3/7/2012	24
Visit at JPL	3/8/2012	18
Part-Time Job Search/Beginning Resume Writing	3/8/2012	31
Interview Skills	3/13/2012	22
Why Can't I Find a Job?	3/14/2012	25
Non-Academic Job Search (Grad Students Only)	3/15/2012	60
Information Table: Kaplan Test Prep	4/4/2012	21
Information Session: Target Distribution	4/5/2012	32
Yikes! I'm Graduating!	4/9/2012	17
Part Time Job Search/Beginning Resume Writing Webinar	4/9/2012	20
Prepare For Spring Job Fair and Dress for Success	4/9/2012	67
Careers in Public Service Webinar	4/10/2012	52
Internships: What, Why & How Webinar	4/10/2012	21
Beginning Resume Writing	4/10/2012	19
Career Station	4/11/2012	26
SPRING JOB FAIR: CAREER NIGHT	4/11/2012	
What Can You Do Besides Becoming a Doctor?	4/12/2012	30
Choosing a Health Professions School	4/12/2012	32
Hands-On Healthcare: Volunteer Opportunities	4/12/2012	41
HEALTH PROFESSIONS SCHOOL FAIR	4/12/2012	
Advanced Resume Writing Webinar	4/16/2012	15
Conversation Skills	4/16/2012	17
Interview Skills	4/17/2012	13
Making Professional Connections	4/17/2012	20
Job Search Skills	4/17/2012	22
Information Table: Peace Corps	4/18/2012	23
Information Table: Kaplan Test Prep	4/18/2012	14
Career Station	4/18/2012	12
Careers at NAVY Info Session	4/19/2012	17
Entrepreneur Career Panel: Starting Your Own Business	4/19/2012	115
Work Green, Earn Green: Careers that Save the Planet	4/20/2012	46
Information Session: City Year Los Angeles	4/20/2012	48
LinkedIn: Network & Get Recruited, Featuring: Fresh & Easy	4/23/2012	68
Now Hiring Part-Time Jobs	4/24/2012	40
Career Station	4/25/2012	25
Job Search (Grad Students Only)	4/25/2012	22

Now Hiring Interns	4/25/2012	24
Information Table: Across the Pond	4/26/2012	23
Visit at Chevron	4/27/2012	36
Internships: What, Why & How	4/30/2012	20
LinkedIn Webinar: Your Professional Version of Facebook	4/30/2012	14
Interview Skills, Featuring: Consolidated Electrical Distributors	5/1/2012	42
Yikes! I'm Graduating!	5/1/2012	35
Jump Start to Law School, Featuring: Kaplan	5/1/2012	22
Advanced Resume Writing, Feat: California Steel Industries	5/2/2012	29
Career Station	5/2/2012	15
Job Search Skills	5/3/2012	12
Interview Skills	5/3/2012	16
Resume & CV Writing (Grad Students Only)	5/8/2012	
Career Station	5/9/2012	
Beginning Resume Writing	5/9/2012	
Interview Skills	5/10/2012	
Job Search Skills Webinar	5/10/2012	
Yikes! I'm Graduating!	5/14/2012	
Career Marathon	5/16/2012	
Information Session: Peace Corps	5/16/2012	
Former Interns Tell All	5/16/2012	
Careers in Defense Industries	5/16/2012	
LAST CHANCE JOB FAIR	5/17/2012	
Seasonal Job Search/Beginning Resume Writing	5/21/2012	
Advanced Resume Writing	5/22/2012	
Conversation Skills	5/22/2012	
Job Search Skills	5/23/2012	

In addition, the College has a very active Undergraduate Research program. Faculty members are very active participants in undergraduate research. Last year, 60 of the 83 faculty in BCOE were research mentors for undergraduates. More than 250 undergraduates worked with faculty on research projects. This research has resulted in a significant number of publications (including in high-profile journals such as *Science*) and research presentations. For example, in the 2010 Southern California Conference on Undergraduate Research, 18 of the 24 research presentations from UCR were by BCOE students. For the second year in a row, BCOE students made more presentations at SCCUR than students from any other engineering college in Southern California. In addition to local conferences, our CEE students have participated in regional and national conferences, including AIChE, winning awards for outstanding presentations.

A summary of the range of Professional Development, Mentoring, and Success program in BCOE appears in Figure 1-4.

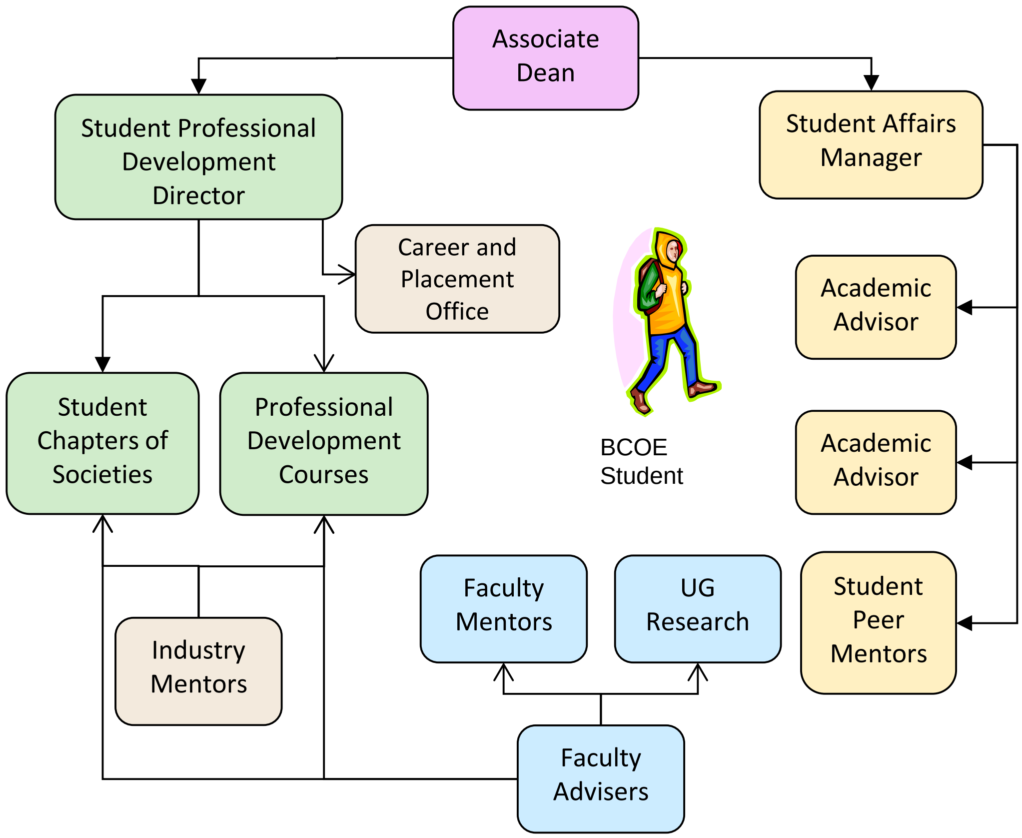


Figure 1-4: Professional development, placement, and success programs offered to BCOE undergraduate students.

Lastly, in their junior year all CEE students are required to take CEE 158, Professional Development for Engineers. This course aims to enable engineering students to make educated decisions regarding their career paths and to pinpoint and develop the necessary skills for success in a wide range of professions. Possible career paths for engineers are explored with specific emphasis on the skills necessary for success after graduating from UCR. In addition, topics relevant to current events and practice of engineering in a global environment are covered through readings from journals, periodicals and news sources. These skills are discussed in detail and developed through interactive activities. Specific topics that are covered in this course include:

- What is an engineering education and where it can get you? What is Chemical/Environmental Engineering?
- What skills do you learn?
- How can you apply these skills?
- What will a graduate degree get you?
- What skills are required for success in the “real world”: Writing, speaking, communication, working in teams, project planning, ethics.
- What skills are critical for me to yet develop while at UCR and beyond to maintain my knowledge and currency in CEE
- How to get a job/internship: Resume writing, cover letter writing, networking, importance of internships and interviewing skills.

- Preparing for the FE: initial evaluation, practice test and identification of weak areas.
- Importance of life-long learning and introduction to 6-sigma training

D.2. Office of Student Affairs

The Office of Student Academic Affairs (OSAA) implements and enforces academic policies developed by UCR/BCOE and its departments/programs. There is constant consultation and feedback between faculty and academic advisors. Below we review the mission of OSAA.

MISSION: The Office of Student Academic Affairs mission is to support engineering students in achieving their educational goals by providing guidance and services which enhance their academic development. We strive to fulfill this mission by:

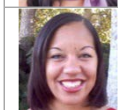
- Upholding academic policies of the university, BCOE and its departments.
- Assisting students in acclimating to and navigating the academic environment, policies and expectations.
- Working intentionally to build respect, trust and cooperation with students in support of their academic success.
- Considering individual student needs while encouraging student development.
- Encouraging academic planning, self-awareness, accountability and resourcefulness.
- Helping students respond proactively and productively to issues impacting academic success.
- Committing to excellence, the academic counseling profession and continued development.

In the Table 1-2 below we list the current OSAA staff, with brief biographical details. Note that they have decades of combined experience, and that we have an exceptionally low turnover rate for OSAA staff.

D.3. Student Satisfaction with Advising

Levels of BCOE student satisfaction with faculty and non-faculty advising are evaluated by exiting senior students as part of a mandatory exit survey (EBI exit survey, see Criterion 4). Figures 1-5 and 1-6 summarize the survey results showing overall satisfaction with non-faculty and faculty advising with average satisfaction scores well above our select six comparison universities (see Criterion 4 for more detail on exit survey), the Carnegie Class, and all institutions partaking in the EBI survey.

Table 1-2. Current staffs in the Office of Student Academic Affairs (OSAA)

	Rod Smith	M.B.A., Business Administration, University of California Irvine, June 1994. 15 years in student affairs, 6 of those at BCOE.
	Tara Brown	Master of Science in Counseling, College Counseling/Student Affairs. California State University, Northridge, May 2002, 9 years in student affairs, 5 of those at BCOE.
	Nikki Measor	M.S. in Higher Education and Student Affairs, Indiana University, Bloomington, May 2003. 9 years in student affairs, 2 of those at BCOE.
	Amber Scott	M.S., Counseling & Guidance (Specialization in College Student Personnel), California Lutheran University, June 2007. 10 years in student affairs, 2.5 of those at BCOE.
	Terri Phonharath	B.A., Political Science/Admin Studies, UCR, June 1998. 12 years in student affairs, 5 of those at BCOE.
	Sonia De La Torre-Iniguez	M.S., Educational Counseling and Guidance with Pupil Personnel Services Credential, CSU San Bernardino, June 2010. 9 years in student affairs, 8 of those at BCOE.
	Thomas McGraw	M.S., Sport Management, California Baptist University, June 2006. 14 years in student affairs, 9 of those at BCOE.
	Jun Wang	M.B.A., Business Administration, University of California Riverside, June 2007. 5 years in student professional development at BCOE

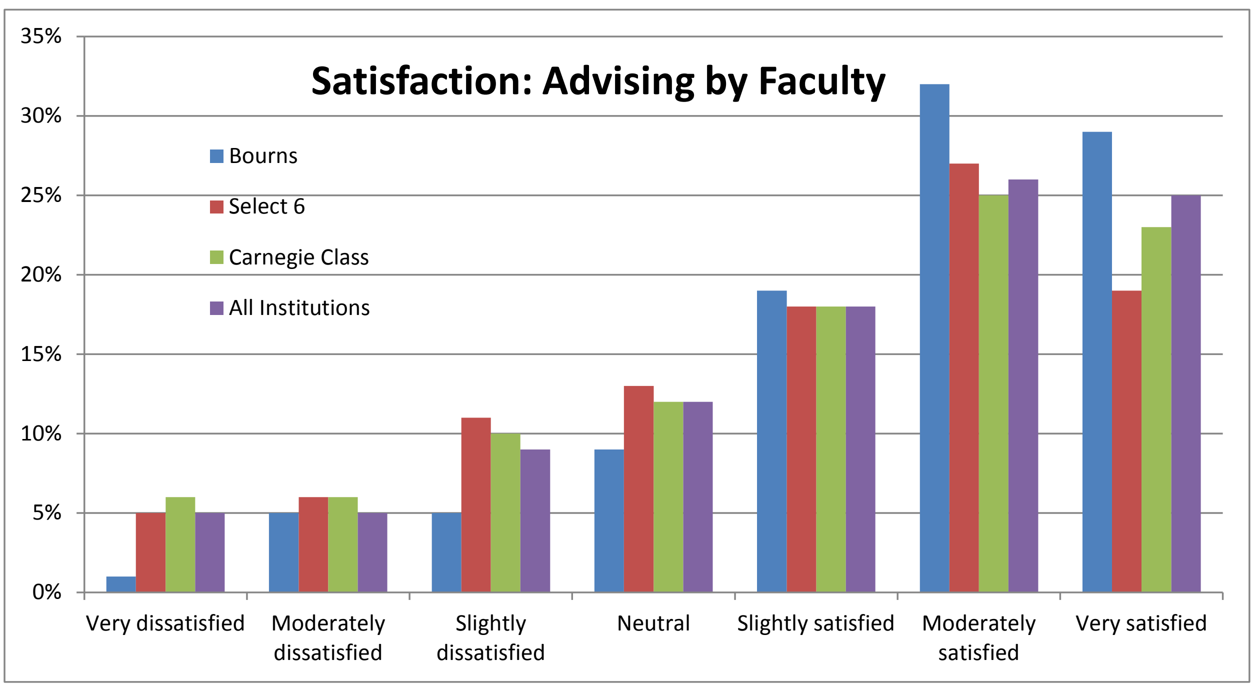


Figure 1-5: EBI BCOE exit survey findings on satisfaction of students with faculty advising

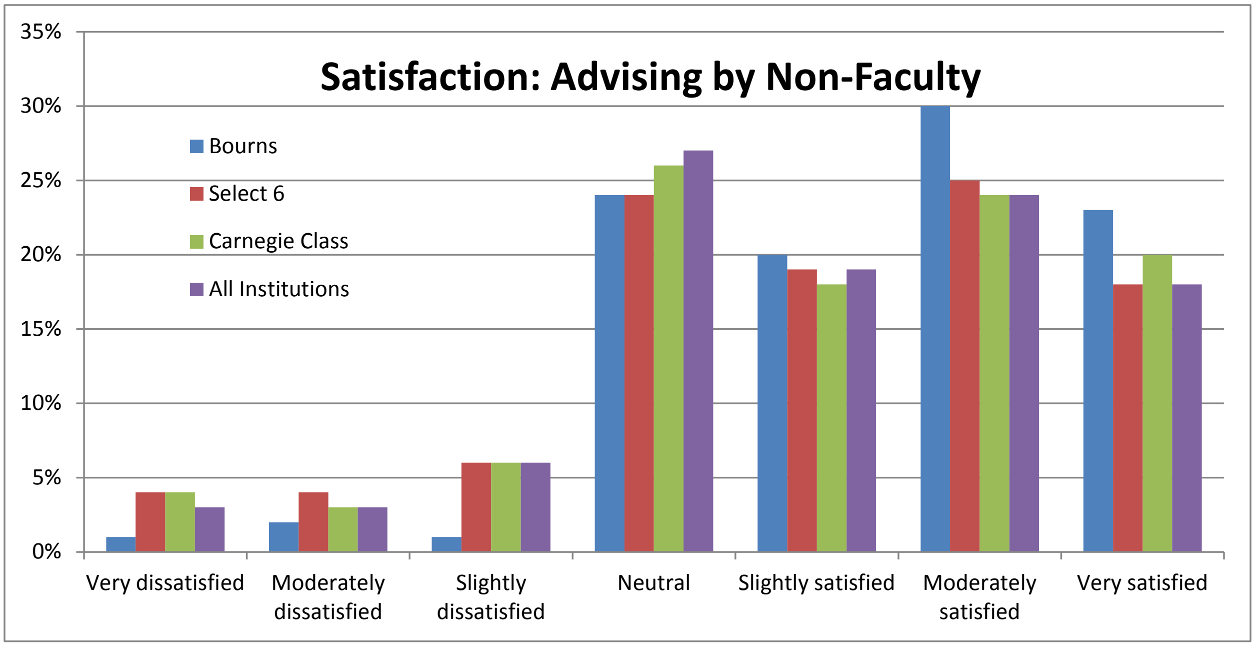


Figure 1-6: EBI BCOE exit survey findings on satisfaction with non-faculty advising.

E. Work in Lieu of Courses

Credit is awarded for selected International Baccalaureate Advanced Placement courses taken in high school, in accordance with the charts on pages 28-31 in the General Catalog for the University of California, Riverside.

Internships and independent study courses may not be used to satisfy College subject requirements, as per the following College regulation:

- **ENR3.2.8.** Internships and independent study courses may not be used to satisfy College subject requirements. (En 25 May 95) (Renumbered & Am 25 May 00)

Credit by Examination is awarded subject to the following College Regulations:

- **ENR2.5.1.** A student who wishes to have the privilege of examination for degree credit must be in residence and not on academic probation.
-
- **ENR2.5.2.** Arrangements for examination for degree credit must be made in advance with the student's Faculty adviser. The approval of the Faculty adviser, the Dean of the college, and that of the instructor who is appointed to give the examination, are necessary before the examination can be given.
-
- **ENR2.5.3.** The results of all examinations for degree credit are entered on the student's record in the same manner as for regular courses of instruction.

F. Graduation Requirements

A summary of the graduation requirements for the program and the process for ensuring and documenting that each graduate completes all graduation requirements for the program follows in accordance with the degree awarded. The Chemical Engineering major uses the following major requirements to satisfy the College's Natural Sciences and Mathematics breadth requirement.

1. Cell and Molecular Biology, BIOL 005A, BIOL 05LA
2. General Chemistry, CHEM 001A, CHEM 001B, CHEM 001C, CHEM 01LA, CHEM 01LB, CHEM 01LC
3. Calculus, MATH 008B or MATH 009A

Chemical Engineering Major Requirements

Students must choose either a Biochemical Engineering, Chemical Engineering, Bioengineering (eliminated Summer, 2011), or Nanotechnology option.

1. Lower-division requirements (62 units)
    a) Cell and Molecular Biology, BIOL 005A, BIOL 05LA
    b) General Chemistry, CHEM 001A, CHEM 001B, CHEM 001C, CHEM 01LA, CHEM 01LB, CHEM 01LC
    c) C++ Programming, CS 010
    d) Calculus, MATH 008B or MATH 009A, MATH 009B, MATH 009C, MATH 010A, MATH 010B, MATH 046
    e) Physics, PHYS 040A (mechanics), PHYS 040B (heat/waves/sound), PHYS 040C (electricity and magnetism)
2. Upper-division requirements (76 units)
    a. Professional Development for Engineering, CEE 158
    b. Organic Chemistry, CHEM 112A, CHEM 112B, CHEM 112C
    c. Engineering Thermodynamics, CHE 100; Chemical Process Analysis, CHE 110A-CHE 110B; Applied Fluid Mechanics, CHE 114; Heat Transfer, CHE 116; Separation Processes, CHE 117; Process Dynamics and Control, CHE 118; Mass Transfer, CHE 120;Chemical Engineering Kinetics, CHE 122; Chemical Engineering Lab, CHE 160B-CHE 160C; Chemical Process Design, CHE 175A-CHE 175B.
    d. Advanced Engineering Thermodynamics, CHE 130/ENVE 130; Chemical & Environmental Engineering Lab, CHE 160A/ENVE 160A.
    e. Engineering Modeling and Analysis, ENGR 118
3. Option requirements: choose one option
    a. Biochemical Engineering option (20 units)
        i. General Biochemistry, BCH 110A
        ii. Introductory Microbiology, BIOL 121/MCBL 121
        iii. Introduction to Chemical and Environmental Engineering, CEE 010
        iv. Biochemical Engineering Principles (with Laboratory), CHE 124, CHE 124L

        v. Four (4) units of technical electives chosen from Green Engineering, CEE 132; Chemistry of Materials, CEE 135; Cell Engineering, CHE 140; Biosensors, CHE 150; Pollution Control for Chemical Engineers, CHE 171; and Biological Unit Processes, ENVE 121
    b. Chemical Engineering option (18 units)
        i. Introduction to Chemical and Environmental Engineering, CEE 010;Analytical Methods, CEE 125
        ii. Twelve (12) units of technical electives chosen from Green Engineering, CEE 132; Chemistry of Materials, CEE 135; Catalytic Reaction Engineering, CHE 102; Advanced Topics in Heat Transfer, CHE 136; Pollution Control for Chemical Engineers, CHE 171; Unit Operations and Processes in Environmental Engineering, ENVE 120; Fundamentals of Air Pollution Engineering, ENVE 133; Technology of Air Pollution Control, ENVE 134; Combustion Engineering, ENVE 138
    c. Bioengineering option (24–26 units)
        i. General Biochemistry, BCH 110A, BCH 110B
        ii. Introduction to Organismal Biology, BIOL 005B, and Introductory Evolution and Ecology, BIOL 005C
        iii. Introduction to Bioengineering, CEE 011
        iv. Six to eight (6–8) units of technical electives chosen from Biomaterials, BIEN 140AB/CEE 140AB; Molecular Biology, BIOL 107A; Advanced Molecular Biology, BIOL 107B; Human Genetics, BIOL 115; Introductory Microbiology, BIOL 121/MCBL 121; Immunology, BIOL 128/CBNS 128; Bio-Microelectromechanical Systems (Bio-MEMS), CEE 147, CEE 159/BIEN 159; Biochemical Engineering Principles, CHE 124; Cell Engineering, CHE 140; Biosensors, CHE 150.
    d. Nanotechnology option (21 units)
        i. Introduction to Chemical and Environmental Engineering, CEE 010
        ii. Introduction to Nanoscale Engineering, CHE 105
        iii. Nanotechnology Processing Laboratory, CHE 161
        iv. Chemistry of Materials, CEE 135
        v. Eight (8) units of technical electives chosen from Fundamentals of Air Pollution Engineering, ENVE 133; Introduction to Materials Science and Engineering, ME 114; Nanostructure Characterization Laboratory, MSE 160; Analytical Materials Characterization, MSE 161

Breadth Requirements:
1. English Composition (12 units):
    a. Beginning Composition, ENGL 001A
    b. Intermediate Composition, ENGL 001B
    c. Applied Intermediate Composition, ENGL 001C; Applied Intermediate Composition for Science and Engineering, ENGL 001SC; or Technical Communications, ENGR 180
2. Humanities (12 units)*:
    a. One course in World History

   b. One course in one of the areas of Fine Arts, Literature, Philosophy, or Religious Studies
   c. One additional course chosen from
      i. History, the Fine Arts, Literature, Philosophy, Religious Studies
      ii. A foreign language at level 3 or above
      iii. Humanities courses offered by Ethnic Studies, Latin American Studies, Linguistics, or Women's Studies

*No course used to satisfy the English Composition requirement can be applied towards Humanities credits. A list of approved courses is available in the Office of Student Academic Affairs.

3. Social Sciences (12 units)**:
   a. One course from Economics or Political Science
   b. One course from Anthropology, Psychology, or Sociology
   c. One additional social science course offered by Ethnic Studies, Geography (cultural geography courses), Human Development, or Women's Studies, or one of the disciplines in (a) or (b) above.

** A list of approved courses is available in the Office of Student Academic Affairs.

4. Ethnicity (4 units)***
   ***The 4-unit ethnicity requirement can be applied to the Humanities or Social Science requirement, depending on content.

To provide depth in satisfying breadth in the humanities and social sciences, at least two of the courses must be upper division. Further, at least two courses, one of them upper division, must be from the same subject area. The list of approved courses is available in the Office of Student Academic Affairs.

G. Transcripts of Recent Graduates

When notified by the Team Chair, the program will provide transcripts from recent graduates to the visiting team along with any needed explanation of how the transcripts are to be interpreted.

Diversity in the Bourns College of Engineering

Figure 1-7: Associate Dean C.V. Ravishankar, left, accepts the 2009 Claire Felbinger Award from ABET President-Elect David Holger.

As we mentioned earlier, the Bourns College of Engineering is proud to be one of the most diverse engineering colleges in America. The number of domestic undergraduates from underrepresented backgrounds jumped 95.6% from the fall of 2006 to the fall of 2010 (the most recent academic year for which full data are available) (Table 1-3). In recognition of our efforts to recruit and retain students from diverse backgrounds to engineering, ABET awarded the Bourns College of Engineering the 2009 Claire Felbinger Award for Diversity (Figure 1-7). Our citation read: “In recognition of extraordinarily successful initiatives for recruiting undergraduate and graduate students from diverse and disadvantaged backgrounds, retaining them though the bachelor's degree, and advancing them to graduate studies and careers in engineering." Our faculty and staff truly appreciate this recognition of their efforts by ABET.

Table 1-3: The number of domestic undergraduates from underrepresented backgrounds in the Bourns College of Engineering has nearly doubled since 2006.

	Fall 2006	Fall 2007	Fall 2008	Fall 2009	Fall 2010
Undergraduate: % domestic underrepresented	27%	29%	31%	31%	33%
Undergraduate: # domestic underrepresented	340	377	449	521	665
Undergraduate: % domestic female	12%	12%	15%	17%	17%
Undergraduate: # domestic female	151	156	222	291	348
Graduate: % domestic underrepresented	16%	21%	18%	16%	17%
Graduate: # domestic underrepresented	14	24	27	24	32

CRITERION 2. PROGRAM EDUCATIONAL OBJECTIVES

A. Mission Statement

UCR's mission statement is as follows: The University of California, Riverside serves the needs and enhances the quality of life of the diverse people of California, the nation and the world through knowledge – its communication, discovery, translation, application, and preservation. The undergraduate, graduate and professional degree programs; research programs; and outreach activities develop leaders who inspire, create, and enrich California's economic, social, cultural, and environmental future.

With its roots as a Citrus Experiment Station, UC Riverside is guided by its land grant tradition of giving back by addressing some of the most vexing problems facing society. Whether it is assuring a safe, nutritious, and affordable food supply; stimulating the human mind and soul through the humanities and arts; or finding solutions to the profound challenges in education, engineering, business, healthcare, and the environment, UC Riverside is living the promise.

The vision and mission of the Bourns College of Engineering is to become a nationally recognized leader in engineering research and education. The College's mission is to:

- Produce engineers with the educational foundation and adaptive skills to serve rapidly evolving technology industries.
- Conduct nationally recognized engineering research focused on providing a technical edge for the United States.
- Contribute to knowledge of both fundamental and applied areas of engineering.
- Provide diverse curricula that will instill in our students the imagination, talents, creativity, and skills necessary for the varied and rapidly changing requirements of modern life.
- Enable our graduates to serve in a wide variety of other fields that require leadership, teamwork, decision-making and problem-solving abilities.
- Be a catalyst for industrial growth in Inland Southern California.

The components of the mission of the Bourns College of Engineering most relevant to the undergraduate program in Chemical Engineering are:

- To produce engineers with the educational foundation and the adaptive skills to serve rapidly evolving technology industries.
- To provide a diverse curriculum that will instill our students with the imagination, talents, creativity and skills necessary for the varied and rapidly changing requirements of modern life and to enable them to serve in a wide variety of other fields that requires leadership, teamwork, decision making, and problem solving abilities.
- To be a catalyst for industrial growth in the Inland Empire (see http://www.engr.ucr.edu/about/mission.html for complete vision and mission statement for the College).

B. Program Educational Objectives

Mission and Program Educational Objectives:

The role of the Chemical and Environmental Engineering department at the University of California, Riverside is to serve and enhance the quality of life of the diverse people of California, the nation, and the world through technical knowledge. Our mission is to develop undergraduate degree programs, research programs, and outreach activities to inspire, create, and enrich California's social, economic, and environmental future. The undergraduate and graduate curricula fosters the growth of ethical global leaders at the interface of engineering and all aspects of basic sciences (chemistry, physics, and biology).

The specific educational objectives (see http://www.cee.ucr.edu/undergrad/abet.html; also available in the UCR general catalog 2012-2013) of our chemical engineering program are:

Graduates will attain high levels of technical expertise to enable their achievement in diverse chemical/environmental engineering practice and research or in allied careers, prepare them for graduate level education, and enable them to be successful members of the professional community, for the benefit of our constituents.

C. Consistency of the Program Educational Objectives with the Mission of the Institution

The broad creation and transmission of knowledge in UCR's mission is consistent with the college mission to provide our students with a diverse curriculum that will engender their creativity in a rapidly changing environment. The college's broad mission is to produce engineers who can function in technological industries. This enables translation of their knowledge for the good of the public, consistent with the University mission and the Chemical and Environmental Engineering Program Educational Objectives (PEOs). The University and college-wide missions are in direct accordance with the PEOs of the Chemical and Environmental Engineering Department. The notion of engineers working successfully in interdisciplinary teams that require technical and non-technical expertise is emphasized in the college mission and in our program objectives. This is specifically stated in our PEOs as "*…prepare them for graduate level education, and enable them to be successful members of the professional community…*" The program offers ample opportunity for undergraduate research experience as a means to motivate graduates to pursue advanced graduate degrees in chemical engineering and other fields. Thus the PEOs are fully consistent with the mission of the Bourns College of Engineering and with the mission of the University of California, Riverside.

The vision of the Department of Chemical and Environmental Engineering over the next five years is to become one of the top 25 programs in both Chemical Engineering and Environmental Engineering in the nation.

We believe that the Department of Chemical and Environmental Engineering will be recognized for leadership in research and education that focuses on both development of safe and renewable energy systems, environmental quality improvements and innovations that improve the quality of life through the application of chemical and environmental engineering principles. The mission of the Department of Chemical and Environmental Engineering is to develop undergraduate degree programs, research programs, and outreach activities to inspire, create, and enrich California's social, economic, and environmental future.

Because of the rapidly changing technological society in which we live, today's chemical and environmental engineering graduates cannot be rooted into a single, standard mode of operation. They must be able to adapt readily to changing technologies and problem emphases, and develop creative solutions that are responsive to society as a whole. Thus, today's engineering students need to be rooted primarily in principles, not techniques.

D. Program Constituencies

The stakeholders of our program are departmental faculty, program alumni, employers in industry, and representatives from graduate schools. The Department of Chemical and Environmental Engineering has an Advisory Board that currently comprises 10 members from industry, regulatory agencies, and academia (see Table 2-1).

Table 2-1: Current Advisory Board for the Department of Chemical and Environmental Engineering. *members listed have served on this advisory board since 2006 (except Hennessey, Silverstein, and Kavanaugh, who were added 2010).

Harvey Blanch	Department of Chemical and Biomolecular Engineering, UC Berkeley
Richard Flagan	Department of Chemical Engineering, California Institute of Technology
Susan Hennessey	BioChemical Science & Engineering, DuPont Central Research & Development
Christian Herencia	Water Resource & Storm Water, Brown & Caldwell
Michael Kaavanaugh	Geosyntec
Sun Liang	Metropolitan Water District of Southern California
Jeffrey Mosher	National Water Research Institute
Neal Richter	Chevron Fellow Emeritus
Brigette Rosendall	Advanced Simulation & Analysis, Bechtel National, Inc.
Jo Ann Silverstein	Department of Civil, Environmental & Architectural Engineering, University of Colorado

Before 2010, several others served on the board (Table 2-2). Their membership was discontinued because of lack of participation.

Table 2-2: Past board members (2000-2010).

Shu Chien	Institute for Biomedical Engineering, UC San Diego
Muzaffar Iqbal	Calzyme Laboratories
Eric Mische	Parsons Engineering
Robert Nelson	Riverside County Waste Management District
John Seinfeld	California Institute of Technology
Geoffrey Slaff	Amgen
Gerald Thibeault	California Regional Water Quality Control Board, Region 8
King-Ning Tu	UCLA
Barry Wallerstein	South Coast Air Quality Management District
Joseph Zuback	U.s. Filter (Vivendi subsidiary)

The primary purpose of the Advisory Board is to provide insight and counsel to the Chair and CEE faculty toward defining the future direction of the department, provide feedback on the curricula and degree programs (BS, MS, and PhD), and research directions. The input of the Advisory Board is a critical component of the feedback loop we have developed that continuously improves the department, through redefining the program educational objectives and the curriculum. The Board guidelines include convening once every other year for a day to discuss current issues. On occasion, the Chair may also call upon Board members for individual advice and input. Areas for which the Chair seeks such counsel include, but are not limited to educational needs, industry trends and needs, industry collaboration opportunities, centers of excellence, program expansion, industry recruitment process, internship and employment opportunities for CEE students, and assist as stakeholders in ABET accreditation process. The next advisory board meeting will be convened on the first week of September, 2012.

In addition to the Advisory Board, the CEE department also initiated an alumni board in 2012. The 2012 Alumni Advisory Board (Table 2-3) is composed of 4 Environmental Engineering and 4 Chemical Engineering alumni who graduated between 2006 and 2011. They are currently either working in industry/government or attending graduate schools, well representing the broad versatility of the CEE's graduates. These alumni were invited to visit campus and evaluate CEE's undergraduate programs. The half-day event included (1) introduction of recent CEE's progress by the departmental chair, (2) meeting with ABET faculty members, (3) interacting with current senior students and evaluating their senior design projects, (4) open discussion for suggestions on improvements, and (5) a welcome dinner. Topics such as Program Educational Objectives, undergraduate curricula, and lab facilities have been actively discussed, and the visiting alumni gave many insightful suggestions, e.g., (1) putting more efforts on the development of communication skills especially with non-engineers, (2) more efficient literature search skills, (3) more research relevant experiences, and (4) more and earlier advices on career paths including graduate schools. These valuable suggestions have been seriously considered by the CEE faculty to implement teaching practices in relevant courses. The first year for this board was 2012, and because of the success of the first meeting the CEE department plans to hold such event every 2-3 years pursuing continuous improvements of our undergraduate programs.

Table 2-3: 2012 alumni advisory board.

Name	Program (Year)	Title	Current employer
Andrés Aguirre	Enve (2006)	Sanitary Engineer	California Department of Public Health Drinking Water Field Operations Branch
Jordan Barta	Enve (2006)	Test and Evaluation Engineer	Naval Surface Warfare Center Corona
Nichola Kinsinger	Che (2008)	Graduate Student	UCR
Nicha Chartuprayoon	Che (2007)	Graduate Student	UCR
John Johnson	Che (2010)	Graduate Student	UCR
Chris Salinas	Che (2009)	Graduate Student	UCR
Ryan Honda	Enve (2010)	Graduate Student	UCR
Jake Lanphere	Enve (2011)	Graduate Student	UCR

E. Process for Revision of the Program Educational Objectives

E.1. Historical Perspective for Program Educational Objectives

The current program educational objectives evolved from those set at the inception of the CHE program in the early 1990s as the program evolved and matured and as the curricula were adapted to better suit the needs of our students. In the process, CEE faculty and lecturers have developed program outcomes following ABET established guidelines, consistent with the program educational objectives. A rational assessment process has been established to judge the extent to which program outcomes and educational objectives have been met. Assessment results are documented and used to improve the program to ensure closure of the assessment and improvement process. This ensures that the program educational objectives are consistent with the accreditation criteria. These educational objectives were modified, in 2000, 2003, 2007 and most recently in 2011. Since 1990, Table 2-4 describes the review and any modifications to our PEOs by constituents (including our Board of Advisors, BOA):

Table 2-4: Timeline describing changes to PEOs from department inception in 1990.

Year	**Action**	**Group***
1990	Inception of CEE Program	BCOE
1994	PEO predecessor formulated**	CEE faculty and BOA
2000	PEO predecessor updated **	CEE faculty and BOA
2003	First PEOs formulated	CEE faculty and BOA
2006	PEOs added and modified after ABET review of 2000***	CEE faculty, BOA and ABET
2011	PEOs modified (details below in timeline)****	CEE faculty and BOA

* Group refers to those initiating process. All constituents must "buy-in" to PEOs.

** At the time of the ABET review in FY2000, Program Educational Objectives did not exist. Instead, the department had Program Objectives, which included "Our Vision", "Our Mission" and a set of specific objectives for the undergraduate program.

In FY2000, Our Vision stated: "*The Department of Chemical and Environmental Engineering at UCR will be known for leadership in research and education that focuses on environmental quality improvements through the application of chemical engineering principles.*"

In FY2000, Our Mission stated: "*The mission of the Department of Chemical and Environmental Engineering is to prepare students for professional practice, graduate study, and life-long learning, and to advance the scientific and technological basis for chemical and environmental engineering practice.*"

In FY2000, the objectives of the Chemical Engineering undergraduate program were to:

- Instill graduates of our program with principles that will enable them to analyze and solve a wide range of problems and situations facing chemical engineers today and in the future,
- provide students with the skills necessary to meet the challenges of modern engineering practice, and
- provide a high-quality undergraduate education necessary for a student to advance to the M.S. and Ph.D. degree level.

*** The following text was first published in the 2003-2004 UCR catalog describing our original PEOs. These goals, and the specific goals that follow, were adopted based on internal faculty discussion and consultation with our stakeholders, in particular the CEE faculty together with our alumni and our advisory board.

> Chemical Engineering focuses on transforming raw materials into useful everyday products. Chemical engineers turn the discoveries of chemists and physicists into commercial realities. They find work in a variety of fields including pharmaceuticals, materials, chemical, fuels, pollution control, medicine, and nuclear and electronic industries. At UCR, the B.S. degree in Chemical Engineering offers students four options: Biochemical Engineering, focusing on biochemical processes; Bioengineering, focusing on the biomedical industry; Chemical Engineering, emphasizing traditional chemical engineering issues; Nanotechnology, which enables students to learn nanoscale materials and technologies. (Note: As of Fall 2011, Bioengineering is no longer an option for incoming students, and will be phased out by Summer, 2014.)

****In 2006, following the last ABET site visit, the PEOs were modified as follows based on input from our constituencies to better reflect the core values and objectives of our program graduates to achieve early in their professional careers. They read as follows:

The Program Educational Objectives are to produce graduates who demonstrate in their careers and professional pursuits, the following:

- An ability to apply mathematics, engineering principles, computer skills, and natural sciences to chemical engineering practice.
- Application of fundamental chemical engineering principles at an advanced level, and competence in synthesizing knowledge from multiple disciplines to develop and evaluate design solutions.
- Engagement in chemical engineering careers in diverse areas including biochemical engineering, nanotechnology, petrochemicals and chemicals, alternative energy, and semiconductor manufacturing.
- Pursuit of graduate education and research in chemical engineering at major research universities.
- Exercise of professional responsibility and sensitivity to a broad range of societal concerns, such as ethical, environmental, economic, regulatory, and global issues.
- Effective performance in a team environment, outstanding communication, and involvement in personal and professional growth activities.

*****In 2011, based on feedback from our Board of Advisors meeting, the PEOs were updated to their current version

> Program Educational Objective (PEO): “Graduates will attain high levels of technical expertise to enable their achievement in diverse chemical engineering practice and research, or in allied careers, prepare them for graduate level education, and enable them to be successful members of the professional community, for the benefit of our constituents”.

E.2. Process for revision of PEOs

PEOs are periodically reviewed by all constituencies (faculty, alumni, employers, and the departmental board of advisors). The review cycle includes:

- Faculty review PEOs annually at faculty retreat. Any suggested changes are forwarded to ABET committee for further evaluation.
- Board of advisors asked to review and comment on PEOs. (Every other year or as requested by department, whichever is sooner).
- Alumni and Employers are sent a survey every other year to provide feedback on PEOs. Additionally, an alumni board was formed in 2012 for additional feedback and approval of PEOs.
- ABET committee reviews PEOs annually and as requested/required by constituents and/or faculty.

Recommended changes to PEOs are forwarded to ABET committee, who reviews inputs of constituents as well as existing PEOs. The ABET committee is responsible for recommending specific changes to the PEOs after feedback from faculty. Figure 2-1 provides the flow diagram for ***campus*** approval of PEO changes. Specific examples of PEO review and continuous improvement are provided in Criteria 4.

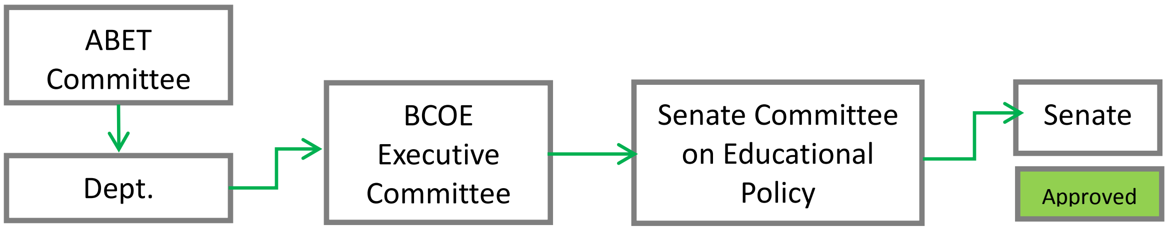


Figure 2-1: PEO revision and approval process.

CRITERION 3. STUDENT OUTCOMES

A. Student Outcomes

In 2008, the CEE faculty voted to subdivide several ABET outcomes to further increase the specificity of the ABET (a) – (k) outcomes for quantitative assessment of student outcome. Therefore it was decided to split outcome (a) into 3 separate outcomes; outcome (b) into 3 separate outcomes and split outcome (f) into two separate outcomes. The new outcomes are directly related to the (a) thru (k) with the mapping summarized in the Table 3-1 below.

Table 3-1: Reorganization of Student Outcomes.

Outcomes (a) through (k)	UCR CHEs outcome (1) through (16)
(a) Ability to apply mathematics, science, and engineering principles	{1) Ability to apply mathematics
	(2) Ability to apply science
	(3) Ability to apply engineering principles
(b) Ability to design and conduct experiments, analyze and interpret data	(4) Ability to design experiments
	(5) Ability to conduct experiments
	(6) Ability to analyze and interpret data
(c) Ability to design a system , component, or process to meet desired needs	(7) Ability to design a system , component, or process to meet desired needs
(d) Ability to function on multidisciplinary teams	(8) Ability to function on multidisciplinary teams
(e) Ability to identify, formulate, and solve engineering problems	(9) Ability to identify, formulate, and solve engineering problems
(f) Understanding of professional and ethical responsibility	(10) Understanding of professional responsibility
	(11) Understanding of ethical responsibility
(g) Ability to communicate effectively	(12) Ability to communicate effectively
(h) The broad education necessary to understand the impact of engineering solutions in a global and societal context	(13)The broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) Recognition of the need for and ability to engage in life-long learning	(14) Recognition of the need for and ability to engage in life-long learning
(j) Knowledge of contemporary issues	(15) Knowledge of contemporary issues
(k) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	(16) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

B. Relationship of Student Outcomes to Program Educational Objectives

Several discussions were conducted, both formally and informally, among members of the all stakeholders to establish consistency between PEOs and Student Outcomes. The current set of PEOs is the result of the 2010 Advisory Board meeting and our faculty retreat held in 2011 (see Criteria 2). The current set of PEOs is as follows:

Graduates will attain high levels of technical expertise to enable their achievement in diverse chemical/environmental engineering practice and research or in allied careers, prepare them for graduate level education, and enable them to be successful members of the professional community, for the benefit of our constituents.

Student Outcomes 1-3 (ABET “A”) provide graduates with fundamental knowledge in core math, science, and engineering which lay the foundation for students to achieve high levels of technical expertise in their respective fields. Student Outcomes 4-6 (ABET “B”) in turn provide students with the necessary experimental expertise necessary for designing, conducting and interpreting experiments necessary for engineering practice as well as research careers/graduate education. Student Outcome 7 (ABET “C”) again focuses on the technical expertise for achievement within chemical engineering while Student Outcome 9 (ABET “E”) ensures students can identify/formulate problems within their technical field. The open-ended nature of the modules aimed to test Student Outcomes 4-7 and 9 broadly promote students’ problem solving skills, which will allow their success in diverse careers in the chemical/environmental engineering fields. Student Outcomes 8 (ABET “D”) and 12 (ABET “G”) ensure students can work in teams and effectively communicate within their team as well as communicate their findings to clients/journals/or the general public. Student Outcomes 10 and 11 (ABET “F”) educates the students on professional and ethical responsibility. The skills taught and evaluated through Student Outcomes 8, 10, 11, and 12 provide the non-technical skill sets that allow our students to be integrated as successful members and even leaders of their respective professional communities. Student Outcomes 13-16 (ABET “H”-“K”) are key components of the student’s education, enabling them to adapt to the rapidly changing field of chemical engineering. These outcomes promote the students continued success in their chosen careers, many years after graduation.

Table 3-2 shows a direct relationship between specific aspects of our Program’s Educational Objective and the specific outcomes that feed into those aspects.

As can be seen in Table 3-2, specific Student Outcomes address multiple facets of our Program Educational Objectives.

Specifically, each set of specific Student Outcomes is targeted to meet specific goals in our PEOs and in turn is focused on important skill sets that are beneficial to our graduating students. For example, students who graduate from our program have the opportunity to *enter graduate school* or a *chemical/environmental engineering research-related field*. In these careers, alumni will be exposed to a diverse set of problems to solve, will need to have been thoroughly prepared to apply math, science and engineering skills to address problems that are or can be multidisciplinary in nature. Thus, our Student Outcomes 1 – 3 (“a”) provide well-established core knowledge in these areas that address specific aspects of our PEOs.

Table 3-2: Corresponding relationships between Program Educational Objectives and Student Outcomes.

CEE Program Educational Objectives	CEE Student Outcomes
1. Graduates from the CEE program will be successful in diverse chemical /environmental engineering practices and allied careers	Outcome 3: Ability to apply engineering (“a”) Outcome 7: Ability to design a system, component, or process to meet desired needs (“c”) Outcome 9: Ability to identify, formulate, and solve engineering problems (“e”) Outcome 10: Understanding of professional responsibility (“f”) Outcome 11: Understanding of ethical responsibility (“f”) Outcome 12: Ability to communicate effectively (“g”) Outcome 13: The broad education necessary to understand the impact of engineering solutions in a global and societal context (“h”) Outcome 16: Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (“k”)
2.Graduate will be successful on research in chemical/ environmental engineering and related areas	Outcome 1: Ability to apply mathematics (“a”) Outcome 2: Ability to apply science (“a”) Outcome 3: Ability to apply engineering principles (“a”) Outcome 4: Ability to design experiments (“b”) Outcome 5: Ability to conduct experiments (“b”) Outcome 6: Ability to analyze and interpret data (“b”) Outcome 8: Ability to function on multidisciplinary teams (“d”) Outcome 9: Ability to identify, formulate, and solve engineering problems (“e”) Outcome 11: Understanding of ethical responsibility (“f”) Outcome 12: Ability to communicate effectively (“g”) Outcome 15: Knowledge of contemporary issues (“j”)
3. Graduates will be well prepared for graduate level education	Outcome 1: Ability to apply mathematics (“a”) Outcome 2: Ability to apply science (“a”) Outcome 3: Ability to apply engineering principles (“a”) Outcome 4: Ability to design experiments (“b”) Outcome 5: Ability to conduct experiments (“b”) Outcome 6: Ability to analyze and interpret data (“b”) Outcome 10: Understanding of professional responsibility (“f”) Outcome 11: Understanding of ethical responsibility (“f”) Outcome 12: Ability to communicate effectively (“g”) Outcome 14: Recognition of the need for and ability to engage in life-long learning (“I”)
4. Graduates will be successful members of the professional community	Outcome 8: Ability to function on multidisciplinary teams (“d”) Outcome 10: Understanding of professional responsibility (“f”) Outcome 11: Understanding of ethical responsibility (“f”) Outcome 12: Ability to communicate effectively (“g”) Outcome 13: The broad education necessary to understand the impact of engineering solutions in a global and societal context (“h”) Outcome 14: Recognition of the need for and ability to engage in life-long learning (“I”) Outcome 15: Knowledge of contemporary issues (“j”)

In addition, any graduating student who will move into fields that require research (i.e., graduate school or industrial research) will need to be able to (i) design experiments, (ii) conduct those experiments and (iii) analyze and interpret the results from their experiments. Thus, Student Outcomes 4 – 6 (“b”) provide our students will these abilities, enabling them to move on to a research-related career, a core value in our PEOs.

Students who graduate from our program will be exposed to a diversity of career opportunities, even within a specific industry and/or company. Thus, it is essential that we enable our students to *design systems, components, or processes to meet desired needs*, for a wide variety of applications. We achieve this, in part, by Student Outcome 7 (“c”).

In all settings, academia, industry, and life, our graduates must be able to interact with others and perform in a wide diversity of team settings. Student Outcome 8 (“d”), the “Ability to function on multidisciplinary teams” clearly addresses this PEO.

All engineers, in academia or industry, must be able to identify, formulate, and solve engineering problems (Student Outcome 9 (“e”)), thus our graduating students will be able to enter industrial or research settings (academia or industry) with this ability.

Similarly to Student Outcome 8 (“d”), Student Outcomes 10 – 12 (“f,g”) are broad in scope and provide all students the ability to succeed in academic, industrial and life environments. It is clear that each of these environments requires the understanding of professional responsibility, ethical responsibility, and the ability to communicate effectively.

Our students not only have to *identify* and solve many current engineering problems, but they have to be able to recognize these existing and future problems, but formulate solutions in such a way that they *understand the global and societal impacts of their work*, which is obtained through Student Outcomes 13 and 15 (“h,i,j”).

Finally, as new and emerging problems occur, our students must be able to use the state of the art techniques, skills, and *modern engineering tools* necessary for safe engineering practice (Student Outcome 16 (“k”)), but also recognize that in order to deal with new problems, continuous, *life-long education* (Student Outcome 14 (“i”)) is needed to keep up with these emerging problems that create new challenges for our engineers.

These student outcomes, covered in our courses enable our Chemical Engineering graduates to meet our PEOs: to be well prepared to attain high levels of technical expertise to enable their achievement in diverse chemical/environmental engineering practice and research or in allied careers, prepare them for graduate level education, and enable them to be successful members of the professional community, for the benefit of our constituents.

CRITERION 4. CONTINUOUS IMPROVEMENT

Figure 4-1 depicts the feedback control loops for continuous improvement for the Chemical Engineering program. The "Inner Loop" focuses on course objectives/student outcome achievement improvements while the "Outer Loop" ties together the PEOs with departmental, college, and university mission statements. Feedback/forward from all constituents (alumni, faculty, employers, and board of advisors) is included in Figure 4-1.

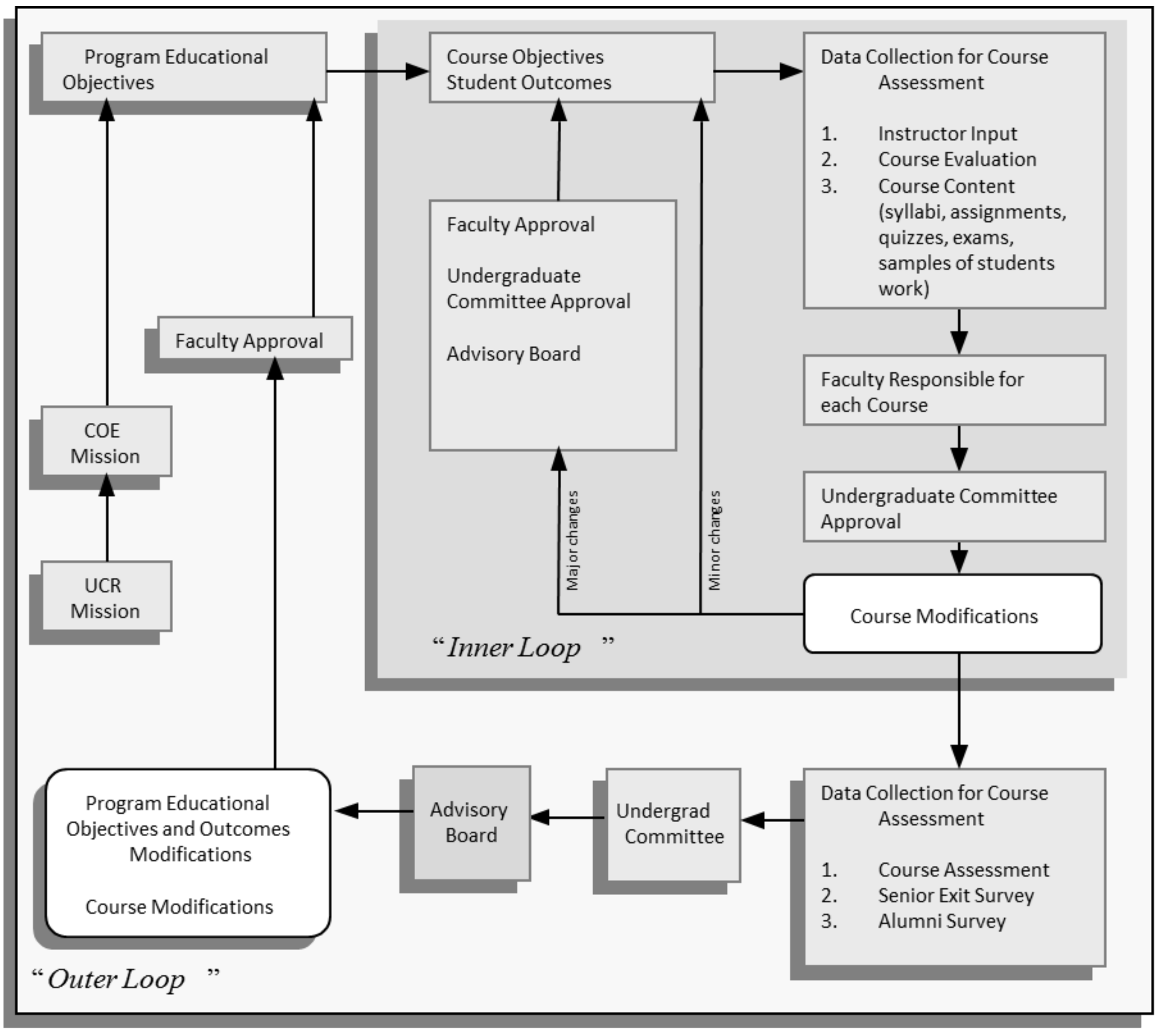


Figure 4-1: Feedback loops for continuous program improvement.

A. Program Educational Objectives

1. The CHE programs have been reviewed on a regular basis since it was founded in 1992. ABET accreditation visits took place in 1994, 2000 and in 2006. The review of the educational objectives of the programs (PEOs as of 2006) has been a continual process, conducted by the CEE faculty (at faculty meetings, meetings of the

undergraduate education and CEE ABET Committees, and CEE faculty retreat) with significant input from alumni and the CEE Advisory Board.

2. PEOs are reviewed annually at the CEE faculty retreat. Alumni surveys, on a three year cycle, also provide input and evaluate buy-in of PEOs. The CEE advisory board, during every meeting (alternate year) are also asked for input/buy-in/recommended changes on PEOs. A listing and description of the assessment processes used to gather the data upon which the evaluation of each the program educational objective is based. Examples of data collection processes may include, but are not limited to, employer surveys, graduate surveys, focus groups, industrial advisory committee meetings, or other processes that are relevant and appropriate to the program.

3. Frequency of review: Table 4-1 summarizes the frequency of the reviews.

Table 4-1: Summary of feedback frequency.

Survey	Frequency	Last feedback
Alumni surveys	Every three years	2011
Employer surveys	Every three years	2012
External advisory board	Every other year	2011
ABET committee	Every year	2011
CEE faculty	Every year	2011
Informal feedback	Intermittent	2012
Alumni board	Every two years*	2012

*Inaugurated 2012

- Alumni surveys: The Bourns College of Engineering maintains an account with a web-based surveying service (SurveyMonkey) so it can conduct surveys of alumni and employers. We also review surveys that other engineering programs conduct. Since it is understood that PEOs speak to the performance and abilities of alumni three to five years after completion of the bachelor's degree, this survey is conducted on students three to five years after graduation. In some circumstances, the survey window is extended an additional 1-2 years based on size of alumni group.

- Employer surveys: We use the same survey system to ask employers about the qualities of our alumni and students achievement of PEOs. When we send the survey to our alumni, we ask them to forward a message to their supervisors with a link to a second survey to complete. Our experience, however, has been that the return on this survey is generally poor. We hypothesize that some of our alumni do not feel comfortable asking their supervisors to complete the survey, and that some employers do not respond because they are fearful of legal consequences.

- Board of Advisors meetings: We strive to have companies that hire our alumni on our advisory boards. Thus, the Board of Advisors industry members often stand in as surrogates for employers for our evaluation purposes. The Board of Advisors is asked to comment on the PEOs themselves providing useful feedback on direction and achievement of PEOs and suggest changes when appropriate.

- ABET committee: The ABET committee is comprised of faculty members and is charged with the upkeep of the PEOs, ensures publication of PEOs, and evaluates responses/suggestions from faculty, employers, alumni, and board of advisors. The ABET committee suggests changes for discussion/approval of the faculty and maintains the PEO related surveys.

- Faculty: ABET is an agenda item on every faculty annual retreat. Part of the agenda is to read the PEOs aloud to the entire faculty and then have an open ended discussion on whether the program provides the educational background for students to achieve PEOs. Feedback from constituents on the PEOs is also provided to the faculty at this time. Additional meetings during the year, as necessary, address changes/suggestions to PEOs.

- Alumni board: We have initiated an alumni board formed of 4-6 members who are invited to campus and meet with the department chair, ABET faculty, and students. The board is timed to overlap with the evaluation of the senior design projects for which the board members are asked to observe. The purpose of this board is to provide critical feedback on curriculum, goals, and achievement of PEOs 3+ years after graduation.

- Informal feedback: We obtain additional information from the UCR Career Center about placement of our alumni and their career progress, and UCR's Alumni Affairs office makes efforts to track our alumni. Further, alumni often come back to visit, or contact faculty members for recommendations when they have applied to graduate school or jobs (or are seeking prestigious graduate fellowships). These contacts give us a sense for how the students are performing after graduation, although the information does not come in a consistent enough format for a data-driven analysis of our Program Educational Objectives.

It is expected that all graduates will attain all of the PEOs. The current PEOs were adopted in 2011 and are scheduled to be evaluated again in 2014. Generally, alumni and employers have been satisfied with attainment of the PEOs. The most recent change was driven by the 2011 Board of Advisors meeting. Our most recent surveys (2011/2012) have been adapted to specifically ask for agreement with new PEOs (with open-ended feedback from the survey on PEOs and to evaluate achievement of the PEOs).

4. The expected level of attainment for each of the program educational objectives is as follows:
    - Alumni and Employer Surveys (3.5 out of 5)
    - External advisory board: Approval of ¾ of board
    - Positive feedback from Alumni board
    - ABET committee/CEE faculty review: not applicable
    - Alumni 3-5 years out will have

- Enable achievement in diverse environmental engineering practice and research

5. The following survey as it relates to the new PEOs was conducted with the following two questions (both alumni and employer):

   Program Educational Objective (PEO): “Graduates will attain high levels of technical expertise to enable their achievement in diverse chemical engineering practice and research, or in allied careers, prepare them for graduate level education, and enable them to be successful members of the professional community, for the benefit of our constituents”.

   Question 1: Are you in agreement with the PEO? (Please rank from 1 – 5, where 1 = disagree and 5 = completely agree. If the score is 3 or lower, please provide a comment and if any improvements are needed.)

   Question 2: Has the PEO been satisfactorily accomplished? (Please rank from 1 – 5; where 1 = not satisfied and 5 = completely satisfied. If the score is 3 or lower, please provide a comment and if any improvements are needed.)

Table 4-2 below summarizes the responses to each question. The general feedback on the PEOs and achievement of the PEOs was very high and did not trigger any additional actions at this time. While the PEOs have been modified in 2011, the students 3-5 years from graduation and their employers responded positively that the new PEOs were instilled in the existing graduates. The PEOs will continue to be evaluated.

Table 4-2: Summary of Alumni and Employer response.

	Alumni Response (# of responses)	Employer Response (# of responses)
Question 1	4.83 (12)	4.8 (5)
Question 2	4.75 (12)	5 (5)

B. Student Outcomes

B.1. Achievement of Student Outcomes is primarily evaluated through quantitative assessment of coursework focusing on the core curricula courses. Each core course is assigned 4 to 8 Student Outcomes that must be independently assessed within the course. Each instructor is expected to directly link (whole or part) of a homework, quiz, midterm exam question(s), oral report, written report, design project, laboratory report, or final exam question(s) to the Student Outcomes assigned to the course. Each element used must independently assess a single Student Outcome so as to ensure the uniqueness of the result to the Student Outcome score from the class. Each outcome is evaluated in 5 to 8 courses with each Student Outcome score derived from the average of the individual outcome scores across the relevant core courses. Only core courses are used to assess Student Outcomes to ensure that all students are evaluated. Table 4-3 below summarizes the course/Student Outcome assignment.

Table 4-3: Student Outcomes assessed by course.

