

ABET
Self-Study Report

for the

Bioengineering Program

at

University of California, Riverside

Riverside, California

July 1, 2012

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BACKGROUND INFORMATION

A. Contact Information

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B. Program History

This is the first review for the Bioengineering program. The material below is a summary of the creation and early years of the B.S. in Bioengineering at the University of California, Riverside.

| Proposed Major in Bioengineering August 3, 2004 | |
|--|---|
| I. Overview | <p>The College of Engineering proposes the establishment of a B.S. degree entitled "Bioengineering." This degree program will be administered by a Bioengineering program committee to be selected by the Dean of Engineering. The Bioengineering program committee is expected to have representatives from each of the Departments in the College of Engineering.</p> <p>Initially, the Bioengineering program Committee will have the responsibility for approval and management of Bioengineering courses within the curriculum. Also, in the early phase of establishing the Bioengineering Curriculum, the teaching faculty for the program will be drawn from the College of Engineering with the approval of the Dean and the chairs of the respective departments.</p> <p>Over the next five years, the plan is to hire new faculty with bioengineering expertise to carry the major teaching and research thrusts of the program. During this transition period – each of the newly hired bioengineering faculty will be housed in one of existing departments of the College of Engineering that most closely matched their training. Then a new Department of Bioengineering will be formed, and the existing primary Bioengineering Faculty at that time will transfer their primary appointments to the Department of Bioengineering.</p> |

II. The Major

Major requirements for the Bachelor of Science in Bioengineering are as follows:

Lower-division requirements (65 units)

- a) First Year Calculus; Multivariable Calculus; Differential Equations
- b) General Chemistry
- c) General Physics – Mechanics, Heat, Sound, Phys, Electricity,
- d) Cell and Molecular Biology, Organismal Biology
- e) Introduction to Bioengineering
- f) C++ Programing

Proposed Upper-division requirements

- a) Organic Chemistry
- b) Biochemistry
- c) Modeling and Analysis
- d) Bioinstrumentation
- e) Biosystems and Signals
- f) Biotechnology and Molecular Bioengineering
- g) Biotransport
- h) Biophysics and Biothermodyamics
- i) Biomechanics
- j) Biomaterials
- k) Biostatistics
- l) Senior Biodesign
- m) Technical Electives

III. Justification

The proposed major in Bioengineering will allow students to complete a B.S. degree that will provide them with the basic education to enter the fields of bioengineering and biotechnology. Although the major will be termed “bioengineering” the course requirements will allow students to participate in the biotechnology industry as well. In general the term “bioengineering” is sometimes associated more with the medical industry and the term “biotechnology” is more associated with the pharmaceutical and food industries. (More descriptions of these terms are given below). Training bioengineers is particularly important in the State of California. As shown in Figure 1 from the **2004 Annual Report of the California Healthcare Institute.**

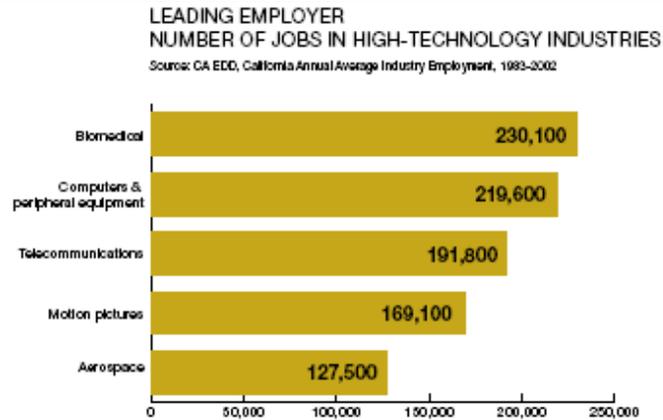


Figure 1. Leading employers of bioengineers

As can be seen, the biomedical and biotechnology industry is one of the prime employers of **technology** trained individuals in the State of California. This report goes on to give the following encouraging statistics for opportunities for students with a bioengineering education.

“Today 2,600 biomedical companies in California—86% of them founded in the last 25 years—and 87 public and private research institutions continue to advance scientific knowledge and develop new treatments for serious diseases such as cancer, and cardiovascular, respiratory, and infectious disease. The pace of progress is accelerating with the expansion of information-based technology approaches—for example, genomics is mining the human genome for biological information to create preventive therapies, and nanotechnology is developing sensor technology and using microchips to diagnose disease. And as the industry matures in California with more products in advanced clinical trials, it is moving beyond a primarily R&D-based industry, adding more manufacturing to its repertoire.

California continues to receive more funds from the National Institutes of Health (NIH)—in 2003, approximately \$2.9 billion—than any other state. And the total reported private investment in research and development is \$15.5 billion, with the average company investing 48% of its revenues back into R&D. The industry employs more than 230,000 Californians in jobs with an estimated average annual salary of \$67,000, and total estimated wages and salaries paid of \$14 billion. It generates \$32.3 billion in worldwide revenue and more than \$7 billion for the state in exports. California companies are addressing issues of global health in new ways—developing medicines for diseases in developing countries, and new pricing strategies to balance the industry’s successes with responsibilities to the developing world. They are balancing business risks by building networks of alliances that enable them to integrate virtually, with each member of a network focused on a specific role in bringing high value products to market. In many ways, it is an exciting time for what has always been a vibrant, innovative, and resilient industry.”

The following is a definition of bioengineering that was developed at NIH:

“Bioengineering is rooted in physics, mathematics, chemistry, biology, and the life sciences. It is the application of a systematic, quantitative, and integrative way of thinking about and approaching the solutions of problems important to biology, medical research, clinical practice, and population studies.

Bioengineering integrates physical, chemical, or mathematical sciences and engineering principles for the study of biology, medicine, behavior, or health. It advances fundamental concepts, creates knowledge for the molecular to the organ systems levels, and develops innovative biologics, materials, processes, implants, devices, and informatics approaches for the prevention, diagnosis, and treatment of disease, for patient rehabilitation, and for improving health.”

The national biotechnology industry trade organization, BIO, gives the following definition of biotechnology:

“New” Biotechnology—the use of cellular and biomolecular processes to solve problems or make useful products. Biotechnology is a collection of technologies that capitalize on the attributes of cells, such as their manufacturing capabilities, and put biological molecules, such as DNA and proteins, to work for us.

IV. Draft Description from the UCR General Catalog

Bioengineering uses the principles of physics, mathematics, chemistry, biology, to develop processes and products that are important for health and treatment of diseases, new materials, protecting the environments, and food production. Bioengineers are employed by the pharmaceutical, biotechnology, medical device, environmental and food industries. For those interested in medicine, the Bioengineering program provides the basic courses to allow one to apply to medical schools.

Bioengineering program Approval Timetable

Approval of the Bioengineering B.S. degree and Department was in two stages. First approval by the College of Engineering Executive Committee was required, and then approval of the University Academic Senate was required. The Engineering Executive Committee has representatives of all engineering departments and the Academic Senate is comprised of the entire faculty at the University of California, Riverside. The Bioengineering Undergraduate Program and B.S. Degree were approved first, and then after the first cohort of faculty was recruited the Bioengineering Department was approved.

- | | |
|--------------|---|
| May 24, 2005 | The B.S. Degree in Bioengineering was approved by the University Academic Senate. |
| May 2006 | The Department Bioengineering was approved by the University Academic Senate. |
| Fall 2006 | The first undergraduate students enrolled in the program. |

Bioengineering Faculty Plan

The strategic plan for the Bioengineering Department is to have a core faculty of 15 members. Figure 2 shows the growth of the faculty since its inception. Today the Department of Bioengineering has eleven tenure-track faculty; their names, research areas, and dates of appointment are listed below. We are currently recruiting an additional faculty member.

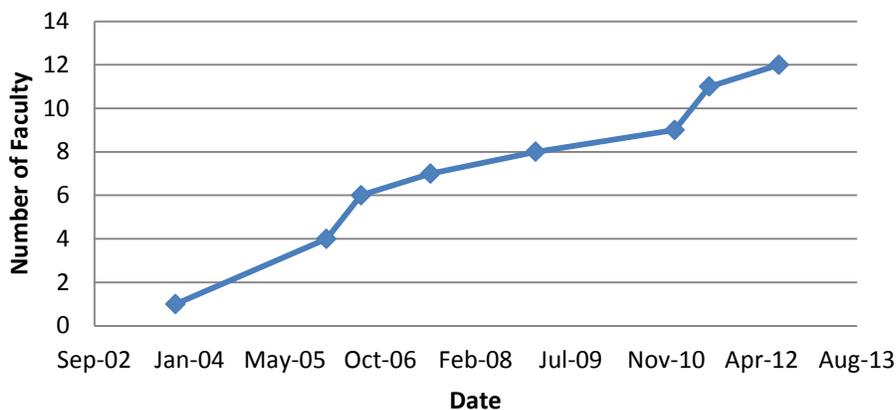


Figure 2. Growth of the number of bioengineering faculty

Table 1. Bioengineering faculty

| Faculty Name | Rank | Research Area | Joined UCR |
|-------------------|-------------|---|------------|
| Jerome S. Schultz | Professor | Biosensors and metabolic controls | 11-01-03 |
| Jiayu Liao | Asst. Prof. | Signal transduction pathways, high-throughput screening | 01-01-06 |
| Victor Rodgers | Professor | Biotransport phenomena, bio-separations | 01-01-06 |
| Valentine Vullev | Asst. Prof. | Biophysics, microfluidics and charge transfer | 01-01-06 |
| Bahman Anvari | Professor | Phototherapy, electromechanical of cell membranes | 07-01-06 |
| Dimitrios Morikis | Professor | Immunophysics/engineering, rational drug design | 07-01-06 |
| Julia Lyubovitsky | Asst. Prof. | Optical imaging/spectroscopy, protein self-assembly | 07-01-07 |
| Hyle Park | Asst. Prof. | Optical electrodes, optical coherence tomography | 01-01-09 |
| Huinan Liu | Asst. Prof. | Nano-biomaterials, orthopedics, tissue engineering | 01-01-11 |
| Kaustabh Ghosh | Asst. Prof. | Injectable nanotherapeutics for targeted drug delivery | 09-01-11 |
| Jin Nam | Asst. Prof. | Orthopedic tissue engineering | 09-01-11 |
| William Grover | Asst. Prof. | Medical devices | 09-01-12 |

Figure 3 and Table 2 and Figure 4 and Table 3 show the trends in undergraduate and graduate enrollment, respectively. Freshman enrollment in 2010-2011 was unusually high because of an aberration in the University admission system. Subsequently, the College of Engineering has instituted enrollment controls for each of the undergraduate programs. In 2011 the Bioengineering faculty decided on a target of about 80 freshmen each year for our program.

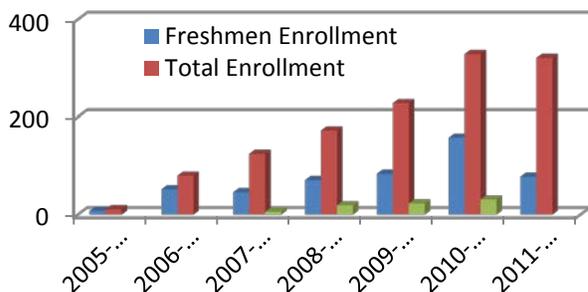


Figure 3. Undergraduate enrollment in bioengineering at UCR

Table 2. Bioengineering undergraduate enrollment and degrees by year

| Academic Year | Freshmen Enrollment | Total Enrollment | B.S. Degrees |
|---------------|---------------------|------------------|--------------|
| 2005-06 | 8 | 11 | |
| 2006-07 | 52 | 80 | |
| 2007-08 | 46 | 125 | 6 |
| 2008-09 | 71 | 173 | 19 |
| 2009-10 | 84 | 228 | 23 |
| 2010-11 | 158 | 329 | 31 |
| 2011-12 | 78 | 321 | |

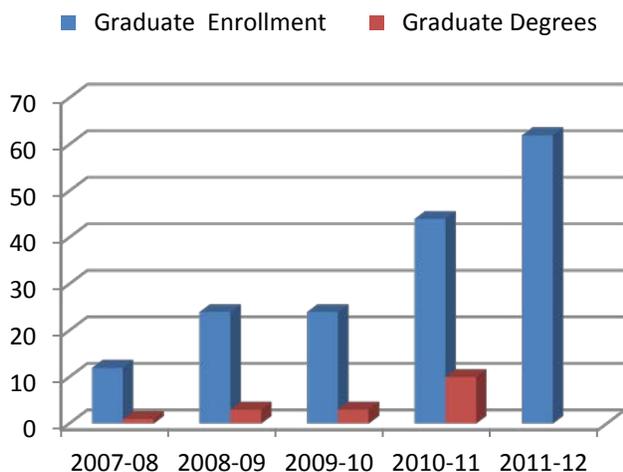


Figure 4. Bioengineering graduate enrollment

Table 3. Graduate bioengineering enrollment

| Academic Year | Enrollment | Degrees |
|---------------|------------|---------|
| 2007-08 | 12 | 1 |
| 2008-09 | 24 | 3 |
| 2009-10 | 24 | 3 |
| 2010-11 | 44 | 10 |
| 2011-12 | 62 | |

C. Options

No options.

D. Organizational Structure

Administrative Organizational Structure for Engineering Programs

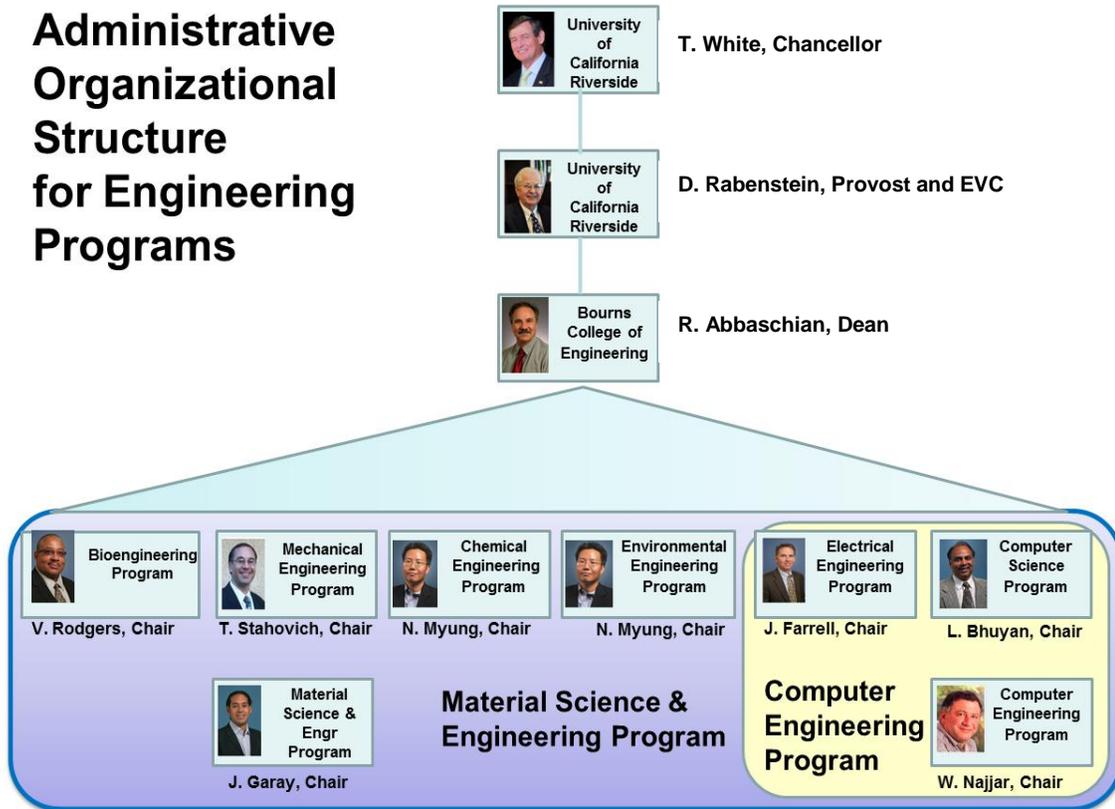


Figure 3. Administrative organizational structure for engineering programs

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.

The program is delivered over three academic quarters, each of three months duration. The academic year usually starts the first week of October and finishes the last week of June. When allowance is made for exams and holidays, each quarter has about 10 weeks of class time available. Our courses are offered primarily during the normal academic year.

F. Program Locations

All courses are delivered on the campus of the University of California, Riverside.

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

This is an initial accreditation for the Bioengineering program.

H. Joint Accreditation

This program is seeking EAC accreditation only.

GENERAL CRITERIA

CRITERION 1. STUDENTS

A. Student Admissions

The admissions processes for all Bourns College of Engineering 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 in the State. 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 6 summarizes the admissions process to our College. Prospective students submit their applications to the Office of Admissions for the University of California, which serves all ten campuses of the University. 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.

Within UCR, processing of these forwarded 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, which operates as follows. 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 (IB) 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.

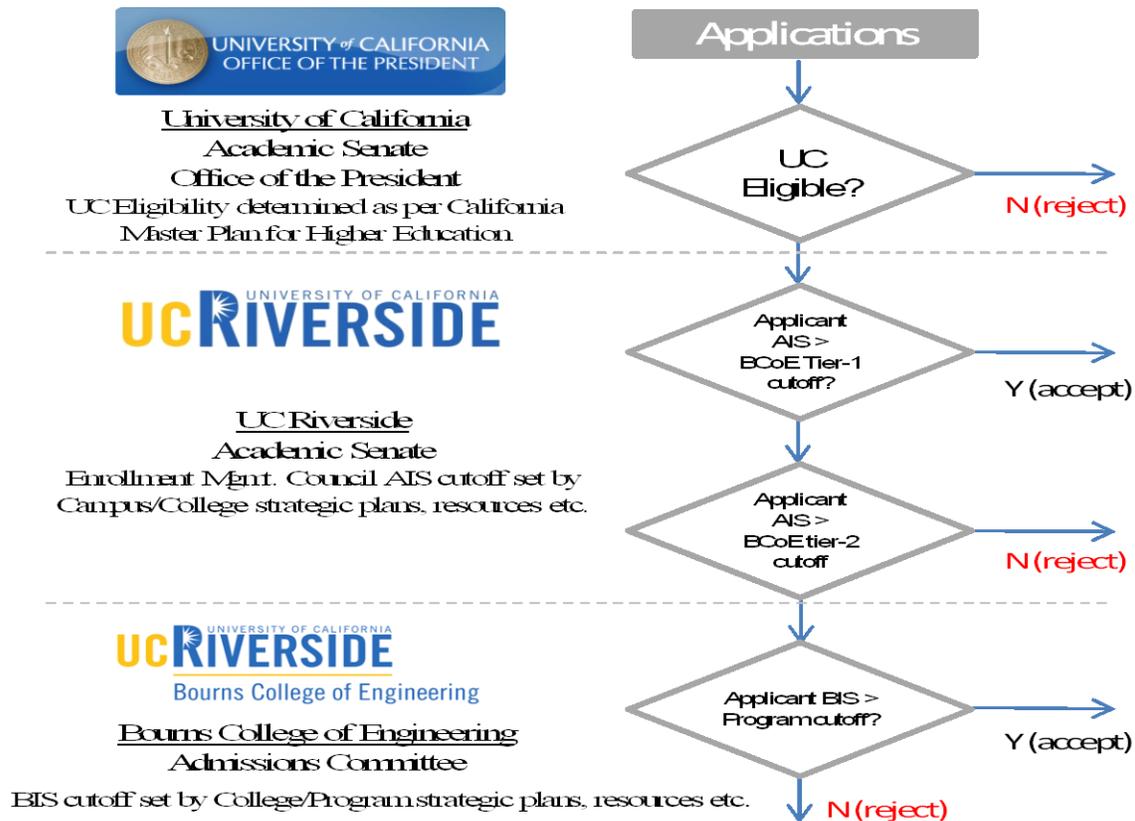


Figure 4. The admission process

B. Evaluating Student Performance

B1. Overview

Student performance monitoring is primarily the role of the Office of Student Academic Affairs, under the supervision of the Associate Dean. In the Bioengineering Department Professor Jerome Schultz is the 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 Academic Affairs (OSAA) supports the undergraduate programs.

The Office of Student Academic Affairs (OSAA) implements and enforces academic policies developed by UCR/BCOE & 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. This mission is implemented 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 Table 4, we list the current OSAA staff, with brief biographical details. Note that they have decades of combined experience, and they have an exceptionally low turnover rate for OSAA staff.

Table 4. Office of Student Academic Affairs Staff

| | |
|---------------------------|---|
| 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 |

Each student is assigned to a staff adviser in the OSAA, and encouraged to meet with this adviser whenever the need arises, but at least once quarterly. In addition, attendance at a mandatory Annual Major Advising session is required of all undergraduates in the college.

The Annual Major Advising session for Bioengineering is conducted jointly by the OSAA staff and Professor Jerome Schultz, and provides information on a variety of topics to students, including program requirements as well as academic success strategies and professional development opportunities.

Figure 7 depicts the process for monitoring student progress. Students are required to maintain a GPA of 2.0 each quarter, as well as cumulatively. 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 OSAA review the academic records of BCOE students and identify all whose term and cumulative GPAs are below 2.0.

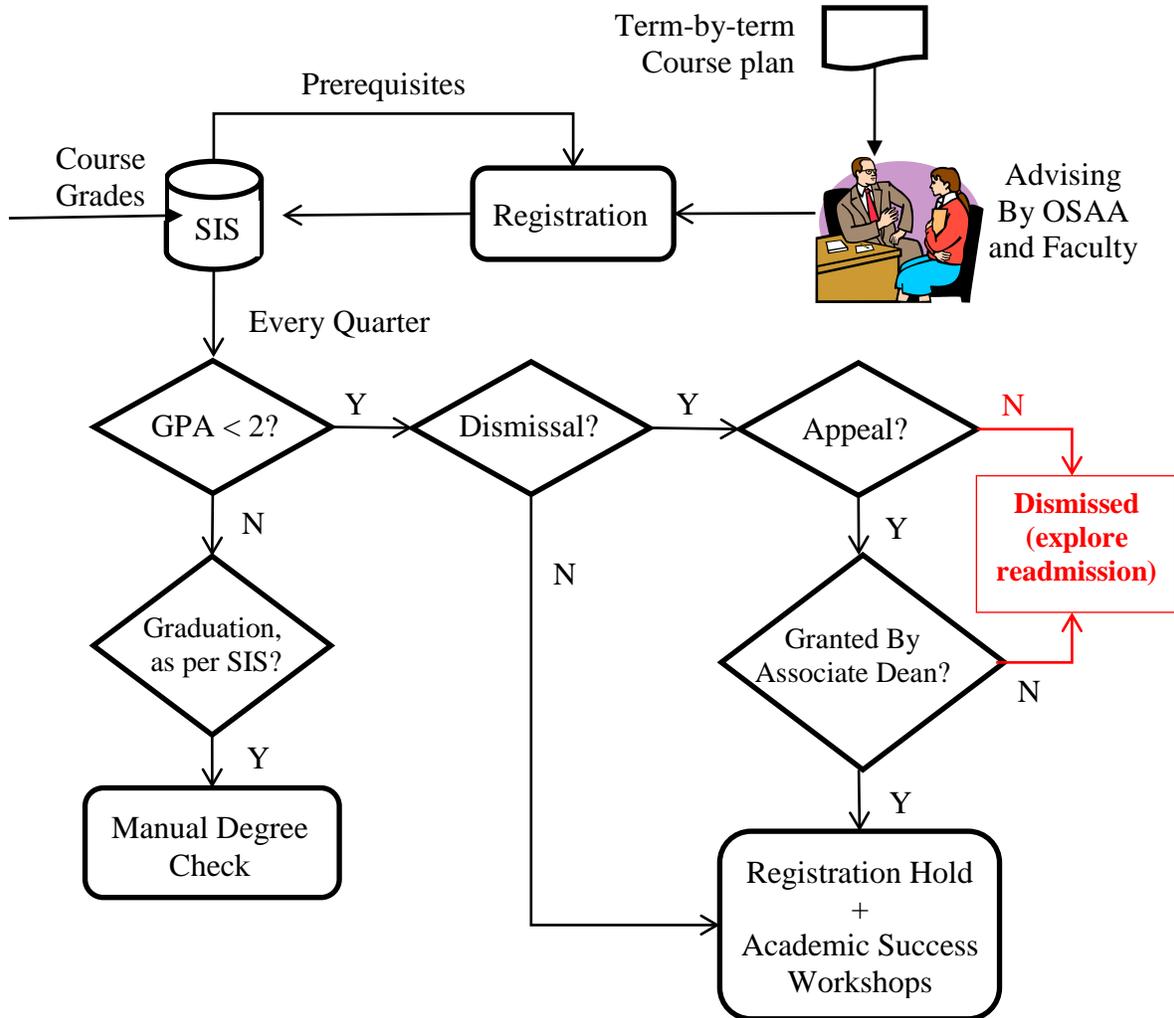


Figure 5. Flow diagram for academic advising and performance monitoring

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 now placed on the student's record, to be released only upon the completion of Academic Success Workshops and other advising and mentoring activities through the OSAA. 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), which records all student registrations and grades, and which is maintained by the Computing and Communications organization. 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. This system is used regularly by the staff of the OSAA to monitor student progress.

B.2 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 is not permitted to take the course without such a waiver.

(GROWL is the secure student portal used to complete the majority of administrative transactions needed during a student's academic career. This includes submission of a student's Statement of Intent to Register, control of all privacy through FERPA based controls, access to bills, submission of payment, term registration, review of administrative or advising holds, grades, transcript requests and review and acceptance of their financial aid to name a few.)

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 OSAA 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 major being applied to. Incoming transfer students may transfer up to 105 quarter units (70 semester units) towards their degrees from the University. To ease the burden of consulting <http://www.assist.org> 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, as well as on the Web. Some examples appear at 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 OSAA 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.

Bourns College of Engineering Transfer Admission Requirements

Transfer applicant to the College of Engineering must meet both UCR Admission criteria and BCOE major-selection criteria. Here are the selection criteria for a transfer student into a Bioengineering Major (UCR course equivalents shown in parentheses):

- A cumulative GPA of at least 2.80 in UC-transferable coursework
- Minimum 2.50 GPA in one year of single-variable calculus (MATH 9A, 9B, 9C).
- Completion of one year of college level English composition (ENGL 1A, 1B, 1C).
- Two courses in general chemistry with labs (CHEM 1A/1LA, 1B/1LB)
- One course in introduction to cellular and molecular biology with lab (BIOL 5A/5LA).
- A minimum of three (3) additional courses chosen from*:
 - One course in introduction to organismal biology (BIOL 5B)
 - One course in general chemistry with lab (CHEM 1C/1LC)
 - Three courses in calculus based physics with labs (PHYS 40A, 40B, 40C)

*The selection of the three additional courses should ensure that a second science sequence is complete with at least a 2.50 GPA. Potential sequences are:

- General Chemistry - CHEM 1A/1LA, CHEM 1B/1LB, CHEM 1C/1LC
- Biology - BIOL 5A/5LA, BIOL 5B
- Physics - PHYS 40A, PHYS 40B, PHYS 40C

D. Advising and Career Guidance

The mechanisms by which students receive academic advice have already been outlined in **Section B: Evaluating Student Performance**. Here, we will describe the mechanisms for providing Career and Professional guidance. A summary of the range of Professional Development, Mentoring, and Success program in BCOE appears the Figure.

Professional guidance and mentoring is 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 work completing prerequisite coursework in mathematics, sciences, and the humanities and social sciences.

In the Bioengineering program we provide an introductory course to our students during the first term they are on campus. Bioengineering 10 – (BIEN 010) Overview of Bioengineering provides our students with a perspective of the engineering discipline and in particular it is designed to motivate students towards careers in engineering. In addition, all of the Bioengineering students

are required to meet with a Bioengineering faculty member at least twice during each academic year. In these meetings the faculty reviews the student progress in their courses as well as review possible career paths with them. During these discussions the faculty will suggest possible technical electives that would support the student’s career interests. This yearly meeting of students with faculty is enforced by withholding student registration for the next term until the mentoring session is completed.

Also, many of the Bioengineering students participate in research projects with the Bioengineering faculty. Approximately one-half of the upper-division students (juniors and seniors) work with faculty on projects; and in the course of these activities the students receive individual mentoring by faculty and graduate students in these laboratories.

In addition to the mentoring that the students receive by Bioengineering faculty, 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 8 and Table 5 summarize these milestones.