	Outcomes															
Courses	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
		a			**b**		**c**	**d**	**e**	**f**		**g**	**h**	**i**	**j**	**k**
CEE 10/11				x						x	x				x	x
CEE 130		x				x			x							x
CEE 158										x	x	x		x	x	
CHE 100	x	x	x	x	x		x	x			x					
CHE 114	x		x						x				x			
CHE 116	x	x		x					x							x
CHE 120	x		x				x						x	x		
CHE/ENVE 160A					x	x		x			x	x		x		
CHE/ENVE 175A			x	x			x	x		x		x		x	x	
CHE/ENVE 175B			x	x		x	x			x	x	x		x		
CHE 160B	x	x	x	x	x	x		x		x		x		x	x	
CHE110A		x				x			x							x
CHE110B			x				x									x
CHE117	x	x	x			x	x								x	x
CHE118	x		x	x		x	x							x		
CHE122	x	x		x			x		x							
CHE160C				x	x	x		x				x		x	x	
ENGR 118	x					x			x							x

Each course instructor identifies unique question(s) used to assess the outcome and reports the student averages on that question. For example, the first quarter senior capstone design course ENVE 175A/CHE 175A reported for 2011 the following (Table 4-4):

Table 4-4: CHE 175A / ENVE 175A – Winter 2011, Student Outcomes

	Score (%)	Source
3	83	Average score from Problem Sets 4, 5 and 6
4	84	Average score from Problem Sets 2 and 3
7	89	End of Winter quarter report
8	85	Oral presentation updates for winter quarter
10	94	Memo scores
11	98	Timesheet scores
12	85	End of Winter quarter oral presentation
14	77	Problem Set 1
15	72	Final exam General Knowledge section 1 (part 2)

Each Student Outcome score, linked to specific classroom achievement, is then updated into the master spreadsheet file to obtain average Student Outcome scores as shown in Table 4-5 below:

Table 4-5: Course/Student matrix example (2010-2011).

	Outcomes															
Courses	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
ABET (a) - (k)	**a**	**a**	**a**	**b**	**b**	**b**	**c**	**d**	**e**	**f**	**f**	**g**	**h**	**i**	**j**	**k**
CEE 10/11				**89**						**86**	**94**				**88**	**81**
CEE 130		**60**												**60**	**57**	
CEE 158										**85**	**89**	**78**				
CHE 100		**76**	**73**	**73**					**89**				**82**		**89**	
CHE 114	**84**		**82**	**75**		**70**	**80**		**75**				**70**			
CHE 116	**75**	**75**		**75**					**75**							**75**
CHE 120	**46**		**84**				**86**						**59**	**64**		
CHE/ENVE 160A					**83**	**81**		**90**				**87**		**85**		
CHE/ENVE 175A			**83**	**84**			**89**	**85**		**94**	**98**	**85**		**77**	**72**	
CHE/ENVE 175B			**75**	**77**		**85**	**85**			**90**	**69**	**83**		**91**		
CHE 160B				**90**	**83**	**82**		**91**		**52**		**87**		**30**	**85**	
CHE110A																
CHE110B			**70**			**75**	**84**		**95**				**83**			**66**
CHE117																
CHE118	**75**		**76**	**82**		**79**	**89**									
CHE122	**75**		**63**	**65**			**52**		**89**							
CHE160C																
ENGR 118	**86**					**83**			**89**							**87**
Average	**73.6**	**70.3**	**75.8**	**78.8**	**83.1**	**79.2**	**80.7**	**88.5**	**85.4**	**81.3**	**87.5**	**83.9**	**73.5**	**67.9**	**78.2**	**77.2**
StDev	14.4	9.0	7.1	8.0	0.2	5.2	13.1	3.1	8.4	16.9	12.9	3.7	11.3	21.9	13.7	9.1
#	6	3	8	9	2	6	7	3	5	5	4	5	4	6	5	3

The Student Outcome scores are then evaluated first by the ABET/undergraduate committee and then by the entire Chemical and Environmental Engineering faculty. Section B.3 discusses the expectations of achievement of Student Outcomes. Scores are plotted against previous years (Section B.4), and trends evaluated to assess whether changes in previous years were successful in improving Student Outcome scores and to identify any potential trouble areas before the outcome might slip below criteria values.

Additionally, Student Outcomes are evaluated through the EBI senior exit survey administered to every graduating senior in chemical engineering. This survey has been administered every year since 2002, with a series of survey questions linked to ABET (a) – (k) outcomes. For example, Figure 4-2 shows three questions linked to ABET outcome (a)

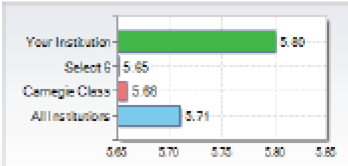
The (a) – (k) results are then compiled, evaluated by the undergraduate/ABET committee and reported to the entire Chemical and Environmental Engineering faculty. Feedback from the committee and/or faculty is then incorporated into the following year's classes. An example of the trends is shown if Figure 4-3.

EBI surveys are available for evaluation of achievement of Student Outcomes (a) – (k) as well as faculty performance and facilities and will be available at the review.

Additionally, all courses (see syllabi, Appendix B) are required to list course objectives to be achieved. These objectives are created by the faculty and their achievement is evaluated by the students through a survey at the end of each course. Survey responses are used by the faculty for continuous improvement of their courses. For example, CHE 175A/ENVE 175A (1st quarter senior design) listed the course objectives shown in Table 4-5.

ABET Criterion 3 (a) an ability to apply knowledge of mathematics, science, and engineering

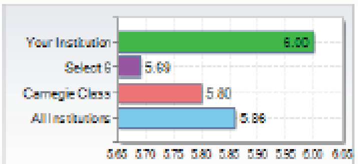
Q047. Program Outcomes and Assessment - Skill Development - Degree that engineering education enhanced ability to: Apply knowledge of mathematics



	N	Mean	Std Dev
Your Institution	10	5.8	0.98

	N	Mean	Std Dev	Min	Max	Difference	Rank
Select 6	26	5.65	1.13	4.5	6.25	0.15	2
Carnegie Class	130	5.66	1.29	4.5	6.5	0.14	8
All Institutions	175	5.71	1.2	4.5	6.5	0.09	12

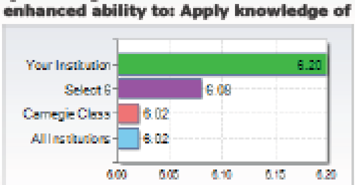
Q048. Program Outcomes and Assessment - Skill Development - Degree that engineering education enhanced ability to: Apply knowledge of science



	N	Mean	Std Dev
Your Institution	10	6	0.77

	N	Mean	Std Dev	Min	Max	Difference	Rank
Select 6	26	5.69	1.16	4.5	6.25	0.31	3
Carnegie Class	130	5.8	1.16	4.5	6.5	0.20	8
All Institutions	175	5.86	1.09	4.5	6.5	0.14	12

Q049. Program Outcomes and Assessment - Skill Development - Degree that engineering education enhanced ability to: Apply knowledge of engineering



	N	Mean	Std Dev
Your Institution	10	6.2	0.75

	N	Mean	Std Dev	Min	Max	Difference	Rank
Select 6	26	6.08	0.98	4.5	6.5	0.12	3
Carnegie Class	129	6.02	1.08	4.5	6.62	0.18	6
All Institutions	174	6.02	1.05	4.5	7	0.18	9

Figure 4-2: EBI exit survey questions related to ABET outcome (a).

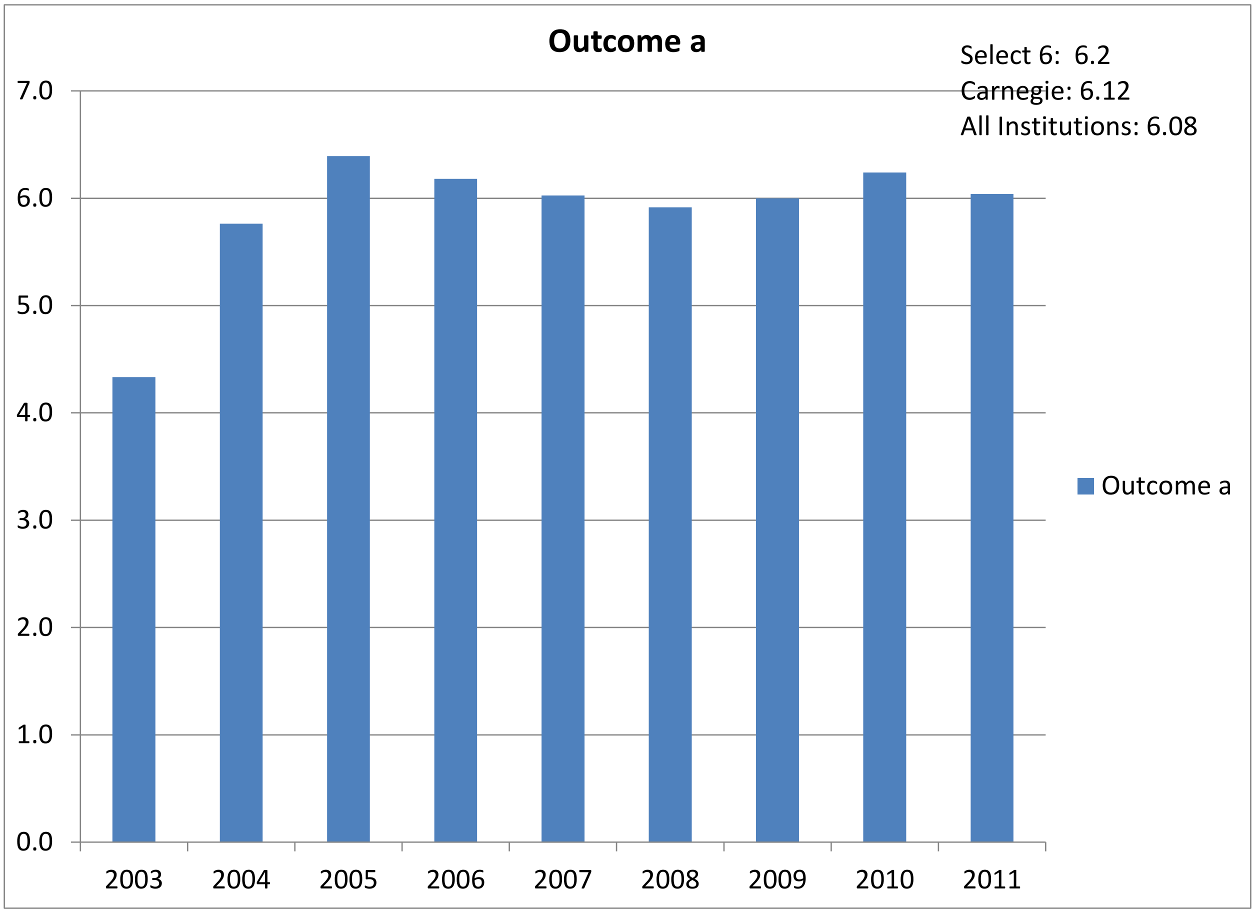


Figure 4-3: Student Outcome "a" EBI trends 2003-2011.

Table 4-5: CHE 175 A / ENVE 175 A – Winter 2011, Course Objectives.

Ability to write an end-of-quarter progress report of design project in teams
Ability to produce memos and timesheets similar to a consultation practice in groups; effectively present oral updates and end-of-quarter oral presentation
Research design topic, determine and critically analyze design parameters and their effects in teams; research alternative processes and having ability to determine best solution based on design, safety and economics in teams
Ability to formulate block and process flow diagrams and perform associated mass and energy balances in teams
To understand concepts of health and safety in process design, including regulations and agencies, risk, and fire and explosion hazards
Ability to use process safety (HAZOP) protocol, be familiar with inherently safer designs
To understand concepts of engineering economy including cost estimation, and time value of money, taxes and depreciation
Understanding and using the methods of project evaluation or profitability for comparing alternative projects.
To generate computer simulations to model processes (SuperPro, PROII)

These course objectives were then evaluated with the following provided back to the instructor (Table 4-6):

Table 4-6: Achievement of course learning objectives.

Learning Objective	(out of 3)
Ability to write an end-of-quarter progress report of design project in teams	2.85
Ability to produce memos and timesheets similar to a consultation practice in groups; effectively present oral updates and end-of-quarter oral presentation	2.95
Research design topic, determine and critically analyze design parameters and their effects in teams; research alternative processes and having ability to determine best solution based on design, safety and economics in teams	2.82
Ability to formulate block and process flow diagrams and perform associated mass and energy balances in teams	2.56
To understand concepts of health and safety in process design, including regulations and agencies, risk, and fire and explosion hazards	2.67
Ability to use process safety (HAZOP) protocol, be familiar with inherently safer designs	2.56
To understand concepts of engineering economy including cost estimation, and time value of money, taxes and depreciation	2.82
Understanding and using the methods of project evaluation or profitability for comparing alternative projects.	2.67
To generate computer simulations to model processes (SuperPro, PROII)	2.74

Each course objective is mapped to Student Outcomes (provided for each course in Appendix B) and excerpted for ENVE 175A/CHE 175A (1st quarter senior design) as detailed in Criterion 5 (curricula – outcome relationship). The course objective scores are then used by the faculty as part of a post-assessment process for the course on how to make continued improvements (course level). This also provides a roadmap for faculty to readily identify course objectives related to Student Outcomes (1-16 or "a"-"k") that are to be addressed specifically by instructors as part of the continuous improvement loop for each Student Outcome. (e.g., course objectives 3, 4, 7 and 8 are most important focal points if instructor has been asked to emphasize/address outcome 1). These points of emphasis are outlined by the instructor as part of their course pre-evaluation (Table 4-7).

Table 4-7: Course objective – Student Outcome relationship.

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Ability to write an end-of-quarter progress report of design project in teams							1	3	2	3	3	3	2	2	1	2
Ability to produce memos and timesheets similar to a consultation practice in groups; effectively present oral updates and end-of-quarter oral presentation								3		3	3	3	1	2		1
Research design topic, determine and critically analyze design parameters and their effects in teams; research alternative processes and having ability to determine best solution based on design, safety and economics in teams	3	3	3	3	2	2	3	3	3	3	3	3	3	3	3	3
Ability to formulate block and process flow diagrams and perform associated mass and energy balances in teams	3		3	2	2	2	3	3	3							2
To understand concepts of health and safety in process design, including regulations and agencies, risk, and fire and explosion hazards						2	1	2	3	3	3		3	3	3	2
Ability to use process safety (HAZOP) protocol, be familiar with inherently safer designs						2				2	2		3	2	2	2
To understand concepts of engineering economy including cost estimation, and time value of money, taxes and depreciation	3		3						3	2				2	1	3
Understanding and using the methods of project evaluation or profitability for comparing alternative projects.	3			3						2						3
To generate computer simulations to model processes (SuperPro, PROII)			3				2	2	3			2		1		3

Finally, Table 4-8 is provided to all faculty to help guide them on assessment responsibilities/deadlines for each course they teach.

Table 4-8: Course Assessment calendar – TO DO LIST.

Date	Action Item
1 week before start of quarter	Course Pre-evaluation – "What will you do this year based on last year?" E-mail pre-evaluation to ceeabet@engr.ucr.edu
1 week before start of quarter	Update Course Objectives – "What are the objectives of the course you are instructing?" – (Good template is prior year matrix). E-mail course objectives to ceeabet@engr.ucr.edu
1 week before start of quarter	Update Course Syllabus. E-mail course syllabus to ceeabet@engr.ucr.edu
Throughout quarter	Collect Homeworks, Midterms, Finals, Designs, Presentations, etc. – Include two best, two average, two below average. Turn in weekly (or as often as collected) to ABET mailbox in CEE mailroom.
Update throughout quarter – Due with campus grade report	Track course scores on targeted Student Outcome questions (One or a few selected questions to evaluate specific Student Outcome for course – check ABET spreadsheet to see specific course objective to be evaluated – normally this will be a midterm/final/design/lab score. If needed, homework score on specific problem (or assignment) can be used. E-mail ceeabet@engr.ucr.edu with final scores.
Week 10	Student survey/course assessment – form will be delivered to instructor mailbox Monday of week 9. Collect from students during final week and return to ABET mailbox for tabulation.
Due Week 2 of following quarter	Course evaluation – "How did the course go—what would you recommend to improve the course next year?" – turn in to ABET mailbox or email to ceeabet@engr.ucr.edu. Student Survey results will be returned to the instructor to aid your evaluation by the 2nd day of classes.

B.2. The Student Outcomes are summarized and evaluated as described above on an annual basis. All Student Outcomes are evaluated each year. Student Outcome scores are discussed, when ready, at the faculty retreat or in the early Fall quarter of the following year.

B.3. Expectations for the Student Outcomes are as follows:

a. No average Student Outcome scores below 70%
b. Trend on Student Outcome should not be negative for 3 or more years
c. EBI survey scores should be within 0.1 of Carnegie 6 comparison class
d. EBI survey scores should not exhibit negative trend for 3 or more years

B.4. A summary of the achievement of Student Outcome scores is presented in this section. The 2011-2012 results will be available upon visit. (UC Riverside quarter ends third week of June, numbers to be compiled July 2012). An annual trend chart of the Student Outcome trends (1) – (16) are found in Figure 4-4.

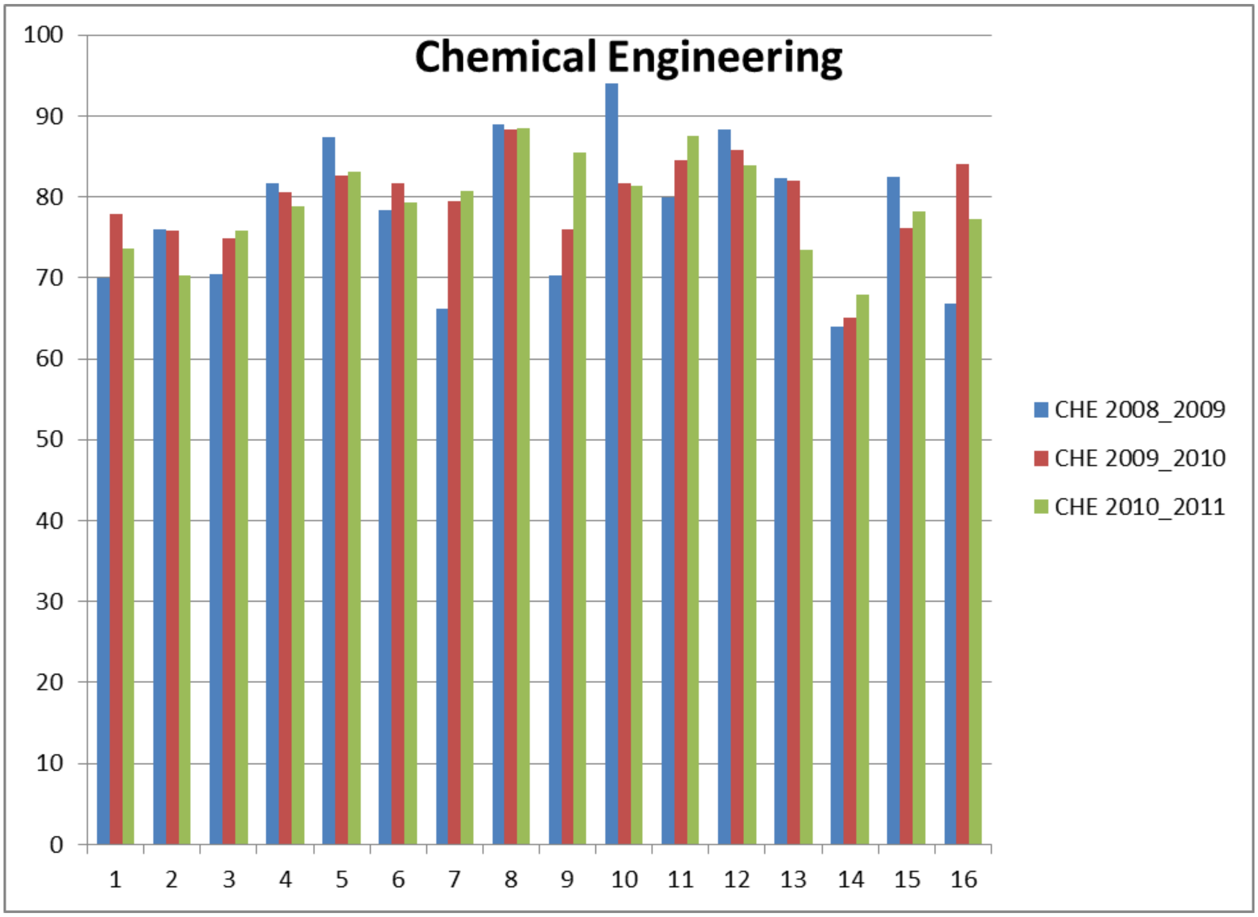


Figure 4-4: 2011 Student Outcome summary.

Generally, the Student Outcome scores currently exceed the threshold criteria of 70% with the exception of Student Outcome 14 (ABET Student Outcome (f))—the need to engage in lifelong learning. As a result, the primary focus for 2011-2012 was to maintain outcome scores for Student Outcomes 1-13, 15 and 16 and focus on improvement of Student Outcome 14 (ABET Student Outcome (f)) in the current academic year. The capstone senior design course (CHE 175AB) and the professional development course (CEE 158) were given primary responsibility for improving Student Outcome 14 performance, although all faculty have been asked to contribute wherever possible within their own courses. Furthermore, Student Outcome 2 has been put on "watch" with all faculty notified of the fact that the Student Outcome 2 score has slipped to near the 70% threshold. All courses have been asked to improve on this Student Outcome, with primary focus on the thermodynamic series (CHE 100/CEE 130) that resulted in the lower scores this past year.

The EBI survey results are summarized below. In general, the CHE students scored well above their comparative 6 institutions during the past year. Student Outcomes (d), (h) and (i) were identified as areas for improvement during the current year. These results surprised the ABET committee and faculty given the emphasis of the current degree program. For example, the ability to function on multidisciplinary teams (Student Outcome (d)) is an area where the student receive significant exposure given the multidisciplinary nature of the department. Many courses, including the capstone design course, merge CHE and ENVE students into single teams to work together to achieve the project goal. Furthermore, Student Outcome (d) (Student Outcome 8), was assessed as one of the highest Student Outcome achievements based on quantitative assessment with scores exceeding 85%. Discussions with senior students about this assessment indicated that the scores may reflect the difficulty encountered in working within individual groups of varying academic ability rather than difficulty in working across disciplines. This Student Outcome is continuing to be monitored with students engaging within ENVE/CHE 160A (lab), ENVE/CHE 175A (senior design), ENVE/CHE 175B (senior design), and many technical electives in multidisciplinary team settings. Outcome (h), the broad education necessary to understand the impact of engineering solutions in a global or societal context, has been sourced to CEE 158 and ENVE/CHE 175AB. It is noted that the Student Outcome scores from the classroom performance remain acceptable for this Student Outcome (Student Outcome 13). Student Outcome (i) has become a focal point (when combined with the quantitative Student Outcome scores for Student Outcome 14 (which maps to outcome (i)) for the current year to help improve the students engagement in lifelong learning through increases in the number of academic reports/current events that the students are expected to engage in throughout their curricula. All faculty have been informed of the need to engage students in activities related to Student Outcome (i).

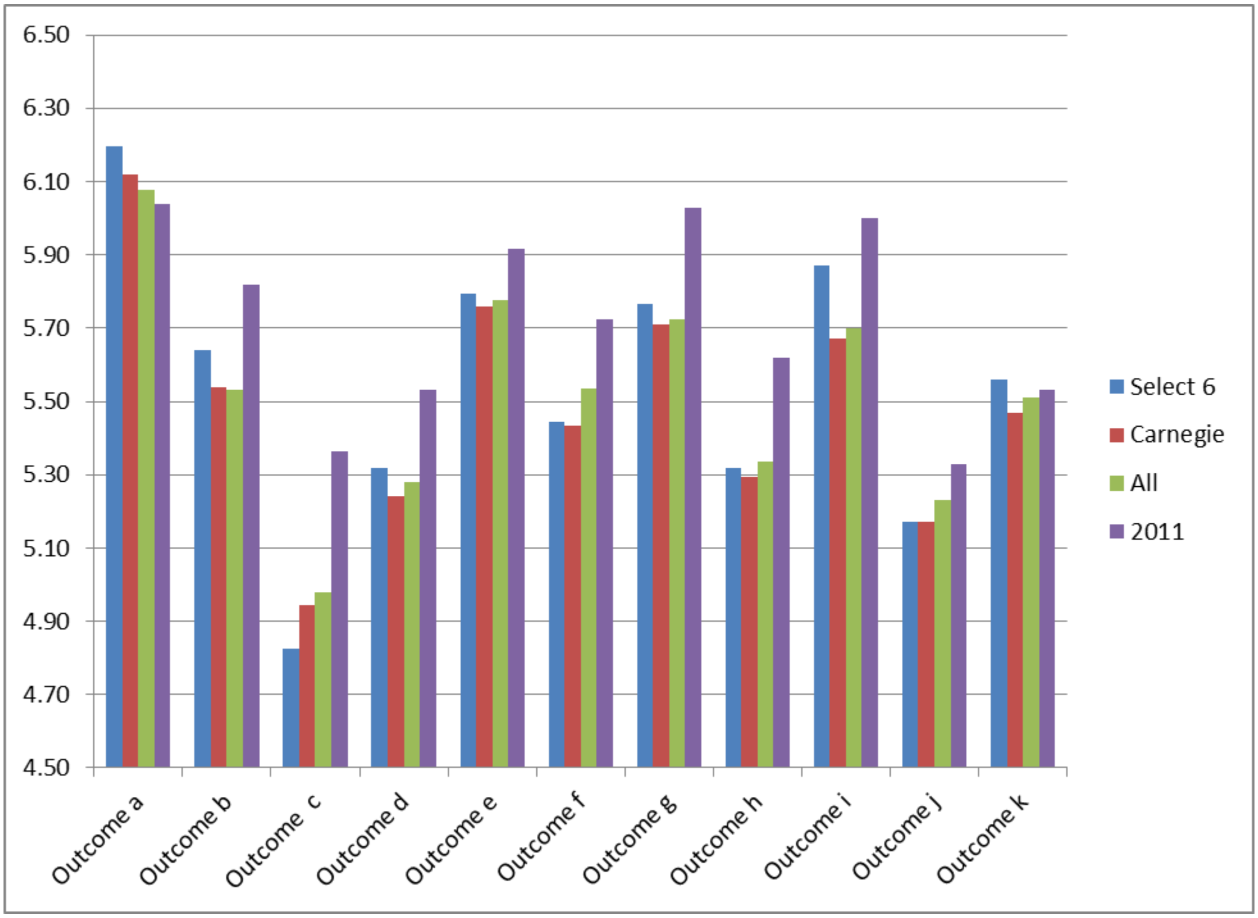


Figure 4-5: CHE 2011 EBI survey summary.

4. The results of the Student Outcome evaluation are kept in undergraduate/ABET meeting minutes and/or faculty meeting minutes. The summaries and all numerical values are kept on a secure ABET network folder.

C. Continuous Improvement

C.1. Overview of continuous improvement (see also 4.A.1. for loop). A number of review loops are used in the chemical engineering degree program for continuous improvement.

Course level: Each course instructor is required to, prior to the start of the class:

1. Perform a course pre-assessment, where the faculty member reviews the notes and evaluation (described below) of the class from the year prior. Any changes to the course as a result of the prior year's pre-assessment or based on departmental ABET needs are documented there (e.g., an increased emphasis on a course objective or an Student Outcome/PEO).
2. Evaluate and update course syllabus.
3. Evaluate and update course objectives—especially in light of student performances from the previous year or as a result of increased emphasis as cited by ABET needs (outcome/PEO).

At the end of the class, the students are surveyed to assess achievement of course objectives. These surveys are quickly returned to the instructor within two weeks of the end of the course to be used in a post-course evaluation form. In the post-evaluation course form, improvements/changes in the course are assessed for their effectiveness and suggested changes based on student grades and/or course surveys are suggested (see 4.B.3 above).

Program level: At the program level, the course Student Outcome (1-16) scores and EBI exit surveys linked to ABET Student Outcomes (a-k) are reviewed by the ABET/undergraduate committee and action items are suggested by the committee for the upcoming academic year to improve upon outcomes as specified by the committee. These changes may include:

1. Recommendation to faculty of specific courses to incorporate changes to improve attainment of course outcomes.
2. Recommendation to all faculty to emphasize various Student Outcomes.
3. Recommendation for major changes (course addition/removal) to reflect constituent needs.

All recommendations are then discussed at the departmental level and implemented by entire faculty.

C.2. Examples of continuous improvement-course level.

Case study 1: Student Outcome-based improvement

CEE 10 Introduction to chemical and environmental engineering:

Student Outcome 15 – a knowledge of contemporary issues

Quarter	Student Outcome Score (%)	Description of current or changes for improvement
Fall 2007	70	Invited speakers from Cal Department of Public Health & Nutrilite; added textbook, first time implementation
Fall 2008	82	Invited guest speakers from Nutrilite and the Riverside County Flood Control District; highlighted contemporary issues during lectures in each topical class
Fall 2009	86	Invited guest UCR faculty speakers; discussion of cutting-edge research; continued to highlight contemporary issues during lectures in each topical class
Fall 2010	88	Invited UCR faculty speaker and PE engineer; highlight contemporary issues
Fall 2011	82	Invited UCR faculty speaker; highlight contemporary issues

Note: having invited guest speaker and highlighting the contemporary issues during each topical lecture in energy, water issues, and biochemical engineering has made a significant impact in the outcome 15 (contemporary issues) score since Fall 2007.

Case study 2: Student Outcome-based improvement

CHE 175A / ENVE 175A (W08) and CHE 175B / ENVE 175B (S09): Chemical Process Design and Senior Design Project: Student Outcome 4 – an ability to design

Quarter	Student Outcome Score (%)	Description of current or changes for improvement
Winter 2008	66	Heat Exchange Network (HEN) design
Spring 2009	78	HEN design moved to Spring quarter to accommodate economics lectures to prepare student competition teams in time for deadlines of competitions. More thorough discussion during class.
Spring 2010	77	No further changes for HEN design
Spring 2011	77	No further changes for HEN design

*Case study 3: **Student** Outcome-based improvement*

CHE 175A / ENVE 175A (W08) and CHE 175B / ENVE 175B (S09): Chemical Process Design and Senior Design Project: Student Outcome 11 **–** an understanding of ethical responsibility

Quarter	Student Outcome Score (%)	Description
Spring 2008	65	Covered ethics topic over two classes (~2 h); included a few case studies
Spring 2009	66	No change was done to determine whether it was the ability of previous graduating senior class; still a 2 h lecture on ethics with a few case studies.
Spring 2010	70	Increased the ethics lecture to ~3 h lecture using some of the lab hour period to enable this and added more discussion of case studies
Spring 2011	69	Ethics lecture reduced to 2 h to accommodate the inclusion of additional transient software simulations (DYNSIM) during the lab period.

Case study 4: Continuing improvement for PEOs

In 2007, the PEOs were modified to better reflect program goals for alumni to achieve 3-5 years after graduation and reduce overlap with Student Outcomes. Therefore, the changes initiated were evaluated and approved by the CEE department faculty, BCOE executive committee and eventually the academic Senate. Feedback was obtained from alumni and employers in a 2008 survey that indicated (greater than 4 out 5) general agreement with PEOs. However, it became obvious by the next survey iteration that direct measurement of PEO achievement was difficult using the current survey; therefore, the survey was rewritten by the ABET committee to directly assess achievement of PEOs. Historical PEO changes are provided in Criterion 2.

Case study 5: Continuing improvement for PEOs

PEOs are reviewed annually by ABET committee and faculty, every other year by the Board of Advisors, and every three years by alumni/employers. In 2011, the Board of Advisors met for CEE and determined that achievement of PEOs was too difficult to measure and that the PEOs should be rewritten with measurable results. Therefore, the ABET committee was charged with modifying the PEOs resulting in the current version.

"*Graduates will attain high levels of technical expertise to enable their achievement in diverse chemical engineering practice and research, or in allied careers, prepare them for graduate level education, and enable them to be successful members of the professional community, for the benefit of our constituents.*"

The faculty met and approved the changes. The Board of Advisors, alumni, and employers were then provided the new PEOs to ensure buy-in from all constituents with options for "free-response" to allow for additional PEO improvements. Alumni, employers, and board members all provided extremely positive feedback on the new PEOs. Alumni and employers also indicated excellent achievement of the PEOs. They will continue to be reviewed annually with the newest set of graduates providing feedback in 2014 (as 3+ year alumni).

Case study 6: Continuing course improvements: ***CEE 158***

6-a) **CEE 158, Student Outcome 11, an understanding of ethical responsibility**

All courses undergo continued improvement. This example is for Student Outcome 11, an outcome that both CHE and ENVE students have exceeded 80% for all three years and therefore has no required ABET changes. Regardless, the professor notes in his course post-evaluation:

"*In 2010, one area with considerable enhancement was engineering ethics as a Professor of Ethics from the Religious Studies Department presented a lecture and discussion session from her perspective. In addition to ethical situations, the students were assigned into teams and at least two teams were presented with the same problem from the Journal of Professional Issues in Engineering Education and Practice. During discussion of the two approaches to handling the situation, the section gathered good student participation."*

6-b) **CEE 158, Student Outcome 14: A recognition of the need for, and an ability to engage in life-long learning**

Student Outcome 14 has been found to be a challenging outcome to achieve and is under perennial review as mandated by <70% outcome scores Chemical Engineering (ENVE ~75%). An increasing year-to-year trend has been seen for the last three years. CEE 158 is provided as a course used to improve overall achievement of outcomes although this course is not used for final outcome score calculation (therefore, not CEE 158 specific trend data for Student Outcome 14 is presented). Course modifications are summarized below:

- Until 2007 the course promoted the importance of lifelong learning through the introduction to and review of the FE/EIT engineering licensing exam.

- In 2007, modules were added to expand the focus of CEE 158 on Student Outcome 14 through the use of outside speakers that are Professional Engineers (PEs).. These speakers discuss the importance of the PE to career development. In addition, the roles of professional societies in the work place and in the continued education of alumni were discussed in lectures.

- Lastly, a large assignment was added to the course requiring students to interview an engineer from a related field. Through these interviews, many students hear first-hand encouragement, from active engineers, on the importance of life-time learning for career success.

- These additions received very positive feedback from the students and were continued in subsequent years, 2008, 2009, 2010, 2011.

- In 2010, another enhancement was the introduction of materials from the National Academy of Engineering for professional development and career planning; for example, Engineer 2020, Outsourcing Engineering and others. In the professional development area, we invited five speakers with a range of engineering experience, including two PhDs, two MS/PEs, and one BS. The students liked the discussion with engineers. Career development and planning with a career brochure from MIT lead to interesting discussions. Other professional topics were introduced by the instructor based on his experience, including, career paths and promotion; team work based on the McKinsey Studies; studies of influencing others and handling situational leadership.

- In 2012, a new instructor taught the course, but many of the core modules and approach towards promoting lifetime learning were continued. An additional module was added, where the instructor voice recorded interviews with 6 engineers working in various fields. In all interviews the engineers were asked what skills they are continuing to develop, and how this impacts their career success. This gave the students extra motivation to continue life-time learning, as every engineer interviewed stated that this was necessary for career success.

6-c) **CEE 158, Student Outcome 15: Knowledge of contemporary issues.**
To enhance the student's knowledge of contemporary issues, a module was added to the course in 2012. Specifically the students were required to read 8 technical perspectives on the future of biomass and solar energy for the production of transportation fuels and commodity chemicals. The students were required to write a 5 page, technical summary of the information in these articles and develop personal hypotheses (based solely on the facts presented in the provided materials) as to which emerging sustainable resources could play the biggest role in our economy in the near (5 to 15 years) and far (~50 years) future. This module provided the students a better understanding of current efforts to reduce reliance on fossil resources and the most feasible emerging solutions.

Numerous other documented improvements will be available in the course folders available at the time of the visit that document course level improvements (see pre- and post-assessments).

C.3. Significant potential upcoming changes (under discussion for 2013-2014):

CHE: Proposed changes in course ordering and Technical Electives (TEs) to reflect changing dynamics of major. Prerequisite and course ordering changes are being evaluated to ensure prerequisite structure and offering list is best suited for four-year and community college transfer students with special emphasis in redistribution of timing of TEs. The technical elective list for each option is undergoing a periodic review. No changes to core CHE curricula are foreseen in the near future.

D. Additional Information

Copies of the assessment instruments and materials referenced in 4.A, 4.B, or 4.C will be available for review at the time of the visit along with course folders that include ABET syllabus, course syllabus, lecture notes, student examples (homework, labs, reports, exams, etc.), pre- and post-evaluations, student survey scores, and Student Outcome assessments per class (used for overall Student Outcome evaluation) will be available along with applicable minutes from ABET committee meetings, faculty meetings, and Board of Advisors as well as survey outcomes for each constituent.

CRITERION 5. CURRICULUM

A. Program Curriculum

The following Tables provide the curriculum requirements for each option. UC Riverside operates on the quarter system.

Table 5-1a Curriculum

Chemical Engineering – Biochemical Engineering Option

Course (Department, Number, Title) List all courses in the program by term starting with first term of first year and ending with the last term of the final year.	Indicates Whether the Course is Required (R), Elective (E) or a Selected Elective (SE)..[1]	*Subject Area (Credit Hours)*				Last Two Terms the Course was Offered: Year and, Semester, or Quarter	Maximum Section Enrollment for the Last Two Terms the Course was Offered[2]
		Math & Basic Sciences	Engineering Topics Check if Contains Significant Design (√)	General Education	Other		
CEE 010 – Introduction to Chemical and Environmental Engineering	R		*2*(√)			*11F, 12W*	*58, 60*
CHEM 001A – General Chemistry	R	*4*				*11F, 12W*	*1141, 539*
CHEM 001LA – General Chemistry Lab	R	*1*				*11F, 12W*	*1105, 527*
ENGL 001A – Beginning Composition	R			*4*		*12W, 12S*	*918, 272*
MATH 009A – First Year Calculus	R	*4*				*12W, 12S*	*276, 110*
CHEM 001B – General Chemistry	R	*4*				*12W, 12S*	*979, 489*
CHEM 001LB – General Chemistry Lab	R	*1*				*12W, 12S*	*919, 455*
ENGL 001B – Intermediate Composition	R			*4*		*12W, 12S*	*1715, 1203*
MATH 009B - First Year Calculus	R	*4*				*12W, 12S*	*847, 567*
PHYS 040A – General Physics	R	*5*				*11F, 12W*	*284, 353*
CHEM 001C – General Chemistry	R	*4*				*11F, 12S*	*425, 829*

CHEM 001LC – General Chemistry Lab	R	*1*				*11F, 12S*	*406, 815*
ENGL 001C (or alt. writing course) – Applied Intermediate Composition	R			*4*		*12W, 12S*	*23, 1210*
MATH 009C - First Year Calculus	R	*4*				*12W, 12S*	*407, 417*
PHYS 040B – General Physics	R	*5*				*12W, 12S*	*261, 281*
CHEM 112A – Organic Chemistry	R	*4*				*11F, 12W*	*726, 518*
CHE 110A – Chemical Process Analysis	R		*3*			*11F, 10F*	*78, 43*
MATH 046 – Introduction to Ordinary Differential Equations	R	*4*				*12W, 12S*	*273, 278*
PHYS 040C – General Physics	R	*5*				*11F, 12S*	*289, 285*
BIO 005A – Introduction to Cell and Molecular Biology	R	*4*				*11F, 12W*	*793, 874*
BIO 005LA – Introduction to Cell and Molecular Biology Laboratory		*1*				*11F, 12W*	*773, 835*
CHEM 112B – Organic Chemistry	R	*4*				*12W, 12S*	*593, 520*
MATH 010A - Calculus of Several Variables	R	*4*				*12W, 12S*	*331, 277*
CHE 110B – Chemical Process Analysis	R		*3*			*11W, 12W*	*30, 60*
CHE 122 – Chemical Engineering Kinetics	R		*4*(√)			*11S, 12S*	*63, 52*
CHEM 112C – Organic Chemistry	R	*4*				*11F, 12S*	*267, 501*
MATH 010B – Calculus of Several Variables	R	*4*				*12W, 12S*	*195, 225*
CS010 – Introduction to Computer Science for Science, Mathematics, and Engineering or CS030 – Introduction to Computational Science	R	*4*				*12W, 12S* *11S, 12S*	*239, 210* *12, 16*
BCH 110A – General Biochemistry	R	*4*				*10F, 11F*	*257, 293*
CHE 114 – Applied Fluid Mechanics	R		*4*(√)			*10F, 11F*	*53, 100*
ENGR 118 – Engineering Modeling and Analysis	R		*5*(√)			*10F, 11F*	*45, 81*
BREADTH I	SE			*4*			
CEE 158 – Professional Development for Engineers	R		*3*			*11W, 12W*	*64, 77*
CHE 120 – Mass Transfer	R		*4*(√)			*11W, 12W*	*42, 73*
CHE 100 – Engineering Thermodynamics	R		*4*			*11W, 12W*	*55, 119*
BREADTH II	R			*4*			
ENVE/CHE 130 – Advanced Engineering Thermodynamics	R		*4*			*11S, 12S*	*50, 99*
ENVE/CHE 160A – Chemical and Environmental	R		*3*(√)			*11S, 12S*	*38, 30*

Engineering Lab							
CHE 116 – Heat Transfer	R		*4(√)*			*11S, 12S*	*38, 63*
BREADTH III	R			*4*			
BIOL/MCBL 121 – Microbiology	R	*4*				*12W, 12S*	*180, 119*
CHE 117 – Separation Processes	R		*4(√)*			*10F, 11F*	*26, 28*
CHE 160B – Chemical Engineering Lab	R		*3(√)*			*10F, 11F*	*23, 28*
CHE 124 – Biochemical Engineering Principles	R		*4*			*08F, 09F*	*11, 6*
CHE 118 – Process Dynamics and Control	R		*4(√)*			*11W, 12W*	*24, 30*
CHE 160C – Chemical Engineering Lab	R		*3(√)*			*11W, 12W*	*23, 29*
CHE/ENVE 175A – Senior Design Project	R		*4(√)*			*11W, 12W*	*12, 14*
BREADTH IV	SE			*4*			
CHE 124L – Biochemical Engineering Laboratory	R		*2*			*09W, 10S*	*3, 3*
CHE/ENVE 175B – Senior Design Project	R		*4(√)*			*11S, 12S*	*12, 14*
CEE 132 – Green Engineering	SE		*4*			*11S, 12S*	*12, 36*
CEE 135 - Chemistry of Materials			*4*			*10F, 11F*	*38, 47*
CHE 140 - Cell Engineering			*4*			*03S, 05S*	*2, 6*
CHE 150 – Biosensors			*4*			*02S, 04S,*	*4, 1*
CHE 171 – Pollution Control for Chemical Engineers			*4*			*01S, 03W*	*8, 5*
ENVE 121 - Biological Unit Processes			*4*			*11S, 12S*	*11, 13*
BREADTH V	SE			*4*			
BREADTH VI	SE			*4*			
Add rows as needed to show all courses in the curriculum.							
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		83	*75*	*36*			
OVERALL TOTAL CREDIT HOURS FOR COMPLETION OF THE PROGRAM	194						
PERCENT OF TOTAL		42.8%	*38.7%*	*18.6%*			
Total must satisfy either credit hours or percentage	Minimum Quarter Credit Hours	32 Hours	48 Hours				
	Minimum Percentage	25%	37.5 %				

Table 5-1b Curriculum

Chemical Engineering – Chemical Engineering Option

Course (Department, Number, Title) List all courses in the program by term starting with first term of first year and ending with the last term of the final year.	Indicates Whether the Course is Required (R), Elective (E) or a Selected Elective (SE).[1]	*Subject Area (Credit Hours)* Math & Basic Sciences	Engineering Topics Check if Contains Significant Design (√)	General Education	Other	Last Two Terms the Course was Offered: Year and, Semester, or Quarter	Maximum Section Enrollment for the Last Two Terms the Course was Offered[2]
CEE 010 – Introduction to Chemical and Environmental Engineering	R		*2*(√)			*11F, 12W*	*58, 60*
CHEM 001A – General Chemistry	R	*4*				*11F, 12W*	*1141, 539*
CHEM 001LA – General Chemistry Lab	R	*1*				*11F, 12W*	*1105, 527*
ENGL 001A – Beginning Composition	R			*4*		*12W, 12S*	*918, 272*
MATH 009A – First Year Calculus	R	*4*				*12W, 12S*	*276, 110*
CHEM 001B – General Chemistry	R	*4*				*12W, 12S*	*979, 489*
CHEM 001LB – General Chemistry Lab	R	*1*				*12W, 12S*	*919, 455*
ENGL 001B – Intermediate Composition	R			*4*		*12W, 12S*	*1715, 1203*
MATH 009B - First Year Calculus	R	*4*				*12W, 12S*	*847, 567*
PHYS 040A – General Physics	R	*5*				*11F, 12W*	*284, 353*
CHEM 001C – General Chemistry	R	*4*				*11F, 12S*	*425, 829*
CHEM 001LC – General Chemistry Lab	R	*1*				*11F, 12S*	*406, 815*
ENGL 001C (or alt. writing course) – Applied Intermediate Composition	R			*4*		*12W, 12S*	*23, 1210*
MATH 009C - First Year Calculus	R	*4*				*12W, 12S*	*407, 417*
PHYS 040B – General Physics	R	*5*				*12W, 12S*	*261, 281*

CHEM 112A – Organic Chemistry	R	*4*				*11F, 12W*	*726, 518*
CHE 110A – Chemical Process Analysis	R		*3*			*11F, 10F*	*78, 43*
MATH 046 – Introduction to Ordinary Differential Equations	R	*4*				*12W, 12S*	*273, 278*
PHYS 040C – General Physics	R	*5*				*11F, 12S*	*289, 285*
BREADTH I	R			*4*			
CHEM 112B – Organic Chemistry	R	*4*				*12W, 12S*	*593, 520*
MATH 010A - Calculus of Several Variables	R	*4*				*12W, 12S*	*331, 277*
CHE 110B – Chemical Process Analysis	R		*3*			*11W, 12W*	*30, 60*
CHE 122 – Chemical Engineering Kinetics	R		*4*(√)			*11S, 12S*	*63, 52*
CHEM 112C – Organic Chemistry	R	*4*				*11F, 12S*	*267, 501*
MATH 010B – Calculus of Several Variables	R	*4*				*12W, 12S*	*195, 225*
CS010 – Introduction to Computer Science for Science, Mathematics, and Engineering or CS030 – Introduction to Computational Science	R	*4*				*12W, 12S* *11S, 12S*	*239, 210* *12, 16*
BIO 005A – Introduction to Cell and Molecular Biology	R	*4*				*11F, 12W*	*793, 874*
BIO 005LA - Introduction to Cell and Molecular Biology Laboratory	R	*1*				*11F, 12W*	*773, 835*
CHE 114 – Applied Fluid Mechanics	R		*4*(√)			*10F, 11F*	*53, 100*
ENGR 118 – Engineering Modeling and Analysis	R		*5*(√)			*10F, 11F*	*45, 81*
BREADTH II	SE			*4*			
CEE 158 – Professional Development for Engineers	R		*3*			*11W, 12W*	*64, 77*
CHE 120 – Mass Transfer	R		*4*(√)			*11W, 12W*	*42, 73*
CHE 100 – Engineering Thermodynamics	R		*4*			*11W, 12W*	*55, 119*
CEE 125 – Analytical Methods for Chem. and Environ. Engineers	R		*4*			*11W, 12W*	*18, 56*
ENVE/CHE 130 – Advanced Engineering Thermodynamics	R		*4*			*11S, 12S*	*50, 99*
ENVE/CHE 160A – Chemical and Environmental Engineering Lab	R		*3*(√)			*11S, 12S*	*38, 30*
CHE 116 – Heat Transfer	R		*4*(√)			*11S, 12S*	*38, 63*
BREADTH III	R			*4*			
Technical Elective I	SE						

CEE 132 - Green Engineering			*4*			*11S, 12S*	*12, 36*
CEE 135 – Chemistry of Materials			*4*			*10F, 11F*	*38, 47*
CHE 102 - Catalytic Reaction Engineering			*4*			*10F, 11F*	*16, 17*
CHE 136 – Advanced Topics in Heat Transfer			*4*			*00F, 01F*	*3, 5*
CHE 171 – Pollution Control for Chemical Engineers			*4*			*01S, 03W*	*8, 5*
ENVE 120 – Unit Operations and Processes in Environ. Engineering			*4*			*10F, 11F*	*14, 16*
ENVE 133 – Fundamentals of Air Pollution Engineering			*4*			*11W, 12W*	*30, 55*
ENVE 134 – Technology of Air Pollution Control			*4*			*11S, 12S*	*7, 5*
ENVE 138 Combustion Engineering			*4*			*00W, 01W*	*17, 12*
CHE 117 – Separation Processes	R		*4*(√)			*10F, 11F*	*26, 28*
CHE 160B – Chemical Engineering Lab	R		*3*(√)			*10F, 11F*	*23, 28*
BREADTH IV	SE			*4*			
CHE 118 – Process Dynamics and Control	R		*4*(√)			*11W, 12W*	*24, 30*
CHE 160C – Chemical Engineering Lab	R		*3*(√)			*11W, 12W*	*23, 29*
CHE/ENVE 175A – Senior Design Project	R		*4*(√)			*11W, 12W*	*12, 14*
Technical Elective II (see Technical Elective I for list)	SE		*4*				
CHE/ENVE 175B – Senior Design Project	R		*4*(√)			*11S, 12S*	*12, 14*
Technical Elective III (see Technical Elective I for list)	SE		*4*				
BREADTH V	SE			*4*			
BREADTH VI	SE			*4*			
Add rows as needed to show all courses in the curriculum.							
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		75	*81*	*36*			
OVERALL TOTAL CREDIT HOURS FOR COMPLETION OF THE PROGRAM	192						
PERCENT OF TOTAL		39.1%	*42.2%*	*18.8%*			
Total must satisfy either credit hours or percentage	Minimum Quarter Credit Hours	32 Hours	48 Hours				
	Minimum Percentage	25%	37.5 %				

Table 5-1c Curriculum

Chemical Engineering – Nanotechnology Option

Course (Department, Number, Title) List all courses in the program by term starting with first term of first year and ending with the last term of the final year.	Indicates Whether the Course is Required (R), Elective (E) or a Selected Elective (SE).[1]	*Subject Area (Credit Hours)* Math & Basic Sciences	Engineering Topics Check if Contains Significant Design (√)	General Education	Other	Last Two Terms the Course was Offered: Year and, Semester, or Quarter	Maximum Section Enrollment for the Last Two Terms the Course was Offered[2]
CEE 010 – Introduction to Chemical and Environmental Engineering	R		*2*(√)			*11F, 12W*	*58, 60*
CHEM 001A – General Chemistry	R	*4*				*11F, 12W*	*1141, 539*
CHEM 001LA – General Chemistry Lab	R	*1*				*11F, 12W*	*1105, 527*
ENGL 001A – Beginning Composition	R			*4*		*12W, 12S*	*918, 272*
MATH 009A – First Year Calculus	R	*4*				*12W, 12S*	*276, 110*
CHEM 001B – General Chemistry	R	*4*				*12W, 12S*	*979, 489*
CHEM 001LB – General Chemistry Lab	R	*1*				*12W, 12S*	*919, 455*
ENGL 001B – Intermediate Composition	R			*4*		*12W, 12S*	*1715, 1203*
MATH 009B - First Year Calculus	R	*4*				*12W, 12S*	*847, 567*
PHYS 040A – General Physics	R	*5*				*11F, 12W*	*284, 353*
CHEM 001C – General Chemistry	R	*4*				*11F, 12S*	*425, 829*
CHEM 001LC – General Chemistry Lab	R	*1*				*11F, 12S*	*406, 815*
ENGL 001C (or alt. writing course) – Applied Intermediate Composition	R			*4*		*12W, 12S*	*23, 1210*
MATH 009C - First Year Calculus	R	*4*				*12W, 12S*	*407, 417*
PHYS 040B – General Physics	R	*5*				*12W, 12S*	*261, 281*
CHEM 112A – Organic Chemistry	R	*4*				*11F, 12W*	*726, 518*

CHE 110A – Chemical Process Analysis	R		*3*			*11F, 10F*	*78, 43*
MATH 046 – Introduction to Ordinary Differential Equations	R	*4*				*12W, 12S*	*273, 278*
PHYS 040C – General Physics	R	*5*				*11F, 12S*	*289, 285*
BREADTH I	R			*4*			
CHEM 112B – Organic Chemistry	R	*4*				*12W, 12S*	*593, 520*
MATH 010A - Calculus of Several Variables	R	*4*				*12W, 12S*	*331, 277*
CHE 110B – Chemical Process Analysis	R		*3*			*11W, 12W*	*30, 60*
CHE 122 – Chemical Engineering Kinetics	R		*4*(√)			*11S, 12S*	*63, 52*
CHEM 112C – Organic Chemistry	R	*4*				*11F, 12S*	*267, 501*
MATH 010B – Calculus of Several Variables	R	*4*				*12W, 12S*	*195, 225*
CS010 – Introduction to Computer Science for Science, Mathematics, and Engineering or CS030 – Introduction to Computational Science	R	*4*				*12W, 12S* *11S, 12S*	*239, 210* *12, 16*
BIO 005A – Introduction to Cell and Molecular Biology	R	*4*				*11F, 12W*	*793, 874*
BIO 005LA - Introduction to Cell and Molecular Biology Laboratory	R	*1*				*11F, 12W*	*773, 835*
CHE 114 – Applied Fluid Mechanics	R		*4*(√)			*10F, 11F*	*53, 100*
ENGR 118 – Engineering Modeling and Analysis	R		*5*(√)			*10F, 11F*	*45, 81*
CEE 135 – Chemistry of Materials	R		*4*			*10F, 11F*	*38, 47*
CEE 158 – Professional Development for Engineers	R		*3*			*11W, 12W*	*64, 77*
CHE 120 – Mass Transfer	R		*4*(√)			*11W, 12W*	*42, 73*
CHE 100 – Engineering Thermodynamics	R		*4*			*11W, 12W*	*55, 119*
CHE 105 – Introduction to Nanoscale Engineering	R		*4*			*11W, 12W*	*32, 22*
ENVE/CHE 130 – Advanced Engineering Thermodynamics	R		*4*			*11S, 12S*	*50, 99*
ENVE/CHE 160A – Chemical and Environmental Engineering Lab	R		*3*(√)			*11S, 12S*	*38, 30*
CHE 116 – Heat Transfer	R		*4*(√)			*11S, 12S*	*38, 63*
BREADTH II	R			*4*			
Technical Elective I CEE 132 - Green Engineering CEE 135 – Chemistry of Materials	SE		 *4* *4*			 *11S, 12S* *10F, 11F*	 *12, 36* *38, 47*

CHE 102 - Catalytic Reaction Engineering			*4*			*10F, 11F*	*16, 17*
CHE 136 – Advanced Topics in Heat Transfer			*4*			*00F, 01F*	*3, 5*
CHE 171 – Pollution Control for Chemical Engineers			*4*			*01S, 03W*	*8, 5*
ENVE 120 – Unit Operations and Processes in Environ. Engineering			*4*			*10F, 11F*	*14, 16*
ENVE 133 – Fundamentals of Air Pollution Engineering			*4*			*11W, 12W*	*30, 55*
ENVE 134 – Technology of Air Pollution Control			*4*			*11S, 12S*	*7, 5*
ENVE 138 Combustion Engineering			*4*			*00W, 01W*	*17, 12*
CHE 117 – Separation Processes	R		*4*(√)			*10F, 11F*	*26, 28*
CHE 160B – Chemical Engineering Lab	R		*3*(√)			*10F, 11F*	*23, 28*
BREADTH III	SE			*4*			
BREADTH IV	SE			*4*			
CHE 118 – Process Dynamics and Control	R		*4*(√)			*11W, 12W*	*24, 30*
CHE 160C – Chemical Engineering Lab	R		*3*(√)			*11W, 12W*	*23, 29*
CHE/ENVE 175A – Senior Design Project	R		*4*(√)			*11W, 12W*	*12, 14*
BREADTH V	SE			*4*			
CHE/ENVE 175B – Senior Design Project	R		*4*(√)			*11S, 12S*	*12, 14*
Technical Elective III (see Technical Elective I for list)	SE		*4*				
CHE 161 – Nanotechnology Processing Laboratory	R		*4*			*11S, 12S*	*16, 22*
BREADTH VI	SE			*4*			
Add rows as needed to show all courses in the curriculum.							
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		75	*85*	*36*			
OVERALL TOTAL CREDIT HOURS FOR COMPLETION OF THE PROGRAM	196						
PERCENT OF TOTAL		38.3%	*43.4%*	*18.4%*			
Total must satisfy either credit hours or percentage	Minimum Quarter Credit Hours	32 Hours	48 Hours				
	Minimum Percentage	25%	37.5 %				

Table 5-1d Curriculum

Chemical Engineering – Bioengineering Option (cancelled Summer, 2011)

Course (Department, Number, Title) List all courses in the program by term starting with first term of first year and ending with the last term of the final year.	Indicates Whether the Course is Required (R), Elective (E) or a Selected Elective (SE).[1]	*Subject Area (Credit Hours)* Math & Basic Sciences	Engineering Topics Check if Contains Significant Design (√)	General Education	Other	Last Two Terms the Course was Offered: Year and, Semester, or Quarter	Maximum Section Enrollment for the Last Two Terms the Course was Offered[2]
CEE 010 – Introduction to Chemical and Environmental Engineering	R		*2*(√)			*11F, 12W*	*58, 60*
CHEM 001A – General Chemistry	R	*4*				*11F, 12W*	*1141, 539*
CHEM 001LA – General Chemistry Lab	R	*1*				*11F, 12W*	*1105, 527*
ENGL 001A – Beginning Composition	R			*4*		*12W, 12S*	*918, 272*
MATH 009A – First Year Calculus	R	*4*				*12W, 12S*	*276, 110*
CHEM 001B – General Chemistry	R	*4*				*12W, 12S*	*979, 489*
CHEM 001LB – General Chemistry Lab	R	*1*				*12W, 12S*	*919, 455*
ENGL 001B – Intermediate Composition	R			*4*		*12W, 12S*	*1715, 1203*
MATH 009B - First Year Calculus	R	*4*				*12W, 12S*	*847, 567*
PHYS 040A – General Physics	R	*5*				*11F, 12W*	*284, 353*
CHEM 001C – General Chemistry	R	*4*				*11F, 12S*	*425, 829*
CHEM 001LC – General Chemistry Lab	R	*1*				*11F, 12S*	*406, 815*
ENGL 001C (or alt. writing course) – Applied Intermediate Composition	R			*4*		*12W, 12S*	*23, 1210*
MATH 009C - First Year Calculus	R	*4*				*12W, 12S*	*407, 417*
PHYS 040B – General Physics	R	*5*				*12W, 12S*	*261, 281*
CHEM 112A – Organic Chemistry	R	*4*				*11F, 12W*	*726, 518*
CHE 110A – Chemical Process Analysis	R		*3*			*11F, 10F*	*78, 43*

MATH 046 – Introduction to Ordinary Differential Equations	R	*4*				*12W, 12S*	*273, 278*
PHYS 040C – General Physics	R	*5*				*11F, 12S*	*289, 285*
BIO 005A – Introduction to Cell and Molecular Biology	R	*4*				*11F, 12W*	*793, 874*
BIO 005LA – Introduction to Cell and Molecular Biology Laboratory		*1*				*11F, 12W*	*773, 835*
CHEM 112B – Organic Chemistry	R	*4*				*12W, 12S*	*593, 520*
MATH 010A - Calculus of Several Variables	R	*4*				*12W, 12S*	*331, 277*
CHE 110B – Chemical Process Analysis	R		*3*			*11W, 12W*	*30, 60*
BIO 005B – Organismal Biology	R	*4*				*12W, 12S*	*576, 676*
CHEM 112C – Organic Chemistry	R	*4*				*11F, 12S*	*267, 501*
MATH 010B – Calculus of Several Variables	R	*4*				*12W, 12S*	*195, 225*
CS010 – Introduction to Computer Science for Science, Mathematics, and Engineering or CS030 – Introduction to Computational Science	R	*4*				*12W, 12S* *11S, 12S*	*239, 210* *12, 16*
BCH 110A – General Biochemistry	R	*4*				*10F, 11F*	*257, 293*
CHE 114 – Applied Fluid Mechanics	R		*4*(√)			*10F, 11F*	*53, 100*
ENGR 118 – Engineering Modeling and Analysis	R		*5*(√)			*10F, 11F*	*45, 81*
BIO 005C – Evolution and Ecology	R	*4*				*11F, 12S*	*546, 476*
CEE 158 – Professional Development for Engineers	R		*3*			*11W, 12W*	*64, 77*
CHE 120 – Mass Transfer	R		*4*(√)			*11W, 12W*	*42, 73*
CHE 100 – Engineering Thermodynamics	R		*4*			*11W, 12W*	*55, 119*
BCH 110B – General Biochemistry	R	*4*				*11W, 12W*	*173, 210*
ENVE/CHE 130 – Advanced Engineering Thermodynamics	R		*4*			*11S, 12S*	*50, 99*
ENVE/CHE 160A – Chemical and Environmental Engineering Lab	R		*3*(√)			*11S, 12S*	*38, 30*
CHE 116 – Heat Transfer	R		*4*(√)			*11S, 12S*	*38, 63*
CHE 122 – Chemical Engineering Kinetics	R		*4*(√)			*11S, 12S*	*63, 52*
CHE 117 – Separation Processes	R		*4*(√)			*10F, 11F*	*26, 28*
CHE 160B – Chemical Engineering Lab	R		*3*(√)			*10F, 11F*	*23, 28*
BIEN/CEE 140A - Biomaterials	SE		*4*			*11S, 12W*	*44, 49*
BIEN/CEE 140B - Biomaterials	SE		*4*			*10F, 11F*	*21, 26*

BIEN/CEE 159 - Dynamics of Biological Systems	SE		*4*			*10F, 11F*	*39, 46*
CEE 147 - Bio-Microelectromechanical Systems	SE		*4*				
CHE 124 - Biochemical Engineering Principles	SE		*4*			*08F, 09F*	*11, 6*
CHE 140 - Cell Engineering	SE		*4*			*03S, 05S*	*2, 6*
CHE 150 - Biosensors	SE		*4*			*02S, 04S,*	*4, 1*
BREADTH I	SE			*4*			
BREADTH II	SE			*4*			
CHE 118 – Process Dynamics and Control	R		*4*(√)			*11W, 12W*	*24, 30*
CHE 160C – Chemical Engineering Lab	R		*3*(√)			*11W, 12W*	*23, 29*
CHE/ENVE 175A – Senior Design Project	R		*4*(√)			*11W, 12W*	*12, 14*
BREADTH III	SE			*4*			
BREADTH IV	SE			*4*			
CHE 124L – Biochemical Engineering Laboratory	R		*2*			*09W, 10S*	*3, 3*
CHE/ENVE 175B – Senior Design Project	R		*4*(√)			*11S, 12S*	*12, 14*
BIEN/CEE 140A - Biomaterials	SE		*4*			*11S, 12W*	*44, 49*
BIEN/CEE 140B - Biomaterials	SE		*4*			*10F, 11F*	*21, 26*
BIEN/CEE 159 - Dynamics of Biological Systems	SE		*4*			*10F, 11F*	*39, 46*
BIO 107A – Molecular Biology	SE	*4*				*12W, 12S*	*120, 116*
BIO 107B – Advanced Molecular Biology	SE	*3*				*11S, 12S*	*32, 24*
BIO 115 – Human Genetics	SE	*3*				*02S, 03S*	*45, 63*
BIO/MCBL 121 – Introductory Microbiology	SE	*4*				*12W, 12S*	*119, 180*
BIO/CBNS 128 - Immunology	SE	*4*				*11S, 12S*	*131, 133*
CEE 147 - Bio-Microelectromechanical Systems	SE		*4*				
CHE 124 - Biochemical Engineering Principles	SE		*4*			*08F, 09F*	*11, 6*
CHE 140 - Cell Engineering	SE		*4*			*03S, 05S*	*2, 6*
CHE 150 – Biosensors	SE		*4*			*02S, 04S,*	*4, 1*
BREADTH V	SE			*4*			
BREADTH VI	SE			*4*			
Add rows as needed to show all courses in the curriculum.							
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		83	*75*	*36*			
OVERALL TOTAL CREDIT HOURS FOR COMPLETION OF THE	194						

PROGRAM							
PERCENT OF TOTAL		42.8%	*38.7%*	*18.6%*			
Total must satisfy either credit hours or percentage	Minimum Quarter Credit Hours	32 Hours	48 Hours				
	Minimum Percentage	25%	37.5 %				

5.2. Curriculum Alignment with PEOs

The relationship between our Program Educational Objective, "*Graduates will attain high levels of technical expertise to enable their achievement in diverse chemical/environmental engineering practice and research or in allied careers, prepare them for graduate level education, and enable them to be successful members of the professional community, for the benefit of our constituents,*" and the curricula is discussed in some detail below.

A detailed curriculum is presented in Tables 5-1a-d. The Chemical Engineering PEOs presented earlier in this section are broadly met through a curriculum that offers:

1. A well-rounded and balanced education achieved through required studies in selected areas of the Humanities and Social Sciences.
2. Strong training in the areas of mathematics, science, and the fundamentals of chemical engineering that constitute the foundation of the discipline.
3. Extensive laboratory and hands-on experience to strengthen understanding of fundamental principles, with opportunities for team work, written, and oral communication.
4. Use of computer simulation and modeling in problem solving and in design.
5. Application of knowledge to design problems common to modern chemical engineering practice.
6. Introduction of design for manufacturability, engineering economics, and engineering ethics into the curriculum to emphasize the relationship between design, fabrication, cost, and impact on society.
7. Freedom for the student to mold his or her program of professional specialty studies by allowing each student to choose between four (now three*) options (traditional chemical engineering, nanotechnology, biochemical engineering; *bioengineering option cancelled, Summer, 2011), and also choose from a number of technical electives, including credit for independent research, and offering a selection of senior design capstone projects sponsored by faculty and relevant to industrial sponsors.

The relationship between each PEO and the curriculum is discussed in some detail below. The curriculum is closely tied to the departmental PEOs. This link was described earlier in Criterion 2 and is described in more detail in section 5-3. However, there are specific aspects of the PEO that are linked to our curricula. These aspects include (i) affording students the opportunity to be successful in diverse chemical engineering practices and allied careers by achieving a high level of technical expertise, (ii) preparing them for graduate-level education, and (iii) enabling them to be successful members of the professional community, thus benefitting our constituents.

We prepare these students to meet all aspects of our PEOs by exposing them to a well-balanced curricula that includes (i) Mathematics and Basic Sciences and (ii) Engineering Sciences, to prepare students to have a strong technical basis for either industrial or academic (e.g., through graduate education) careers in multidisciplinary fields; (iii) Hands-on Laboratory Exposure; (iv) Design, which enables our students to excel in research and application-driven careers; and (v)

General education, to broaden their views of our world and prepare them to be well rounded individuals that can interact with the professional community, including non-engineers.

Specifically for Math and Basic Sciences, our chemical engineering curriculum is built on a foundation of courses in mathematics and the basic sciences, which are taken in the first two years at the University. The basic sciences and mathematics courses that were selected emphasize concepts and principles. Students acquire a strong grounding in Physics through PHYS 40A, 40B, and 40C. Each of these courses includes an extensive laboratory component. At the same time, students take a variety of basic sciences courses or introductory engineering courses that will provide them with the breath necessary to solve multidisciplinary problems. These include programming (CS 10) and biology (BIO 5A), for all students.

The chemical engineering curriculum is also based on solid grounds of chemistry. General chemistry education starts with the CHEM 1A, 1B, and 1C series, which include laboratories. The students then acquire theoretical and laboratory experience in organic chemistry (CHEM 112A, 112B, 112C) which are the same courses taken by chemistry majors.

During the first two years, students take five courses in mathematics that cover multivariable differential and integral calculus. These courses, MATH 9A, 9B, 9C, and 10A and 10B, are followed by a course in ordinary differential equations, MATH 46. The basic mathematics knowledge will be later complemented with engineering mathematics and statistics in ENGR 118.

For the majority of engineering topics, courses are taken after the student has acquired the necessary foundation in mathematics and the basic sciences. Several courses help students to become proficient in computer programming and the use of computer software. The computer knowledge acquired in CEE 10/11 (taken as freshman) and CS 10 (Introduction to Computer Science) is later reinforced in ENGR 118 (Engineering Modeling and Analysis), where students formulate computer models for engineering systems. Most courses taught in the junior and the senior year incorporate computer based problems and projects.

Engineering topics taken either in the sophomore or in the junior year introduce students to the fundamentals of chemical engineering. Our curriculum incorporates solid foundations in transport phenomena, thermodynamics and breadth and depth in unit operations, kinetics, and process control. The chemical engineering curriculum emphasizes principles; however, each course trains the students to carry the concepts forward towards creative applications. In the fall and winter of the sophomore year (junior year for transfer), students learn basic mass and energy balances in CHE 110A and CHE 110B (Chemical Process Analysis), before learning chemical engineering kinetics (CHE 122). The curriculum then focuses on Thermodynamics (CHE 100, CHE/ENVE 130), Transport Phenomena (CHE 114 Applied Fluid Mechanics, CHE 120 Mass Transfer, CHE 116 Heat Transfer), and selected option specific engineering courses. In the fall quarter of the junior year, students take ENGR 118, a five-unit course, which teaches engineering numerical methods, formulation of engineering models and their solutions through the numerical methods.

Advanced engineering topics taken by seniors include applications of transport phenomena in Separation Processes (CHE 117), which include computer aided process design using professional software (SuperPro Designer), and Process Control (CHE 118), which uses MATLAB. In addition, the curriculum allows the student to mold his or her program of professional specialty studies by allowing each student to choose from a number of technical electives. Examples of these electives include Catalysis (CHE 102), Analytical Methods for Chemical and Environmental Engineers (CEE 125), Chemistry of Materials (CEE 135), Technology of Air Pollution Control (ENVE 134), and Green Engineering (CEE 132), Introduction to Nanotechnology (CHE 105), and Nanoscale Processing Laboratory (CHE 161) for the chemical and nanotechnology engineering option; Biochemical Engineering Principles (CHE 124) and Laboratory (CHE 124L), Cell Engineering (CHE 140) and Biosensors (CHE 150) for the biochemical engineering option; Biosensors (CHE 150), Biochemical Engineering Principles (CHE 124) and a variety of upper division biology for the students following the bioengineering option.

In the junior year, CEE 158, Professional Development for Engineers, exposes students to career paths; interview strategies; professional registration and preparation for certification examinations; ethics; risk management and environmental health and safety; regulatory issues; and lifelong learning. This course aims to enable engineering students to make educated decisions regarding their career paths and to pinpoint and develop the necessary skills for success in a wide range of professions. Possible career paths for engineers will be explored with specific emphasis on the skills necessary for success after graduating from UCR. In addition, topics relevant to current events and practice of engineering in a global environment will be covered through readings from journals, periodicals and news sources.

For laboratory experiences, students are exposed in both laboratory classes as well as individual research in faculty labs. The broad objectives of all laboratory classes are to reinforce concepts learned in lectures, provide hands-on experience in collecting data and operating engineering systems, challenge students in planning and conducting experiments, working in a team, practice and improve technical writing and oral skills. The laboratory courses are based on the idea that students are in the best position to appreciate engineering experiments only when they have familiarity with the underlying theoretical principles. Thus, the first engineering laboratory course, CHE 160A (Chemical Engineering Laboratory I), is offered in the Spring quarter of the junior year. This course is designed to train students in basic measurement techniques, and their application to fluid mechanics and mass transfer systems. Students perform seven out of the ten available lab exercises on a rotating basis. CHE 160A is followed by CHE 160B and CHE 160C (Chemical Engineering Laboratory II and III), which are offered in the fall and the winter of the senior year, CHE 160B and 160C work on a similar principle as CHE 160A. CHE 160B focuses on kinetics, reactor design, and heat transfer. Students further practice physical measurements, experimental design, critical analysis of results, and preparation of engineering reports. Experimental design, critical analysis of results, and preparation of engineering reports are emphasized. When applicable, students are asked to compare their results with previously published ones, or to use their experimental data to size a unit operation, or conduct an engineering design exercise. Students are then challenged with an open ended experimental design to apply their knowledge of kinetics and heat transfer parameter analysis to real world systems. CHE 160C deals with laboratory exercises in separation processes and in process control. Students are required to use their experimental data for scale-up purposes or for an application in engineering design. Open-ended labs are included to challenge students with contemporary issues such as to design environment-benign and energy-saving separation processes.

Additional laboratory experience is acquired in CHE 124L (Biochemical Engineering Laboratory) for students following the biochemical engineering option, Analytical Methods for Chemical and Environmental Engineers (CEE 125) laboratories for students following the chemical engineering option, Nanoscale Processing Laboratory (CHE 161) for students following the nanotechnology option, and advanced biology for students following the bioengineering option. Selected additional technical electives include a lab section as well.

For a majority of students, the senior design project (CHE 175A and 175B) offers another opportunity to perform experimental work. In many cases, the design project requires either to verify an assumption, to determine the property of a complex mixture, or to construct a model system or a prototype for a proof of concept. The department and the faculty have been very supportive in terms of funding such laboratory work and the necessary resources have been made available. The process usually starts with the students analyzing their needs for laboratory work. Students will then go through a decision making process for the selection of the materials, for the determination of the best experimental design, and for the development of the experimental protocol. Usually some device, equipment, or a pilot plant/reactor will be constructed. All the steps challenge the creativity of the students and stimulate their analytical skills. This is usually a very enjoyable process for the students, which contributes greatly to their overall education experience.

Further laboratory experience is often acquired by our students while conducting research with our faculty, either extracurricular activity (summer internship, or part-time research assistantships during the academic year) or for course credit through CHE 190 Special Studies. This provides one more opportunity to acquire advanced laboratory skills in emerging research areas.

For the Design aspects of Chemical Engineering, many of our courses, including laboratory courses, incorporate design, which addresses real-world problems whose solution requires creativity and consideration of alternatives to achieve stated objectives. Most students are introduced to the concept of design in their freshman, sophomore or junior year through individual design projects in which students are asked to design a system or a component that satisfies specified constraints.

Examples of courses that have a specific design project include, but are not limited to, Applied Fluid Mechanics (CHE 114), Heat Transfer (CHE 116), Mass Transfer (CHE 120), Engineering Modeling and Analysis (ENGR 118), Separation Processes (CHE 117), and Process Control (CHE 118). Specific design projects are based on material covered in the course. The design usually includes the following components: a) converting the design problem into quantifiable statements, b) formulating the equations that govern the design, c) developing assumptions necessary for solving the problem, and collecting the necessary information from vendors, books, publications, etc., d) selecting a method for solving the design problem and solving the design problem (analytically, numerically, sometimes iteratively), e) critically reviewing the design and optimizing the design including ethical concerns and operation and maintenance considerations, and f) writing a summary report, and in selected cases presenting results in front of the class.

These individual design projects prepare the students for the capstone design project, a two-quarter capstone design course, CHE 175A and 175B, in which students draw upon various aspects of their previous engineering science and design knowledge to address a meaningful design problem. Students learn to define the objectives (in a global context), explore the possible options, plan and conduct experiments if needed, formulate preliminary solutions, and evaluate the proposed alternatives with respect to economics, feasibility, societal, health and safety impacts, and sustainability. This approach may require a number of iterations before a final comparative solution is achieved. Senior design projects are always team projects (usually three to five students). Chemical and environmental engineering students are encouraged to form mixed groups to promote diversity and a multidisciplinary approach. CHE 175A and 175B is run in a very professional manner. Each team maintains a chronological log of all project work (to demonstrate the evolution of their design), submits timesheets and bimonthly reports consisting of 5-10 minute oral presentations (similar to an internal review in a consulting firm) and a 1-2 page technical memo.

Bimonthly oral presentations as well as an end-of-first-quarter team oral presentation (15-20 min) are critiqued to provide feedback for developing effective communication skills. The first quarter (CHE 175A) focuses on project (concept) analysis, preliminary evaluation (economical and technical), data and literature collection, preliminary process design and evaluation, and becoming functional in simulation software packages such as PROII and SuperPro for modeling of an entire process or treatment plant. The first quarter also includes risk analysis, occupational health and safety of treatment systems, environmental regulations and ethical concerns, sustainability concepts and operation and maintenance considerations.

The second quarter (CHE 175B) of the capstone design course focuses on the detailed engineering design of the process (equipment sizing and specification, etc.), comprehensive profitability evaluation and process optimization, in addition to ethics issues in the profession. In some cases, students build a prototype of their design concepts and prove the concept by laboratory experiments and obtain the kinetics of a treatment system required for scaling up to a full-scale system using simulation software to model steady state processes.

Students also learn to use other simulators such as DYNSIM, which provide transient responses related to startup, modifications, or shut down of their environmental treatment systems. Students are provided with the skills for conducting group meetings, and brainstorming in an ethical and professional manner. Monitoring and assessment of ethical and professional conduct are done with written and confidential self-group assessments, which are provided to the instructor and done twice each quarter. This provides students with a means to learn to work productively in teams by addressing professional and personality issues that may arise throughout the capstone design course (much like conflicts which may arise in a real world setting). The course concludes with a formal oral presentation (30-40 min), which is evaluated by the faculty and a comprehensive written technical report.

Finally, our students should be balanced. A major goal of engineering is to contribute to the welfare of society. This contribution is best made when students have a broad understanding of the Humanities and the Social Sciences (HMNSS). This understanding is derived from the study of world history; political and economic systems; the ethnic, cultural, and religious diversity of the peoples of the earth; the arts and letters of all cultures; the social and natural sciences; and technology. Although not a formal part of the required HMNSS course of study for engineering majors, this understanding is strengthened by a stringent requirement in written communication (ENGL 1A, 1B, 1C). The requirements in the Humanities consist of a minimum of three courses: one course in World History; one from Fine Arts, Literature, Philosophy, or Religious Studies; and one additional Humanities course. Breadth requirements in the Social Sciences are similarly structured: one course from either Economics or Political Science; one course from Anthropology, Psychology, or Sociology; and one additional Social Science course.

In addition, the campus breadth requirement in Ethnic Studies has the option of being incorporated into the above, or standing alone as an additional course. For depth, at least two Humanities or Social Science courses must be completed at the upper-division level and, at least two courses must be from the same subject area (for example, two courses in History), with at least one of them being an upper-division course.

5.3. How the curriculum and its associated prerequisite structure support the attainment of the Student Outcomes

Student Outcomes are achieved throughout the Chemical/Environmental Engineering curricula. Table 5-2 shows how Student Outcomes are quantitatively assessed throughout the core Chemical Engineering curricula. The sum of these courses working on specific Student Outcomes provides thorough coverage of all 16 Student Outcomes.

Table 5-2: Course-Student Outcome relationship.

	Outcomes															
Courses	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
		a			**b**		**c**	**d**	**e**	**f**		**g**	**h**	**i**	**j**	**k**
CEE 10/11				x						x	x				x	x
CEE 130		x				x			x							x
CEE 158										x	x	x		x	x	
CHE 100		x	x	x					x				x		x	
CHE 114	x		x	x		x	x		X				x			
CHE 116	x	x		x					X							x
CHE 120	x		x				x						x	x		
CHE/ENVE 160A					x	x		x			x	x		x		
CHE/ENVE 175A			x	x	x		x	x		x		x		x	x	
CHE/ENVE 175B			x	x		x	x			x	x	x		x		
CHE 160B				x	x	x		x		x		x		x	x	
CHE110A		x				x			X							x
CHE110B			x			x	x		X				x			x
CHE117	x	x	x			x	x								x	x
CHE118	x		x	x		x	x									
CHE122	x	x		x			x		X							
CHE160C				x	x	x		x				x		x	x	
ENGR 118	x					x			X							x

Listed on page 2 of each course syllabus (Appendix A) for all ENGR, CHE, CEE, and ENVE numbered required/SE courses are the topics covered in each course and the Student Outcomes that are often achieved many times through each course specific objective. As can be seen from the syllabi, each Student Outcome is covered multiple times throughout the engineering curricula. Shown in Table 5-2, the core curricula as outlined in prerequisite tree Figures 5-1a-d achieves Student Outcomes through the following matrix.

Student Outcome 1: An ability to apply mathematics
The core coverage of mathematics is in the required math series: Math 9A-9B-9C (first-year calculus); Math10A-10B (multivariable calculus); Math 46 (ordinary differential equations); and ENGR 118 (numerical analysis for engineers). The specific achievement of the Student Outcome is measured by courses throughout the engineering program including CHE 114 (applied fluid mechanics), CHE 116 (heat transfer), CHE 120 (mass transfer), CHE 118 (dynamics and process control), CHE 122 (kinetics), and ENGR 118 (numerical methods for chemical and environmental engineering). Additional mathematics, specific to engineering courses, are also covered as needed. Clearly the application of mathematics to engineering solutions is covered in all courses within CHE.

Student Outcome 2: An ability to apply knowledge of science
Core coverage of science is achieved through the required chemistry series, CHEM 1A-1B-1C (general chemistry) and CHEM 112A-112B-112C (organic chemistry); physics series, PHYS

40A-40B-40C (general calculus-based physics); and a biology course, BIOL 5A (Introduction to cell and molecular biology). Both CHEM 112 series and PHYS 40 series include laboratory components. CHEM 1 series has concurrent 1LA-1LB-1LC required laboratory courses, as does BIOL 5A (BIOL 5LA). The specific achievement of the Student Outcome is measured throughout the engineering program including CHE 100 (thermodynamics), CEE 130 (advanced thermodynamics), CEE 135 (chemistry of materials, required for the Nanotechnology option), and CHE 116 (heat transfer). Clearly, the application of science to engineering is covered in all courses within CHE.

Student Outcome 3: An ability to apply the knowledge of engineering
Core coverage of knowledge of engineering comes from the engineering courses throughout the engineering curricula. Achievement of this outcome is measured in CHE 100 (thermodynamics), CHE 114 (applied fluid mechanics), CHE 120 (mass transfer), CHE 175A (chemical process design), CHE 175B (chemical process design), CHE 110B (chemical process analysis), CHE 117 (separation processes), CHE 118 (dynamics and process control), CHE 122 (kinetics), and CEE 135 (chemistry of materials, required for the Nanotechnology option). All engineering courses require students to demonstrate their ability to apply knowledge of engineering for successful completion of the courses.

Student Outcome 4: An ability to design experiments
Core coverage of the ability to design is covered in most engineering courses. Achievement of this outcome is measured in CEE 10 (introduction to chemical and environmental engineering, CHE 100 (thermodynamics), CHE 114 (applied fluid mechanics), CHE 116 (heat transfer), CHE 175A (chemical process design), CHE 175B (chemical process design), CHE 160B (senior lab), CHE 118 (dynamics and process control), and CHE 122 (kinetics). Design problems are assigned throughout the engineering curricula. Specifically, design experiments are covered in the CHE 160A-CHE 160B-CHE 160C senior engineering labs where students are required to design experiments to achieve specific goals. The laboratories within the course specifically require students to provide their own approaches toward solving engineering problems or obtaining critical engineering data. The capstone senior design course (CHE 175A and 175B) emphasizes engineering design and projects typically require a laboratory component. Additionally, there are courses within the TE options such as CEE 125 (analytical methods, Chemical Engineering (req)/Nanotechnology (TE list) option), CEE 161 (nanoscale processing laboratory, Chemical Engineering (TE list)/Nanotechnology (req) option), or CHE 124L (bioengineering laboratory, Bioengineering (req) option), which all have additional experimental design.

Student Outcome 5: An ability to conduct experiments
Core coverage of this Student Outcome is covered within the chemistry labs (six quarters), physics labs (3 quarters), biology (1 quarter), CHE 160 senior laboratory series (three quarters), CHE 175 senior design course (2 quarters) and at least one additional lab (CEE 125 (chemical engineering option); CHE 124L (biochemical engineering option); CHE 161 (nanotechnology option). Within each of these courses the students conduct laboratory experiments ranging from standard science laboratories to rigorous design based engineering laboratories. CHE 160A, CHE 160B, and CHE 160C (senior lab course series) are used to evaluate performance in this outcome.

Student Outcome 6: An ability to analyze and interpret data

This is achieved in a similar fashion to outcome 5. Within the basic science courses, students must evaluate their experimental findings; within the engineering laboratories the students must evaluate the data obtained to meet design goals. In addition, other courses also require the ability to interpret data during course design projects and/or through homework or test questions. For example, in CEE 135 (chemistry of materials, Chemical Engineering (req)/Nanotechnology), students are given solutions to problems and asked to "reverse engineer" the data; essentially analyzing and interpreting results from specific experiments to determine which materials were utilized in the specific experiment. An example from ENGR 118 requires students to analyze spatial height or depth measurements from a lake and use Newton Cotes numerical integration methods to determine the contour, and total volume of the lake. The outcomes are evaluated as part of CHE 114 (fluid mechanics), CHE 160A (senior lab course), CHE 175B (senior design), CHE 110B (chemical process analysis, CHE 118 (dynamics and process control), ENGR 118 (numerical methods for engineers), and CEE 135 (chemistry of materials, Chemical Engineering (req)/Nanotechnology).

Student Outcome 7: An ability to design a system, component, or process to meet desired needs within realistic boundaries

This Student Outcome is achieved through the core engineering courses. All courses have a design component to them where students are required to design components or aspects of larger design problems. The outcome is evaluated through CHE 114 (fluid mechanics), CHE 120 (mass transfer), CHE 175A (senior design), CHE 175B (senior design), CHE 110B (chemical process analysis), CHE 118 (dynamics and process control), and CHE 122 (kinetics). However, as seen throughout the engineering course syllabi, each engineering course has a design component. For example, in CHE 122 Chemical Reactor Engineering students are asked to calculate the reactor size for a desired conversion of a real-world reaction or optimize a system to produce and harvest the most expensive product formed in complex series-parallel reactions. During the learning and solution process, students utilize fundamental principles to determine the desired parameters. This outcome also forms the critical basis of the required assignment in CHE 175A&B. The students are required to design a complex system (multiple chemical, physical or biological processing units in series and parallel), while constrained by economics, utilizing realistic engineering models and real world feed stocks.

Student Outcome 8: An ability to function on multidisciplinary teams

This outcome is easily achieved through overlap between the chemical and environmental engineering courses. This includes core courses CHE 114, CHE 120, CHE/ENVE 160A, CHE/ENVE 175A, CHE/ENVE 175B, CHE/ENVE 100, CEE 130, and ENGR 118. Additional overlap occurs through technical electives within each respective program/option. Within CHE 114, CHE 120, CHE/ENVE 100, and CEE 130, students work together (across disciplines) to achieve specific design goals/projects. CHE/ENVE 160A (senior lab course), students are split into laboratory groups that include both CHE and ENVE students and must work in teams to approach experimental design and conduct experiments to meet design goals. CHE/ENVE 175A and CHE/ENVE 175B (capstone senior design), students are broken up across their disciplines (CHE and ENVE) and must work in teams to complete a capstone senior design. ENGR 118 includes CHE and ENVE as well as on occasion other majors and has a component where students work in teams to solve a minor design project. Outcome 8 is evaluated using courses CHE 160A (senior lab course), CHE 175A (senior design), and CHE 160B (senior lab course).

Student Outcome 9: An ability to identify, formulate, and solve engineering problems
The engineering specific courses all overlap with this outcome (CHE, ENVE, CEE, ENGR). The goal of each engineering class is to develop within students their ability to identify, formulate, and solve engineering problems. Achievement of this outcome is tested through CHE 100 (thermodynamics), CHE 114 (fluid mechanics), CHE 116 (heat transfer), CHE 110B (chemical process analysis, CHE 122 (kinetics), and ENGR 118 (numerical methods for chemical and environmental engineers). All courses develop this outcome through homework, exams, and design projects.

Student Outcome 10: An understanding of professional responsibility
While each engineering course integrates within it professional responsibility, CEE 10 (introduction to chemical and environmental engineering), CEE 158 (professional development), and CHE 175A and 175B (capstone senior design) are the primary courses for coverage of this outcome. Achievement of this outcome is evaluated through CEE 10 (introduction to chemical and environmental engineering), CEE 158 (professional development), CHE 175A (senior design), CHE 175B (senior design), and CHE 160B (senior lab class). In CHE 160A, 160B, and 160C the idea of professional responsibility is reinforced through data analysis and reporting techniques. Students are taught that proper statistical analysis is a key component of professional responsibility. Additional professional development is obtained by most students through participation in undergraduate research or in student organizations. In CEE 158, concepts of professional responsibility are discussed through multiple mechanisms. The core values and code of conduct of AIChE are provided in class and discussed in details. Case studies are provided to groups of students that have to analyze situations that have major professional responsibility issues and students are required to identify issues, develop “solutions” or action routes and present the results to the class. This provides an excellent forum for group discussion of issues paramount to professional responsibility. In addition, CEE 158, CHE 175A, CHE175B, and CEE 10 both have guest speakers with industrial experience that discuss the importance of professional responsibility for successful business operation and career success. Finally, to prepare them for industry, in CHE 175A and 175B students work on teams and perform duties required in a professional setting including the submittal of weekly timesheets, biweekly memos and oral updates to their manager (which is the instructor), undergoing performance evaluations (through their group assessments) and the documentation of the evolution of their design in a design notebook.

Student Outcome 11: An understanding of ethical responsibility
Similar to Student Outcome 10, each engineering course integrates within it ethical responsibility to varying degrees. CEE 10 (introduction to chemical and environmental engineering), CEE 158 (professional development), and CHE 175A and 175B (capstone senior design) are the primary courses for coverage of this outcome. The CHE 160A, 160B, and 160C (senior lab series) also reinforces ethical responsibility through data analysis. Proper statistical analysis and reporting of data is critical component of engineering ethical responsibility. Students are taught to repeat measurements, report errors associated with their data, and draw sound conclusions based on

quantitative analysis of their systems. Achievement of Student Outcome 11 is evaluated through CEE 10 (introduction to chemical and environmental engineering), CEE 158 (professional development), CHE 175A (senior design), and CHE 175B (senior design). Additional ethics responsibility is obtained by most students through participation in undergraduate research or in student organizations. In CEE 10, the code of ethics are introduced and discussed. CEE 158 has guest speakers with industrial experience to cover ethical responsibility as well as use special videos (e.g., "Incident at Morales: An Engineering Ethics Story", developed by National Institute of Engineering Ethics). This video was shown in class and students were required to write 2 page essays detailing the ethical issues that pervaded the video and whether the situations were handled correctly, or not. In cases where students deemed decisions unethical, they were instructed to propose alternate routes that should have been taken. In CHE 175B, a number of case studies from the online ethics website (www.onlineethics.org) are presented in class and discussed. Guest speakers from industry are also invited to provide further discussion on ethics and preparation for industry.

Student Outcome 12: An ability to communicate effectively

Many engineering courses help the student achieve this Student Outcome, often through oral and/or written presentation of design problems, laboratory results and/or literature reviews. Within CHE, CEE10 (introduction to chemical and environmental engineering, CHE 160 series (three quarters, senior engineering lab), CHE 175 series (two quarters, senior design), and CEE 135 (chemistry of materials, Chemical Engineering (req)/Nanotechnology), CHE 105 (introduction to nanoscale science and engineering, Chemical Engineering (req)/Nanotechnology), and CHE 122 (chemical engineering kinetics) all have written and/or oral presentations. Beginning in their freshman year, students in CEE 10 are required to conduct a literature search on a chemical engineering research topic and present their review in teams of two. In CHE 122 students are asked to analyze journal articles related to kinetics and chemical reaction engineering. The students then present the key findings and analysis of the article to the entire class. In CEE 158 students are required to write at least 20 pages of material that include scientific background research, personal reflection and ethical and professional responsibility analysis. In addition oral communication is practiced through regular presentations in class and a final exam where each student has a 1 on 1 mock engineering interview with the instructor. In CHE 175A and 175B, students have end of quarter presentations and biweekly oral updates on the progress of their design project. Additionally, this is met through English 1 series (three quarters, ENG 1C (or substitute through W course)). Achievement of this outcome is evaluated in CEE 158 (professional development), CHE 175A (senior design), CHE 175B (senior design), CHE 160A (senior lab class), and CHE 160B (senior lab class).

Student Outcome 13: The broad education necessary to understand the impact of engineering solutions in a global economy

This Student Outcome is primarily achieved through CEE 158 (professional development), CHE 175A and CHE 175B (senior design) although this is in part covered by many other core CHE courses. Performance in this outcome is measured through CHE 100 (thermodynamics), CHE 114 (fluid mechanics), CHE 120 (mass transfer), CHE 110B (chemical process analysis), CEE 135 (chemistry of materials, Chemical Engineering (req)/Nanotechnology), and CHE 105 (introduction to nanoscale science and engineering, Chemical Engineering (req)/Nanotechnology). See design section 5-6 for more details about 175 series course. In CEE

158, we disuses the impact of engineering solutions in a global economy through a number of modules including, critical evaluation of current and emerging energy resources and discussion on the effect of outsourced manufacturing on US and global economies.

Student Outcome 14: A recognition of the need for, and an ability to engage in life-long learning

Student Outcome 14 is generally covered throughout the engineering curricula (ENGR, ENVE, CHE, and CEE). Examples include review of journal articles (160, senior lab series; CHE 122, chemical reaction engineering, CHE 105, introduction to nanoscale science and engineering, CHE 117, separation processes) and incorporation of state-of-the-art methods based on faculty research/conference experience. The need to remain up-to-date within the engineering field is stressed in CEE 10 (introduction to chemical and environmental engineering), CEE 158 (professional development), and CHE 175A and CHE 175B (senior design courses). The subject of professional licensure is also stressed within CEE 10 and CEE 158. In CEE 158, students are introduced to all materials covered in the FE exam and required to take practice exams and identified individual weakness in the materials. In addition guest speakers and interviews performed by both the instructor and students provide first hand advice from engineering professionals on the importance of life-long education for career success. Throughout the CHE 175A and 175B course of working on their design projects, students experience the need to continually learn and research new concepts pertaining to their unique team projects; from researching regulations on chemicals, safety codes, permitting, and contacting vendors for quotes to evaluating an appropriate and cost effective location for building their plant, students realize that this process of life-long learning is necessary. In CHE 117 (separation processes), the students are provided with reprints of recent journal publications on current research in separation, making them understand the importance of life-long learning even for a well-established subject. Topics include new development of energy-saving distillation processes and critical analysis of different separation methods for microalgal biodiesel production. These help the students to get into the habit of reading, understanding, evaluating and simplifying research publications, a critical set of skills in highly dynamic industries. Achievement of outcome 14 is evaluated in CEE 130 (advanced thermodynamics), CHE 120 (mass transfer), CHE 175A (senior design), CHE 175B (senior design), CHE 160A (senior lab class), and CHE 160B (senior lab class).

Student Outcome 15: A knowledge of contemporary issues

Student Outcome 15 is covered quite similarly in the curricula as Outcome 14 with coverage throughout engineering courses. Examples include review of journal articles (160, senior lab series; CHE 105, introduction to nanoscale science and engineering) and incorporation of state-of-the-art methods based on faculty research/conference experience. The need to remain up-to-date within the engineering field is stressed in CEE 10 (introduction to chemical and environmental engineering), CEE 158 (professional development), and the senior design course. In CEE 158 the students are required to write a critical analysis of emerging global energy solutions, with specific focus on near term issues that must be overcome to develop economically viable energy solutions. In CHE 175A and 175B, students must evaluate all possible alternatives and technologies relevant to achieving their design criteria and objectives before they can select the best solution; hence acquire the knowledge of contemporary issues. Achievement of outcome 15 is evaluated in CEE 10 (introduction to chemical and environmental engineering), CEE 130 (advanced thermodynamics), CHE 100 thermodynamics), CEE 135 (chemistry of materials, Chemical Engineering (req)/Nanotechnology), CHE 175A (senior design) and CHE 160B (senior lab class).

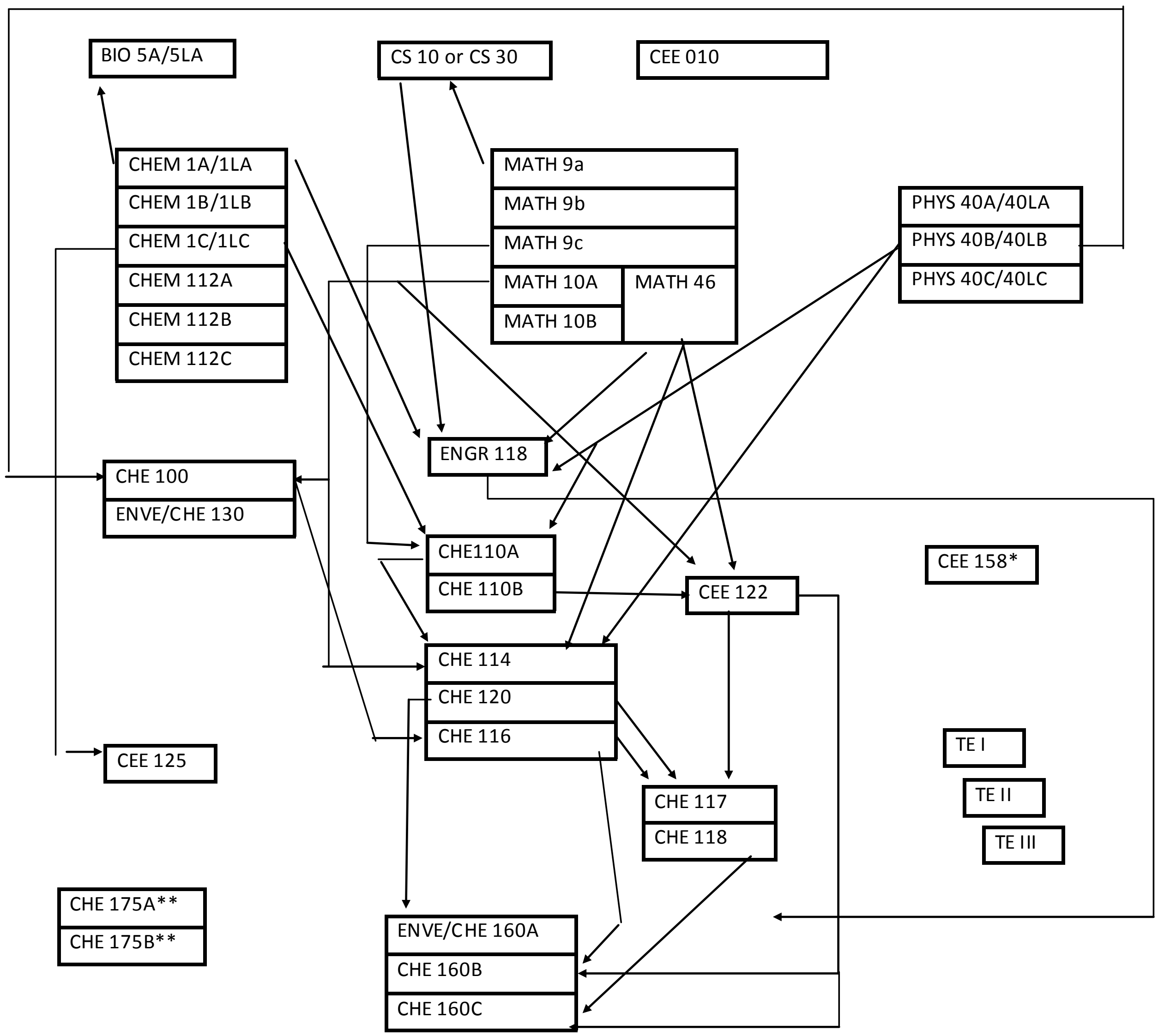
Student Outcome 16: An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Primary coverage of the use of modern instrumentation as part of this Student Outcome is covered within the laboratories of the basic science courses: Chemistry (6 quarters), Physics (3 quarters), and Biology (1 quarter) as well as the 160 series (3 quarter senior laboratory course). Modeling tools are used throughout the curricula with CEE 10 (introduction to chemical and environmental engineering), ENGR 118 (numerical methods for engineers), CS 10/30 (programming), CHE 117, CHE 118 and CHE 175 series (2 quarters, senior design) using/teaching specific computer modeling tools. In CEE 10, students become proficient in their use of Word, Excel, PowerPoint and MATLAB through various tutorials. In ENGR 118, students must use Excel and MATLAB to forecast the salinity and elevation concerns of the Salton Sea, the largest inland body of water in Southern California which is plagued with water recharge and quality problems. In CHE 117, two computer lab sections are included to introduce SuperPro Designer software to the students for analysis, evaluation and design of separation units such as distillation tower. In CHE 118, MATLAB is used to simulate the control processes. CHE 175 teaches the use of multiple simulation software programs including PROII and SuperPro to enable modeling of chemical and biological process and environmental treatment plants at steady state and DYNSIM, a dynamic simulation program for modeling systems at transient conditions. Students use these programs to optimize the design of their full-scale chemical process plants in their respective design projects. All engineering courses are designed to teach techniques and skills necessary for engineering design cumulating in the 175 capstone design courses. Outcome 16 is evaluated by performance in CEE 10 (introduction to chemical and environmental engineering), CHE 116 (heat transfer), CHE 110B (chemical process analysis), and ENGR 118 (numerical methods for engineers).

5.4. Prerequisite structure.

Figures 5-1 (a)-(d) shows the prerequisite structure for Chemical Engineering.

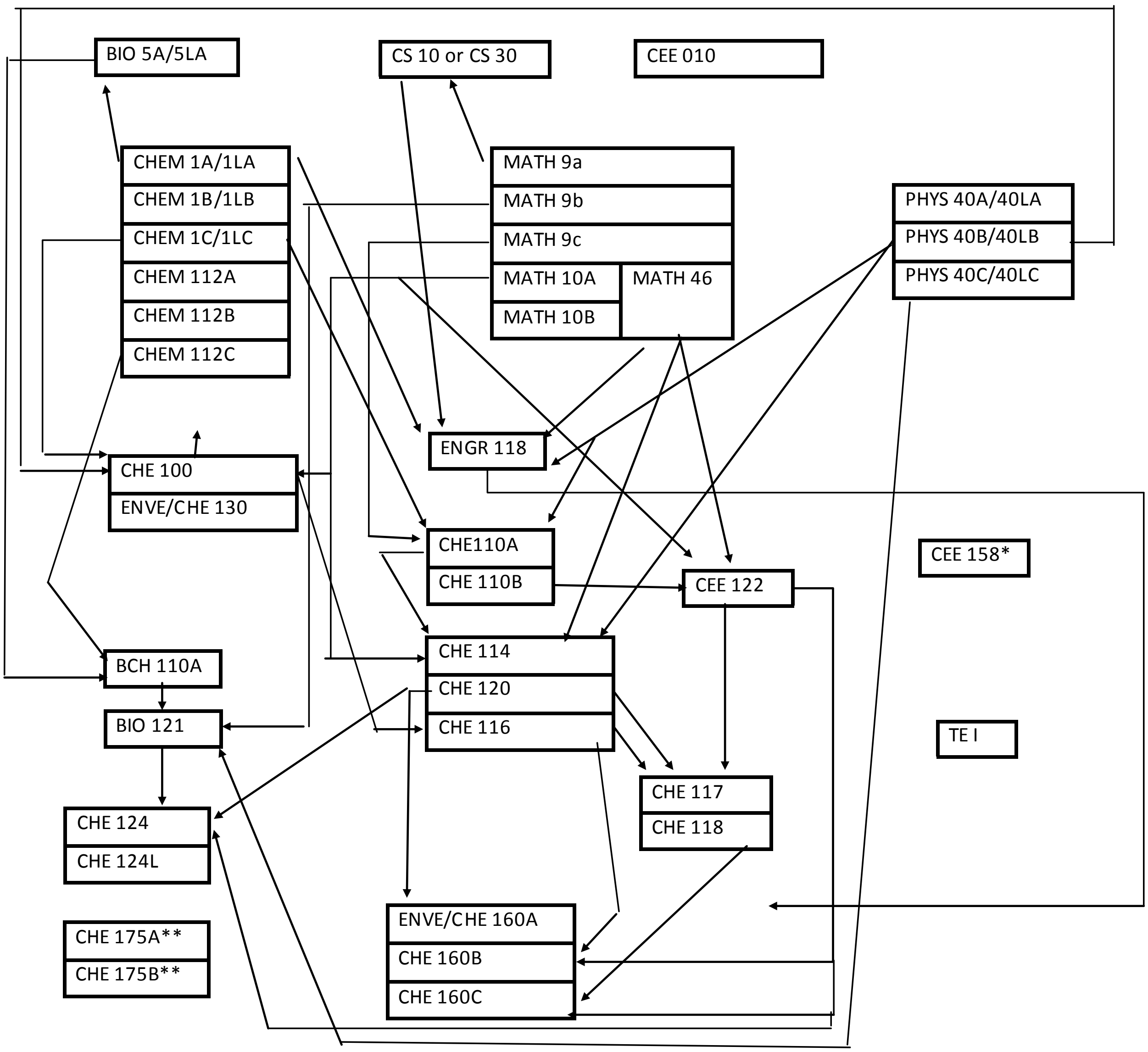
CHE—Chemical Engineering Tree



*Pre-requisite is upper-division standing; **prerequisite is senior standing

Figure 5-1 (a). Prerequisite structure for Chemical Engineering.

CHE—Biochemical Engineering Tree



*Pre-requisite is upper-division standing; **prerequisite senior standing

Figure 5-1 (b). Prerequisite structure for Biochemical Engineering track.

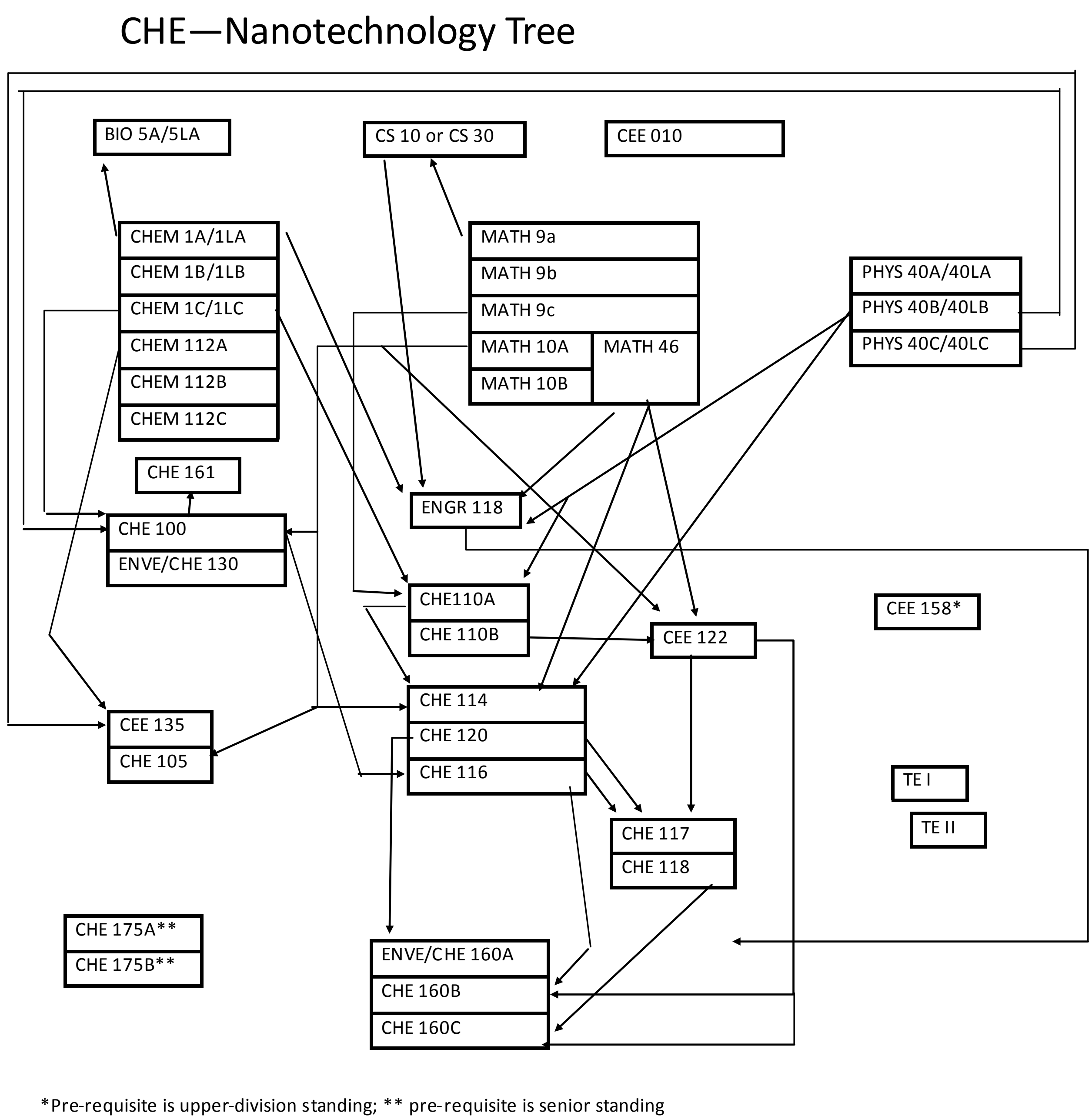
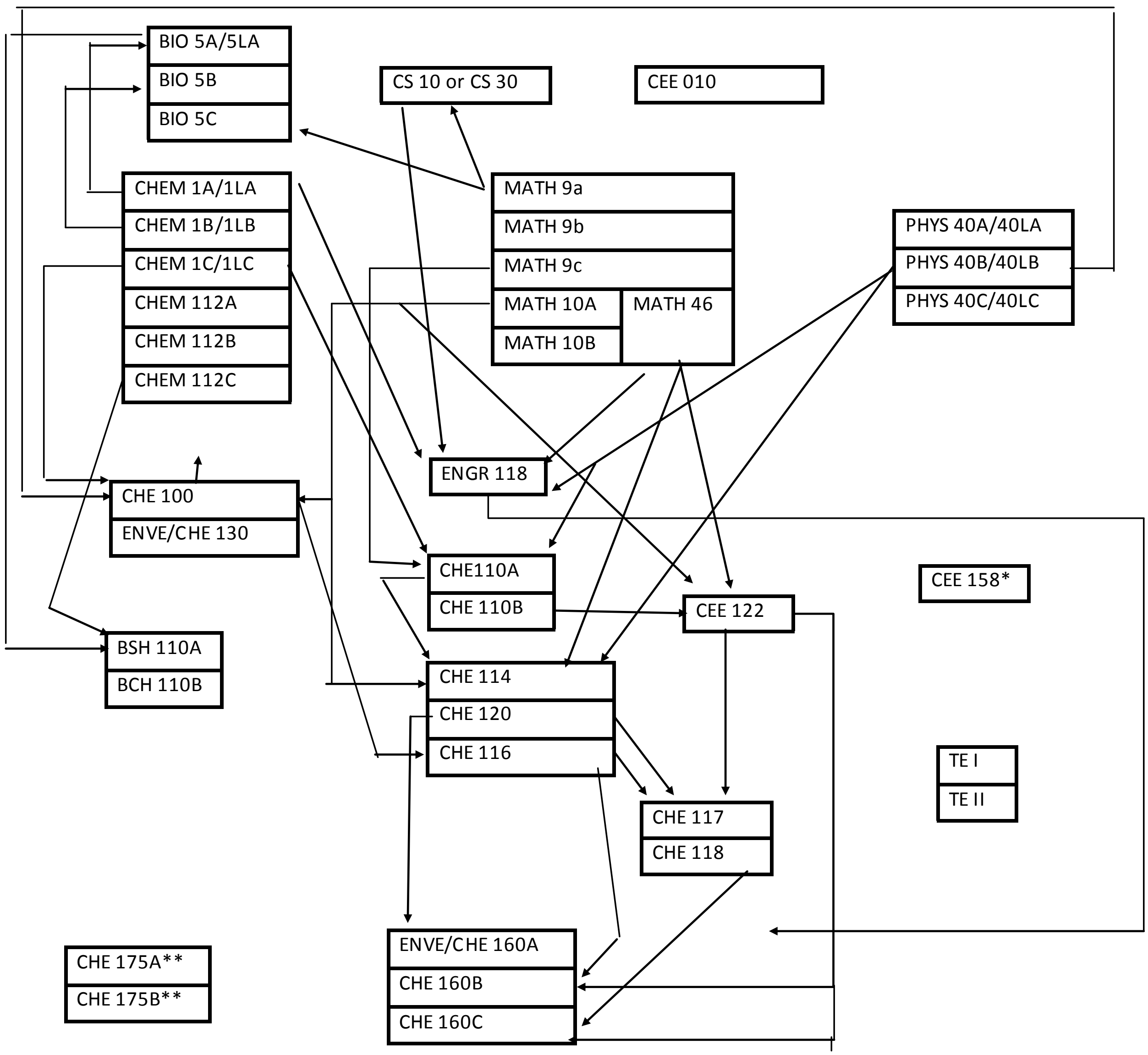


Figure 5-1 (c). Prerequisite structure for the Nanotechnology track.

CHE—Bioengineering Tree



*Pre-requisite is upper division standing; **pre-requisite is senior standing

Figure 5-1 (d). Prerequisite structure for Chemical Engineering bioengineering track.

5.5. How program meets the requirements in terms of hours and depth of study for each subject area

General Education. UCR has defined a set of Core Curriculum requirements that all students at UCR must satisfy as part of their baccalaureate (bachelor's) degree program. This set of courses in the Core Curriculum consists of 36 credit hours, and is designed to provide all undergraduates with a balanced, broad and coherent general education, and to promote competence in reading, writing, speaking, listening, critical thinking, computer literacy and mathematics.

The principal goal of the program is to teach students the fundamental knowledge associated with Chemical Engineering and hands-on experience that demonstrates how this knowledge is applied to engineering design and problem solving, thereby providing an excellent base for a successful engineering career. This involves building a sufficient knowledge base and analytical capabilities so that graduates can continue to expand their knowledge as the underlying technology and target applications not in Chemical Engineering change during their professional career.

The core courses, consisting of CHE courses are intended to provide a broad base so that those who terminate their formal education with the Bachelor's degree can continue to grow as professionals throughout their careers. This goal is met by a curriculum in which there is a progression of coursework in which fundamental knowledge acquired in earlier years is applied in later engineering courses. Satisfaction of these goals prepares the students to attain the objectives of the program.

Mathematics & Basic Sciences: CHE students must take a minimum of 71 credit (quarter) hours in this component. CHE students are required to take the following

<u>Minimum Mathematics & basic science courses</u> (75 credit (quarter) hours):

MATH 009A - 009C	First Year Calculus	12
MATH 010A - 010B	Multivariable Calculus	8
MATH 046	Differential Equations	4
CHEM 001A - 001C	General Chemistry	12
CHEM 001LA-001LC	General Chemistry Lab	3
CHEM 112A - 112C	Organic Chemistry	12
PHYS 040A-040C	General Physics	15
BIOL 005A/005LA	Cell/Molec Biology	5
CS 010/CS 030	C++/Matlab	4

These courses provide a strong foundation in mathematics as well as in laboratory based science courses (all science courses have lab associated with it). Additional math and basic science courses beyond those listed above are required as needed by a specific CHE option.

Engineering Topics. Every CHE student must take a minimum of 75 credit (quarter) hours with most options requiring more. All CHE students take the following courses:

CEE 10	Intro to Chem. and Env. Engr.	2
CHE 110A-110B	Chemical Process Analysis	6
CHE 122	Chem. Engr. Kinetics	4
CHE 114, 116, 120	Momentum, heat, mass transfer	12
CEE 158	Prof. Dev. For Engrs.	3
ENGR 118	Engineering Modeling and Analysis	5
CHE 100/130	Thermodynamics	8
CHE 160A-C	Senior Lab	9
CHE 117	Separations	4
CHE 118	Process Control	4
CHE 175A/B	Senior Design	8
Upper Engr. Div TE	Option Specific TE	>=10

These courses form the core engineering curricula for CHE and are used to demonstrate achievement of Student Outcomes 1-16 ("a"-"k").

Design Components. CEE 010 – CHE 114/116/120 - CHE 160ABC – CHE 117/118/122 - CHE 175AB form the basic design courses inside of the CHE curricula. CEE 010 (intro) first introduces students to engineering design; the lab courses cover experimental design (160 series); CHE 117 (separations)/ CHE 118 (process control)/ CHE 122 (kinetics) as well as the transport phenomena series (114 (fluids), 116 (heat), 120 (mass)) teach basic design within the courses leading to the capstone senior design (175 series) course described in the next section.

Program criteria specific curricula are also discussed in depth as part of section PC (Program Criteria).

5.6 Description of the major design experience that prepares students for engineering practice.

The culmination of the chemical engineering students' design experience is the two-quarter capstone design course called Chemical Process Design (CHE 175A and 175B), in which students draw upon various aspects of their previous engineering science and design knowledge to address a meaningful design problem. Students learn to define the objectives (in a global context), plan and conduct experiments if needed, explore and determine the feasibility of possible alternatives, narrow the selection and evaluate the proposed alternatives with respect to performance, economics, societal, health and safety impacts, and sustainability constraints. This approach may require a number of iterations before a final comparative solution is achieved.

Senior design projects are always team projects; ranging from three to five team members. Teams are generally formed by the instructor. The only exception is if students opt to participate in regional, national or international student design competitions which always require work to be started and/or completed prior to the start of the Chemical Process Design course. For competitions, students are allowed to select their team members (multidisciplinary teams are encouraged including chemical, environmental, and business students) so that team members have similar work ethic and complementary knowledge in order to have the strongest competitive edge possible to compete against regional, national and international student teams. For all other students, when the capstone course begins during the Winter quarter, chemical and environmental engineering students are placed into multidisciplinary teams to promote diversity and multidisciplinary approaches.

CHE 175A and 175B team projects are organized and run in a very professional and structured manner; similar to projects assigned to consultation firms. The teams report and provide updates of their progress to the instructor who acts as the general manager of the firm. Every team must have a leader; and the student leadership position rotates every two weeks for all students to develop their leadership abilities. To develop professional responsibilities, each team maintains a chronological log of all project work; design, calculations, findings and communications (to demonstrate the evolution of their design), schedule their own weekly team meetings, submit weekly timesheets and bimonthly reporting of their work to the general manager (instructor) of the company in the form of either 5-minute oral presentations (similar to an internal review in a consulting firm) and a 1-3 page internal technical memo. The ability to communicate their progress is a critical professional requirement. In addition to the bimonthly oral presentations throughout the two quarters, the teams also present an end-of-first-quarter team oral presentation (15 minutes) and a final presentation at the end of the Spring quarter (30 minutes) to the faculty and guests. The end-of-first-quarter team oral presentation is videotaped and critiqued to provide further feedback for the teams' development of effective communication skills when the Spring quarter commences.

The first quarter's (CHE 175A) course materials focus on professional and technical skills including guidance for effective and professional team interactions, project (concept) analysis, preliminary evaluation (economical and technical), data and literature collection, preliminary process design and evaluation, and becoming functional in simulation software packages such as PROII and SuperPro for steady state modeling of an entire plant of unit operations. Comprehensive profitability evaluations are also taught in the first quarter so that competition teams have this knowledge to complete their competition projects. The first quarter also includes sensitivity analyses, occupational health and safety of treatment systems, environmental and ethical concerns, sustainability concepts and operation and maintenance considerations. The second quarter (CHE 175B) of the capstone design course focuses on the detailed engineering design of the process (equipment sizing and specification, materials selection, etc.) and process optimization in addition to ethics issues in the profession. An additional simulator such as DYNSIM is taught during the second quarter; this software is useful in providing transient responses related to startup, modifications, or shut down of their process systems.

In some cases, students build a prototype of their design concepts and prove the concept by laboratory experiments and obtain the kinetics of a treatment system required for scaling up to a full-scale system using simulation software to model steady state processes. In projects submitted to competitions such as the Environmental Protection Agency (EPA) P3 Sustainability Design competition, the Waste-management, Education and Research Consortium (WERC) environmental design competition, the Southern California World Water Forum College Grant sponsored by a consortium including the Metropolitan Water District and the U.S. Bureau of Land Management (BLM) and others, and the Hydrogen Student Design Contest, students gain additional professional opportunities such as grant proposal writing, writing of a business plan, building a prototype to be demonstrated and presented to a panel of 12-15 expert judges from the EPA, the U.S. Department of Energy, Sandia National Laboratories, U.S. BLM, the Food and Drug Administration, and various consultation firms. These activities are effectively aligned with ABET criteria of multidisciplinary teamwork, professional and ethical aspects, knowledge of math, engineering and sciences, contemporary issues, design and experimental work, data analysis, effective communication, recognition of life-long learning and global understanding of engineering solutions.

Two to three awards have been won every year with 7 awards in 2011. Since 2007, students have won monetary grants and awards in excess of $92,500 to implement the students' designs or for scholarships and brought recognition to the school. A list is provided below.