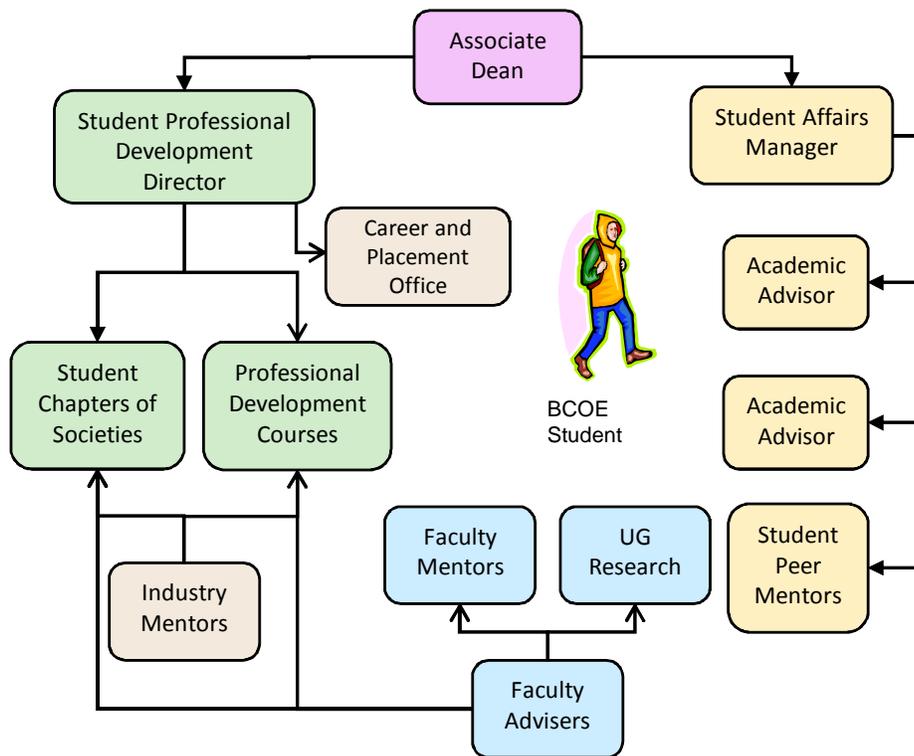
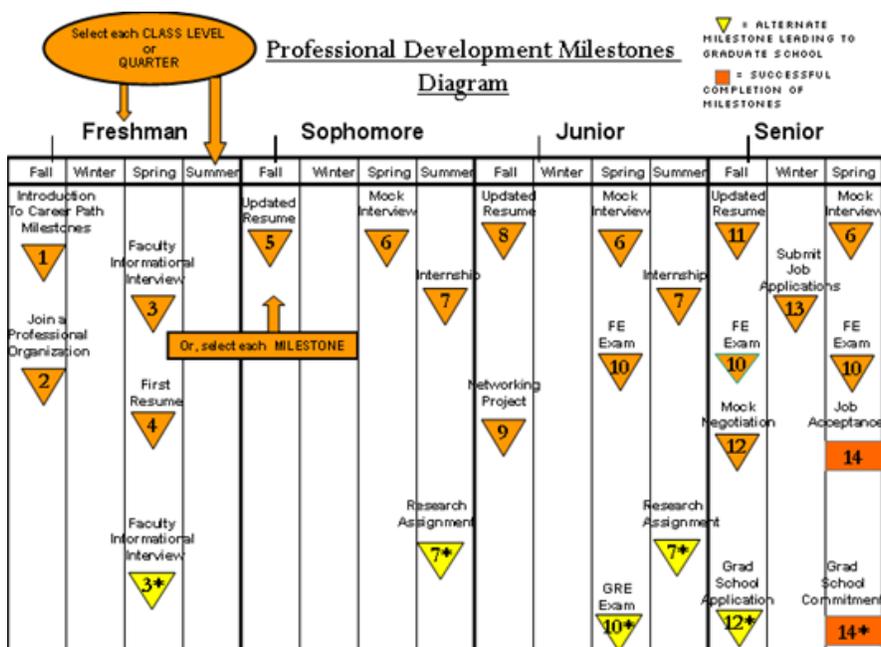


Figure 6. Advising resources for undergraduates

Table 5. Calendar of Professional Development Milestones



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 College). Some of the organizations that are of particular interest to Bioengineering students are:

- BMES (Biomedical Engineering Society)
- BCOE SLC (Student Leadership Council)
- EWB (Engineers Without Borders)
- MRS (Material Research Society)
- NSBE (National Society of Black Engineers)
- OSA (Optical Society of America)
- SACNAS (Society for Advancement of Chicanos and Native Americans in Science)
- SHPE (Society of Hispanic Professional Engineers)
- SWE (Society of Women Engineers)
- 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 2011-12 academic year are shown in Table 6.

Table 6. Summary of Student Professional Organization Activities for 2011-12

| 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, Feating Target | 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, Feating 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 |

| Event | Date | Attendees |
|--|-------------|------------------|
| 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 |

| Event | Date | Attendees |
|---|-------------|------------------|
| 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 |

| Event | Date | Attendees |
|---|-------------|------------------|
| 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 | |

| Event | Date | Attendees |
|--|-------------|------------------|
| 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 | |

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

Graduation requirements fall into three categories – (a) University – Breadth Requirements, (b) College Requirements, and (c) Program Requirements.

(a) University Breadth Requirement Unit Summary for the B.S. in Engineering.

| | |
|----------------------------------|-----------|
| English Composition | 12 |
| Humanities | 12 |
| Social Sciences | 12 |
| Ethnicity (4 units)* | |
| Natural Sciences and Mathematics | 20 |
| Total Units | 56 |

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

(b) College Requirements

As required by the University's general breadth requirements the College of Engineering requires 20 units of natural sciences and mathematics. Each department can select courses appropriate to their program needs. The Bioengineering major uses the following courses to satisfy this College Requirement. These courses are selected to meet the Bioengineering major requirement as well.

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

(c) Bioengineering program Requirements

In addition the science/mathematics/engineering requirements of the Bioengineering program fall into the following categories:

1. Lower-division (freshman/sophomore years) requirements (72 units)
2. Upper-division requirements (80 units)
3. Technical electives (16 units):

A typical course plan provided to the students is shown in Table 7.

Table 7. Typical course plan for Bioengineering



Suggested Course Plan for a UC Riverside Major in

BIOENGINEERING

Catalog Year: 2011

| Fall Quarter | Units | Winter Quarter | Units | Spring Quarter | Units |
|---|-------|--|-------|--|-------|
| FIRST YEAR | | | | | |
| BIEN 010 <i>Overview of Bioengineering</i> | 2 | BIOL 005A & BIOL 05LA <i>Cell & Molecular Biology & Lab</i> | 5 | BIOL 005B <i>Organismal Biology</i> | 4 |
| CHEM 001A & CHEM 01LA <i>General Chemistry & Lab</i> | 5 | CHEM 001B & CHEM 01LB <i>General Chemistry & Lab</i> | 5 | CHEM 001C & CHEM 01LC <i>General Chemistry & Lab</i> | 5 |
| ENGL 001A <i>Beginning Composition</i> | 4 | ENGL 001B <i>Intermediate Composition</i> | 4 | ENGL 001C or Alternate* <i>Applied Intermediate Composition</i> | 4 |
| MATH 009A <i>First Year Calculus</i> | 4 | MATH 009B <i>First Year Calculus</i> | 4 | MATH 009C <i>First Year Calculus</i> | 4 |
| SECOND YEAR | | | | | |
| CHEM 112A <i>Organic Chemistry</i> | 4 | CHEM 112B <i>Organic Chemistry</i> | 4 | CHEM 112C <i>Organic Chemistry</i> | 4 |
| MATH 046 <i>Differential Equations</i> | 4 | CS 010 <i>C++ Programming</i> | 4 | EE 001A & EE 01LA <i>Engineering Circuit Analysis I & Lab</i> | 4 |
| PHYS 040A <i>Physics (Mechanics)</i> | 5 | MATH 010A <i>Multivariable Calculus</i> | 4 | MATH 010B <i>Multivariable Calculus</i> | 4 |
| Breadth _____ <i>Humanities/Social Sciences</i> | 4 | PHYS 040B <i>Physics (Heat/Waves/Sound)</i> | 5 | PHYS 040C <i>Physics (Electricity/Magnetism)</i> | 5 |
| THIRD YEAR | | | | | |
| BCH 100 <i>Elementary Biochemistry</i> | 4 | BIEN 105 <i>Circulation Physiology</i> | 4 | BIEN 115 <i>Quantitative Physiology</i> | 4 |
| BIEN 110 <i>Biomechanics of the Human Body</i> | 4 | BIEN 125 <i>Biotechnology & Molecular Engr.</i> | 4 | BIEN 130 <i>Bioinstrumentation</i> | 4 |
| STAT 155 <i>Probability & Statistics for Engr</i> | 4 | BIEN/CEE 140A <i>Biomaterials</i> | 4 | BIEN 130L <i>Bioinstrumentation Lab</i> | 2 |
| Breadth _____ <i>Humanities/Social Sciences</i> | 4 | Breadth _____ <i>Humanities/Social Sciences</i> | 4 | BIEN 120 <i>Biosystems & Signals Analysis</i> | 4 |
| FOURTH YEAR | | | | | |
| BIEN 135 <i>Biophysics & Biothermodynamics</i> | 4 | BIEN 175A <i>Senior Design</i> | 4 | BIEN 175B <i>Senior Design</i> | 4 |
| BIEN 155 <i>Biotechnology Lab</i> | 2 | Technical Elective** | 4 | Technical Elective** | 4 |
| BIEN/CEE 159 <i>Dynamics of Biological Systems</i> | 4 | Technical Elective** | 4 | Technical Elective** | 4 |
| Breadth _____ <i>Humanities/Social Sciences</i> | 4 | Breadth _____ <i>Humanities/Social Sciences</i> | 4 | Breadth _____ <i>Humanities/Social Sciences</i> | 4 |

Total Units: 193
Maximum Units: 236

To earn a B.S., you must complete all College and University requirements. For a full list of requirements, go to www.catalog.ucr.edu.

ENGLISH COMPOSITION*

A C or better is required in all English Composition courses to satisfy the graduation requirement. Please consult with your Academic Advisor for ENGL 1C alternatives.

BREADTH REQUIREMENTS

For an approved list of Breadth courses, go to <http://student.engr.ucr.edu/policies/requirements/breadth.html>.

Humanities: (3 courses)

- A. World History: _____
B. Fine Arts, Lit., Phil. or Rlst: _____
C. History of Science: _____

Social Sciences: (3 courses)

- A. Econ. or Posc.: _____
B. Anth., Psyc, or Soc.: _____
C. Additional Social Science: _____

Ethnicity: (1 course)

1. _____

ABET Upper Division Depth: (2 courses)

1. _____

2. _____

TECHNICAL ELECTIVES **

Please note that Technical Electives may be offered throughout the Academic Year. Consult with your Academic Advisor about potential offerings. See approved technical electives on back.

Course Plan is subject to change.

Documentation of Graduation Requirements

Students who are about to graduate are required to complete a graduation application. At this point, the student's academic adviser in OSAA 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 that the degree may be awarded.

G. Transcripts of Recent Graduates

Copies of transcripts and corresponding checklist by the Office of Student Affairs used to verify that those students have met the graduation requirements will be provided separately from this self-study report.

H. Diversity in the Bourns College of Engineering

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 8). 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. Our citation read:

"In recognition of extraordinarily successful initiatives for recruiting undergraduate and graduate students from diverse and disadvantaged backgrounds, retaining them through 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 8. The number of domestic underrepresented minority undergraduates has nearly doubled since 2006.

| | Fall 2006 | Fall 2007 | Fall 2008 | Fall 2009 | Fall 2010 |
|-----------------------------|-----------|-----------|-----------|-----------|-----------|
| Undergraduates | | | | | |
| % Domestic Underrepresented | 27 | 29 | 31 | 31 | 33 |
| # Domestic Underrepresented | 340 | 377 | 449 | 521 | 665 |
| % Domestic Female | 12 | 12 | 15 | 17 | 17 |
| # Domestic Female | 151 | 156 | 222 | 291 | 348 |
| Graduates | | | | | |
| % Domestic Underrepresented | 16 | 21 | 18 | 16 | 17 |
| # Domestic Underrepresented | 14 | 24 | 27 | 24 | 32 |

CRITERION 2. PROGRAM EDUCATIONAL OBJECTIVES

A. Mission Statements

A.1 Mission of the University of California, Riverside

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 **Mission of the Bourns College of Engineering** 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; and
- Be a catalyst for industrial growth in Inland Southern California.

The **Vision of the Bourns College of Engineering** is to become a nationally recognized leader in engineering research and education.

A.2 Mission of the Department of Bioengineering

Our unique interdisciplinary program combines building a solid fundamental foundation in biological science and engineering, developing diverse communication skills and providing training in the most advanced quantitative bioengineering research. The result is a rigorous, but exceptionally interactive and welcoming educational training for Bioengineering students leading towards B.S., M.S. and Ph.D. degrees.

The following mission statement was reviewed and approved by the Bioengineering Advisory Board in May 2007

The mission of the newly formed Department of Bioengineering at the University of California, Riverside focuses on two interrelated themes:

- Advancing Bioengineering research, particularly in BioCellular Engineering, and,
- Preparing future leadership in Bioengineering and related fields.

The next meeting of the Advisory Board, July 2011, suggested the following slight modification that was approved by the faculty

- Advancing Bioengineering research, particularly in cellular, molecular, and tissue systems and in-silico models and,
- Building future leaders in Bioengineering and related fields.

The Bioengineering Department Mission Statement is posted on the Bioengineering web site, <http://www.bioeng.ucr.edu/index.php?content=events/ABET.html>

B. Program Educational Objectives

The Department of Bioengineering program Educational Objectives listed below are published in the UCR Catalog of courses and on our web site <http://www.bioeng.ucr.edu/index.php?content=events/ABET.html>

Table 9. Program Educational Objectives shows the **Program Educational Objectives**.

Table 9. Program Educational Objectives

| Program Educational Objectives | |
|---|--|
| The Bioengineering program is to produce graduates who: | |
| 1. | Have a strong foundation to apply science, engineering and biological principles to meet the challenges at the interface of engineering, life sciences, and medicine. |
| 2. | Have the capability to pursue graduate studies, careers in the medical device or biotechnology industries, or entry into medical or other health related professional schools. |
| 3. | Are effective working professionally as individuals and in teams and can communicate effectively to integrate contributions from multiple disciplines to address biological and medical problems |
| 4. | Have an appreciation of and sensitivity to a broad range of ethical and social concerns related to bioengineering |

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

The mission of the Bourns College of Engineering is inherently broader than the goals of the Bioengineering Department since the College's mission includes its graduate programs and several centers. Bioengineering Departmental PEOs are focused on the undergraduate program.

Table 10 compares several of the mission elements for the Bourns College of Engineering with the PEOs of the Department of Engineering. Although the Mission Statements for the College

are somewhat broader in scope they certainly encompass the PEOs for the Bioengineering program.

Table 10. Relationship of the College and Departmental mission elements

| Bourns College of Engineering Mission Statements | Department of Bioengineering Program Educational Objectives |
|---|--|
| Produce engineers with the educational foundation and adaptive skills to serve rapidly evolving technology industries; | 1. Have a strong foundation to apply science, engineering and biological principles to meet the challenges at the interface of engineering, life sciences, and medicine. |
| Conduct nationally recognized engineering research focused on providing a technical edge for the United States; | 2. Have the capability to pursue graduate studies, careers in the medical device or biotechnology industries, or entry into medical or other health related professional schools. |
| Enable our graduates to serve in a wide variety of other fields that require leadership, teamwork, decision-making and problem-solving abilities; and | 3. Are effective working professionally as individuals and in teams and can communicate effectively to integrate contributions from multiple disciplines to address biological and medical problems. |
| 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; | 4. Have an appreciation of and sensitivity to a broad range of ethical and social concerns related to bioengineering. |

D. Program Constituencies

The Department of Bioengineering faculty considered the appropriate constituencies for the undergraduate program in 2007. In discussion with the Advisory Board in 2007 the key significant constituencies of the Bioengineering program were determined to be the following:

1. The students enrolled in the program
2. The faculty and staff responsible for delivering the program
3. The various organizations that are associated with the graduates of our program (e.g, industrial/government/academic/higher education organizations)
4. Graduates of our program

Students during their enrollment in the program benefit from a foundation in science, engineering and biological principles that will provide them with employment opportunities post-graduation. The faculty of the Department benefit from the capability of these students to participate in individual research projects. As mentioned earlier, about half of our junior/senior cohort carries out an individual research project with a faculty member.

Organizations that employ our students benefit from their ability to work in teams and communicate effectively. The graduates of our program have intense and broad capabilities in a variety of technical areas, but very importantly, they are able to apply their technical knowledge in a socially responsible way.

Table 11 below maps how the Bioengineering program Educational Objectives meet the needs of the various constituencies of the Bioengineering program as determined in a March 2012 faculty meeting.

Table 11. How Bioengineering PEOs meet the needs of the Department’s constituencies

| Constituencies | Bioengineering Program Educational Objectives | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| The students enrolled in the program | | | | |
| The faculty and staff responsible for delivering the program | | | | |
| The various organizations that are associated with the graduates of our program | | | | |
| Graduates of our program | | | | |

E. Process for Revision of the Program Educational Objectives

This is the first review of the Bioengineering program, thus there are no changes in the Program Educational Objectives to report since the last review.

The constituencies involved in the review of the PEOs are the departmental faculty, alumni of the program, Departmental Advisory Board, and employers of our graduates.

During the start-up period of the Department of Bioengineering the following Program Educational Objectives were formulated by the Department faculty and the Departmental Advisory Committee in April 2007. These PEOs were published in the UC Riverside 2008-2009 General Catalog.

The objective of the bioengineering (undergraduate) program is to produce graduates who:

1. have life-long learning skills that maintain their high level of professional competence,
2. have the skills to apply engineering and biological principles to meet the challenges of this rapidly evolving field,
3. be prepared for advanced postgraduate training in bioengineering and biomedical allied fields.

Subsequently, as the Department matured and a new Dean was appointed, we reformulated our PEOs to be in concert with the goals of the Bourns College of Engineering. This refinement of our PEOs was formulated by the Bioengineering faculty in 2008 our new statement of

Bioengineering program Educational Objectives was published in the UC Riverside 2009-2010 General Catalog. During the recent meeting of the Bioengineering Board of Advisors in July 2011, these PEOs were reviewed and approved as listed below.

1. Have a strong foundation to apply science, engineering and biological principles to meet the challenges at the interface of engineering, life sciences, and medicine.
2. Have the capability to pursue graduate studies, careers in the medical device or biotechnology industries, or entry into medical or other health related professional schools.
3. Are effective working professionally as individuals and in teams and can communicate effectively to integrate contributions from multiple disciplines to address biological and medical problems.
4. Have an appreciation of and sensitivity to a broad range of ethical and social concerns related to bioengineering.

Our process for revision of the PEOs in the future will involve obtaining input from alumni, Bioengineering Advisory Board and employers of our students. This information will be discussed at a Bioengineering faculty meeting, and a revision in the PEOs will be made if the faculty determines it is necessary.

This year we obtained input from Bioengineering alumni and employers via a survey, outlined in Table 12.

In March, 2012, bioengineering alumni were surveyed concerning these PEOs. The survey was sent to all of the bioengineering alumni and 75 students, and 31 responded. Overall our alumni are satisfied that our undergraduate program has prepared them to meet the targets stated in the Program Educational Objectives.

Table 12. Survey for Bioengineering alumni

| The department of Bioengineering has established several objectives to serve as a base for your future career. We would like to know how well the undergraduate program prepared you to meet these goals. <i>Please rate on a scale of one to five; five being very well, and one being minimally.</i> | | | | | | |
|---|-----------------------------|----------|----------|----------|----------|-------------|
| Bioengineering Department Program Educational Objectives | Alumni Survey Scores | | | | | |
| | 5 | 4 | 3 | 2 | 1 | Avg. |
| 1. A strong foundation to apply science, engineering, and biological principles to meet the challenges at the interface of engineering, life sciences, and medicine. | 9 | 15 | 6 | 0 | 1 | 4.0 |
| 2. A capability to pursue graduate studies, careers in the medical device or biotechnology industries, or entry into medical or other health related medical schools | 14 | 11 | 5 | 0 | 1 | 4.2 |
| 3. Training to effectively work professionally as an individual and in teams and with skills to communicate effectively to integrate contributions from multiple disciplines to address biological and medical problems. | 18 | 9 | 2 | 1 | 1 | 4.3 |
| 4. An appreciation of and sensitivity to a broad range of ethical and social concerns related to bioengineering. | 15 | 4 | 8 | 2 | 1 | 4.0 |

The information from our alumni survey and workplace survey was provided to our Advisory Board in May 2012 and feedback from them was received.

Faculty reviewed and evaluated the three assessments – alumni survey, workplace survey, and Advisory Board comments at a faculty meeting in May 2012 and came to the conclusion that no revisions in the PEOs were required at this time.

The next review will be in three years. We realize that it is difficult to obtain feedback from employers of our students. So in the future we will increase the number of industrial representatives on our Advisory Board and discuss with them how well our graduates are meeting our PEO's and any suggested changes in our PEOs.

CRITERION 3. STUDENT OUTCOMES

A. Student Outcomes

Student Outcomes are documented on the Departmental Web Site www.bioeng.ucr.edu.

In 2008 the Department of Bioengineering modified the (a) through (k) Student Outcomes listed in Criteria 3 to include the ABET Program Criteria for Bioengineering programs.

For the purposes of this Self Study the curriculum Program Criteria designated for Bioengineering programs were parsed into three components noted below as PC1, PC2, and PC3.

PROGRAM CRITERIA FOR BIOENGINEERING AND BIOMEDICAL ENGINEERING AND SIMILARLY NAMED ENGINEERING PROGRAMS

These program criteria apply to bioengineering and biomedical engineering programs with the exception of agriculturally-based engineering programs.

1. Curriculum

The structure of the curriculum must provide both breadth and depth across the range of engineering topics implied by the title of the program. The program must demonstrate that graduates have:

(PC1) an understanding of biology and physiology,

(PC2) and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology;

(PC3) the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems.

The specific ABET Bioengineering program curricula criteria PC1, PC2, and PC3, were incorporated into the ABET Student Outcomes (a) through (k) in the following way:

| <u>Bioengineering program Criteria</u> | <u>Modified ABET Student Outcome</u> |
|--|--------------------------------------|
| PC1 | (a) |
| PC2 | (e) |
| PC3 | (b) |

Thus the new combined Department of Bioengineering Student Outcomes are listed below. *(Components relate to Bioengineering program Criteria are given in italics)*

- (a) an ability to apply knowledge of mathematics, science *(including biology and physiology (PC1))*, and engineering
- (b) an ability to design and conduct experiments, *make measurements, analyze and interpret data from living systems addressing the problems*

associated with the interaction between living and non-living materials and systems. (PC3)

- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- (d) an ability to function on multidisciplinary teams
- (e) an ability to identify, formulate, and ***apply advanced mathematics (including differential equations and statistics), science, and engineering to solve problems at the interface of engineering and biology. (PC2)***
- (f) an understanding of professional and ethical responsibility
- (g) an ability to communicate effectively
- (h) a broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- (i) a recognition of the need for, and an ability to engage in life-long learning
- (j) a knowledge of contemporary issues ***related to bioengineering***
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

B. Relationship of Student Outcomes to Program Educational Objectives

Table 13 maps the Student Outcomes to the Program Educational Objectives of our Bioengineering program.

Table 13. Relationship between Student Outcomes and Program Educational Objectives

| | | Program Educational Objectives | | | |
|-----|--|---------------------------------------|---|---|---|
| | | 1 | 2 | 3 | 4 |
| | Student Outcomes | | | | |
| 1. | Have a strong foundation to apply science, engineering and biological principles to meet the challenges at the interface of engineering, life sciences, and medicine. | | | | |
| 2. | Have the capability to pursue graduate studies, careers in the medical device or biotechnology industries, or entry into medical or other health related professional schools. | | | | |
| 3. | Are effective working professionally as individuals and in teams and can communicate effectively to integrate contributions from multiple disciplines to address biological and medical problems. | | | | |
| 4. | Have an appreciation of and sensitivity to a broad range of ethical and social concerns related to bioengineering. | | | | |
| (a) | an ability to apply knowledge of mathematics, science (<i>including biology and physiology (PCI)</i>), and engineering | | | | |
| (b) | an ability to design and conduct experiments, <i>make measurements, analyze and interpret data from living systems addressing the problems associated with the interaction between living and non-living materials and systems. (PC3)</i> | | | | |
| (c) | an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability | | | | |
| (d) | an ability to function on multidisciplinary teams | | | | |

Program Educational Objectives

1. Have a strong foundation to apply science, engineering and biological principles to meet the challenges at the interface of engineering, life sciences, and medicine.
2. Have the capability to pursue graduate studies, careers in the medical device or biotechnology industries, or entry into medical or other health related professional schools.
3. Are effective working professionally as individuals and in teams and can communicate effectively to integrate contributions from multiple disciplines to address biological and medical problems.
4. Have an appreciation of and sensitivity to a broad range of ethical and social concerns related to bioengineering.

| Student Outcomes | Relevant Program Educational Objectives | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| (e) an ability to identify, formulate, and <i>apply advanced mathematics (including differential equations and statistics), science, and engineering to solve problems at the interface of engineering and biology. (PC2)</i> | | | | |
| (f) an understanding of professional and ethical responsibility | | | | |
| (g) an ability to communicate effectively | | | | |
| (h) a broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context | | | | |
| (i) a recognition of the need for, and an ability to engage in life-long learning | | | | |
| (j) a knowledge of contemporary issues <i>related to bioengineering</i> | | | | |
| (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. | | | | |

CRITERION 4. CONTINUOUS IMPROVEMENT

A. Program Educational Objectives

Assessment Process

The general approach for our continuous improvement process is illustrated in Figure 9. Basically the process starts with the key inputs for the program to satisfy – namely the ABET Student Outcomes combined with the ABET Bioengineering program Criteria – and ends with the Curriculum Plan and the individual Course Syllabi.

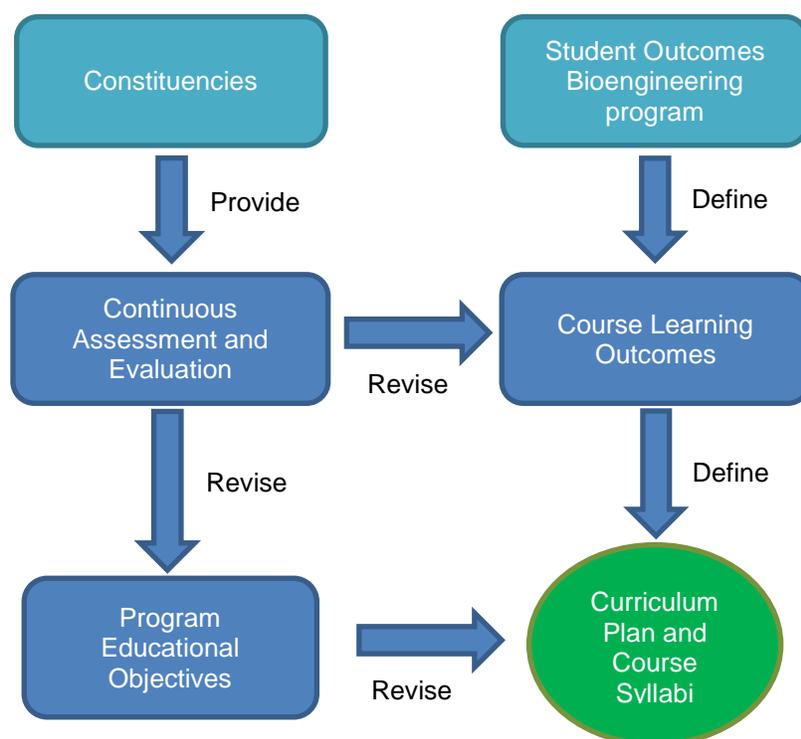


Figure 7. Continuous improvement process

The assessment process for Program Educational Objectives consists of data collection from four sources listed in Table 14.

Table 14. Dates of Data Collection of Constituents

| | Input Dates |
|--|------------------|
| A. Departmental faculty | 2006, 2008, 2012 |
| B. Departmental Advisory Board | 2008, 2011, 2012 |
| C. Survey of alumni of the program | 2012 |
| D. Survey of employers of graduates of the program | 2012 |

The planned frequency with which these assessment processes will be carried out is every three years. However we have just started this cycle of complete assessment for our Continuous Improvement Program.

Soon after our Bioengineering program was established we formulated tentative Program Educational Objectives for the program with input from our Departmental Advisory Board. These initial PEOs listed below were published in the UCR Course Catalog for the 2006-2007 academic year.

The objective of the Bioengineering program is to produce graduates who:

1. Have life-long learning skills that maintain their high level of professional competence,
2. Have the skills to apply engineering and biological principles to meet the challenges of this rapidly evolving field,
3. Be prepared for advanced postgraduate training in bioengineering and biomedical allied fields.

Subsequently through discussions at faculty meetings and Advisory Board meetings, these PEOs were modified to be more consistent with the mission of the Department and College. The modified PEOs were published in the UCR Catalog for the academic year 2009-2010.

1. Have a strong foundation to apply science, engineering and biological principles to meet the challenges at the interface of engineering, life sciences, and medicine.
2. Have the capability to pursue graduate studies, careers in the medical device or biotechnology industries, or entry into medical or other health related professional schools.
3. Are effective working professionally as individuals and in teams and can communicate effectively to integrate contributions from multiple disciplines to address biological and medical problems.
4. Have an appreciation of and sensitivity to a broad range of ethical and social concerns related to bioengineering.

Since the PEOs are targeted to the performance of graduates several years post-graduation, we waited on surveying our alumni until there were a sufficient number of alumni with several years of post-graduate experience. Our first alumni survey was conducted this year. We believe that this is a successful survey as 35 of a total of 75 graduates responded. In addition this year we surveyed the employers of our graduates.

Frequency of Assessment

Thus we have now started a successful cycle of including input from all four of our constituencies for the assessment and continuous improvement of our Program Educational Objectives.

Level of Attainment

Our intention is to continue surveying our graduates at three year intervals. The surveys have a scoring system of 5=very well and 1=minimally. Based on discussions at our faculty meetings, the Bioengineering Faculty decided that a **score of 3.5 or better was the expected level of attainment for the program.**

B. Results of the Evaluation Processes

We have sent surveys to graduates of our program and their workplace supervisors.

C. Survey of Alumni (See Appendix F)

Table 12 shows the summary of this survey for March, 2012 with respect to the PEOs for the program.

D. Workplace Survey of Bioengineering Graduates

Although we have been successful in maintaining contact information for our alumni, we have not been as fortunate in maintaining their workplace information. We plan to improve our interaction with our alumni through interactive networking and thus have better information on their employment situation.

This year our survey was sent to 10 institutions, eight from academia and two from industry. Useful responses were obtained from four in academic institutions.

Workplace Questionnaire

The results of the workplace questionnaire are shown in Table 15.

Table 15. Results for Workplace Survey

“We would like to have your evaluation of our how our students are meeting the objectives of our undergraduate program and, if needed, how we might implement improvements. We would like to know how well the UCR undergraduate program prepared the bioengineer(s) that you supervise to meet the goals of our undergraduate program.

Please provide your evaluation on a scale of one to five; 5 = Very well; 3 = Satisfactory; 1 = Poorly

| Bioengineering Department Program Educational Objectives | Workplace Scores | | | | | Avg. |
|--|-------------------------|----------|----------|----------|----------|-------------|
| | 5 | 4 | 3 | 2 | 1 | |
| 1. An ability to apply science, engineering, and biological principles to meet the challenges at the interface of engineering, life sciences, and medicine. | 2 | 2 | | | | 4.5 |
| 2. A capability to pursue graduate studies, careers in the medical device or biotechnology industries, or entry into medical or other health related medical schools. | 3 | | 1 | | | 4.5 |
| 3. Training to effectively work professionally as an individual and in teams and with skills to communicate effectively to integrate contributions from multiple disciplines to address biological and medical problems. | 4 | | | | | 4.0 |
| 4. An appreciation of and sensitivity to a broad range of ethical and social concerns related to bioengineering. | 3 | 1 | | | | 4.75 |

Further verification of graduates meeting the PEOs

From the Alumni Survey several outcomes were determined. These are shown here.

PEO 1

- 30% of our graduates belong to professional societies
- 60% read professional journals,
- 20% collaborated on projects related to intellectual property
- 30% received awards

PEO 2

- 40% of the respondents were in graduate programs
- 13% in related professional programs
- 26% were in a bio-related industry
- 30% received awards
- 20% have received a post-graduate degree.