- 2012-2013 Southern California World Water Forum College Grant, MWD
- 2012 Phase II EPA P3 student design competition award (SU 835329) ($90,000)
- 2012 WERC competition, 1st Place Award & the Intel Environmental Innovation Award
- 2011-2012 Phase I EPA P3 student design competition EPA Grant Number: SU836024
- 2011 Phase II EPA P3 student design competition Student Choice Award (SU834726)
- 2011 WERC competition, 1st Place Award / Terry McManus Outstanding Student Award
- 2011 Hydrogen student design contest, 2nd place – Honorable Mention Award
- 2011 American Public Power Association (APPA) Demonstration of Energy-Efficient Developments (DEED) Research Grants (two separate teams)
- 2010-2011 Phase I EPA P3 student design competition EPA Grant Number: SU834726
- 2010-2011 Phase I EPA P3 student design competition EPA Grant Number: SU834709
- 2009-2010 Phase II EPA P3 Honorable Mention Award (SU834325)
- 2009-2010 Phase I EPA P3 student design competition EPA Grant Number: SU834325
- 2009-2010 Phase I EPA P3 student design competition EPA Grant Number: SU834294
- 2010 WERC competition, Second Place Award
- 2009 WERC competition, Terry McManus Outstanding Student Award
- 2008-2009 Southern California World Water Forum College Grant, MWD
- 2007-2008 Phase I EPA P3 student design competition EPA Grant Number: SU833526
- 2008 1st prize in the undergraduate student poster/paper competition at the annual Air & Waste Management Association conference, Portland, OR, June 24, 2008
- 2007 WERC competition, U.S.D.A. Teamwork award for innovative use of agricultural waste for value added products / Terry McManus Outstanding Student Award
- 2007 1st prize in the International student design competition hosted by Intelligen

Aside from the competition projects, many projects have additional faculty involvement; thus students have the opportunity to conduct experiments in the respective faculty-led projects, with experience in experimental design and data analysis. All design projects (competition and non-competition teams) are assessed. critiqued, and mentored by professionals with considerable experience in the field. These projects are generally cutting edge technology types of projects focusing on contemporary issues and highlighting to students the need for life-long learning.

Monitoring and assessment of ethical and professional conduct are done with written and confidential self-group assessments, which are provided to the instructor and done twice each quarter. This provides students with a means to learn to work productively in teams by addressing professional and personality issues that may arise throughout the capstone design course (much like conflicts which may arise in a real world setting). A number of ethical case studies are discussed in preparation of situations that may arise when the students continue their engineering career. This once again instills the importance of ethics in engineering prior to graduation. Finally, the course concludes with a comprehensive written technical report of their engineering project solution and a formal oral presentation (30 min) to the faculty and guests in which the teams get the experience to professionally sell their design concepts and defend their work.

5.7. Cooperative education

Cooperative education is not used to satisfy either general or program criteria.

5.8. Materials available for review during the visit to demonstrate achievement related to this criterion.

ABET formatted syllabi, course syllabi, lecture notes, sample student work (high, average and low), sample design projects (high, average, low) including videotaped design presentations, pre-course evaluations, post-course assessments, student evaluation of course objectives, and student outcome scores (with associated questions used for quantitative, orthogonal, review of each Student Outcome) will be made available in course binders specific to each course. Course textbooks, readers, and lab-manuals will also be made available.

B. Course Syllabi

The syllabi for engineering courses are provided in Appendix A. Syllabi for non-engineering courses will be available during the site visit.

CRITERION 6. FACULTY

A. Faculty Qualifications

All of the department faculty members are very actively engaged in scholarly research, consistent with the mission of the department, college, and University. In addition to being actively engaged in teaching undergraduate and graduate students, members of the department faculty supervise research of graduate students pursuing MS and PhD degrees, and provide research opportunities to undergraduate students in their research laboratories. Three of the faculty (Mulchandani, Walker, and Kisailus) have received the prestigious Chancellor's Award for Excellence in Fostering Undergraduate Research. NSF-REU (i.e., supplement for undergraduate research) are systematically requested. Based on their active research, faculty are publishing research papers in the leading journals in their fields of expertise, attending technical conferences, and generating extramural funding for research from various local, state, federal, and industrial agencies. Several faculty serve as editors and are on editorial boards of major journals. All faculty are very active professionally in their respective professional societies. The CEE department is one of the most active and successful departments on campus, in terms of research and funding per faculty. Five faculty members have received prestigious NSF CAREER grants.

Faculty members have resources from initial complements, "various donors" funds, internal allocation accounts and contract and grant awards to travel to meetings and conferences in their disciplinary areas or in engineering education. Some additional funds are available from the College, the campus, and the Faculty Senate. These resources are sufficient to assure that professors are able to maintain currency in their fields.

The program faculty is extremely adept at teaching and is fully engaged in all curricular matters pertaining to the undergraduate program. When needed, the department provides resources to further increase teaching competence and effectiveness. For example, several junior faculty have attended workshops on how to improve their teaching. Other sources of funding are also available to lecturers from the Non-Senate Faculty Professional Development Award program. For example, Dr. Kawai Tam has received this award five times enabling her to attend workshops in Process Safety and annual conferences to keep current with the latest developments and pedagogical techniques to enhance teaching and obtain new simulation software programs for the department. After these workshops, faculty members share their experience with others during the faculty meetings usually held on a weekly or bi-weekly basis. Funding for these activities are provided from departmental or college funds, on an as-needed basis. In addition, junior faculty attend on-campus teaching seminars to improve their teaching skills, *i.e.* Innovative Teaching Award Lectures presented by the Academy of Distinguished Teachers, Luncheon seminar for new teachers.

Teaching assignments are made by the Department Chair in consultation with the faculty, usually in the Spring, and are finalized in the Summer. Usually, a faculty member will teach the same courses several years in a row. This is to maximize teaching quality and effectiveness. Also, continuity in teaching is an important factor in the assessment of our courses and program.

Teaching assistants are provided for undergraduate courses with enrollment above 40 students only. Classes with enrollments of 90+ received an additional grader allocation. Lab classes receive 2 teaching assistants (one per section); 4 were assigned to the ENVE/CHE combination lab (CHE/ENVE 160A). Graders are assigned to courses with enrollment between 20 and 40 students as budget allows. Except for the laboratories where TA involvement is heavy in ensuring proper handling of the laboratory equipment, the TAs' duties are usually limited to grading homework and being available during office hours for students' questions. CEE faculty grade mid-terms and final exams, hold office hours, and usually handle all discussion hours rather than leaving discussions to the TA. In some cases, a grader is provided instead of a TA. This usually increases the workload of the faculty.

Faculty are accessible to students in class, in teaching laboratories, during office hours, on appointment and via e-mail at all other times. Faculty are very active in encouraging and supervising research carried out by undergraduate students in their research laboratories, which provides further opportunities for student-faculty contact. All students in the program are required to meet with their faculty mentors for a one-on-one mentoring session, at least once every quarter, except for select quarters where the students meet as a group with the undergraduate advisor and the office of student affairs. Faculty are thus actively engaged in ensuring student advising and retention in the program.

Faculty and lecturers are involved in various student clubs in the department and college. Examples include: American Association for Aerosol Research (AAAR), American Institute of Chemical Engineers (AIChE; environmental engineering students are encourage to participate), Engineers Without Borders (EWB), Tau Beta Pi, and the Society of Women Engineers (SWE).

Faculty research expertise is broadly divided into 6 categories: air quality systems engineering, water quality systems engineering, advanced materials and nanotechnology, energy conversion and storage, computation and molecular modeling, and biotechnology and bioremediation. These topics broadly cover the educational program for environmental engineering with emphasis on energy, air and water. The topics broadly cover the educational program for chemical engineering with emphasis on energy, advance materials and nanotechnology, computation and molecular modeling, and biotechnology and bioremediation.

Air Quality Systems Engineering: Akua Asa-Awuku, David Cocker

Air quality systems engineering research is conducted at the College of Engineering, Center for Environmental Research and Technology (CE-CERT, www.cert.ucr.edu) where the laboratories of Professors Akua Asa-Awuku and David Cocker are located. The research center, established in 1992, has major research efforts in air quality, energy systems, and transportation, housing over 130 faculty, staff, and students who conduct research in these three areas.

Professor David Cocker's research focuses on secondary organic aerosol (SOA) formation and combustion emissions with some additional collaborative work ongoing to investigate the health effects of particulate matter from these sources. The major thrust of the SOA work is the study of gas-particle partitioning and improving predictions of SOA formation. This work involves studies of the influence of gas-phase chemistry, temperature, humidity, light source, light intensity, and chemical structure on the density, volatility, chemical composition and aerosol yield for select aromatic and biogenic precursors as well as several studies on the influence of ammonia and amines on SOA formation. The SOA research is conducted in a six+ million dollar environmental chamber research laboratory uniquely designed for the study of atmospheric chemistry under low-NOx conditions. Combustion emission work primarily focuses on detailed and accurate characterizations of in-use emissions from a variety of sources including heavy heavy-duty diesel vehicles, marine engines, back-up generators, locomotives, jet aircraft, and prescribed burns including the influences of changing fuels and control technologies.

Professor Asa-Awuku's research investigates the formation, composition, and measurement of anthropogenic and biogenic aerosol to explore the impacts on foremost climate and subsequently health. Her work focuses on understanding aerosol-cloud-climate interactions, which is imperative to improved predictive understanding of climate. Atmospheric particulate matter, or aerosol, either directly reflects incoming solar radiation to space, the "direct" effect, or affects the hydrological cycle by modifying cloud microphysical processes, the "indirect" effect. Aerosols that can uptake water and form droplets are called Cloud Condensation Nuclei (CCN) and their thermodynamic properties are important for constraining the global aerosol-indirect effect. Her research laboratory strives to quantify the links between anthropogenic and biogenic CCN chemistry and physics that also influence air quality and health.

Water Quality Systems Engineering: David Jassby, Haizhou Liu, Mark Matsumoto, Sharon Walker

Dr. Walker's research interest lies at the intersection of physical, chemical, and biological processes in natural and engineered aquatic systems. In particular, work has focused on understanding the factors controlling particle adhesion and transport in subsurface environments. The emphasis has been to explore the fundamental mechanisms involved in cellular adhesion, and the interactions occurring at the molecular scale between the bacterium and mineral surfaces. These mechanisms apply to not only to bacterial-mineral interactions, but also between bacteria with surfaces such as membranes, filter media, and biomedical materials. Additionally, these approaches are applied to the area of nanoparticle stability and fate in aquatic environments. The overall goal of Dr. Walker's work is to optimize effective water treatment and distribution, wastewater reclamation, and to understand mechanisms controlling particle transport in aquatic environments.

The development, design, and analysis of engineered systems to improve and/or protect the quality of the environment have been the focus of Dr. Matsumoto's throughout his career. Over the past 30 years, he has conducted various investigations involving land treatment systems for municipal and industrial wastewater; sludge treatment and co-disposal with solid wastes by land spreading and composting, primary effluent filtration, and fed-batch biological treatment of hazardous wastes. However, the bulk of his research career has centered on the remediation of contaminated soils and underlying groundwater. His research has emphasized mixed contaminant situations that include multiple heavy metals (particularly lead, cadmium, hexavalent chromium, and arsenic), chlorinated solvents, and more recently perchlorate remediation. The overall goal has been to develop a systems approach, which can be used for in situ and ex situ soil and groundwater remediation.

David Jassby, an incoming CEE faculty member, has research interests that can be broadly defined as surface chemistry, physical/chemical processes in environmental systems, and the environmental applications and implications of nanomaterials, with particular interests in interfacial phenomenon, which govern particle-particle and particle-organism interactions. Dr. Jassby investigates how surface interactions can be harnessed for applications in water treatment, solar energy harvesting, environmental remediation, and anti-fouling.

Dr. Haizhou Liu, another incoming CEE faculty member, has research interests that focus on advancing the knowledge and application of environmental physicochemical processes at the molecular level to provide more reliable water supplies and protect public health, particularly in the following areas: (1) enhancement of water quality in drinking water distribution systems; (2) remediation of contaminated soil and groundwater at hazardous sites; (3) development of novel advanced oxidation technologies for water treatment; and (4) assessing the environmental impacts of advanced water treatment and reclamation. The connections among these fields lie in the combined application of aquatic chemistry, process design and modeling techniques to solve environmental problems.

Energy Systems: Charles Wyman, Joe Norbeck, Nosang Myung, David Kisailus, Phil Christopher, Ian Wheeldon, Xin Ge, Juchen Guo

The faculty has significant expertise in the development of energy systems. The primary focus is on designing new processes for the production of sustainable fuels and energy production architectures. The expertise in energy systems is focused in three areas, conversion of biomass to fuels, the development of solar-to-fuel platforms and electrochemical energy storage and conversion.

Professors Charles Wyman and Joe Norbeck have significant industrial and academic experience focused on the conversion of biomass to sustainable fuels. Prof. Wyman is one of the world's leading experts on cellulosic biomass conversion with more than 30 years of experience in pretreatment, fermentation, and process engineering. Prof. Wyman has published more than 150 book chapters and articles in leading journals such as PNAS, Nature Biotech, and EES. Prof. Norbeck is a leader in the field of thermochemical conversion of biomass-based feedstocks to sustainable fuels, evidenced by numerous patents and publications in the field. In addition, three new faculty members were hired in 2011 (Phil Christopher, Xin Ge and Ian Wheeldon) with demonstrated experience in the development of thermo-catalysts (Christopher) and biological catalysts (Ge and Wheeldon) and are currently exploring new catalytic routes for biomass conversion to fuels.

Professors David Kisailus and Phil Christopher have experience in the development of materials and processes for the utilization of solar energy to produce sustainable fuels. Both Prof. Kisailus and Prof. Christopher have published papers on this topic in leading journals such as: PNAS, Nature Chemistry, JACS, Nature Materials and Advanced Materials. In general the focus of their research is to design processes that efficiently utilize solar energy to convert abundant natural resources such as H_2O and CO_2 into sustainable fuels such as H_2 and CH_4.

Professors Nosang V. Myung, David Kisailus and Juchen Guo all work in the general area of developing electrochemical energy conversion and storage approach. All three faculty members focus on the design of new materials for advanced batteries. In addition, Prof. Myung also works in the area of thermo-electric energy conversion.

Advanced Materials and Nanotechnology: Robert Haddon, David Kisailus, Nosang Myung, Phil Christopher, Jianzhong Wu, Juchen Guo

Another major area of expertise of the faculty is the synthesis, characterization and utilization of advanced materials and nanomaterials. The expertise of the faculty is broad covering topics including, 1D and 2D carbon nanostructures, semiconductors, metallic nanostructures, metal/semiconductor composites, organic-inorganic composites and hybrids of all these materials. The materials are applied in the development of magnetic materials, superconductors, thermo-electrics, sensors, plasmonics, tissue engineering scaffolds, and ultra-strong materials among many others. Prof. Robert Haddon is a world leader in the areas of superconductivity, and carbon chemistry. He was recently listed as one of the top 100 chemists in the world. The selection was based on Haddon’s distinguished publication and citation record. Prof. Nosang Myung has expertise in the area of electrochemical synthesis of metallic, semiconducting and hybrid nanomaterials. Prof. Jianzhong Wu is a leader in modeling of colloidal processing of nanocomposites, DNA/RNA self-assembly and viral replication, nanocrystals formation, and the design and fabrication of antifouling surfaces and self-healing materials. Prof. David Kisailus, the Winston Chung Endowed Professor of Energy Innovation, has significant expertise in biomediated, biomimetic and bio-inspired solution-based syntheses of nanomaterials with controlled size, shape and phase by controlling solution and precursor chemistry to produce energy conversion and storage-based materials as well as nanocomposites. Prof. Phil Christopher has demonstrated experience in the solution-based synthesis of metal and semiconductor nanoparticles and hybrids with controlled size, shape and composition. Prof Juchen Guo works with the development of novel hybrid nanomaterials containing polymers, various higher surface area carbons, transition metal oxides and others for electrochemical systems. The expertise of the faculty in this area is demonstrated by hundreds of publications in top journals.

Computation and Molecular Modeling: Jianzhong Wu, Phil Christopher

The research covers many aspects of molecular theories and simulation methods and their applications to the behavior of complex fluids, solvation, catalytic reactions, interfacial phenomena, and phase transition that are pertinent to chemical and environmental engineering, in particular to energy production and storage, biomedical applications, environmental remediation and protection. The molecular theories utilized bridge both classical and quantum mechanics, with a focus on understanding fundamental materials properties and how to tailor these properties’ many applications.

Biotechnology and Bioremediation: Xin Ge, Ashok Mulchandani, Ian Wheeldon

Biotechnology faculty research in the major is focused on nanobiotechnology, environmental biotechnology, protein and metabolic engineering. Capitalizing directed evolution, synthetic biology and tools of nanotechnology, they develop (1) enzymes and microorganisms for improved catalytic conversion to produce chemicals, fuels and materials (Ge and Wheeldon); (2) bioanalytical devices for applications in medical diagnostics, environmental monitoring and water and food safety (Mulchandani); (3) antibodies and biologics for therapeutic and diagnostic applications (Ge); (4) biotechnologies for remediation of heavy metals and other emerging contaminants (Mulchandani); and (5) novel approaches of nanomaterial synthesis through the utilization of free and/or immobilized enzymes (Kisailus).

Details of faculty qualifications and experience are completed in Table 6-1. Faculty and instructor resumes are available in Appendix B.

B. Faculty Workload

A normal classroom teaching load in the Department of Chemical and Environmental Engineering is three formal undergraduate or graduate lectures and or laboratory courses plus three graduate specialty courses per year. With minor exceptions (e.g., laboratories), the formal courses are all 4 credit hours. The specialty graduate courses (CEE 250-260 series) are usually 1-2 credit hours, with instruction given in an interactive style, such as seminars or discussions. They promote active learning, and train graduate students in their specialty area.

Deviations from the above teaching load include the following:

- New faculty members are usually given one quarter teaching relief when joining UCR in order to get their research started. New faculty may also delay teaching their graduate specialty course until a significant body of graduate students is established in their research specialty.
- Consistent with campus practice, one quarter formal lecture course relief is provided for the Department Chair, Graduate Advisors, Associate Dean. Center Directors, faculty members with split appointment or with special administrative duties may have a different agreement. No course relief is provided for the Undergraduate Advisor.

Table 6-1 summarizes faculty workload.

C. Faculty Size

Currently, the Department of Chemical and Environmental Engineering has 16.5 faculty. This includes 0.5 FTE for a split appointment with Chemistry (Haddon), and a faculty with significant administrative commitments (Matsumoto), and three recent hires (Jassby, Guo, and Liu). Because we are a joint department with many courses cross-listed between the chemical engineering and environmental engineering programs, it is not possible to separate the faculty into the two respective programs.

The department also employs two adjunct faculty members (J. Wayne Miller, Kanok Booribonsomsin (pending)), a full-time lecturer (Kawai Tam), and three part-time lecturers (Daniel Gerrity, Hosik Park, and Tom Perina). The biographies of the faculty and lecturers are provided in Appendix B.

Each Chemical and Environmental Engineering undergraduate student is assigned his or her own faculty mentor. The students meet with the faculty mentor to discuss degree expectations (e.g., career opportunities within the degree), curricula (e.g., importance in enrolling in math, physics and chemistry in winter quarter first year; selection of technical electives that best fit career plans, selection of options within the major), training and growth opportunities outside of the classroom (e.g., internships, research opportunities, participation in professional student organizations, etc.), recommendation of the use of additional student resources (e.g., learning center), and any additional discussion items the students may have. A key role of these meetings is to familiarize students with faculty and to increase the retention of students within the degree program. Students are required to meet with the faculty prior to registration for courses (office of student affairs enforces a registration hold) each quarter. (In some quarters, the students are bulk mentored through the undergraduate advisors and the office of student affairs in lieu of individual meetings).

All faculty have active externally funded research programs that require interaction with private and public agencies, which in turn serve as potential employers of students. These research programs in turn serve as a major opportunity for students to conduct undergraduate research with over half of all graduating chemical and environmental engineering students having been involved in undergraduate research (volunteer, internship, or directed studies) during their course of studies at the university. All departmental faculty perform university service activities as part of their regular university duties (see faculty workload) and are actively involved in professional organizations within their field and regularly present their research findings at professional meetings.

D. Professional Development

All faculty members are active in research and professional activity throughout their careers. It is common for new faculty hires to have research funds in their initial complements for travel to meetings of professional societies or other scholarly events. Later in their careers, grant funding typically supports the cost of travel to meetings and conferences, where they share research results.

The University has a conventional sabbatical program to maintain faculty proficiency and currency. In addition, the Academic Senate offers grant travel assistance, and the campus provides grants to support innovative teaching. Also, funds are available to all faculty from their faculty support accounts, which are funded by a number of activities including a (small) portion of indirect costs generated by grants and contracts.

Intramurally, professional development opportunities include workshops on teaching skills, interpersonal skills, and other matters. Faculty and students attend these sessions. State law and

University policy also require training in sexual harassment prevention, laboratory safety, and other matters. The departments and degree programs also cooperate to present lecture series every academic year. These series bring leading researchers and distinguished guests from academia, government, and industry to campus.

In recent years, the National Science Foundation (NSF) has required grantees to provide training in responsible conduct of research (RCR) to all trainees who are paid on NSF grants. In response, UCR and the College have established training resources including an on-line tutorial, and departments are encouraged to include topics in research ethics and engineering ethics in their lecture series and courses. By being required to train their students in RCR, faculty members continually refresh themselves in this subject area. Similarly, NSF requires postdoctoral trainees who are supported by its grants to be mentored by their faculty advisors so they can become independent investigators. This mentoring takes many forms but requires faculty members to maintain their skills as mentors.

E. Authority and Responsibility of Faculty

The faculty within Chemical and Environmental Engineering guide all aspects of the Chemical and Environmental programs including the development and implementation of the processes for the evaluation, assessment, and continuing improvement of the program, including its program educational objectives, student outcomes, new courses, prerequisites, etc. The department has an undergraduate committee/ABET committee responsible for initial evaluation of new courses or proposed changes to PEOs, major requirements, etc. Changes to the curricula and requirements can be initiated by any faculty member (outside of the formal committee). After evaluations, the UG/ABET committee presents its findings at faculty departmental meetings and subsequent changes are brought to a vote. Once approved by the department, the changes are forwarded for evaluation to the BCOE executive committee and ultimately the academic senate through the flowchart below (Figure 6-1, see also Criterion 1).

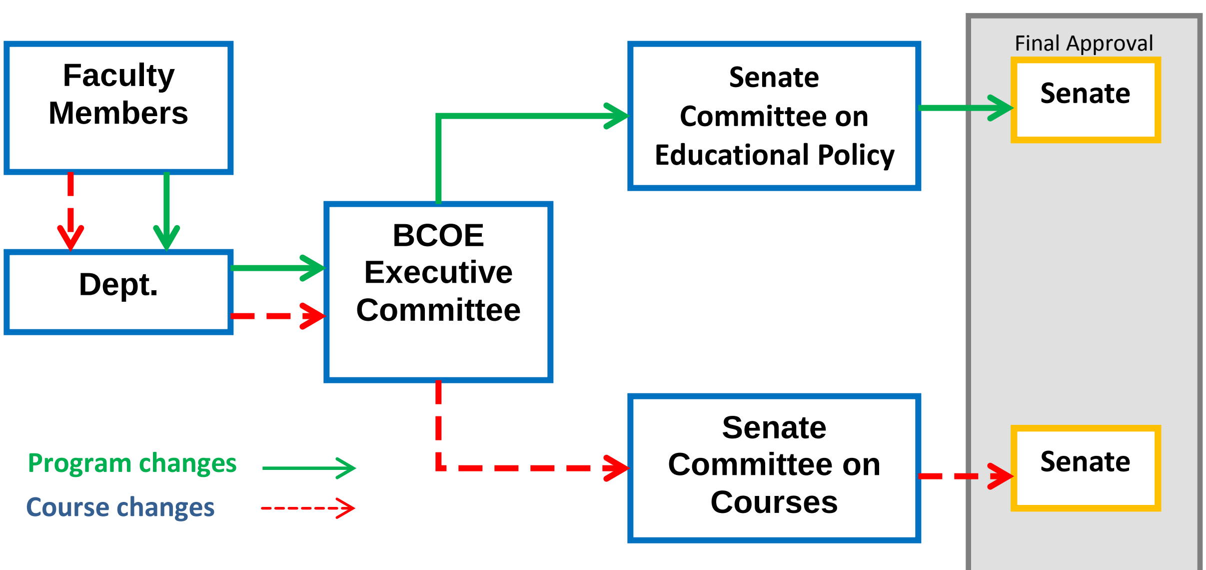


Figure 6-1: Curricula/PEO flow chart.

Table 6-1. Faculty Qualifications

Chemical and Environmental Engineering

Faculty Name	Highest Degree Earned- Field and Year	Rank [1]	Type of Academic Appointment[2] T, TT, NTT	FT or PT[3]	Years of Experience			Professional Registration/ Certification	Level of Activity[4] H, M, or L		
					Govt./Ind. Practice	Teaching	This Institution		Professional Organizations	Professional Development	Consulting/summer work in industry
Akua Asa-Awuku	Ph.D., Chemical Engineering, 2008	AST	TT	FT	0	5	3	None	H	M	L
Phil Christopher	Ph.D. Chemical Engineering, 2011	AST	TT	FT	0	3	1	None	H	M	M
David Cocker	Ph.D. Environmental Engineering Science with minor in Chemical Engineering, 2001	P	T	FT	0	12	12	FE	M	M	L
Xin Ge	Ph.D., Chemical Engineering, 2008	AST	TT	FT	0	1	1	None	L	M	M
Robert Haddon	Ph.D., Chemistry, 1971	P	T	FT	22	10	5	None	M	M	H
David Kisailus	Ph.D., Chemical Engineering, 2002	AST	TT	FT	3.5	5	4.5	None	H	L	M
Mark Matsumoto	Ph.D., Civil Engineering, 1982	P	T	FT	2	30	18	FE	M	M	L
Ashok	Ph.D., Chemical Engineering, 1985	P	T	FT	4	21	20	None	M	L	L

Mulchandani											
Nosang Myung	Ph.D., Chemical Engineering, 1998	P	T	FT	2	9	9	None	H	H	H
Sharon Walker	Ph.D. Environmental Engineering, 2004	ASC	T	FT	0	7	7	None	H	H	L
Ian Wheeldon	Ph.D. Chemical Engineering, 2009	AST	TT	FT	0	1	1	None	H	M	L
Jianzhong Wu	Ph.D. Chemical Engineering, 1998	P	T	FT	0	12	12	None	M	M	L
Charles Wyman	Ph.D., Chemical Engineering,	P	T	FT	24	17	7	None	M	M	H
Tom Perina		I	NTT	PT	10	7	7	None	L	M	H
Dan Gerrity	Ph.D., Environmental Engineering	I	NTT	PT	4	1	1	None	L	H	H
Wayne Miller	Ph.D., Chemical Engineering	A	NTT	PT	26	11	11	None	L	L	H
Hosik Park	Ph.D., Environmental Engineering	I	NTT	PT	0	1	2	None	L	L	L
Kawai Tam	Ph.D., Biosystems Engineering, 2002	I	NTT	FT	1	18	15	None	L	H	L

Instructions: Complete table for each member of the faculty in the program. Add additional rows or use additional sheets if necessary. Updated information is to be provided at the time of the visit.

1. Code: P = Professor ASC = Associate Professor AST = Assistant Professor I = Instructor A = Adjunct O = Other
2. Code: T = Tenured TT = Tenure Track NTT = Non Tenure Track
3. Code: FT = Full-time PT = Part-time Appointment at the institution.
4. The level of activity (high, medium or low) should reflect an average over the year prior to the visit plus the two previous years.

Table 6-2. Faculty Workload Summary

Chemical/Environmental Engineering

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
Akua Asa-Awuku	FT	F-CHE 160B/3,W-CEE204/4, S-CHE 122/4	40	40	20	100
Phil Christopher	FT	F-CHE 102/4, W-CEE 158/4	30	50	20	100
David Cocker	FT	F-ENVE 160B/3, W-ENVE 133/4	30	40	30	100
Xin Ge	FT	F-CHE 117/4, W- CHE 160C/4	30	50	20	100
Robert Haddon	FT		20	40	40	50%
David Kisailus	FT	F-CEE 135/4, W-CHE 105/4	40	40	20	100%
Mark Matsumoto	FT	F- ENVE 120/4, W- ENVE 142/4, S-ENVE 146/4	30	30	40	100%
Ashok Mulchandani	FT	F-CHE 110A/4, W-CEE 125/4, CHE 116/4	40	40	20	100%
Nosang Myung	FT	F-CHE 114/4, W-CHE 110B/4, S-CHE 161/4	30	40	30	100%
Sharon Walker	FT	S-CEE 225/4	10	40	50	100%
Ian Wheeldon	FT	W-CHE 118/4, S-CHE/ENVE 160A/3	30	50	20	100%
Jianzhong Wu	FT	F-CEE 200/4 W-CHE 100/4, S-CHE/ENVE 130/4	40	40	20	100%
Charles Wyman	FT	F-CHE 120/4, W-CEE202/4	20	60	20	100%
Lecturers						

Dan Gerrity	PT	F-ENVE 171/4	17	0	0	100%**
Wayne Miller	PT	W-ENVE 160C/4, S-ENVE 134/4	33	57	10	100%**
Tom Perina	PT	W-ENVE 135/4	17	0	0	100%**
Hosik Park	PT	S-ENVE 121/4	17	0	0	100%**
Kawai Tam	PT	F-CEE 10/2, ENGR 118/5 W-CEE 10/2, CHE/ENVE175A/4 S-CEE 132/4, S-CHE/ENVE 175B/4	93	7	0	100%**

1. FT = Full Time Faculty or PT = Part Time Faculty, at the institution
2. For the academic year for which the self-study is being prepared.
3. Program activity distribution should be in percent of effort in the program and should total 100%.
4. Indicate sabbatical leave, etc., under "Other."
5. Out of the total time employed at the institution.

* % teaching effort based on 4 classes (1 class being graduate seminar series).

** % time at UCR dedicated to program

CRITERION 7. FACILITIES

A. Offices, Classrooms and Laboratories

The office, classroom, and laboratory facilities available within CEE are summarized in Tables 7-1 (a)-(c), below. Sufficient space is available for all teaching/training conducted in the CEE.

Table 7-1a: Classroom availability.

CLASSROOMS			
Room #	**Program(s) Supported (please describe)**	**Type (UG, G)**	**Availability (e.g., time of day, open to UG, GS, etc.)**
B108	CEE-	UG	24/7 (UG/GS)
B134	CEE-	UG	24/7 (UG/GS)
B118A	CEE-	UG	24/7 (UG/GS)
B235	CEE-	UG, G	24/7 (UG/GS)
B235A	CEE-	UG, G	24/7 (UG/GS)
B235B	CEE-	UG, G	24/7 (UG/GS)
B255	CEE-	UG	24/7 (UG/GS)
Office TYPES = Administrative (A), Faculty (F), Clerical (C), Graduate Student (GS), Post Doc (PD), Teaching Assistants (TA), Lecturer (L) **Instructional space TYPES = UnderGraduate (UG), Graduate (G)**			

Table 7-1b: Office space availability.

OFFICES			
Room #	**Program(s) Supported (please describe)**	**Type (A, F, C, GS, TA, L)**	**Availability (e.g., time of day, open to UG, GS, etc.)**
A203	CEE-	L	Ref to course syllabi (UG/GS)
A204	CEE-	A	8am-5pm/M-F (UG/GS)
A205	CEE-	L	Ref to course syllabi (UG/GS)
A207	CEE-	GS	24/7 (GS)
A209	CEE-	GS	24/7 (GS)
A211	CEE-	GS	24/7 (GS)
A212	CEE-	GS	24/7 (GS)
A213	CEE-	GS	24/7 (GS)
A215	CEE-	F	Ref to course syllabi (UG/GS)
A216	CEE-	TA	Ref to course syllabi (UG/GS)
A217	CEE-	L	Ref to course syllabi (UG/GS)
A219	CEE-	F	Ref to course syllabi (UG/GS)
A220	CEE-	A	8am-5pm/M-F (UG/GS)
A221	CEE-	F	Ref to course syllabi (UG/GS)
A222	CEE-	A	8am-5pm/M-F (UG/GS)
A223	CEE-	F	Ref to course syllabi (UG/GS)
A225	CEE-	F	Ref to course syllabi (UG/GS)
A227	CEE-	A	8am-5pm/M-F (UG/GS)
A228	CEE-	A	8am-5pm/M-F (UG/GS)
A229	CEE-	A	8am-5pm/M-F (UG/GS)
A231	CEE-	A	8am-5pm/M-F (UG/GS)
A233	CEE-	A	8am-5pm/M-F (UG/GS)
A235	CEE-	L	Ref to course syllabi (UG/GS)
A237	CEE-	F	Ref to course syllabi (UG/GS)
A239	CEE-	F	Ref to course syllabi (UG/GS)
A241	CEE-	F	Ref to course syllabi (UG/GS)
B307	CEE-	F	Ref to course syllabi (UG/GS)
B308	CEE-	GS	24/7 (GS)
B309	CEE-	F	Ref to course syllabi (UG/GS)
B311	CEE-	F	Ref to course syllabi (UG/GS)
B313	CEE-	GS	24/7 (GS)
B313A	CEE-	A	8am-5pm/M-F (UG/GS)
B313B	CEE-	A	8am-5pm/M-F (UG/GS)
B315	CEE-	GS	24/7 (GS)
B317	CEE-	F	Ref to course syllabi (UG/GS)
B319	CEE-	F	Ref to course syllabi (UG/GS)
B321	CEE-	F	Ref to course syllabi (UG/GS)
Office TYPES = Administrative (A), Faculty (F), Clerical (C), Graduate Student (GS), Post Doc (PD), Teaching Assistants (TA), Lecturer (L) **Instructional space TYPES = UnderGraduate (UG), Graduate (G)**			

Table 7-1c: Research area availability.

OFFICES			
Room #	Program(s) Supported (please describe)	PI	Availability (e.g., time of day, open to UG, GS, etc.)
A204	CEE-	mailroom	8am-5pm/M-F (UG/GS)
A220	CEE-	Admin suite	8am-5pm/M-F (UG/GS)
A229	CEE-	K. Cocker	
A233	CEE-	C. Gerry	8am-5pm/M-F (UG/GS)
A247	CEE-	vacant	N/A
A249	CEE-	J. Wu	
B230	CEE-	UG/G computer lab	24/7
B236	CEE-	vacant	N/A
B254	CEE-	Myung Lab	
B255	CEE-	UG/G computer lab	24/7
B256	CEE-	vacant	N/A
B312	CEE-	Research support	
B314	CEE-	Mulchandani Lab	
B316	CEE-	Wheeldon Lab	
B318	CEE-	Matsumoto Lab	
B324	CEE-	cold room	
B328A	CEE-	Christopher Lab	
B328B	CEE-	Christopher Lab	
B328C	CEE-	Christopher Lab	
B328D	CEE-	Ge Lab	24/7 (UG/GS)
B328E	CEE-	vacant (new faculty)	N/A
B328F	CEE-	Walker Lab	
B336	CEE-	cold room/freezer	
B350	CEE-	Myung Lab	
B356	CEE-	Kisailus Lab	
B360E	CEE-	Walker Microscopy Lab	
B362	CEE-	Kisailus Temp space	

B. Computing Resources

Information technology support, services and facilities are available from several sources for use by the programs of The Marlan and Rosemary Bourns College of Engineering and its students, faculty, and staff:

1. Campus-wide support, services, and facilities are provided by Computing and Communications (C&C) and managed by full-time professional staff.

2. The College, through its programs of Chemical/Environmental Engineering, Computer Science and Engineering, Electrical Engineering, and Mechanical Engineering, and its Research units also provide a variety of technical services and support.

Details of these support, services, and facilities are as follows:

C&C Overview

C&C (which includes the Instructional Technology Group, Computing Infrastructure and Security, the Computer Support Group, and Communications) is directed by the Associate Vice Chancellor and Chief Informational Officer (CIO), who report to the Provost. The Instructional Technology Group, Computer Support Group, and Communications sub-units have primary responsibility for providing network access and general computing services to the UC Riverside campus.

Support Services

- **Instructional Technology Support**

  C&C's Instructional Technology Group offers faculty and students technical and pedagogical support that is academic discipline specific. The Instructional Technology Group emphasize a "hands-on" approach to its services including Blackboard (learning management system) training and support and the management and support of campus site-licensed software.

- **Classroom Technology Support**

  C&C provides classroom technology support, services, and infrastructure services (e.g. connection to the wireless network, projection systems, etc.). UCR's best-of-breed technology-enabled classrooms include the following:

  - The capability to present materials from a wide variety of sources, including (at a minimum) DVD, document camera, a personal computer, laptop computer, and Internet.
  - Chalkboard or whiteboard that is available and viewable at the same time digital or analog presentations are underway.
  - Combination of high-powered data projectors and/or lighting zone controls that allow students to take notes and view presentation material at the same time.
  - "Self-service" design which allows instruction to occur without the aid of technical operators and without the delivery of equipment.
  - High quality sound-systems and data projection resolution; the minimum standards for sound and data projection are based on the academic disciplines.

UCR has implemented "clicker" technology in all its classrooms. In actual use on this campus clicker technology has been shown to:

  - Increase attendance (sometimes dramatically)
  - Encourage participation from normally non-participative students

- Create a more engaging lecture environment

Additionally, all UCR classrooms are equipped with podcasting capabilities. This can be in the form of audio podcasting or lecture capture as supported by Echo360 course capture technology. Students in these classrooms will have on-demand access to archived educational content as presented during lecture, including a video camera feed and classroom audio.

- **General Technology Support**

  C&C provides UCR faculty and students with technology to assist them in their instructional and academic pursuits. Services like e-mail, iLearn (Blackboard Learning Management System) and the wireless network ensure that all of UCR faculty and students stay connected with their colleagues, peers and the rest of the world. The Computer Support Group provides desktop computing support for faculty and staff. Services include consulting on hardware, software and networking, plus assistance with acquiring, learning and using stand-alone or networked microcomputers (Windows, Macintosh, Linux, and UNIX platforms). Services offered include telephone support, on-site and carry-in services, on-line remote support, a knowledgebase and software downloads. C&C also implemented and spearhead the Microcomputer Support Specialist (MSS) program, which provides decentralized departmental support.

- **Multimedia Development and Research Visualization Support**

  This group provides innovative and creative full service web and graphic design for the UCR campus and community. With fully integrated, back-end programming solutions tailored to each client's specific needs, the group supports university's efforts to secure extramural funds and the campus' various outreach efforts.

Facilities and Infrastructure

- **Computer Labs**

  Student Computing Services maintains four public computer labs featuring approximately 149 computers available for academic use by all UCR students, with open hours of approximately 160 hours per week. Faculty instructing a course may reserve the public computing facilities for instructional use or request to have software installed on the machines. Lab assistance and software checkout is available in the labs. C&C provides research software (SAS, SPSS, Mathematica) in most public computer labs.

- **Classrooms and Learning Spaces**

  The Multimedia Technologies Group maintains all of UCR's general assignment classrooms that have been equipped with data/video projectors, document cameras, DVD players, PC computer on the network, computer interface for laptop users and network connections. Lecture halls are also equipped with wireless microphones and multiple (two to three) projection systems. The Multimedia Technologies Group's commitment to instructional technology has led the design and implementation of "smarter" classrooms, such as the Flex Rooms and the Hyperstruction Studio. These rooms feature mobile furniture, whiteboards on every wall, and multiple projection systems.

All general assignment classrooms are equipped with a multimedia controller maintained by C&Cs Multimedia Technologies Group for operation of the various presentation technologies and audio equipment. Internet connectivity is via a robust wired and wireless network. Each controller has a "Help" button for the instructor to alert technicians if there is a problem with the equipment.

A help desk is staffed full time, and at least one field technician is available on campus during instructional hours. Either the help desk (working remotely) or the field technician (in the classroom) can quickly resolve any problem that occurs. In a survey (most recently conducted in 2011), 90% of instructors responded that UCR's available classroom technology either "Completely" or "Mostly" met their pedagogical needs.

- **Research Technology**

As part of UCR's Cyberinfrastructure (CI) strategy, C&C supports three computational cluster support models. These include departmentally maintained clusters, dedicated clusters, and a shared collaborative cluster. Three programs are described as follows:

1. A centrally managed, standardized/dedicated cluster of processors, in which researchers pay an annual fee for essentially unlimited use.

2. A collaborative computational cluster, in which each PI can buy a certain amount of hardware, which Computing and Communications will manage. The PI has priority access to the equipment that he or she acquired, plus access to the entire cluster as available. UCR's collaborative cluster provides a shared system as a computing resource for campus researchers with limited financial resources.

3. Departmentally maintained clusters, centrally managed. This type of cluster is meant for researchers who have computing needs that fall outside of the campus cluster standards. These systems are built to particular PI/lab/center specifications and managed by PI funded staff, but housed within C&C's data center.

C&C also provides other research technology support, ranging from network creation / configuration, colocation support, budget preparation / equipment configuration, and cloud services provisioning.

- **Wired and Wireless Networks**

UCR supports 1,200+ wireless access points that provide wireless connectivity to approximately 8,000 concurrent users daily. Additionally, the campus network backbone consists of 10 GB fiber-optic connections, with a minimum of 1 GB capacity to each building on campus. The campus has more than 500,000 feet of air blown fiber conduit, which enables the addition of fiber connectivity essentially "on demand".

Other Services and Support

- **Libraries**
  - The UCR Libraries have over 400 public computers among the four campus libraries with selected information resources and software to support and enhance student learning and the research and scholarship activities of the University. Specialized software has been installed on the Learning Commons Computers located in Rivera Library 1st Floor, Rivera Basement, Rivera 2nd Floor, Rivera 3rd Floor, and Science Library 1st Floor. 20 wireless laptops/netbooks are available in Rivera and Science Libraries to faculty, students and staff.

Additional information on library services (beyond computer use) are provided below:

- **CENIC Regional Higher Education Network**
  - C&C provides support and maintenance of off-campus network access via connections to the CENIC regional higher education network. All Bourns College of Engineering computing facilities and faculty have high-speed access to CENIC members (e.g. other UC campuses, private research universities in California, the California State University System, etc.) and to Internet2 via C&C support of the CENIC network.

CEE-Student Computing Lab

The CEE department maintains computer labs (B230 and B255, Table 7-1) with 24/7 student access. The computer labs are used for CEE instruction (e.g., CEE 10 (introduction to chemical and environmental engineering), CHE/ENVE 175AB (senior design), etc.). The computer lab has 30 modern computers (purchased 2011) complete with Microsoft Office Suite, MATLAB, and special simulation and modeling software for chemical process including Intelligen SuperPro Designer, PROII, DYNSIM, Aspen Tech HYSYS, CHEMCAD, etc..

C. Guidance

Training on use of computational tools is highly integrated within the CEE curricula. For example, in CHE 117 – Separation Processes, multiple computer lab sections are instructed for students learning SuperPro Designer for simulation, evaluation, and design of single unit operations and/or chemical processes having multiple separation steps. These computer lab sections not only remind students of the reality that most of industrial designs are done using software now, but also complement with the separation principles learned through lectures. Thus, there is a significant enhancement of the students' overall learning experience as indicated by the post-course survey which shows that 93% (2.8/3) of the students agree that they learned how to use SuperPro designer software for separation processes.

In CEE 10 – Introduction to Chemical and Environmental Engineering, students (majority are freshmen) are provided instruction to introduce or further develop their skills in using software programs that will be integral in their technical and oral communications, computational and data analysis skills for their engineering curriculum. These programs include Microsoft Word (learning of shortcut keystrokes and formatting to enhance the efficiency and professional look of students' reports), Microsoft Excel (efficient use of spreadsheets, optimization tools such as Solver, data filtration, plotting of graphs, etc.), Microsoft PowerPoint (for producing professional and legible slides), and MATLAB (a powerful mathematical programming tool). The post-course survey showed that 95% (2.85/3) of the students agreed that they learned how to use these software programs successfully.

In addition, CHE 175 AB senior students are further trained in the use of SuperPro, introduced to PROII and DYNSIM for their use to model, optimize and conduct sensitivity analyses on their respective senior design team projects. SuperPro and PROII provide steady-state simulations while DYNSIM enables transient behavior simulations. Multiple simulation programs are taught to provide a broader spectrum of tools for the students' use. For example, SuperPro is capable of modeling biological systems while PROII and DYNSIM are not. PROII enables the determination of molecular attributes if literature data is unavailable through the use of a "molecule builder" option where molecular characteristics can be derived from the group contributions of a molecule while SuperPro lacks this ability. The collective of simulation programs enables students to characterize their systems of interest.

D. Maintenance and Upgrading of Facilities

The aim of maintenance and upgrade planning is to ensure that all teaching equipment is kept in a good state of repair and in full working order. Upgrades are needed to give the students experience on systems that are current and what they might expect to see in the future. It is currently the role of the lab manager (Ms. Kathalena Cocker) to maintain the current equipment and perform repairs as necessary.

There are two avenues of financial resources for the upgrades and maintenance of teaching equipment. First, the college of engineering allocates funding each year for the faculty to use for the acquisition of new equipment and upgrades. These funds are used according to priorities determined by the faculty. The second is through the use of student lab fees ($30/dry lab; $50/wet lab, ~$16k for 2011-2012). These funds are generally used for equipment maintenance, lab supplies and repairs.

The equipment is inspected prior to the start of a new quarter for functionality and condition. Any trouble areas on the equipment are identified and repaired before the students are in lab. However, on occasion, repairs are needed as equipment sometimes fail during teaching labs. At the end of the quarter, recurring problems are identified and brought to the attention of the faculty teaching the class and the department chair. Plans can then be made for long-term resolutions to any standing issues.

A list of instrumental allocations and what was purchased is summarized in Table 7-2.

E. Library Services

Library collections that support the Bourns College of Engineering are housed in the Orbach Science Library. The Orbach Science Library has a seating capacity of 1,500 including individual carrels, study tables and 25 group study rooms. The library makes available 79 computer workstations for students to use in their research and study, and another 32 computers to support information literacy instruction. The entire UCR library system provides both wired and wireless access to the internet for student laptop use, and laptops are available for check-out at the Circulation Desk.

Normal library hours during the regular school year are as follows:
Monday-Thursday: 7:30am – 11pm
Friday: 7:30am to 5:00pm
Saturday: Noon to 5:00pm and Sunday: 1:00pm to11:00pm.

The Orbach Science Library maintains a professional staff of eight librarians, all of whom provide reference and research assistance to engineering students, faculty, and staff. Of these librarians, one is assigned subject responsibility for engineering and is available to assist students, faculty and staff with in depth research questions. The Engineering Librarian and Subject Specialist also offer tutorials and classes on engineering information topics, and maintain Web pages and path-finders to assist engineering students, faculty, and staff in locating the information they need.

The UCR Libraries offer a full range of reference services, including walk-up, telephone, and 24/7 e-mail reference services (Ask A Librarian) through a UC-wide and national network as well as reference by appointment. The Orbach Science Library reference desk is staffed 52 hours per week during the academic year (Monday-Thursday: 9am-8pm, Friday: 9am-5pm) and 40 hours per week during inter-session periods. In addition to these standard services, engineering students can receive additional reference help from other reference librarians who are assigned to the Science Information Services desk. The Engineering Librarian is available for extended consultation on Senior Design or other research projects.

Incoming freshman typically receive library orientation sessions in their introductory classes. They might also have additional information literacy instruction in classes that require independent research, such as the introductory chemical and environmental engineering course (CEE 10) and senior design classes. One-on-one or group tutorials are available for any research topic that might be desired and helpful to engineering students.

Library Collections: Books

Engineering books are acquired as part of the Orbach Science Library's purchasing profile, ordered from catalogs or suggested by students, faculty, and staff. Within the past three years, the library has initiated the purchase of engineering e-books and currently supports and maintains a collection of thousands of electronic books in the discipline. The Libraries provide licensed access to all of the current Springer books online, many of the e-books from the CRC EngNetBase, the Knovel Collection, Perry's Chemical Engineer's Handbook, the Wiley Online collection and many more.

Recently, through a special competitive initiative, the UCR Libraries have brought to our campus, from its former Berkeley location, the extensive and world class Water Resources and Archives Collection (WRCA) containing many materials relevant to dam and bridge construction, which is also available to engineering students and researchers from across UCR and the UC system.

Library Collections: Journals

The Libraries currently subscribe to 121 engineering print journals, and Engineering students have access to a vast collection of online journals (**94,770** unique titles). UCR maintains access, for example, to all of the journals and proceedings of IEEE, OSA, MRS, and ACM, as well as either proceedings or journals from many other societies. Faculty, staff, and students may suggest new books, journals or other media to be purchased by the library. Library users may request materials that are not available on campus through Interlibrary Loans, and the materials will be made available to them at no cost in a very reasonable amount of time.

Library Collections: Research (Journal Article) Databases

UC Riverside engineering students have access to a number of journal databases to assist them in their research in engineering and in other areas of study. Through co-investments with the other eight UC campuses and the California Digital Library (CDL) Inspec, Compendex, and the Web of Science as well as SciFinder Scholar for chemistry and chemical engineering and Biosis or MEDLINE for biotechnological literature are all available to engineering faculty and students. UCR also licenses Water Resources Abstracts locally with the arrival on our campus in 2010 of the Water Resources Archives and Collections.

Table 7-2 summarizes library resources.

Table 7-2: Library resources.

LIBRARY COLLECTIONS

	Books	Periodicals
Entire Institutional Library	2,810,229: (Print Vols.) 404,191: (e-Books) Total Vols.: 3,214,420	6,329 (Active Local Titles)
Engineering and Computer Science	71,757 Print / 29305 online	168 print / 3976 online

LIBRARY EXPENDITURES (See Table Explanations below)

	2008-2009	2009-2010	2010-2011
Expenditures for Engineering (Total)	$75,749	$75,107	$45,975
Print Books	$13,264	$11,824	$9,629
*Local Costs Only for Engineering Periodicals Subscriptions	$47,589	$47,706	**$21,163
E-Book Packages (EngNetbase, O'Reilly)	$7,043	$7,332	$6,483
***Research Databases	$15,185	$14,741	$15,957

* This figure does not include the total amount ($2.4 million) expended annually by the UCR Libraries as co-investments with other UC campuses and the California Digital Library (CDL) to support access to e-journals, e-books, and electronic databases. The value of the e-journals for supporting engineering alone is over a million dollars annually.

** This figure reflects a major journal cancellation which included duplicate and low use titles especially targeting print titles that duplicated e-journal titles. This was a UCR project in response to budget reductions.

*** Cost for Compendex and Inspec databases. Other databases such as SciFinder, Water Resources Abstracts, Web of Science support multiple disciplines, in addition to Engineering.

F. Safety

All undergraduates are required to take the Laboratory Safety Training through EH&S online. Once the course is passed, the students must bring in the certificate confirming course completion. No student will be allowed to participate in the course labs until this requirement is met. Students are given information about the online course at their first lab class meeting.

At this first meeting, the Lab Safety Officer (LSO) verbally reviews the university lab rules as well as pointing out the PPE requirements for the lab. All students must wear a lab coat, closed toed shoes and safety glasses while in the lab. Students are also instructed as to where safety equipment in the lab is located; i.e., showers, eyewashes and spill kits. Emergency evacuation procedures are reviewed as well. The students then have the opportunity to ask specific questions about safety in the lab.

An overview of good housekeeping procedures in the lab is reviewed. This includes instructions on labeling chemical containers, waste handling procedures and best practices. Students are cautioned about some of the specific chemical hazards they may encounter in the lab and the best way to proceed when working with these substances.

The laboratory safety rules are posted in several places in the lab to serve as a visible reminder of the rules. Students must comply with these rules anytime they are in the lab even if they are not actively working on a lab task. A TA or the lab manager is present in the lab with the students at all times. No student may work unsupervised in the lab.

All undergraduates can find additional safety resources on the CEE Safety Webpage which contains links to safety training, training needs assessment, MSDS forms as well as what to do in the event of an emergency. The webpage address is: http://www.cee.ucr.edu/ceesafety.htmlCHE.

CRITERION 8. INSTITUTIONAL SUPPORT

A. Leadership

The CEE Department is led by the CEE Chair and supported by full time department staff as discussed in Section 8.C. The Chair has responsibility for organizing the faculty to ensure the quality, integrity, and continuity of the CEE degree program. The Chair appoints a faculty member to be the CEE ABET/Undergraduate Advisor and a representative set of faculty to serve as the undergraduate committee.

The UG Advisor leads the UG committee and has responsibility for overseeing course content, catalog course descriptions, new course approvals and redesign or removal of obsolete courses. The UG advisor attends BCOE UG committee meetings and is the lead CEE person in interactions with the staff in the BCOE Student Affairs Office. The CEE Chair and UG Advisor discuss each year's course offerings and teaching assignments. The Chair has the responsibility for the final decisions.

The CEE Chair and UG Advisor discuss issues, ideas, and plans frequently. This is one of the highest bandwidth feedback loops. Students, faculty, the Dean's office or Student Affairs may contact either the Chair or Advisor. The subsequent discussions funnel these issues into either short-term fixes or longer-term projects. Longer-term projects, such as redefinition of courses or program structure, are vetted through the UG committee and brought to the CEE faculty meeting for discussion. Depending on the project, it may also be brought before the BCOE Executive Committee or the CEE Board of Advisors. These feedback loops are presented in Figure 4.1.

The course offerings determine the CEE TA and grader requirements. The TA and grader assignments to meet those requirements are the responsibility of the CEE Graduate Advisor who works with the CEE Graduate Student Affairs Officer and the faculty teaching each course.

B. Program Budget and Financial Support

This section describes (1) the process used to establish the program's budget and continuity of institutional support; (2) how teaching is supported; (3) how resources are provided for infrastructure; and (4) the adequacy of resources.

B.1 Budgeting Process and Continuity of Financial Supports

The University of California, Riverside has a multi-step budget development process. The major steps in the annual process are:

February:	Campus Budget Call Letter is distributed and meetings are held with academic units to discuss faculty renewal models
March:	Comprehensive Planning Documents are submitted to the Executive Vice Chancellor

April: Individual unit hearings with senior UCR management
May: Input and feedback from Faculty Senate Committee on Planning and Budget to EVC
June: Final unit budgets announced

All BCOE academic programs receive Permanent University funding for tenure track faculty, program staff, materials and supplies and travel. Table 8-1 summarizes Permanent University funding allocations to BCOE departments over the last five fiscal years.

Table 8-1: History of the Bourns College of Engineering permanent budget by degree program.

College of Engineering 5-year PERM Budget History					
PERMANENT BUDGET	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**
Bioengineering	1,058,145	1,227,145	1,234,245	1,396,905	1,518,223
Chemical Engineering	1,123,049	1,162,226	1,180,026	914,226	944,701
Environmental Engineering	1,123,049	1,162,226	1,180,026	914,226	944,701
Computer Science	2,665,015	2,759,768	2,739,142	2,747,073	2,649,119
Electrical Engineering	2,122,786	2,249,370	2,285,339	2,144,774	2,297,533
Computer Engineering	1,196,950	1,252,284	1,256,120	1,222,848	1,236,663
Mechanical Engineering	1,787,872	1,874,172	1,861,691	1,831,767	1,859,708
Materials Science & Engr.	31,018	40,058	40,058	85,452	85,452
Grand Totals >	**11,107,884**	**11,727,248**	**11,776,646**	**11,257,270**	**11,536,099**

In addition, BCOE academic departments receive Temporary University funding each fiscal year for lecturers, teaching assistants, instructional equipment, etc. The amounts of these annual allocations over the last five fiscal years can be found in Table 8-2. (Note: FY 11/12 allocations for Instructional Equipment will be made at the end of the fiscal year).

As detailed in the table above, each BCOE academic program receives annual Temporary University funding allocations for teaching assistants and graders. Each program allocates these resources independently but in general, each lab section is supported by a 25% time TA.

Details of BCOE offices, classrooms and Laboratories can be found in Criterion 7.

Table 8-2: Temporary funding per degree program.

College of Engineering 5-year TEMP Funding Summary						
TEMP Funding	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**Totals**
Bioengineering						
Lecturers	0	0	0	3,022	0	**3,022**
Teaching Asst/Grd Stdnts	25,608	108,305	68,665	138,785	193,129	**534,492**
Instructional Equipment	5,000	20,000	46,470	0	0	**71,470**
Other	26,683	44,190	71,724	91,781	39,498	**273,876**
Totals >	**57,291**	**172,495**	**186,859**	**233,588**	**232,627**	**882,860**
Chemical Engineering						
Lecturers	57,278	57,000	47,984	63,815	55,078	**281,155**
Teaching Asst/Grd Stdnts	104,680	111,477	104,659	124,318	114,733	**559,867**
Instructional Equipment	19,000	13,500	20,000	13,000	0	**65,500**
Other	20,845	32,660	76,563	45,783	21,065	**196,915**
Totals >	**201,803**	**214,637**	**249,205**	**246,916**	**190,876**	**1,103,436**
Environmental Engineering						
Lecturers	57,278	57,000	47,984	63,815	55,078	**281,155**
Teaching Asst/Grd Stdnts	104,680	111,477	104,659	124,318	114,733	**559,867**
Instructional Equipment	19,000	13,500	20,000	13,000	0	**65,500**
Other	20,845	32,660	76,563	45,783	21,065	**196,915**
Totals >	**201,803**	**214,637**	**249,205**	**246,916**	**190,876**	**1,103,436**
Computer Science						
Lecturers	191,271	202,562	225,179	238,845	222,222	**1,080,079**
Teaching Asst/Grd Stdnts	705,498	759,944	684,066	639,820	684,945	**3,474,274**
Instructional Equipment	38,966	35,449	20,000	21,486	0	**115,901**
Other	77,283	78,908	68,020	88,449	47,647	**360,307**
Totals >	**1,013,018**	**1,076,863**	**997,265**	**988,600**	**954,814**	**5,030,560**
Electrical Engineering						
Lecturers	65,875	51,850	46,018	102,119	74,275	**340,137**
Teaching Asst/Grd Stdnts	321,434	313,379	270,354	274,592	288,312	**1,468,071**
Instructional Equipment	30,756	32,000	58,394	22,135	0	**143,285**
Other	47,067	57,586	61,998	50,162	91,260	**308,073**
Totals >	**465,132**	**454,814**	**436,764**	**449,009**	**453,847**	**2,259,566**
Computer Engineering						
Lecturers	64,286	63,604	67,800	85,241	74,124	**355,055**
Teaching Asst/Grd Stdnts	256,733	268,331	238,604	228,603	243,314	**1,235,585**
Instructional Equipment	17,430	16,862	19,598	10,906	0	**64,796**
Other	31,088	34,124	32,505	34,653	34,727	**167,097**
Totals >	**369,538**	**382,921**	**358,507**	**359,403**	**352,165**	**1,822,533**
Mechanical Engineering						
Lecturers	81,501	60,282	47,724	83,217	59,625	**332,348**
Teaching Asst/Grd Stdnts	308,637	306,214	324,148	315,198	366,875	**1,621,072**
Instructional Equipment	84,306	36,632	46,000	31,254	0	**198,191**
Other	83,077	73,636	75,742	68,461	42,120	**343,036**
Totals >	**557,520**	**476,764**	**493,614**	**498,130**	**468,620**	**2,494,648**
Materials Science & Engineering						
Lecturers	0	0	6,500	12,000	12,000	**30,500**
Teaching Asst/Grd Stdnts	1,000	0	12,000	18,000	18,887	**49,887**
Instructional Equipment	0	0	0	0	3,201	**3,201**
Other	15,880	9,947	11,732	23,572	17,723	**78,854**
Totals >	**16,880**	**9,947**	**30,232**	**53,572**	**51,811**	**162,441**
Grand Totals >	**2,882,985**	**3,003,078**	**3,001,651**	**3,076,133**	**2,895,636**	**14,859,482**

B.2 Teaching Resources Provided to the Program

The program is supported by staff, part-time student assistants, teaching assistants, readers, and graders as needed to support individual courses and program administration. The College provides Student Advisors who interact with program students, monitor academic progress, enable registration, and direct them to appropriate services on campus for tutoring, career counseling, etc. Through *Tau Beta Pi* - engineering honors society at UCR, tutoring service is provided at the Learning Center and in the student dormitories (free for students living on campus). The College has developed a Professional Milestones Program to enable each program student to prepare for internships, job interviews, and research opportunities.

The College provides funds to support teaching assistants, graders, and readers, assigned based on course enrollment and need for laboratory supervision. Graders and teaching assistants grade assignments and lab reports. Instructors and teaching assistants conduct discussion sessions in which students are exposed to additional problems and concepts to reinforce material covered in lectures, and to enable students to complete course assignments. All instructors and teaching assistants maintain posted office hours for assisting students outside scheduled classes. The program has a designated Undergraduate Advisor to oversee curricular matters and to offer advice on curricular issues.

B3. Additional Funding for Maintaining and Upgrading Infrastructures

BCOE budgets approximately $300,000/year for instructional equipment acquisition and upgrades. These funds are allocated to BCOE academic programs on an annual request basis. The instructional equipment obtained by this process over the past three fiscal years for the CEE program is listed below:

1. Ozone Generator
2. Spectronic 200 Spectrophotometers
3. Micro 100 Lab Turbidimeters
4. New Brunswick Scientific Excella E5 and E10
5. Adjustable volume pipetters
6. UV Lamp
7. Masterflex L/S Economy Variable
8. Computers
9. Nanotechnology Processing Lab (CHE 161):
10. Multi-channel potentiostat
11. Antivibration table
12. Electrical Measurement
13. Mass Flow Controllers
14. Computer controlled DC power supply
15. Portable fume hood
16. Incubator
17. Lab Benches and equipment for BH 235

In addition, CEE undergraduate lab courses charge a Course Materials Fee of $30 for a dry lab and $50 per student for a wet lab. Per UCR policy, these fees can only be used to purchase expendable laboratory materials and supplies including chemicals, glassware, software, computers, etc. For FY 11/12, approximately $16,000 was generated in Course Materials Fees for the CEE academic program.