PEO 3

- 60% of the graduates had successfully worked in teams and had supervisory responsibilities

From the Workplace (Employer) Survey

PEO 4

All respondents indicated that our graduates were sensitive to social and ethical issues. For example:

- “No doubt, the diverse training in bioengineering at UCR was very helpful for them to see a wide range of areas in the discipline.”
- “The results of these surveys were reviewed by Bioengineering Advisory Committee who considered the response from alumni and the workplace of alumni to be very satisfactory.”
- “The input from three constituencies alumni of our program, workplace of alumni, and Bioengineering Advisory Committee on the Bioengineering program Engineering Objectives were evaluated by the Bioengineering Faculty at a faculty meeting.”
- “The conclusion of this evaluation by the faculty was that our students are making satisfactory progress in meeting the Bioengineering PEO’s and no further changes are needed at this time.”

Documentation and Maintenance of Results.

Surveys are carried out using the web program called SurveyMonkey. The survey text and results are maintained by the Dean’s Office of the College of Engineering and are available for inspection of the College of Engineering Intranet site.

E. Student Outcomes

Student Outcome Assessment Process and Frequency

Student Outcomes are assessed by four methods as illustrated in Table 16.

Table 16. Student outcome assessment process and frequency

| Assessment Methods | Frequency | Evaluation |
|---|-------------------|--------------------------------------|
| A. Individual course measures | Annually | Course Instructors |
| B. Departmental administered senior surveys before graduation | Annually | Department Faculty |
| C. College administered EBI survey at graduation | Annually | Department Faculty Advisory Board |
| D. Departmental administered alumni survey | Every three years | Department Faculty Advisory Board |

Three methods (B, C, and D) are based on surveys. Even though these assessments provide numerical results, they are somewhat subjective in character as they do not provide direct actionable indications for improvement. Thus two years ago we decided to initiate Method A that involves individual assessments of each course by the instructor on an annual basis. This assessment method turned out to be very effort intensive as it required the instructor to gather data for all students in the class for each of the specific illustrative exercises. In the future we plan to select a fewer number of courses for the evaluation of each of the Student Outcomes by Method A.

Examples of Data Collection for Each Assessment Method

Method A

Each required course in the Bioengineering Department is assigned one or more of the student outcomes to cover during the course. These initial **Student Outcomes Course Assignments** are outlined in the matrix below.

The assignment of Student Outcomes to specific courses was determined by the faculty after the curriculum was taught for a few years). Then each faculty member selected which of Student Outcome was addressed in his or her courses. These preliminary assignments were discussed at a faculty retreat and the following primary assignments were selected. Subsequently, as noted below, this year we have examined each course to review specific student work related to Student Outcomes. Based on this evaluation, some of the Student Outcome assignments to certain courses will be modified.

Table 17. Mapping of Student Outcomes to required Bioengineering courses

| Student Outcomes (SO) | a | b | c | d | e | f | g | h | i | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BIEN 10 Overview | | | | ■ | | ■ | ■ | | ■ | ■ | |
| BIEN 105 Circulation Physiology | ■ | | | ■ | ■ | | ■ | | | | ■ |
| BIEN 110 BioMechanics | ■ | | ■ | | ■ | | | | | | ■ |
| BIEN 115 Quantitative Physiology | ■ | ■ | | | ■ | | | | | ■ | ■ |
| BIEN 120 Signals and Systems | | | ■ | | ■ | | ■ | | | | ■ |
| BIEN 125 Biotechnology | ■ | | ■ | | | | | ■ | | | ■ |
| BIEN 130 Bioinstrumentation | ■ | | ■ | | ■ | | | | | | ■ |
| BIEN 130L Bioinstrumentation Lab | ■ | | ■ | | ■ | | ■ | | | | ■ |
| BIEN 135 Biophysics and Thermodynamics | ■ | | | | ■ | | | | | | ■ |
| BIEN 140 A Biomaterials | ■ | ■ | | | ■ | ■ | | | ■ | ■ | |
| BIEN 155 Biotechnology Lab | | ■ | ■ | | ■ | | ■ | | | | ■ |
| BIEN 159 Dynamics of Biological Systems | | ■ | | | ■ | | ■ | | ■ | | |
| BIEN 175 A,B Senior Design | | ■ | | | ■ | | ■ | | ■ | | ■ |

We have a Faculty Course Appraisal Form (FCAR) for each of the courses. In the FCAR each faculty member (instructor) designates certain course elements (exam questions, homework questions, projects, reports, etc.) that are related to the SOs, and student performance and grades for these elements are assembled for the assessment and evaluation.

For each of these items, each time the course is offered all the student grades are evaluated and the instructor rates the performance of the class. Then each of those items from all the courses are collected and sorted according to Student Outcome.

For example, for Student Outcome (a) examples of student work was collected from the following Bioengineering courses: 105, 110, 115, 125, 130, 130L, 135, 140A, and 159. This collection of student work is evaluated by a Bioengineering faculty member and a report written for SO (a) as illustrated in Table 18.

Table 18. Example of process for evaluation of Student Outcome (a)

| |
|---|
| <p><i>Evaluation of Student Outcome (a).</i></p> <p><i>(a) an ability to apply knowledge of mathematics, science (including biology and physiology (PCI)), and engineering</i></p> <p>Several core Bioengineering courses provide students with instruction that meets the characteristics of this required student capability.</p> <p>In order to illustrate the range of materials and concepts that students were exposed to in our program we selected a few examples of student work that shows the depth and breadth of student abilities to apply these fundamental principles.</p> |
| <p>BIEN 130L – Bioinstrumentation Laboratory</p> <p><i>Hands-on utilization of biomedical instruments is a focus of this course. Students are required</i></p> |

Table 18. Example of process for evaluation of Student Outcome (a)

to assemble instruments and evaluate their behavior. An example report from a student illustrates the in depth discussion of the circuitry of an electrocardiogram device and the thorough analysis of measurements made on a person.

63% of the students performed satisfactorily in this experiment.

BIEN 135 – Biophysics and Biothermodynamics

The fundamental principles of free energy considerations are applied to protein structure and function in this course. This homework example challenges the students to predict protein structural changes caused by hypothetical mutations of various amino acids.

92% of the students were able to able to satisfactorily apply thermodynamic principles to this situation.

BIEN 140A – Biomaterials

This course emphasizes the importance of certain chemical/biophysical properties of materials that tend to determine their behavior when placed in a biological milieu. One of the key materials often overlooked in discussing biomaterial behavior is the ubiquitous solvent – water.

In this quiz students were challenged to show how the unique properties of water distinguish this solvent from others.

67% of the students were able to answer these questions satisfactorily.

BIEN 159 – Dynamics of Biological Systems

This course focuses on the modeling of kinetic behavior of biological systems. These particular exam questions challenge the students to explain oxygen binding to various proteins (such as hemoglobin) and how those binding characteristics affect oxygen exchange in the body.

54% of the students were able to answer these questions satisfactorily.

SUMMARY

Overall students in the Bioengineering program satisfactorily meet the Criteria (a) of Student Outcomes. The departmental goal is for at least 70% of the students to reach the level of satisfactory performance in the Student Outcome Criteria. Although we meet our goal if one averages student performance in the examples quoted above, there are some spots that will need attention in the future. In particular we will place emphasis on providing students more thorough lecture material in BIEN 130L (Bioinstrumentation Laboratory), BIEN 140A (Biomaterials), and BIEN 159 (Dynamics of Biological Systems) to enhance their performance. This will be implemented in the 2012-2013 academic year.

Similar reports are assembled for all the other Student Outcomes. These reports are collected in Appendix E.

All the faculty reports for each of the Student Outcomes are then **reviewed and evaluated by the Bioengineering faculty at a retreat**. If remedial action is indicated that information is provided to the course instructors to implement the next time the course is taught.

In addition each bioengineering course has designated **Course Learning Objectives** that relate to the **Student Outcomes**. The Course Objectives for each bioengineering course are given in Appendix A along with the syllabus for each course. An example of the Course Objectives for BIEN 105 Circulation Physiology is shown in Table 19.

Table 19. Example of Course Objectives for BIEN 105 Circulation Physiology

-
- i. You will be able to understand the basic governing momentum conservation equations and associated basic constitutive equations for describing biofluid processes.
 - ii. You will be able to apply these governing equations to real biological systems and describe these systems mathematically, develop strategies to analyze the biofluid problem, recognize particular behavior of real processes, and recognize limitations in approximating the process.
 - iii. You will have developed an ability to utilize practical and mathematical tools, an ability to logically think through biomechanical problems from conception to design, and be familiar with the relative significance of your results.
 - iv. You will have had opportunities to further your professional development through practicing written and oral communication skills, working on group assignments, and using modern computer tools.
 - v. You will demonstrate confidence in assessing and developing basic mathematical/computational models of biomechanical problems.
 - vi. AND, you will demonstrate professional accountability for your engineering design analysis.
-

In addition there is an assessment of senior project presentations.

Method B

The second assessment tool for Student Outcomes is a **Senior Survey**. The survey is shown below along with the student responses for the last four years. This survey is carried out every year. The expected level of attainment is 3.5. and Figure 10 summarize these outcomes for the last four years.

Table 20. Results of Senior Survey

SENIOR SURVEY STUDENT OUTCOMES

1=Not Prepared, 2=Somewhat Prepared, 3=Prepared, 4=Well Prepared, 5=Very Well Prepared

| Student Outcome | 2009 | 2010 | 2011 | 2012 |
|---|------|------|------|------|
| a An ability to apply knowledge of mathematics, science, and engineering (<i>including biology and physiology (PC1)</i>) | 4.1 | 4.1 | 3.6 | 4.2 |
| b An ability to design and conduct experiments, <i>make measurements, analyze and interpret data from living systems addressing the problems associated with the interaction between living and non-living materials and systems. (PC3)</i> | 4.3 | 4.1 | 3.9 | 4.2 |
| c An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability | 3.6 | 3.7 | 3.6 | 3.9 |
| d An ability to function on multidisciplinary teams | 4.5 | 4 | 4 | 4.4 |
| e An ability to identify, formulate, and <i>apply advanced mathematics (including differential equations and statistics), science, and engineering to solve problems at the interface of engineering and biology. (PC2)</i> | 3.9 | 3.9 | 3.5 | 4.2 |
| f An understanding of professional and ethical responsibility | 4.2 | 4.1 | 3.7 | 4.3 |
| g An ability to communicate effectively | 4.6 | 4.4 | 4.3 | 4.6 |
| h Awareness of the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context | 4.2 | 4 | 3.6 | 4.0 |
| i A recognition of the need for, and an ability to engage in life-long learning | 4.7 | 4.4 | 4.2 | 4.5 |
| j A knowledge of contemporary issues <i>related to bioengineering</i> | 3.7 | 3.8 | 3.5 | 3.9 |
| k An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice | 4.4 | 3.8 | 3.3 | 4.3 |

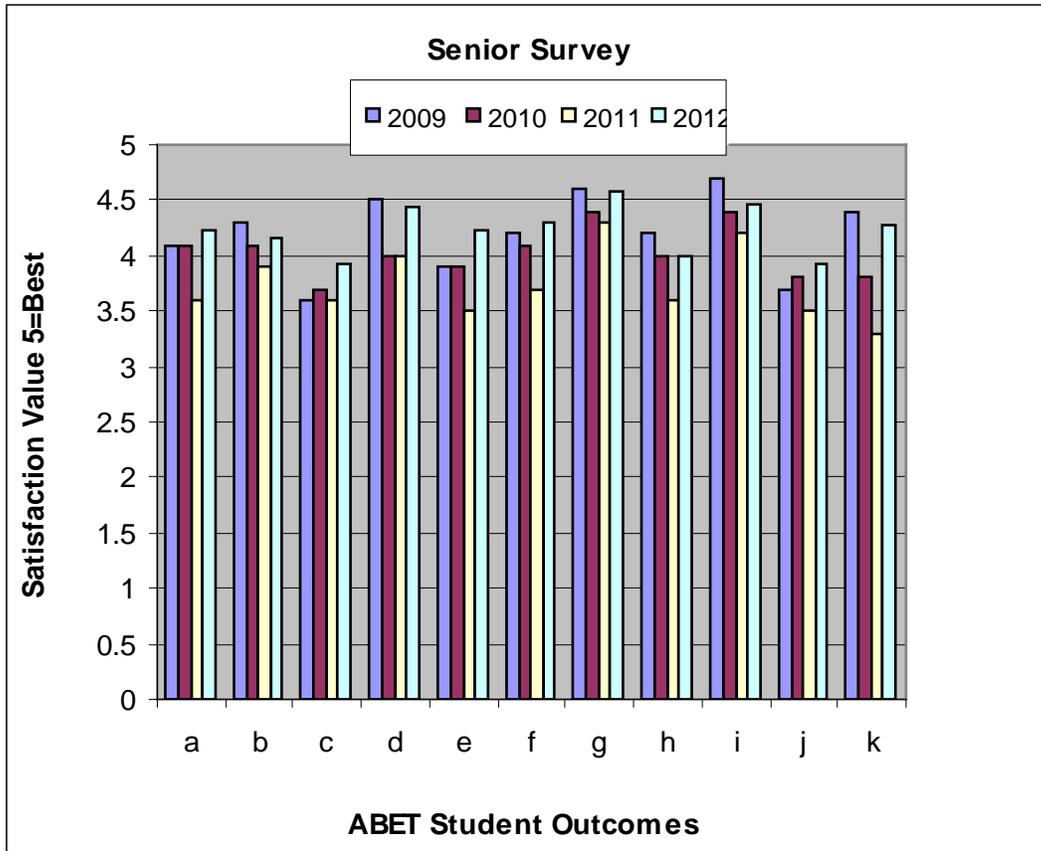


Figure 8. Summary of Senior Survey

Method C

The third method of assessment of Student Outcomes is the **EBI Survey** produced by the Educational Benchmarking Company. This survey is required of all engineering graduating seniors and is administered by the Office of Student Affairs. The responses are coded by program. EBI has associated several of its questions to the ABET (a) through (k) Student Outcomes. Using the algorithm produced by EBI we assembled the responses of the graduating seniors in a manner similar to our Senior Survey. In particular, the EBI survey scores on a basis of 1 to 7, whereas our Senior Survey (and Alumni Survey) score on a basis of 1 to 5. Therefore we scaled the EBI results to a range of 1 to 5. The results are shown in Figure 11.

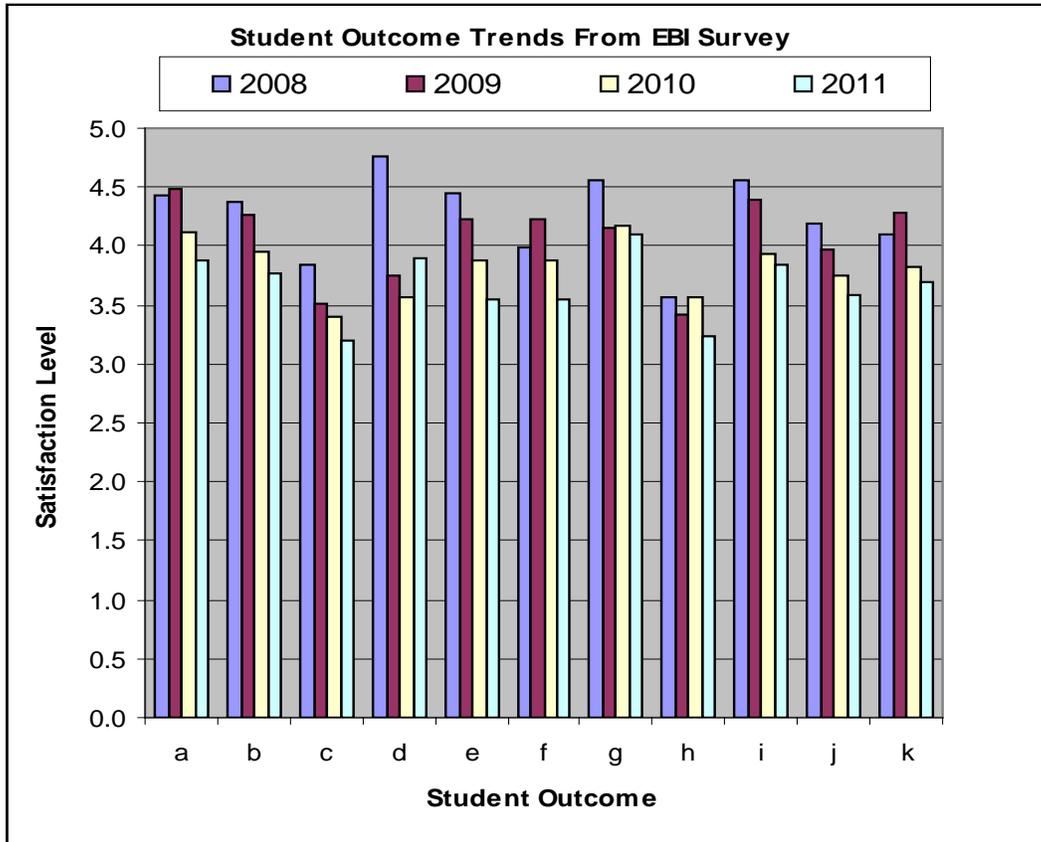


Figure 9. Student Outcome Trends from EBI Survey Corrected for a Range from 0 - 5

Method D

The fourth method of assessing Student Outcomes is by an **Alumni Survey**. Since we are a new program, this is the first year this survey has been conducted. The results of this recent survey are shown in Table 21. The entire Alumni Survey results are given in Appendix F. Even though Student Outcomes are targeted for students at graduation, we wanted to get additional feedback from our alumni on their perception of the preparation provided by the undergraduate program.

ALUMNI SURVEY

Table 21. Alumni Survey of Student Outcomes

| Student Outcomes | | | | | | | | | | |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| a | b | c | d | e | f | g | h | i | j | k |
| 4.0 | 3.9 | 3.8 | 4.4 | 4.0 | 4.1 | 4.3 | 4.0 | 4.3 | 4.1 | 4.0 |

Expected Level of Attainment for Each of the Student Outcomes

For **Method A**, the specific course assessment has an expected level of attainment of 70%. For the survey **Methods B, C, and D** the acceptable level of attainment is 3.5 out of a total score of 5.

Summary of the Results of the Evaluation Process and an Analysis

A departmental faculty meeting was held to evaluate the data from the four assessment methods outlined above. The three student surveys (Methods B, C, and D) indicated that from the point of view of the students and alumni that the Departmental Bioengineering program is satisfactorily meeting the level of attainment (3.5) specified.

However the faculty made an in depth review of the specific examples of student work in each of these Student Outcome areas. A summary of faculty review of student performance (Method A) showed that we can enhance our program in several areas as described below. The suggested improvements will be initiated in the 2012-2013 AY.

Faculty Retreat - Summaries of Proposed Actions Related to Student Outcomes

Student Outcome (a)

An ability to apply knowledge of mathematics, science, and engineering (including biology and physiology (PC1)).

Summary

Overall students in the Bioengineering program satisfactorily meet the Criteria (a) of Student Outcomes. The departmental goal is for at least 70% of the students to reach the level of satisfactory performance in the Student Outcome Criteria. Although we meet our goal if one averages student performance in the examples quoted above, there are some spots that will need attention in the future.

Action Plan

In particular we will place emphasis on providing enhanced lecture materials for BIEN 130L (Bioinstrumentation Laboratory), BIEN 140A (Biomaterials), and BIEN 159 (Dynamics of Biological Systems).

Student Outcome (b)

An ability to design and conduct experiments, make measurements, analyze and interpret data from living systems addressing the problems associated with the interaction between living and non-living materials and systems.

Summary

Seven courses, BIEN 115 (Quantitative Physiology), BIEN 125 (Biotechnology), BIEN 130 (Bioinstrumentation), BIEN 140A (Biomaterials), BIEN 155 (Biotechnology Lab), BIEN 159 (Dynamics of Biological Systems), and BIEN 175 (Senior Design) include components that contribute to this SO.

Action Plan

In particular, students show proficiency in interpreting data from living systems in BIEN 130 (Bioinstrumentation). They show proficiency in designing and conducting experiments with living systems in BIEN 155 (Biotechnology Laboratory).

Student Outcome (c)

An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

Summary

The following courses are listed as contributing to Student Outcome (c): BIEN 120, BIEN 130, BIEN 130L, BIEN 155, and BIEN 175 (course titles are shown below). The examples given for BIEN 120, BIEN 130, BIEN 130L and BIEN 175 clearly provide support for demonstrating that the program meets this Student Outcome. The example for BIEN 155 did not clearly meet the objectives for this Student Outcome based on the example given.

BIEN 120 Signals and Systems

A term-long project to design a feedback control of a student prescribed process relevant to bioengineering. The control system design is analyzed within the limits of the process. The design project has an objective and considers a realistic project. The students are asked to consider limitations.

BIEN 130 Bioinstrumentation

A question on final exam asking to design iron suit armor to respond to various signals from the user. The students must design within limits of available equipment and pricing. A well-defined question that requires students to design a specific device within economic and part-availability limitations.

BIEN 130L Bioinstrumentation Lab

A lab to acquire ECG signals from a human subject. An important lab where the students are required to design a circuit to measure ECG signals.

BIEN 155 Biotechnology Lab

A lab to conduct recombinant fluorescence protein production. Although an important lab, the students need only follow instruction and provide no design components. Remove.

BIEN 175 Senior Design

A two-term project to design and build a device for specific applications with an economic, health and safety constraint.

Action Plan

The program is strong with respect to Student Outcome (c). It is recommended that BIEN 155 be removed from the list of courses that demonstrate proficiency in this Student Outcome.

Student Outcome (d)

An ability to function on multidisciplinary teams

Summary

The examples provided clearly demonstrate the ability of our students to work in teams on projects of a multidisciplinary nature. However, they do little with regard to demonstrating an

ability to work in teams composed of people with a background in different academic disciplines.

Action Plan

The multidisciplinary team experience is currently being addressed through the recent integration of business students and material into our Senior Design course (BIEN 175A) in the current 2011-2012 AY.

Develop a more direct assessment of SO (d) in the future. While it is difficult to imagine a truly objective method for doing so, a subjective measure can be made through student feedback specifically asking to assess their ability to work in i) teams ii) of a multidisciplinary nature.

Student Outcome (e)

An ability to identify, formulate, and apply advanced mathematics, science, and engineering to solve problems at the interface of engineering and biology. (PC2)

Summary

In the following courses our undergraduate students have demonstrated ability to combine advanced mathematics, science, and engineering to solve bioengineering problems: BIEN 105 (Circulation Physiology), BIEN 110 (BioMechanics), BIEN 115 (Quantitative Physiology), BIEN 120 (Signals and Systems), BIEN 130 (Bioinstrumentation), BIEN 135 (Biophysics and Thermodynamics), and BIEN 140A (Biomaterials). The assessments show that most of the students have met the performance standard in these classes.

Action Plan

Based on the presented course material, the following recommendations will be implemented to strengthen SO (e) in our program:

- (i) Increase experimental and data analysis content. Emphasize statistical analysis of experimental data.
- (ii) Increase bioimaging and medical content.

Student Outcome (f)

An understanding of professional and ethical responsibility

Summary

Primary courses BIEN 10 (Overview) and BIEN 140A (Biomaterials).

Action Plan

Overall, SO Criterion (f) needs to be stressed more in other courses, for example, in courses related to drug development, tissue engineering, etc

Student Outcome (g)

An ability to communicate effectively

Summary

Primary courses BIEN 10 (Overview), BIEN 105 (Circulation Physiology), BIEN 120 (Signals and Systems), BIEN 130L (Bioinstrumentation Lab).

These courses require group projects involving several students. Students are required to write comprehensive reports on their projects. Also, they make presentations that evaluated for effectiveness. Overall student performance is very good.

Action Plan

No changes needed.

Student Outcome (h)

Awareness of the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

Summary

In a range of courses (BIEN 120 Signals and Systems, and 159 Dynamics of Biological Systems), our undergraduate students have demonstrated the use of engineering solutions in an economic and societal context. For example, in BIEN125, students learned to compare a few approaches to characterize engineering protein products in an economic and societal context, which is, considering the cost of labor and time for each approach when making a decision on choice of engineering solution. The environmental and global context is less evident for both courses.

The assessments show that most of the students (75%) have met the performance standard for BIEN 120, and 54% met the performance standard for BIEN 159.

Action Plan

Based on the presented course materials, the following recommendations will strengthen SO (h) in our program.

- (i) *Widen the courses involving economic and societal context.* Out of the two courses providing SO (h), only one showed obvious economic and societal context. We need to develop more course material for SO (h). An introduction level presentation on “Engineering Ethics and Impacts on Global, Economic, Environmental, and Societal Context” will be beneficial.
- (ii) *Demonstrating the global and environmental context.* None courses targeted to cover this item had sufficient material to satisfy this Student Outcome. More course material needs to be provided to demonstrate global and environmental context. Again, an introduction level “Engineering Ethics and Impacts on Global, Economic, Environmental, and Societal Context” will be added.

Student Outcome (i)

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

Summary

Review of student work in this area indicated that much more effort needs to be devoted to this topic.

Action Plan

- (i) *Introduce examples in the cognitive domain (analysis) that represent students' mastery of the skills as lifelong learners.* An example from BIEN10 (Overview) course showing analysis of new information, concept, etc. by breaking it down, comparing and contrasting, recognizing patterns, interpreting information, etc. as appropriate. BIEN140A (Biomaterials) can include examples of students' skills to access information from variety of sources, to assess the quality of information and categorize/classify it. Include courses at an upper level that provide our students' skills to model, simplify, approximate, make and recognize assumptions as well as inquiring.
- (ii) *Expand examples in the affective domain (attitudes and values) that represent students' development into the lifelong learners.* The development of the skills in the cognitive domain depends on the attitudes and values of the learners and our program will overall benefit from students gaining competence in the affective domain, which directs behaviors. Example exercises will introduce the theory and practice of engineering ethics using a multidisciplinary and cross-cultural approach focusing on sciences and engineering case studies. This will introduce the professional attitudes and ethical values to help students recognize the need for lifelong learning beyond their engineering degree.

Student Outcome (j)

A knowledge of contemporary issues

Summary

This outcome is an important criterion for the B.S. degree in Bioengineering. The awareness of contemporary issues will not only make students more motivated but also clues for their future career and responsibilities. Many courses can contribute to this Student Outcome. The example should come from higher level knowledge, other than a very specific example for a specific issue.

Action Plan

We will to select at least one course from each category to enhance this Student Outcome, e.g. BIEN125 (Biotechnology), BIEN130 (Bionstrumentation), BIEN120 (Signals and Systems), and BIEN135 (Biophysics and Thermodynamics). This emphasis will also make students aware of scientific and social issues in various disciplines to their studies as bioengineering and their future careers.

Student Outcome (k)

An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Summary

In a range of courses our undergraduate students have demonstrated the use of theoretical (e.g., BIEN 135), computational (e.g., BIEN 105) and experimental (e.g., BIEN 155) skills for bioengineering at various scales: i.e., from protein engineering (e.g., BIEN 155) to device engineering (BIEN 175). The assessments show that most of the students have met the performance standard for all classes.

Action Plan

Based on the presented materials course materials, the following recommendations will strengthen SO (k) in our program:

- (i) *Widen the courses involving experimental skills.* Out of the ten courses providing SO (k) only three involve the use of hands-on experimental skills. Concurrently, all of the ten courses involve the use of theoretical or computational abilities.
- (ii) *Demonstrating the use of statistics.* According to Program Criteria for Bioengineering, “The program must prepare graduates to have: an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology.”

Having enough biology and physiology courses suffices to satisfy some of the program criteria. Regarding advanced math and statistics, however, the students have to demonstrate the use of these skills via SO (k). The lab courses are the best for allowing students to demonstrate skills in statistics (and just placing error bars will not be sufficient).

Documentation

The results of these reviews are documented and maintained in Course Note books and Departmental minutes.

F. Continuous Improvement

Continuous improvement of the Bioengineering program is implemented in several ways.

Continuous improvement related to the **Program Educational Objectives** is implemented in the following manner. First the content of the PEOs are discussed in faculty meetings and with input from the Advisory Board. This has occurred over a 3-4 year period and resulted in a change in the content of the PEOs. Assessment of the extent that our students meet the PEOs is obtained by a survey of our alumni, particularly those who have significant post-graduate experience. Since we are a new program the first alumni survey was held this year. The results of the recent survey of alumni (given above in Section A) showed that our alumni are satisfied that our undergraduate curriculum prepared them to meet the PEOs. This information was discussed at a faculty meeting and it was decided that remedial action is not required at this time.

We will also solicit input from employers of our students to obtain further feedback concerning the PEOs.

Continuous improvement of the **Student Outcomes** occurs through several modes.

First, and very importantly, a **Course Notebook** is maintained by each faculty member for each course over the last two years. The Course Notebook contains the following information (also known as the Faculty Course Assessment Report) shown in Table 22. These Course Notebooks contain examples of student work that demonstrate how well the students are meeting the **Course Learning Objectives, and Student Outcomes**.

Table 22. Faculty Course Assessment Report Template

Faculty Course Assessment Report Template

Date of Preparation: _____ **Course:** _____ **Academic Term:** _____
Instructor: _____
Catalog Description: _____ **Prerequisites:** _____
Class/Laboratory Schedule: _____
Required or Elective Course: _____
Engineering Science Components: _____ **Engineering Design Components:** _____
Textbooks/Required Material: _____
Course Topics/Syllabus: _____
Final Course Grade Distribution: _____
Course Learning Outcomes: _____

FACULTY ASSESSMENT

“Assignment” can be homework, exam question, term paper, presentation, etc.

| Course Learning Outcomes | FACULTY EXPECTATIONS | Assessment Method | Average Score | Performance Standard | % Meeting Standard |
|--------------------------|----------------------|-------------------|---------------|----------------------|--------------------|
| | | | | | |

STUDENT ASSESSMENT BY SURVEY

| Course Learning Outcomes | STUDENT ASSESSMENT Score: Strongly Agree = 5, Agree = 4, Neutral = 3, Disagree = 2, Strongly Disagree = 1 | Avg. Score | Perform. Standard | % Meeting Standard |
|--------------------------|--|------------|-------------------|--------------------|
| | | | | |

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES:

| Program Outcome | Assessment Method Program Outcomes | Avg. Score | Perform. Standard | % Meeting Standard |
|-----------------|------------------------------------|------------|-------------------|--------------------|
| | | | | |

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

PERSON(S) WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:

Faculty members review the course and make suggestions for course improvement. Annually all course instructors review student performance propose actions for course improvement. We have

gone through two cycles of this process. Complete records of the continuous improvement process at the course level are given in **Appendix G**.

A typical record for BIEN 10 – Introduction to Bioengineering is shown in Table 23.

Table 23. Example of Record for Continuous Improvement

BIEN 10 Fall 2009

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

Included a text in bioengineering, Biomedical Engineering: Bridging Medicine and Technology, W. Mark Saltzman, Cambridge University Press, ISBN:978-0-521-84099-6.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

The Pass/Fail structure of this course does not allow an appropriate structure for assessment.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

This course has been changed to a Letter Grade course so as to motivate students to focus on course material.

PERSON(S) WHO PREPARED THIS DESCRIPTION

Victor G. J. Rodgers

AND DATE OF PREPARATION: July 20, 2010

Other important contributions to the continuous improvement of Student Outcomes are the various surveys reviewed above.

Evaluation of these various sources of information has led to several changes in the program over the past few years. All technical electives are engineering courses. Two years ago, the technical elective requirement was changed from allowing chemistry and biology courses as technical electives to only engineering courses. Thus we have worked with the other engineering departments to select a suite of technical elective courses that would be open to Bioengineering students. This required approval from the instructors of these courses to allow Bioengineering student to take their courses using bioengineering courses to satisfy the prerequisites.

In several of the surveys students commented on a desire to have several in depth courses to supplement the general overview of bioengineering topics provided in the core curriculum. Also, our recent review has indicated that more emphasis needs to be placed on ethical and social issues. We will make adjustments in our core courses in the future for these topics.

G. Additional Information

Course Notebooks and departmental meeting minutes will be made available at the visit.

CRITERION 5.CURRICULUM

A. Bioengineering program Curriculum

In order to simplify the presentation of the curriculum in Table 24, we have separately presented the recommended student schedule by year and term in Table 7 “Typical Course Plan”. Table 24 corresponds to the canonical Table 5-1 in the EAC Self-Study template.

Table 24. Bioengineering program courses

| BIOENGINEERING PROGRAM COURSES | | Required, Elective or a Selected Elective (R, E, SE) | Subject Area (Credit History) | | | | Last Two Terms the Course was Offered: | Maximum Section Enrollment for Last Two Terms Course was Offered: |
|--------------------------------|----------------------------------|--|-------------------------------|---|-------------------|-------------------------------|--|---|
| Department and Course Number | Title | | Math & Basic Sciences | Engineering Topics (if contains signif. Design) | General Education | Courses with design component | | |
| Humanities | | | | | | | | |
| ENGL 001A | Beginning Composition | R | | | 4 | W2012, F2011 | 917, 1136 | |
| ENGL 001B | Intermediate Composition | R | | | 4 | W2012, S2011 | 1716, 2145 | |
| ENGL 001C or Alternate* | Applied Intermediate Composition | R | | | 4 | W2012, F2011 | 23, 22 | |
| Breadth _____ | Humanities/Social Sciences | R | | | 4 | | | |
| Breadth _____ | Humanities/Social Sciences | R | | | 4 | | | |
| Breadth _____ | Humanities/Social Sciences | R | | | 4 | | | |
| Breadth _____ | Humanities/Social Sciences | R | | | 4 | | | |
| Breadth _____ | Humanities/Social Sciences | R | | | 4 | | | |
| Breadth _____ | Humanities/Social Sciences | R | | | 4 | | | |
| Math and Basic Science | | | | | | | | |
| CHEM 001A & CHEM 01LA | General Chemistry & Lab | R | 5 | | | W2012, F2011 | 539, 1140 | |
| CHEM 001B & CHEM 01LB | General Chemistry & Lab | R | 5 | | | W2012, S2011 | 977, 724 | |
| CHEM 001C & CHEM 01LC | General Chemistry & Lab | R | 5 | | | F2011, S2011 | 425, 792 | |
| CHEM 112A | Organic Chemistry | R | 4 | | | W2012, F2011 | 517, 725 | |
| CHEM 112B | Organic Chemistry | R | 4 | | | W2012, S2011 | 593, 521 | |
| CHEM 112C | Organic Chemistry | R | 4 | | | F2011, S2011 | 267, 510 | |
| | | | | | | | | |
| MATH 009A | First Year Calculus | R | 4 | | | W2012, F2011 | 275, 440 | |
| MATH 009B | First Year Calculus | R | 4 | | | W2012, F2011 | 848, 756 | |
| MATH 009C | First Year Calculus | R | 4 | | | W2012, F2011 | 407, 423 | |
| MATH 046 | Differential Equations | R | 4 | | | W2012, F2011 | 272, 421 | |
| MATH 010A | Multivariable Calculus | R | 4 | | | W2012, F2011 | 331, 257 | |
| MATH 010B | Multivariable Calculus | R | 4 | | | W2012, F2011 | 196, 100 | |

| BIOENGINEERING PROGRAM COURSES | | Required, Elective or a Selected Elective (R, E, SE) | Subject Area (Credit History) | | | | Last Two Terms the Course was Offered: | Maximum Section Enrollment for Last Two Terms Course was Offered: |
|--------------------------------|--|--|-------------------------------|---|-------------------|-------------------------------|--|---|
| Department and Course Number | Title | | Math & Basic Sciences | Engineering Topics (if contains signif. Design) | General Education | Courses with design component | | |
| Technical Elective** | | SE | | 4 | | | | |
| Technical Elective** | | SE | | 4 | | | | |
| | | | | | | | | |
| TECHNICAL ELECTIVES | | | | | | | | |
| BIEN 140B | Biomaterials | SE | | 4 | | F2011, F2010 | | |
| BIEN 160 | Biomedical Imaging | SE | | 4 | | W2011, W2010 | 26, 21 | |
| BIEN 165 | Biomolecular Engineering | SE | | 4 | | S2010 | 22, 16 | |
| CEE 135 | Chemistry of Materials | SE | | 4 | | F2011, F2010 | 20 | |
| CHE 105* | Introduction to Nanoscale Engineering | SE | | 4 | | W2012, W2011 | 47, 38 | |
| CHE 122 | Chemical Engineering Kinetics | SE | | 4 | | S2011, S2010 | 22, 32 | |
| CHE 161* | Nanotechnology Processing Lab | SE | | 3 | | S2011, S2010 | 63, 40 | |
| EE 100A | Electronic Circuits | SE | | 4 | | W2012, F2011 | 16, 11 | |
| EE 100B | Electronic Circuits | SE | | 4 | | W2012, S2011 | 32, 47 | |
| EE 105 | Modeling & Simulation of Dynamic Systems | SE | | 4 | | W2012, W2011 | 46, 21 | |
| EE 110A | Signals and Systems | SE | | 4 | | W2012, F2011 | 58, 41 | |
| EE 110B | Signals and Systems | SE | | 4 | | W2012, S2011 | 34, 52 | |
| EE 114 | Probability, Random Variables and Random Processes in Electrical Engineering | SE | | 4 | | S2011, S2010 | 46, 26 | |
| EE 138 | Electrical Properties of Materials | SE | | 4 | | F2011, F2010 | 45, 27 | |
| EE 139 | Magnetic Materials | SE | | 4 | | W2012, W2011 | 28, 14 | |
| EE 143 | Multimedia Technologies and Programming | SE | | 4 | | F2004, S1999 | 36, 29 | |
| EE 144 | Introduction to Robotics | SE | | 4 | | S2011, S2010 | 9, 4 | |
| EE 146* | Computer Vision | SE | | 4 | | W2012, W2011 | 22, 21 | |
| EE 152* | Image Processing | SE | | 4 | | W2009, W2008 | 34, 20 | |
| ENVE 133 | Fundamentals of Air Pollution Engineering | SE | | 4 | | W2012, W2011 | 18, 34 | |
| ENVE 142 | Water Quality Engineering | SE | | 4 | | W2012, W2011 | 55, 30 | |
| ENVE 171 | Fundamentals of Environmental Engineering | SE | | 4 | | F2011, F2010 | 33, 19 | |
| ME 114 | Introduction Materials Science and Engineering | SE | | 4 | | F2011, F2010 | 54, 34 | |
| ME 138 | Transport Phenomena in Living Systems | SE | | 4 | | F2011, F2009 | 128, 111 | |
| ME 153 | Finite Element Methods | SE | | 4 | | W2012, S2011 | 15, 20 | |
| ME 180 | Optics & Lasers in Engineering | SE | | 4 | | W2012, | 34, 60 | |

| BIOENGINEERING PROGRAM COURSES | | Required, Elective or a Selected Elective (R, E, SE) | Subject Area (Credit History) | | | | Last Two Terms the Course was Offered: | Maximum Section Enrollment for Last Two Terms Course was Offered: |
|--------------------------------|-------|--|-------------------------------|---|-------------------|-------------------------------|--|---|
| Department and Course Number | Title | | Math & Basic Sciences | Engineering Topics (if contains signif. Design) | General Education | Courses with design component | | |
| | | | | | | | S2008 | |
| | | | | | | | | |

| | | | | | | | | |
|--|--|--|-----|----|--|--|--|--|
| TOTALS-ABET BASIC-LEVEL REQUIREMENTS | | | 79 | 78 | | | | |
| OVERALL UNITS FOR COMPLETION OF THE PROGRAM 79+78+36= | | | 193 | | | | | |

PERCENT OF TOTAL

Total must satisfy either credit hours or percentage

Total must satisfy either credit hours or percentage

| | | | | | | | |
|------------------------------|--|----------|----------|--|--|--|--|
| Minimum Quarter Credit Hours | | 48 Units | 72 Units | | | | |
| Minimum Percentage | | 25% | 37.5 % | | | | |
| | | | | | | | |

B. Alignment of the Curriculum with the Program Educational Objectives

Table 25 shows how the Bioengineering core courses contribute to the Program Educational Objectives.

From Table 9. Program Educational Objectives

1. Have a strong foundation to apply science, engineering and biological principles to meet the challenges at the interface of engineering, life sciences, and medicine.
2. Have the capability to pursue graduate studies, careers in the medical device or biotechnology industries, or entry into medical or other health related professional schools.
3. Are effective working professionally as individuals and in teams and can communicate effectively to integrate contributions from multiple disciplines to address biological and medical problems
4. Have an appreciation of and sensitivity to a broad range of ethical and social concerns related to bioengineering

Table 25. Relationship between core curriculum and PEOs

| | | Program Educational Objectives | | | |
|--------------|---------------------------------|--------------------------------|---|---|---|
| | | 1 | 2 | 3 | 4 |
| BIEN 10 | Overview of Bioengineering | | | | |
| BIEN 105 | Circulation Physiology | | | | |
| BIEN 110 | Biomechanics of the Human Body | | | | |
| BIEN 115 | Quantitative Physiology | | | | |
| BIEN 120 | Biosystems & Signals Analysis | | | | |
| BIEN 125 | Biotechnology & Molecular Engr. | | | | |
| BIEN 130 | Bioinstrumentation | | | | |
| BIEN 130L | Bioinstrumentation Lab | | | | |
| BIEN 135 | Biophysics & Biothermodynamics | | | | |
| BIEN/140A | Biomaterials | | | | |
| BIEN 155 | Biotechnology Lab | | | | |
| BIEN/ 159 | Dynamics of Biological Systems | | | | |
| BIEN 175A, B | Senior Design | | | | |

Attainment of the Student Outcomes through the Curriculum

The curriculum of the Bioengineering program provides students with a rigorous preparation for professional and graduate studies in bioengineering. In the freshman and sophomore years students receive a comprehensive background in the basic sciences and mathematics. In particular they take two courses in biology and organic chemistry to prepare for the departmental core courses. The bioengineering core courses provide students with a thorough understanding of biomechanics, fluid mechanics, systems analysis, bioinstrumentation, biotechnology, biomaterials, model building, and thermodynamics. Students are required to take four technical electives to provide further breadth and depth related to their areas of interest. For example a student interested in biomaterials could elect BIEN 140B Biomaterials which is a follow-up to the required BIEN 140A Biomaterials UCR.A student interested in imaging could elect BIEN 160 Medical Imaging.

All students are required to take BIEN 175 A&B Senior Design. Here they work in teams to formulate and execute a prototype design.

Mapping of the bioengineering courses to Student Outcomes was presented above in under Criterion 4, in

Table 17, which is repeated here for convenience. The darkened locations indicate which courses contribute to a specific Student Outcome.

Table 17. Mapping of Student Outcomes to required Bioengineering courses

| Student Outcomes (SO) | a | b | c | d | e | f | g | h | i | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BIEN 10 Overview | | | | | | | | | | | |
| BIEN 105 Circulation Physiology | | | | | | | | | | | |
| BIEN 110 BioMechanics | | | | | | | | | | | |
| BIEN 115 Quantitative Physiology | | | | | | | | | | | |
| BIEN 120 Signals and Systems | | | | | | | | | | | |
| BIEN 125 Biotechnology | | | | | | | | | | | |
| BIEN 130 Bioinstrumentation | | | | | | | | | | | |
| BIEN 130L Bioinstrumentation Lab | | | | | | | | | | | |
| BIEN 135 Biophysics and Thermodynamics | | | | | | | | | | | |
| BIEN 140 A Biomaterials | | | | | | | | | | | |
| BIEN 155 Biotechnology Lab | | | | | | | | | | | |
| BIEN 159 Dynamics of Biological Systems | | | | | | | | | | | |
| BIEN 175 A,B Senior Design | | | | | | | | | | | |

A flowchart for the prerequisite structure of the Bioengineering program is shown in Table 26.

Program Requirements in Math and Basic Sciences, Engineering Topics, and General Education

Over the past few years we have been fine-tuning our curriculum to meet our Educational Objectives (Table 27).

Biology 5C was dropped as a requirement in 2008 because it deals mainly with evolution and ecology that are not particularly relevant to bioengineering.

Biochemistry Laboratory 102 was substituted for Biochemistry 101 in 2008 because of changes in the prerequisites.

Biology 171 (Physiology) was added in 2008 because of ABET’s requirement for physiology in the Bioengineering Program Criteria (PC1). It was then learned that ABET requires engineering analysis in physiology. For this reason we developed BIEN 115 – Quantitative Physiology to meet the PC1 requirement. This course was offered for the first time in the 2009-2010 AY.

In AY 2007 and 2008 we found that some students were electing advanced biology courses as their technical electives. Although these courses enhanced the student’s capabilities in biology they would not meet the minimum ABET Engineering Topics requirement of 72 units. Thus we have made it mandatory that students elect engineering courses for their technical electives. We also created several additional Bioengineering elective courses such as BIEN 160 Biomedical Imaging and BIEN 165 Biomolecular Engineering to provide further depth in bioengineering subjects. In addition we contacted other engineering departments to develop a list of courses that would be open to our students as technical electives (listed below).

Table 26. Flowchart for prerequisite structure for Bioengineering

| Year | Term | Dept | CRS NO | Course Title | PREREQUISITES | |
|----------|------|------|--------|--|--|-------------------------------|
| | | | | | Science | Bioengineering |
| Freshman | 1 | BIEN | 010 | Overview of Bioengineering | | |
| Junior | 1 | BIEN | 110 | Biomechanics of the Human Body | CHEM 001C or CHEM 01HC, MATH 010A, PHYS 040B | |
| Junior | 2 | BIEN | 105 | Circulation Physiology | BIOL 005B, MATH 046, PHYS 040A | |
| Junior | 2 | BIEN | 125 | Biotechnology and Molecular Bioengineering | BCH 100 | |
| Junior | 2 | BIEN | 140A | Biomaterials | BCH 100, CHEM 112C, MATH 010B, PHYS 040B | |
| Junior | 3 | BIEN | 115 | Quantitative Physiology | | BIEN 110 |
| Junior | 3 | BIEN | 120 | Biosystems and Signal Analysis | BIOL 005B, CS 010, MATH 046, PHYS 040C | |
| Junior | 3 | BIEN | 130 | Bioinstrumentation | | BIEN 120 |
| Junior | 3 | BIEN | 130L | Bioinstrumentation Laboratory | | co-enroll BIEN 130 |
| Senior | 1 | BIEN | 135 | Biophysics and Biothermodynamics | BCH 100, MATH 010B, MATH 046, PHYS 040C | |
| Senior | 1 | BIEN | 155 | Biotechnology Laboratory | BCH 100, PHYS 040C | |
| Senior | 1 | BIEN | 159 | Dynamics of Biological Systems | BCH 100 or BCH 110A | |
| Senior | 2 | BIEN | 175A | Senior Design | | BIEN 130; BIEN 130L; BIEN 135 |
| Senior | 3 | BIEN | 175B | Senior Design | | BIEN 175A |

In AY 2008 EE 1A and EE ILA (Engineering Circuit Analysis and its lab) were added as required courses to provide students with adequate preparation in circuits for BIEN 130 Bioinstrumentation and BIEN 130L Bioinstrumentation Laboratory.

In AY 2008 ME 10 Statics was deleted from the program because the needed material was incorporated into BIEN 110 Biomechanics of the Human Body.

Table 27. Evolution of B.S. Bioengineering curriculum

| Mathematics and Basic Sciences | | | | | Engineering Topics | | | | |
|---|--------------|-------------|-------------|-------------|---|--------------|-------------|-------------|-------------|
| ABET Math and Basic Science Reqt. (48) | | | | | ABET Engineering Topics Reqt. (72) | | | | |
| Course | Units | 2007 | 2008 | 2009 | Course | Units | 2007 | 2008 | 2009 |
| MATH 9A | 4 | 4 | 4 | 4 | ME 1C | 1 | 1 | | |
| MATH 9B | 4 | 4 | 4 | 4 | ME 18 | 2 | 2 | | |
| MATH 9C | 4 | 4 | 4 | 4 | ME 10 | 4 | 4 | | |
| MATH 10A | 4 | 4 | 4 | 4 | ME 118 | 4 | 4 | | |
| MATH 10B | 4 | 4 | 4 | 4 | CS 10 | 4 | | 4 | 4 |
| MATH 46 | 4 | 4 | 4 | 4 | EE 1A | 3 | | 3 | 3 |
| CHEM 1A | 4 | 4 | 4 | 4 | EE 1LA | 1 | | 1 | 1 |
| CHEM 1LA | 1 | 1 | 1 | 1 | STAT 155 | 4 | 4 | 4 | 4 |
| CHEM 1B | 4 | 4 | 4 | 4 | BIEN 10 | 2 | 2 | 2 | 2 |
| CHEM 1LB | 1 | 1 | 1 | 1 | BIEN 105 | 4 | | 4 | 4 |
| CHEM 1C | 4 | 4 | 4 | 4 | BIEN 110 | 4 | 4 | 4 | 4 |
| CHEM 1LC | 1 | 1 | 1 | 1 | BIEN 115 | 4 | | | 4 |
| CHEM 112A | 4 | 4 | 4 | 4 | BIEN 120 | 4 | 4 | 4 | 4 |
| CHEM 112B | 4 | 4 | 4 | 4 | BIEN 125 | 4 | 4 | 4 | 4 |
| CHEM 112C | 4 | 4 | 4 | 4 | BIEN 130 | 4 | 4 | 4 | 4 |
| PHYS 40A | 5 | 5 | 5 | 5 | BIEN 130L | 2 | 2 | 2 | 2 |
| PHYS 40B | 5 | 5 | 5 | 5 | BIEN 135 | 4 | 4 | 4 | 4 |
| PHYS 40C | 5 | 5 | 5 | 5 | BIEN 140A | 4 | 4 | 4 | 4 |
| BIOL 5A | 4 | 4 | 4 | 4 | BIEN 140B | 4 | 4 | | |
| BIOL 5LA | 1 | 1 | 1 | 1 | BIEN 155 | 2 | 2 | 2 | 2 |
| BIOL 5B | 4 | 4 | 4 | 4 | BIEN 159 | 4 | 4 | 4 | 4 |
| BIOL 5C | 4 | 4 | | | | | | | |
| BIOL 171 | 4 | | 4 | | | | | | |
| BCH 100 | 4 | 4 | 4 | 4 | Major Design Experience | | | | |
| BCH 101 | 3 | 3 | | | BIEN 175A | 4 | 4 | 4 | 4 |
| BCH 102 | 4 | | | | BIEN 175B | 4 | 4 | 4 | 4 |
| Total | | 86 | 83 | 79 | Required Courses | | 61 | 58 | 62 |
| Humanities and English 36 | | | | | Tech Electives 16 | | | | |
| ENGL 1A | 4 | 4 | 4 | 4 | BIEN 140B | 4 | 4 | 4 | 4 |
| ENGL 1B | 4 | 4 | 4 | 4 | BIEN 160 | 4 | 4 | 4 | 4 |
| ENGL 1C | 4 | 4 | 4 | 4 | BIEN 165 | 4 | 4 | 4 | 4 |
| BREATH | 24 | 24 | 24 | 24 | Other | 4 | 4 | 4 | 4 |
| Total | | 122 | 119 | 115 | Engineering Topics | | 81 | 74 | 78 |
| Total Units for B.S. | | | | | | | 203 | 193 | 193 |

Capstone Design Experience

Bioengineering 175A&B is the two-quarter capstone design experience, a combined total of 8 credits: Lecture, 2 hours; practicum, 3 hours; discussion, 1 hour. Prerequisite(s): BIEN 130; senior standing in Bioengineering.

Skills needed for senior design include hands-on laboratory experience, team project experience, and communication experience. Primary courses providing these laboratory skills are Bioinstrumentation Laboratory BIEN 130L and Biotechnology Laboratory BIEN 155. Team project and communication experience is obtained in nearly all of our undergraduate courses, but is particularly emphasized in Circulation Physiology, BIEN 105, Quantitative Physiology, BIEN 115, and the two laboratory courses.

A. Catalog Description of Course

Preparation of formal engineering reports and statistical analysis on a series of problems illustrating methodology from various branches of applied bioengineering. Covers the entire design process: design problem definition, generation of a design specification, documentation, design review process, prototype fabrication, testing and calibration, cost estimation, and federal guidelines. Requires a term project and oral presentation. Graded In Progress (IP) until BIEN 175A and BIEN 175B are completed, at which time a final, letter grade is assigned.

B. Syllabus

Typical Design Sequence

Characterization of product or process need

Review of existing methods

Generation and evaluation of several design concepts

Order of Magnitude Calculations

Planning of design project including skill and resource requirements

Utilization of engineering principles and software (e.g. COMSOL, Matlab) to develop specifications and documentation for the product or process

Design, build and test

component elements

completed prototype

Analyze and interpret data (statistical methods)

Evaluation of design solution

Create finalized design

Course Components

Project team development and operation including

a. organization

b. communication

Project Notebook

 Web based systems

Create a Web site for the project

Periodic Written Reports

Periodic Oral Reports using PowerPoint

Final Oral Presentation using PowerPoint

Final Poster Presentation
Final Written Report
c. project management
maintain a timeline for the project

Lecture Topics

Industry overview

Biomedical instruments

Biomedical devices

Biotechnology products – drugs, enzymes, hormones, etc.

Agriculture and food products

(Environmental products and processes)

(Economic analysis)

(Market considerations)

Intellectual property including licensing, patents, and trade secrets

Regulatory considerations, e.g. FDA (Food and Drug Administration)

Good manufacturing standards, e.g. ISO

Relevant Standards, e.g. ASTM

(OSHA standards for laboratory safety)

Ethical and safety considerations in product development, testing, commercialization

(Human factors)

(Risk management and hazard considerations)

(Lifecycle considerations)

Quality control

Materials selection

Prototyping and testing, including clinical trials

Provide full documentation of the design

Manufacturability

Medicare payments CMS

Table 28. Evaluation rubric for senior design teams

| Objective (from a – k list) | 4 Exemplary | 3 Proficient | 2 Apprentice | 1 Novice | 0 | Team Score |
|--|--|---|---|---|--|--|
| (b) an ability to design and conduct experiments, <i>make measurements, analyze and interpret data from living systems</i> addressing the <i>problems associated with the interaction between living and non-living materials and systems. (PC3)</i> | Design is thorough. Several options considered. Appropriate measurement techniques selected and utilized. Clear recognition of interactions between living and non-living systems. Data interpretation and analysis very thorough. | Design process satisfactory but somewhat limited. Measurements adequate. Interpretation of data sound. Data are good. | Design process limited. Measurements are incomplete. Interpretation of data limited. Techniques satisfactory. | Design process poor. Measurements and data interpretation are inadequate. Poor laboratory skills. | Analysis not done. No records from lab. | <u>A</u> ____ <u>B</u> ____ <u>C</u> ____ <u>D</u> ____ <u>E</u> ____ <u>F</u> ____ <u>G</u> ____ <u>H</u> ____ |
| (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability | Design is adapted based on acquired information to meet needs within specified constraints | Design plan modified somewhat during implementation. | Little consideration given to improvement of design. | Original design flawed and not corrected. | Design not completed | <u>A</u> ____ <u>B</u> ____ <u>C</u> ____ <u>D</u> ____ <u>E</u> ____ <u>F</u> ____ <u>G</u> ____ <u>H</u> ____ |
| (d) an ability to function on multidisciplinary teams | Team highly coordinated, responsibilities clearly delineated but highly cooperative. Specific areas of expertise assigned | Team members carried out tasks, sharing of responsibilities, satisfactory cooperation | Team members worked independently, | Some Team members not fully participating | No teamwork | <u>A</u> ____ <u>B</u> ____ <u>C</u> ____ <u>D</u> ____ <u>E</u> ____ <u>F</u> ____ <u>G</u> ____ <u>H</u> ____ |
| (g) an ability to communicate effectively | Teamwork highly evident in written report. Weekly progress reports very informative. Oral presentation excellent, succinctly presenting conclusions supported by data. | Reports are well organized and provide information in an easily understood format. Conclusions clearly stated | Reports are somewhat sketchy in content. Not thorough, tables and graphs not well explained. | Project not clearly presented. Reports not organized in a coherent manner. Errors in the report. | Reports do not follow an organized pattern, data and results not presented | <u>A</u> ____ <u>B</u> ____ <u>C</u> ____ <u>D</u> ____ <u>E</u> ____ <u>F</u> ____ <u>G</u> ____ <u>H</u> ____ |

| Objective (from a – k list) | 4 Exemplary | 3 Proficient | 2 Apprentice | 1 Novice | 0 | Team Score |
|--|--|--|---|--|-----------------------------------|--|
| (i) a recognition of the need for, and an ability to engage in life-long learning | Clear recognition of previous history of this project with clear discussion of relevant literature. Clear description and recommendations for follow-up to this project. | Appropriate citing of relevant literature with discussion of relationship to this project. | Evidence of some literature search, follow-up not thoroughly discussed. | Minimal reference to other sources mentioned. Unjustified speculation. | No literature search | <u>A</u> ____ <u>B</u> ____ <u>C</u> ____ <u>D</u> ____ <u>E</u> ____ <u>F</u> ____ <u>G</u> ____ <u>H</u> ____ |
| (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. | Excellent selection of measurement techniques. Novel and thorough utilization of computational tools for design and analysis. | Competent application of techniques learned in the curriculum. | Somewhat limited in application of computational methods and laboratory techniques. | Application of engineering principles limited. | Poor understanding of engineering | <u>A</u> ____ <u>B</u> ____ <u>C</u> ____ <u>D</u> ____ <u>E</u> ____ <u>F</u> ____ <u>G</u> ____ <u>H</u> ____ |

Cooperative Education

Not applicable.

Materials Available for Review

Course Notebooks containing course syllabi, sample student work and assessments will be made available at the visit. Textbooks will also be available. Course Syllabi are in **Appendix A**.

CRITERION 6. FACULTY

A. Faculty Qualifications

The Bioengineering faculty is now comprised of 11 individuals, all of whom have Ph.D.s in fields that include engineering, chemistry, physics, and biology (Table 29. Bioengineering faculty qualifications. The diverse expertise of our faculty in science and engineering allows us to capitalize these capabilities in our teaching assignments. For example the biological based courses are taught by Prof. Liao a molecular biologist, and the thermodynamics course is taught by Prof. Morikis, a biophysicist.

Four of our faculty are members of the American Institute of Biological and Medical Engineering and Fellows of AAAS. One individual is a member of the National Academy of Engineering. All of our faculty members belong to technical societies such as the Biomedical Engineering Society, American Chemical Society, American Institute of Chemical Engineering, and Materials Research Society. Various faculty have funding from major institutions such as NSF and NIH. As can be seen in Appendix B all of our faculty have extensive publications in major scientific and professional journals.

Several of our faculty have industrial experience – Profs. Liao, Liu, Park, Rodgers, Schultz, and Vullev.

Table 29. Bioengineering faculty qualifications

| 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 |
| Bahman Anvari | Ph.D. Bioengineering, 1993 | P | T | FT | | 17 | 6 | | M | L | H |
| Kaustabh Ghosh | Ph.D. – Biomedical Engineering, 2006 | AST | TT | FT | 0 | 1 | < 1 | None- | M | M | L |
| Jiayu Liao | Ph.D. Biological Chemistry 1999 | AST | TT | FT | 4 | 11 | 6 | | H | M | H |
| Huinan Liu | Ph.D.-Biomedical Engineering, 2008 | AST | TT | FT | 1 | 6 | 1 | Teaching Certificate Higher Ed | H | H | M |
| Julia G. Lyubovitsky | PhD, Chemistry, 2003 | AST | TT | FT | 0.25 | 7 | 4.5 | N/A | L | L | L |
| Dimitrios Morikis | Ph.D., Physics, 1990 | P | T | FT | 0 | 6 | 11 | N/A | H | L | L |
| Jin Nam | PhD/Materials Science and Engineering/2006 | AST | TT | FT | 0 | 1 | 1 | N/A | H | H | L |
| B. Hyle Park | Ph.D., Physics, 2005 | AST | TT | FT | | 5 | 3 | | M | M | L |
| Victor G. J. Rodgers | D.Sc. 1989 | P | T | FT | 3 | 23 | 6 | None | M | L | L |
| Jerome S. Schultz | Ph.D., Biochemistry, 1958 | P | T | FT | 9 | 50 | 7 | None | M | L | L |
| Valentine Vullev | Ph.D. Chemistry 2001 | AST | TT | FT | 2 | 7 | 7 | None | M | M | L |

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.

B. Faculty Workload

Typically full time senior faculty is expected to teach four courses throughout the academic year. This is a combination of undergraduate and graduate courses. Thus although fewer than four courses are listed in Table 30 (EAC Self-Study Table 6-2) for some of the faculty, some are given course relief for major administrative duties. Research and professional service account for the balance of faculty effort. The entire faculty listed has 100% full-time appointments in the Department of Bioengineering.