B4. Adequacy of Resources for Achieving Student Outcomes

The resources provided by the institution to support classroom education including the allocated funds for teaching assistants, graders, readers and the extracurricular tutoring services are outlined above. Also detailed above is the funding provided from the institution to create intensive, "hands-on" laboratory and design experiences for our students. Our laboratories include all of the traditional modules to teach the core curriculum and in addition, include a significant amount of higher-level equipment for specialized education. A specific focus has been placed on using institutional resources to develop "hands on" laboratory modules that provide our students with opportunities for open-ended engineering problem solving experiences. Additionally in Criterion 7, we detail the institutionally-provided, regularly updated computing resources (with program specific software packages), well-equipped classroom facilities (with all technology needed for interactive teaching and learning experiences) and up-to-date and extensively stocked library and e-library collections of reference volumes. All of these institutionally provided resources enable our program, and more specifically the students in our program, to achieve and surpass our standards for the student outcomes. Specifically, the resources described above provide a holistic and interactive educational environment that promotes the more than adequate education of our students towards the Student Outcomes.

C. Staffing

The total headcount of administrative, instructional and technical staff in BCOE for FY 11/12 can be found in Appendix D2.

Several years ago, BCOE centralized the following functions in the Dean's Office: undergraduate student affairs and advising; contract/grant pre-award processing and academic personnel. All other administrative functions (purchasing, payroll, grad student support, etc.) are provided at the departmental level. Over the past five fiscal years, the number of BCOE administrative and technical staff has decreased by 8.75 FTE due to UCR budget reductions. However, all but 0.25 FTE of these positions have occurred in central Dean's Office operations and were accomplished with little direct impact on BCOE's academic programs.

During each fiscal year, BCOE administrative and technical staff salaries are compared with salaries of similar positions within BCOE and within other UCR academic and administrative units. Any significant salary lags are addressed through UCR's staff equity and reclassification process. During the past two fiscal years, 10-11 staff reclass/equities were processed per year. This process has helped to reward and retain experienced BCOE staff.

In addition to offering on-line and in-class training required to perform a staff position's basic responsibilities (i.e., payroll, purchasing, etc.), UCR offers extensive career development training programs including:

- Certificate programs in Building Core Competencies, Diversity Training, Performance Management, Professional Academic Advising, Professional Graduate Student Advising, Grant Writing Seminars and Work Leadership
- Emerging Leader (mentorship) Program
- Management Skills Assessment Program

Most of the above training is at no cost to the employee. All required and optional training is offered through UCR's Human Resource's Learning Center. The completion of the employee's required and optional training is recorded in UCR's automated Learning Management System (LMS).

D.1 Faculty Recruitment Process

BCOE is still growing towards its target size of approximately 120 faculty members; despite budget pressures, faculty recruitment is an annual event. The basic faculty hiring process is as follows:

1. Each year, departments are asked to submit a faculty recruitment plan that is consistent with their strategic plan.
2. The recruitment plan is sent to the Dean for review.
3. The Dean then outlines a collective recruitment plan for the College and requests ladder-rank faculty lines from the Provost.
4. The Provost makes an allocation of ladder-rank faculty lines to the College and the Dean determines the overall priorities for the College.
5. The Dean lets the departments know if they can begin a search for faculty members and, if so, how many.
6. The department then forms a faculty committee to prepare a detailed recruitment plan for the position(s). The detailed recruitment plan includes a listing of the search committee, written ads and where they will be placed, flyers for distribution at professional conferences, letter templates for bulk mailings to other relevant departments, an affirmative action plan, and a deadline for priority recruitment.
7. Those detailed plans are sent to the Dean, Provost, and Affirmative Action offices for approval.
8. Once approved, ads are placed, mailings are sent, and the College on-line recruitment website is opened. All applications are received through the College recruitment website.
9. All applications received by the priority deadline are reviewed by the faculty search committee. The committee assesses how well the applicants meet the goals of the department and their potential as a faculty colleague.
10. An initial short-list is developed and further refined through comparison of reference letters and intradepartmental discussions until a list of interviewees is developed.

11. Once the list of interviewees is developed, the list is shared with the department at large, the Dean, and the Affirmative Action office. The Affirmative Action office requires reasons for why candidates were not considered for further consideration.
12. Once the department, Dean, and Affirmative Action Office approve the list, the candidates are invited to campus for an interview where they give one or two seminars, meet with the department and other potentially relevant faculty, and the Dean.
13. Following the interviews, the department recommends one or more candidates to the Dean for approval to make an offer of appointment. Upon his approval, the candidates are informed of the offer.
14. The offer is contingent upon approval through the campus policies (Academic Personnel Manual and the Call) for faculty appointments. Procedures differ depending on level of appointment.
15. Once a formal offer is signed and approved by the Chancellor, the candidate becomes a faculty member in the department.

D.2 Faculty Retention

The primary strategy is to maintain an atmosphere conducive to achieving excellence in all that we do. We strive to recognize excellent performance in teaching, research and service. We provide sufficient resources for the faculty to advance their research: initial complement funds, laboratory space, and assigned students. Annual training is provided for improving teaching methods. The faculty is encouraged to take online training on a regular basis in topic areas such as Health and Safety, Information Security, Leadership, Effective Use of Advanced Technology in the Classroom, etc. They are given assignments to college and campus committees to provide service and growth of responsibilities. We work to accelerate promotion opportunities for outstanding performance. Junior faculty are provided with mentoring by senior faculty members and provided opportunities for them to mentor students.

We want our faculty to be of the highest quality and thereby attractive to other engineering schools. If as result a faculty member receives an offer from another institution we provide matching offers to retain the individual. These strategies and actions are predominately successful.

E. Support of Faculty Professional Development

Faculty professional development funds are provided to assistant professors as part of their faculty start-up packages. In addition, the Academic Senate provides travel assistance grants, and the campus provides grants to support innovative research and teaching to professors at all levels. Funds are also available to all faculty from their faculty support accounts, which are funded by a number of activities including a (small) portion of indirect costs generated by grants and contracts.

The University offers leaves of absence with pay to attend professional meetings or other University business in addition to its normal sabbatical leave program in order to maintain faculty currency. The University also offers other types of leave with or without pay that may extend over a longer period of time, for good cause. The University Leave policies are covered in section V. (Benefits and Privileges) of the Academic Personnel Manual (APM) http://www.ucop.edu/acadpersonnel/apm/sec5-pdf.html.

The College provides funds to cover the cost of the faculty member's replacement while on leave. Faculty are also given latitude to modify class schedules/exams to some extent when necessary to accommodate specific professional development needs that require short or intermittent absences during the academic year. In some cases, other department faculty assist with covering a particular class or exam.

PROGRAM CRITERIA

Curriculum

Chemical engineering students satisfy ABET Chemical Engineering criteria through a variety of required courses in science and engineering. The ABET Chemical Engineering program criteria are reinforced in laboratory courses (CHE 160ABC series) and technical electives. The concepts are further integrated in senior design projects. Details are provided in Table PC-1.

"The curriculum must provide a thorough grounding in the basic sciences including chemistry, physics, and biology, with some content at an advanced level, as appropriate to the objectives of the program. The curriculum must include the engineering application of these basic sciences to the design, analysis, and control of chemical, physical, and/or biological processes, including the hazards associated with these processes."

Table PC-1: Chemical Engineering (CHE) Program Criteria

ABET Program Criterion for Chemical Engineers	
The ChE program provides graduates grounding in basic sciences including: (a)Chemistry, (b)Physics (c)Biology	***a) <u>Chemistry:</u>*** CHE students are required to complete one year of general chemistry CHEM 1ABC (which includes laboratories). In addition, CHE students complete three quarters of organic chemistry (CHEM 112ABC). All of these courses are the same as those taken by chemistry majors. ***b) <u>Physics</u>***: CHE students are required to take the PHYS 40ABC series. 3 calculus-based physics courses that are designed for engineering and physical science students covering mechanics, heat, waves, sound, electricity and magnetism. ***c) <u>Biology:</u>*** All CHE students take BIOL 5A and 5LA: Introduction to Cell and Molecular Biology, which includes a laboratory.
The ChE program provides graduates some content of basic sciences mentioned above, at an advanced level, as appropriate to the objectives of the program	***<u>a) Chemistry:</u>*** In addition to the core chemistry courses mentioned above, students can choose from the following technical electives: CHEM 135 (atmospheric chemistry), CEE 125 (analytical methods), CHE 102 (catalytic reaction engineering) and CEE 135 (Chemistry of Materials). ***b) <u>Physics:</u>*** Students in all CHE options are required to take CHE 114 (Fluid mechanics), CHE 120 (Mass Transfer) and CHE 116 (Heat Transfer), which cover the underlying physics associated with the program objectives.

	c) ***<u>Biology:</u>*** In addition to the core biology courses mentioned above, students taking the biochemical engineering option are required to take: BCH 110A (general biochemistry), CHE 124 + 124L (Biochemical Eng. Principles and associated lab), BIOL/MCBL 121 (microbiology). In addition, students have the option to take CHE 140 (Cell Engineering).
The CHE program includes the engineering application of these basic sciences to the (a) Design,(b) Analysis, and(c) Control of chemical, physical, and/or biological processes	***a)*** ***<u>Design:</u>*** CHE students gain design experience through a number of required and elective courses that make up the curriculum (see Table 5-1 for presence of design content). Elements of engineering design are included in lectures, laboratories, design projects, homework assignments, and in examination questions. Example of design activities include sizing of equipment to meet a particular need, solving open-ended problems often using iterative approaches, evaluating alternative design solutions. The culmination of the students' design experience is the two-quarter capstone design course, CHE 175AB, in which students draw upon various aspects of their previous knowledge gained in chemical engineering, science and design knowledge to address a meaningful design problem (see Criterion 4 for more detail on CHE 175AB). CHE 122 is another required course that includes a significant design component. In CHE 122, students use fundamental engineering principles to size and design modern reactor systems for a range of chemical, environmental, and biomolecular reactions. ***b)*** ***<u>Analysis:</u>*** Analysis is a critical component of all required upper division courses in the CHE curriculum. Specifically, in ENGR 118 (Engineering Modeling & analysis), CHE 114 (Fluid Mechanics), CHE 125 (Analytical methods), CHE 120 (Mass Transfer), CHE 122 (Chemical Engineering Kinetics), CHE 116 (Heat Transfer), CHE 117 (Separation processes) and CHE 118 (Process Control and Dynamics). At the core of all of these courses is the development of mathematical models to analyze and predict physical situations relevant to the CHE program outcomes. Specifically, the courses analyze the crucial variables that control system performance, using a fundamental and applied approach. ***c)*** ***<u>Control:</u>*** CHE students gain an understanding of the fundamental principles of control theory through the course, CHE 118 (Process Control and Dynamics). In addition, the students gain hands on experimentation with controls in CHE 160 C. Also, the students implement these strategies in the two-quarter capstone design course, CHE 175 A,B.

The CHE program covers the hazards associated with engineered chemical, physical and biological processes.	The CHE program covers the hazards associated with engineered chemical, physical and biological processes through required courses: CHE 158 (Professional development) which covers the ethics associated with designing engineering systems, and the two-quarter capstone course, CHE 175 AB which covers regulatory, health and safety, risk, process safety management (PSM) and hazard analysis concepts as they are applied to the design of a chemical system. In CHE 175 AB students become familiar with the pertinent regulatory acts and agencies, which they may encounter in their future careers. Risk and accident statistics are covered in addition to the elements of PSM. Fire and explosion considerations, equipment sizing, plant layout and spacing for safety and loss prevention, inherent safety techniques, and case studies are discussed. In addition, videos from the U.S. Chemical Safety and Hazard Investigation Board (CSB) are shown in class to emphasize and provide realism of the dangers and hazards that may exist in industry and how knowledge in procedural, inherent safety and hazard analyses may have mitigated or prevented loss of life. Many video case studies are shown from the hazards of nitrogen asphyxiation at the Valero Refinery in Delaware City to the Imperial Sugar Company dust explosion and fire combustible dust hazards. In addition, a number of the other core courses CHE 117 (separation principles), CHE 118 (Process controls), CHE 122 (Chemical Reaction Engineering) and CHE 160 A,B,C (CHE lab series) all include modules that cover the hazards associated with and design of engineered chemical, physical and biological systems. For example in CHE 117 and CHE 160C time is dedicated for PSM to cover the safety issues of the separation units operated at elevated temperatures (dryer, distillation), higher pressures than atm (distillation), and using volatile solvents (Liquid-Liquid extraction). Process safety is a central component of CHE 118. One example of a module focused on this is the design and understanding of control systems for the temperature in an unstable steady state reaction in a continuous stirred tank reaction. These courses provide a through education in the analysis and control of hazards associated with engineered systems pertinent to the curriculum. Additional elective courses are also available that cover hazards associated with engineered systems: CEE 132 (Green Engineering), ENVE 120 (Unit operations and processes in Environmental Engineering), CHE 171 (Pollution control for Chemical Engineers).

APPENDICES

APPENDIX A – COURSE SYLLABI

1. CEE 10: Introduction to Chemical and Environmental Engineering

2. 2.0 units, 1 hour lecture, 3 hours lab

3. Kawai Tam

4. Textbook: Electronic textbook with excerpts from *Engineering Fundamentals and Problem Solving*, 6th edition, McGraw-Hill, Boston, 2008 by A.R. Eide, R. D. Jenison, L.L. Northup, and S.K. Mickelson (Chapters 1 – 5 , 15; Appendices D – F).

5. Specific course information:
    a. Catalog description: Introduction to chemical and environmental engineering for engineering and nonengineering majors. Aims to enrich an appreciation of chemical, biochemical, and environmental engineering. Discusses typical careers, key applications, latest developments and the need to engage in lifelong learning in the field. Provides hands-on experiences and includes a field trip.
    b. Prerequisite(s): None
    c. Required

6. Specific goals for the course
    a. See attached Table for specific course objectives.
    b. Outcomes 4, 10, 11, 15, 16 are evaluated in this course.

7. Brief list of topics to be covered: Careers and functions in chemical, environmental and biochemical engineering and the educational requirements, problem solving techniques, the engineering design process, networking, teamwork, internships and research opportunities, representation of technical information (tables and graphs), flowcharts and programming in MATLAB, water-related environmental processes, technical communication (oral and written), energy sources and alternatives.

Contribution of course to meeting the professional component:
This is a freshman series introductory course which focuses on providing students with the knowledge and tools necessary for the chemical and environmental engineering curricula and future careers. Effective communication, networking, problem solving, teamwork, design and software tools for professional communication are emphasized. Students learn to learn use Word, Excel, Powerpoint and MATLAB effectively. Students work in teams to solve in-class problems, and present technical research topic presentations in the chemical, biochemical or environmental engineering fields. In addition, teams must learn to work together to design a prototype given stringent engineering criteria. Students were required to assemble a tower with a minimum height of two feet made of eighty straws and one roll of tape within 30 minutes time and with a base no larger than a nine-inch diameter. The tower had to sustain a load of 16 oz of a full soda can for a minimum of 5 seconds. Effective communication, design and teamwork were necessities for this successful completion.

Relationship of course to Student Outcomes: The contribution of CEE 10 to Student Outcomes (1) – (16) is summarized in the objective-Student Outcome matrix table on page 2.

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Familiarity with numerous chemical, biochemical, and environmental engineering processes and typical careers										3	3		3	3	3	
Ability to research and compile a technical review on a chemical or environmental process including process block diagrams		2	3							3	3		3	3	3	
Plant tour to an environmental industry to familiarize students with day to day operations, safety considerations, and troubleshooting requirements.										3	3		2	2	3	
Familiarity to research and internship opportunities										3	2		2	2	2	
Ability to present research topics to a large audience within time allotted										1	1	3	1	1		
Familiarity with library system for research topics and computer lab usage		1								1			2	1	2	2
Ability to use computer software for word processing, constructing tables and graphs, data analysis and making presentation slides.						2										3
Knowledge of latest developments in the field from current researchers.										2			3	3	3	
Ability to design an apparatus within certain constraints to accomplish a set objective in teams of three or more students.		3	2	3	3	1	3	3	3	2						

1. CEE 125 – Analytical Methods for Chemical and Environmental Engineers

2. 4.0 units, 2 hours lecture, 6 hours laboratory

3. Ashok Mulchandani

4. Textbook: Analytical Chemistry by Gary D. Christian

5. Specific course information
   a. Catalog: Topics include chromatographic separations, mass spectrometry, atomic absorption, and electrophoresis. Presents total carbon analysis as an introduction to analytical methods and their use in the chemical and environmental engineering fields
   b. Pre-requisites: CHEM 001C, CHEM 01LC or consent of instructor
   c. Selected Elective

6. Specific goals for the course
   a. See attached table for specific course objectives
   b. Outcomes

7. Topics covered: Effective use of basic laboratory glassware; operation principles of Spectroscopy – UV-Vis, Fluorescence and Atomic; Chromatography – GC and HPLC; and Electroanalytical methods; statistical techniques used to evaluate and process experimental data.

Contribution of course to meeting the professional component: This course is essential to students who want to work in a laboratory. Identification and quantification of samples using instrumentation skills is one of the most important skills for chemical and environmental researchers.

Relationship of course to Student Outcomes: The contribution of CEE 125 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table (next page

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Quantitatively prepare calibration solutions. Effective use of basic laboratory glassware including pipette, buret, mass balance, etc.	2	3						1								
Calculate the precision and accuracy of a measurement technique. Ability to perform and understand error analysis.	2	3									1					
Analyze chemical samples using acid-base titration, UV/Vis spectrophotometer, gas chromatography (GC), high-performance liquid chromatography (HPLC), atomic absorption (AA), and total organic carbon analysis (TOC)		3		2					2	3						
Define spectroscopy. Identify the regions of the spectrum. Describe the chemical property that each region analyzes for. Distinguish between absorption, fluorescence, phosphorescence		2								3						
Define chromatography. Describe chromatographic separation principles in terms of resolution, etc. Identify the relative importance of each term for liquid, and gas, chromatography.		1					2			2	2					
Define electrochemical analysis and different electrochemical techniques		1					2	1			2					
Prepare effective laboratory reports on research team outputs including abstracts, background, experimental set-up, and discussion of results.		1					2	1			3					

1. CEE 132: Green Engineering

2. 4.0 units, 3 hours lecture, 1 hour discussion.

3. Kawai Tam

4. Textbook: D. Allen and D. Shonnard, Sustainable Engineering, Prentice Hall, 2012.
    a. Reference text by D. Allen and D. Shonnard, Green Engineering: Prentice Hall, 2002

5. Specific course information:
    a. Catalog description: An introduction to the design, commercialization, and use of feasible and economical processes and products that minimize risks to human health and the environment. Topics covered include environmental risk assessment, regulations, chemical process flow-sheet analysis for pollution prevention, product life-cycle assessment, and industrial ecology.
    b. Prerequisite(s): CHE 110A or ENVE 175 and senior standing
    c. Selected Elective

6. Specific goals for the course
    a. See attached Table for specific course objectives.
    b. Outcomes 2, 10 - 13 are evaluated in this course.

7. Brief list of topics to be covered: Life cycle analysis, life cycle stages, climate change, environmental emissions, risk assessment, environmental law and regulations, green chemistry, green engineering, structure activity relationships to determine partitioning and persistence of chemicals in the environment, sustainable energy alternatives, evaluating environmental performance.

Contribution of course to meeting the professional component:
This is a technical elective course aimed to provide students with tools to account for life-cycle thinking and understanding the laws and regulations for which companies must adhere and maintain compliance. Two presentations are made in this course to improve oral communication skills. The topics range from innovative green chemistry award subjects to familiarity with sustainable practices being implemented in industry to highlight relevant contemporary green practices today.

Relationship of course to Student Outcomes: The contribution of CEE 132 to program outcomes (1) – (16) is summarized in the objective-Student Outcome matrix table on page 2.

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Familiarity with and ability to explain: environmental issues relating to global warming, smog formation, acidification, criteria air pollutants and effects on ecosystem.		3								1	1		3	1	2	
Determine health risk (carcinogenic and non-carcinogenic) associated with contaminant exposure	1	2	2							2	1		3	2	2	2
Familiarity with the concepts of sustainability, sustainable energy processes and industrial cooperation in sustainability advancements. Oral presentation by teams.		3						3		3	3	3	3	3	3	
Ability to conduct a literature search on a green engineering process and describe the green chemistry principles involved, the potential uses of the process, challenges to the process and prediction of success. Oral presentation by teams.		3						3		2	2	3	3	3	3	
Familiarity with Type I and Type II assessments on a chemical process. Assess environmental hazards through TLVs, PELs, bioaccumulation of all material flows including fugitive emissions.	2	1	2										1		1	2
Familiarity with and ability to explain the concept of life cycle assessment (LCA), ability to define system boundaries for LCA and understanding of the ambiguities and limitations of LCA.		2								2			1	3	3	2
Familiarity with and ability to explain the 9 prominent federal environmental statutes.										3	3		2	2		
Ability to evaluate the environmental fate of a chemical based on a chemical structure approach including concepts of octanol-water partition, soil sorption coefficients, melting and boiling point temperatures, vapor pressures and bioconcentration.	2	3	2						3	1			1	1	1	3

1. CEE 158: Professional Development for Engineers

2. 3.0 units, 3 hours lecture

3. Phillip Christopher

4. Textbook: The FE Exam Study Handbook (can be downloaded for free at http://www.ncees.org/Exams/Study_materials/Download_FE_Supplied-Reference_Handbook.php).
   a. For chemical engineers, **FE Chemical Sample Questions and Solutions Book**, ISBN: 978-1-932613-43-8. For environmental engineers, **FE Environmental Sample Questions and Solutions Book**, ISBN: 978-1-932613-45-2.

5. Specific course information
   a. Catalog description: A review of various topics relevant to the professional development of chemical engineers. Includes career paths; interview strategies; professional registration and preparation for certification examinations; ethics; risk management and environmental health and safety; regulatory issues; and lifelong learning.
   b. Prerequisite(s): Upper-division Standing
   c. Required

6. Specific Goals for the course
   a. See attached Table for specific course objectives.
   b. Outcomes 10-12, 14, 15 are evaluated in this course.

7. Topics covered: What is an engineering education and where it can get you: What is Chemical/Environmental Engineering? What skills do you learn? How can you apply these skills? Where can an engineering education take you? What will a graduate degree get you? What skills are required for success in the "real world": Writing, speaking, communication, working in teams, project planning, ethics. How to get a job/internship: Resume writing, cover letter writing, networking, importance of internships and interviewing skills. Preparing for the FE: initial evaluation, practice test and identification of weak areas. Importance of lifelong learning and introduction to 6-sigma training.

Contribution of course to meeting the professional component:
This course aims to enable engineering students to make educated decisions regarding their career paths and to pinpoint and develop the necessary skills for success in a wide range of professions. Possible career paths for engineers will be explored with specific emphasis on the skills necessary for success after graduating from UCR. In addition, topics relevant to current events and practice of engineering in a global environment will be covered through readings from journals, periodicals and news sources. These skills will be discussed in detail and developed through interactive activities.

Relationship of course to Student Outcomes: The contribution of CEE 158 to Student Outcomes (1) – (16) is summarized in the objective Student- Outcome matrix table on page 2

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Understand what an engineering education is and where it can get you What skills do you learn from an engineering degree? How/where can these skills be applied? Career paths (traditional/non-traditional) Higher education										3			3		3	
What skills are required for success in the “real world”? Writing Speaking/communication What type of person are you? Ethics Emotional intelligence										2	3	3			2	
How to get a job/internship Resume/cover letter writing Networking Importance of internships and experience Interviewing skills										3				2		
Preparing for the FE Exam Have a working knowledge of material covered on FE exam Identify weaknesses	2	2	2						2					3		
Understand importance of lifelong learning General importance of continuing education (PE and advanced training) 6 sigma training										3				3		

1. CHE 100: Engineering Thermodynamics
2. 4.0 units, 3 hours lecture, 1 hour discussion
3. Jianzhong Wu
4. Textbook: J. M. Smith, H. C. Van Hess, M. M. Abbott, Introduction to Chemical Engineering Thermodynamics, 7th Ed. (2005) McGraw-Hill.
    a. Supplementary texts: Stanley I. Sandler, Chemical, Biochemical, and Engineering Thermodynamics, 4rd Edition (2005), John Wiley & Sons; B.G. Kyle, Chemical and Process Thermodynamics, 3rd edition (1999) Prentice Hall

5. Specific course information
    a. Catalog description: An introduction to engineering thermodynamics with emphasis on chemical and environmental engineering systems. Topics include concepts of equilibrium, temperature, and reversibility; the first law and concept of energy; and the second law and concept of entropy. Also examines equations of state, thermodynamic properties, and engineering applications used in the analysis and design of closed and open systems. The course is cross-listed with ENVE 100.
    b. Prerequisite(s): CHEM 001C, MATH 010A, PHYS 040B or consent of instructor
    c. Required course

6. Specific goals of the course
    a. See attached Table for specific course objectives.
    b. Outcomes 1-5, 7, 8 and 11 are evaluated in this course.

7. Brief list of topics to be covered: Definitions of equilibrium system, work, heat, internal energy, state functions; phase rule, units of thermodynamic variables; the first law and its applications to closed systems; the first law for open systems; thermodynamic properties of an ideal gas and one-component fluids; cubic equations of state, virial equation and principle of corresponding states; applications of mass and energy balance; the second law: entropy change and reversibility; entropy changes of ideal gases and one-component fluids; entropy balance for open systems; Carnot engine and Linde process for liquefaction; power generation and refrigeration; thermodynamic partial derivatives and Maxwell relations; evaluation of changes in thermodynamic properties using equation of state and heat-capacity data; heat effects; criteria for thermodynamic equilibrium and stability; phase diagrams of one-component fluids; molar Gibbs energy (chemical potential) and fugacity of a pure component; calculation of fluid-phase equilibrium for one-component fluids; thermodynamic properties of phase transitions

Contribution of course to meeting the professional component: After attending the lectures in this class, students will be able to apply the first and second laws of thermodynamics to close systems as well as to fluid-flow processes, calculate changes in thermodynamic properties, justify the conditions of thermodynamic equilibrium and stability, and perform one-component vapor-liquid equilibrium calculations.

Relationship of course to Student Outcomes: The contribution of CHE 100 to program Student Outcomes (1) – (16) is summarized in the objective-Student Outcome matrix table on page 2.

Item	STUDENT OUTCOME-RELATED LEARNING OBJECTIVES	STUDENT OUTCOMES													
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	To introduce the issues of thermodynamics						1		2	1	1				
2	Apply energy balance in terms of internal energy and enthalpy; apply the 1st law for open systems and flow processes	3													
3	Find or calculate thermodynamic properties of ideal gases and real matters including steam	3				1									
4	Apply the problem-solving skills				3	3		2							
5	Explain in none technical terms 1) Clausius' statement of the 2nd law 2) Carnot Cycle 3) Carnot Theorem 4) Kelvin-Planck's statement of the 2nd law							3			1				
6	Understand maximum work output; Helmholtz energy and Gibbs energy, microscopic meaning of entropy and entropy balance	3													
7	Apply the 2nd law for flow processes	3													
8	Able to perform thermodynamic calculations for steady-state engineering devices and thermodynamic cycles	3		3								2			
9	Able to apply a general procedure for the calculation of the changes in thermodynamic properties using an equation of state	3													
10	To establish the concepts of thermodynamic equilibrium and stability	3													
	SUBTOTALS	**21**	**0**	**3**	**3**	**4**	**1**	**5**	**2**	**1**	**2**	**2**	**0**	**0**	**0**

1. CHE 102: Catalytic Reaction Engineering

2. 4.0 units, 3 hours lecture, 1 hour discussion

3. Phillip Christopher

4. Textbook: No Textbook required
    a. The course will utilize various resources including journal articles, patent literature, etc.

5. Specific course information
    a. Catalog description: Principles of surface reactions and heterogeneous catalysis. Catalyzed reaction kinetics, heterogeneous reactions, diffusion and heterogeneous catalysis, analysis and design of heterogeneous reactors.
    b. Prerequisite(s): CHE 122 or consent of instructor
    c. Selected Elective

6. Specific Goals for the course
    a. See attached Table for specific course objectives.
    b. No outcomes evaluated for this course (elective)

7. Topics covered: How and where is catalysis applied: chemical industry, energy sector and environmental protection. Crucial descriptors of catalyst performance: activity, selectivity and stability. Understanding surface catalyzed kinetic mechanisms: Langmuir-Hinshelwood mechanism, rate determining steps, selectivity control and basics of transition-state theory. Structure-function relationships for supported metal catalysts: effect of the metal composition, effect of particle geometry, bimetallic and support effects and transport issues (mass transport and pore diffusion). Synthesis and characterization of supported metal catalysts: classical and emerging synthetic approaches, structural characterization and chemical characterization. Emerging applications: electrocatalysis and photocatalysis.

Contribution of course to meeting the professional component:
This course aims to provide students a general understanding of heterogeneous catalysis, its importance, common applications, governing performance factors, characteristics (compositional and geometric) of heterogeneous catalysts that dictate performance, synthesis and characterization of heterogeneous catalysts, and their emerging applications. An underlying goal of the course is for students to practice and continue to develop technical communication skills (both written and oral). Homework, in-class examples, and the on-going class project develop students' problem solving skills and the ability to apply engineering fundamentals to real world situations. Contemporary issues and emerging technologies are discussed through the use of journal articles and recent literature.

Relationship of course to Student Outcomes: The contribution of CEE 158 to Student Outcomes (1) – (16) is summarized in the objective-Student Outcome matrix table on page 2

Student Objective-Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Understand what an engineering education is and where it can get you What skills do you learn from an engineering degree? How/where can these skills be applied? Career paths (traditional/non-traditional) Higher education										3			3		3	
What skills are required for success in the "real world"? Writing Speaking/communication What type of person are you? Ethics Emotional intelligence										2	3	3			2	
How to get a job/internship Resume/cover letter writing Networking Importance of internships and experience Interviewing skills										3				2		
Preparing for the FE Exam Have a working knowledge of material covered on FE exam Identify weaknesses	2	2	2						2					3		
Understand importance of lifelong learning General importance of continuing education (PE and advanced training) 6 sigma training										3				3		

1. CHE 110A – Chemical Process Analysis – Material Balance

2. 3.0 units, 2 hours lecture, 1 hour discussion

3. Ashok Mulchandani

4. Textbook: *Elementary Principles of Chemical Processes*; Richard M. Felder, R. W. Rousseau, 3rd Edition, John Wiley & Sons, 2000.

5. Specific course information
    a. Catalog: Introduces the principles of conservation of mass in chemical process systems. Topics include the development of steady-state mass balances, and application of mass balances to existing industrial processes.
    b. Pre-requisites: CHEM 001C, MATH 009C, PHYS 040B; or consent of instructor
    c. Required

6. Specific goals for the course
    a. See attached table for specific course objectives
    b. Outcomes 2,6,9,16 are evaluated in this course

7. Topics covered: Introduces the principles of conservation of mass in chemical process systems. Topics include the development of steady-state mass balances, and application of mass balances to existing industrial processes.

Contribution of course to meeting the professional component:
This course serves as an introduction to the chemical engineering, providing the importance of mass balance on process design and analysis. More importantly, practical examples involving different unit operations were provided as an introduction to the chemical engineering industry.

Relationship of course to Student Outcomes: The contribution of CHE 110A to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Introduction to engineering calculations and process variables	3						2			2						
Set up balance equations for non-reactive systems and able to apply them for system analysis and design	3	1	1		2	1	2	1			2					
Set up balance equations for reactive systems and able to apply them for system analysis and design	3	1	1		2	1	2	1			2					
Extend the mass balance analysis to gas phase systems	3	1	1		2	1	2	1			2					
Incorporation of multi-phase systems into the mass balance analysis	3	1	1		2	1	2	1			2					
Setup balance equations for different chemical engineering processes	2		2				2		1							

1. CHE 110B – Chemical Process Analysis – Energy Balance

2. 3.0 units, 2 hours lecture, 1 hour discussion

3. Nosang V. Myung

4. Textbook: Elementary Principles of Chemical Processes; Richard M. Felder, R. W. Rousseau, 3rd Edition, John Wiley & Sons, 2000.

5. Specific course information
   a. Catalog description: Applies principles of conservation of energy to chemical process systems. Topics include the development of steady-state and unsteady-state energy balances, and combined mass and energy balances in industrial processes..
   b. Prerequisite(s): CHE 110A; or consent of instructor.
   c. Required

6. Specific goals for the course
   a. See attached Table for specific course objectives.
   b. Outcomes 3,7, and 16 are evaluates in this course.

7. Brief list of topics to be covered: Multiphase Systems, Introduction to Energy Balance, Energy Balance (Non-reactive Systems), Energy Balance (Reactive Systems), Transient Mass and Energy Balances

Contribution of course to meeting the professional component: This course teaches the application of energy conversion to chemical process systems. Topic includes the development of steady-state and unsteady-state energy balances, and combined mass and energy balances in industrial process. More importantly, practical examples involving different unit operations were provided as an introduction to the chemical engineering industry. The homework assignments are mostly practical problem from textbook.

Relationship of course to Student Outcomes: The contribution of CHE 110B to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Familiarity with and ability to perform unit conversions related to basic fluid properties, fluid statics, and fluid mechanic relationships	2	1		1												
Ability to present solutions, calculations, and results in a logical, readable format	0	1			1	2										
Ability to apply mass balance to multiphase systems	3		3		3		3									2
Ability to apply energy balance to non-reactive systems.	3		3		3		3									2
Ability to apply energy balance to reactive systems	3		3		3		3									2
Ability to solve transient mass and energy balance	3		3		3		3									2

1. CHE 114 – Applied Fluid Mechanics

2. 4.0 units, 3 hours lecture, 1 hour discussion

3. Nosang V. Myung

4. Textbook: Fluid Mechanics for Chemical Engineers, Third Edition Noel de Nevers

5. Specific course information
   a. Catalog description: An introduction to fluid statics, fluid flow, flow of compressible and incompressible fluids in conduits and open-channel flow, flow past immersed bodies, transportation and metering of fluids, and agitation and mixing of liquids. Credit is awarded for only one of CHE 114 or ME 113.
   b. Prerequisite(s): Math 010A, Math 046; or consent of instructor.
   c. Required

6. Specific goals for the course
   a. See attached Table for specific course objectives.
   b. Outcomes 1,3,9, and 13 are evaluates in this course.
7. Brief list of topics to be covered: Properties of Fluids, Fluid Statics, Mass and Energy Balance, The first law of thermodynamics, Bernoulli's Equation (BE), Applications and Limitation of BE, Fluid Friction in Steady, One-Dimensional Flow, Momentum Balance, 1-D, High Velocity Gas Flow, Models, Dimensional Analysis, Dimensionless Number, Pumps, Compressors, and Turbines, Flow through Porous Media, Gas-Liquid Flow, Two- and Three-Dimensional Fluid Mechanics, Potential Flow, The Boundary Layer, Turbulence

Contribution of course to meeting the professional component: This course teaches the fundamental of fluid mechanics for both chemical and environmental engineering students. During the course, fluid statics, fluid flow, flow of compressible, and incompressible fluids in close-channel and open-channel flow, flow part immersible bodies, transportation and metering of fluids, and agitation and mixing of liquid are covered. More importantly, practical examples involving different unit operations were provided as an introduction to the chemical engineering industry. The homework assignments are mostly from practical problem from textbook.

Relationship of course to Student Outcomes: The contribution of CHE 114 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Familiarity with and ability to perform unit conversions related to basic fluid properties, fluid statics, and fluid mechanic relationships	2	1		1									1			
Ability to present solutions, calculations, and results in a logical, readable format		1			1	2	3				1		1			
Ability to apply mass balance and energy balance to appropriate system for design of hydraulic structures	3		3		3				3				1			
Ability to apply Bernoulli's equation to appropriate systems for design of hydraulic structures	3		3		3				3				1			
Ability to apply fluid friction to appropriate systems for design of open and close system	3		3		3				3				1			
Ability to apply differential method for solution of momentum balances with Newton's second law	3		3		3				3							
Ability to derive basic relations such as Hagen-Poisseulle equation from Navier Stokes equations of motion	3		3						3				1			
Understanding of the principals of operation for turbomachinery - pumps, compressors, turbines	2				2								1			
Ability to predict fluid mechanics behavior from tabulated experimental data via plotting, regression analyses, and interpolation/extrapolation	3	2	2		3			3					2			

1. CHE 116 – Heat Transfer

2. 4.0 units, 3 hours lecture, 1 hour discussion

3. Ashok Mulchandani

4. Textbook: Heat Transfer by J.P. Holman Tenth Edition, McGraw Hill

5. Specific course information
    a. Catalog: An analysis of heat transfer for Chemical Engineering and Environmental Engineering majors. Topics include steady- and unsteady-state heat conduction, forced convection, basic radiation heat transfer, and design of heat exchangers.
    b. Pre-requisites: CHE 100, CHE 114; or consent of instructor
    c. Required

6. Specific goals for the course
    a. See attached table for specific course objectives
    b. Outcomes 1,2,4,9, and 16 are evaluated in this course

7. Topics covered: Steady-state conduction-one dimension, Steady-state conduction-multiple dimensions, Unsteady-state conduction, Principles of convection, Empirical and practical relations for forced-convection heat transfer, Natural convection, Radiation heat transfer and Heat exchangers.

Contribution of course to meeting the professional component: The course contributes to the engineering science and engineering design components of the Chemical Engineering and Environmental Engineering curriculum. Students learn the mechanism and calculation of heat transfer by the three modes, and apply them to design heat transfer equipment. The students work on design of a shell-and-tube heat exchanger to perform a specified task. Homework, classroom sample problems, and exams challenge students in their problem solving skills.

Relationship of course to Student Outcomes: The contribution of CHE 116 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ability to identify and evaluate plane wall, radial, and spherical steady state conduction systems	3				3						1					
Evaluation of resistances to heat transfer in composite and finned systems. Composite systems in application to construction design.	3		2		3						1					
Ability to solve heat transfer problems in two dimensional states	3		2		3						2					
Ability to determine transient conduction in planar, cylindrical and spherical coordinates	3		1		3						1					
Understanding and applying fluid mechanics to forced convection heat transfer	3	1	1		3						1					
Understanding heat transfer concepts in free convection and phase changing systems	3	1	1		3						1					
Understanding benefits and limitations of several types of heat exchanger systems	3	2	2		2			1	1	1	2					
Ability to design a heat exchanger system to accommodate specified conditions and provide results in a technical report	3	2	3	1	3	2	3	1	1		3					
Ability to solve heat transfer problems involving radiation	3	1	1		3						1					

1. CHE 117: Separation Processes

2. 4.0 units, 3 hours lecture, 1 hour discussion

3. Xin Ge

4. Textbook: Seader, Henley and Roper, Separation Process Principles – Chemical and Biochemical Operations (3rd Edition), 2010

5. Specific course information
   a. Catalog description: Fundamental concepts and practical techniques for designing equipment based on equilibrium stage processes such as gas-liquid absorption, distillation, liquid-liquid extraction, solid-liquid extraction, humidification, drying, and membrane processes.
   b. Prerequisite(s): CHE 130, CHE 120, CHE 116; or consent of instructor.
   c. Required

6. Specific goals for the course
   a. See attached Table for specific course objectives.
   b. Outcomes 1,2,3, 6,7,15,16 are evaluates in this course.

7. Brief list of topics to be covered: Integration of mass balance, equilibrium, and transport phenomena for separation process design of: (1) Absorption: gas-liquid equilibrium, graphic and algebraic methods for unit analysis and design, number/height of transfer unit, equipment selection and packed column design; (2) Distillation: vapor-liquid equilibrium, McCabe–Thiele theory, stage efficiency, rate-based analysis and batch distillation; (3) Extraction: ternary equilibrium diagram, graphic-based analysis of extractor, equipment and scale-up; (4) Membrane based separation: membrane theory, microfiltation, ultrafiltration, dialysis, reverse osmosis, and selection of membrane equipment; (5) Dryer: psychrometry, moisture content equilibrium, drying periods, dryer models; (6) Overall evaluation of competing separation processes and discussion of special considerations for bioseparations.

Contribution of course to meeting the professional component: This course focuses on the fundamental aspects of separation processes for chemical engineering. The course develops the students' abilities to employ thermodynamics and mass/heat transfer principles for systems design of separation processes in both traditional and non-traditional chemical engineering applications. Homework, in-class examples, and class project using industry designer software develop students' design and problem solving skills to meet specific separation requirements. Contemporary issues, such as recent developments of energy-efficient processes and separation of biofuels etc (journal reprints), are discussed in the class for students to get into the habit of reading, understanding, evaluating and simplifying research publications, a critical set of skills particularly valuable for their careers in the highly dynamic chemical industries.

Relationship of course to Student Outcomes: The contribution of CHE 117 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Broad overview of industrial separation processes. Understand their principles and mechanisms		3	3	1			3							1	2	
Know how to use graphical and numerical techniques to analyze separation processes in terms of the equilibrium stage	3	3	2	1		3	3									
Apply the basic thermodynamic laws to develop phase equilibrium data. Use mass transfer concept for the design of separation units	2	3	2	2		3	2		2							
Acquire basic skills that enable to sizing absorbers, distillation towers, liquid-liquid extraction units (i.e., determine the number of stages, height of packing, dimensions etc.)	3	3	3	2		2	3		2							
Acquire basic knowledge of equipment used in chemical processes		1	2	2			2									
Practice problem solving skills through homework and classroom exercises. Know to how to use correlations, graphs, vendor information etc to estimate the necessary parameters for design of separations units	3	3	2	1			2		2							
Acquire basic knowledge of commercial computer aided design software (SuperPro Designer) for design of separation processes	1	3	3	2			2								3	3
Aware the trends of development in separation processes through the invited lecture and recent research publications													3	2	3	3

1. CHE 118: Process Dynamics and Control

2. 4.0 units, 3 hours lecture, 1 hours discussion

3. Ian Wheeldon

4. Textbook: George Stephanopoulos, Chemical Process Control: An Introduction to Theory and Practice, 1984

5. Specific course information
   a. Catalog description: Fundamentals of process control. Feedback and feedforward control of dynamic processes. Frequency response analysis. Introduction to multivariate control.
   b. Prerequisite(s): CHE 117, CHE 122, ENGR 118; or consent of instructor.
   c. Required

6. Specific goals for the course
   a. See attached Table for specific course objectives.
   b. Outcomes 1,3,4,6,7, and 14 are evaluates in this course.

7. Brief list of topics to be covered: Introduction and fundamentals of process control, modeling chemical processes, linearization of nonlinear systems, solving state equations and Laplace transforms, dynamic behaviors of chemical systems, stability of dynamic chemical processes, stability of chemical process controllers, design of feedback controllers, frequency response analysis, feedforward control.

Contribution of course to meeting the professional component: This course focuses on the fundamental aspects of chemical process dynamics and the control of chemical processes. The course develops the students' ability to understand the dynamic behavior of chemical processes and develops the skills required to create models describing the dynamics of chemical processes. The course develops the students' ability to understand the fundamental aspects of proportional, integral and derivative controllers, and the tuning and implementation of such controllers. Contemporary issues in the application of chemical process control strategies are discussed in class and exercises are given to help translate the knowledge of the fundamentals of chemical process control to applications in the laboratory and in industrial settings.

Relationship of course to Student Outcomes: The contribution of CHE 118 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Analysis and identification of chemical process systems and identification of control aspects			2	1			2	2	2	3	3					
Ability to develop mathematical models of a chemical process based on mass, species mass, and energy balances	3	3	3	2					2							
To solve non-linear mathematical models using linearization and Laplace transforms	3	2	2			2			2							
Application of transfer functions to model input-output chemical process systems	3	3	3	2		2	1		3							
Stability determination of chemical processes and feedback control systems	3	3	3	2		2	2		3	1	1					
Identification of first, second, and third order system behaviors due to disturbances and their associated gains, time constants, and lags	1	1	3	2	1	3	1		1							
Selection of appropriate feedback control strategies for a chemical process (P, PI, PID)	3	1	3	3		1	3		1	1						
Ability to use frequency response analysis to solve for sinusoidal inputs to chemical processes	3	3	3	1		1	3		1	1						
Ability to use MatLab software to solve mathematical models of chemical processes and process control problem of chemical processes	1	1	3	2		3	2	3	2					3		
Ability to work in teams to characterize and develop a control strategy for maintaining a reaction at a stable steady state of a non-ideal reaction system	3	2	3	3		3	3	3	3	2	2	2				

1. CHE 120: Mass Transfer
2. 4.0 units, 3 hours lecture, 1 hour discussion
3. Charles Wyman
4. Textbook: Welty, Wicks, Rorrer and Wilson, Fundamentals of Momentum, Heat and Mass Transfer, 5th edition, John Wiley & Sons, 2008
    a. Supplemental text: Cussler, Diffusion: Mass Transfer in Fluid Systems, 2nd edition, Cambridge University Press, 1997
5. Specific course information
    a. Catalog description: Introduction to analysis of mass transfer in systems of interest to chemical and environmental engineering practice. Explores transport of matter by diffusion, free, and forced convection.
    b. Prerequisite(s): CHE 114 with a grade of "C-" or better, MATH 046; or consent of instructor.
    c. Required
6. Specific goals for the course
    c. See attached Table for specific course objectives.
    d. Outcomes 1,3, 7, 13, 14 are evaluates in this course.
7. Brief list of topics to be covered: This course will introduce mass transfer concepts that are vital to understanding and predicting the behavior of chemical systems. The objective of this course is to develop solid fundamentals that will facilitate the application of students' mathematical, scientific, and engineering skills to analyze chemical reactions systems in an a' priori manner. Introduction to concentrations, velocities, flux; fundamentals of mass transfer; Fick's law; diffusion coefficients; steady-state molecular diffusion; thin film diffusion; stagnant gas film; pseudo-steady-state diffusion; diffusion and reaction; differential equations of mass transfer; the continuity equation; application to wetted wall columns; unsteady-state molecular diffusion theory and examples; convective mass transfer; boundary layer analysis; film theory; penetration and surface theories; interphase mass transfer; two film theory; applications to equipment design.

Contribution of course to meeting the professional component: This course focuses on the fundamental aspects of mass transfer. The course develops the students' ability to apply mathematics and engineering to mass transfer problems; the ability to design engineering system, components, or processes; broad knowledge to understand engineering in a global environment; and the recognition of the need to engage in lifelong learning. Homework, in-class examples, and the class design project develop students design and problem solving skills within given problem constraints.

Relationship of course to Student Outcomes: The contribution of CHE 120 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Understand basic mass transfer theory	3		2													
Understand the importance of mass transfer in chemical and environmental engineering			3				2									
Understand the similarity between heat, momentum and mass transfer	2		3				2									
Know how to calculate diffusion coefficients in liquids and gases	3		2				2									
Know how to solve steady-state and dynamic problems of diffusive mass transfer, with and without reaction	3		3				2									
Understand the theory and applications of convective mass transfer	3		2				3									
Understand the theory and applications of interphase mass transfer	2		3				3									

1. CHE 122: Chemical Engineering Kinetics

2. 4.0 units, 3 hours lecture, 1 hour discussion

3. Akua Asa-Awuku

4. Textbook: Levenspiel, O., Chemical Reaction Engineering, John Wiley & Sons, Inc.
    a. other supplemental materials: Fogler, H. Scott, Elements of Chemical Reaction Engineering, Prentice Hall
    b. Handouts

5. Specific course information
    a. Catalog description: Introduction to homogeneous and heterogeneous kinetics and reactor design for chemical and bio-chemical processes engineering. Experiments cover physical measurements, fluid mechanics, and mass transfer. Principles, modeling, and design of systems for atmospheric emission control of pollutants such as photochemical smog and by-products of combustion. Effects of air pollution on health.
    b. Prerequisite(s): MATH 10A, MATH 046, CHE 110A; or consent of instructor.
    c. Required course

6. Specific goals for the course
    a. See attached Table for specific course objectives.
    b. Outcomes 1,2,4,7 and 9 are evaluated in this course.

7. Brief list of topics to be covered: : In this course, we will develop an understanding of the fundamentals (e.g., mole balances, rate laws, stoichiometry, energy balances, and diffusion) of chemical reaction engineering and reactor design. We will then apply these basic ideas to solve a wide range of chemical reaction problems involving collection and analysis of reaction data, multiple reactions, chemical and biochemical reactions, steady state and unsteady state heat effects, multiple reactions with heat effects, homogenous reactions, reaction mechanisms, residence time distribution effects, and nonideal reactors.

Contribution of course to meeting the professional component: This course focuses on the fundamental aspects of chemical kinetics engineering. Homeworks, in-class examples, and the class design project develop students design and problem solving skills within given problem constraint. Emphasis is placed on developing skills to analyze reactions and reactors based on fundamental principles and not in applying a formulaic approach to analysis and design. This approach provides sufficient flexibility to handle the wide range of situations that are likely to be encountered in reaction analysis and reactor engineering beyond the classroom experience. Real-world kinetics applications are discussed from scientific literature (journal reprints) are discussed and presented in the class.

Relationship of course to Student Outcomes: The contribution of CHE 122 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Understand key kinetics and reaction engineering terms (e.g., equilibrium, reaction rate, fractional conversion, reaction order, elementary reaction, batch reactor, plug flow reactor (PFR), continuous stirred tank reactor (CSTR), residence time distribution)	3	3	3	3			3	2	3				3	2	2	1
Apply thermodynamic data (e.g., Enthalpy, and Gibbs Free Energy) at different temperatures to obtain equilibrium constants for kinetics based calculations	3	3	3													
Derive reaction rate expressions from experimental data and verify proposed reaction mechanisms.	3	3	3	1		2						1		2	1	
Solve multi-reaction and multi-reactor based problems in parallel and series configurations	3	3	3	2			2	2				1	1		1	
Apply ideal Batch, PFR, and CSTR design equations for reaction design, sizing, and conversion predictions for ideal isothermal and non-isothermal systems	3	3	3	3			3	3	3			1	2		2	1

1. CHE 124– Biochemical Engineering Principles

2. 4.0 units, 3 hours lecture, 1 hour discussion

3. Ashok Mulchandani

4. Textbook: Biochemical Engineering by J.M. Lee

5. Specific course information
   a. Catalog: Examines the principles of biochemical engineering. Topics include kinetics of enzymatic reactions and microbial growth, batch and continuous culture reactors, product formulation, and nutrient utilization. Also studies oxygen transfer, bioreactor scale-up, air and media sterilization, fundamentals of bioreactor design, and bioseparations.
   b. Pre-requisites: BCH 110A, BIOL 121/MCBL 121 (BIOL 121/MCBL 121 may be taken concurrently), CHE 120, CHE 122; or consent of instructor.
   c. Selected Elective

6. Specific goals for the course
   a. See attached table for specific course objectives
   b. Outcomes

7. Topics covered: Kinetics of enzyme reactions, Application of enzyme kinetics to design batch and continuous enzyme reactors, Kinetics of immobilized enzymes, Microbial growth, substrate consumption and product formation kinetics, Application of microbial kinetics to design batch and continuous bioreactors, Design and scale-up of stirred tank reactors and Design of liquid and air sterilizers.

Contribution of course to meeting the professional component: The course contributes to the engineering science and engineering design components of the Chemical Engineering and Environmental Engineering curriculum. Students learn of enzyme and microbial kinetics and apply the knowledge to design of batch and continuous enzyme and microbial reactors. Additionally, the course integrates the concepts of momentum, mass and heat transfer into design and scale-up of stirred tank bioreactors and design of liquid and air sterilizers. Homework, classroom sample problems, and exams challenges students in their problem solving skills.

Relationship of course to Student Outcomes: The contribution of CHE 124 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Knowledge of basics of biology, workings of cells and metabolic pathways and identify microorganisms and enzymes used in bioprocessing technologies	2			2			2		1							
An ability to choose and apply simple models of enzyme kinetics, formulate kinetic models based on given reaction sequence and determine kinetic parameters	3	2			3											
An ability to set-up design equations and apply them for batch and continuous enzyme reactors design - sizing or conversion	3		3		3											
An ability to apply simple models of cell growth kinetics and determine kinetic parameters	3	2			3											
An ability to set-up design equations and apply them for batch, chemostat, fed-batch and recycle microbial bioreactors design - sizing or conversion	3		3		3											
An ability to apply chemical engineering principles of momentum, mass and heat transfers, kinetics and thermodynamics in the design and scale-up of bioreactors and design sterilizers	3	2	3		3											
An ability to research the literature for a given topic in the area of biotechnology and report in oral and written form	1			2			3		1	2						

1. CHE/ ENVE 130: Advanced Engineering Thermodynamics

2. 4.0 units, 3 hours lecture, 1 hour discussion

3. Jianzhong Wu

1. Textbook: J. M. Smith, H. C. Van Hess, M. M. Abbott, Introduction to Chemical Engineering Thermodynamics, 7th Ed. (2005) McGraw-Hill.
    a. Recommended texts: Stanley I. Sandler, Chemical, Biochemical, and Engineering Thermodynamics, 4rd Edition (2005), John Wiley & Sons (Chapters 8-15); B.G. Kyle, Chemical and Process Thermodynamics, 3rd edition (1999) Prentice Hall (Chapters 9-17)

5. Specific course information
    a. Catalog description: Advanced study of chemical thermodynamics and their applications to chemical and environmental engineering processes. The class applies principles for the thermodynamic behavior of pure solutions and mixtures, phases, and chemical equilibria for homogeneous and heterogeneous systems to a variety of processes common to chemical and environmental engineering. Cross-listed with ENVE 130.
    b. Prerequisite(s): CHE 100
    c. Required course

2. Specific goals for the course
    a. See attached table for specific course objectives
    b. Outcomes 2,6,9, and 16 are evaluated in this course

7. Brief list of topics to be covered: Ideal Vapor-Liquid Equilibrium; Fugacities of Vapor and Liquid; Thermodynamics of Mixing and Partial Molar Properties and Auxiliary Functions for Phase and Chemical Equilibria; Excess Gibbs Energy Models; Applications of VLE in Chemical and Environmental Engineering; Solubility and Enhancement factor; Solution Thermodynamics ; Fluid-Solid Equilibrium and Freezing Point Depression; Osmotic Equilibrium; Chemical Equilibrium for Single Chemical Reaction; Multireaction Equilibrium and Combined Chemical and Phase Equilibrium

Contribution of course to meeting the professional component: Upon completion of this course, students will be able to apply the thermodynamics laws to flow processes, fluid-phase equilibrium, and chemical-reaction equilibrium. They will also able to evaluate the properties of pure fluids and fluid mixtures and use them in fluid- phase equilibrium and in mixing processes

Relationship of course to Student Outcomes: The contribution of CHE/ENVE 130 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table
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Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Item	STUDENT OUTCOME-RELATED LEARNING OBJECTIVES	OUTCOMES													
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	Understand the practical relevance of phase/chemical equilibrium	2		3				1	2			1			
2	Ideal Models of Vapor-Liquid Equilibrium	3				2		1				1			
3	Thermodynamics of Mixing and Partial Molar Properties and Auxiliary Functions for Phase and Chemical Equilibrium	3				2		1				1			
4	Fugacity and Excess Gibbs Energy Models	3	2			2		1				1			
5	Phase Equilibrium and Partial Miscibility	3				2		1				1			
6	Ideal Solubility and Enhancement factor	3				2		1				1			
7	Freezing Point Depression and Osmotic Equilibrium	3				2		1				1			
8	Chemical Equilibrium for Single Chemical Reaction	3				2		1				1			
9	Chemical Equilibrium for Multiple Chemical Reactions	3				2		1				1			
10	Multireaction Equilibrium and Combined Chemical and Phase Equilibrium	3				2		1				1			
	SUBTOTALS	**29**	**2**	**3**	**0**	**18**	**0**	**10**	**2**	**0**	**0**	**10**	**0**	**0**	**0**

1. ENGR 118: Engineering Modeling and Analysis
2. 5.0 units, 4 hours lecture, 1 hour discussion
3. Kawai Tam
4. Textbook: Numerical Methods for Engineers, by S.C. Chapra and R.P. Canale, 6th ed, McGraw Hill, 2010.
    a. Optional software: MATLAB latest student version (can be purchased on-line from www.mathworks.com in the Academia menu tab)
5. Specific course information:
    a. Catalog description: Covers the formulation of mathematical models for engineering systems. Includes applying mass, momentum, and energy balances to derive governing differential equations; solving equations with the use of spreadsheets and other software packages; and fitting linear and nonlinear models to experimental data.
    b. Prerequisite(s): CHEM 001A or CHEM 01HA; CS 010 or 030; MATH 046; PHYS 040B; or consent of instructor.
    c. Required
6. Specific goals for the course
    a. See attached Table for specific course objectives.
    b. Outcomes 1, 6, 9, 16 are evaluated in this course.
7. Brief list of topics covered: Development of mathematical models based on conservation laws, programming logic using flowcharts and MATLAB programming language, application of Excel for solving of mathematical models, application of Taylor's series, solving of roots of equations using bracketing and open methods, solving of multiple roots, systems of non-linear equations, and linear algebraic equations, sample and population statistics (mean, standard deviation, coefficient of variation, and variance, normal distribution and confidence intervals), student t-test, z-test, curve fitting (least squares regression), interpolation (linear, polynomial), Lagrange interpolation, spline interpolation, Newton-Cotes integration formulas, multiple integrals, numerical differentiation using high-accuracy formulas, Runge-Kutta methods for simple and systems of equations including Euler, Heun and Fourth-Order Runge-Kutta.

Contribution of course to meeting the professional component:
This course focuses on providing students with the tools to readily create and solve mathematical models using numerical methods. The ability to determine transient behavior of processes and systems is paramount in industry (start up and shut down of processes) and in modeling of the environment. Learning is done through examples provided in class, homework assignments, and a class project where students work in teams of 3 or 4 students and model the salinity and water level of the Salton Sea in California over 50 years given the existing environmental issues. The project requires extensive programming and modeling using MATLAB. The Salton Sea is a real-world and current problem in California which integrates contemporary issues and the discussion of ethical and professional responsibilities to act.

Relationship of course to Student outcomes: The contribution of ENGR 118 to Student Outcomes (1) – (16) is summarized in the objective-Student Outcome matrix table below

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Ability to use various bracketing and open numerical methods to solve for roots of linear, nonlinear functions, and system of equations	3		2			1										
Ability to use matrix based numerical methods including Naïve Gauss elimination, LU decomposition and inverse matrices for obtaining roots of complex equations	3		1			2										
Formulating mathematical models for mass, momentum, and energy balances	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3
Understanding of the relationship between statistics and curve fitting and the ability use appropriate numerical techniques to curve fit or perform interpolation	3					2	2	2	3	1				1		
Understanding of approximations and round-off errors in relationship to numerical methods	3		1			2										
Application of optimization to case studies with use of Solver in Excel	3	2	3	2		3	2									3
Ability to solve integral equations using Newton-Cotes integration formulas (trapezoidal, Simpson's rules)	3	2	3	3		3	2	2	3							3
Ability to use Euler's and Runge-Kutta methods to solve ordinary differential equations and system of equations	3		2			2	2	2	3							3
Ability to research a design problem and apply numerical methods and/or curve fitting to solve or determine trends from raw data	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3
Use of Excel and MATLAB to compute numerical methods	3		3			3										3

1. ENVE 120: Unit Operations and Processes in Environmental Engineering

2. 4.0 units, 3 hours lecture, 1 hour discussion

3. Mark Matsumoto

4. Textbooks: (1) Water Treatment: Principles and Design, 2nd edition, Montgomery Watson Harza MWH), John Wiley & Sons, 2005. (2) Unit Operations and Processes in Environmental Engineering, 2nd edition, Reynolds, T.D. and P. Richards, PWS Publishing Co., 1996. (3) Theory and Practice of Water and Wastewater Treatment, Droste, R.L. John Wiley & Sons, 1997.

   Supplemental Textbooks: (1) Wastewater Engineering: Treatment and Reuse, 4th ed, Metcalf & Eddy, Inc. , McGraw-Hill Book Co., 2003. (2) Water Quality: Characteristics, Modeling, Modification, Tchobanoglous, G. and E.D. Schroeder, Addison-Wesley Publishing Co., 1985.

5. Specific course information

   a. Catalog description: Fundamentals of physicochemical unit processes used in environmental engineering. Addresses coagulation and flocculation, sedimentation, filtration, adsorption, redox processes, and heat and mass transfer processes.
   b. Prerequisite(s): CHE 120, or ENVE 133; or consent of instructor.
   c. Selected elective

6. Specific goals for the course
   a. See attached Table for specific course objectives.
   b. Outcomes 1, 3-4, 6-7, 9, and 15 are evaluated in this course.