Table 30. Bioengineering faculty workload summary

| 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 + Admin. | |
| Bahman Anvari | FT | BIEN 110 (4), BIEN 115 (4), BIEN 223 (3) | 30 | 40 | 30 Undergrad Advisor | 100 |
| Dimitri Morikis | FT | BIEN 135(4), BIEN 249(3) | 30 | 40 | 10 (Sabbatical) | 100 |
| Jiayu Liao | FT | BIEN 125(4), BIEN 155(2), BIEN 223(3) | 40 | 400 | 20 | 100 |
| Huinan Liu | FT | BIEN 130L(2) | 30 | 40 | 10 New Faculty | 70 |
| J. Lyubovitsky | FT | BIEN 159(4), BIEN 160(4). BIEN 251 (3) | 40 | 40 | 20 | 100 |
| Hyle Park | FT | BIEN 130(4), | 15 | 75 | 10 NIH Fellow | 100 |
| Victor Rodgers | FT | BIEN 10(2). BIEN 105(4), BIEN 120(4), BIEN 264(3) | 50 | 40 | 10 | 100 |
| Jerome Schultz | FT | BIEN 175A(4), BIEN 175B(4) | 30 | 20 | 50 Chair | 100 |
| V. Vullev | FT | BIEN 140B (4), BIEN 140A(4), BIEN 245 (3) | 40 | 40 | 20 | 100 |
| J. Nam | FT | New faculty 10/12 | | 100 | | |
| K. Ghosh | FT | New Faculty 10/12 | | 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.

C. Faculty Size

The current faculty size in the Department of Bioengineering is 11 individuals. This year we are recruiting an additional person that will bring out total to 12. In addition to faculty with engineering degrees, some of the bioengineering faculty has degrees in chemistry, biology, biophysics, physics, and material science. All of our faculty teach at least one undergraduate course, thus providing undergraduates with a wide diversity of faculty backgrounds.

Most of the faculty sponsor undergraduates in research projects; many of our undergraduates have publications in scientific journals before finishing their program.

Each of our faculty members is available for student advising and counseling on an as needed basis. In addition students are required to meet with faculty to discuss their progress in the program at least once a year.

Our faculty serves on a variety of College and University committees including the College Executive Committee, laser safety committee, Stem Cell Center Advisory Committee, University Wellness Committee, UC Biophotonics Committee, and UC Systemwide Bioengineering Committee.

Our faculty has served as symposium organizers for the American Chemical Society, American Institute of Chemical Engineers, Biomedical Engineering Society, and Gordon Conferences.

D. Professional Development

All faculty members are expected to be active in research and professional activity throughout their careers. It is common for new faculty hires to have money 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 departments and degree programs cooperate to present lecture series every academic year. These series bring faculty candidates and distinguished guests from academia or industry to campus. Faculty and students attend these sessions.

Intramurally, professional development opportunities include workshops on teaching skills, interpersonal skills, and other matters. State law and University policy also require training in sexual harassment prevention, laboratory safety, and other matters.

For the past few years, the National Science Foundation 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

All program issues are initiated by the Departmental faculty. Many of the faculty devise new courses as technical electives based on their research expertise. Changes in program must be approved by a vote of the Departmental faculty and also the Executive Committee of the College of Engineering as depicted in the chart below. The process for program approval is shown in Figure 10. Process for obtaining academic approval for program and course changes

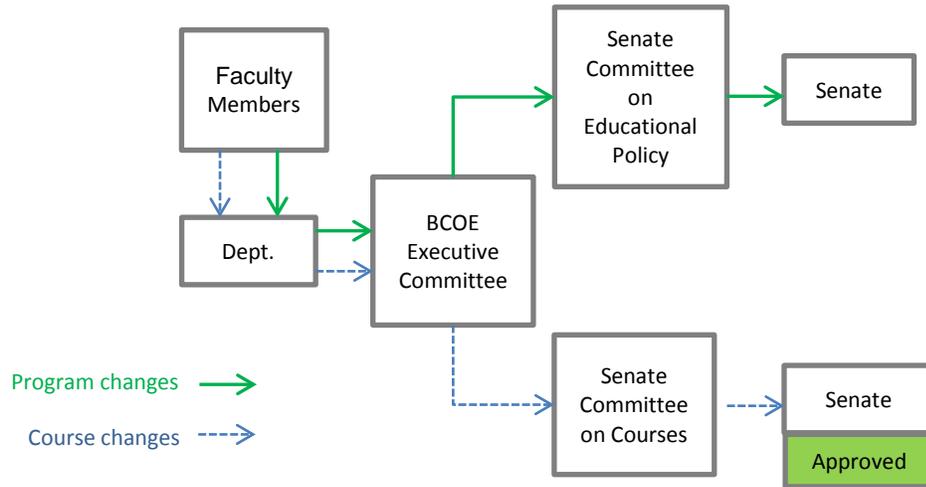


Figure 10. Process for obtaining academic approval for program and course changes

The Bioengineering faculty have the primary responsibility for the development, initiation and implementation the continuous improvement processes in our program below (repeated for convenience) shows the three primary roles for faculty – namely revision of course learning outcomes, Program Educational Objectives, curriculum plan, and course syllabi.

CRITERION 7. FACILITIES

A. Offices, Classrooms and Laboratories

The Bioengineering Department recently moved into the new Materials Science and Engineering Building. Bioengineering occupies most of the second floor of this facility. Research laboratories, faculty offices and the departmental office are adjacent to each other. The undergraduate teaching laboratory is on the floor below. This environment provides an integrated educational facility that allows student easy access to faculty, staff, and laboratories.

Graduate student teaching assistants (TAs) have office space in Bourns Hall, an adjacent building. The Bioengineering computing laboratory is in Bourns Hall as well. Floor layouts are summarized in Appendix C. Table 31 summarizes the space allocation for bioengineering.

Table 31. Summary of Space Allocation for Bioengineering

| Bioengineering Department Facilities | Square Feet |
|---|---------------|
| 13 Faculty offices | 1620 |
| Department Office Spaces | 951 |
| 4 Post Doc and Visitor offices | 405 |
| Faculty Research laboratory space total | 8637 |
| Core Facilities | |
| Animal Care Facility | 1065 |
| Cell Culture Facility | 665 |
| Cold Room Facility | 665 |
| Grad Student Office Space | 2717 |
| Undergrad Instructional lab space | 1754 |
| Undergrad Design Space | 935 |
| Instructional Computer Lab | 454 |
| Total | 19,868 |

B. Computing Resources



Figure 13. Computer laboratory



Figure 14. Instructional laboratory

Bioengineering Computer Lab: Bourns Hall B265

This room is available 24/7 to all undergraduate Bioengineering students. The computers have software listed below available at all times. This software suite is sufficient for all the undergraduate courses.

Approximately 1300 sq. ft.

Number of Computer Stations: 34

Dell Vostro 460 Mini Tower with 21.5" monitor

Manufacturer: Dell

Total cost of computers: \$34,000

Number of printers: 1

HP Laserjet 4250 Printer

Manufacturer: HP

Cost: \$400

List of Instructional Software Installed:

COMSOL 4.2a, latest version teaching license (**\$5821**)

Matlab

Solid Work

Mathematica

MS office 2010

The following is the list of free software installed for Professor Dimitrios Morikis's class

Deep View-Swiss-PDB Viewer (<http://spdbv.vital-it.ch/disclaim.html>)

Chimera (<http://www.cgl.ucsf.edu/chimera/download.html>)

R-base (<http://cran.r-project.org/bin/windows/base/>)

Modeller (http://salilab.org/modeller/download_installation.html)
DOCK (http://dock.compbio.ucsf.edu/Online_Licensing/index.htm)
APBS (<http://sourceforge.net/projects/apbs/>)
VMD (<http://www.ks.uiuc.edu/Development/Download/download.cgi?PackageName=3D3D>)
NAMD (<http://www.ks.uiuc.edu/Development/Download/download.cgi?PackageName=3D3D>)
MGL Tools (<http://mgltools.scripps.edu/downloads>)

The instructional equipment obtained by this process over the past three fiscal years is listed below:

Bioengineering Student Instructional Laboratories

Both undergraduate laboratory courses are taught in the same room (MSE 154) approximately 1300 sq.ft. These courses are taught in alternate terms so that the equipment is changed for each course. Instructional equipment is supplied by the Bourns College of Engineering

Bioinstrumentation Laboratory (BIEN 130L):

Lab Quest, Spirometer, O2 Sensors, etc.
Pasco Stress Strain testers
Balance
Gel Columns
National Instruments ELVIS
Computers and monitors
for NI ELVIS
BioPac MP36 Physiological Experiments
Stress-strain Experiments
Lung Capacity Experiment

Biotechnology Laboratory (BIEN 155):

Gene Pulser Xcell System
Biomate 3 UV-Vis Spectrophotometer
Pipettes
Electrophoresis
Combination biotech pH electrode
Eppendorf Mastercycler
UV/Vis/NIR Spectrophotometer
Undergrad Computer Facility
Micro Centrifuge
Balance 400-500g
Electrophoresis
Gene Pulser Xcell Main Unit

A separate room MSE of approximately 1000 sq. ft. is used for senior design projects.

University Computer Support

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 listed in Appendix I:

Other Services and Support

- **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.

C. Guidance

Students are advised to take the appropriate on-line safety classes (<http://www.ehs.ucr.edu/training/online/>) from the following list:

- Laboratory Safety Orientation
- Hazardous Waste Management
- Laser Safety
- Bloodborne Pathogens
- Biosafety

D. Maintenance and Upgrading of Facilities

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.

In addition, most BCOE undergraduate lab courses charge a (\$20-50/student) Course Materials Fee. Per UCR policy, these fees can only be used to purchase expendable laboratory materials and supplies including chemicals, glassware, software, computers, etc. For FY 10/11,

approximately \$210,000 was generated in Course Materials Fees by BCOE academic programs. (NOTE: This information also applies to Criterion 8.B.3)

E. Library Services

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.

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 to 11:00pm.

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 offers tutorials and classes on engineering information topics, and maintains Web pages and path-finders to assist engineering students, faculty, and staff in locating the information they need.

The UCR Libraries offers 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 (9am-8pm. Monday-Thursday, 9am-5pm on Friday) 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 senior design classes. One-on-one or group tutorials are available for any research topic that might be desired and helpful to engineering students.

Information on Library Collections are provided in Appendix I.

F. Overall Comments on Facilities

The Department of Bioengineering has a full time staff person (Development Engineer) who oversees the instructional and research laboratories. She insures that all laboratories and personnel meet University safety standards.

BCOE takes community safety seriously and utilize a variety of resources and strategies to maximize our community's safety and security and protect the environment.

BCOE follows the University of California Policy on Management of Health, Safety and the Environment – a systemwide policy applied to all UC campuses. The policy has received personal commitment from the President of the University of California.

University of California Policy on Management of Health, Safety and the Environment

The University of California is committed to achieving excellence in providing a healthy and safe working environment, and to supporting environmentally sound practices in the conduct of University activities. It is University policy to comply with all applicable health, safety, and environmental protection laws, regulations and requirements.

To meet this standard of excellence, the University implements management initiatives and best practices to systematically integrate health, safety, and environmental considerations and sustainable use of natural resources into all activities. All University activities are to be conducted in a manner that ensures the protection of students, faculty, staff, visitors, the public, property, and the environment.

The University's goal is to prevent all workplace injuries and illnesses, environmental incidents, and property losses or damage. Achieving this goal is the responsibility of every member of the University community. Supervisors have particular responsibility for the activities of those people who report to them.

BCOE also partners closely with UCR's Office of Environmental Health & Safety, UC Police Department, Office of Risk Management, and to implement UC safety policies and best practices. UCR EHS uses methods developed by the systemwide Environment, Health, & Safety Leadership Council in an effort to implement the UC systemwide policy on management of health, safety, and the environment in order to bring safety, health, and sustainability into work practices at all levels.

BCOE Safety Partners

BCOE employs a full time Safety & Facilities Coordinator. This individual coordinates the facilities, health, safety, and training activities for the entire college. The Safety & Facilities Coordinator represents BCOE on the campus Research Integrated Safety Committee (RISC) and the campus Laboratory Safety Officers group. Membership on these committees enables BCOE to stay abreast of the latest safety best practices, regulations and policies as well as allowing BCOE to plan in advance to manage special processes and potential hazards. The Safety & Facilities Coordinator also participates in UC systemwide laboratory safety conference calls and facilitates monthly meetings of the BCOE department and program Laboratory Safety Officers.

BCOE utilizes the many UCR Environmental Health & Safety's Laboratory / Research Safety program safety and compliance implementation tools, training courses, and safety guidelines for hazards found in the laboratory setting including: chemical safety, radiation safety, biological safety, field research safety, and general safety. Maintaining safe laboratories provides a safe and healthy environment for faculty and students to expand research ideas, develop new techniques, and master their subject matter.

BCOE Laboratory Safety Officers act as their departments' safety liaisons and are the Chemical Hygiene Officer and Hazard Communication officer for their departments. They direct and advise faculty, staff, and students on laboratory safety, the proper handling and disposal of chemicals, perform department lab safety audits, provide and document safety training, and attend both campus and college-wide Laboratory Safety Officer meetings. Safety information and best practices are shared between College departments via the BCOE Laboratory Safety Officers group.

In addition to setting up instructional labs, LSOs provides course-specific laboratory safety training at the beginning of the course and as needed prior to each laboratory experiment. Documentation is managed by the LSO in concert with the department administrative staff.

CRITERION 8. INSTITUTIONAL SUPPORT

A. Leadership

The Chair of the Department of Bioengineering is responsible for ensuring the quality and continuity of the program. Typically the Chair is appointed for a three year term by the Dean. The Chair participates in a biweekly meeting of Chairs and Center Directors that is led by the Dean. This meeting provides the Chair to represent the needs of the Department of Bioengineering to the College Administration and also through this meeting the Chair informs the Bioengineering Faculty of college-wide issues and initiatives. The Chair's leadership is evaluated by the Dean.

The Chair appoints a faculty member to be the Undergraduate Advisor who has the responsibility of overseeing course content and student advising.

At the end of each course the students complete a course evaluation form that can be reviewed by the Chair and corrections made if needed.

B. Program Budget and Financial Support

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. 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. 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 (currently Dr. Jerome Schultz) to oversee curricular matters and to offer advice on curricular issues.

Budgeting

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 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

In response to the February Budget Call Letter, the Dean’s Office in the Bourns College of Engineering requests budget proposals from each academic unit in the College. These proposals include undergraduate and graduate student projections, course load information, staffing requirements and needs for additional supply, travel and miscellaneous expenses. Any additional resources requested are presented in the context of departmental Five-Year Plans. In this way, departments demonstrate their progress in attaining Five-Year goals and request the resources required for the next year to maintain that progress. In most cases, departmental current year (Permanent) budgets are the starting points for the next fiscal year’s budgets. UC Permanent Budget resources do not have expiration dates and are used to fund long-term commitments from the University. In addition to Permanent funds, departments can request Temporary funds from the Dean’s Office either during the budget proposal cycle or during the fiscal year for exceptional (one-time) expenses. The Dean’s Office evaluates annual departmental funding requests and submits a combined budget proposal from the College in late March to the EVC’s Office. After the final College budget is announced in June, any additional resources approved are allocated to the departments beginning the start of the fiscal year, July 1. Temporary funding requests approved during the fiscal year are allocated at the time of approval or are reimbursed to departments after expenses are incurred. Each department is responsible for monitoring its expenses and projected ending balances during the fiscal year.

All BCOE academic programs receive Permanent University funding for tenure track faculty, program staff, materials and supplies and travel. Table 32 summarizes Permanent University funding allocations to BCOE departments over the last five fiscal years.

Table 32. 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 33. (Note: FY 11/12 allocations for Instructional Equipment will be made at the end of the fiscal year).

Table 33. 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 |

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.

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 is listed below:

Bioengineering Student Instructional Laboratories

Both undergraduate laboratory courses are taught in the same room (MSE 154) approximately 1300 sq.ft. These courses are taught in alternate terms so that the equipment is changed for each course.

Bioinstrumentation Laboratory (BIEN 130L):

Lab Quest, Spirometer, O2 Sensors,
etc.

Pasco Stress Strain testers

Balance

Gel Columns

Ni ELVIS

Computers and monitors for Ni

ELVIS

BioPac MP36

Stress-strain Experiments

Lung Capacity Experiment

Biotechnology Laboratory (BIEN 155):

Gene Pulser Xcell System

Biomate 3 UV-Vis

Spectrophotometer

Pipettes

Electrophoresis

Combination biotech pH electrode

Eppendorf Mastercycler

UV/Vis/NIR Spectrophotometer

Undergrad Computer Facility

Micro Centrifuge

Balance 400-500g

Electrophoresis

Gene Pulser Xcell Main Unit

A separate room MSE of approximately 1000 sq. ft. is used for senior design projects.

C. Staffing

Below is a brief description of the adequacy of the staff (administrative, instructional, and technical) and institutional services provided to the program. Methods used to retain and train staff are also indicated.

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 reclassifications/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 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 employee's required and optional training is recorded in UCR's automated Learning Management System (LMS).

D. Faculty Hiring and Retention

Summary of Hiring Process

Each year, departments are asked to submit a faculty recruitment plan that is consistent with their strategic plan.

The recruitment plan is sent to the Dean for his review.

The Dean then outlines a collective recruitment plan for the College and requests ladder-rank faculty lines from the Provost.

The Provost makes an allocation of ladder-rank faculty lines to the College and the Dean determines the overall priorities for the College.

The Dean lets the departments know if they can begin a search for faculty members and, if so, how many.

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.

Those detailed plans are sent to the Dean, Provost, and Affirmative Action offices for approval.

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.

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.

An initial short-list is developed, and then further refined until a list of interviewees is developed.

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.

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 department and other potentially relevant faculty, and the dean.

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.

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.

Once a formal offer is signed and approved by the Chancellor, the candidate becomes a faculty member in the department.

Strategies Used to Retain Current Qualified Faculty

The primary strategy is to maintaining an atmosphere conducive to achieving excellence in all that we do. We strive to recognize excellent performance in teaching, research and service. We provide adequate 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 topics including. Health and Safety, Information Security, Leadership, and Effective Use of Advanced Technology in the Classroom. 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.

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 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.

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

Our curriculum meets all the ABET Program Criteria for Bioengineering. Some of the courses that directly contribute to the Program Criteria are shown in Table 34.

Table 34. How program meets ABET Program Criteria for Bioengineering

| | |
|---|--|
| The structure of the curriculum must provide both breadth and depth across the range of engineering topics implied by the title of the program. | CS 10 C++ Programming EE 1A Engineering Circuit Analysis and Lab BIEN 10 Overview Bioengineering BIEN 110 BioMechanics BIEN 120 Signals and Systems BIEN 135 Biophysics and Thermodynamics BIEN 159 Dynamics of Biological Systems |
| The program must prepare graduates to have: an understanding of biology and physiology | BIO 5A Cell and Molecular Biology and Lab BIO 5B Organismal Biology BIO 100 Elementary Biochemistry BIEN 115 Quantitative Physiology BIEN 125 Biotechnology |
| and the capability to apply advanced mathematics (including differential equations and statistics), | MATH 10A, B Multivariable Calculus MATH 46 Differential Equations STAT 155 Statistics for Engineers and Scientists |
| science, and | CHEM 1A,1B, 1C General Chemistry & Lab CHEM 112A, 112B, 112C Organic Chemistry PHYS 40A, 40B, 40C Physics (Mechanics, Heat, Waves, Sound, Electricity, Magnetism) |
| engineering to solve the problems at the interface of engineering and biology | BIEN 105 Circulation Physiology BIEN 115 Quantitative Physiology BIEN 120 Signals and Systems |
| the curriculum must prepare graduates with the ability to make measurements on and interpret data from living systems | BIEN 115 Quantitative Physiology BIEN 130 Bioinstrumentation BIEN 130L Bioinstrumentation Lab BIEN 155 Biotechnology Lab |
| addressing the problems associated with the interaction between living and non-living materials and systems | BIEN 130L Bioinstrumentation Lab BIEN 140 A Biomaterials BIEN 175 A,B Senior Design |

For the purposes of assessment and continuous improvement the Bioengineering Program Criteria as specified by ABET have been incorporated into the Student Outcomes as described in Criterion 3. In particular the specific elements for Bioengineering Program Criteria are shown below, and we illustrate some specific examples of student work that relate particularly to the Bioengineering program Criteria. Details of these examples will be available at the team visit.

Table 35. Specific elements of Bioengineering Program Criteria

| Department of Bioengineering definition of Student Outcomes (<i>Components relate to Bioengineering program Criteria (PC)</i>) | |
|---|--------------------------------|
| (a) an ability to apply knowledge of mathematics, science (<i>including biology and physiology (PCI)</i>), and engineering | Percent Students Meet Criteria |
| BIEN 115 Quantitative Physiology Midterm Exam 1. Glomerular filtration of a drug being cleared from plasma 2. Pharmacokinetics of ghrelin hormone | 70 |
| BIEN 130 Bioinstrumentation Final Exam 4. Determine a Fourier Transform | 76 |
| BIEN 135 Biophysics and Biothermodynamics Homework 4. Computational evaluations of lysozyme structure | 92 |
| (b) an ability to design and conduct experiments, <i>make measurements, analyze and interpret data from living systems addressing the problems associated with the interaction between living and non-living materials and systems. (PC3)</i> | |
| BIEN 115. Quantitative Physiology Quiz 1 Interpret pharmacokinetics of insulin distribution in plasma | 21 |
| BIEN 130 Bioinstrumentation - Quiz 7 Analyze data on blinking and breathing | 90 |
| BIEN 155 Biotechnology Laboratory – Lab report – Characterization of a protein by gel electrophoresis, imaging, spectroscopy, and FRET techniques. | 95 |
| (e) an ability to identify, formulate, and <i>apply advanced mathematics,(including differential equations and statistics) science, and engineering to solve problems at the interface of engineering and biology. (PC2)</i> | |
| BIEN 105 Circulation Physiology Design Challenge – A computational analysis of the corkscrew vessels as a result of Thromboangiitis Obliterans (Buerger’s Disease) | 80 |
| BIEN 115 Quantitative Physiology Quiz 4 – Using heat to destroy a tumor, determine temperature distribution | 42 |
| BIEN 120 Biosystems and Signal Analysis – Design Challenge – Thermoregulatory sweat response of the human body due to a change in environmental conditions. | 63 |
| BIEN 130 Bioinstrumentation – Homework 4 – Using statistical analyses to evaluate an instrument’s performance for the detection of cancer | 89 |

APPENDICES

Appendix A – Course Syllabi

Section I. Engineering Topics

BIOENGINEERING CURRICULUM COURSE OBJECTIVES AND SYLLABUS

1. BIEN 010 Overview of Bioengineering

2. 2 units, 1 hour lecture, 3 hours laboratory
Design: 1 unit

3. Professor Victor Rodgers

4. **Textbooks** Studying Engineering, 3rd Edition, Raymond B. Landis
Biomedical Engineering: Bridging Medicine and Technology, W. Mark Saltzman,
Cambridge University Press

Specific Course Information

5. **a. Catalog Description** Provides an overview of the various aspects of bioengineering. Illustrates the application of engineering principles for the design of the various aspects of bioengineering. Illustrates the various products and processes related to the health science industries. Covers diagnostic instruments, artificial organs, biotechnology, and cell and tissue

b. No prerequisites

c. Required

6. Course Goals - Student Outcomes d, f, g, i, j

Specific outcomes. The student will

- i. be able to better prepare yourself for studying the engineering curriculum.
- ii. have developed an introductory ability to utilize basic practical and mathematical tools, an ability to logically think through basic problems from conception to design, and be familiar with the relative significance of your results.
- iii. have had opportunities to further your professional development through practicing written and oral communication skills, working on group assignments, and using modern computer tools.
- iv. demonstrate confidence in assessing and developing basic mathematical/computational models of basic bioengineering problems.
- v. will demonstrate professional accountability for your effort.

7. Syllabus

Assessment of Self, Building Foundation and Creative Expression

Schedule

Part 1:

L: Chapter 1: Keys to Success in Bioengineering Study

Self actualization

Challenge: *Who am I in here with?*

S: Chapter 1: Challenge: *What do Bioengineers do?*

Group Signature Project 1: *Yeah, Bioengineers do this!*

Part 2:

L: Chapter 2: The Engineering Profession
S: Chapter 1-9: Relating Science to Bioengineering
Challenge: *Applying Concepts to Bioengineering*
What do Biomedical and Bioengineers do?
Group Signature Project 2: *This Science is Needed for This!*

Part 3:

L: Chapter 3: The Teaching/Learning Process
Learning about the Learning Center and How it Helps YOU
S: Chapter 10-16: Biomedical Engineering
Challenge: *Designing an Artificial Organ*
Group Signature Project 3: *Significance of Math in Artificial Organ Design*

Part 4:

L: Chapter 4: Making The Most of How You are Taught
Effective Use of Your Professors: Are you helping yourself?
S: Chapter 10-16: Biomedical Engineering
Challenge: *Designing an Artificial Organ*
Group Signature Project 3: *Significance of Math in Artificial Organ Design*

Part 5:

Profession Engineering Ethics in Bioengineering Design
Challenge: *Designing an Artificial Organ*
Group Signature Project 4: *Ethical Issues in Your Artificial Organ Design*

Part 6:

L: Chapter 5: Making the Learning Process Work for You
S: Chapter 10-16: Biomedical Engineering
Challenge: *Analysis in Bioengineering*
Group Signature Project 5: Depth in a Biomedical Engineering
Rapid Learning: Excel and its Application to Bioengineering

Part 7:

L: Chapter 6: Personal Growth and Development
S: Chapter 10-16: Biomedical Engineering
Challenge: *Analysis in Bioengineering*
Group Signature Project 6: Depth in a Biomedical Engineering
Learning to Learn: Fun with Matlab (Part One)

Part 8:

L: Chapter 7: Broadening YOUR Education
Introduction to BMES
Challenge: *Analysis in Bioengineering*
Group Signature Project 7: Depth in a Biomedical Engineering
Learning to Learn: Fun with Matlab (Part Two)

Part 9:

L: Chapter 8: Orientation to Engineering Education

Challenge: *Analysis in Bioengineering C*

Group Signature Project 7: Depth in a Biomedical Engineering

Learning to Learn: Fun with Matlab (Part Three)

1. BIEN 105 Circulation Physiology

2. 4 units, 3 hours lecture, 1 hour discussion
Design: 2 units

3. Professor Victor Rodgers

4. **Textbook** Transport Phenomena in Biological Systems, George A. Truskey, Fan Yuan, David F. Katz, Prentice Hall (January 2, 2009), 2nd Edition

5. **a. Catalog Description** Introduces tensor and vector mathematics that describe the conservation of momentum and mass transport in biological sciences, the cardiovascular system, and pulmonary system. Includes constitutive equations such as the Navier-Stokes and Casson models, significance of fluid stress in biological vessels, and the physiological relevance of fundamental parameters. Emphasizes the relation between function and system behavior.

b. Prerequisite(s): BIOL 005B, MATH 046, PHYS 040A.

c. Required

6. Course Goals - Student Outcomes a, d, e, g, k Specific outcomes.

- i. You will be able to understand the basic governing momentum conservation equations and associated basic constitutive equations for describing biofluid processes.
- ii. You will be able to apply these governing equations to real biological systems and describe these systems mathematically, develop strategies to analyze the biofluid problem, recognize particular behavior of real processes, and recognize limitations in approximating the process.
- iii. You will have developed an ability to utilize practical and mathematical tools, an ability to logically think through biomechanical problems from conception to design, and be familiar with the relative significance of your results.
- iv. You will have had opportunities to further your professional development through practicing written and oral communication skills, working on group assignments, and using modern computer tools.
- v. You will demonstrate confidence in assessing and developing basic mathematical/computational models of biomechanical problems.
- vi. AND, you will demonstrate professional accountability for your engineering design analysis.

7. Syllabus

Introduction

Conservation, Control Schemes: Feedback, Feedforward & Inferential

Process Dynamics

Mathematical Modeling

Linear Systems and Linearization

Static Analysis of Physiological Systems

Process Control

Analysis of Transient Linear Control Systems
Frequency-Domain Analysis of Linear Control Systems
Stability Analysis
Identification of Physiological Control Systems
Optimization in Physiological Control

1. BIEN 110 Biomechanics of the Human Body

2. 4 units, 3 hours lecture. 1 hour discussion

3. Professor Bahman Anvari

4. Textbook (Suggested Reading)

Biomechanics-Mechanical Properties of Living Tissues (Fung)

Introductory Biomechanics (Ethier and Simmons)

5. a. Catalog Description. Introduces the motion, structure and function of the musculoskeletal system, the cardiovascular system, and the pulmonary system. Topics include applied statics, kinematics, and dynamics of these systems and the mechanics of various tissues (ligament, bone, heart, blood vessels, lung). Emphasis is on the relation between function and material properties of these tissues.

b. Prerequisite(s): CHEM 001C or CHEM01HC, MATH010A, PHYS 040B.

c. Required

6. Course Goals - Student Outcomes a, b, c, e, k

Specific outcomes. The student will

- i. develop an understanding of fundamental biomechanical properties of hard and soft tissues, and cells;
- ii. acquire analytical skills and physiological understanding in a unified way to develop mechanical models of biological systems; and
- iii. develop written and oral communication skills through a report and presentation of a project related to hard or soft tissue, or cellular biomechanics.

7. Syllabus

| | |
|----------|---|
| Jan 7 | Stress, Strain |
| Jan 12 | Mechanical Properties |
| Jan 14 | Elastic Solids |
| Jan 19 | “ |
| Jan 21 | Viscoelasticity |
| Jan 26 | Maxwell, Voight, & Kelvin Bodies |
| Jan 28 | “ |
| Feb 2 | Bone & Cartilage Mechanics |
| Feb 4 | Muscle Mechanics |
| Feb 9 | Proposal Presentations |
| Feb 11 | Proposal Presentations |
| Feb 16 | Proposal Presentations, Written Proposals Due |
| Feb 18 | Cell Mechanics & Measurement Methods |
| Feb 25 | Membrane Mechanics |
| March 4 | Project Presentations |
| March 9 | Project Presentations |
| March 11 | Project Presentations |

1. BIEN 115 Quantitative Physiology

2. 4 units, 3 hours lecture, 1 hour discussion

3. Professor Bahman Anvari

4. Textbook (Suggested Reading)

Vander's Human Physiology, The Mechanism of Body Function (Widmaier, Raff, Strang)
Basic Transport Phenomena in Biomedical Engineering (Fournier)

5. a. Catalog Description. Analyzes engineering aspects of physiological systems and artificial organs. Covers the nervous system, muscular system, cardiovascular system, respiratory system, and renal system. Addresses ethical and professional considerations in the development and utilization of medical devices and interventions.

b. Prerequisite(s): BIEN 110, enrollment priority is given to Bioengineering majors; consent of instructor is required for nonmajors.

c. Required

6. Course Goals - Student Outcomes a, b, e, j, k

Specific outcomes. The student will

- i. Understand some of the theories that underlie the analysis of physiological systems;
- ii. Acquire analytical skills and physiological understanding in a unified way to develop quantitative models and computational tools for engineering analysis of a given physiological system; and
- iii. Develop written and oral communication skills through a report and presentation of a final project related to engineering analysis of a physiological system.

7. Syllabus

| | |
|---------|--|
| Week 1 | Mathematical modeling of physiological systems, Compartmental (lumped parameter) modeling |
| Week 2 | Distributed parameter modeling, rate laws and flux |
| Week 3 | Diffusion processes |
| Week 4 | Midterm, Chemical and electrochemical potentials |
| Week 5 | Membrane physiology |
| Week 6 | Ion permeation |
| Week 7 | Action potentials |
| Week 8 | Circulatory system modeling, compliance and impedance analysis |
| Week 9 | Respiratory Analysis |
| Week 10 | Project presentations |

1. BIEN 120 Biosystems and Signals

2. 4 units, 3 hours lecture, 1 hour discussion

3. Professor Kaustabh Ghosh

4. Textbook Process Control. A First Course with MATLAB, P. C. Chau, Cambridge University Press

5. a. Catalog Description. Provides basic knowledge for the quantitative analysis of the dynamic behavior of biological systems. Particular applications include neural systems, control of metabolic and hormonal systems, and design of instruments for monitoring and controlling biological systems. Topics include system theory, signal properties, control theory, and transfer functions.

b. Prerequisite(s): BIOL 005B, CS 010, MATH 046, PHYS 040C.

c. Required

6. Course Goals - Student Outcomes c, d, e, g, k

Specific outcomes. So, by the end of this course, you will strengthen your skill level so that:

- i. You will be able to understand time-dependent differential equations, the relationship between differential equations and real operations, single input/output systems and multiple input/multiple output systems.
- ii. You will be able to mathematically model time-dependent real processes, recognize particular behavior of real processes, analyze a real or modeled process behavior for identification, and design a control schemes to model these bioprocesses.
- iii. You will have had opportunities to further your professional development through practicing written and oral communication skills, working on group assignments, and using modern computer tools.
- iv. You will demonstrate confidence in assessing and developing basic feedback control strategies to SISO systems.
- v. AND, you will demonstrate professional accountability for your dynamic modeling and control strategy recommendations.

7. Syllabus

Introduction

Conservation, Control Schemes: Feedback, Feed-forward & Inferential

Process Dynamics

Mathematical Modeling

Linear Systems and Linearization

Static Analysis of Physiological Systems

Process Control

Analysis of Transient Linear Control Systems
Frequency-Domain Analysis of Linear Control Systems
Stability Analysis
Identification of Physiological Control Systems
Optimization in Physiological Control

1. BIEN125 Biotechnology and Molecular Bioengineering

2. 4 units, 3 hours lecture, 1 hour discussion

Design: 1 unit

3. Professor Jiayu Liao

4. Textbook (Suggested Reading)

Walsh G.: Proteins Biochemistry and Biotechnology. John Wiley & Sons, Inc., 2002

Nielsen J., Villadsen J., and Liden G.: Bioreaction Engineering Principles. Kluwer 2003

5. a. Catalog Description. Provides an overview of biochemical processes in cells and their use in developing new products and processes. Presents cellular processes such as metabolism, protein synthesis, enzyme behavior, and cell signaling and control from an engineering viewpoint of modeling and control.

b. Prerequisite(s): BCH 100.

c. Required

6. Course Goals - Student Outcomes a, c, h, i, j, k

Specific outcomes. The student will know

- i. the scope of biotechnology and molecular engineering in biotechnology industry
- ii. the process and regulations of biotechnology industry
- iii. the cellular processes and derived biotechnology/biopharmaceutical products
- iv. the mathematic models of enzymatic reaction and cell growth
- v. how to produce biotechnology products and perform quality control through different cellular processes from different organisms
- vi. different biotechnology and biopharmaceutical products and their basic molecular and physiological mechanisms
- vii. fermentation process and bioreactor, and mathematic control
- viii. protein engineering approaches and most recent concept and technology developments
- ix. basic scientific and technique trainings for searching for biotechnology industrial jobs

7. Syllabus

- | | |
|----------|--|
| Week 1. | Introduction of cellular functions to industry products; Protein structure and sources; |
| Week 2. | Enzyme kinetics/bioprocess kinetics; |
| Week 3. | Cell growth and kinetics; |
| Week 4. | Fermentation process and control; |
| Week 5. | Large-scale protein purification and characterization; |
| Week 6. | Midterm: 2/9/2010Therapeutical proteins (I): Hormones and cytokines; |
| Week 7. | Therapeutical proteins (II): Antibody therapy and vaccine; |
| Week 8. | Industrial enzymes and enzyme immobilization; |
| Week 9. | Protein engineering (I): DNA Recombination and shuffling technology; |
| Week 10. | Protein engineering (II): Protein post-translational modifications and unnatural amino acid engineering; |

1. BIEN 130 Bioinstrumentation

2. 4 units, 3 hours lecture, 1 hour discussion

Design: 1 unit

3. Professor Hyle Park

4. Textbook Bioinstrumentation, John G. Webster (Editor), John Wiley (2003)

5. a. Catalog Description. Introduces basic components of instruments for biological applications. Explores sources of signals and physical principles governing the design and operation of instrumentation systems used in medicine and physiological research. Topics include data acquisition and characterization; signal-to-noise concepts and safety analysis; and interaction of instrument and environment.

b. Prerequisite(s): BIEN 120; concurrent enrollment in BIEN 130L.

c. Required

6. Course Goals - Student Outcomes a, b, c, e, k

Specific outcomes. The student will

- i. be able to select and configure basic electronic circuits (e.g., voltage dividers, filters, and amplifiers) used in bioinstrumentation
- ii. gain familiarity with the function and operating principle of modern bioinstrumentation
- iii. be able to use and analyze data from a bioinstrument appropriately chosen in response to a given bioengineering task
- iv. be able to schematically design a method or device within set constraints, including ethical and safety concerns, in response to a bioengineering challenge
- v. gain familiarity with the origin and analysis of physiologic signals

7. Syllabus

Week 01: Basic circuits / Filters and op-amps

Week 02: Biopotentials / Non-electronic bioinstrumentation

Week 03: Fourier transforms I / Signal-to-noise I

Week 04: Statistics I / Midterm review

Week 05: Statistics II / Fourier transforms II

Week 06: Signal-to-noise II / Electrical safety

Week 07: Sensor mechanisms (physical)

Week 08: Sensor mechanisms (chemical/biological)

Week 09: Bioinstrumentation design

Week 10: Survey of modern bioinstrumentation

1. BIEN 130L Bioinstrumentation Laboratory

2. 2 units, 3 hours laboratory, 1 hour discussion

Design: 1 unit

3. Professor Professor Huinan Liu

4. Textbook - Notes

5. a. Catalog Description. Laboratory experience with instrumental methods of measuring biological systems. Introduces various sensors and transducers to measure physical, chemical, and biological properties. Covers reliability, dynamic behavior, and data analysis.

b. Prerequisite(s): concurrent enrollment in BIEN 130.

c. Required

6. Course Goals - Student Outcomes a, b, c, d, g, k

Specific outcomes. The student will

- i. gain an understanding of some of the fundamental physical principles that underlie the operation of specific types of biosensors
- ii. acquire skills to build instrumentations for making physiological measurements, and understand the concepts of noise filtering and signal amplification
- iii. develop an ability to utilize commercially available instrumentation coupled with computer-based techniques to make biologically relevant measurements
- iv. gain data analysis skills
- v. develop written communication skills

7. Syllabus

Week 01: Introduction to ELVIS prototyping system

Week 02: DC circuit analysis

Week 03: AC circuit analysis (filters and amplifiers)

Week 04: Electrocardiogram measurements

Week 05: LabView analysis

Week 06: Circuit test

Week 07: Frequency analysis and signal conditioning

Weeks 08, 09, 10: rotations between

Biomechanical measurements

Respiratory analysis

Ultrasound measurements

Optical methods for hemoglobin characterization

1. BIEN 135 Biophysics and Biothermodynamics

2. 4 units, 3 hours lecture, 1 hour discussion

Design: 1 unit

3. Professor Dimitrios Morikis

4. **Textbook:** K. E. van Holde, W. C. Johnson, P. S. Ho (2006) Principles of physical biochemistry, 2nd Edition, Prentice Hall Inc

5. **a. Catalog Description.** An introduction to the application of thermodynamic principles to understanding the behavior of biological systems. Discusses biophysical properties of biomacromolecules, such as proteins, polynucleotides, carbohydrates, and lipids, and methods of characterizing their properties and interactions.

b. Prerequisite(s): BCH 100, MATH 010B, MATH 046, PHYS 040C.

c. Required

6. **Course Goals - Student Outcomes a, e, k**

Specific outcomes. The student will;

- i. Obtain fundamental knowledge on biological complexity by focusing on biomolecular structure, dynamics, interactions, and the formation of supramolecular assemblies.
- ii. Obtain fundamental knowledge of molecular and statistical thermodynamic principles applied on biological systems, including thermodynamics and equilibria of biomolecules in solution, thermodynamics of transport processes, and thermodynamics of biomolecular interactions.
- iii. Survey biophysical methods for biomolecular separation and characterization; obtain quantitative knowledge of the underlying physics for various spectroscopies, scattering methods, microscopies, calorimetry, surface plasmon resonance, sedimentation, electrophoresis, mass spectrometry, single molecule methods.
- iv. Obtain an overview of biocomputational methods and their applications in modeling of biomolecular systems. Obtain detailed understanding of force field-based molecular dynamics simulations and Poisson-Boltzmann electrostatic calculations.
- v. Appreciate the role of biocomputation in modeling biological complexity: solve small research problems related to calculation of free energies for protein folding and stability and protein-protein interactions.
- vi. Appreciate the role of computational modeling in the design of proteins and peptides with tailored physicochemical properties. Perform hands-on computational analysis of proteins.
- vii. Design protein mutants with altered physicochemical properties. Validate the computational design using experimental data from the literature.
- viii. Appreciate the role of biocomputation in rational drug design.
- ix. Develop skills in critically reading a research paper and digesting its main findings into a technical report.

7. Syllabus

Week 1. Biological macromolecules: building blocks, structure, interactions with solvent, complex formation, symmetry relations, cell.

- Week 2. Thermodynamic principles: heat, work, energy, enthalpy, 1st law of thermodynamics, entropy, 2nd law of thermodynamics, free energy.
- Week 3. Molecular thermodynamics: complexities of biomolecules, molecular mechanics, intra- and inter-molecular forces, energy functions, bonded & non-bonded interactions (covalent geometry, van der Waals, electrostatic, dipole-dipole), stabilizing interactions, biomolecular simulation.
- Week 4. Statistical thermodynamics: statistical weights and partition function, structural transitions (with applications, e.g., helix-coil, folding-unfolding, DNA transitions), prediction of secondary structure, random walk.
- Week 5. Thermodynamics and equilibria of biomolecules in solution: chemical potential, ideal & non-ideal solutions, applications of chemical potential to physical equilibria (membrane, sedimentation, steady state electrophoresis). Thermodynamics of transport processes: diffusion, transport across membranes.
- Week 6. Thermodynamics of biomolecular interactions: biomolecular reactions, protein-protein and protein ligand interactions, proton binding and titration curves, catalysis, aggregation, nucleic acid binding.
Overview of biocomputation methods.
- Week 7. Separation & characterization of biomolecules: hydrodynamics, sedimentation methods, electrophoresis.
- Week 8. Mass spectrometry.
Calorimetry: differential scanning and isothermal titration.
Surface plasmon resonance.
Spectroscopy: quantum mechanical principles, absorption (electronic, vibrational), linear & circular dichroism, emission (fluorescence), EPR.
- Week 9. Scattering: static & dynamic light scattering, Rayleigh, Raman, low angle X-ray, neutron, X-ray diffraction (emphasizing 3D structure determination).
Overview of microscopy (light and electron).
Overview of single molecule methods.
- Week 10. NMR spectroscopy (emphasizing 3D structure determination & dynamics).

1. BIEN 136 Tissue Engineering – New course not taught yet

2.

3. Professor Huinan Liu

4. Textbook

5. a. Catalog Description Covers progress in cellular and molecular biology, and engineering, to provide the basis for advancing tissue repair and regeneration with the goal of restoring compromised tissue functions. Presents methods for cell culture, tissue design and development, manipulation of the cell/tissue microenvironment, and current strategies for functional reconstruction of injured tissues

b. Prerequisite(s):

c, Elective

6. Course Goals

a. Specific outcomes.

7. Syllabus

1. BIEN 140A Biomaterials

2. 4 units, 3 hours lecture, 1 hour discussion

Design: 1 unit

3. Professor Julia Lyubovitsky

4. Textbook

5. a. Catalog Description Covers the principles of materials science and engineering, with attention to topics in bioengineering. Explores atomic structures, hard treatment, fundamentals of corrosion, manufacturing processes, and characterization of materials.

b. Prerequisite(s): BCH 100, CHEM 112C, MATH 010B, PHYS 040B.

c. Required

6. Course Goals - Student Outcomes a, b, e, f, i, j

Specific outcomes.

i. Students will be able to understand interdisciplinary issues involved in biomaterials design, synthesis, evaluation and analysis, so that they may pursue higher-level, more focused graduate courses in biomaterials, address research problems, or pursue a job opportunities in the medical-device and tissue engineering industries.

ii. Students will understand the use of applied science and mathematics (e.g., physics, chemistry, biology and statistics) for materials engineering.

Students will learn the basic classes of biomaterials and their characteristics.

iii. Students will learn the basic bulk and surface properties required for biomaterials with various applications.

iv. Students will learn about the basic techniques for characterization of the mechanical, chemical, optical, and biological properties of biomaterials.

v. Students will learn the basic interactions between biomaterials and biological environment

vi. Students will gain familiarity with the biomaterials research literature

vii. Students will gain understanding about the ethical issues related to the biomaterials research and development

viii. Students will gain training in communication of scientific and engineering ideas via presentations and discussions

7. Syllabus

Lecture Topics:

Week 1: Introduction and Mechanical Properties of Materials

Week 2: Optical Properties of Materials

Week 3: Surface Properties of Materials and Surface Characterization

Week 4: Types of Biomaterials: Metals

Week 5: Polymers and Biodegradable Polymers

Week 6: Siloxanes, Fibers and Hydrogels

Week 7: Ceramics and Glasses (Artificial Hip Joints)

Week 8: Composites and Carbon Materials

Week 9: Response of Biological Systems to Foreign Objects

Week 10: Response to Foreign Objects and Testing for Biocompatibility. Animal Models

Discussion Topics:

Week 1: Introduction

Week 2: Biocompatible Interfaces

Week 3: Engineering of Artificial Organs

Week 4: Nanomaterials for Biological Imaging

Week 5: Materials for Dentistry

Week 6: Implants and Biocompatibility

Week 7: Immune Response to Biomaterials

Week 8: Poly(dimethylsiloxane) and Microfluidics

Week 9: FDA Approval and Animal Models

Week 10: Review and Summary

1. BIEN 140B Biomaterials

2. 4 units, 3 hours lecture, 1 hour discussion

Design: 1 unit

3. Professor Val Vullev

4. Textbook

5. a. Catalog Description. Covers the structure-property relations of metals, ceramics, polymers, and composites, as well as hard and soft tissues such as bone, teeth, cartilage, ligament, skin, muscle, and vasculature. Focuses on behavior of materials in the physiological environment.

b. Prerequisite(s): BIEN 140A/CEE 140A.

c. Elective

6. Course Goals

Specific outcomes. The student will;

i. demonstrate familiarity with the advantages and disadvantages of different types of biological and synthetic (organic and inorganic) materials, based on materials properties and on the physiological responses they may trigger

ii. demonstrate familiarity of physiological responses toward foreign objects composed of various materials

iii. demonstrate familiarity with different types of in vitro and in vivo testing of biomaterials and of types of model animals that are the most appropriate for different types of materials applications

iv. develop the ability to do literature search (using different data bases, such as SciFinder), to find peer-reviewed journal publications on biomaterials-related topics, and familiarize themselves on these topics from the published work

v. demonstrate the ability to recognize the values, the strengths and the weaknesses of each publication they read

7. Syllabus

Week 1: Overview of different types of materials and characterization of materials

Week 2: Overview of optical characterization of biomaterials and bioimaging

Week 3: Protein and cell adhesion; Protein and cellular mechanics

Week 4: Overview of ECM and tissues

Week 5: Project progress discussion

Week 6: Overview of cells, cell injury, and cell mechanics

Week 7: Host response to biomaterials: degradation, corrosion and calcification

Week 8: Overview of blood response to materials and devices: in vitro and in vivo testing

Week 9: Blood materials interactions: biocompatible interfaces

Week 10: Standards, regulations and ethical aspects of biomaterials research and development

1. BIEN 155 Bioengineering Laboratory

2. 2 units, 3 hours laboratory, 1 hour discussion

Design: 1 unit

3. Professor Jiayu Liao

4. Textbook (Suggested Readings)

Sambrook J and Russell D, Molecular Cloning: A Laboratory Manual. CHSL Press, 2001

Walsh G.: Proteins Biochemistry and Biotechnology. John Wiley & Sons, Inc., 2002

5. a. **Catalog Description.** Laboratory experience in cell culture, bioreactors, optical techniques, array techniques, and separation and purification methods.

b. **Prerequisite(s):** BCH 100, PHYS 040C.

c. **Required**

6. Course Goals - Student Outcomes b, e, g, k

Specific outcomes. The student will understand

- i. plan, execution, quality control and summarize of the process to make biotechnology product
- ii. experimental techniques to produce biotechnology and biopharmaceutical product
- iii. experimental optical techniques for fluorescence measurements.
- iv. informatics tools for biotechnology
- v. protein engineering techniques and quality/quantity control
- vi. the project management skills and critical analysis of experimental results
- vii. scientific writing skills
- viii. scientific presentation skills and technique skills in searching for biotechnology jobs

7. Syllabus

Recombinant Fluorescence Protein Production and FRET Assay

Week 1. Trasfect pET 28(b)-CyPet-SUMO1 and pET 28(b)-Ypet-Ubc9, respectively, into DH5a by eletroporation.

TA Discussions: Molecular cloning;

Week 2. Purify plasmid DNA from bacterial cells by mini-prep, validate the genes by restriction enzyme digestion, and submit for sequencing.

TA Discussions: DNA sequencing and NCBI Bioinformatics Softwares;

Week 3. Verify and compare the sequencing result of clones with sequences from NCBI database.

TA Discussions: Protein expression systems in bacterial in general.

Week4. (Report due)Trasfect pET 28(b)-CyPet-SUMO1 and pET 28(b)-Ypet-Ubc9, respectively,into protein expression bacterial strain BI21(DE3).

TA Discussion: His-tagged or other tagged protein purification.

- Week5. CyPet-SUMO1 and Ypet-Ubc9 protein expression.
TA Discussions: Quantitative protein and gel electrophoresis.
- Week 6. CyPet-SUMO1 and Ypet-Ubc9 protein purification. Fermentor demonstration.
TA Discussions: Fluorescence and Detections.
- Week7. (Report due) Protein concentration measurements and gel electrophoresis/Coomassie staining.
TA Discussions: Protein purity checking methods.
- Week8. Fluorescence protein identification by imaging and spectroscopy.
TA Discussions: Fluorescence Energy Transfer.
- Week 9. Fluorescence Energy Transfer Assay.
TA Discussions: Presentation of research results.
- Week10. (Report due) Presentations.
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1. BIEN 159 Dynamics of Biological Systems

2. 4 units, 3 hour lecture, 1 hour discussion

Design: 1 unit

3. Professor Jerome Schultz

4. Textbook Basic Transport Phenomena in Biomedical Engineering, Ronald Fournier, CRC Press (2012)

5. a. Catalog Description. Covers engineering principles for the analysis and modeling of biological phenomena. Topics include molecular diffusion and transport, membranes, ligand-bioreceptor interactions, enzyme kinetics, and dynamics of metabolic pathways. Examines the application of these principles to the design of bioreactors, bioassays, drug delivery systems, and artificial organs.

b. Prerequisite(s): BCH 100 or BCH 110A.

c. Required

6. Course Goals - Student Outcomes b, e, g, h

Specific outcomes. The student will understand

- i. the concepts of the fundamental nature of the spontaneous processes and basic thermodynamics so that they will be able to pursue higher-level experimental bioengineering research and biosensor product development.
- ii. the general features of dynamic processes used in both research and commercial products.
- iii. the relationship between dynamic and thermodynamic processes.
and to discuss advanced topics related to dynamic processes in biological systems as applied to design of bioreactors, bioassays, drug delivery systems and tissue engineering.
- iv. diffusion equation and its application to various bio-transport processes.
- v. the role of energy, its production (loss) within biological systems
- vi. written and oral communication skills

7. Syllabus

1. Overview of Thermodynamic Concepts
2. Physical Properties of Body Fluids, Cell Membrane, Solute Transport
3. Oxygen Transport in Biological Systems
4. Dynamics of Tissues and artificial tissues
5. Ligand-Receptor Interactions
6. Dynamics of Metabolic Pathways
7. Enzyme Kinetics and Conformational Dynamics

1. BIEN 160 Biomedical Imaging

2. 4 units, 3 hours lecture, 1 hour discussion

3. Professor Julia Lyubovitsky

4. Textbook

5. a. Catalog Description An introduction to the fundamental physics and engineering principles for medical imaging systems. Covers Xray, ultrasound, radionuclide, magnetic resonance imaging, positron emission tomography, optical coherent tomography, and other optical methods. Includes image formation and reconstruction, image characteristics, and quality and image processing.

b. Prerequisite(s): BIEN 120.

c. Elective

6. Course Goals

Specific outcomes. The student will understand

- i. the fundamental physics and engineering principles for biological and medical imaging systems.
- ii. optical imaging systems, X-ray, radionuclide and MRI imaging systems.
- iii. the basics of light-matter interactions, image formation, image reconstruction, image characteristics, image quality and image processing.
- iv. the scope of current biomedical imaging applications and approaches in research, technology development and therapy.

7. Syllabus

1. Radiation and interactions with matter
2. Optics and Optical Imaging
3. Image Analysis and Processing
4. Radiography
5. Radionuclide imaging
6. Magnetic resonance imaging
7. Imaging Applications in Therapy
8. Other methods

1. BIEN 165 Biomolecular Engineering

2. 4 units, 3 hours lecture, 1 hour discussion

3. Professor Dimitrios Morikis

4. **Textbook:** *Protein Structure and Function* (2004) by G. Petsko and D. Ringe, Sinauer/New Science Press, London, UK.

Manuals and tutorials for Swiss-PDBViewer, Chimera, VMD, NAMD, APBS, DOCK

5. a. Catalog Description. Emphasizes engineering, biochemical, and biophysical concepts and technologies intrinsic to specific topics of biomolecular engineering. Introduces the history of genetic and protein engineering. Topics include biological thermodynamics, molecular kinetics, biochemical and biophysical approaches, protein engineering, high-throughput screening technologies, and protein engineering with unnatural amino acids.

b. Prerequisite(s): BIEN 120.

c. Elective

6. Course Objectives Student Outcomes a, e, k

- i Obtain fundamental knowledge on relations between protein sequence and structure.
- ii Obtain fundamental knowledge on protein architecture.
- iii Obtain fundamental knowledge on protein structure-dynamics-interactions-relations.
- iv Obtain fundamental knowledge on enzymatic catalysis.
- v Obtain fundamental knowledge on protein regulation.
- vi Survey experimental methods for structure determination. Survey experimental methods for protein-protein interactions.
- vii Obtain fundamental knowledge on protein design. Obtain knowledge on structural and functional genomics efforts.
- viii Obtain detailed understanding of modern drug discovery process, using computational and experimental tools. Obtain good understanding of the drug pipeline, including in silico, in vitro, in vivo, ex vivo, pre-clinical trial preparations, formulations for storage and delivery, clinical trials, and delivery to clinic.
- iv Develop expertise in using computational tools to critically analyze: (a) protein sequences; (b) protein structures; (c) protein complexes; (d) protein dynamics; and (e) protein-ligand interactions.

7. Syllabus

Week 1.

- From sequence to structure. Biomolecular building blocks. Physicochemical origins of protein stability. Membrane proteins.
- Hands-on sequence alignments.
- Project 1: Explore web resources and servers for protein sequence and structure. Identify tools for sequence alignments and structure classifications.

Week 2.

- Protein architecture. Motifs, domains, modules, and repeats. Protein complexes and supramolecular assemblies. Protein dynamics.
- Hands-on homology modeling.
- Project 2: Perform sequence alignment of an evolutionary related protein family. Prepare a phylogenetic tree. Perform homology modeling for an unknown structure using as a template an experimentally determined structure of a homologous protein.

Week 3.

- From structure to function. Recognition and binding. Properties of binding sites. Enzymatic catalysis. Multi-step reactions and multi-functional enzymes.
- Hands-on analysis of protein structure and function.

Week 4.

- Regulation of protein function. Control by pH and redox environment. Cooperativity and allostery. Regulation by conformational switching. Regulation by degradation, signaling, proteolysis, and post-translational modifications.
- Invited lecture 1: Time-resolved fluorescence anisotropy and the measurement of protein conformational flexibility.
- Project 3: Analyze the physicochemical and geometric properties of protein-protein interaction interfaces. Perform comparative analysis for different interfaces. Discuss the origins of protein-protein association.

Week 5.

- From sequence to function. Evolutionary conservation. Protein profiling, threading, and Rosetta methods. Divergent and convergent evolution. Case studies in structural and functional genomics.
- Hands-on protein interactions using electrostatics and free energy calculations.

Week 6.

- Overview of experimental methods for structure determination. X-ray diffraction, NMR spectroscopy, and low-resolution optical methods. Overview of experimental methods for protein-protein interactions.
- Invited lecture 2: G-protein coupled receptors. Protease activated receptor-2 and beta-arrestins: a proinflammatory signal in the airway?
- Project 4: Calculate electrostatic potentials for protein-protein interactions. Perform critical mutations that are important for the integrity of the association interface. Use thermodynamic cycles to calculate electrostatic free energies of association for the parent and mutant proteins. Discuss the driving forces of protein-protein interactions.

Week 7.

- Midterm exam.
- Invited lecture 3: High-throughput screening.

Week 8.

- Protein design methods. Overview of computational methods used in CASP and CAPRI competitions.
- Hands-on molecular dynamics simulations and biomolecular function.
- Final Project: Perform molecular dynamics simulations for a parent and an engineered gain-of-function mutant protein. Analyze the molecular dynamics trajectories in view of structural, dynamic, and physicochemical differences between the parent and mutant proteins. Explain the origin of gain of function.

Week 9.

- Rational drug design methods-1. (L)ADME(T). Lipinski's rules. Clinical trials. Drug targets and modes of action. Drug properties, affinity and selectivity. From lead compound to drug: optimization of structural and physicochemical properties. Networks of protein-protein, protein-drug, and drug-drug interactions.
- Invited lecture 4: Contribution of specific amino acid changes in penicillin binding protein-1 to amoxicillin resistance in clinical *Helicobacter pylori*
- Hands-on protein docking.

Week 10.

- Rational drug design methods-2. Pharmacophores. Clustering methods. Bioisosters. QSAR methods.
- Case study: Design and optimization of compstatin family peptides and peptidomimetics – the case of a complement system inhibitor in clinical trials for age-related macular degeneration.

Week 11.

- Final project due.
-

1. BIEN 166 Bioinspired Engineering for Sustainable Energy- New course

2. 4 units, 3 hours lecture, 1 hour discussion

3. Professor Valentine Vullev

4. Textbooks: Biochemistry, 6th edition, by J. M. Berg, J. L. Tymoczko, and L. Stryer, "Molecular Fluorescence" by B. Valeur, and "Principles of Fluorescence Spectroscopy," 3rd edition, by J. R. Lakowicz

5. a. Catalog Description. Introduces the use of concepts from basic biological sciences (including biochemistry and biophysics) for applied energy engineering. Covers biological energy conversion (including photosynthesis) and its implication for sustainable energy technologies. Discusses recent advances in biomimetic and bioinspired energy.

b. Prerequisite(s): BIEN 120.

c. Elective

6. Course Objectives

Objectives of the course:

- i. To teach students the fundamentals of energy conversion and energy storage.
- ii. To provide the students with quantitative understanding of the world energy consumption and energy production trends.
- iii. To teach students how the principals of natural photosynthesis provide the means for advancing the sustainable-energy technologies.
- iv. To teach students the experimental techniques used for studying and for characterization of the photoinduced energy and charge transduction processes.
- v. To make students appreciate the current challenges in sustainable energy, such as energy storage, photocatalytic water splitting, and carbon-dioxide fixation.
- vi. To demonstrate to students key features of living systems that are still unexplored in engineering, such as self-replacement and damage management.
- vii. To provide some training in critical thinking and analysis

7. Syllabus

Week 1

Present and projected energy-production and energy-consumption rates

Comparison between energy sources and their potential for sustainability

Carbon-neutral energy sources, such as nuclear, wind, hydro, geothermal and solar

How solar energy has sustained life on Earth, and why solar is the path toward sustainability?

Reading:

- Reports from the US National Commission on Energy Policy.
- Lewis, N. S., "Toward Cost-Effective Solar Energy Use," Science, 2007, 315, 798-801.
- Barnham, K. W. J.; Mazzer, M.; Clive, B. "Resolving the Energy Crisis: Nuclear or Photovoltaics?", Nature Materials, 2006, 5, 161-164.
- Gray, H. B., "Powering the Planet with Solar Fuel," Nature Chemistry, 2009, 1, 7.

Week 2:

Light-matter interaction

Energy harvesting, and energy transduction

Photoinduced charge transfer, transition-state theory, and electron-transfer pathways

Reading:

- Valeur, B. in "Molecular Fluorescence," chapters 1 and 2
- Marcus, R. A.; Sutin, N., "Electron transfers in chemistry and biology," *Biochim. Biophys. Acta, Rev. Bioenerg.*, 1985, 811, 265-322.
- Beratan, D. N.; Betts, J. N.; Onuchic, J. N., "Protein Electron Transfer Rates Set by the Bridging Secondary and Tertiary Structure," *Science*, 1991, 252, 1285-1288.
- Vullev, V. I.; Jones, G., "Photoinduced Charge Transfer in Helical Polypeptides," *Res. Chem. Inter.*, 2002, 28, 795-815.
- Jones, G.; Vullev, V. I., "Photoinduced Electron Transfer between Non-Native Donor-Acceptor Moieties Incorporated in Synthetic Polypeptide Aggregates," *Org. Lett.*, 2002, 4, 4001-4004.