7. Brief list of topics to be covered: Review of water quality characteristics, aquatic chemistry, reaction kinetics and reactor analysis. Coagulation/flocculation, sedimentation, granular-medium filtration, membrane filtration, disinfection processes (chlorination, ozonation, uv disinfection), adsorption, chemical redox, reverse osmosis.

Contribution of course to meeting the professional component: This course focuses on unit operations and processes used in municipal water treatment and wastewater treatment systems. Treatment mechanism principles, design and operation criteria, and process flowsheet integration are covered.

Relationship of course to Student Outcomes: The contribution of ENVE 120 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Understand the purpose and mechanisms associated with the unit operations and processes listed below and their typical placement in a municipal water treatment system.			2	2			2		2						3	
Ability to perform basic calculations to specify typical design parameters, operating condition, and appropriate chemical dosages (if appropriate) • Coagulation/flocculation • Sedimentation • Granular-medium filtration • Membrane filtration • Disinfection – chlorination, ozone, UV irradiation • Activated carbon adsorption • Chemical oxidation/reduction • Precipitation (softening and metals) • Ion exchange • Reverse osmosis	2		3	3		2	3		3						2	

1. ENVE 121: Biological Unit Process
2. 4.0 units, 3 hours lecture, 1 hour discussion
3. Hosik Park
4. Textbook: Wastewater engineering: Treatment and reuse (4th edition), Metcalf & Eddy, McGraw-Hill
5. Specific course information
    a. Catalog description: 1) To introduce fundamentals of the wastewater treatment plants and their unit operations and processes. 2) To provide basic design skills and knowledge on the wastewater treatment plants and their unit operations and processes
    b. Prerequisite(s): Environmental chemistry, Environmental biology.
    c. Selective Elective
6. Specific goals for the course
    a. See attached Table for specific course objectives.
    b. Outcomes 1-5 are evaluates in this course.
7. Brief list of topics to be covered: 1) Great concern for the long term health and environmental impacts of wastewater constituents. 2) Improved techniques for the characterization of wastewater. 3) Improved fundamental understanding of unit operations and processes used for wastewater treatment (i.e., a) mixing and flocculation, b) basics of biological treatment, c) Suspended growth, attached growth, combined biological treatment processes), 4) Advanced water treatment process, 5) Disinfection theory.

Contribution of course to meeting the professional component: This course focuses on the fundamental aspects of wastewater treatment based on the biological processes. The course develops the students ability to understand the chemistry and physics behind wastewater treatment, provides the key knowledge needed for design of unit processes for wastewater treatment. Specifically, this course provide the students ability to understand 1) wastewater characteristics and analytical approaches for characterization of wastewater, 2) mathematical models for biological treatment based on mass balances and reaction kinetics, 3) Knowledge of conditions favorable for biological organic carbon removal, nitrification/denitrification, and phosphorus removal, as well to enhance 4) the ability to formulate and utilize mathematical models for biological treatment based on mass balances and reaction kinetics, and 5) Enhance the ability to select appropriate design parameters and perform calculations necessary for the preliminary design of suspended growth biological processes (activated sludge). Homework, in-class examples develop students design and problem solving skills within given problem constraints.

Relationship of course to Student Outcomes: The contribution of ENVE 121 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Understand the key wastewater constituents in relation to environmental impact, and biological process operation		3							3	2	1		2			
Wastewater characteristics and analytical approaches for characterization of wastewater (i.e., BOD, ThOD, COD, SS, Alk, Hardness and so on)	3	2	3	2	2	1										
Understand the fundamentals of biological growth mechanism and knowledge of conditions favorable for biological organic matters.	3	2	3				3									
Improved fundamental understanding of unit operations and processes used for wastewater treatment (i.e., a) mixing and flocculation, b) basics of biological treatment, c) Suspended growth, attached growth, combined biological treatment processes	3	2	3	3	3	2	3		2							
Enhance the ability to select appropriate design parameters and perform calculations necessary for the preliminary design of suspended growth biological processes	3	2	2	3	2	1	3		3							

1. ENVE 133: Fundamentals of Air Pollution Control Engineering

2. 4.0 units, 3 hours lecture, 1 hour discussion

3. David Cocker

4. Textbook: Seinfeld and Pandis, Atmospheric Chemistry and Physics - From Air Pollution to Climate Change (2nd Edition), 2006

5. Specific course information
    a. Catalog description: Principles, modeling, and design of systems for atmospheric emission control of pollutants such as photochemical smog and by-products of combustion. Effects of air pollution on health.
    b. Prerequisite(s): CHE 114, CHEM 112B, ENVE 171; or consent of instructor.
    c. Selective elective

6. Specific goals for the course
    a. See attached Table for specific course objectives.
    b. Outcomes 1-4, 15 are evaluates in this course.

7. Brief list of topics to be covered: Air pollution terminology, national and state air quality standards, air pollutants and their adverse health effects (toxicity, carcinogenicity, visibility, etc.), adiabatic lapse rate, temperature inversions, basic structure of atmosphere, potential temperature, semi-empirical atmospheric diffusion equation, Gaussian dispersion, plume rise, averaging times, plume trapping, wind-rose, wind speed as a function of height, point/line/area sources and dispersion, definitions of particulate matter, measurement of particulate matter, particulate size distributions, sources of ultrafine/fine/course particulate matter, secondary organic aerosol, ozone formation, alkene/alkane/aromatic/carbonyl atmospheric chemistry, kinetic rate expressions, ozone and NOx measurement, sources of and control strategies for ozone and particulate matter, indoor air quality, sick building syndrome, radiative forcing, stratospheric ozone depletion.

Contribution of course to meeting the professional component: This course focuses on the fundamental aspects of air quality control engineering. The course develops the students ability to understand the chemistry and physics behind atmospheric pollution formation and atmospheric dispersion, provides the key knowledge needed for design of air quality control programs; relates local and regional emissions to air quality degradation including ozone formation, particulate matter (primary and secondary), and visibility. Homework, in-class examples, and the class design project develop students design and problem solving skills within given problem constraints (e.g., cost). Contemporary issues from scientific literature (journal reprints) and news media outlets (typically local newspaper articles on air quality in Southern California) are discussed in the class in terms of control/mitigation strategies, air quality pollution control engineering and human health and welfare.

Relationship of course to Student Outcomes: The contribution of ENVE 133 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Define air pollution, aerosol, primary and secondary pollutant, and familiarity with NAAQS, identify sources of and health effects for ozone, NOx, SOx, particulate matter, and formaldehyde. Be able to identify and classify a number of critical air pollutants including sulfur, nitrogen and carbon containing species, photochemical oxidants, halogen containing compounds and air toxics.		2	1													
Describe the vertical profile of the atmosphere. Understand the driving forces for temperature versus altitude for troposphere, mesosphere, stratosphere, and thermosphere. Be able to discuss thermal structures in atmosphere including adiabatic lapse rate (wet and dry), potential temperature, identification of inversion layers, vertical mixing.	2	2	2													
Familiarity with the semi-empirical atmospheric diffusion equation, eddy correlations, and its application to atmospheric dispersion processes.	3		3						1							
Estimate ambient concentrations from point, line and area sources. Estimate wind variation with altitude and plume rise. Account for ground reflection, inversion heights, and multiple sources. Use of atmospheric box models to predict ambient concentrations.	3		3				1		2							
Derive the photostationary state. Describe basic VOC-NOx interactions and their impact on ozone formation. Ability to predict atmospheric oxidation routes for alkanes, alkenes, carbonyls, and to a lesser extent aromatics including importance of hydroxyl and nitrate radicals, ozone, hydroperoxy and ROO. radicals in ozone formation. Ability to read ozone isopleth curves, causes of VOC and NOx limited regions, and understanding of the NOx-VOC interplay for ozone formation. Write basic chemical kinetic expressions to describe atmospheric chemistry.	3	3	3				2		2							
Explain the sources of atmospheric particulate. Familiarity with size, area, and volume distribution curves, calculate terminal settling velocities, impact of particles on visibility, Understand PM10, PM2.5, PM1 and the sources of each. Discuss secondary aerosol including secondary organic aerosol formation.	3	2	2		2		1		1							
Discuss possible control strategies for PM and O3	2	2	3		2		2		2				3			
Discuss concerns with Indoor Air Quality including the Sick Building Syndrome; relationship of outdoor to indoor pollutants	1		2													
Global air quality issues. Discuss causes of global warming/cooling and potential atmospheric implications. Describe processes leading to the Antarctic ozone hole.	2	1	1		1						1		3	2		
Work together as a design team to estimate the impacts of expanding urban development on local air quality. Impacts must include cost/benefit analysis and ethical/environmental justice considerations. Present findings in written and oral report.	3	1	3	3		3	3	3	3	2	2	3	2	3	3	

1. ENVE 134: Fundamentals of Air Pollution Control Engineering
2. 4.0 units, 3 hours lecture, 1 hour discussion
3. Wayne Miller
4. Textbook: **Air Pollution Control Technology:** ***A Design Approach;*** Authors: C. David Cooper and F. C. Alley; **Fourth Edition;** Waveland Press, Inc.
    - Original journal articles related to the development of equations used for the design of air pollution control technologies.
    - Supplemental materials from EPA's Air Pollution Training Institute
    - Perry's Chemical Engineering Handbook (electronic book)
    - Supplemental materials from current industrial catalogues
5. Specific course information
    a. Catalog description: Processes and design of control technologies for gaseous and particulate pollutants. Methods and design of ambient air quality measurements and for both gaseous and particulate pollutants
    b. Prerequisite(s): CHE 133 or consent of instructor.
    c. Selected Elective
6. Specific goals for the course
    a. See attached Table for specific course objectives.
    b. Outcomes 1-4, 15 are evaluates in this course.
7. Brief list of topics to be covered: Background on the development of State Implementation Plans (SIP) and concept of air carrying capacity using Los Angeles air basin as an example of the need for air pollution controls. Review of the physical and chemical properties of particulate matter. Review of physical processes associated with the movement of particles; for example, gravity, impaction and others. Coverage of the unit operations associated with control of particulates beginning with the physics of the approach; leading to the application of engineering data in the unit operation. Review of classic journal articles on the engineered control process. Similar approach with the control of gases. Some discussion of examples about the life of a project and profitability. Coverage of the use of ambient monitors and Continuous Emission Monitors during visit to a power plant using CEMS and SCR for NOx control. Students to prepare a presentation to teach their classmates about a current topic of air pollution control.

Contribution of course to meeting the professional component: This course provides the student with a fundamental understanding of the nature of the driving forces that can be used to remove particles and gases from an industrial exhaust and the application of these principles in the design of economical processes to remove them. The course is aimed at enhancing the student's ability to apply concepts and use engineering judgment in selecting the most profitable air pollution control. Homework, in-class examples, and the class project develop student design and problem solving skills within given problem constraints (e.g., cost). Providing a class on a current control topic to their classmates improves communication skills. Contemporary issues from the literature (both journal and industrial reporting) and news media outlets are discussed in class in terms of new problems and emerging control technologies.

Relationship of course to Student Outcomes: The contribution ENVE 134 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Understand the basic motivation and need for Air Pollution Controls. Review the concept of Air Basin carrying capacity using the air quality model generated for 2023 in the Los Angeles area.							2						2		3	
Review the fundamentals associated with heat and mass balances using homework problems. Review the fundamentals of particle number, mass and particle size distribution.	2		3													
Understand the fundamental forces acting on particles and how to use this theory in designing a process to remove particles from a gas stream.			3													
Review the basic journal articles where the engineering understanding and data were developed for the equations used the text book. Discuss the differences between the fundamental theory and the applicable engineering equations.			3		1	2										
Review the process design equations used for calculating the removal of particulate from air by: gravity (settling), cyclones, electrostatic precipitators, fabric filters and scrubbers.			2	3			2									
Discuss the design and application of particulate removal from gases using the commercial fluid catalytic cracker as an example, including the newly invented cyclone technology for the third stage cleaning. Discuss the new processes using charged droplets to remove ultrafine PM.				3			2									
Review the principles of project engineering including the accounting and engineering paths. Using Perry, discuss the various phases of the engineering project and the associated confidence limits for the project cost at each phase. Discuss the differences between Capital cost and Operating cost and the depreciation link.			3												2	
Discuss parameters associated with gaseous scrubbing and review the mass transfer concepts associated with the HTU and number of stages. Work practical examples.			3				2									
Review the air pollution control technologies applied to mobile sources and control of carbon sources. .			2										3		3	
Present a seminar on a real air pollution problem and your design for control; include all options for control and their associated cost.			2				2					3				

1. CHE/ENVE 160A: Chemical and Environmental Engineering Laboratory I

2. 3.0 units, 6 hours laboratory, 3 hours written work

3. Ian Wheeldon

4. Textbook: none
   a. CEE Department UCR, Chemical & Environmental Engineering Laboratory I Lab Manual, 2012 Edition

5. Specific course information
   a. Catalog description: Involves laboratory exercises in chemical and environmental engineering. Experiments cover physical measurements, fluid mechanics, and mass transfer. Emphasizes experimental design, analysis of results, and preparation of engineering reports.
   b. Prerequisite(s): CHE 114, CHE 120.
   c. Required

6. Specific goals for the course
   a. See attached Table for specific course objectives.
   b. Outcomes 5,6,8,11,12, and 14 are evaluates in this course.

7. Brief list of topics to be covered: Mass transfer of oxygen in aqueous solutions, mass transfer of acetone in air, headloss and friction in pipe flow; wetted wall experimental apparatus, Arnold cell experimental apparatus, aeration stirred tank experimental apparatus, and pipe flow headloss measurement experimental apparatus; writing and oral presentation of engineering reports, laboratory preparation and experimental protocol development.

Contribution of course to meeting the professional component: This course focuses on the experimental aspects of fluid mechanics and mass transfer. The course develops the students' ability to prepare for, safely conduct, and generate reports on laboratory experiments. The course develops the students' ability to understand the translation of fundamental aspects of fluid mechanics and mass transfer developed in the prerequisite course to the practical application in industrially relevant unit operations. Laboratory safety is discussed and continually emphasized. Emphasis is placed on the developing the students' ability to generate written and oral engineering reports.

Relationship of course to Student Outcomes: The contribution of CHE/ENVE 160A to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table
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Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Relate phenomena and theories learned in courses on fluid mechanics and mass transport to processes, practices and apparatuses utilized as a professional chemical or environmental engineer	1	3	3	1	2	2	1	3	1							
Develop pre-lab write-ups prior to experimentation that contain an appropriate review of the relevant theory and equations to be applied in laboratory practice	1	3	3	3	3	1	3	3	3	1	1	3				
Develop a hypothesis that can be tested through laboratory experimentation to achieve a specific experimental objective		3	3		1				3							
Develop experimental protocols for data collection (i) to test a scientific hypothesis and (ii) to achieve specific experimental objective		3	3	3	2	1	1	1	3							
Observe, understand, and explain sources of experimental errors	3	3	3			3										
Observe, understand, and explain phenomena associated with mass and fluid transport from experimental data	3	3	3			3			1							
Perform data analysis, present key data in clear and illustrative graphical and tabular form, and concisely discuss key results obtained from data analysis	2	1	1		1	3		3				3				
Make recommendations that can be used to improve future experimental procedures		2	2	3		3		1		1		3		3		
Write technical laboratory reports in a professional format representative of publications in science and technology journals	1	1	1			3		3		2	2	3		3		
Prepare effective oral presentations that discuss the key theory, experimental methods, and results explored during the laboratory session, as well as draw appropriate scientific conclusions supported by the data collected in laboratory	1	1	1			3		3		2	2	3		3		

1. CHE 160B: Chemical Engineering Laboratory
2. 3.0 units, 6 hours laboratory work, 3 hours written work
3. Akua Asa-Awuku
4. Textbook: None
    a. Supplemental documents:
        a. CHE 160B Laboratory Manual
        b. Levenspiel, O., Chemical Reaction Engineering, John Wiley & Sons, Inc.
        c. Fogler, H. Scott, Elements of Chemical Reaction Engineering, Prentice Hall
        d. Incropera, F.P., and DeWitt, D.P., Fundamentals of Heat and Mass Transfer, John Wiley & Sons, New York
        e. Strunk and White, Elements of Style, http://www.bartleby.com/141/
5. Specific course information
    a. Catalog description. Consists of laboratory exercises in chemical engineering. Includes experiments in physical measurements, heat transfer, reactor analysis, and chemical kinetics. Emphasis is on experimental design, analysis of results, and preparation of engineering reports
    b. Prerequisite(s): CHE 116, CHE 122; or consent of instructor.
    c. Required course
6. Specific goals for the course
    a. See attached Table for specific course objectives.
    b. Outcomes 1-6, 8, 10, 12, 14, 15 are evaluates in this course.
7. Brief list of topics to be covered: The course, Chemical Engineering Laboratory II, CHE 160B is the second in a series of three laboratory courses required of all Chemical Engineering majors. The topics of this course: 1) reinforce concepts learned in previously taken lecture courses (heat transfer and kinetics; CHE 116 and CHE 122) 2) provide students with hands-on experience in collecting design and operating data from engineering systems, 3) begin to challenge students in planning and conducting experiments to obtain relevant data needed for proper design and operation of chemical engineering systems, and 4) give students an opportunity to practice and improve their technical writing and oral presentation skills.

Contribution of course to meeting the professional component:
This course focuses on applying hands on experiences to the fundamental aspects of chemical engineering concepts learned in previous courses. The laboratory assignments are comprehensive and student groups are kept small to facilitate involvement. Students are also required to apply 160B knowledge and techniques to the real world and commonly used devices and design and execute experiments to generate data. Student's characterize a commonly used heat transfer or kinetics reactor device, devise simple experiments to safely measure heat transfer or reaction kinetic parameters. Students then analyze, compare measurements to theory, evaluate efficiency/effectiveness of the device and suggest measures to improve design parameters. A cost analysis is also included.

Relationship of course to Student Outcomes: The contribution of CHE 160B to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table
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Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Reinforce laboratory skills and technical concepts learned in previously taken courses	3	3	3		3	2	1		1	1			1	2	1	2
Provide students with experience in collecting and analyzing data from chemical engineering modules in heat transfer and kinetics and reactor design.	3	3	3			3	2		1		2			1		3
Challenge students in planning, conducting, and designing experiments to obtain relevant data needed for proper design and operation of heat transfer and kinetics and reactor systems				3	3	3	3		2	2	2		2	2	3	
Provide student opportunities to practice and improve technical writing and oral presentation skills								2		3	2	3				2
Provide students with collaborative experiences in team-building and leadership								3		1	1	3				2

1. CHE 160C: Chemical Engineering Lab III

2. 3.0 units, 6 hours laboratory, 3 hour written works

3. Xin Ge

4. Textbook: Chemical Engineering Laboratory III Lab Manual, 2012

5. Specific course information
    a. Catalog description: Consists of laboratory exercises in chemical engineering. Includes experiments and simulations in separation processes and in process control. Emphasis is on experimental design, analysis of results, and preparation of engineering reports.
    b. Prerequisite(s): CHE 117, CHE 118 (CHE117 and CHE118 may be taken concurrently), CHE 122.
    c. Required

6. Specific goals for the course
    a. See attached Table for specific course objectives.
    b. Outcomes 4,5,6,8,12,14,15 are evaluates in this course.

7. Brief list of topics to be covered: Five separation/process control experiments with two additional open-ended labs covering tried dryer, distillation, liquid-liquid extraction, liquid-gas absorption, and liquid temperature/level controller. Prior to each lab: review relevant theories, specify experimental objectives, understand apparatus operation, and develop concise and step-by-step experimental plans. During labs: conduct experiments, explain experimental phenomena, and collect data. After experiments: preform data analysis, extract the key results, and discuss by lab reports and group-based oral presentation. Additional coverage for open-ended labs: identify environmental benign solvents (to replace the usage of methylene chloride), design an extraction-distillation integrated separation process for solvent recycle, design experimental procedures and optimize operation parameters, present lab design and discuss how to improve.

Contribution of course to meeting the professional component: This course focuses to deepen students understanding of separation and process control principles by experiments. At the end of the course, students acquire the ability to design and efficiently conduct laboratory, analyze results and present in written and oral forms. Open-ended labs develop students design and problem solving skills within the given problem constraints (*e.g.* development of eco-friendly processes). With contemporary issues (sustainable chemical processes) in mind and trained with the skills to adapt to new needs, students will definitely benefit from these problem-solving experiences for their future career in either industry or academia.

Relationship of course to Student Outcomes: The contribution of CHE 160C to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Broad overview of industrial separation processes. Understand their principles and mechanisms		3	3	1			3							1	2	
Know how to use graphical and numerical techniques to analyze separation processes in terms of the equilibrium stage	3	3	2	1		3	3									
Apply the basic thermodynamic laws to develop phase equilibrium data. Use mass transfer concept for the design of separation units	2	3	2	2		3	2		2							
Acquire basic skills that enable to sizing absorbers, distillation towers, liquid-liquid extraction units (i.e., determine the number of stages, height of packing, dimensions etc.)	3	3	3	2		2	3		2							
Acquire basic knowledge of equipment used in chemical processes		1	2	2			2									
Practice problem solving skills through homework and classroom exercises. Know to how to use correlations, graphs, vendor information etc to estimate the necessary parameters for design of separations units	3	3	2	1			2		2							
Acquire basic knowledge of commercial computer aided design software (SuperPro Designer) for design of separation processes	1	3	3	2			2								3	3
Aware the trends of development in separation processes through the invited lecture and recent research publications													3	2	3	3

1. CHE 161 Nanotechnology Processing Laboratory

2. 3.0 units, 6 hours laboratory, 3 hours written work

3. Nosang V. Myung

4. Textbook: Chemical Engineering Laboratory Manual 161 (N. V. Myung (eds), Sylvia Lee, Hyunsung Jung, Chong-Hyun Chang, Nicha Chartuprayoon, Carlos Hangarter, Sandra Hernandez, Syed Mubeen)

5. Specific course information
    a. Catalog description: An introduction to growth and characterization techniques that involve nanomaterials and devices. Includes preparing thin films; synthesize of gold and CdS nanoparticles, synthesizing carbon nanotubes, synthesizing alumina nanotemplates, synthesizing gold and nickel nanowires, and assembling of nanowires. Also including imaging samples with optical, scanning electron microscope, scanning tunneling microscope, and atomic force microscope.

    b. Prerequisite(s): CHE 100 or consent of instructor.
    c. Selected Elective

6. Specific goals for the course
    a. See attached Table for specific course objectives.
    b. Outcomes 5,6,8 are evaluates in this course.

Brief list of topics to be covered:

Experiment #1. Synthesis of gold nanostructures using amino acid
Experiment #2. AC dielectrophoretic assembly of single-walled carbon nanotubes
Experiment #3. Single-walled carbon nanotube sensor for ammonia gas detection
Experiment #4. Fabrication of nanoporous alumina templates
Experiment #5. Synthesis of nickel nanowires
Experiment #6. Magnetic assembly of nickel nanowires

Contribution of course to meeting the professional component: This course teaches hand-on experience on nanoscale materials synthesis and characterization. In addition, the course teaches the application of nanomaterials into devices. Topic includes preparing thin films; synthesizing gold and CdS nanoparticles, synthesizing carbon nanotubes, synthesizing alumina nanotemplates, synthesizing gold and nickel nanowires, and assembling of nanowires. This course teaches various material characterization tools including imaging samples with optical, scanning electron microscope, scanning tunneling microscope, and atomic force microscope.

Relationship of course to Student Outcomes: The contribution of CHE 161 to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table.

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ability to organize pre-lab write-ups prior to experimentation and review phenomena					3		2									
Understanding and determination of experimental errors	0				3	3	1									
Determine and explain phenomena from experimental data					3	3	1									
Ability to summarize data analysis and present in concise format and make recommendations to experimental procedures						3	1									
To write technical reports in format of publication papers in journals						3	1					2				
Effective oral presentation of experiments conducted and discussion of results												3				
Relating phenomena studied in course to industrial processes and orally presenting processes researched.																
Ability to design laboratory experiments efficiently within time limit.								3								3

1. CHE 175A: Chemical Process Design

2. 4.0 units, 1 hour lecture, 6 hours lab, 1 hour consultation

3. Kawai Tam

4. Textbook: R. Turton, R. Bailie, W. Whiting and J. Shaeiwitz, Analysis, Synthesis, and Design of Chemical Processes, 3rd ed., by Prentice Hall, New Jersey, 2009.
   a. M. S. Peters, K. D. Timmerhaus and R. E. West, Plant Design and Economics for Chemical Engineers, 5th ed, McGraw-Hill, New York, 2003.

5. Specific course information:
   a. Catalog description: Introduction to chemical process plant design procedures through economic analysis and actual design of chemical processes. Addresses practical applications to current chemical and biochemical processes and economic constraints. Concentrates on general design considerations and economic principles.
   b. Prerequisite(s): CHE 117, CHE 122, MATH 010B, senior standing in Chemical Engineering; CHE 118 (may be taken concurrently).
   c. Required

6. Specific goals for the course
   a. See attached Table for specific course objectives.
   b. Outcomes 3, 4, 7, 8, 10-12, 14, 15 are evaluated in this course.

7. Brief list of topics to be covered: Teamwork, process safety, HAZOPS, regulations, fire and explosion, flowsheeting (BFD, PFD, P&IDs), cost estimation, time value of money, taxes, insurance and depreciation, profitability, cash flow, project evaluation techniques (return on investment, payback period, rate of return, benefit to cost ratio, net present value, sensitivity analysis, and Monte Carlo sensitivity analysis. Use of simulation software (SuperPro, PRO-II, DYNSIM)

Contribution of course to meeting the professional component:

The coursework and design project of this capstone course provide meaningful preparation for industry and consultation. Teams of students are assigned a project with faculty oversight and provide deliverables such as oral updates and memos, timesheets, milestone charts and employee reviews much like a consultation firm or in industry. Each student has a turn at being team leader during the quarter. In their design project, students learn to define the objectives (in a global context), plan and conduct experiments if needed, explore and determine the feasibility of possible alternatives, narrow the selection and evaluate the proposed alternatives with respect to performance, economics, societal, health and safety impacts, and sustainability constraints. This approach may require a number of iterations before a final comparative solution is achieved. In addition, simulation software programs such as PROII, DYNSIM and SuperPro are learned to provide tools to model and optimize full-scale systems theoretically.

Relationship of course to Student Outcomes: The contribution of CHE 175A to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ability to write an end-of-quarter progress report of design project in teams							1	3	2	3	3	3	2	2	1	2
Ability to produce memos and timesheets similar to a consultation practice in groups; effectively present oral updates and end-of-quarter oral presentation								3		3	3	3	1	2		1
Research design topic, determine and critically analyze design parameters and their effects in teams; research alternative processes and having ability to determine best solution based on design, safety and economics in teams	3	3	3	3	2	2	3	3	3	3	3	3	3	3	3	3
Ability to formulate block and process flow diagrams and perform associated mass and energy balances in teams	3		3	2	2	2	3	3	3							2
To understand concepts of health and safety in process design, including regulations and agencies, risk, and fire and explosion hazards						2	1	2	3	3	3		3	3	3	2
Ability to use process safety (HAZOP) protocol, be familiar with inherently safer designs						2				2	2		3	2	2	2
To understand concepts of engineering economy including cost estimation, and time value of money, taxes and depreciation	3		3						3	2				2	1	3
Understanding and using the methods of project evaluation or profitability for comparing alternative projects.	3			3						2						3
To generate computer simulations to model processes (SuperPro, PROII)			3				2	2	3			2		1		3

1. CHE 175B: Chemical Process Design

2. 4.0 units, 1 hour lecture, 6 hours lab, 1 hour consultation

3. Kawai Tam

4. Textbook: R. Turton, R. Bailie, W. Whiting and J. Shaeiwitz, Analysis, Synthesis, and Design of Chemical Processes, 3rd ed., by Prentice Hall, New Jersey, 2009.
   a. M. S. Peters, K. D. Timmerhaus and R. E. West, Plant Design and Economics for Chemical Engineers, 5^{th} ed, McGraw-Hill, New York, 2003.

5. Specific course information:
   a. Catalog description: Introduction to chemical process plant design procedures through economic analysis and actual design of chemical processes. Topics address practical applications to current chemical and biochemical processes and economic constraints. Students complete a detailed analysis and process design of the projects begun in CHE 175A. A final report and oral presentation are required.
   b. Prerequisite(s): CHE 175A

8. Required
   a. See attached Table for specific course objectives.
   b. Outcomes 3, 4, 6, 7, 10-12, 14 are evaluated in this course.

9. Brief list of topics to be covered: Heat exchanger network design, pinch technology, pump performance and design, materials of construction, ethics, and green engineering. Continued use of simulation software (SuperPro, PRO-II, DYNSIM)

Contribution of course to meeting the professional component:

This is the second half of the capstone design course and the professional component is similar to that of CHE 175A. Students continue in their team projects and conduct themselves in a professional manner in preparation for industry. Deliverables of oral updates and memos, timesheets, and employee reviews much like a consultation firm or in industry are continued. Leadership by students continues to be by rotation every two weeks. Teams will optimize their design and provide assessments including economics, societal, health and safety impacts, and sustainability constraints. More simulation software tutorials in PROII, DYNSIM and SuperPro are learned to provide tools to model and optimize full-scale systems theoretically.

Relationship of course to Student Outcomes: The contribution of CHE 175B to Student Outcomes (a)-(k) or (1) – (16) is summarized in the objective-Student Outcome matrix table

Objective-Student Outcome Matrix: 1-Slightly 2-Moderately 3-Substantially

Student Outcome Related Learning Objectives	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Ability to create an organized design notebook featuring evolution of design work and calculations, and write a final design report in teams	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3
Ability to produce memos and timesheets similar to a consultation practice in groups								3		3	3	3	1	2		1
Research design topic, determine and critically analyze design parameters and their effects in teams	3	3	3	3	2	2	3	3	3	3	3	3	3	3	3	3
Research alternative processes and having ability to determine best solution based on design, safety and economics in teams	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3
To understand the concepts of optimization including heat exchanger network optimizations	3		3	3	2	3		3								3
To generate computer simulations to model processes (SuperPro, PROII, DYNSIM)			3				2	2	3			2		1		3
To be familiar with concepts of materials selection and corrosion		3											1	1	2	
Effectively present oral updates, and final oral presentation of the design project in teams.								3		3	3	3	3	3	3	3
To be familiar with concepts in ethics										2	3				2	
To be familiar with concepts for implementation of green technologies		2	2				2			3	3		3	2	2	

CS10: Introduction to Computer Science for Science, Mathematics and Engineering I

Lecture: 3 hours; laboratory 3 hours

Prerequisite(s): MATH 009A (may be taken concurrently), First Year Calculus. Introduction to the differential calculus of functions of one variable.

Instructor: In the last five years, the following instructors have taught this class: Kris Miller

Text book(s):

- Big C++, Cay Horstmann and Timothy Budd

Course Objectives with Mapping to Student Outcomes: **<u>(This is CS and CE mapping, outcomes are not evaluated as part of CHE self-study)</u>**

Objective Outcome Matrix											
Objective Addresses Outcome: 1-slightly 2-moderately 3-substantially											
Outcome Related Learning Objectives	A	B	C	D	E	F	G	H	I	J	K
Use variables to store computer program data	2	0	0	0	0	0	0	0	0	0	3
Form and use mathematical and Boolean expressions of Variables	3	0	0	0	0	0	0	0	0	0	3
Process program input and generate program output	1	0	2	0	0	0	0	0	0	0	3
Use branches to create programs incorporating decision Making	1	0	2	0	0	0	0	0	0	0	3
Use loops to create programs that repeat certain behaviors	1	0	2	0	0	0	0	0	0	0	3
Use functions to modularize programs	1	0	2	0	0	1	0	0	0	0	3
Use arrays to store collections of data	1	0	2	0	0	0	0	0	0	0	3
Use strings to handle textual data	1	0	2	0	0	0	0	0	0	0	3
Use classes as a record that keeps related data together	1	0	2	0	0	0	0	0	0	0	3
Convert a problem description into a set of about 50-100 computer instructions	3	0	3	0	0	0	0	0	0	0	3
Debug programs written by oneself or by others	3	3	0	0	0	0	0	0	0	0	3
Understand very basic methods of testing a program	3	2	0	0	0	0	0	0	0	0	3
Incorporate useful comments into programs	0	0	0	0	0	1	0	0	0	0	3

Catalog Description:

Structured and object-oriented programming in C++, emphasizing good programming principles and development of substantial programs. Topics include recursion, pointers, linked lists, abstract data types, and libraries. Also covers software engineering principles.

Requirement Status: Required

APPENDIX B – FACULTY VITAE

Akua Asa-Awuku
Assistant Professor

Educational Training

Massachusetts Institute of Technology	Chemical Engineering	BS, 2003
Georgia Institute of Technology	Chemical Engineering	MS, 2006
	Chemical Engineering	PhD, 2008
Carnegie Mellon University	Atmospheric Chemistry	Post doc 2008, 2009

Academic Experience

2008 -2009 Camille and Henry Dreyfus Post doctoral Scholar, Dept. of Chemical Engineering, Center for Atmospheric Particle Studies, Carnegie Mellon University

2008 -present Assistant Professor, Dept. of Chemical and Environmental Engineering Research Faculty, Bourns College of Engineering – Center for Environmental Research Technology (CE-CERT)

Current Memberships in Professional Organizations

American Association for Aerosol Research (AAAR)
American Chemical Society (ACS)
American Geophysical Union (AGU)
American Institute of Chemical Engineers (AIChE)
Air & Water Management Association (A&WMA)
American Meteorological Society (AMS)
Alpha Chi Sigma (AXE)
European Geophysical Union (EGU)
National Society of Black Engineers, (NSBE)

Honors and Awards

NSF CAREER Award, 2012
EPA Early Career Award, 2011
NSF-Georgia Tech FACES Career Initiation Grant Recipient, 2009
NSF-Georgia Tech FACES Postdoctoral Fellowship, 2008
Camille and Henry Dreyfus Post Doctoral Scholar 2008
Outstanding Teaching Assistant 2006, Chemical and Biomolecular Engineering Department
NASA ESS (Earth Sun-System) Fellow, Georgia Institute of Technology, 2005, 2006, 2007
NSF-FACES (Facilitating Academic Careers in Engineering and Science) Graduate Fellow, Georgia Institute of Technology, 2003, 2004, 2005, 2006, 2007
Dow Chemical Scholarship Recipient in Chemical Engineering, Georgia Institute of Technology 2004
MIT, Barnett D. Gordon Scholar Grant Recipient 2001, 2002, & 2003

Service Activities

1. Reviewer - Journal of Geophysical Research-Atmospheres, Atmospheric Chemistry and Physics, Environmental Science and Technology, Journal of Physical Chemistry, Geophysical Research Letters
2. Faculty Student Chapter Advisor, UCR American Association for Aerosol Research (AAAR) Student Chapter (2009 – present)
3. Undergraduate Student and ABET Committee, Chemical and Environmental Engineering Dept. UCR
4. Formal Undergraduate Mentoring - Environmental Engineering Mentor, UCR CEE department (2009-Present ; 47 students, 22 URM, and 19 Female), Georgia Tech Summer Undergraduate Research in Engineering/Science (SURE) Mentor , 2004-2007 (3 URM Students)
5. Conference Session Chair and Session Organizer – American Chemical Society, American Institute of Chemical Engineers, American Association for Aerosol Research

Selected Publications (within Past 5 Years)

1. Asa-Awuku, A., Nenes, A., Gao, S., Flagan, R. C., and Seinfeld, J. H.: Water-soluble SOA from Alkene ozonolysis: composition and droplet activation kinetics inferences from analysis of CCN activity, Atmos. Chem. Phys., 10, 1585-1597, 2010.
2. Asa-Awuku, A., G. J. Engelhart., B.H. Lee, S.N. Pandis and A. Nenes, Relating CCN activity, volatility, and droplet growth kinetics of β-caryophyllene secondary organic, Atmospheric Chemistry and Physics, 9, 795-812, 2009
3. Engelhart G. J., A. Asa-Awuku, A. Nenes and S. N. Pandis, CCN activity and droplet growth kinetics of fresh and aged monoterpene secondary organic aerosol , Atmospheric Chemistry and Physics, 8, 3937-3949, 2008
4. Asa-Awuku, A., A. P. Sullivan, C.J. Hennigan, R. J. Weber and A. Nenes, Investigation of Molar Volume and Surfactant Characteristics of water-soluble Organic Compounds in Biomass Burning Aerosol, Atmospheric Chemistry and Physics, 8, 799-812, 2008
5. Asa-Awuku, A., and A. Nenes (2007), Effect of solute dissolution kinetics on cloud droplet formation: Extended Koehler theory, Journal of Geophysical. Research., 112, D22201, 2007 doi:10.1029/2005JD006934

Selected Professional Development Activities

- UC Export Control training in 2011.
- Purdue University - First Annual Conference for Pre-Tenure Women 2010
- ACCESS 2009. The Atmospheric Chemistry Colloquium for Emerging Senior Scientists (ACCESS)
- Facilitating Academic Careers in Engineering and Science (FACES) Teaching Practicum:
- Advance RICE: Negotiating the Ideal Faculty Position workshop:

Phillip Christopher
Assistant Professor

Education

Ph.D. Chemical Engineering, University of Michigan, Ann Arbor 2011
M.S. Chemical Engineering, University of Michigan, Ann Arbor 2008
B.S. Chemical Engineering, University of California, Santa Barbara 2006

Academic Experience

2011-Present. Assistant Professor II, Department of Chemical and Environmental Engineering & Materials Science and Engineering, UC Riverside.

Current Memberships in Professional Organizations

American Institute of Chemical Engineers, American Chemical Society, American Society of Engineering Education

Honors and Awards

Outstanding Ph.D. Student Research Award: Inaugural University of Michigan College of Engineering award (1 award for the College of Engineering), 2010.
Outstanding Poster Presentation: Gordon Research Conference on Catalysis, 2010.
Rackham Predoctoral Fellowship: Rackham Graduate School, University of Michigan 2010-2011
Best Poster Presentation: Walt Weber Sustainability Symposium, University of Michigan, 2009.
Kokes Award Winner: 21st National Annual Meeting: North American Catalysis Society.
Outstanding Poster Presentation: Gordon Research Conference on Catalysis, 2008.
Outstanding Student Presentation: Michigan Catalysis Society Annual Symposium, 2008.
Dean's Named Fellow: University of Michigan, 2006-2007

Service Activities

NSF review panel committee member for Solid State and Materials Chemistry: Energy-Related Materials.

Invited Speaker at TEDxUCR conference, December 3 2011. Title: "Manipulating atoms for your everyday life".

Reviewer for Journal of the American Chemical Society, Journal of Physical Chemistry (2011-Present)

Organizer/Judge, Science Olympiad held at UC Riverside, Feb 2012.

Selected Publications, Past 5 Years

Phillip Christopher and Suljo Linic, "Engineering Selectivity in Heterogeneous Catalysis: Ag Nano-wires as Selective Ethylene Epoxidation Catalysts", *Journal of the American Chemical Society*, **2008**, 130, 11264.

Phillip Christopher and Suljo Linic, "Shape and Size Specific Chemistry of Ag Nanoparticles in Catalytic Ethylene Epoxidation". *ChemCatChem*, **2010**, 2, 78-83.

Phillip Christopher, David B. Ingram, and Suljo Linic, "Enhancing Photo-chemical activity of semiconductor nanoparticles with optically active Ag nano-structures: Photo-chemistry mediated by Ag surface plasmons". *J. Phys. Chem. C*, **2010**, 114, 9173.

Phillip Christopher, Hongliang Xin Suljo Linic, "Catalysis at lower temperatures: visible light enhanced oxidation catalysis on plasmonic Ag nanostructures". *Nature Chemistry*, **2011**, 3, 467.

Suljo Linic, **Phillip Christopher**, David B. Ingram, "Plasmonic metal nanostructures for efficient conversion of solar to chemical energy". *Nature Materials*, **2011**, 10, 9.

Selected Professional Development Activities

Attended grant writing seminar at UCR put on by Stephen Russell, "Grant Writers': Seminars and Workshops", Jan 2012.

Organizer/session chair of "Catalysis and Surface Science" session at American Chemical Society annual meetings, March and August 2012.

Organizer/session chair in Catalysis division in American Institute of Chemical Engineers meeting, Nov 2012.

Organizer/session chair of "Catalysis and Surface Science" symposium at Colloids Division ACS symposium, UCR 2013.

David R. Cocker III
Professor

Education
Ph.D., Environmental Engineering Science w/ Chemical Engineering Minor, Caltech, 2001
M.S., Environmental Engineering Science, Caltech, 1998
B.S., Environmental Engineering and Chemistry, UC Riverside, 1996

Academic Experience (University of California, Riverside)

2012-present	Professor II
2010-2012	Associate Professor IV
2008-2010	Associate Professor III
2006-2008	Associate Professor I
2004-2006	Assistant Professor IV
2002-2004	Assistant Professor III
2001-2002	Assistant Professor II
1996	Teaching Assistant

Registrations: EIT

Current Memberships in Professional Organizations
American Association for Aerosol Research (AAAR)
American Chemical Society (ACS)

Honors and awards
National Science Foundation Graduate Fellowship (1996-1999)
Outstanding Teaching Award, Bourns College of Engineering, 2004
National Science Foundation Early Career Development Award, 2005
Annual Technical Achievement Award, U.S.A.F. Arnold Engineering Development Center, 2006
Los Angeles Area Emmy Award, Instructional Programming, On Camera Talent, 2009

Service Activities (Current Year Only)
Undergraduate Advisor
Chair, Undergraduate Committee
Chair, ABET Committee
CE-CERT Academic Committee
Manager of CE-CERT Atmospheric Processes Laboratory
University Writing Committee
Reviewer – Environmental Science and Technology, Atmospheric Environment, Atmospheric Chemistry and Physics, Aerosol Science and Technology; National Science Foundation, etc.,

Selected Publications, Past 5 Years

Nakao, S., Clark, C., Tang, P., Sato, K., and Cocker, D. 2011. Secondary organic aerosol formation from phenolic compounds in the absence of NOx,. Atmospheric Chemistry and Physics. Vol. 11: 20 p.10649-10660

Sato, K., Nakao, S., Clark, C., Li, Q., and Cocker III, D.R., 2011, Secondary organic aerosol formation from the photooxidation of isoprene, 1,3-butadiene, and 2,3-dimethyl-1,3-butadiene under high NOx conditions, Atmospheric Chemistry and Physics, Vol. 11:14 p. 7301-7317

Nakao, S., Shrivastava, M., Nguyen, A., Jung, H., Cocker III, D.R. 2011, Interpretation of Secondary Organic Aerosol Formation from Diesel Exhaust Photooxidation in an Environmental Chamber, Vol. 45: p.954-962

Li, Q., Nakao, S., Malloy, Q.G., Warren, B.A., Cocker III, D.R. 2010. Can secondary organic aerosol formed in an atmospheric simulation chamber continuously age?. Atmospheric Environment. Vol. 44: p.2990-2996

Li, Q., Nakao, S., Tang, P., Cocker III, D.R. 2010. Temperature effect on physical and chemical properties of aerosols from m-xylene photooxidation. Atmospheric Chemistry and Physics. Vol. 10: p.3847-3854.

Hosseni, E., Li, Q., Cocker III, D.R., Weise, D., Miller, A., Shrivastava, M., Miller, J.W., Mahalingham, S., Princevac, M., Jung, H. 2010. Particle size distributions from laboratory-scale biomass fires using fast response instruments. Atmospheric Chemistry and Physics. Vol. 10: p.8065-8076.

Warren, B.A., Malloy, Q.GJ., Yee, L.D., Cocker III, D.R . 2009. Secondary Organic Aerosol Formation from Cyclohexene Ozonolysis in the Presence of Water Vapor and Dissolved Salts. Atmospheric Environment. Vol. 43: 10 p.1789-1795

Malloy, Q.GJ., Nakao, S., Li, Q., Austin, R., Stothers, C., Hagino, H., Cocker III, D.R. 2009. Real-Time Aerosol Density Determination Utilizing a Modified Scanning Mobility Particle Sizer " Aerosol Particle Mass Analyzer System. Aerosol Science and Technology. Vol. 43: 7 p.673-678

Warren, B., Song, C., Cocker, D. 2008. Light intensity and light source influence on secondary organic aerosol formation for the m-xylene/NOxphotooxidation system. Environmental Science and Technology. Vol. 42: 15 p.5461-5466

Johnson, K.C., Durbin, T.D., Jung, H., Chaudhary, A.A., Cocker III, D.R., Herner, J., Robertson, W., Huai, T., Ayala, A., Kittelson, D. 2009. Evaluation of the European PMP Methodologies during On-Road and Chassis Dynamometer Testing for DPF Equipped Heavy Duty Diesel Vehicles. Aerosol Science and Technology. Vol. 43: 10 p.962-969.

Agrawal, H.A., Eden, R., Zhang, X., Fine, P., Katzenstein, A., Miller, J.W., Ospital, J., Teffera, S., Cocker III, D.R. 2009. Primary Particulate Matter from Ocean going Engines in Southern California Air Basin. Environmental Science and Technology. Vol. 43: 14 p.5398-5402.

Selected Professional Development Activities

Ethical and Responsible Conduct of Research, 2012
UC Export Control Training, 2012
Sexual Harassment Prevention Training, 2012

Xin Ge

Assistant Professor

Education

Ph.D., Chemical Engineering, McMaster University, 2008
M.S., Biochemical Engineering, Tsinghua University, 2003
B.S., Chemical Engineering, Tsinghua University, 2000

Academic Experience

2008-2010: NSERC Postdoctoral Fellow, Department of Chemical Engineering, UT Austin
2010-2011: Research Associate, Department of Chemical Engineering, UT Austin
2011- : Assistant Professor, Department of Chemical and Environmental Engineering, UCR

Current Memberships in Professional Organizations

AIChE, ACS

Honors and Awards

Natural Sciences and Engineering Research Council of Canada Postdoctoral Fellowship, 2008-2010; Chinese Government Award for Outstanding Self-financed Students Abroad, 2007; Ontario Graduate Scholarship, 2006-2007; E. Hameilec Award, McMaster University, 2006;

Service Activities

- Faculty Member, Microbiology Graduate Program, UCR (2011-)
- Undergraduate Committee, Department of Chemical and Environmental Engineering, UCR (2011-)
- Graduate Research Committee, Department of Chemical and Environmental Engineering, UCR (2011-)
- Senior Design Advisor, Department of Chemical and Environmental Engineering, UCR (2012)

Selected Publications, Past 5 Years

Journal Paper:

- **Ge X**, Lebert JM, Monton MN, Lautens LL, Brennan JD. Materials Screening for Sol-Gel Derived High-Density Multi-Kinase Microarrays. *Chemistry of Materials* (2011) 23[16]: 3685–3691.
- Reddy ST, **Ge X**, Miklos AE, Hughes RA, Kang SH, Hoi KH, Chrysostomou C, Hunicke-Smith SP, Iverson BL, Tucker PW, Ellington AD, Georgiou G. Monoclonal Antibodies Isolated Without Screening by Analyzing the Variable-Gene Repertoire of Plasma Cells. *Nature Biotechnol*ology (2010) 28[9]: 965–969.
- **Ge X**, Mazor Y, Hunicke-Smith SP, Ellington AD, Georgiou G. Rapid Construction and Characterization of Synthetic Antibody Libraries Without DNA Amplification. *Biotechnology and Bioengineering* (2010) 106[3]: 347-357.
- **Ge X**, Hoare T, Filipe CDM. Protein Based Aqueous-Multiphasic Systems. *Langmuir* (2010) 26[6]: 4087-4094.
- **Ge X**, Conley A, Brandle JE, Truant R, Filipe CDM. *In Vivo* Formation of Protein Based Aqueous Microcompartments. *Journal of the American Chemical Society* (2009) 131[25]: 9094-9099.

- **Ge X**, Trabbic-Carlson K, Chilkoti A, Filipe CDM. Purification of an Elastin Like Fusion Protein by Microfiltration. *Biotechnology and Bioengineering* (2006) 95[3]: 424-432.
- **Ge X**, Filipe CDM. Simultaneous Phase Transition of ELP Tagged Molecules and Free ELP: An Efficient and Reversible Capture System. *Biomacromolecules* (2006) 7[9]: 2475-2478.
- **Ge X**, Yang DSC, Trabbic-Carlson K, Kim B, Chilkoti A, Filipe CDM. Self-Cleavable Stimulus Responsive Tags for Protein Purification Without Chromatography. *Journal of the American Chemical Society* (2005) 127[32]: 11228-11229.

Presentation:

- **Ge X**, Georgiou G. Novel Methods for the Discovery of Highly Potent Therapeutic Antibodies, Biomedical Engineering Society Annual Meeting, Austin, TX, October 2010
- Reddy ST, **Ge X**, Georgiou G. Rapid Generation of Monoclonal Antibodies Without Screening by Exploiting High-throughput DNA Sequencing of Immunized Repertoires, Biomedical Engineering Society Annual Meeting, Austin, TX, October 2010
- **Ge X**, Georgiou G. Novel Methods for the Discovery of Highly Potent Therapeutic Antibodies, 60th Canadian Chemical Engineering Conference, Saskatoon, SK, Canada, October 2010
- **Ge X**, Georgiou G. Rapidly Construction of Synthetic Antibody Libraries and Analysis by High Throughput Sequencing, IBC Antibody Engineering, San Diego, CA, December 2009

Selected Professional Development Activities

UC Export Control training, 2011.

Grant Writers Seminar Workshop, 2012.

Robert C Haddon
Distinguished Professor

Education

Ph.D., Organic Chemistry, Pennsylvania State University, 1971
B.S. (Hon.), Chemistry, Melbourne University, Australia, 1966

Academic Experience

In chronological order: institutions and appointments. Include any chairmanships or coordinator roles.

1997-2000, Professor of Chemistry and Physics, University of Kentucky
2000- Distinguished Professor of Chemistry and Chemical & Environmental Engineering, University of California, Riverside
2000- Director, Center for Nanoscale Science and Engineering, University of California, Riverside
2012- Distinguished Adjunct Professor, King Abdul Aziz University, Saudi Arabia

Non-Academic Experience

1976-1997, Bell Telephone Laboratories (AT&T, Lucent Technologies)
Distinguished Member of Technical Staff
Chemical Physics and Materials Chemistry Departments

1998-2006, Carbon Solutions Inc, Founder and President
2006- Carbon Solutions Inc, Chief Technical Advisor

Current Memberships in Professional Organizations

Member of the American Chemical Society

Fellow of the Royal Australian Chemical Institute (1988)

Fellow of the American Association for the Advancement of Science (1993)

Fellow of the American Physical Society (1996)

Honors and Awards

Queen Elizabeth II Fellow (1973-75)
Superconductor Week Person of the Year (1991)
Distinguished Member of Technical Staff, AT&T Bell Laboratories (1992)
Department of Energy, Office of Science, Top Ten Discoveries (2002, Fourth Nationwide)
ISI Highly Cited Researcher in Chemistry, Materials Science and Physics
American Physical Society James C. McGroddy Prize for New Materials (2008)

Richard E Smalley Research Award of the Fullerenes, Nanotubes, and Carbon Nanostructures Division of the Electrochemical Society (2010)
ISI Top 100 Chemist of the Previous Decade (2000-2010).

Service Activities

Service on the Editorial Advisory Boards of:
Advanced Materials
Journal of the American Chemical Society
Chemical Physics Letters; Chemistry of Materials
Molecular Crystals and Liquid Crystals
Fullerenes, Nanotubes and Carbon Nanostructures.

Selected Publications, Past 5 Years

1. Itkis, M. E.; Borondics, F.; Yu, A.; Haddon, R. C., Bolometric Infrared Photoresponse of Suspended Single-Walled Carbon Nanotube Films. *Science* **2006,** 312, 413-416.
2. Bekyarova, E.; Itkis, M. E.; Ramesh, P.; Berger, C.; Sprinkle, M.; de Heer, W. A.; Haddon, R. C., Chemical Modification of Epitaxial Graphene: Spontaneous Grafting of Aryl Groups. *J. Am. Chem. Soc.* **2009,** 131, 1336-1337.
3. Ramesh, P.; Itkis, M. E.; Bekyarova, E.; Wang, F.; Niyogi, S.; Chi, X.; Berger, C.; de Heer, W. A.; Haddon, R. C., Electro-Oxidized Epitaxial Graphene Channel Field-Effect Transistors with Single-Walled Carbon Nanotube Thin Film Gate Electrode. *J. Am. Chem. Soc.* **2010,** 132, (41), 14429–14436.
4. Niyogi, S.; Bekyarova, E.; Itkis, M. E.; Zhang, H.; Shepperd, K.; Hick, J.; Sprinkle, M.; Berger, C.; Lau, C. N.; de Heer, W. A.; Conrad, E. H.; Haddon, R. C., Spectroscopy of Covalently Functionalized Graphene. *Nano Lett.* **2010,** 10, (10), 4061–4066.
5. Sarkar, S.; Bekyarova, E.; Niyogi, S.; Haddon, R. C., Diels-Alder Chemistry of Graphite and Graphene: Graphene as Diene and Dienophile. *J. Am. Chem. Soc.* **2011,** 133, 3324-3327.

David Kisailus
Assistant Professor

Education
Ph.D., Materials Science and Engineering, UC Santa Barbara, 2002
M.S., Materials Science and Engineering, University of Florida, 1999
B.S., Chemical Engineering, Drexel University, 1993

Academic Experience

2002 – 2005	Post-Doctoral Researcher, California NanoSystems Institute, UC Santa Barbara
2007 – Present	Assistant Professor, Chemical and Environmental Engineering, UC Riverside
2007 – Present	Participating faculty, Materials Science and Engineering Program, UC Riverside
2008 – Present	Undergraduate Chair, Materials Science and Engineering Program, UC Riverside
2011 – Present	Winston Chung Endowed Chair of Energy Innovation, UC Riverside

Non-Academic Experience

2005 – 2007	Research Scientist, HRL Laboratories, LLC, Malibu, CA

Certifications or Professional Registrations
N/A

Current Memberships in Professional Organizations
American Ceramic Society
American Chemical Society
American Institute of Chemical Engineers
Materials Research Society

Honors and Awards
Winston Chung Endowed Chair of Energy Innovation, UC Riverside 2011

Service Activities
-Served on department faculty hiring committees (2009, 2011, 2012)
-Served on Materials Science and Engineering faculty hiring committee (2011)
-Served as outside member of Chemistry department faculty hiring committee (2012)
-Served on department development engineer hiring committee (2011)
-Served on department ABET committee (2011- present)
-Served on department Undergraduate committee (2008- present)
-AIChE faculty advisor (2008-present)
-Department seminar organizer (2010-2011)
-Materials Science and Engineering Building Committee (2010-2011)
-Honors program advisor for Chemical and Environmental Engineering (2008- present)
-Honors program advisor for Materials Science and Engineering Program (2008- present)

-Undergraduate advisor for Materials Science and Engineering Program (2008-present)
-Spearheaded $10,000,000 Endowment for UC Riverside from Chinese Donor
-Conference Organizer (Chair), American Association for Crystal Growth, June 2012
-Symposium Organizer (Chair), Materials Research Society, Spring 2009, San Francisco
-Collaborator: Alliance for Education, Outreach to San Bernardino County High Schools
-American Institute for Chemical Engineers (AICHE) Faculty Advisor
-Mentored more than 50 graduate, undergraduate and high school students as part of academic training
-Public Outreach at Riverside Metropolitan Museum (2011)
-Public Outreach at San Diego Zoo (2011)

Selected Publications, Past 5 Years

Crystal Growth of $Li[Ni_{1/3}Co_{1/3}Mn_{1/3}]O_2$ as a Cathode Material for High-Performance Lithium Ion Batteries, J. Zhu, T. Vo, D. Li, N. Kinsinger, L. Xiong, Y. Yan, D. Kisailus, Crystal Growth and Design, in press (2012).

Solvothermal Synthesis of a Highly Branched Ta-doped TiO_2, S. Arab, D. Li, N. Kinsinger, F. Zaera, D. Kisailus, Journal of Materials Research, 26 (20) (2011) 2653-2659.

Photocatalytic Titanium Dioxide Composite, N. Kinsinger, A. Tantuccio, Minwei Sun, Yushan Yan, D. Kisailus, J. Nanoscience and Nanotechnology, 11 (8) (2011) 7015-7021.

Hierarchically Ordered Macro-Mesoporous TiO_2-Graphene Composite Films: Improved Mass Transfer, Reduced Charge Recombination, and Their Enhanced Photocatalytic Activities, J. Du, X. Lai, N. Yang, J. Zhai, D. Kisailus, F. Su, D. Wang, L. Jiang, ACS Nano, v.5 (1) (2011) 590-596.

Nucleation and crystal growth of nanocrystalline anatase and rutile phase TiO_2 from a water soluble precursor, N. Kinsinger, A. Wong, D. Li, F. Villalobos, D. Kisailus, Crystal Growth and Design, v.10 (12) (2010) 5254-5261.

Unifying Design Strategies in Demosponge and Hexactinellid Skeletal Systems, J. Weaver, G. Milliron, P. Allen, A. Miserez, A. Rawal, J. Garay, P. Thurner, J. Seto, B. Mayzel, L. Friesen, B. Chmelka, P. Fratzl, J. Aizenberg, Y. Dauphin, D. Kisailus, D. Morse, Journal of Adhesion, 86 (2010) 72-95.

Porous Platinum Nanotubes for Oxygen Reduction and Methanol Oxidation Reactions, S. Alia, G. Zhang, D. Kisailus, D. Li, S. Gu, K. Jensen, and Y. Yan, Adv. Funct. Mat., 20, (2010) 3742-3746.

Analysis of an ultra hard magnetic biomineral in chiton radular teeth, J. Weaver, QQ. Wang, A. Miserez, A. Tantuccio, R. Stromberg, KN. Bozhilov, P. Maxwell, R. Nay, ST. Heier, E. DiMasi, D. Kisailus, Materials Today, 13 (2010) 42-52.

Selected Professional Development Activities

UC Export Control training (2011)

Mark R. Matsumoto
Professor and Associate Dean

Education
Ph.D., Environmental Engineering, UC Davis, 1982
M.S., Environmental Engineering, UC Davis, 1980
B.S., Civil Engineering, UC Irvine, 1977

Academic Experience (University of California, Riverside)

2006-present	Professor V
2005-present	Associate Dean for Research and Graduate Education, College of Engineering
2010	Interim Dean, School of Engineering, University of California, Merced
2004-2005	Interim Dean, College of Engineering, University of California, Riverside
2003-2006	Professor IV
2000-2003	Professor III
1999-2005	Associate Dean, College of Engineering
1997-2000	Professor II
1994-2000	Chair, Chemical & Environmental Engineering
1994-1997	Professor I
1981-1982	Associate Development Engineering, University of California, Davis
1979-1981	Postgraduate Research Engineering, University of California, Davis
1978-1979	Research Assistant, University of California, Davis
1977-1978	Teaching Assistant, University of California, Davis

Academic Experience (State University of New York at Buffalo)

1989-1994	Associate Professor, Civil Engineering
1990-1994	Director, Environmental Science Program
1983-1989	Assistant Professor, Civil Engineering

Non-Academic Experience
Consultant: Orange County Sanitation District; Camp, Dresser, and McKee; Energy Resource Institute; U.S. Filter
Project Engineer, Lowry and Associates, Irvine, CA, 1976-1977
Technician, Bioacoustical Engineers, Tustin, CA 1975-1976

Registrations: EIT (California, No. 34513)

Current Memberships in Professional Organizations
American Association for the Advancement of Science (AAAS)
American Society of Engineering Education (ASEE)
Association of Environmental Engineering and Science Professors (AEESP)
Water Environment Federation (WEF)

Honors and awards

Lilly Foundation Teaching Fellow, 1987 – 1988
Outstanding Teaching Award, Bourns College of Engineering, 2000
Fellow, AAAS, 2001

Service Activities (Current Year Only)

UC Riverside, WaterSENSE, campus-wide interdisciplinary research center development
Associate Dean for Research and Graduate Education, College of Engineering
Bourns College of Engineering Executive Committee, Ex Officio Member
Department of Chemical and Environmental Engineering, Faculty Search Committee Chair
Reviewer – Environmental Science and Technology, J. Environmental Quality, National Science Foundation, Qatar National Priorities Research Program Water Research,
One Water One Watershed Project, Santa Ana Watershed Projects Authority

Selected Publications, Past 5 Years

Li, B.-j., J. Hu, L.-y. Huang, Y. Lv, J. Zuo, W. Zhang, W.-c. Ying, and M.R. Matsumoto (2012) Removal of MTBE in Biological Activated Carbon Adsorbers. *Environmental Progress and Sustainable Energy* (accepted for publication).