Week 3 and 4:

Biomimicry, biomimesis and bioinspiration

Fundamentals of photosynthesis

Design of biomimetics and bioinspired light-harvesting systems

Artificial photosynthesis

Reading:

- Vullev, V. I., "From Biomimesis to Bioinspiration: What's the Benefit for Solar-Energy-Conversion Applications?," *J. Phys. Chem. Lett.*, 2011, 2, 503-508.
- Berg, J. M.; Tymoczko, J. L.; Stryer, L. in "Biochemistry," chapter on photosynthesis.
- Zhou, H., et al., "Artificial Inorganic Leafs for Efficient Photochemical Hydrogen Production Inspired by Natural Photosynthesis," *Advanced Materials*, 2010, 22, 951-956.
- Rabanal, F.; DeGrado, W. F.; Dutton, P. L., "Toward the Synthesis of a Photosynthetic Reaction Center Maquette: A Cofacial Porphyrin Pair Assembled between Two Subunits of a Synthetic Four-Helix Bundle Multiheme Protein," *J. Am. Chem. Soc.*, 1996, 118, 473-474.
- Cristian, L.; Piotrowiak, P.; Farid, R. S., "Mimicking Photosynthesis in a Computationally Designed Synthetic Metalloprotein," *J. Am. Chem. Soc.*, 2003, 125, 11814-11815.
- Steinberg-Yfrach, G.; Rigaud, J.-L.; Durantini, E.N.; Moore, A. L.; Gust, D.; Moore, T. A., "Light-Driven Production of ATP Catalyzed by F₀F₁-ATP Synthase in an Artificial Photosynthetic Membrane," *Nature*, 1998, 392, 479-482.
- Bennett, I. M., et al., "Active transport of Ca²⁺ by an artificial photosynthetic membrane," *Nature*, 2002, 420, 398-401.

Week 5

Techniques for studying photoinduced processes and light-harvesting systems

Electrochemical methods

Time-resolved spectroscopy

Reading:

- Lakowicz, J. R. in "Principles of Fluorescence Spectroscopy," chapters on time-resolved spectroscopy.
- Bao, D., et al., "Electrochemical Reduction of Quinones: Interfacing Experiment and Theory for Defining Effective Radii of Redox Moieties," *J. Phys. Chem., B*, 2010, 114, 14467-14479.
- Bao, D., et al., "Electrochemical Oxidation of Ferrocene: A Strong Dependence on the Concentration of the Supporting Electrolyte for non-Polar Solvents," *J. Phys. Chem., A*, 2009, 113, 1259-1267.
- Wan, J., et al., "Solvent Dependence of the Charge-Transfer Properties of a Quaterthiophene-Anthraquinone Dyad," *J. Photochem. Biotobiol. A: Chemistry*, 2008, 197, 364-374.
- Jones, G.; Vullev, V. I., "Photoinduced Electron Transfer between Non-Native Donor-Acceptor Moieties Incorporated in Synthetic Polypeptide Aggregates," *Org. Lett.*, 2002, 4, 4001-4004.

Week 6

Photovoltaics

Nanotechnology for solar-energy devices: quantum-dot sensitized solar cells

Reading:

- Kalyanasundaram, K.; Graetzel, M., "Artificial Photosynthesis: Biomimetic Approaches to Solar Energy Conversion and Storage," *Curr. Opin. Biotechnol.*, 2010, 21, 298-310.
- Kamat, P. V. "Quantum Dot Solar Cells. Semiconductor Nano-crystals as Light Harvesters," *J. Phys. Chem. C*, 2008, 112, 18737-18753.

Week 7 and 8

Photocatalytic water splitting

Natural water oxidation: photosystem II

Natural and biomimetic hydrogenases

Artificial water splitting: advances and challenges

Reading:

- Loll, B. et al., "Towards complete cofactor arrangement in the 3.0 Å resolution structure of photosystem II," *Nature*, 2005, 438, 1040-1044.
- Jordan, P., et al., "Three-dimensional structure of cyanobacterial photosystem I at 2.5 Å resolution," *Nature*, 2001, 411, 909-917.
- Rauchfuss, T. B., "A Promising Mimic of Hydrogenase Activity," *Science*, 2007, 316, 553-554.
- Gloaguen, F.; Rauchfuss, T. B., "Small Molecule Mimics of Hydrogenases: Hydrides and Redox," *Chem. Soc. Rev.*, 2009, 38, 100-108.
- Dismukes, G. C., et al., "Development of Bioinspired Mn₄O₄-Cubane Water Oxidation Catalysts: Lessons from Photosynthesis," *Acc. Chem. Res.*, 2009, 42, 1935-1943.
- Brimblecombe, R., et al., "Solar Driven Water Oxidation by a Bioinspired Manganese Molecular Catalyst," *J. Am. Chem. Soc.*, 2010, 132, 2892-2894.

Week 9

Carbon-dioxide fixation

Dark photosynthetic cycle

Artificial carbon-dioxide reduction: advances and challenges

Reading:

- Grills, D. C.; Fujita, E., "New Directions for the Photocatalytic Reduction of CO₂: Supramolecular, scCO₂ or Biphasic Ionic Liquid-scCO₂ Systems," *J. Phys. Chem. Lett.*, 2010, 1, 2709-2718.
- Berg, J. M.; Tymoczko, J. L.; Stryer, L. in "Biochemistry," sections on Calvin cycle.

Week 10

Self-repairing and self-healing

Difference between living systems and engineered devices

Damage prevention vs. damage management

- Straight, S. D.; Kodis, G.; Terazono, Y.; Hamburger, M.; Moore, T. A.; Moore, A. L.; Gust, D., "Self-Regulation of Photoinduced Electron Transfer by a Molecular Nonlinear Transducer," *Nature Nanotechnology*, 2008, 3, 280-283.
- Ivanov, A. G.; Sane, P. V.; Hurry, V.; Oquist, G.; Huner, N. P. A., "Photosystem II Reaction Centre Quenching: Mechanisms and Physiological Role," *Photosynth. Res.*, 2008, 98, 565-574.
- Trask, R. S.; Williams, H. R.; Bond, I. P., "Self-Healing Polymer Composites: Mimicking Nature to Enhance Performance," *Bioinspiration Biomimetics*, 2007, 2, P1-P9.

1. BIEN 175A/B Senior Design

**2. 8 units, 2 hours lecture, 3 hours practicum, 1 hour discussion
Design: 8 units**

3. Professor Hyle Park

4. Textbook: Design of Biomedical Devices and Systems. R. Fries and P. King, Marcel Dekker

5. a. Catalog Description. Preparation of formal engineering reports and statistical analysis on a series of problems illustrating methodology from various branches of applied bioengineering. Covers the entire design process: design problem definition, generation of a design specification, documentation, design review process, prototype fabrication, testing and calibration, cost estimation, and federal guidelines. Requires a term project and oral presentation.

b. Prerequisite(s): BIEN 130; BIEN 130L; BIEN 135; senior standing in Bioengineering.

c. Required

6. Course Goals - Student Outcomes b, c, d, g, i, k

Specific outcomes. The student will

- i. Generate and evaluate several new design concepts
- ii. Utilize engineering principles and software to develop specifications for the product or process
- iii. Create the finalized design, provide full documentation and test a prototype when applicable
- iv. Evaluate marketing, commercialization, patents
- v. Document regulations from FDA, IRB, others and ethical guidelines
- vi. Maintain a time-line for the project and prepare periodic reports on design progress and changes
- vii. Present project reports using Microsoft PowerPoint and maintain a Web site for the project
- viii. Participate effectively in a team project
- ix. Show an ability to design and conduct experiments, analyze and interpret data

7. Syllabus

Design Sequence

Characterization of product or process need

Review of existing methods

Generation and evaluation of several design concepts

Order of Magnitude Calculations

Planning of design project including skill and resource requirements

Utilization of engineering principles and software (e.g. COMSOL, Matlab) to develop specifications and documentation for the product or process

Design, build and test

component elements
completed prototype
Analyze and interpret data (statistical methods)
Evaluation of design solution
Create finalized design

1. **Statistics 155, Probability and Statistics for Science and Engineering**
2. 4 Units, 3 hours Lecture, 1 hour Discussion
3. Instructor's or course coordinator's name – This course is taught by the Statistics Department
4. **Textbook:** Probability and Statistics for Engineering and the Sciences, seventh edition, by Jay L. Devore, Brooks/Cole
5. a. Catalog Description. Covers sample spaces and probability; random variables and probability distributions; elements of statistical inference; and testing and estimation. Also addresses selected topics in multivariate distributions and introduces stochastic processes.
- b. **Prerequisite(s):** MATH 009C or MATH 09HC (MATH 009C or MATH 09HC may be taken concurrently).prerequisites or co-requisites
- c. **Required Course**
6. **Course Goals**
 - a. Provide students with the basic knowledge of statistics for future engineering applications
 - b. No specific outcomes related to Criteria 3 are addressed by the course.
7. Brief list of topics to be covered

| Week | Topics Covered |
|------|--|
| 1 – | Introduction; Basic Terminology of Statistics; Pictorial and Tabular Methods in Descriptive Statistics; Measures of Location |
| 2 – | Measures of Variability; Sample Spaces and Events; Properties of Probability |
| 3 – | Counting Techniques; Conditional Probability; Independence Random Variables; Discrete Probability Distributions |
| 4 – | Expected Values; Binomial Probability Distribution; Hypergeometric and Negative Binomial Distributions |
| 5 – | Poisson Probability Distribution; Continuous Probability Distributions; Probability Density Functions; Cumulative Distribution Functions and Expected Values |
| 6 – | Normal Distribution; Exponential and Gamma Distributions; Other Continuous Distributions; Probability Plots; Jointly Distributed Random Variables |
| 7 – | Expected Values, Covariance, and Correlation; Statistics and Their Distributions; Distribution of the Sample Mean; Distribution of a Linear Combination; |
| 8 – | Some General Concepts of Point Estimation; Methods of Point Estimation |
| 9 – | Basic Properties of Confidence Intervals; Large-Sample Confidence Intervals for a Population Mean and Proportion; Intervals Based on a Normal Population Distribution; Confidence Intervals for the Variance and Standard Deviation of a Normal Population |

10 – Hypotheses and Test Procedures; Tests About a Population Mean; P-values; Tests Concerning a Population Proportion; Some Comments on Selecting a Test; Introduction to Stochastic Processes

1. CS 010. Introduction to Computer Science for Science, Mathematics, and Engineering (4)

2. Lecture, 3 hours; laboratory, 3 hours.

3. Instructor: Kris Miller, Computer Science Department, Bourns College of Engineering

4. Textbook: Big C++, Cay Horstmann and Timothy Budd

5. a. Catalog Description. Covers problem solving through structured programming of algorithms on computers using the C++ object-oriented language. Includes variables, expressions, input/output (I/O), branches, loops, functions, parameters, arrays, strings, file I/O, and classes. Also covers software design, testing, and debugging.

b. Prerequisites: A UCR Mathematics course (may be taken concurrently) or credit for MATH 009A from the Advanced Placement Examination or the Mathematics Advisory Examination.

c. Required Course

6. Course Goals

| Outcome Related Learning Objectives Student Outcomes |
|---|
| Use variables to store computer program data |
| Form and use mathematical and Boolean expressions of variables |
| Process program input and generate program output |
| Use branches to create programs incorporating decision making |
| Use loops to create programs that repeat certain behaviors |
| Use functions to modularize programs |
| Use arrays to store collections of data |
| Use strings to handle textual data |
| Use classes as a record that keeps related data together |
| Convert a system description into a set of about 50-100 computer instructions |
| Debug systems written by oneself or by others |
| Understand very basic methods of testing a device |
| Incorporate useful comments into devices |

7. Brief List of Topics Covered

Week 1: Introduction to Computers & Programming/Algorithms

Week 2: Data Types/Variables/Assignment/Input/Output

Week 3: Control Structures - Branching

Week 4: Control Structures - Looping

Week 5: Functions that return values

Week 6: Procedures (Void Functions)
Week 7: Variable Scope/Reference Parameters
Week 8: Vectors
Week 9: Vectors cont./2d Vectors
Week 10: Software Development/Testing

BIEN 190

Special Studies

Provides individual study to meet special curricular needs.

BIEN 197

Research for Undergraduates

Directed research on a topic relevant to bioengineering.

Section II. Syllabi for Supporting Sciences and Mathematics

I. Chemistry Courses

A. CHEM 001A. General Chemistry (4) F, W, Summer

Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): a score of 3, 4, or 5 on the College Board Advanced Placement Chemistry Examination or a passing score on the California Chemistry Diagnostic Test or a grade of "C-" or better in MATH 005 or concurrent enrollment in MATH 008B or a grade of "C-" or better in MATH 008B or a grade of "C-" or better in an equivalent college-level mathematics or chemistry course; concurrent enrollment in CHEM 01LA or a grade of "C-" or better in CHEM 01LA. An introduction to the basic principles of chemistry. Credit is awarded for only one of CHEM 001A or CHEM 01HA.

➤ Course Syllabus for Chemistry 001A

| Week | Date of Lectures | Textbook Chapter(s) (McMurray & Fay, GENERAL CHEMISTRY: Atoms First) |
|------|---------------------------------|--|
| 1 | January 3, 5, 7 | 1 |
| 2 | January 10, 12, 14 | 2 |
| 3 | January 19, 21 | 3 |
| 4 | January 24, 26 | 3, 4 |
| 5 | January 31, February 2, 4 | 4,5 |
| 6 | February 7, 9, 11 | 5 |
| 7 | February 14, 16, 18 | 5, 6 |
| 8 | February 23 (Feb. 21 = holiday) | 6 |
| 9 | February 28, March 2, 4 | 7 |
| 10 | March 7, 9, 11 | 8 |

➤ Course Materials for Chemistry 001A only:

1. Textbook: J.E. McMurray and R. C. Fay, GENERAL CHEMISTRY: Atoms First, Custom Edition for UCR, Pearson Learning Solutions, 2010. An optional Selected Solutions Manual is available.
2. Scan-Tron test-grading forms #882-E (1 pack)
3. Supplementary Texts on Reserve in the Science Library:
 - Brown and LeMay, Chemistry: The Central Science, 1988, QD31.2 .B783 1988
 - Dickerson, Gray, and Haight, Chemical Principles, 1979, QD31.2 .D52 1979
 - Peters, Problem Solving for Chemistry, 1976, QD42 .P47 1976
 - Smith and Pierce, Solving General Chemistry Problems, 1980, QD42 .S556 1980
 - Masterson and Slowinski, Mathematical Preparation for General Chemistry, QD42 .M335 1970

Dear Student:

In this course you will be using MasteringChemistry®, an online tutorial and homework program that accompanies your textbook.

B. CHEM 001B. General Chemistry (4)

Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): grades of "C-" or better in CHEM 001A and CHEM

01LA or grades of "C-" or better in CHEM 01HA and CHEM 1HLA; concurrent enrollment in CHEM 01LB or a grade of "C-" or better in CHEM 01LB. An introduction to the basic principles of chemistry. Credit is awarded for only one of CHEM 001B or CHEM 01HB.

➤ Course Syllabus Chemistry 001 B

The topics covered include:

| |
|---|
| Ch 9 – gases |
| Ch 10 - liquids and solids/phase changes; |
| Ch 11 - properties of solutions; |
| Ch 12 – reaction kinetics; |
| Ch 13 – chemical equilibrium; |
| Ch 14 – acid-base equilibria. |

Course Goals

The general goal of Chem 001B is to continue your training in general chemistry, in particular continuing to master the basic concepts and problem solving strategies required in the field of chemistry, as well as gaining a more complete understanding of fundamental concepts such as the interaction of molecules and the behavior of chemical reactions. Successfully completing this course will allow you to apply your understanding of the properties of matter and chemical reactions to organic reactions, which will be covered in organic chemistry, (chemistry majors, pre-med students, biochemistry majors) and you should be prepared to continue the more in-depth discussions of chemical reactions that you will encounter in physical chemistry (chemistry majors).

Required Materials

- Textbook: Custom Edition of the McMurray/Fay Chemistry Text Book, General Chemistry: Atoms First

Student Learning Goals

The specific learning goals for each chapter are listed in the chapter outlines. The chapter outlines are available on the Blackboard site.

| | |
|---------|---|
| Jan. 3 | Course Logistics & Goals/Student Learning Goals/Gases (9.6) |
| Jan. 5 | Gases (9.1---9.3) |
| Jan. 7 | Gases (9.8, 9.4---9.5) |
| Jan. 10 | Gases (9.7---9.8) |
| Jan. 12 | Liquids/Solids/Phases (10.1---10.2) |
| Jan. 14 | Liquids/Solids/Phases (10.3---10.5) |
| Jan. 17 | MLK Holiday |
| Jan. 19 | Liquids/Solids/Phases (10.6---10.10) |

| | |
|---------------------|--|
| Jan. 21 | Solutions (11.1---11.2, 11.4) |
| Jan. 24 | Solutions (11.3, 11.6---11.7) |
| Jan. 26 | Solutions (11.5, 11.7---11.8) |
| Jan. 28 | Review |
| Jan. 31 | Exam 1 (Chapters 9---11) |
| Feb. 2 | Kinetics (12.1, 12.3) |
| Feb. 4 | Kinetics (12.12---12.14) |
| Feb. 7 | Kinetics (12.2, 12.3) |
| Feb. 9 | Kinetics (12.4---12.8) |
| Feb. 11 | Kinetics (12.9---12.11) |
| Feb. 14 | Kinetics (12.9---12.11) |
| Feb. 16 | Equilibrium (13.11, 13.1---13.2) |
| Feb.18 | Equilibrium (13.3---13.5) |
| Feb. 21 | President's Day |
| Feb. 23 | Equilibrium (13.6---13.10) |
| Feb. 25 | Review |
| Feb. 28 | Exam 2 (Chapters 12---13) |
| Mar. 2 | Acids---Bases (14.1---14.16) |
| Mar. 4 | Acids---Bases (14.15, 14.11) |
| Mar. 7 | Acids---Bases (14.2, 14.3, 14.8, 14.4, 14.5) |
| Mar. 9 | Acids---Bases (14.7, 14.9, 14.12, 14.13) |
| Mar. 11 | Acids---Bases (14.12---14.14) |
| Mar. 12---18 | Review Session and Final Exam TBA |

C. CHEM 001C. General Chemistry (4)

Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): grades of "C-" or better in CHEM 001B and CHEM 01LB or grades of "C-" or better in CHEM 01HB and CHEM 1HLB; concurrent enrollment in CHEM 01LC or a grade of "C-" or better in CHEM 01LC. An introduction to the basic principles of chemistry. Credit is awarded for only one of CHEM 001C or CHEM 01HC.

➤ Course Syllabus for Chemistry 001C

- Textbook: John. E. McMurry and Robert C. Fay, "General Chemistry: Atom First", Custom Edition for University of California, Riverside, Pearson Learning Solutions, see Section D for more details.
- The six Chemistry 1C textbook chapters and titles and likely order of coverage are:

| | |
|------------|--|
| Chapter 15 | Applications of Aqueous Equilibria |
| Chapter 16 | Thermodynamics |
| Chapter 17 | Electrochemistry |
| Chapter 20 | Transition Elements and Coordination Chemistry |
| Chapter 21 | Metals and Solid State Materials |
| Chapter 25 | Nuclear Chemistry |

D. CHEM 01LA. General Chemistry Laboratory (1)

Laboratory, 3 hours. Prerequisite(s): concurrent enrollment in CHEM 001A or a grade of "C-" or better in CHEM 001A. An introduction to laboratory principles and techniques related to lecture topics in CHEM 001A. Credit is awarded for only one of CHEM 01LA or CHEM 1HLA.

➤ Course/Lab Syllabus for Chemistry 01LA

- Laboratory Manual: CHEM 1LA/1HLA Laboratory Manual, 2010-11 Edition, Hayden-McNeil Publishing Company

Chemistry 01LA Laboratory Schedule

| Week | Date | Experiment |
|---|-------------|---|
| 1 | January 7 | Check-in; Introduction; Laboratory Safety; Science Library Orientation & Exercises. You must check in to keep your place in class |
| 2 | January 14 | Experiment 1 – Densities of Liquids and Solids; Quiz #1 (which will cover Safety and Experiment 1) |
| 3 | January 21 | Experiment 2 – Emission of Light from Hydrogen and Metal Atoms; Quiz #2; Library Exercises due by 5:00 pm |
| 4 | January 28 | Experiment 4 – Water of Hydration; Quiz #3 |
| NOTE: Experiment #4 before Experiment #3 | | |
| 5 | February 4 | Experiment 3 – Using Models to Predict |
| Molecular Shapes; Quiz #4 | | |
| 6 | February 11 | Experiment 5 – Molar Mass of a Solid Acid; Quiz #5 |
| 7 | February 18 | Experiment 6 – The Alkaline Earths and |
| Halogens; Quiz #6 | | |
| 8 | February 25 | Experiment 7 – Calorimetry; Quiz #7; Checkout; Expt. #7 Report is due 5:00 pm, Monday, February 28 (turn in to TA's box adjacent to stockroom window) |
| 9 | March 4 | Review for Final Exam; Reports #6 and #7 returned |
| 10 | March 11 | No lab meeting for Friday sections |

Laboratory Practices

What is required in your notebook for each experiment?

For each experiment you must include the following five sections in your laboratory notebook. You will retain the original pages in your notebook and turn in the carbonless duplicate pages (marked "COPY") to your Teaching Assistant.

1. Purpose
2. Procedure (in outline form)
3. Data (measurements and observations recorded in your lab notebook)
4. Calculations (written in your lab notebook)
5. Results and Conclusion; this section includes these two components:
 - a. Error Analysis
 - b. Conclusion

Below is an explanation of what needs to be in each section.

1. Purpose - the purpose of the experiment should a succinct statement of the main point of the lab. It should not be more than 2-3 sentences long.

2. Procedure - a step-by-step procedure in outline form. Do not write the procedure in paragraph format. The outline be should as concise as possible, but include sufficient detail for you to carry out the experiment without the aid of your lab manual. Refer to the example on page 80 in the lab manual.

Turn in the copy of the notebook pages containing the Purpose and Procedure to your TA at the beginning of the period.

3. Data – Begin a new page and record all your measurements and observations in a table format (see example on page 81 in the lab manual) and underneath the table write any observations or comments pertaining to the experiment. Use the whole page for this. You might find it useful to set up the data table before coming to lab. Do not include calculated values in the Data section. At the conclusion of each lab period you must get your TA's signature (in the "Witness/TA" box at the bottom) on each of the Data pages in your lab notebook and turn in the copy.

4. Calculations - on a new page following the Data, show sample calculations of all the important calculations leading to the final results of the experiment. If you did multiple trials, use only the first trial to show the set-up of the calculations. Keep in mind that in some instances you will be asked by the TA to show sample calculations of all the trials. The duplicate notebook pages containing the Calculations are attached to your Report sheets and turned in the following week.

5. Results and Conclusion. This section must include these two components. The duplicate pages from your notebook are to be attached to your Report sheets and turned in the following week.

a. Error Analysis - If your final results were not what was expected, then use this section to describe what went wrong and to give any possible sources of error. For example, suppose you performed three titrations to determine the molarity of an acid solution and one of the titrations resulted in a value of the molarity significantly different than the other two. If you noticed halfway through one titration that there was an air bubble in the tip of the buret, you would discuss what effect this might have on the accuracy of your results.

b. Conclusion - In no more than 3 to 5 coherent sentences state your final conclusions of the lab BASED on your experimental results. Most importantly you want to answer the question: "Did I

accomplish the purpose of this experiment?" and if so, you must relate how you accomplished the purpose by stating your final results. For example, if the purpose of the experiment was to determine the concentration of a base by titration with an acid, your conclusion should state the average concentration of base, and assess the precision of your results by providing the standard deviation of your trials. Moreover, in your conclusion you should present one or two new ideas that were learned by doing the experiment. This section should be written in the third person, and kept concise.

Laboratory Safety. The instructors and staff place the highest priority on your safety. To this end, you are required to understand and follow the safety precautions and rules that are printed below and in your lab manual (pages v-ix). In addition, you may be given specific instructions for each experiment and you are expected to follow these. The most basic safety requirement in lab is that goggles are to be worn at all times that experiments are in progress. This means that even after you have finished the experiment, you are required to wear your goggles so long as any other person in the lab is still working. **NOTE:** You are not allowed to bring food or beverages (even in closed containers) or wear sandal-type shoes in the lab.

Department of Chemistry Laboratory Safety Instructions and Rules

1. **EYE PROTECTION:** One of the most common (and damaging) types of laboratory accidents involves the eyes.

EYE PROTECTION IS MANDATORY AT ALL TIMES IN ALL TEACHING AND RESEARCH LABORATORIES. NO EXCEPTIONS. PERSONS WITH INADEQUATE EYE PROTECTION WILL BE TOLD TO LEAVE THE LABORATORY.

- a. All persons in a laboratory must wear safety goggles.
- b. Persons who normally wear prescription glasses must wear safety goggles over their glasses. Regular prescription glasses do not provide adequate protection for chemical laboratories.

2. **PROPER ATTIRE:** You will not be allowed in lab unless you are wearing clothing which completely covers the torso and legs (to within six inches above your ankles). Shoes must completely enclose the foot. A lab coat or apron is recommended. You may wear shorts only under a full-length lab coat. For your protection, you will not be allowed to attend lab without appropriate attire.

3. **MEDICAL CONDITIONS:** Notify the supervising laboratory instructor immediately if you have any medical conditions (such as pregnancy, allergies, diabetes, etc.) that may require special precautionary measures in the laboratory.

4. **EMERGENCY EQUIPMENT:** Know the locations of the lab fire extinguishers, safety showers, eyewash fountains, hallway emergency telephones, fire alarms, and lab and building exits.

5. **FIRE:** Immediately alert the TA, who will give instructions. A fire confined to a small container or flask can usually be extinguished by covering the container with something nonflammable (e.g. a large beaker). Use a fire extinguisher if necessary, but only if it appears that the fire can be easily contained; if not, pull the fire alarm and exit the building. Go directly to the designated assembly area. Do not use the elevator.

If a person's clothing is on fire, use the safety shower to put out the flames. If the shower is not readily available, douse the individual with water or wrap the person in a coat or whatever is available to extinguish the fire and roll the person on the floor. Fire blankets must be used with caution because wrapping someone while they are in the vertical position can force flames toward the face and neck.

6. **INJURY:** Immediately report any injury to a Teaching Assistant, no matter how minor. The TA will initiate emergency procedures and arrange for transportation to a medical care facility. Do not transport a seriously injured person. Call for help. Complete an Incident Report in consultation with your TA as soon as possible, and submit it to the Stockroom staff (see Item 7).

NOTE: The Student Health Center is open only during the day, from 8:00 – 4:30. Laboratory injuries after these hours will be treated at the Emergency Room at Riverside Community Hospital or a nearby Urgent Care Center. Students (or their health insurance company) will be assessed Emergency Room charges for off campus treatment. The Chemistry Department (or University) cannot pay. Students under 18 years must submit in advance, a treatment release form signed by parents or guardians to be held on file in the stockroom.

7. **CHEMICAL SPILLS:** Chemical contact with eyes and skin must be washed immediately with lots of water for no less than 15 minutes. **USE THE EYE WASH AND SAFETY SHOWER.** Quickly remove all contaminated clothing. Report chemical spills on persons, tables, or floors to a TA immediately regardless of how minor they appear.

8. **EARTHQUAKE:** Exit the laboratory if possible, but stay in the building and protect yourself from breaking windows or objects falling from above. When the quake subsides, quickly check, if possible, that all gas valves are closed and all electrical heating devices are turned off to stop reactions and prevent fires. Exit the building to the designated assembly area (see item 9). Do not use elevators.

9. **BUILDING ALARM:** Leave the building immediately and quietly to the designated assembly area, which is the grassy mall adjacent to the south wing of Pierce Hall and east of the bell tower (see map on the following page). Do not return until specifically told to re-enter. Note: Do not leave the building during active shaking from an earthquake.

10. **REPORT OF INCIDENT:** All incidents of fire, explosion, injury, or chemical spills (including mercury from broken thermometers) should be reported immediately to a TA. A written report is required after the incident; the stockroom has forms for filing written reports.

11. PREPARATION FOR LABORATORY: All students are expected to have read the experiment thoroughly prior to starting the lab work. Questions about procedures or precautions should be resolved by asking the TA or professor before the experiment.

12. ADDITIONAL LABORATORY RULES:

a. You may not bring nor consume any food or beverage in the laboratories. Smoking and application of cosmetics is not permitted in the labs.

b. You may not remove chemicals, equipment or supplies from the laboratories or stockrooms without written permission of the instructor, teaching assistant, or Laboratory Coordinator. Removal of any of the mentioned items will be treated as Academic Dishonesty and may result in a grade of F for the course.

c. Do not deliberately smell or taste chemicals.

d. Do not mix reagents unless you are instructed to do so or know the likely results.

e. Do not use unlabeled chemicals. Report them to the TA.

f. Never adulterate reagents by "pouring back" unused portions into stock bottles or using a contaminated pipet.

g. Do not dump chemicals into trash cans or sinks. Waste chemicals are to be disposed of in specially labeled containers only.

h. Extinguish matches with water and dispose of them in trash cans, never in the sinks.

i. Absolutely no horseplay of any kind is permitted in the labs.

j. Do not store chemicals in your lab drawer, unless specifically instructed to do so by your TA (e.g., when an experiment requires more than one lab period). All containers for storing chemicals must be clearly labeled (your name, experiment, and the full chemical name(s) of the contents).

k. No visiting by friends is allowed during lab sessions. Pets or children are not allowed.

l. Do not drink water from lab faucets. This water may not be safe.

E. CHEM 01LB. General Chemistry Laboratory (1)

Laboratory, 3 hours. Prerequisite(s): grades of "C-" or better in CHEM 001A and CHEM 01LA or grades of "C-" or better in CHEM 01HA and CHEM 1HLA; concurrent enrollment in CHEM 001B or a grade of "C-" or better in CHEM 001B. An introduction to laboratory principles and techniques related to lecture topics in CHEM 001B. Credit is awarded for only one of CHEM 01LB or CHEM 1HLB. CHEM 01LC.

➤ **Course Syllabus for Chemistry 01LB**

General Chemistry Laboratory CHEM 01LB consists of one three-hour laboratory period per week. If you have not previously completed the lecture course, CHEM 001B, you are required to be enrolled in both courses concurrently. The material covered in lab is directly related to the lecture topics.

Required Course Materials for CHEM 01LB Laboratory:

- Laboratory Manual: CHEM 1LB/1HLB Laboratory Manual, 2012 Edition, Hayden-McNeil Publishing Company.