Jin, L. and M.R. Matsumoto, In Situ Remediation of Perchlorate in Vadose Zone Soil, 27th Annual Conference on Soils, Sediments, Water and Energy, University of Massachusetts, Amherst, October 17-20, 2011.

B.-J. Koo, D.E. Fletcher, T.G. Hinton, C.D. Barton, and M.R. Matsumoto (2010). Assessment of Stream Fish Mortality from Short-Term Exposure to Illite Clays Used as an In Situ Method for Remediating 137CS Contaminated Wetlands, *International Journal of Soil, Sediment, and Water*, 3, 2, Article 2 (1-15), 2010.

Lao, U.L., M. Sun, M.R. Matsumoto, A. Mulchandani, and W. Chen (2007) Genetic Engineering of Self-Assembled Protein Hydrogel Based on Elastin-Like Sequences with Metal Binding Functionality, *Biomacromolecule*s, 8, 3736-3739.

Yu, X., C. Amrhein, M.A. Deshusses, and M.R. Matsumoto (2007), Perchlorate Reduction by Autotrophic Bacteria Attached to Zero-Valent Iron in a Flow-Through Reactor, *Environmental Science and Technology*, 41(3), 990-997.

Selected Professional Development Activities

Ethical and Responsible Conduct of Research, 2012
UC Export Control Training, 2011
Sexual Harassment Prevention Training, 2010

Ashok Mulchandani
Professor

Education

Ph.D., Chemical Engineering, McGill University, 1985
M.S., Chemical Engineering, Indian Institute of Technology, Powai, India, 1978
B.S., Chemical Engineering, Nagpur University, India, 1976

Academic Experience

1990-1991, Assistant Professor, Department of Chemical and Biochemical Engineering, University of Western Ontario, Canada
1991-1995. Assistant Professor, Department of Chemical and Environmental Engineering, UCR
1995-1999. Associate Professor, Department of Chemical and Environmental, UCR
1999-Present. Professor, Department of Chemical and Environmental Engineering, UCR
2000-2004. Chair, Department of Chemical and Environmental Engineering, UCR

Non-Academic Experience

1978-1980, Project Engineer, Vulcan-Laval, Pune, India.
1987-1990, Research Associate, Biotechnology Research Institute, Montreal, Canada
1985-1987, Postdoctoral Fellow, Laval University, Quebec, Canada
1999-2000, Visiting Researcher, Oak Ridge National Laboratory, Oak Ridge, TN

Certifications or Professional Registrations

Current Memberships in Professional Organizations

American Chemical Society
American Association for the Advancement of Sciences
American Institute of Medical and Biological Engineering

Honors and Awards

Elected Fellow of the American Association for the Advancement of Sciences
Elected Fellow of the American Institute of Medical and Biological Engineering
Faculty Research Participation Award, Department of Energy, 1999-2000
UCR Chancellor's award for Excellence in Undergraduate Research, 2007-2008
National Science Foundation, Research Initiation Award, 1993-1996

Service Activities

Editor-in-Chief, Applied Biochemistry and Biotechnology

Member, NIH Instrumentation and Systems Development Study Section – 7/09 - Present
Editorial Board, International Journal of Industrial Biotechnology, 3/11 - Present
Editorial Board, Biosensors, 8/10 – Present
Editorial Board, Frontiers in Microbial Ecotoxicology and Bioremediation, 7/10 - Present
Editorial Board, Journal of Nanomedicine & Nanotechnology, 7/10 – Present
Editorial Board, Journal of Bionanoscience, 2007 - Present
Editorial Board, Open Access Journal of Biotechnology, 2006 – Present
Editorial Board, Recent Patents in Biotechnology, 2006 – Present
Editorial Board, Medical Devices: Evidence and Research, 2008 - Present
Editorial Board, Molecular Biotechnology (1997-2002)
Member, UCR Academic Senate Committee on Committees
Member, UCR Academic Senate Academic Planning and Budget Committee
Chair, Bourns College of Engineering Faculty
Member, UCR Academic Senate Committee of Academic Personnel

Selected Publications, Past 5 Years

H. Y. Yeh, M. V. Yates, A. Mulchandani, W. Chen, "Visualizing the dynamic of viral replication in living cells via TAT-peptide delivery of nuclease-resistant molecular beacons," *Proceeding of the National Academy of Sciences of the United States of America*, 105, 45, 17522-17525, 2008.

L. N. Cella, W. Chen, N. V. Myung, A. Mulchandani, "Single-walled carbon nanotube-based chemiresistive affinity biosensors for small molecules: ultrasensitive glucose detection," *Journal of the American Chemical Society*, 132, 5024-5026, 2010.

C. Garcia-Aljaro, L. N. Cella, D. J. Shirale, M. Park, F. J. Munoz, M. V. Yates, A. Mulchandani, "Carbon nanotubes-based chemiresistive biosensors for detection of microorganisms," *Biosensors & Bioelectronics*, 26, 1437-1441, 2010.

R. K. Paul, S. Badhulika, S. Niyogi, R. C. Haddon, V. M. Boddu, C. Costales-Nieves, K. N. Bozhilov, A. Mulchandani, "The production of oxygenated polycrystalline graphene by one-step ethanol-chemical vapor deposition," *Carbon*, 49, 3789-3795, 2011.

A. Mulchandani, Rajesh, "Microbial biosensors for organophosphates," *Applied Biochemistry and Biotechnology*, 165, 687-699, 2011.

Selected Professional Development Activities

UC Export Control training in 2011.

Nosang V. Myung
Professor and Chair
Department of Chemical and Environmental Engineering
University of California-Riverside
Riverside, CA 92521

Education

Ph.D., Chemical Engineering, University of California-Los Angeles, 1998
M.S., Chemical Engineering, University of California-Los Angeles, 1997
B.S., Chemical Engineering, University of California-Los Angeles, 1994

Academic Experience

1995-1998, Graduate Research Assistant, Department of Chemical Engineering, UCLA
1998-2001, Visiting Research Engineer, Department of Chemical Engineering, UCLA
2003-2004, Assistant Professor III, Department of Chemical and Environmental Engineering (CEE), UCR
2004-2005, Assistant Professor IV, CEE department, UCR
2005-2006, Assistant Professor V, CEE department, UCR
2006-2007, Associate Professor II, CEE department, UCR
2007-2008, Associate Professor IV, CEE department, UCR
2008-2010, Professor II, CEE department, UCR
2010-Present, Professor III, CEE department, UCR
2011-Present, Chair, CEE department, UCR

Non-Academic Experience

Jet Propulsion Laboratory (MEMS Technology Group), Full time member of Engineering Staff
Developing nano and microfabriacted devices for space applications.

Current Memberships in Professional Organizations

American Institute of Chemical Engineers, The Electrochemical Society, International Society of Electrochemistry, and Materials Research Society

Honors and Awards

NASA Patent Award (2007), NSF Travel Grant (Sept. 2006), Faculty Career Development Award (June, 2006), Regents' Faculty Fellowship (June, 2004), NASA Tech Brief Award (April, 2004, May 2007, Feb. 2008), UCR-AICHE Student Chapter Recognition Award (May, 2004), Jet Propulsion Laboratory Spot Award (2002, 2006), ***Abner Brenner Gold Medal Award*** from American Electroplaters and Surface Finishers Society (AESF) (June, 2001), First Time Author's Award from Plating and Surface Finishing (June, 2000), National Science Foundation Fellowship, Department of Education Fellowship, American Electroplating and Surface Finishing Summer Scholarship, Electrochemical Society Student Grant, Hughes Aircraft Company Scholarship, Korean American Edward Lee Scholarship

Service Activities

International Advisory Committee for the 5th International Symposium on Functional Materials: **UKC Technical Track Chair** (Aug. 2012): **Symposium organizer** for “Bio-Enabled Materials, Processes, and Devices” (Oct. 2012): **Track Committee** the “Nanoelectronics: Graphene, CNTs, Nanowires” as a part of IEEE NANO 2012 Conference (Aug. 2012): **Lead symposium organizer** for "4th International Symposium on Electrodeposition of Nanoengineered Materials and Devices" (Oct. 2011): **International Advisory Committee** for the 4th International Symposium on Functional Materials (Aug. 2-6, 2011): **International Advisory Committee** for the International Conference of Nanomaterials Synthesis and Characterization (INSC 2011) (July 2011): **Lead symposium organizer** for "3rd International Symposium on Electrodeposition of Nanoengineered Materials and Devices" (Oct. 2009): **Co-chair** for “Nanowires V: Applications to Sensors, Devices and Energy Storage” (Nov. 2008): **Session Chair** for "Magnetic Materials Processes and Devices 10" (Oct. 2008): **Program committee member** for 2008 SPIE Defense & Security Symposium: **Session Chair** for "Nanostructured Materials and Fabrication" at International Symposium on Advanced Magnetic Materials and Application (ISAMMA)(Jeju, Korea) (July, 2007): **Lead symposium organizer** for “Second International Symposium on Electrodeposition of Nanoengineered Materials and Devices” (Oct. 2007): **Session Chair** for "Nanowire Technologies" in the Micro (MEMS) and Nanotechnologies (Apr. 2007): **Co-chair** for “Nanowires III: Integration of Nanowires (Nov. 2006): **Session Chair** for "Magnetic Materials Processes and Devices 9" (Oct. 2006): **Lead symposium organizer** for “First International Symposium on Electrodeposition of Nanoengineered Materials (Oct. 2005):

Selected Publications, (Published 122 peer-review papers)

1. N. Chartuprayoon, C. M. Hangarter, Y. W. Rheem, **N. V. Myung***, “Wafer-Scale Fabrication of Single Polypyrrole Nanoribbon Based Devices”, *J. Phys. Chem. C*, 114(25) 11103-11108, 2010.
2. A. Mulchandani* and **N. V. Myung,** “Conducting Polymer Nanowires Based Label-free Biosensors”, *Current Opinion in Biotechnology*, 22, 502-508, 2011.
3. T. P. McNicholas, K. Zhao, C. Yang, S. C. Hernandez, A. Mulchandani, **N. V. Myung**, M. A. Deshusses, “Sensitive Detection of Elemental Mercury Vapor by a Gold Nanoparticle Decorated Carbon Nanotube Sensor”, *J. Phys. Chem. C*, 115(28), 13927-13931, 2011.
4. D. J. Shirale, M. A. Bangar, M. Park, W. Chen, M. Yates, **N. V. Myung**, A. Mulchandani*, “Label-Free Chemiresistive Immunosensors for Viruses”, *Environmental Science and Technology*, 44(23) 9030-9035, 2010.
5. M. Park, L. Cella, W. Chen, **N. V. Myung**, A. Mulchandani*, “Carbon Nanotubes-Based Chemiresistive Immunosensor for Small Molecules: Detection of Nitroaromatic Explosives” *Biosensors and Bioelectronics*, 26(4) 1297-1301, 2010.

Selected Professional Development Activities

UC Export Control 2011

Sharon L. Walker

Associate Professor and the John Babbage Chair in Environmental Engineering

Education

Ph.D., Environmental Engineering, Yale University 2004
M.S., Chemical Engineering, Yale University, 2000
B.S., Environmental Engineering, University of Southern California, 1998
B.S., Environmental Studies, biological emphasis, University of Southern California, 1998

Academic Experience

2005-2010. Assistant Professor, Dept. of Chemical and Environmental Engineering UCR
2010-present. Associate Professor, Dept. of Chemical and Environmental Engineering UCR
2011-present. Graduate Advisor, Dept. of Chemical and Environmental Engineering UCR

Current Memberships in Professional Organizations

American Chemical Society (ACS), American Institute of Chemical Engineers (AIChE), American Society of Microbiology (ASM), Society of Women Engineers (SWE), Association of Environmental Engineering and Science Professors (AEESP), Association of Women in Science (AWIS), Air and Waste Management Association (AWMA), Society of Environmental Toxicology and Chemistry (SETAC)

Honors and Awards

2011 Chancellor's Award for Excellence in Undergraduate Research and Creative Achievement, 2010 NSF Career Award, 2009-2010 Fulbright Fellowship, John Babbage Chair in Environmental Engineering (2005-present), 2008 Woman of Distinction, Girl Scouts of San Gorgonio Award 2005 and 2007 UC Regents Faculty Fellowship, 2005 and 2008 UC Faculty Senate Research Award, Tau Beta Pi- National Engineering Honors Society - member
Chi Epsilon- Civil Engineering Honors Society – member

Service Activities (past 5 years)

Department of Chemical and Environmental Engineering

Graduate Advisor 2011-present; Graduate Committee 2010-present; Faculty Search Committee 2004-2005, 2006-2007. 2008-2009, 2010-2011, 2011-2012; Department Seminar Series Coordinator 2007-2008; Undergraduate Committee 2005-2010; ABET Committee 2005-2010

Bourns College of Engineering

BCOE Civil Engineering Faculty Search Committee 2008-2009; Society of Women Engineers, Chapter Advisor; Tau Beta Pi - Alpha Beta Chapter Advisor

University level

Chancellor's Budget Advisory Committee; Undergraduate Honors College Faculty Advisor; Vice Provost for Academic Personnel Hellman Award Committee; Athletic Director Search Committee; Athletics Appeals Committee; Academic Senate member

Conferences symposium organizer:

ACS Colloids and Surface Symposium Lead Organizer (2013); AIChE National Meeting (2006-2008, 2010-2011); ACS Colloid and Surface Science Symposium (2007, 2009, 2010); ACS/AIChE Joint Spring Meeting (4/08); ACS National Meeting(2005, 2006)

Publication and proposal reviewer

Reviewer, *Environmental Science & Technology, Journal of Colloid and Interface Science, Biotechnology and Bioengineering, Journal of Medical Microbiology, Industrial & Engineering Chem. Research, ,Biomacromolecules*, *Langmuir*, *Water Resources Research, Journal of Contaminant Hydrology*, *Environmental Engineering Science* and *Water Research*
Proposal review: NSF (ADVANCE & Graduate Research Fellowships), Army Research Office, Engineering and Physical Sciences Research Council (UK), Dutch Research Council

Selected Publications, Past 5 Years

Marcus, I.M.; Bolster, C.H.; Cook, K.L.; Opot, S.R.; and Walker, S.L 2012 "Impact of Growth Conditions on Transport Behavior of E. coli" *Journal of Environmental Monitoring* DOI: 10.1039/C2EM10960C

Chowdhury, I. and Walker, S. L. 2012 "Deposition and Attachment Mechanisms of TiO_2 Nanoparticles in a Parallel Plate System" *Journal of Colloid and Interface Science* 369:16-22 DOI : 10.1016/j.jcis.2011.12.019

Haznedaroglu, B.Z.; Yates, M.; Maduro, M.; Walker, S.L. 2012 "Effects of Residual Antibiotics in Groundwater on *Salmonella typhimurium*: Changes in Antibiotic Resistance, in vivo and in vitro Pathogenicity" *Journal of Environmental Monitoring* DOI: 10.1039/C1EM10723B; 14(1):41-47

Gong, A.; Lanzyl, C.; Cwertiny, D.; Walker, S. 2012 "Influence of Varying Levels of Extracellular Polymeric Substances (EPS) on Hydroxyl Radical Mediated Disinfection of *Escherichia coli*" *Environmental Science and Technology* (published online 11/14/2011) 46(1) 241-249

Chowdhury, I., Hong, Y., and Walker, S. L. 2010 "Container to Characterization: Impacts of Metal Oxide Nanoparticle Handling, Preparation and Solution Chemistry on Particle Stability" *Colloids and Surfaces A.* 368(1-3) 91-95. doi: 10.10161j.colsurta2010.07.019

Bolster, C., Cook, K., Marcus, I., Haznedaroglu, B.Z., and Walker, S.L. 2010 "Correlating Transport Behavior with Cell Properties for Eight Porcine *Escherichia coli* Isolates" *Environmental Science and Technology 44* (13) 5008-5014.

Selected Professional Development Activities

NSF ADVANCE program for faculty women in STEM at UCR, 2011-2014 (co-PI); USDA CSREES HSI funded program for community college student research, 2010-2013 (lead PI); USDA International Science and Education Grant for graduate student exchange with Ben Gurion University in Israel, 2010-2013 (lead PI); *Mentoring Year-round in Biological Engineering, Science and Technology* (*MY BEST*), NSF funded undergraduate research and mentoring program, 2007-2012 (lead PI); *Building Bridges through Water Quality Research,* USDA CSREES HSI funded program for community college student research, 2006-2009 (co-PI); *Graduate Fellowships to Address the National Need for Diverse Chemical, Environmental, and Biological Engineers in the Professoriate and Workforce*, US Department of Education funded PhD student fellowship program, 2006-2009 (co-PI); *Society of Women Engineers,* UCR Chapter Faculty Advisor (2005-present); *Tau Beta Pi*, UCR's Alpha Beta Chapter Faculty Advisor (2005-present); *AEESP Board of Advisors* (7/2011-present); *Division Officer,* ACS Division of Colloid and Surface Science, Symposium Committee Standing Member (1/2009-12/2013); UC Export Control training (2011)

Ian Wheeldon
Assistant Professor

Education

Columbia University, New York	Chemical Engineering	Ph.D., 2009
The Royal Military College of Canada	Chemical Engineering	MASc., 2003
Queen's University, Ontario, Canada	Chemical Engineering	BASc., 1999

Academic Experience

2011-present. Assistant Professor III, Department of Chemical and Environmental Engineering, UCR

2009-2011. Post Doctoral Research Fellow, Harvard Medical School, and The Wyss Institute for Biologically Inspired Engineering, Harvard University.

2004. Visiting Scholar, The Institute of Chemical Physics of Materials, Environment, and Energy, The University of Buenos Aires

Current Memberships in Professional Organizations

American Institute of Chemical Engineers, member 2006 - present
Society for Biological Engineers, AIChE, member 2008 - present
American Chemical Society, Biochemical Technology Division, member 2008 - present

Selected Honors and Awards

Doctor of Philosophy awarded with Distinction, Graduate School of Arts and Sciences, Columbia University in the City of New York, 2009

New York Academy of Sciences, 2nd Annual Advances in Biomolecular Engineering: Protein Design Symposium, Jun. 30th 2008: Poster Award

Electrochemical Society Travel Award: 213th ECS, Phoenix AZ, May 18-23, 2008.

SEAS, Columbia University, Outstanding Teaching Assistant Award: Department of Chemical Engineering, Columbia University, Spring semester 2005.

National Science and Engineering Research Council of Canada (NSERC) Doctoral Scholarship, Mar. 2004.

Service Activities

External

Session Co-Chair, Advances in Biocatalysis and Biosynthesis AIChE Annual meeting, 2012

Session Co-Chair, Advances in Protein Engineering AIChE Annual meeting, 2012

Reviewer for the Biochemical Engineering Journal

Session Chair, Advances in Biocatalysis and Biosynthesis, AIChE Annual meeting, 2011

Internal

Member of the Graduate Committee, Dept. Chemical and Environmental Engineering, University of California, Riverside 2011- present

Member of the Bourns College of Engineering Undergraduate Breath Committee, 2011-12

Selected Publications, Past 5 Years

1. Kwon CH, **Wheeldon I**, Kachouie N, Lee SH, Bae H, Kang JW, Khademhosseini A, Controlled release microarrays for cell-based screening of chemical-induced apoptosis, *Analytical Chemistry* 2011;83(11):4118-25
2. Wu J*, **Wheeldon I***, Guo Y, Lu T, Du T, Wang B, He J, Hu Y, Khademhosseini, A sandwiched microarray platform for benchtop cell-based high throughput screening, *Biomaterials* 2011;32(3):841-848 (* equal contributions).
3. Banta S, **Wheeldon IR**, Blenner M. Protein engineering in functional protein-based hydrogels, *Annual Reviews of Biomedical Engineering* 2010;(12):167-186.
4. Lu HD, **Wheeldon IR**, Banta S., Catalytic Biomaterials: Engineering organophosphate hydrolase to form self-assembling enzymatic hydrogels, *Protein Engineering Design and Selection* 2010;(23):559-566.
5. Campbell EC, **Wheeldon IR**, Banta S. Broadening the cofactor specificity of a thermostable alcohol dehydrogenase using rational protein design introduces novel kinetic transient behavior, *Biotechnology and Bioengineering*, 2010;107(5):763-774.
6. **Wheeldon IR**, Campbell EC, Banta S. A chimeric fusion protein engineered with disparate functionalities— enzymatic activity and self assembly, *Journal of Molecular Biology* 2009;392(1):129-142.
7. **Wheeldon IR**, Gallaway JW, Calabrese Barton S, Banta S. Bioelectrocatalytic hydrogels from electron-conducting metallo-polypeptides co-assembled with bifunctional enzymatic building blocks, *Proceedings of the National Academy of Sciences of the United States of America* 2008;105(40):15275-1528.
8. Gallaway JW, **Wheeldon IR**, Rincon R, Atanassov P, Banta S, Calabrese Barton S. Oxygen-reducing enzyme cathodes produced from SLAC, a small laccase from *Streptomyces coelicolor*, *Biosensors and Bioelectronics* 2008;23:1229-1235.

Selected Presentations, Past 5 Years

1. Hatton B, **Wheeldon I**, Kim P, Hoberman C, Ingber D, Aizenberg J. "From molecules to buildings: Biologically inspired engineering for adaptive architecture" , Adaptive Architecture, An International Conference at the Building Center, London, UK, Mar. 3 – 5, 2011 (Presenter)
2. **Wheeldon IR**, Bick A, Khademhosseini A "Combinatorial biomaterials screening for cardiac epithelial-to-mesenchymal transformation", American Chemical Society Spring 2011 Annual Meeting, Anaheim, CA, USA, Mar. 27-31
3. **Wheeldon I,** "Proteins as functional materials: engineering multi-functional and biologically active hydrogels", Department of Chemical and Biomolecular Engineering, University of Maryland, College Park, Mar. 8th, 2011
4. **Wheeldon IR**, Campbell E, Calabrese Barton S, and Banta S."Engineering enzymes to self-assemble into hydrogels for bioelectrocatalysis", American Chemical Society Fall 2009 Annual Meeting, Washington, D.C., USA, Aug.16-20, 2009.

Selected Professional Development Activities

Laboratory and Biohazard Safety Training, 2012.

UC Export Control training in 2011.

Conference attendee, Electrofuels, SBE and AIChE Conference, Providence RI Nov 6-9. 2011

Jianzhong Wu
Professor
A249 Bourns Hall, University of California, Riverside, CA 92521
Tel: (951) 8272413; Fax: (951) 8275696; Email: jwu@engr.ucr.edu;
http://www.cee.ucr.edu/jwu/

Education

Ph.D., Chem. Eng., University of California, Berkeley, 1998
M.S., Chem. Eng., Tsinghua University, Beijing, 1994
B.S., Applied Math, Tsinghua University, Beijing, 1991
B.E. in Chem. Eng., Tsinghua University, Beijing, 1991

Academic Experience

10/1998 – 12/2000, Postdoctoral Researcher, Lawrence Berkeley National Laboratory

1/2001 –6/2005, Assistant Professor, Department of Chemical and Environmental Engineering, University of California at Riverside

7/2005 –6/2008, Associate Professor, Department of Chemical and Environmental Engineering, University of California at Riverside

7/2008–, Professor, Department of Chemical and Environmental Engineering, University of California at Riverside

2/2010-, Cooperating Faculty, Department of Mathematics, University of California at Riverside

Current Memberships in Professional Organizations

American Institute of Chemical Engineers; American Chemical Society; American Physical Society; Biophysical Society; International Association of Chemical Thermodynamics; Society for Industrial and Applied Mathematics

Honors and Awards

Alexander von Humboldt Research Fellowship (2008); Regents' Faculty Development Award (2003); Regents' Faculty Fellowship (2001); Outstanding Performance Award, Lawrence Berkeley National Laboratory (2000); Progress in Science and Technology Award (2nd place team award), Ministry of Education, P. R. China (1999); Shen Graduate Award, University of California at Berkeley (1996).

Service Activities

Chair of Committee on Scholarships and Honors at UCR (2007-2008)
Chair of Graduate Committee and Graduate Adviser, Department of Chemical and Environmental Engineering (2004-2007; 2009-2011)

Organizer, the National Science Foundation Workshop entitled "Molecular Models for Carbon-Neutral Industrialization", Palm Desert, CA, 2010.

Selected Publications, Past 5 Years

1. D. Jiang, Z. Jin, and J. Wu “Oscillation of Capacitance inside Nanopores”, *Nano Letters*, 11, 5373-5377, 2011.
2. C. L. Ting, J. Wu and Z.G. Wang, “On the Thermodynamic Basis for the Genome to Capsid Charge Relationship in Electrostatically-Driven Viral Encapsidation”, *Proceedings of National Academy of Science of the United State*, 108(41), 16985-16990, 2011.
3. L. Wang, T. Wu, F. Zuo, X. Z., X. Bu, J. Wu, and P. Feng, “Self-Similarity in Metal Chalcogenide Nanocluster Chemistry: Assembly of Supertetrahedral T5 Copper-Indium Chalcogenide Clusters into Super-Supertetrahedron of Infinite Order”, *Journal of the American Chemical Society*, 132(10), 3283–3285, 2010.
4. J. Wu and J. M. Prausnitz, “Pairwise additive hydrophobic effect for alkanes in water”, *Proceedings of National Academy of Science of the United States*, 105(28): 9512–9515, 2008.
5. J. Wu and Z. Li, “Density functional theory for complex fluids”, *Annual Review of Physical Chemistry*, 58:85-112, 2007.

Selected Presentations

1. “Classical density functional theory: A Tutorial”, summer school on “Growth of Hierarchical Functional Materials in Complex Fluids”, *Kavli Institute of Theoretical Physics*, Beijing, July 11, 2011.
2. “Density Functional Theory (DFT): A Chemical Engineering Approach”, Department of Chemical Engineering, *Virginia Polytechnic Institute and State University*, January 31, 2011.
3. “Density functional theory for complex molecular systems”, IGRTG 1524 Colloquium, Department of Theoretical Chemistry, *the Technical University of Berlin*, June 25, 2010

4. “Viral fugacity in vitro and in vivo”, Center for Theoretical Biological Physics (CTBP), *University of California, San Diego*, November 6, 2009.
5. “Primitive models of polymer brushes and nanoparticle composites”, Materials Research Laboratory, *University of California, Santa Barbara*, October 28, 2009.

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Charles E. Wyman

Professor, Chemical and Environmental Engineering Department

Education

Ph.D., Chemical Engineering, Princeton University, Princeton, NJ , 1971

MBA, Business, University of Denver, Denver, CO, 1988

MA, Chemical Engineering, Princeton University, Princeton, NJ, 1969

BS, Chemical Engineering, University of Massachusetts, Amherst, MA, 1967

Academic Experience

1974-1978, Assistant Professor, Chemical Engineering Department, University of New Hampshire, Durham, NH.

1998-2002, Professor, Thayer School of Engineering, Dartmouth College, Hanover, NH.

2002-2005, Paul and Joan Queneau Distinguished Professor in Environmental Engineering Design, Thayer School of Engineering, Dartmouth College, Hanover, NH

2004-2005, Interim Senior Associate Dean, Thayer School of Engineering, Dartmouth College, Hanover, NH.

2005-2010, Adjunct Professor, Thayer School of Engineering, Dartmouth College, Hanover, NH.

2005-present, Ford Motor Company Chair in Environmental Engineering Bourns College of Engineering, Center for Environmental Research and Technology, University of California, Riverside, CA.

2005-present, Professor, Chemical and Environmental Engineering Department, University of California, Riverside, CA.

Non-Academic Experience

1971-1974, Monsanto Company, Senior Chemical Engineer, Process Technology Department, Inc., Springfield, MA. Full time position in development and commercialization of new continuous polymerization processes.

1978-1981, Solar Energy Research Institute, Staff Engineer, Senior Engineer, Group Manager, Program Coordinator, and Deputy Division Manager, Golden, CO. Full time positions that evolved from working on energy storage technologies to leading energy storage research at SERI, providing technical leadership for entire DOE thermal energy storage program, and then leading SERI biofuels program.

1981-1984, Badger Company, Inc., Manager of Process Development, R&D Department, Cambridge, MA. Full-time position in charge of process development and taking technologies from laboratory to commercial scale.

1984-1997. National Renewable Energy Laboratory (formerly Solar Energy Research Institute), Branch Manager, Division Director, Center Director, Golden, CO. Full time positions that evolved from leading all biotechnology research at NREL to being in charge of all biofuels program of over $50 million and over 120 personnel at NREL.

1997-2004, BC International, Director of Technology, Dedham, MA. Full time position from 1997 to 1998 and then consulting until 2004 to lead development of process technology for first-of-a-kind cellulosic ethanol plant planned to use sugar cane bagasse in Jennings, LA.

2005-present, Mascoma Corporation, Co-Founder, Chair of Scientific Advisory Board, Chief Development Office, Lebanon, NH. Founded company to develop and commercialize advanced technology for biological conversion of cellulosic biomass into fuel ethanol, with company now employing about 100 engineers, scientists, and staff with laboratories in Lebanon, NH, a demonstration plant in Rome, NY, and a target commercial site in Kinross, MI.

Current Memberships in Professional Organizations
American Association for Advancement of Science; American Chemical Society; American Institute of Chemical Engineers; Biomass Energy Research Association; Division of Biochemical Technology, American Chemical Society.

Honors and Awards
Tang Lecturer, University of Massachusetts, 2007; Fellow, American Association for Advancement of Science, 2006; C.D. Scott Award in Biotechnology, 1999; Honorary Master of Arts, Dartmouth College, 2004; NREL Hubbard Leadership Award, 1992; NREL Staff Leadership Award, 1991.

Service Activities
Technical Advisory Committee, National Advanced Biofuels Consortium; Founding Editor-in-Chief, *Biotechnology for Biofuels*; Editorial Board, *Biofuels, Bioproducts, and Biorefining*; Editorial Board, *Applied Biochemistry and Biotechnology*; Editorial Board, *BioResources* web based journal; Editorial Board, *Biotechnology and Bioengineering*; Board of Directors, Biomass Energy Research Association; Industrial Board of Advisers, Speed Scientific School, University of Louisville; International Editorial Board, *Biomass and Bioenergy*; Organizing Committee, 8th through 34th Symposia on Biotechnology for Fuels and Chemicals.

Selected Publications (of over 110 peer-reviewed papers and 30 book chapters)
"Lignin Content in Natural *Populus* Variants Affects Sugar Release," Studer MH, DeMartini JD,
"Removal of Minerals from Cellulosic Biomass," Wyman CE, Lloyd TA, U.S. Patent 8,101,024, January 24 (2012).

Davis MF, Sykes RW, Davison BH, Keller M, Tuskan GA, Wyman CE, *Proceedings of the National Academy of Science* **108**(15): 6300-6305 (2011).

"Comparison of Microwaves to Fluidized Sand Baths for Heating Tubular Reactors for Hydrothermal and Dilute Acid Batch Pretreatment of Corn Stover," Shi J, Pu Y, Yang B, Ragauskas A, Wyman CE, *Bioresource Technology* **102**(10): 5952-5961 (2011).

"A Novel Mechanism and Kinetic Model to Explain Enhanced Xylose Yields from Dilute Sulfuric Acid Compared to Hydrothermal Pretreatment of Corn Stover," Shen J, Wyman CE, *Bioresource Technology* **102**: 9111–9120 (2011).

"Renewable Gasoline from Aqueous Phase Hydrodeoxygenation of Aqueous Sugar Solutions Prepared by Hydrolysis of Maple Wood," Li N, Tompsett GA, Zhang T, Shi J, Wyman CE, Huber GW, *Green Chemistry* **13**(1): 91-101 (2011).

"Small Scale and Automatable High-Throughput Compositional Analysis of Biomass," DeMartini JD, Studer MH, Wyman CE, *Biotechnology and Bioengineering* **108**(2): 306-312 (2011).

"Physical and Chemical Characterizations of Corn Stover and Poplar Solids Resulting from Leading Pretreatment Technologies," Kumar R, Mago G, Balan V, Wyman CE, *Bioresource Technology* **100**(17): 3948-3962 (2009).

"Comparative Sugar Recovery and Fermentation Data Following Pretreatment of Poplar Wood by Leading Technologies," Wyman CE, Dale BE, Elander RT, Holtzapple M, Ladisch MR, Lee YY, Mitchinson C, Saddler JN, *Biotechnology Progress* **25**(2): 333-339 (2009).

"How Biotech Can Transform Biofuels," Lynd LR, Laser MS, Bransby D, Dale BE, Davison B, Hamilton R, Himmel M, Keller M, McMillan JD, Sheehan J, Wyman CE, *Nature Biotechnology*, **26**(2): 169-172, February (2008).

"Lignin Blocking Treatment of Biomass and Uses Thereof," Yang B, Wyman CE, U.S. Patent 7,604,967, October 20 (2009).

Joseph M. Norbeck
Emeritus Professor
Department of Chemical and Environmental Engineering
Bourn College of Engineering Center for Environmental Research and Technology
CE-CERT
University of California, Riverside

Professional Experience

2011- Professor Emeritus-Bourns College of Engineering, University of California, Riverside

2004-2011 Founding Director, Environmental Research Institute, University of California, Riverside

W. Ruel Johnson Professor of Engineering

1992-2004 Yeager Families Professor of Engineering, Department of Chemical and Environmental Engineering, University of California, Riverside.

Founding Director, Center for Environmental Research and Technology, University of California, Riverside

1986-1991 Manager, Chemistry Department, Ford Research Staff, Ford Motor Company, Dearborn, MI

1977-1982 Research Scientist, Research Staff, Ford Motor Company,

1974-1977 Research Scientist/Computer Systems Manager, Department of Chemistry, University of Wisconsin, Madison

1973-1974 Postdoctoral Research Fellow, Department of Chemistry, University of Sheffield, Sheffield, England

Research Interests

Dr. Norbeck's research is focused on the development of synthetic transportation fuels and their impact on the environment. There is considerable interest throughout the world in the development of transportation fuels from biomass and other carbonaceous material. This effort is motivated by concerns regarding global climate change, depletion of fossil fuels, and the significant increase in the demand for petroleum in the United States and other parts of the world. Over the last several years his research group has developed a process that allows for the thermo chemical conversion of carbonaceous material (wood, algae, biosolids, crop residues, food wastes, plastic, coal) to clean synthesis gas based on a combination of steam pyrolysis and hydrogasification. This process has considerable potential to combine with bio-chemical processes such as cellulosic ethanol technology for very efficient conversion of a broad range of biomass feedstock materials to fuels and chemicals. Other research interests for Dr. Norbeck include characterization of vehicle and stationary source emissions and assessment of their environmental and health impact.

Professional Honors and Awards

NSF Graduate Fellowship, 1970-1971

NDEA Title IV Pre-Doctoral Fellowship, 1971-1973
Science Research Council (England), Postdoctoral fellowship, 1973-1974
NATO Fellowship for Advanced Study, 1974
Clean Air Award Recipient, South Coast Air Quality Management District, Los Angeles, 1995
Excellence in Environmental Research, Valley Group of Inland Empire, California 1997
Regional Leader of the Year, Riverside Monday Morning Group, Riverside, CA 1998
Elected as a Fellow of the American Association for the Advancement of Science, 1999
Mellon Foundation Fellowship, 2000-2003

Education

Ph.D., Theoretical Chemistry, University of Nebraska, Lincoln, 1974
B.Sc., Chemistry, University of Nebraska, Lincoln, 1970

Recent Engineering/Scientific Committees and Professional Activities

Board of Directors, Science and Technology Education Partnership (STEP), Riverside County (1999-present)
Program and Peer Reviewer – Small Business Innovative Research Program, USEPA (1997-present)
Editorial Board of the Journal of Scientific Industrial Research (JSIR) (2001-present)
Editorial Board of the International Journal of Automotive Technology (2000-present)
Gubernatorial Appointment: California Inspection Maintenance Review Committee, Air Quality Expert, (1994-2001)
California Energy Commission Advisory Committee for AB118 Alternative and Renewable Fuel and Vehicle Technology Program (2010-present)

Selected publications and presentations

- Jonathan Davidson and Joseph M. Norbeck, "*An Interactive History of the Clean Air Act: Scientific and Policy Perspectives*", Elsevier Inc. London NW1 7 BY England, ISBN: 978-0-12-416035-4, 154 pages (2012)
- Xin Fan, Chan S Park*, Joseph M Norbeck, " Steam Hydrogasification of Biomass Using a Lab-scale Inverted Batch Reactor", Submitted to Energy and Fuels, (2012)
- Arun Raju, C. S. Park, J. M. Norbeck, "Synthesis Gas Production using Steam Hydrogasification and Steam Reforming " Fuel Processing Technology, 90, 330-336 (2009)
- Kim, S. K. Jeon, C. Vo, C. S. Park, J. M. Norbeck "Removal of H2S from steam-hydrogasifier product gas by zinc oxide sorbent" Ind. Eng. Chem. Res. 2007, 46,5848.

J. Wayne Miller
Adjunct Professor CEE & Associate Director, CE-CERT

Education
Ph.D., California Institute of Technology, Chemical Engineering
B.S., Worcester Polytechnic Institute, Chemical Engineering

Academic Experience (2001 -2012)
- Adjunct Professor in Chemical and Environmental Engineering Department
- Associate Director of College of Engineering –Center for Environmental Research Technology (CE-CERT)

.
Non-Academic Experience
JWM Technical Services 2001 -2012
- Principal, Consulted for multiple companies, including law firms

Sunoco Inc, Philadelphia, PA. 1995-2001
- Vice President for Technology and Product Development**,**

Unocal Corp, Los Angeles CA 1975-1995
- Manager, Fuels Technology (1990-95); Manager, Fuels and Lubricants Research (1985-90); Team Leader, Obed Coal Company (1984-85); Supervisor, Exploratory Process Research (1981-85); Senior Research Engineer (1975-81)

Honors and Awards
- UCR Non-Faculty Research and Teaching Award (2008)
- EPA's 2007 Climate Change Award for the Joint Strike Fighter Project
- Honorary Judge for the Secretary of Defense Environmental Awards (2003-2011)
- U.S. Air Force's Arnold Engineering Development Center for its Annual Technical Achievement Award. (2006)
- Air Pollution Control Board member; appointed by Mayor, City of Philadelphia (1998-2000) Co-Chair Environmental Justice Committee for City of Philadelphia

Service Activities
- Worcester Polytechnic Institute's Chemical Engineering Advisory Group (2000 to 2007)
- Technical Advisor for South Coast Air Quality Management Board's Clean Fuels Program (2001-2012)
- Selected as team member by UC Office of the President to review research activities at the Institutes of Transportation for: UC Berkeley, UC Davis and UC Irvine (2004)
- Reviewer for new state-funded centers of excellence:
  - State of Idaho Universities (2006)
  - Universities of Minnesota (2006)

- Reviewer for the following journals: Aerosol Science and Technology, Journal of the Air & Waste Management Association, Atmospheric Environment, Atmospheric Chemistry and Physics, Environmental Science and Technology, Journal of Engineering for Gas Turbines and Power, Journal of Propulsion and Power, Science of the Total Environment, International Journal of Hydrogen Energy

Most Recent Publications, (total of 32 from 2001)

1. Murphy, S. H., Agrawal, H., Sorooshian, A., Padr, L. T., Gates, H., Hersey, S., Welch, W. A., Jung, H. Miller, J. W., Cocker, D. R., Nenes, A., Jonsson, H. H., Flagan, R. C., and. Seinfeld, J. H Comprehensive Simultaneous Shipboard and Airborne Characterization of Exhaust from a Modern Container Ship at Sea *Environmental Science & Technology*, 43 (13) pp 4626-4640- **2009**
2. Agrawal, H., Eden, R., Zwang, X., Fine, P., Katzenstein, Miller, J. W., A., Ospital, J., Teffera, S., Cocker, D. R. Primary Particulate Matter from Ocean-Going Engines in the Southern California Air Basin, *Environmental Science & Technology* 43 (14) pp 5398-5402- **2009**
3. Agrawal H, Welch WA, Henningsen S, Miller, J. Wayne, Cocker, David R., III, Emissions from main propulsion engine on container ship at sea, *Journal of Geophysical Research-Atmospheres,* Vol 115, (#D23205) Dec. **2010**
4. Hosseini S, Li Q, Cocker D, Weise, D., Miller, A., Shrivastava, M., Miller, J. W., Mahalingam, S., Princevac, M., Jung, H., Particle size distributions from laboratory-scale biomass fires using fast response instruments, *Atmospheric Chemistry and Physics*, Vol 10, (16) pp 8065-8076, **2010**
5. Jayaram V, Nigam A, Welch WA, Miller, J. Wayne, Cocker, David R., III, Effectiveness of Emission Control Technologies for Auxiliary Engines on Ocean-Going Vessels *Journal of Air and Waste Management*, Vol. 61, 14-21- Jan **2011**
6. Jayaram V, Nigam A, Welch WA, Miller, J. Wayne, Cocker, David R., III, Real-time gaseous, PM and ultrafine particle emissions from a modern marine engine operating on biodiesel, *Environmental Science & Technology* 45 (6) pp 2286-2292- **2011**
7. Karavalakis, G., Durbin, T., Vilela, M., Miller, J.W., Air Pollutant Emissions Of Light-Duty Vehicles Operating On Various Natural Gas Compositions *J. of Natural Gas Science & Engineering*; Vol 4, Pages 8–16, January **2012**
8. Browning, L., Bandemehr, A., Hartley, S., Miller, J. W., Demonstration of Fuel Switching on Ocean Going Vessels in the Gulf of Mexico; accepted for publication, *Journal of Air and Waste Management*,**2012**

Kawai Tam
Lecturer

Education:

2002 Ph.D. in Biosystems Engineering, McGill University, Montreal, Quebec, Canada
1994 M. Eng. in Chemical Engineering, McGill University, Montreal, Quebec, Canada
1992 B. Eng. in Chemical Engineering, McGill University, Montreal, Quebec, Canada

Academic Experience:

1994 - 1996 *Research Assistant* and *Teaching Assistant*, McGill University
1997 - 1998 *Lecturer* and *Research Assistant*, University of California, Riverside
2004 – 2009 *Post-doctoral scholar*, University of California, Riverside
2009 *Assistant Project Scientist*, CE-CERT, University of California, Riverside
2002-present. *Lecturer*, Depart. Of Chemical & Environmental Engineering, UCR

***Non-Academic Experience*:**

1994 - 1995 *Consultant*, Corona Technologies Inc., part-time

Membership in Profession Organization:

1992- American Institute of Chemical Engineers (AIChE)

Scholarship and Awards:

- Western Municipal Water District Travel Awards, 2009 / 2010 / 2011 / 2012
- Western Municipal Water District Water Educator of the Year Award, 2007
- UCR Instructional Support in Undergraduate Education Award, Winter 2007
- UCR Faculty Minigrant Award, Spring 2006
- UCR Non-Senate Faculty (NSF) Professional Development Award, 2005-07/ 2008-11
- The Bourns College of Engineering Outstanding Lecturer Award, 2004-2005
- ACS PRF summer scholarship, Massachusetts Institute of Technology, 2005
- EPA P3 student design competition awards, faculty advisor
  - 2011-2012 Phase I **EPA Grant Number:** SU836024
  - 2011 Phase II EPA P3 Student Choice Award (SU834726)
  - 2010-2011 Phase I **EPA Grant Number:** SU834726
  - 2010-2011 Phase I **EPA Grant Number:** SU834709
  - 2010 Phase II EPA P3 Honorable Mention Award (SU834325)
  - 2009-2010 Phase I **EPA Grant Number:** SU834325
  - 2009-2010 Phase I **EPA Grant Number:** SU834294
  - 2007-2008 Phase I **EPA Grant Number:** SU833526
  - 2005-2006 Phase I **EPA Grant Number:** SU832493
- Waste-management, Education and Research Consortium (WERC) Environmental Design competition, faculty advisor
  - 2011 First Place Award & Terry McManus Outstanding Student Award
  - 2010 Second Place Award
  - 2009 Terry McManus Outstanding Student Award
  - 2007 U.S.D.A. Teamwork award for innovative use of agricultural waste for value added products / Terry McManus Outstanding Student Award
- 2011 Hydrogen student design contest, 2nd place – Honorable Mention Award, faculty advisor

- 2011 American Public Power Association (APPA) Demonstration of Energy-Efficient Developments (DEED) Research Grants (two separate teams), faculty advisor
- 2008-2009 Southern California World Water Forum College Grant, MWD, faculty advisor
- 2005-2006 Southern California World Water Forum College Grant, MWD, faculty advisor

Service Activities:

- UCR CEE Undergraduate Education Committee (2011, 3-year appointment)
- UCR CEE ABET Committee (2011-2012)
- UCR Non-Senate Faculty Excellence Review Committee (2010, 3-year appointment)
- Invited guest presenter at the Southern California World Water Forum College Grant Program, "Silica Removal in Brackish Water", Los Angeles, Oct. 7, 2011
- Collaborator with UCR Undergraduate Research in the Community Undergraduate Education program on a community project in Moreno Valley, 2011- present
- Collaborator with the UCR Blakely Center for Sustainable Suburban Development 2010 - present; multidisciplinary interaction with film and engineering students for a community project in Moreno Valley
- Invited presenter at the Western Municipal Water District board meeting, June 2011
- Organizer / presenter: Global Climate Change Workshop for Riverside Unified School District, Oct. 2009; coordinated outreach and high school Science Fair Projects.
- Invited guest panelist for Spring Splash Planet Panel during Earth Week, April 2009
- Invited guest panelist for Society of Women Engineers (SWE) 2004, 2005 and 2007
- Organizer: educational seminar in conjunction with Intelligen. Attended by industrial representatives and open for UCR students (June 2005 and 2007)
- Invited speaker/coordinator for Freshman summer Fridays for Chem. Eng. (2004-05)
- Peer reviewer: Applied Biochemistry and Biotechnology / Biotechnology Progress
- On a radio broadcast for the Green Power Report on Educating Riverside students at all Levels. The 30 minute broadcast on 11/17/2008 entitled, "Educating Riverside Students at All Levels" is found at <http://www.riversideca.gov/utilities/comm-gp-gpreport.asp >
- Filmed and interviewed by News Channel 3 for discussion on incorporating sustainability into education. Interview and filming was done after the radio interview (11/2008).
- Featured in the Press Enterprise newspaper and magazines several times for student design competitions in 2009- 2011

Publications:

K.Tam, C.T. Ho, J-H. Lee, M. Lai, C. H. Chang, Y. Rheem, W. Chen, H-G. Hur, N. V. Myung, "Growth mechanism of amorphous selenium nanoparticles synthesized by *Shewanella* sp. HN-41", *Bioscience, Biotechnology and Biochemistry*, 74(4), 696-700, 2010.

K. Tam, N. Kinsinger, P. Ayala, F. Qi, W. Shi, N. V. Myung, "Real-time monitoring of *Streptococcus mutans* biofilm formation using quartz crystal microbalance", *Caries Research,* 41, 474-483, 2007.

Professional Development Activities**:**

- Training at COMSOL Multiphysics software May 21, 2009, Riverside, CA; investigation of possible integration into CEE courses
- Attendance of AIChE annual meetings enabled in 2005-2011 from NSF Professional Development Awards

Daniel Gerrity, Ph.D.
Lecturer

Education

Ph.D., Environmental Engineering, Arizona State University, 2008
M.S., Environmental Engineering, Arizona State University, 2005
B.S., Civil Engineering, Arizona State University, 2004

Academic Experience

2011-2012. Lecturer, Department of Chemical and Environmental Engineering, University of California, Riverside.

2007-2008. Teaching Assistant, Department of Civil and Environmental Engineering, Arizona State University.

2005-2008. Graduate Research Assistant, Department of Civil and Environmental Engineering, Arizona State University

Non-Academic Experience

Trussell Technologies, Inc., Senior Engineer III, 2011-Present, Full-Time. Responsible for engineering design projects related to the use of ozone and biologically active filtration in groundwater replenishment projects.

Southern Nevada Water Authority, Post Doctoral Researcher, 2008-2011, Full-Time. Evaluated ozone, advanced oxidation processes, and water reuse treatment trains for the removal and destruction of trace organic contaminants, disinfection byproducts, disinfection byproduct precursors, and microorganisms. Evaluated optimization strategies for conventional wastewater treatment to maximize trace organic contaminant removal.

Lawrence Livermore National Laboratory, Department of Homeland Security Fellow, 2006, Full-Time. Performed culture and molecular-based (qPCR) experiments to characterize the recovery of Bacillus anthracis (anthrax) spores deposited onto fibrous substrates.

Certifications or Professional Registrations

Engineer-In-Training #09358

Service Activities

Reviewer for UCR “Sustain-a-Drain” submission to the 2012 WERC Environmental Design Contest.

Selected Publications, Past 5 Years

Gerrity, D., Gamage, S., Holady, J.C., Mawhinney, D.B., Quinones, O., Trenholm, R.A., Snyder, S.A., 2011. Pilot-scale evaluation of ozone and biological activated carbon for trace organic contaminant mitigation and disinfection. Water Res. 45, 2155-2165.

Gerrity, D., Snyder, S., 2011. Review of ozone for water reuse applications: Toxicity, regulations, and trace organic contaminant mitigation. Ozone Sci. Eng. 33, 253-266.

Gerrity, D., Snyder, S., 2011. The economic value of water in metropolitan areas of the United States. Water Pol. 13, 443-458.

Gerrity, D., Trenholm, R.A., Snyder, S.A., 2011. Temporal variability of pharmaceuticals and illicit drugs in wastewater and the effects of a special event. Water Res. 45, 5399-5411.

Mayer, B., Gerrity, D., Rittmann, B.E., Reisinger, D., Brabham, M., 2011. Innovative strategies to achieve low total phosphorus concentrations in high water flows. Crit. Rev. Environ. Sci. Technol. In review.

Pisarenko, A.N., Stanford, B.D., Yan, D., Gerrity, D., Snyder, S.A., 2011. Effects of ozone and ozone/peroxide on trace organic contaminants and NDMA in drinking water and water reuse applications. Water Res. 46, 316-326.

Gerrity, D., Stanford, B.D., Trenholm, R.A., Snyder, S.A., 2010. An evaluation of a pilot-scale nonthermal plasma advanced oxidation process for trace organic compound degradation. Water Res. 44, 493-504.

Mayer, B.K., Ryu, H., Gerrity, D., Abbaszadegan, M., 2010. Development and validation of an integrated cell culture-qRTPCR assay for simultaneous quantification of coxsackieviruses, echoviruses, and polioviruses in disinfection studies. Water Sci. Technol. 61, 375-387.

Even-Ezra, I., Mizrahi, A., Gerrity, D., Snyder, S., Salveson, A., Lahav, O., 2009. Application of a novel plasma-based advanced oxidation process for efficient and cost-effective destruction of refractory organics in tertiary effluents and contaminated groundwater. Desalin. Water Treat. 11, 1-9.

Gerrity, D., Mayer, B., Ryu, H., Crittenden, J., Abbaszadegan, M., 2009. A comparison of pilot-scale photocatalysis and enhanced coagulation for disinfection byproduct mitigation. Water Res. 43, 1597-1610.

Gerrity, D., Ryu, H., Abbaszadegan, M., 2008. UV inactivation of adenovirus type 4 measured by integrated cell culture qPCR. J. Environ. Sci. Health Part A 43(14), 1628-1638.

Gerrity, D., Ryu, H., Crittenden, J., Abbaszadegan, M., 2008. Photocatalytic inactivation of viruses using titanium dioxide nanoparticles and low-pressure UV light. J. Environ. Sci. Health Part A 43(11), 1261- 1270.

Kalkstein, A.J., Kuby, M., Gerrity, D., Clancy, J.J., 2008. An analysis of air-mass effects on rail ridership in three U.S. cities. J. Transport Geogr. 17(3), 198-207.

Ryu, H., Gerrity, D., Crittenden, J., Abbaszadegan, M., 2008. Photocatalytic inactivation of *Cryptosporidium parvum* with TiO_2 and low-pressure ultraviolet irradiation. Water Res. 42(6-7), 1523-1530.

Li, K., Zhang, P., Crittenden, J., Guhathakurta, S., Chen, Y., Fernando, H., Sawhney, A., McCartney, P., Grimm, N., Kahhat, R., Joshi, H., Konjevod, G., Choi, Y., Fonseca, E., Allenby, B., Gerrity, D., Torrens, P., 2007. Development of a framework for quantifying the environmental impacts of urban development and construction practices. Environ. Sci. Technol. 41, 5130-5136.

Hosik Park
Visiting Research Scientist

Education

Ph.D., Environmental Engineering, Gwangju Institute of Science and Technology (Korea), 2010
M.S., Environmental Engineering, Chungnam National University (Korea), 2004
B.S., Environmental Engineering, Chungnam National University (Korea), 2002

Academic Experience

2010-2010. Postdoctoral Researcher, School of Environmental Science and Engineering, Gwangju Institute of Science and Technology (Korea).
2010-Present. Visiting researcher, Department of Chemical and Environmental Engineering, UCR.

Non-Academic Experience

2004-2005. Sunjin Engineering and Architecture (Korea), Civil and Environmental engineer, full time.

Current Memberships in Professional Organizations

American Chemical Society
International Water Association

Honors and Awards

2005-2010. Government sponsored graduate student scholarship (Korea).
2007-2008. National science and technology scholarship award, Korea Student Aid Foundation.

Selected Publications, Past 5 Years

1. Park, H., and Choi, H. (2011). “As(III) removal by hybrid reactive ceramic membrane process combined with ozonation.” Water Research, 45(5), 1933-1940.
2. Evrim Celik, Park, H., and Choi, H. (2011). “Carbon nanotube blended polyethersulfone membranes for fouling control in water treatment.” Water Research, 45(1), 274-282.
3. Park, H., Jung, H., Myung, N. V. and Choi, H. (2009). "As(V) remediation using electrochemically synthesized maghemite nanoparticles." Journal of Nanoparticle Research, 11(8), 1981-1989.
4. Wang, Q., Kanel, S. R., Park, H., Ryu, A. and Choi, H. (2009). "Controllable synthesis, characterization and magnetic properties of nanoscale zerovalent iron with specific high brunauer-emmett-teller surface area." Journal of Nanoparticle Research, 11(3), 749-755.

5. Park, H., Ayala, P., Deshusses, M. A., Mulchandani, A., Choi, H. and Myung, N. V. (2008). "Electrodeposition of maghemite (γ-Fe_2O_3) nanoparticles." Chemical Engineering Journal, 139(1), 208-212.
6. Jung, H., Park, H., Kim, J., Lee, J. H., Hur, H. G., Myung, N. V. and Choi, H. (2007). "Preparation of biotic and abiotic Iron Oxide Nanoparticles (IOnPs) and their properties and applications in heterogeneous catalytic oxidation." Environmental Science and Technology, 41(13), 4741-4747.

Tom Perina
Lecturer

Education

Ph.D., Hydrogeology, UCR, 2003
M.S., Hydrogeology and Geophysics, UCR, 1993
M.S., RNDr. Hydrogeology and Engineering Geology, Charles University in Prague, 1984

Academic Experience

2005-present. Lecturer, Department of Chemical and Environmental Engineering UCR.
1992-1994 UCR, Teaching/Research Assistant, Research Staff

Non-Academic Experience

2002-present, CH2M HILL, Senior Hydrogeologist/Project Manager (full time)
1994-2002 IT Corporation, Senior Hydrogeologist/Project Manager (full time)
1994 - Huntingdon Engineering and Environmental, Project Hydrogeologist (full time)
1984-1991 Stavebni Geologie Praha (Engineering Geology Prague), Hydrogeologist/Project Manager (full time)

Certifications or Professional Registrations

State of California Professional Geologist, Reg. No. 6636

State of California Certified Hydrogeologist, Cert. No. 572

Current Memberships in Professional Organizations

National Groundwater Association, Associate Editor

Honors and Awards

Service Activities

Selected Publications, Past 5 Years

Perina, T. 2010. Derivation of the Theis (1935) equation by substitution. Ground Water, vol. 48, no. 1, pp. 6-7.

Perina, T., and T.C. Lee. 2007. Transient soil vapor extraction from a pressure-controlled well. Groundwater Monitoring and Remediation, vol. 27, no. 1, pp. 47-55.

Selected Professional Development Activities

Haizhou Liu
Assistant Professor (starts 1/1/2013)
Department of Chemical and Environmental Engineering
University of California, Riverside

Education

Ph.D., Environmental Engineering, University of Washington, 2010
M.S., Civil Engineering, University of Washington, 2007
B.S., Environmental Engineering, Sichuan University, China, 2006

Academic Experience

2006-2010. Graduate research assistant, Department of Civil and Environmental Engineering, University of Washington.
2010-2012. Postdoctoral research fellow, Department of Civil and Environmental Engineering, University of California, Berkeley.
Starting 2012. Assistant Professor III, Department of Chemical and Environmental Engineering, University of California, Riverside.

Current Memberships in Professional Organizations

American Chemical Society
American Water Works Association
International Water Association
The Electrochemical Society

Selected Honors and Awards

2010. Honorable mention for best platform presentation, 5th International Water Association Young Water Professionals Conference, International Water Association.
2010. Best student platform presentation, Division of Environmental Chemistry, American Chemical Society Spring Annual Meeting.
2009. Environmental chemistry graduate student paper award, Division of Environmental Chemistry, American Chemical Society.
2009. 1st place in students and young professionals poster presentation, AWWA Annual Conference and Exposition, American Water Works Association.
2009. Joseph W. Richards summer research fellowship, the Electrochemical Society.
2008. Graduate student award in environmental chemistry, Division of Environmental Chemistry, American Chemical Society.
2008. Petty-Stiles memorial scholarship, American Water Works Association Pacific Northwest Section.

Service Activities

2010-2012. Committee member, Specialist group on metals and toxic substances in drinking Water, International Water Association.

2009-2010. Student chapter officer, Chapter of American Water Works Association/Water Environment Federation, University of Washington.

2008-present. Journal reviewer, Environmental Science and Technology, Water Research.

2007-2008. Panelist, Annual graduate research assistants workshop, University of Washington.

Selected Publications, Past 5 Years

Liu, H.; Jeong, J.; Gray, H.; Smith, S.; Sedlak, D.L. Algal uptake of hydrophobic and hydrophilic dissolved organic nitrogen in effluent from biological nutrient removal municipal wastewater treatment systems. *Environmental Science and Technology*. **2012**, *46* (2), 713-721.

Liu, H.; Kuznetsov, A. M.; Masliy, A. N.; Korshin, G.V.; Ferguson, J.F. Formation of Pb(III) intermediates in the electrochemically controlled Pb(II)/PbO_2 System. *Environmental Science and Technology*. **2012**, *46* (3), 1430-1438.

Liu, H.; Schonberger, K. D.; Korshin, G.V.; Ferguson, J.F. Meyerhofer, P; Desormeaux, E.; Luckenbach, H. Effects of blending of desalinated water with treated surface drinking water on copper and lead release. *Water Research*. **2010**, *44* (14), 4057-4066.

Liu, H.; Korshin, G.V.; Ferguson, J.F. Interactions of Pb(II)/Pb(IV) solid phases with chlorine and their effects on lead release. *Environmental Science and Technology*. **2009**, *43* (9), 3278-3284.

Liu, H.; Korshin, G.V.; Ferguson, J.F. Investigation of the kinetics and mechanisms of the oxidation of cerussite and hydrocerussite by chlorine. *Environmental Science and Technology*. **2008**, *42* (9), 3241-3247.

Selected Professional Development Activities

2012. Attendee, Workshops on preparing future faculty: teaching. University of California, Berkeley.

2011. Attendee, Workshop on grant writing. University of California, Berkeley.

David Jassby
Assistant Professor (Starts Fall, 2012)

Education

Ph.D., Civil and Environmental Engineering, Duke University, 2011
M.S., Civil and Environmental Engineering, UC Davis, 2005
B.S., Biology, Hebrew University, 2002

Academic Experience

2011-2012. Executive Director, Center for the Environmental Implications of Nanotechnology, Duke University
2012-. Assistant Professor II, Department of Chemical and Environmental Engineering, UCR

Non-Academic Experience

2005-2006. BBL, Engineer I, full-time, data analysis; field sampling; site investigation.

Certifications or Professional Registrations

Engineer in Training, California, 2005.

Current Memberships in Professional Organizations

American Chemical Society

Honors and Awards

Senol Utku Award – High Distinction, 2011
Jeffery B. Taub Environmental Engineering Graduate Student Award, 2010
California Lake Management Society Scholarship, 2004

Service Activities

NA

Selected Publications, Past 5 Years

Characterization of a Cross-linked Poly(Vinyl Alcohol) – Carbon Nanotube Ultrafiltration Membrane. de Lannoy, C. F.; Jassby, D.; Wiesner, M., Highly Conductive Polymer Membrane: Fabrication and Characterization. Journal of Membrane Science, 2012.

Impact of Aggregate Size and Structure on the Photocatalytic Properties of TiO2 and ZnO Nanoparticles. Jassby, D.; Farner-Budarz, J.; Wiesner, M. Environmental Science and Technology., 2012.

Characterization of ZnS nanoparticle aggregation using photoluminescence. Jassby, D.; Wiesner, M. Langmuir, 2011.

Membrane filtration of fullerene nanoparticle suspensions: Effects of derivatization, pressure, electrolyte species and concentration. Jassby, D.; Chae, S.; Hendren, Z.; Wiesner, M. Journal of Colloid and Interface Science, 2009.

Filament content threshold for activated sludge bulking: Artifact or reality? Schuler, A. J.; Jassby, D., Water Research, 2007.

Distributed state simulation of endogenous processes in biological wastewater treatment. Schuler, A. J.; Jassby, D. Biotechnology and Bioengineering, 2007.

Impact of Size and Structure on the Photocatalytic Properties of TiO_2 and ZnO Nanoparticles. Jassby, D.; Farner Budarz, J.; Wiesner, M., in Water and Nano conference, ACS 242nd national meeting, Denver, CO, 2011.

Characterizing ZnS Aggregation using Photoluminescence. Jassby, D.; Wiesner, M., in GRC on Environmental Nanotechnology, Waterville Valley, NH, 2011.

Aggregation and reactivity. Jassby, D., in Water and Nano conference, Harvard Law School, Cambridge, MA, 2011.

Effects of Pressure and Electrolyte Concentration on Fullerol Separation by Membrane Filtration. Jassby, D.; Chae, S.; Hendren, Z.; Wiesner, M., in IWA conference on particle separation, Durham, NC, 2009.

Juchen Guo (Starts Fall, 2012)
Assistant Professor

Education

Ph.D., Chemical Engineering, University of Maryland, 2007
B.S., Chemical Engineering, Zhejiang University, 1999

Academic Experience

2012-present. Assistant Professor, Department of Chemical and Environmental Engineering UCR.

Certifications or Professional Registrations

None.

Current Memberships in Professional Organizations

American Institute of Chemical Engineers
American Chemical Society
The Electrochemical Society

Honors and Awards

None.

Service Activities

None.

Selected Publications, Past 5 Years

Y. Xu, J. Guo, C. Wang, "Sponge-like porous carbon/tin composite anode materials for lithium ion batteries", *Journal of Materials Chemistry*, 2012, 22, 9562-9567.

J. Guo, Q. Liu, M. R. Zachariah, C. Wang, "Inter-dispersed amorphous MnOx-carbon nanocomposites with superior electrochemical performance as lithium storage material", *Advanced Functional Materials* 2012, 22, 803-811.

Y. Luo, J. Guo, C. Wang, D. Chu, "Acrylate Polymer Based Electrolyte Membrane for Alkaline Fuel Cell Applications", *ChemSusChem* 2011, 4, 1557-1560.

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Appendix C – EQUIPMENT

SHADED ARE EQUIPMENT ACTIVELY USED AND PURCHASED FOR TEACHING EQUIPMENT, RESEARCH EQUIPMENT ALSO FREQUENTLY USED IN CEE 125, CHE 161, CHE 124L

DEPARTMENT: CHEMICAL & ENVIRONMENTAL ENGINEERING

Respondent's Name: Kathy Cocker/Cheryl Gerry

						CURRENT LOCATION		
PROPERTY #	DESCRIPTION	RECEIVAL DATE	MANUFACTURER	MODEL	Active/ Inactive	BUILDING	ROOM #	COST
925001129	SPECTROPHOTOMETER SYSTEM, UV/VIS, WITH CONT	Jun-92	*VARIAN	@00-100471-01	Active	**Bourns**	B312	15,913
925002079	CABINET, BIOLOGICAL SAFETY, CLASS II, TYPE	Dec-92	*FORMA	@1186	Active	Bourns	B328	6,563
935000610	BENCH-HEAT STUDY CONDUCTION, TEACHING UNIT	Apr-93	*ARMFIELD	@HT1-B	Active	**Bourns**	B108 STOR	11,431
935000611	TOWER-WATER COOLING, TEACHING UNIT	Apr-93	*ARMFIELD	@UOP6-10-B	Active	Bourns	B235	16,493
935000612	EXCHANGER-CONCENTRIC TUBE HEAT, TEACHING UN	Apr-93	*ARMFIELD	@HT4-B	Active	**Bourns**	B108	11,492
935000613	BENCH-THERMAL RADIATION STUDY, TEACHING UNI	Apr-93	*ARMFIELD	@HT5-B	Active	Bourns	B134 STOR	16,948
935000614	TRANSFER-FREE & FORCED CONVECTION, TEACHING	Apr-93	*ARMFIELD	@HT6-B	Active	**Bourns**	B134	11,795
935000615	EXCHANGER/REACTOR-HEAT, TUBULAR FLOW, TEACH	Apr-93	*ARMFIELD	@CET-B	Active	Bourns	B134 STOR	17,737
935000616	EXCHANGER-DYNAMIC BEHAVIOR OF STIRRED TANKS	Apr-93	*ARMFIELD	@CEP-B	Active	**Bourns**	B134 STOR	16,156

935000618	COLUMN-LIQUID & GASEOUS DIFFUSION, TEACHING	Apr-93	*ARMFIELD	@CER A&B	Active	Bourns	B235	7,694
935000619	COLUMN-WETTED WALL GAS ABSORPTION, TEACHING	Apr-93	*ARMFIELD	@CES-B	Active	**Bourns**	B108	21,406
935000620	COLUMN-GAS ABSORPTION, TEACHING UNIT	Apr-93	*ARMFIELD	@UOP7-B	Active	Bourns	B108	19,055
935000621	DRYER-TRAY, TEACHING UNIT	Apr-93	*ARMFIELD	@UOP8-B	Active	**Bourns**	B108	12,41-
935000754	MODULE-INJECTION, FULL INJECTION ANALYZER,	May-93	*EPPENDORF	@6603-000-020	Active	Bourns	B314	10,770
935001416	POTENTIOSTAT/GALVANOSTAT, ELECTROCHEMICAL	Aug-93	*EG&G/PARC	@263	Active	**Bourns**	B254	10,764
935001423	INCUBATOR,SHAKING, KING SIZE CHAMBER,ROTARY	Aug-93	*NEW BRUNSWICK	@M1024-1000	Active	Bourns	B235	7,013
935001794	FERMENTOR/BIOREACTOR,BENCHTOP,W/ 5 LITER VES	Oct-93	*NBS	@M1217-0009B	Active	**Bourns**	B312	38,807
935001823	STERILIZER, STEAM, 32.5X63.5 CM, 160 DEG CM	Oct-93	*TOMY	@ES-315	Active	Bourns	B312	5,113
935001887	SPECTROPHOTOMETER,UV-VIS, 190-1100 NM, DOUB	Nov-93	*P-E	@C695-2200	Active	**Bourns**	B350	11,881
945000503	DISTILLATION COLUMN, MICRO-BASED BATCH PLAT	Apr-94	*ARMFIELD INC	@UOP3D-B	Active	Bourns	B108	33,009
945000504	SOLID/LIQUID EXTRACTION UNIT	Apr-94	*ARMFIELD INC	@UOP4-B	Active	**Bourns**	B108	28,476
945000505	LIQUID/LIQUID EXTRACTION UNIT	Apr-94	*ARMFIELD INC	@UOP5-B	Active	Bourns	B108	35,295
945000622	ANALYZER-TOTAL ORGANIC CARBON	May-94	*SHIMADZU	@TOC-5050	Active	**Bourns**	B318	33,466
945000639	APPARATUS, FRICTION MEASUREMENT	May-94	*ARMFIELD	@C6-B	Active	Bourns	B134	53,492
945000640	MULTI-PUMP TEST RIG	May-94	*ARMFIELD	@C3-11B	Active	**Bourns**	B134	53,105
945000641	FLUME, MULT-PURPOSE,	May-94	*ARMFIELD	@C4-5MB	Active	Bourns	B108	30,212
945000642	FLOWMETER,	May-94	*ARMFIELD	@C9-00B	Active	**Bourns**	B235	59,985

945001408	CENTRIFUGE, REFRIGERATED,21,000RPM MAX, W/P	Aug-94	*BECKMAN	@360301	Active	Bourns	B312	18,567
945001441	ANALYZER-PARTICLE SIZE,0.4 TO 1200 UM RANGE	Aug-94	*COULTER	@6604691	Active	**Bourns**	B235	28,037
945001591	BALANCE-ANALYTICAL, TOPLOADING,22GX2UG	Sep-94	*METTLER	@AT20	Active	Bourns	B350	6,999
945001598	DETECTOR,	Sep-94	*BIOANALYTICAL SYS	@LC-44-22000	Active	**Bourns**	B254	9,056
945001621	CELL, FRENCH PRESSURE-SAMPLE PREPARATION,MO	Sep-94	*SLM	@FA-078	Active	Bourns	B312	7,424
945001631	SPECTROPHOTOMETER,	Sep-94	*BECKMAN	@DU-640/517002	Active	**Bourns**	B312	16,526
945002025	SPECTROPHOTOMETER,FLAME/FURNACE ATOMIC ABSO	Nov-94	*SHIMADZU	@AA6501	Active	Bourns	B235	49,996
945002213	BIOREACTOR,	Dec-94	*NEW BRUNSWICK SCI	@M1228-0009C	Active	**Bourns**	B235	26,699
955000569	CHROMATOGRAPH, GAS	Feb-95	*H-P	@5890E	Active	Bourns	B318	14,880
955001810	LASER SYSTEM,	Aug-95	*LEXEL LASER	@M-95A-3	Active	**Bourns**	B328AA	16,163
955002282	CHROMATOGRAPH/SPECTROMETER	Nov-95	*SHIMADZU	@QP-5000	Active	Bourns	B235	71,354
955002307	CHROMATOGRAPH, GAS	Nov-95	*H-P	@6890	Active	**Bourns**	B318	33,171
965001245	PERMEAMETER,	Jun-96	TRAUTWEIN SOIL TEST	M100000	Active	Bourns	B336	37,304
975000015	ILLUMINATION SYSTEM,	Jan-97	PHOTON TECHNOLOGY	L-201	Active	**Bourns**	B314	14,656
975001891	GENERATOR, OZONE	Sep-97	CHLOR-SERV	V10-AO-115-MC	Active	Bourns	B328	5,931
985000909	ANALYZER/DISTILLING UNIT,	May-98	TECATOR KJELTEC	2300	Active	**Bourns**	B336	16,374
985001225	SONIC ANEMOMETER,	Jun-98	CAMPBELL SCIENTIFIC	CSAT3	Active	Bourns	B262	8,536
98500168	DETECTOR,FLOURESCENCE	Aug-98	SHIMADZU	206-62411-	Active	**Bourns**	B312	9,318

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985002233	BLOCK DIGESTOR,	Oct-98	TECATOR	DS12	Active	Bourns	B336	5,578
5000218	ENGINE,DNA	Mar-00	MJ RESEARCH	PTC-200	Active	**Bourns**	B312	8,609
5000219	DCODE SYSTEM,	Mar-00	BIO-RAD	DGGE	Active	Bourns	B312	6,898
5000508	ELECTROCHEMICAL INTERFACE,	May-00	SOLARTRON	1287	Active	**Bourns**	B328	17,491
5000769	ANALYZER,MICROPORE	Jun-00	MICROMERITICS	ASAP 2010MP	Active	Bourns	B328	34,593
5001426	THERMAL CYCLER,	Oct-00	BIO RAD	170-8720	Active	**Bourns**	B312	44,716
15000792	GEL DOC,	May-01	BIO-RAD	2000	Active	Bourns	B316	9,670
15001122	ANALYZER,POTENTIAL	Sep-01	BROOKHAVEN INSTRU	ZETAPALS	Active	**Bourns**	B328	37,625
15001330	FREEZER,CHEST	Sep-01	REVCO	ELITE	Active	Bourns	B312	5,838
25000172	EXTRACTOR,SOLVENT	Feb-02	DIONEX CORP	ASE-200	Active	CECERT709A	CECERT709A	43,516
25000733	ANALYZER,POTENTIAL	May-02	BROOKHAVEN INSTRUMEN	BI-EKA	Active	Bourns	B328	65,274
25000772	WATER PURIFICATION SYSTEM	Jun-02	FISHER SCIENTIFIC	ZMQS6VF01	Active	**Bourns**	B328	8,341
25000964	MICROPLATE READER	Jul-02	BMG LABTECHNOLOGIES	413-201	Active	Bourns	B312	32,325
25001383	CHROMATOGRAPH	Oct-02	DIONEX CORP	DX-120	Active	**Bourns**	B328	26,980
35000940	PROBE STATION	Oct-03	WENTWORTH	P0901	Active	Bourns	B254	9,698
35001065	MULTIPOTENTIOSTAT	Oct-03	ADV MEASUREMENT TECH	VMP2/Z-40	Active	**Bourns**	B350	49,500
35001076	MICROFLUIDIC TOOL KIT	Oct-03	MICRALYNE	UTK	Active	Bourns	B314	17,145
35001184	SHAKER,INCUBATOR	Nov-03	NEW BRUNSWICK	I2400	Active	**Bourns**	B312	6,015
45000109	MICROBALANCE	Feb-04	MAXTEK	60320	Active	Bourns	B350	6,050
45000186	MICRO PROCESSOR	Feb-04	VWR	DIGITAL 600W	Active	**Bourns**	B312	5,705
45000262	CAMERA SYSTEM,DIGITAL	Feb-04	HIROX	KH-3000VD	Active	Bourns	B254	35,000
45000832	MICROMANIPULATOR	Jun-04	SURPLUS EQ	6200	Active	**Bourns**	B314	9,493
45000835	PUMP,BINARY	Jun-04	AGILENT	G1312A	Active	Bourns	B328	11,292
45000837	AUTOSAMPLER	Jun-04	AGILENT	G1313A	Active	**Bourns**	B328	9,115

45000838	COLUMN COMPARTMENT	Jun-04	AGILENT	G1316A	Active	Bourns	B328	7,346
45000839	DETECTOR,DIODE ARRAY	Jun-04	AGILENT	G1315B	Active	**Bourns**	B328	13,286
45000840	DETECTOR,FLUORESCENCE	Jun-04	AGILENT	G1321A	Active	Bourns	B328	9,084
45000841	FRACTION COLLECTOR	Jun-04	AGILENT	G1364A	Active	**Bourns**	B328	7,367
45000842	CHEMSTATION	Jun-04	AGILENT	HPLC2D	Active	Bourns	B328	10,339
45000907	AUTOCLAVE	Jul-04	YAMATO	SM510	Active	**Bourns**	B108	5,146
45000908	FREEZER,UPRIGHT	Jul-04	JOUAN	VXE600	Active	Bourns	B356	5,576
45000913	THERMAL CYCLER	Aug-04	THERMO/HYBAID	PX2/PCR	Active	**Bourns**	ENGRII365	6,159
55000012	SPECTROMETER	Jul-04	PERKIN-ELMER	AANALYST 800	Active	Bourns	B350	49,417
55000034	SHAKER-INCUBATOR	Mar-05	LAB-LINE	4639	Active	**Bourns**	B328	7,313
55000074	SPECTROPHOTOMETER	May-05	FISHER	BIO-MINI 1240	Active	Bourns	B328	5,179
55000089	METER,MICRON	May-05	HIROX	AUTO Z	Active	**Bourns**	B254	6,788
55000097	SPECTROPHOTOMETER,SCANNING	May-05	BARNSTEAD THERMOLYNE	SP-890	Active	Bourns	B328	5,631
55000129	MICROPLATE READER	Jun-05	FISHER		Active	**Bourns**	B362A	7,602
55000218	POTENTIOMETER TITRATOR	Dec-05	BRINKMANN INSTRUM	TITRINO 798/A50	Active	Bourns	B328	7,848
55000314	ANALYZER,PARAMETER	Dec-05	AGILENT	4155A	Active	**Bourns**	B314	17,240
55000326	CENTRIFUGE	Jan-06	BRINKMANN	5804R	Active	Bourns	B328	7,527
55000345	ORBITAL SHAKER	Jan-06	BARNSTEAD THERMOLYNE	SHKA4000-7	Active	**Bourns**	B328	5,640
65000024	HPLC SYSTEM	Apr-06	WATERS CORP	2695XE	Active	CECERT702 A	CECERT702 A	42,668
65000061	FREEZE DRYER	May-06	LABCONCO		Active	CE-CER702A	CE-CER702A	6,301
65000063	ANALYZER	May-06	TELEDYNE	200E	Active	CHBR-CERT	CHBR-CERT	9,416
65000064	ANALYZER,GAS FILTER	May-06	TELEDYNE	300E	Active	CHMBR-CERT	CHMBR-CERT	8,966
65000065	ANALYZER,OZONE	May-06	TELEDYNE	400E	Active	CHMBR-CERT	CHMBR-CERT	6,617
65000162	EVAPORATOR,HIGH VACUUM	Jun-06	DENTON	DV-502	Active	**Bourns**	B254	6,157

65000170	SPECTROPHOTOMETER	Jun-06	BECKMAN	DU800	Active	Bourns	B235	18,458
65000177	INTERNAL DATALOGGER	Jun-06	MET ONE INSTRUMENTS	6 CHANNEL E-BAM PORT.	Active	CHMBE-CERT	CHMBE-CERT	11,586
65000192	SAMPLER	Jun-06	TELEDYNE	AVALANCHE	Active	Bourns	EXT WALLB	5,264
65000226	STERILIZER,	Sep-06	YAMATO	SE510	Active	**Bourns**	B328	5,092
65000227	ELECTROCHEMICAL STATION	Sep-06	CH INSTRUMENTS	CHI 760	Active	Bourns	B314	14,541
65000256	QIMAGING MONOCHROME CAMERA	Sep-06	OLYMPUS	EXI	Active	**Bourns**	B314.	13,756
65000285	SOURCE MEASURE UNIT	Dec-06	KEITHLEY INSTRUMENTS	236	Active	Bourns	B314	8,071
65000307	NANOSCOPE CONTROL STATION	Dec-06	VEECO METROLOGY	NANOSCOPE V	Active	**Bourns**	B362B	109,263
75000020	CRYOSTAT SYSTEM	Mar-07	JANIS	CCS-350S	Active	Bourns	B254	26,182
75000072	ION CHROMATOGRAPH SYSTEM	Apr-07	DIONEX CORP	ICS-1000	Active	711CE-CERT	711CE-CERT	28,797
75000077	CHAMBER,TEMP AND HUMIDITY	Jun-07	TENNEY	USED BTRC	Active	Bourns	B254	8,494
75000111	CAMERA SYSTEM	Jun-07	MIKRON INSTRUMENTS	INFINITY 3-1	Active	**Bourns**	305BSCILAB	10,803
85000020	CHROMATOGRAPH	Feb-08	DIONEX	ICS-1000	Active	Bourns	B318	30,389
85000053	CHROMATOGRAPH SYSTEM	Mar-08	AGILENT	MODEL 1200 REFURBISHED	Active	**Bourns**	B328	45,181
85000054	CHROMATOGRAPH	Mar-08	AGILENT	7890A	Active	Bourns	B328	48,114
85000094	AUTO AIRLOCKPUMP	Mar-08	COY	TYPE B	Active	**Bourns**	B328	13,604
85000117	SPUTTER COATER	Aug-07	EMITECH	K575XD	Active	Bourns	B254	27,882
85000122	GLOVE BOX	Mar-08	LABCONCO	5220100	Active	**Bourns**	B356	7,273
85000155	ANALYZER,ELECTROCHEMICAL	Mar-08	CH INSTRUMENTS	CHI 604C	Active	Bourns	B254	16,040
85000157	PROBE	Apr-08	SUSS	PSM6 USED	Active	**Bourns**	B254	22,000
85000175	ELECTROMAGNET	Apr-08	WALKER SCIENTIFIC	HV-7V	Active	Bourns	B254	5,952
85000183	FLUOROMETER	Apr-08	BARNSTEAD	FM109545	Active	**Bourns**	B328	6,858
85000196	WEDGE WIRE BONDER	Apr-08	WEST BOND		Active	Bourns	B254	16,454
85000203	MICROSCOPE	Apr-08	INNOVA	SPM	Active	**Bourns**	B362B	88,227

85000212	DELTA MODE SYSTEM	Apr-08	KEITHLEY INSTRUMENTS	6221/2182A	Active	Bourns	B254	6,862
85000503	ARC LAMP SOURCE	Nov-08	NEWPORT CORP		Active	**Bourns**	B360E	11,784
85000516	SOURCEMETER,DUAL	Nov-08	KEITHLEY INSTRU	2636	Active	Bourns	B312	13,436
85000517	READER	Nov-08	BIO-TEK	SYNERGY 4	Active	**Bourns**	B312	48,395
85000518	MICROSCOPE	Nov-08	THERMO ELECTRON	DXR RAMAN	Active	Bourns	B362A	63,636
95000121	SOURCEMETER	May-09	KEITHLEY INSTRUMENT	2601A	Active	**Bourns**	B254	5,534
95000161	COUNTER,CLOUD CONDENSATION	Jun-09	DROPLET MEAS.TECH	CCN-100	Active	CECERT108 5	CECERT108 4	83,230
95000218	PARTICLE SIZER	Sep-09	TSI INC	3936	Active	CE-CERT	CE-CERT	70,954
10500004 9	DIMATIX MATERIALS PRINTER	Feb-10	FUJIFILM DIMATIX	DMP-2831	Active	Bourns	B350	52,673
10500005 0	FREEZER	Feb-10	THERMO SCIENTIFIC		Active	**Bourns**	B328	8,531
10500007 0	SOURCEMETER	Feb-10	KEITHLEY INSTRU	2636A	Active	Bourns	B254	11,306
10500009 2	BIOTREATMENT REACTOR UNIT	Apr-10	HARRINGTON INDUSTR	FABRICATION F008/07	Active	**Bourns**	AG OPS	43,303
10500010 7	POTENTIOMETER	Apr-10	BIO-LOGIC	SP-200	Active	Bourns	B254	11,255
10500010 8	POTENTIOMETER	Apr-10	BIO-LOGIC	SP-200	Active	**Bourns**	B254	11,255
10500010 9	SOURCEMETER	Apr-10	KEITHLEY INSTRU	2636A	Active	Bourns	B254	15,312
10500018 7	WATER PURIFICATION SYSTEM	Jun-10	MILLI-Q	ADVANTAGE A10	Active	CE-CERT109	CE-CERT108	6,373
10500018 8	TENSIOMETER	Jun-10	BIOLIN SCIENTIFIC	T200	Active	CE-CERT	CE-CERT	26,441
10500022 2	ANALYZER,TOC	Aug-10	GE	900	Active	104CE-CERT	104CE-CERT	26,027
10500022 3	PHOTOMETER SYSTEM	Aug-10	THERMO ENV INSTR	5012	Active	105 CECERT	104 CECERT	21,665
10500024 4	NANOMECHANICAL TEST SYSTEM	Nov-10	HYSITRON INC	TI 950	Active	**Bourns**	B356	385,04 9

105000289	VISCOMETER	Nov-10	BROOKFIELD Engineer	DV-III	Active	Bourns	B356	5,650
105000290	Vacuum Tube Furnace	Nov-10	MTI CORP	1800X	Active	**Bourns**	B356	12,974
	High Temperature Reaction Chamber	FY12	HARRICK SCIENTIFIC		Active	Bourns	B328C	6,096
	Hiden Precision Residual Gas Analyzers	FY12	HIDEN ANALYTICAL		Active	**Bourns**	B328C	11,542
	Spectrophotometer & Praying Manthis REF ACC	FY12	FISHER SCIENTIFIC		Active	Bourns	B328C	26,511
	HiCube 80 Eco, Turbo pumping station	FY12	PFEIFFER VACUUM		Active	**Bourns**	B328C	5,684
	ALLEGRA X-15R CENTRIFUGE,208V, & 4X750ML SX4750A ARIES SWINGING	FY12	VWR INTERNATIONAL I	X-15R	Active	Bourns	B328D	9,522
	Fisher AccuSpin Micro & Sonic Dismembrator	FY12	FISHER SCIENTIFIC		Active	**Bourns**	B328D	12,776
	EPOCH READER	FY12	BIO-TEK INSTRUMENTS		Active	Bourns	B328D	11,095
	SC-RISE Testing Facility - furnaces & ultrasonicators	FY12	ETAMOTA CORPORATION		Active	**Bourns**	B235A	34,800
	MicroReader	FY12	ARRAYIT CORPORATION		Active	Bourns	B316	35,075
	BioLogic DuoFlow Pathfinder 20 System	FY12	BIO RAD LABORATORIES		Active	**Bourns**	B316	52,695
	ROTOR PK 120V	FY12	BIO RAD LABORATORIES		Active	Bourns	B316	6,917
	NANODROP 2000 W/CUVETTE	FY12	BIO RAD LABORATORIES		Active	**Bourns**	B316	10,633
	Multitron Tem Control Shaker	FY12	APPROPRIATE TECHNIC		Active	Bourns	B316	23,757
	ALLEGRA 25R CENTRIFUGE 208V 60	FY12	VWR FUNDING INC		Active	**Bourns**	B328D	13,269

Additional Research Resources – CE-CERT

PROPERTY #	DESCRIPTION	RECEIVAL DATE	MANUFACTURE	MODEL	ACTIVE/ INNACTIVE	INITIAL LOCATION		COST
						BLDG	ROOM #	
835001003	FLUORESCENT SO2 ANALYZER,25-10PPM RANGE	Nov-83	*MONITOR LABS	@8850	Active	COLUMBIA	STORAGE	$ 7,461.00
885001377	COMPUTERIZED OZONE MONITOR,UV ABSORPTION TY	Oct-88	*ENVIRONICS	@SERIES 300	Active	COLUMBIA	STORAGE	$ 5,899.00
885001378	COMPUTERIZED OZONE MONITOR,UV ABSORPTION TY	Oct-88	*ENVIRONICS	@SERIES 300	Active	COLUMBIA	STORAGE	$ 5,899.00
925001146	GENERATOR-LAB,	Jun-92	*AADCO	@737-15A	Active	COLUMBIA	APL	$ 8,701.00
935000473	MONITOR-OZONE, 0 PPB TO 1PPM MEASUREMENT RA	Mar-93	*DASIBI	@1003-AH	Active	COLUMBIA	STORAGE	$ 5,501.00
935000504	ANALYZER-NITROGEN, FOR NO-N20-NOX, EPA STAN	Mar-93	*THERMO ENVIRON INST	@42	Active	COLUMBIA	CHAMBER	$ 9,562.00
935001899	MONITOR-OZONE, 0 PPB TO 1PPM MEASUREMENT RA	Nov-93	*DASIBI	@1003-AH	Active	COLUMBIA	STORAGE	$ 5,461.00
935002234	CALIBRATOR-FLOW, FOR AIR SAMPLER	Feb-93	*COLUMBIA SCI INDUS	@1700	Active	COLUMBIA	CHAMBER	$ 10,335.00
945000707	RECEIVER SYSTEM-GLOBAL POSITIONING	May-94	*ASHTECH	@Z-12	Active	COLUMBIA	CECERT	$ 17,995.00
945000708	RECEIVER SYSTEM-GLOBAL POSITIONING	May-94	*ASHTECH	@Z-12	Active	COLUMBIA	CAEE703	$ 17,995.00
945001399	DYNAMOMETER, CHASSIS, 2 WHEEL DRIVE,	Aug-94	*BURKE E. PORTER	@3900	Active	COLUMBIA	CAEE	$ 407,626.00
945001693	MICROCOMPUTER,	Sep-94	*SILICON GRAPHICS	@W8A1-1G32	Active	COLUMBIA	SHED	$ 8,562.00
955000506	AIR CLEANER,	Feb-95	*	@	Active	COLUMBIA	ATTIC710	$ 5,000.00
955000507	COMPRESSOR, ROOTS BLOWER/CONTROLLER	Feb-95	*	@	Active	COLUMBIA	BACKLOT	$ 10,000.00
955000509	EVAPORATIVE TEST CHAMBER,	Feb-95	*	@	Active	COLUMBIA	BACK LOT	$

								7,500.00
955000512	HORIBA,	Feb-95	*	@	Active	COLUMBIA	CAEE 705	$ 6,000.00
955000513	HYDROCARBON ANALYZER,	Feb-95	*EAGLE	@	Active	COLUMBIA	CAEE705A	$ 10,000.00
955000516	CHARBROILER,	Feb-95	*NIECO	@	Active	COLUMBIA	STORAGE	$ 10,000.00
955000522	ANALYZER, CO2	Feb-95	*HORIBA	@CMA-331A	Active	COLUMBIA	CAEE705A	$ 15,389.00
955000525	ANALYZER, NOX	Feb-95	*API	@200	Active	COLUMBIA	CAEE710	$ 12,042.00
955000529	INSTRUMENT CALIB EQUIPMENT	Feb-95	*HORIBA	@360341-SGD-710C	Active	COLUMBIA	CAEE705A	$ 5,573.00
955000531	METHOD 5 SAMPLE TRAIN	Feb-95	*NUTECH	@2010.AQMD	Active	COLUMBIA	CAEE705A	$ 6,886.00
955000532	METHOD 5 SAMPLE TRAIN	Feb-95	*NUTECH	@2010.AQMD	Active	COLUMBIA	CAEE705A	$ 6,886.00
955000541	GAS CHROMATOGRAPH,	Feb-95	*HP	@5690	Active	COLUMBIA	CAEE705H	$ 53,115.00
955000612	INLET, TEMPERATURE VAPORIZER	Feb-95	*AC ANALYTICAL CONTR	@	Active	COLUMBIA	CAEE708	$ 27,043.00
955001123	DYNAMOMETER	May-95	*VIBROMETER	@	Active	COLUMBIA	CAEE	$ 62,867.00
955001124	PORTABLE TESTING LAB,	May-95	*	@0116	Active	COLUMBIA	CAEE 710	$ 54,666.00
955001712	MICROBALANCE,	Aug-95	*CAHN	@C-35	Active	COLUMBIA	CAEE 709	$ 8,621.00
955001741	PARTICLE SAMPLER	Aug-95	*MSP	@110-1	Active	COLUMBIA	ADMIN.129	$ 14,600.00
965000144	OSMOMETER, VAPOR PRESSURE	Feb-96	*PETROLAB	@CCA-VPS	Active	COLUMBIA	CAEE709A	$ 14,382.00
965000937	ENGINE CONTROL UNIT	Jun-96	TGM AUTOMOTIVE	M8-SEQ	Active	COLUMBIA	CAEE705J	$ 6,240.00
965001657	VALVE BOX,	Sep-96	H-P	19238A	Active	COLUMBIA	CARTERHALL	$ 7,522.00
965001966	XENON ARC LIGHTING SYSTEM -	Jan-96	FABRICATION	F280/92	Active	COLUMBIA	CHAMBER2ND	$ 74,635.00

965002229	GENERATION SYSTEM, INDIGO II WORKSTATION	Dec-96	SILICON GRAPHICS	B-TW0250EXG4	Active	COLUMBIA	CHAMBER SH	$ 27,072.00
965002267	GENERATION SYSTEM - INDIGO II WORKSTATION	Dec-96	SILICON GRAPHICS	B-TWO250EXG4	Active	COLUMBIA	SHED	$ 27,072.00
975000362	SEDAN, 4 DR,1997	Feb-97	FORD	ESCORT LX	Active	COLUMBIA	ADMIN LOT	$ 13,254.00
975001256	ANALYZER, GAS	Jul-97	CA ANALYTICAL INSTRU	300	Active	COLUMBIA	LOT/BM	$ 9,261.00
985001204	ANALYZER,GAS	Jun-98	MICRO PROCESSOR SYS	SPECTRA 5	Active	COLUMBIA	CAEE709	$ 6,076.00
985001710	CHASSIS DYNAMOMETER,	Sep-98	CLAYTON	CUSTOM - GIFT	Active	COLUMBIA	CAEE	$ 75,000.00
995000447	GLOBAL POSITIONING SYSTEM	Mar-99	NOVATEL	PROPAK II STD	Active	BOURNS	EBUII #369	$ 6,338.00
995000452	GLOBAL POSITIONING SYSTEM,	Mar-99	NOVATEL	PROPAK II STD	Active	BOURNS	EBUII#369	$ 6,338.00
995000671	TRUCK,PICK-UP CHEVROLET 1999	Apr-99	GMC	1999 P-U	Active	COLUMBIA	PARKINGLOT	$ 37,437.00
995001155	TEMPORARY BUILDINGS, MOBILE, OFFICE	Jun-99	SCOTSMAN	CUSTOM	Active	COLUMBIA	CAEE	$ 21,796.00
995001240	ANALYZERS, IMPEDANCE	Jun-99	SOLARTRON	1260	Active	BOURNS	B328 BCOE	$ 25,332.00
995001243	MILL, VARIABLE, SPEED,	Jun-99	BRIDGEPORT	SERIES I	Active	COLUMBIA	CAEE712	$ 9,428.00
995001527	TRUCK LIFT,	Jun-99	FORWARD MFG	27100TLR	Active	COLUMBIA	HIGHBAY	$ 8,125.00
995001877	DYNAMOMETER,	Oct-99	B.E.P.	3900-3595	Active	COLUMBIA	CAEE708A	$ 57,108.00
995002094	HYBRID ELECTRIC DIESELTRUCK	Oct-99	ISE	UNKNOWN	Active	COLUMBIA	CAEE	$ 184,684.00
995002341	ANALYZER,	Dec-99	THERMO ENVIRONMENTAL	48CTL	Active	COLUMBIA	CHAMBER2ND	$ 9,882.00
995002351	CONTROLLER, SEQUENTIAL ENGINE	Dec-99	MOTEC SYSTEMS	M8 SEQ 512	Active	COLUMBIA	CAEE705	$ 5,392.00
995002353	ANALYZER, CHEMILUMINESCENT	Dec-99	THERMO ENVIRONMENTAL	42C-STL	Active	COLUMBIA	CARTERHALL	$ 22,622.00

995002358	FLOWMETER,	Dec-99	PIEBURG INSTRUMENTS	PLU103B150-PSP-X	Active	COLUMBIA	CAEE705	$ 41,329.00
995002381	ENGINE DYNAMOMETER SYSTEM	Dec-99	SUPERFLOW CORP	ENG-1/1200A-TH2	Active	COLUMBIA	CAEE 705	$ 64,941.00
5000213	LASER SPECTROMETER SYSTEM	Mar-00	UNISEARCH ASSOC	MID-IR	Active	COLUMBIA	CHAMBER1ST	$ 155,075.00
5000343	CALIBRATOR,MULTIGAS	Apr-00	THERMO ENV. INSTRUM	146C	Active	COLUMBIA	CAEE 711A	$ 9,108.00
5000645	DIESEL TRAILER,	Jun-00	UCR	F159/99	Active	COLUMBIA	HDD/CD	$ 609,473.00
5000857	GEARBOX	Jul-00	INNOVATION ENG	6020	Active	COLUMBIA	CAEHIGHBAY	$ 7,527.00
5001282	ANALYZER,NO	Oct-00	ECO	USED CLD 780 TR	Active	COLUMBIA	CHAMBER1ST	$ 23,166.00
5001305	ARC LAMP SYSTEM,	Oct-00	VORTEK		Active	COLUMBIA	CHAMBER2ND	$ 300,494.00
5001513	CHROMATOGRAPH,GAS SYSTEM	Nov-00	SRI INSTRUMENTS	8610C	Active	BOURNS	B328 BCOE	$ 11,921.00
15000440	SPECTROMETER,	Mar-01	IMACC	INDUSTRIAL FTIR	Active	COLUMBIA	CAEE 711	$ 77,947.00
15000509	PERMEATION SYSTEM,	Apr-01	LASIR	PTCS3	Active	COLUMBIA	CHAMBER103	$ 6,000.00
15000510	CAMCORDER,	Apr-01	CANON	XL1 DV	Active	COLUMBIA	ADMIN120	$ 5,427.00
15000534	VISION PROCESSOR SYSTEM,	Apr-01	AUTOSCOPE	2004	Active	COLUMBIA	ADMIN1084	$ 16,770.00
15000616	SPECTROMETER,	Apr-01	UNISEARCH	DOAS-0012	Active	COLUMBIA	CAEE711A	$ 43,300.00
15000617	SPECTROMETER,	Apr-01	LASIR	CUSTOM	Active	COLUMBIA	CHAMBER	$ 64,043.00
15000628	DRIVES, HARD, CDROM, & OPTICAL	Apr-01	ELECTRONIX CORP	ARENA II	Active	COLUMBIA	CAEE704	$ 7,620.00
15000655	GAS MEASURING EQUIPMENT,	Apr-01	PIERBURG INSTRUMENTS	AMA4000	Active	COLUMBIA	CAEE709	$ 184,494.00
15001199	ANALYZER,	Sep-01	ADVANCED POLLUTION	360U	Active	COLUMBIA	CHAMBER	$ 10,000.00
25000579	MONITOR,PAH	Apr-02	ECOCHEM	PAS 2000	Active	COLUMBIA	CHAMBER	$

			ANALYTICS					14,977.00
25000612	GENERATOR,PURE AIR	Apr-02	AADCO INSTRUMENTS	737-19	Active	COLUMBIA	CHAMBER	$ 54,042.00
25000613	COUNTER,PARTICLE	Apr-02	TSI INC	3760A	Active	COLUMBIA	CHAMBER2ND	$ 107,406.00
25000614	CHAMBER ENCLOSURE	Apr-02	ALUMINUM COIL CORP		Active	COLUMBIA	CHAMBER	$ 91,045.00
25000734	LOAD BANK	May-02	CRESTCHIC	600KW	Active	COLUMBIA	LOT/CAEE	$ 28,158.00
25000739	CHROMATOGRAPH	May-02	SHIMADZU	SCL-10	Active	COLUMBIA	CAEE 709	$ 9,638.00
25001136	HYPERLOGGER	Aug-02	LOGIC BEACH	HL-1	Active	COLUMBIA	CAEE705A	$ 5,226.00
35000018	KIOSK	Jan-03	KDS PIXEL TOUCH		Active	COLUMBIA	CHAMB.SHED	$ 7,515.00
35000019	KIOSK	Jan-03	KDS PIXEL TOUCH		Active	COLUMBIA	CHAMB.SHED	$ 7,515.00
35000680	VIDEO CONTACT ANALYSIS SYSTEM	Jul-03	AST PRODUCTS	VCA	Active	BOURNS	B328 BCOE	$ 11,861.00
35000794	REFRIGERATED CONTAINER	Jul-03	SOUTHWEST MOBIL	8'X20'	Active	COLUMBIA	LOT	$ 5,010.00
35000882	REACTION SYSTEM	Sep-03	CEM CORP	MARS 5	Active	BOURNS	B328 BCOE	$ 17,000.00
35000925	LABORATORY ROTATOR	Sep-03	PINE INSTRUMENT	AFMSRX	Active	BOURNS	B328 BCOE	$ 6,190.00
35000958	LASER	Oct-03	SPECDILAS	IRCC-1722-GMP-PR	Active	COLUMBIA	CHAMBER1ST	$ 7,015.00
35001244	KIOSK	Dec-03	KDS PIXEL TOUCH	AW15C-P4-HVAC	Active	COLUMBIA	OUTSIDE	$ 7,516.00
35001248	LOADER,POWER	Dec-03	OVERLAND	LTO-2	Active	COLUMBIA	ADMIN 112	$ 13,081.00
45000546	PROBES	May-04	FABRICATION	F163/03	Active	COLUMBIA	STORAGE	$ 107,202.00
45000618	SERVER,	May-04	AMAX ENGINEERING	DUAL XEON	Active	COLUMBIA		$ 12,795.00
45000813	THERMAL DESORPTION SYSTEM	Jun-04	GERSTEL	TDS2	Active	COLUMBIA	CAEE709	$ 29,935.00

55000009	ANALYZER,THERMOGRAVIMETRIC	Aug-04	METTLER	TGA851E/SF	Active	BOURNS	B328 BCOE	$ 39,999.00
55000023	PROBE	Mar-05	N/A	FABRICATION F161/03	Active	COLUMBIA	CAEE 710	$ 64,449.00
55000042	POTENTIOMETER	Mar-05	ADVANCED MEASUREMENT	VMP2-CHAS	Active	BOURNS	B328 BCOE	$ 38,095.00
55000062	GENERATOR SET	Apr-05	CATERPILLAR	XQ350 (USED)	Active	COLUMBIA	CAEE	$ 47,410.00
55000080	THERMODENUDER	May-05	DEKATI	ELA-111	Active	COLUMBIA	CHAMBER2ND	$ 11,696.00
55000131	TEMPERATURE VAPORIZATION	Jun-05	AGILENT	G2617-60506	Active	COLUMBIA	CAEE 706	$ 6,782.00
55000172	MICROCOMPUTER	Jul-04	CONQUEST	INTEL XEON	Active	COLUMBIA	ADMIN 112	$ 6,689.00
55000201	COMPRESSOR	Nov-05	HELIX CORP	8200	Active	COLUMBIA	CAEE	$ 5,571.00
55000216	COMPRESSOR	Dec-05	BITZER	6G-40.2	Active	COLUMBIA	CHAMBER2ND	$ 5,384.00
55000229	MASS MONITOR	Dec-05	DEKATI	DMM-230	Active	COLUMBIA	CAEE	$ 60,696.00
55000262	MOBILITY ANALYZER	Dec-05	TSI	3081	Active	COLUMBIA	CHAMBER2ND	$ 8,081.00
55000291	ANALYZER,HYDROCARBON	Dec-05	CALIF ANALYTICAL	600M	Active	COLUMBIA	CAEE	$ 14,831.00
55000292	ANALYZER	Dec-05	CALIF ANALYTICAL	600	Active	COLUMBIA	CAEE	$ 15,788.00
55000293	ANALYZER	Dec-05	CALIF ANALYTICAL	600	Active	COLUMBIA	CAEE	$ 11,959.00
55000310	ANALYZER,GAS PORTABLE	Dec-05	HORIBA INSTRU	PG 250	Active	COLUMBIA	CAEE 705A	$ 22,851.00
65000079	ANALYZER,MULTI-PURPOSE,PORTABLE	May-06	HORIBA	PG-250	Active	COLUMBIA	CAEE705A	$ 28,431.00
65000156	DYNAMOMETER	Jun-06	FABRICATION	F167/06	Active	COLUMBIA	CAEE	$ 558,677.00
65000176	ANALYZER,GAS	Jun-06	CALIF.ANALYTICAL	602P	Active	COLUMBIA	CAEE	$ 14,740.00
65000199	AUTOCLAVE	Jun-06	AUTOCLAVE	MAG 0.75	Active	COLUMBIA	CAEE702	$

			ENGINEERS					5,468.00
65000205	DETECTOR	Jun-06	HP	5890 SERIES II	Active	COLUMBIA	CAEE705H	$ 13,740.00
65000252	AUGER	Sep-06	INCO	600	Active	COLUMBIA	CAEE702	$ 7,537.00
65000306	SPECTROMETER	Dec-06	IONICON	PTR-MS REFURBISHED	Active	COLUMBIA	CHAMBER2ND	$ 200,000.00
65000315	DEPOSIT IMPACTOR W/ROTATOR	Dec-06	MSP CORP	MDI 110		COLUMBIA		$ 18,336.00
65000316	DEPOSIT IMPACTOR W/ROTATOR	Dec-06	MSP CORP	MDI 110		COLUMBIA		$ 18,336.00
65000333	ANALYZER,PARTICLE MASS	Dec-06	KANOMAX			COLUMBIA	CHAMBER2ND	$ 74,994.00
65000337	SPECTROMETER	Dec-06	AGILENT	G3250AA		COLUMBIA	CHAMBER2ND	$ 277,168.00
65095858	UTILITY VEHICLE	Jun-07	CHRYSLER	GEM 2007		COLUMBIA	CAEE	$ 11,731.00
75000011	ANALYZER,	Mar-07	JUM	3-200		COLUMBIA	CAEE 705A	$ 14,492.00
75000033	MASS SPECTROMETER SYSTEM	Mar-07	AERODYNE	WTOF-AMS		COLUMBIA	CHAMBER2ND	$ 377,125.00
75000078	COPIER,DIGITAL	Jun-07	XEROX	WC255H		COLUMBIA	RM 103	$ 8,380.00
75000121	AEROSOL NEUTRALIZER	Jun-07	TSI INC	3077		COLUMBIA	CHAMBER2ND	$ 6,378.00
75000122	AEROSOL NEUTRALIZER	Jun-07	TSI INC	3077		COLUMBIA	CHAMBER2ND	$ 6,378.00
75000123	AEROSOL NEUTRALIZER	Jun-07	TSI INC	3077		COLUMBIA	CHAMBER2ND	$ 6,378.00
75000124	ANALYZER,MOBILITY	Jun-07	TSI INC	3081		COLUMBIA	CHAMBER2ND	$ 7,247.00
75000125	ANALYZER,MOBILITY	Jun-07	TSI INC	3081		COLUMBIA	CHAMBER2ND	$ 7,247.00
75000126	ANALYZER,MOBILITY	Jun-07	TSI INC	3081		COLUMBIA	CHAMBER2ND	$ 7,247.00
75000127	PARTICLE COUNTER	Jun-07	TSI INC	3771		COLUMBIA	CHAMBER2ND	$ 13,205.00

75000128	PARTICLE COUNTER	Jun-07	TSI INC	3771		COLUMBIA	CHAMBER2ND	$ 13,205.00
75000129	PARTICLE COUNTER	Jun-07	TSI INC	3771		COLUMBIA	CHAMBER2ND	$ 13,205.00
75000130	PARTICLE COUNTER	Jun-07	TSI INC	3776		COLUMBIA	CHAMBER2ND	$ 29,676.00
75000131	PARTICLE COUNTER	Jun-07	TSI INC	3776		COLUMBIA	CHAMBER2ND	$ 29,676.00
75000132	PARTICLE SIZER	Jun-07	TSI INC	3936L72		COLUMBIA		$ 55,562.00
75000149	ANALYZER,HYDROCARBON	Jun-07	HOUSTON ANALYTICAL	3-200		COLUMBIA	CHAMBER2ND	$ 16,081.00
75000169	GENERATOR	Jun-07	TAYLOR	DS13M2		COLUMBIA	CAEE	$ 7,974.00
75000170	NETWORK GC SYSTEM	Aug-07	AGILENT	6890N		COLUMBIA	CHAMBER1ST	$ 65,859.00
85000023	SPECTROPHOTOMETER	Feb-08	UNISEARCH ASSOC.	SM410		COLUMBIA	CAEE 710	$ 9,698.00
85000167	MICROBIAL BIORACTOR	Apr-08	APPLIKON BIOTECH	ZC3B125M03		COLUMBIA	CAEE701	$ 22,582.00
85000170	BALANCE	Apr-08	METTLER	UMX2		COLUMBIA	CAEE 709	$ 19,909.00
85000269	RHEOMETER	May-08	ANTON PAAR	18000		COLUMBIA	CAEE 705A	$ 9,609.00
85000442	GPS RECEIVER	Oct-08	TRIMBLE	R7		COLUMBIA	CAEE 703A	$ 5,274.00
85000580	CHAMBER,GROWTH,COLLECTION	Dec-08	BRECHTEL FABRICATION	4000 F/093/09		COLUMBIA	CHAMBER2ND	$ 22,570.00
85000581	TELESCOPE	Dec-08	CASSAGRAIN	12 "		COLUMBIA		$ 11,492.00
85095786	AUTOMOBILE	May-08	HONDA	CIVIC GX 2005		COLUMBIA	PARKINGLOT	$ 9,993.00
95000030	MULTITRON	Mar-09	ATR	AJ125		COLUMBIA	CAEE 701	$ 14,655.00
95000047	GENERATOR,HYDROGEN	Mar-09	DOMNICK HUNTER	20H		COLUMBIA	CAEE 709	$ 5,156.00
95000061	ROBOT SYSTEM	Mar-09	SYMYX			COLUMBIA	CAEE 701	$

									327,147.00
95000145	SAMPLER	Jun-09	INSTITUT FUR AEROSOL	TEM		COLUMBIA	710 CAEE		$ 11,419.00
95000166	DUST TRACK II	Jun-09	TSI INC	8530		COLUMBIA	CAEE 705A		$ 5,780.00
95000180	CHROMATOGRAPH	Sep-09	AGILENT	7890A		COLUMBIA	CAEE 702		$ 34,483.00
95000187	ANALYZER,COMBUSTION	Sep-09	SHIMADZU	TOC-VCSN		COLUMBIA	701CAEE		$ 40,230.00
105000005	CONTROL UNIT	Feb-10	BIOSTAT	APLUS MICROBIAL		COLUMBIA	CAEE 701		$ 13,902.00
105000006	CONTROL UNIT	Feb-10	BIOSTAT	APLUS MICROBIAL 5 LITER		COLUMBIA	CAEE 701		$ 14,153.00
105000105	PUMP,NAVIGATOR	Apr-10	VARIAN	ISO100		COLUMBIA	CHAMBER2ND		$ 6,113.00
105000132	ANALYZER,MOBILITY	May-10	TSI INC.	3081		COLUMBIA	CHAMBER2ND		$ 10,358.00
105000133	SPECTROPHOTOMETER	May-10	AGILENT	8453		COLUMBIA	CHAMBER1ST		$ 16,098.00
105000134	THERMAL DESORPTION SYSTEM	May-10	ACEM	9305		COLUMBIA	CHAMBER1ST		$ 25,575.00
105000193	ANALYZER,MOBILITY	Jul-10	FABRICATION	F017/01		COLUMBIA	CHAMVER2ND		$ 42,300.00
105000198	HUMIDIFIER	Jul-10	FABRICATION	F323/04		COLUMBIA	CHAMBER2ND		$ 13,053.00
105000201	EMISSIONS MEASUREMENT SYS	Jul-10	FABRICATION	F180/05		COLUMBIA	CAEE 705A		$ 13,492.00
105000202	HEATED TEMP CELL	Jul-10	FABRICATION	F181/05		COLUMBIA	CAEE711A		$ 19,080.00
105000203	AIR QUALITY SIMULATOR COMPUTER	Aug-10	FABRICATION	F193/05		COLUMBIA	ADMINRM112		$ 17,083.00
105000204	SPREADER	Jul-10	FABRICATION	F208/06		COLUMBIA	PARKINGLOT		$ 7,873.00
105000205	SPECTROMETER	Jul-10	FABRICATION	F234/06		COLUMBIA	CHAMBER2ND		$ 42,596.00
105000206	SPECTROMETER	Jul-10	FABRICATION	F234/06		COLUMBIA	CHAMBER2ND		$

								42,596.00
105000207	SPECTROMETER	Jul-10	FABRICATION	F234/06		COLUMBIA	CHAMBER2ND	$ 42,596.00
105000208	CONTROL SYSTEM	Jul-10	FABRICATION	F241/06		COLUMBIA	CAEE/600A	$ 10,490.00
105000210	CHAMBER	Jul-10	FABRICATION	F331/08		COLUMBIA	CHAMBER2ND	$ 25,000.00
105000211	SPECTROMETER	Aug-10	FABRICATION	CAVITY RINGDOWN		COLUMBIA	CHAMBER2ND	$ 149,653.00
105000243	CENTRIFUGE, BENCHTOP	Nov-10	BECKMAN COULTER	X-15R		COLUMBIA	CAEE702	$ 9,332.00
105000252	PRESSURE REACTION APPARATUS	Nov-10	FABRICATION	F316/09		COLUMBIA	705M	$ 68,870.00
105000271	SCANNER,BAR CODE	Nov-10	SPECTRA	T50		COLUMBIA	BCOE/A344	$ 11,512.00
115000086	CENTRIFUGE	Aug-11	ALLEGRA	X-12		COLUMBIA		$ 9,744.00
	High Definition Lidar	FY12	VELODYNE ACOUSTICS					$ 81,267.21
	Dell Server	FY11	DELL MARKETING LP					$ 8,956.72
	Hioki 3390 Power Analyzer (DYNO)	FY12	TEST EQUITY					$ 14,390.02
	Stem Hydro Gasification Reactor	FY11	San Diego Fluids, Star Electronics, MDC Vacuum, B&R Weld, McMaster-Carr, OMEGA, Rexel					$ 100,000.00
	Feedstock Pretreatment Unit	FY11	KH Metals & Parr Instruments					$ 68,177.00
	Mapping platform; Spherical Digital Video Camera & laptop	FY12	Point Grey Research - RoHS Ladybug3 1394b Spherical Digital Video Camera & laptop	RoHS Ladybug3 1394b				$ 150,000.00

	Particle Sizer, Neutralizer	FY12	TSI INCORPORATED					$ 65,517.12
	Electrical Aerosol Detector	FY12	TSI INCORPORATED					$ 15,276.38
	Electrostatic Classifier	FY12	TSI INCORPORATED					$ 45,238.07

APPENDIX D – INSTITUTIONAL SUMMARY

Programs are requested to provide the following information.

1. The Institution

a. University of California, Riverside
   (Legal name: The Regents of the University of California)
   900 University Avenue
   Riverside, CA 92521

b. Name and title of the chief executive officer of the institution
   Timothy P. White, Chancellor

c. Name and title of the person submitting the self-study report.
   Reza Abbaschian, Dean, Bourns College of Engineering

d. Name the organizations by which the institution is now accredited and the dates of the initial and most recent accreditation evaluations.

The University of California, Riverside, is accredited by the Western Association of Schools and Colleges (WASC). UCR was most recently accredited on March 3, 2010. WASC reaccreditation occurs approximately every 10 years, and UCR's next proposal for reaccreditation is due to be submitted to WASC in fall 2016.

Other accreditations at UCR include:

Graduate School of Education, accredited by the California Commission on Teacher Credentialing. Reaccreditation is under way now; a report is due in fall 2012, and the next site visit is expected to be in 2014. Further, the GSOE School Psychology program is being reaccredited in 2012. A site visit was in March 2012, and a decision is due in August 2012.

The Chemistry Department is reviewed by the American Chemical Society. The Chemistry department provides annual reports and 5-year reports on curriculum and student performance. The most recent 5-year report was in June 2010.

The School of Business Administration (SoBA) will begin its AACSB Maintenance of Accreditation in 2012-13, with a site visit expected in January 2013.

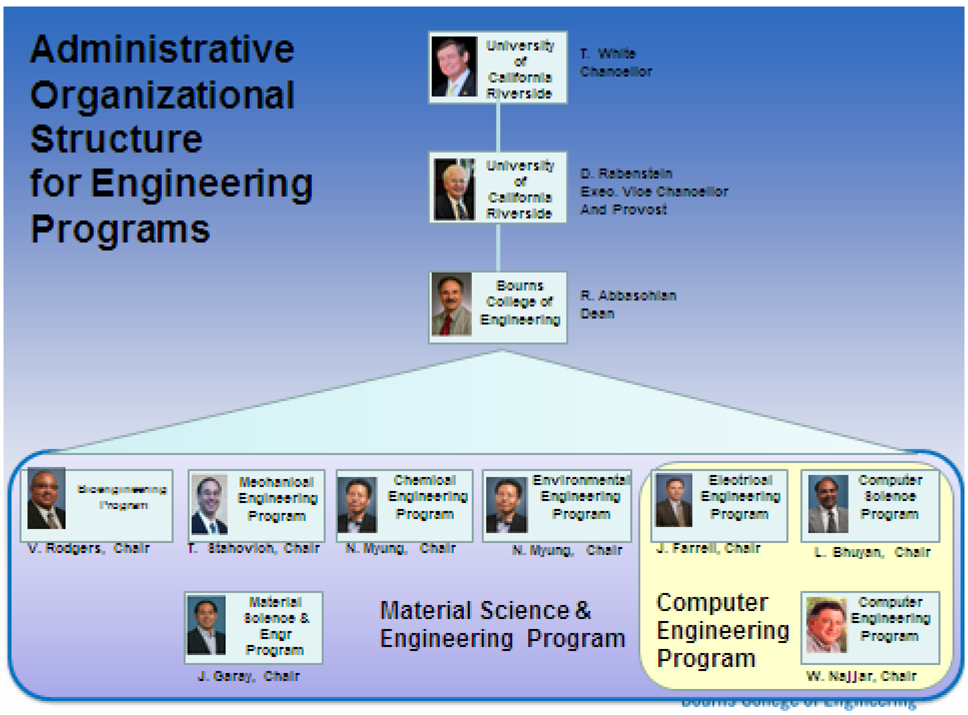
The UCR School of Medicine was denied initial accreditation by the Liaison Committee on Medical Education (LCME) in June 2011 because of budget uncertainties. The University expects to reapply this year with a new funding model that is less reliant on state funds.

2. Type of Control

The University is a state-controlled institution of higher education and an accredited Hispanic Serving Institution (HSI).

3. Educational Unit

The following chart describes the program organizational structure for the Bourns College of Engineering. Each program chair reports to the Dean of the College, who reports to the Vice Chancellor and Provost, who reports to the Chancellor of the UC Riverside Campus. The program chairs shown on the top line of the college section are also Department Chairs. The Computer Engineering Program is supported by faculty from both the Electrical Engineering and Computer Science Programs. The Material Science and Engineering Program includes faculty from the Bioengineering, Mechanical Engineering, Chemical Engineering, Environmental Engineering, Electrical Engineering, and Computer Science Programs.



4. **Academic Support Units**

Department or Unit	Responsible Individual	
	Name	**Title**
Biochemistry	Richard Debus	Chair
Bioengineering	Victor Rodgers	Chair
Biology	Bradley Hyman	Chair
Chemical & Environmental Engineering	Nosang Myung	Chair
Chemistry	Eric Chronister	Chair
Computer Science	Laxmi Bhuyan	Chair
Electrical Engineering	Jay Farrell	Chair
English	Deborah Willis	Chair
Math	Vyjayanthi Chari	Chair
Mechanical Engineering	Thomas Stahovich	Chair
Physics	Jory Yarmoff	Acting Chair
Statistics	Daniel Jeske	Chair

5. **Non-academic Support Units**

UCR Libraries: Dr. Ruth Jackson, University Librarian
Computing & Communications: Charles J. Rowley, Associate Vice Chancellor & Chief Information Officer, C&C Associate Vice Chancellor
Learning Center: Michael P. Wong, Director
Career Center: Sean Gil, Director

6. **Credit Unit**

The UC Riverside academic year consists of three quarters, each with 10 weeks of instruction followed by a week of final exams. Each quarter credit represents one hour of instruction. Three laboratory hours also represent one credit. One hour of additional discussion represents one credit.

7. **Tables**

Complete the following tables for the program undergoing evaluation.

Table D-1. Program Enrollment and Degree Data

Chemical Engineering

	Academic Year		Enrollment Year 1st	2nd	3rd	4th	5th	Total Undergrad	Total Grad	Degrees Awarded Associates	Bachelors	Masters	Doctorates
Current Year	2011-12	FT	58	63	50	33	11	215	70	N/A			
		PT	0	1	2	2	0	5	0				
2010-11		FT	79	54	31	13	7	184	91	N/A	18	11	5
		PT	1	1	4	2	2	10	0				
2009-10		FT	67	31	22	17	16	153	72	N/A	28	8	12
		PT	0	0	2	1	0	3	0				
2008-09		FT	42	29	16	16	8	111	69	N/A	15	1	10
		PT	0	1	0	1	0	2	1				
2007-08		FT	39	22	20	20	11	112	63	N/A	20	4	12
		PT	1	0	0	1	1	3	0				

Give official fall term enrollment figures (head count) for the current and preceding four academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the fall visit.

FT--full time
PT--part time

Table D-2. Personnel

Chemical and Environmental Engineering

Year[1]: Fall 2011

	HEAD COUNT		FTE[2]
	FT	PT	
Administrative[3]	0	0	
Faculty (tenure-track)	11	2	16.50
Other Faculty (excluding student Assistants)	3	6	5.74
Student Teaching Assistants	0	32	16.00
Student Research Assistants	14	12	20.00
Technicians/Specialists	1	8	2.51
Office/Clerical Employees	2	23	5.78
Others[4]	2	0	2.00

[1] Data on this table should be for the fall term immediately preceding the visit. Updated tables for the fall term when ABET team is visiting are to be prepared and presented to the team when they arrive.

[2] For student teaching assistants, Full-time equals 25% or more.

[3] For graduate students, 1 FTE equals 49% or more. (Does not include self-support or fellowships)

[4] Persons holding joint administrative/faculty positions or other combined assignments should be allocated to each category according to the fraction of the appointment assigned to that category.

5 Assistant Deans, Directors/Managers, Specialist, Deputy Director, MSO/FAOs, Analyst IV, Student Affairs Officers III/IV, & Public Info Rep.

Signature Attesting to Compliance

By signing below, I attest to the following:

That the Department of Chemical and Environmental Engineering has conducted an honest assessment of compliance and has provided a complete and accurate disclosure of timely information regarding compliance with ABET's *Criteria for Accrediting Engineering Programs* to include the General Criteria and any applicable Program Criteria, and the ABET *Accreditation Policy and Procedure Manual.*

Reza Abbaschian
Dean's Name (As indicated on the RFE)

Signature ________________________________ **June 26, 2012**
Date