Chemistry 01LB Laboratory Schedule

| Week | Date | Experiment |
|-------------|-------------|--|
| 1 | January 13 | Check-in; Introduction; Laboratory Safety; You must check in to keep your place in class |
| 2 | January 20 | Experiment 1 – Calorimetry; Quiz #1 (which will cover Safety and Experiment 1) |
| 3 | January 27 | Experiment 2 – Composition of an Aluminum-Zinc Alloy; Quiz #2 |
| 4 | February 3 | Experiment 3 – Determination of Iron by Redox Titration; Quiz #3 |
| 5 | February 10 | Experiment 4 – Vapor Pressure and Heat of Vaporization of Liquids; Quiz #4 |
| 6 | February 17 | Experiment 5 – Determination of Molar Mass by Freezing Point Depression; Quiz #5 |
| 7 | February 24 | Experiment 6 – Rates of Chemical Reactions: A Clock Reaction; Quiz #6 |
| 8 | March 2 | Experiment 7 – Spectrophotometry and Beer's Law; Quiz #7; Checkout; Expt. #7. Report is due by 5:00 pm on Monday, March 5 (turn in to TA's box adjacent to stockroom window) |
| 9 | March 9 | Review for Final Exam; Reports #6 and #7 returned |

F. CHEM 01LC. General Chemistry Laboratory (1)

Laboratory, 3 hours. Prerequisite(s): grades of "C-" or better in CHEM 001B and CHEM 01LB or grades of "C-" or better in CHEM 01HB and CHEM 1HLB; concurrent enrollment in CHEM 001C or a grade of "C-" or better in CHEM 001C. An introduction to laboratory principles and techniques related to lecture topics in CHEM 001C. Credit is awarded for only one of CHEM 01LC or CHEM 1HLC. CHEM 003. Concepts of Chemistry (4) S Lecture, 3

➤ Course Syllabus for Chemistry 01LC:

General Chemistry Laboratory CHEM 01LC consists of one three-hour laboratory period per week. If you have not previously completed the lecture course, CHEM 001C, you are required to be enrolled in both courses concurrently. The material covered in lab is directly related to the lecture topics.

Required Course Materials for CHEM 01LC

- Laboratory Manual: CHEM 1LC/1HLC Laboratory Manual, 2011 Edition, (Hayden-McNeil Publishing Company, ISBN: 978-0-7380-4516-0).

Chemistry 01LC Laboratory Schedule

| | | |
|----|--------------------|--|
| 1 | Sept. 26 – 29 | Check-in; Introduction; Laboratory Safety; You must check in to keep your place in class |
| 2 | Oct. 3 – 6 | Experiment 1 – Chemical Equilibrium and Le Châtelier's Principle; Quiz #1 (which will cover laboratory safety and Experiment 1) |
| 3 | Oct. 10 – 13 | Experiment 2 – pH Measurements; Quiz #2 |
| 4 | Oct. 17 – 20 | Experiment 3 – K_a of an Indicator; Quiz #3 |
| 5 | Oct. 24 – 27 | Experiment 4 – Solubility Product; Quiz #4 |
| 6 | Oct. 31 – Nov. 5 | Experiment 5 – Determination of Water Hardness; Quiz #5 |
| 7 | Nov. 7 - 10 | Experiment 6 – Voltaic Cells; Quiz #6 |
| | No lab on Nov. 14; | Monday sections will perform Experiment #7 on Nov. 21 |
| 8 | Nov. 15 – Nov.17 | Experiment 7 – Coordination Complexes and the Spectrochemical Series; Quiz #7; Checkout; Report is due within 24 hours; turn in to TA's box adjacent to stockroom window |
| 9 | Nov. 21 | Experiment 7 – Coordination Complexes and the Spectrochemical Series; Quiz #7; Checkout; Report is due within 24 hours; turn in to TA's box adjacent to stockroom window |
| 10 | Nov. 28 – Dec. 1 | Review for Final Exam; Reports #6 and #7 will be returned |

G. CHEM 112A. Organic Chemistry (4)

Lecture, 3 hours; laboratory, 4 hours. Prerequisite(s): CHEM 001C and CHEM 01LC with grades of "C-" or better or CHEM 01HC and CHEM 1HLC with grades of "C-" or better. Covers modern organic chemistry including structure, nomenclature, reactivity, synthesis, and reaction mechanisms and the chemistry of carbohydrates, lipids, nucleic acids, amino acids, and proteins. Also includes laboratory techniques of purification, isolation, synthesis, reactions, and spectroscopic analysis.

➤ Course Syllabus for Chemistry 112A

Course Content Chem112A is the first course of a three-term sequence. This course covers the fundamentals of structure and reactivity of organic compounds, and the way in which these translate into the chemical and physical behavior that makes organic chemistry ubiquitous.

Required Course Materials for CHEM 112A

1. Text Books (Optional)
 - J. McMurry, Organic Chemistry, (7th, 8th or 9th Edition, Published by Brooks/Cole).
 - S. McMurry, Study Guide and Solutions Manual for McMurry, (7th, 8th or 9th Edition, Published by Brooks/Cole).
2. Lecture notes available on iLearn
3. Microscale Organic Laboratory, adapted for use in Chem 112A – UCR (see laboratory syllabus for required edition).
4. Molecular Models (Darling Organic Chemistry Models – sold through the bookstore).
5. Laboratory Notebook (with numbered carbonless duplicate pages).
6. A laboratory apron or coat is recommended.

Chemistry 112A Laboratory Experiments

- Textbook: Microscale Organic Laboratory Adapted for Use in Chemistry 112A Mayo, Pike, Trumper; J. Wiley and Sons

Schedule of Experiments

No Monday labs

| Week | Experiment |
|-------------|--|
| 1/9-1/13 | Laboratory safety & Check-in. You MUST make sure that you have all of the necessary lab equipment and glassware in your assigned drawers before you leave. Read Lab text, pp 1-41. |
| 1/17 - 1/21 | Molecular Model Exercises (20 pts). pp 118-120. Bring your molecular models to lab. |

| | |
|-------------|--|
| 1/24-1/27 | 50-51, 80-82. Prepare a flow chart showing the sequence of manipulations you will be performing. Do postlab question 2 on p E17 |
| 1/30 – 2/3 | For background read E19-E21,98-100,103-104.Do prelab questions 4-5 on p E3 before coming to lab. Prepare a flow chart showing the sequence of operations you will be performing. Do postlab questions 1 and 2 on p E6. |
| 2/6 - 2/10 | Fractional Semi-Microscale Distillation: Separation of Heptane and alpha-Pinene (25 pts) pp E28-E31. For background read pp 48-50, 61-71,111-115, Do prelab questions 1-4 on p E31 prior to coming to lab. You will use a distillation head obtained from the front table (return it clean at the end of the lab period). |
| 2/13 – 2/17 | Separation of Acid, Base, and Neutral Compounds: Solvent Extraction of a Three-Component Mixture (30 pts) pp E35-E37. Read Lab text, pp 82-83. Do the prelab assignment at the bottom of p E35 prior to coming to lab. Be sure to prepare a flow chart showing the sequence of operations you will be performing. You will use a separatory funnel obtained from the front desk (return it clean at the end of the lab period). Do postlab questions 1-3 on p E37. |
| 2/20 – 2/24 | Bromination of (E)-Stilbene: meso-Stilbene Dibromide (25 pts) pp E44-E47. For background read pp 90-96, Perform this experiment on the semi-microscale amounts on page E48. Do postlab questions 8-23 and 8-24 on p E48 Your product will be saved to use in the next experiment. |
| 2/27 – 3/2 | Dehydrohalogenation of meso-Stilbene Dibromide: Diphenylacetylene (25 pts) pp E49-E52. Perform this experiment on the Microscale (E52). If needed, you may get a neoprene disc from the front desk (return it clean at the end of the lab period). Do postlab questions 8-28 on p E52. |
| 3/5 – 3/9 | Williamson Synthesis of an Ether: Propyl p-Tolyl Ether (25 pts) pp E53-E56. You will use a 12-well porcelain plate from the center bench (return it clean at the end of the lab period). (Report due at the end of the lab period) |

H. CHEM 112B. Organic Chemistry (4)

Lecture, 3 hours; laboratory, 4 hours. Prerequisite(s): CHEM 112A with a grade of "C-" or better. Covers modern organic chemistry including structure, nomenclature, reactivity, synthesis, and reaction mechanisms and the chemistry of carbohydrates, lipids, nucleic acids, amino acids, and proteins. Also includes laboratory techniques of purification, isolation, synthesis, reactions, and spectroscopic analysis.

➤ Course Syllabus for Chemistry 112B

Lecture Instructor: Professor Richard J. Hooley

Required Course Materials for Chemistry 112B

1. Textbook: M. Marsella and C. Switzer, "Organic Chemistry," 1st ed., McGraw-Hill publ. (available on iLearn)
2. D. Mayo, et. al, "Microscale Organic Laboratory- 112B Edition
3. Molecular Models (Darling Organic Chemistry Models)
4. Laboratory Notebook
5. Safety Glasses
6. Lab Apron or Coat (Recommended)

Chemistry 112B Course Schedule

| | |
|-----------------------|---|
| Jan 9 | Course Intro and Review |
| Jan 11, 13 | Chapter 10 IR spectroscopy, UV Spectroscopy, Structural Analysis. |
| Jan 18, 20, 23 | Chapter 11 NMR Spectroscopy – ^1H , ^{13}C NMR, Chemical Shift, Coupling. |
| Jan 25, 27, 30 | Chapter 12 Substitution Reactions |
| Feb 1, 3, 8 | Chapter 13 Properties, formation and reaction of alcohols. |
| Feb 6 | EXAM I Chapters 10 - 12 |
| Feb 10 | Chapter 14 Properties, formation and reaction of ethers, thiols and epoxides. |
| Feb 13 | Chapter 15 Properties, formation and reaction of alkyl halides. |
| Feb 15, 19, 22 | Chapter 16 Properties, formation and reaction of carboxylic acids. |
| Feb 24, 27, 29, Mar 2 | Chapter 17 Substitution Reactions of carboxylic acid derivatives. |
| Mar 5 | Chapters 13 – 17 EXAM II |
| Mar 7, 9, 12, 14 | Chapter 20 Addition reactions to aldehydes and ketones; acetal, imine, enamine formation, Wittig and Baeyer-Villiger reactions. |

| | |
|--------|-----------------------------|
| Mar 16 | Review |
| Mar 20 | FINAL EXAM Chapters 10 – 18 |

Chemistry 112B Laboratory Experiments

- Textbook: Microscale Organic Laboratory Adapted for Use in Chemistry 112B, Mayo, Pike, Trumper eds J. Wiley and Sons “The Organic chem. Lab Survival Manual. J. W. Zubrick, 7th edition John Wiley and Sons
- Laboratory Instructor: Professor Chris Switzer --
Chemical Sciences 436
(951)827-7266
email: christopher.switzer@ucr.edu

Chemistry 112B Experiment Schedule

| Week | Experiment |
|------------|---|
| 1/9 – 1/13 | Laboratory safety & Check-in. You MUST make sure that you have all of the necessary lab equipment and glassware in your assigned drawers before you leave. Reductive Catalytic Hydrogenation of 1-Octene to Octane (25 pts) pp E21-E26. Please be careful as you will only receive 1 balloon and 3 syringes to complete this lab. Do prelab questions 1-4 on p E21 prior to coming to lab. Do postlab questions 6-86 on p E-26. |
| 1/16-20 | Martin Luther King day- NO LABS |
| 1/23-27 | Hydroboration-Oxidation of 1-Octene to 1-Octanol (20 pts) pp E26-E34. Do postlab question 6-87 on pE33. |
| 1/30-2/3 | Diels-Alder Reaction: 9,10-Dihydroanthracene-9,10- α,β -succinic Acid Anhydride (20 pts) pp E34-E39. Do postlab questions 6-102, 6-103, and 6-104 on pp E38-E39. |
| 2/6-10 | Oxidation of Cyclohexanol to Cyclohexanone (20 pts) pp E53-E56. Do the prelab question on p E53. |
| 2/13-17 | Electrophilic Aromatic Substitution: 4-Bromoacetanilide (20 pts) pp E49-E51. Do prelab question 1 on p E49 prior to coming to lab. Do postlab questions 6-180 and 6-183 on p E51. Esterification Using Acidic Resin (25 Points). Pp E1-E3. |
| 2/21-27 | Do postlab question 49-50 on p E3 |
| 2/28-3/5 | Grignard Reaction (Part I): Synthesis of Triphenylmethanol (40 pts) pp E39-E47. (Two lab periods) Disregard the two sentences below the “Alternate Procedure.” Please be careful as you will only receive 2 syringes to complete this lab. Do postlab questions 6-109 and 6-113 on pp E46-E47. |
| 3/6-12 | Grignard Reaction (Part II): Synthesis of Triphenylmethanol. (continuation of previous laboratory experiment). Finish last reports and turn it in. (Check-out for Monday Labs) |
| 3/13-16 | Check out and get last reports returned (TA will be available for office hour) |

I. CHEM 112C. Organic Chemistry (4)

Lecture, 3 hours; laboratory, 4 hours. Prerequisite(s): CHEM 112B with a grade of "C-" or better. Covers modern organic chemistry including structure, nomenclature, reactivity, synthesis, and reaction mechanisms and the chemistry of carbohydrates, lipids, nucleic acids, amino acids, and proteins. Also includes laboratory techniques of purification, isolation, synthesis, reactions, and spectroscopic analysis.

➤ Chemistry 112C Laboratory Experiments Course Syllabus

- Textbooks:

1. Microscale Organic Laboratory: adapted for use in Chem 112C, UCR, Mayo, Pike, Trumper, John Wiley & Sons
2. The Organic Chem Lab Survival Manual: A Student Guide to Techniques, Zubrick, 7th edition, John Wiley & Sons

Laboratory Instructors:

Professor Chris Switzer
Chemical Sciences 1, Room 436
(951) 827-7266;
e-mail: Christopher.switzer@ucr.edu

Lecture Instructors:

Professor Catharine Larsen
Professor Christopher Switzer

Schedule of Experiments for Chemistry 112C

| Week | Experiment |
|-----------|---|
| 3/28-3/31 | Laboratory Safety & Check-in. You MUST make sure that you have all of the necessary lab equipment and glassware in your assigned drawer before you leave. |
| 4/04-4/07 | Synthesis of Dibenzalacetone; 10pts, pp E4-E9. |
| 4/11-4/14 | Identification of Carbohydrates by Chemical Tests; 15pts, pp E51-E56. Do prelab questions on p E53 and p E55. |
| 4/18-4/21 | Qualitative Identification of Organic Compounds; 10pts, Chapter 10: pp 702-717. Read pp E0-E2. Solubility, Lucas Test, Chromic Anhydride Test. Do Prelab Question 10-7 on p 726 |
| 4/25-4/28 | Qualitative Identification of Organic Compounds; 10pts, Chapter 10: pp 702-717. Read pp E0-E2. Hinsberg Test, 2,4-Dinitrophenylhydrazine test, and Benedicts test. Do Prelab Question 10-9 on p 726 |
| 5/02-5/05 | Identification of General Unknowns; 30pts/unknown, Chapter 10 (Three lab periods) |
| 5/09-5/12 | Identification of General Unknowns; Chapter 10. |
| 5/16-5/19 | Identification of General Unknowns; Chapter 10. |
| 5/23-5/26 | Nylon 66; 15pts, pp E44-E50. Do prelab queries 1 and 2 on p E44. Do postlab questions 8-42 and 8-43 on pp E48-E49 Turn in reports at the end of the lab period. Monday does Check-out |
| 5/30-6/02 | Check out and get returned labs. TA will be available for questions. (Monday is a Holiday) |

II. Physics Courses

A. PHYS 040A. General Physics (5)

Lecture, 3 hours; discussion, 1 hour; laboratory, 3 hours. Prerequisite(s): MATH 008B with a grade of "C-" or better or MATH 009A with a grade of "C-" or better or MATH 09HA with a grade of "C-" or better; MATH 009B or MATH 09HB (MATH 009B or MATH 09HB may be taken concurrently). Designed for engineering and physical sciences students. Covers topics in classical mechanics including Newton's laws of motion; friction; circular motion; work, energy, and conservation of energy; dynamics of particle systems; collisions; rigid-body motion; torque; and angular momentum. Laboratories provide exercises illustrating experimental foundations of physical principles and selected applications. Credit is awarded for only one of PHYS 002A, PHYS 040A, or PHYS 041A.

➤ Physics 40A Course Syllabus for Winter 2012

Dr. Robert Clare

Course Information:

Web pages: The web pages for this course are on Blackboard: <http://ilearn.ucr.edu/>.
Communication: All communication will be done via Blackboard. Announcements, homework assignments, solutions, etc. will be available there. Check there ASAP, particularly for the first assignment.

Text: The required text is Physics for Scientists and Engineers, A Strategic Approach, 2nd Edition by Randall Knight, published by Pearson/Addison Wesley. Also available is the Student Solutions Manual. This is not required but will be helpful. It is also published by Pearson/Addison Wesley and can be obtained from various online bookstores. The publisher has provided an online site with interactive "ActivPhysics" demos.

Scope of the course: We will be covering chapters 1-12 in the book.

| Chapter | Topic |
|---------|---------------------------------|
| 1 | Concepts of Motion |
| 2 | Kinematics in One Dimension |
| 3 | Vectors and Coordinate Systems |
| 4 | Kinematics in Two Dimensions |
| 5 | Force and Motion |
| 6 | Dynamics I: Motion Along a Line |
| 7 | Newton's Third Law |
| 8 | Dynamics II: Motion in a Plane |
| 9 | Impulse and Momentum |
| 10 | Energy |
| 11 | Work |
| 12 | Rotation of a Rigid Body |

This is 12 chapters, and the quarter is only 10 weeks long, so we will spend on average less than one week per chapter. However, some chapters are longer than others, so our schedule will vary.

Math: We will be using algebra, trig, calculus, and vectors rather freely - math is a tool, much like a language. It will be like taking literature in a foreign language, which up to now you have learned only in class. I realize that the math may be difficult. You must learn to be comfortable with it. I encourage you to take out your old math books and relearn the material if necessary. Without being comfortable with math, you will be lost.

Homework: Using MasteringPhysics: There will be about 2 homework assignments per week. These will be done on-line using MasteringPhysics (<http://www.masteringphysics.com>).

B. PHYS 040B. General Physics (5)

Lecture, 3 hours; discussion, 1 hour; laboratory, 3 hours. Prerequisite(s): MATH 009C or MATH 09HC (may be taken concurrently); PHYS 040A with a grade of "C-" or better. Designed for engineering and physical sciences students. Covers topics in mechanics and thermodynamics including elasticity; oscillations; gravitation; fluids; mechanical waves and sound; temperature, heat, and the laws of thermodynamics; and the kinetic theory of gases. Laboratories provide exercises illustrating the experimental foundations of physical principles and selected applications.

➤ Physics 040B Course Syllabus

Text: "Physics for Scientists and Engineers" (2nd Edition) by Randall Knight

During the quarter we will cover Chapters 13-23 of the text. An approximate list of topics and lectures is listed below. Please note that this is only intended as a guide and we may diverge from this schedule, depending on class needs.

Course Schedule

| Lectures | Chapter & Sections & Topics |
|----------|--|
| 1-2 | Newtonian Gravity Gravitational Potential Satellite Orbits |
| 3-4 | Fluids, Pressure, Buoyancy, Fluid Dynamics |
| 5-6 | Simple Harmonic Motion Energy and Dynamics Pendulum |
| | Damped Oscillations |
| | Driven Oscillations |
| 7-10 | Waves |
| | Sound and Light |
| | Power and Intensity |
| | Doppler Effect |
| | Superposition Standing Waves Interference Beats |
| 11-17 | Solids, Liquids and Gases |
| | Temperature Phase Changes Ideal Gases |
| | Work and Heat |
| | First Law of Thermodynamics |
| | Thermal Properties Calorimetry Specific Heats |
| | Heat Transfer |
| 18 | Molecular Speeds |
| | Pressure and Temperature |
| | Thermal Energy |
| | Second Law of |
| | Thermodynamics |
| 19 | Heat Engines |
| | Refrigerators |
| | Efficiencies |
| | Carnot Cycle |
| 18-19 | Electric Charge |
| | Insulators and Conductors |

| | |
|--|---------------|
| | Coulomb's Law |
| | Field Model |

PHYS 040C. General Physics (5)

Lecture, 3 hours; discussion, 1 hour; laboratory, 3 hours. Prerequisite(s): MATH 009C or MATH 09HC; PHYS 040B with a grade of "C-" or better. Designed for engineering and physical sciences students. Covers topics in electricity and magnetism including electric fields and potential; Gauss' law; capacitance; magnetic fields; Ampere's law; Faraday's law and induction; electromagnetic oscillations; dc and ac current; and circuits. Laboratories provide exercises illustrating the experimental foundations of physical principles and selected applications. Credit is awarded for only one of PHYS 040C or PHYS 041B.

➤ Physics 040C Course Syllabus

Calculus-based Physics course for physical sciences and engineering majors.

-Recommended Text: Fundamentals of Physics, fifth edition by Halliday, Resnick, and Walker; John Wiley & Sons Publishing, Chapters 24 through 33

| Lecture | Topic | Hours |
|----------------|--|--------------|
| 1. | Gauss' Law - Chapter 24 | 2.5 |
| 2. | Electrical Potential - Chapter 25 | 2 |
| 3. | Capacitance - Chapter 26 | 2 |
| 4. | Current and Resistance - Chapter 27 | 2 |
| 5. | Circuits - Chapter 28 | 3 |
| 6. | The Magnetic Field - Chapter 29 | 2.5 |
| 7. | Ampère's Law - Chapter 30 | 2 |
| 8. | Faraday's Law of Induction - Chapter 31 | 5 |
| 9. | Magnetism and Matter, Maxwell's Equations - Chapter 32 | 2 |
| 11. | Electromagnetic Oscillations and Alternating Currents - Chapter 33 | 5 |

III. Biology Courses

A. BIOL 005A. Introduction to Cell and Molecular Biology (4)

Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 05LA (may be taken concurrently); CHEM 001A and CHEM 011A with grades of "C-" or better or CHEM 01HA and CHEM 1HLA with grades of "C-" or better; consent of instructor is required for students repeating the course. An intensive course designed to prepare students for upper-division courses in cell and molecular biology. Covers biochemical, structural, metabolic, and genetic aspects of cells. (Required for Biology majors; recommended for science majors desiring an introduction to biology.) Credit is not awarded for BIOL 005A if it has already been awarded for BIOL 002.

➤ Biology 005A Course Syllabus

Instructor: Dr. Bradley C. Hyman

Course Schedule

| Week | Day | Date | Reading | Lecture Topic | Lecturer |
|------|-----|---------|--------------|---|----------|
| | F | Sept 23 | | Introduction and Expectations | BH |
| 1 | M | Sept 26 | Ch. 2 | Atoms, Molecules and Bonding | BH |
| | W | Sept 28 | Ch. 3 | Water and its Properties | BH |
| | F | Sept 30 | Ch. 4 | Carbon-based life and functional groups | BH |
| 2 | M | Oct 3 | Ch. 5 | Macromolecules I: lipids and carbohydrates | BH |
| | W | Oct 5 | Ch. 5 | Macromolecules II: proteins and nucleic acids | BH |
| | F | Oct 7 | Ch. 7 | Membranes I: Structure | BH |
| 3 | M | Oct 11 | Ch. 7 | Membranes II: Function | BH |
| | W | Oct 13 | Ch. 6 | Cell structure I: Overview | BH |
| | F | Oct 15 | Ch. 6 | Cell structure II: Endomembranes | BH |
| 4 | M | Oct 17 | Ch. 8 | Energy and enzymes | BH |
| | W | Oct 19 | Ch. 9 | Glycolysis and Fermentation | BH |
| | F | Oct 21 | Everything! | In class Midterm I (20% of grade) | |
| 5 | M | Oct 24 | Ch. 9 and 6 | Cellular Respiration | BH |
| | W | Oct 26 | Ch. 10 and 6 | Photosynthesis – light reactions | BH |
| | F | Oct 28 | Ch. 10 | Photosynthesis- light independent reactions | BH |
| 6 | M | Oct 31 | Ch. 16 | (Happy Halloween) DNA as the Genetic Material | SC |
| | W | Nov 2 | Ch. 16 | DNA structure | SC |
| | F | Nov 4 | Ch. 16 | DNA replication | SC |
| 7 | M | Nov 7 | Chs. 12 & 13 | Mitosis and Meiosis | SC |
| | W | Nov 9 | Ch. 15 | Meiosis in inheritance: Genetic crosses | SC |
| | F | Nov 11 | Catch up! | Veterans' Day Holiday | |

| | | | | | |
|----|---|------------------|---|------------------------------------|-------|
| 8 | M | Nov 14 Nov 16 | Ch. 17 Transcription: Gene structure and expression | The Genetic Code | SC SC |
| | F | Nov 18 | Everything! | In class Midterm II (30% of grade) | |
| 9 | M | Nov 21 | Ch. 17 | Translation: Ribosomes and tRNAs | SC |
| | W | Nov 23 | Ch. 17 | Translation: The ribosome cycle | SC |
| | F | Nov 25 | Catch up! | Thanksgiving Holiday! | |
| 10 | M | Nov 28 | Ch. 17 | Mutations and their consequences | SC |
| | W | Nov 30 | Ch. 17 | From Gene to Protein | SC |
| | F | Dec 2 | TBA | Special topics | SC |

From Reece et al., Campbell Biology 9th edition; specific pages covered in each Chapter will be posted on the course web site several days prior to each lecture.

B. BIOL 05LA. Introduction to Cell and Molecular Biology Laboratory (1)

Laboratory, 3 hours. Prerequisite(s): BIOL 005A (may be taken concurrently); consent of instructor is required for students repeating the course. An introduction to laboratory exercises on fundamental principles of and techniques in cell and molecular biology. Illustrates the experimental foundations of the topics covered in BIOL 005A. Credit is not awarded for BIOL 05LA if it has already been awarded for BIOL 002.

➤ Laboratory Syllabus

- * Introductions to lab write-ups are due at the beginning of the lab period. Late papers will not be graded.
- **Lab Exam: To be given on Monday, 3/12 at 7 PM. Seating will be by laboratory section in a room to be announced. I

Laboratory Schedule

| Week | Dates | Lab Topic | Graded Item or Item Due | Possible Points |
|------|-------------|---|--|-----------------|
| 1 | 1/9 – 1/13 | 1. Intro. to Microscopy and Practical Microscope Use. | | |
| 2 | 1/16 – 1/20 | Martin Luther King Day(no labs scheduled) | | |
| 3 | 1/23 – 1/27 | 2. Spectrophotometry & Quantitative Data Analysis. | Lab Quiz – lab 1 + prep. for lab 2. Start Library Exercises (1/23) | 5 |
| 4 | 1/30 – 2/3 | 3. Diffusion, Osmosis and the Permeability of Cell membranes. | | |
| 5 | 2/6 – 2/10 | 4. Hypothesis-Based Inquiries & Intro. Writing Clinic. | Lab Quiz – labs 2&3 + prep. for lab 4. Note: Please bring your texts to lab for reference. | 15 |
| 6 | 2/13 – 2/17 | 5. Enzymes. | Enzyme Introduction due@ lab start.* | 20 |
| 7 | 2/20 – 2/24 | Presidents Day (no labs scheduled) (2/24) | End Library Exercises | |
| 8 | 2/27 – 3/2 | 6. Fermentation and Respiration. | F. & R. Intro. Due @ lab start.* Hand in a copy of graphs & v0 calculations for | 25 10 |

| | | | | |
|--------------------------|-------------|----------------------------|---|-----|
| | | | the Enzyme lab. | |
| 9 | 3/5 – 3/9 | 7. Genetic Transformation. | Hand in a copy of results calculations for the F & R lab. | 10 |
| 10 | 3/12 – 3/16 | No lab exercise this week. | Lab Exam – 7 PM 3/12.** | 100 |
| Library Exercises | | 15 | | |
| Total Lab Points | | 200 | | |

C. BIOL 005B. Introduction to Organismal Biology (4)

Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): BIOL 005A and BIOL 05LA with grades of "C-" or better; CHEM 001A or CHEM 01HA; CHEM 001B or CHEM 01HB; consent of instructor is required for students repeating the course. An intensive course designed to prepare students for upper-division courses in organismal biology. Covers developmental biology, physiology, and regulation at the level of the organism. (Required for Biology majors; recommended for science majors desiring an introduction to biology.) Credit is awarded for only one of BIOL 003 or BIOL 005B.

➤ Biology 005B Course Syllabus

Course Instructors:

Professor: Dr Helen Regan

Office: Speith 3358

Office Phone: 951-827-3961

Email: helen.regan@ucr.edu

Office hours: MW 10am – 11am, or by appointment

Professor: Dr Richard Redak

Office: Entomology 238

Office Phone: 951-827-7250

Email: Richard.redak@ucr.edu

Office hours: MW 11am-noon, or by appointment

Course Description and Objectives

This is an intensive course designed to prepare students for upper-division courses in organismal biology. This course covers developmental biology, physiology, and regulation at the level of the organism. A main objective of the course is for you to learn about the conceptual framework of diversity, form and function.

In order to succeed in your educational and career objectives, you need scientific knowledge and a variety of skills. Therefore, our goal is that at the end of this course you'll be able to:

1. Describe the hierarchical structure of and system of organization of organisms
2. Explain the role evolution plays in the hierarchical structure in the classification of life.
3. Articulate the relationship between function and form in organism structure.
4. Make a scientific argument and support it with appropriate examples or scientific justification.
5. Apply the scientific process.
6. Integrate and build on concepts learnt in Biology.

Course Materials

- Textbook: Biology. 2011. Campbell, Reece, Urry, Cain, Wasserman, Minorsky, & Jackson. Ninth

Edition. Pearson, Benjamin Cummings. San Francisco, CA, USA. Editions 8 and 7 are acceptable.

Course Schedule

| | | | |
|-------------|--|-----------------------|----|
| 9-Jan-2012 | Phylogeny and the Tree of Life | Chapter 26 | HR |
| 11-Jan-2012 | Prokaryotes: Bacteria and Archaea | Chapter 27 | HR |
| 13-Jan-2012 | Protist Life Cycles | Chapter 28 | HR |
| 16-Jan-2012 | Public Holiday | | |
| 18-Jan-2012 | Introduction to Animal Diversity | Chapter 32 | HR |
| 20-Jan-2012 | Invertebrates: Sponges and Cnidarians | Chapter 33 | HR |
| 23-Jan-2012 | Invertebrates: Lophotrochozoans Flatworms, Molluscs, Annelids | Chapter 33 | HR |
| 25-Jan-2012 | Invertebrates: Ecdysozoans & Deuterostomia, Arthropods and echinoderms | Chapter 33 | HR |
| 27-Jan-2012 | Vertebrates I: Chordates, craniates, vertebrates, gnathostomes | Chapter 34 | HR |
| 30-Jan-2012 | Vertebrates II: Tetrapods & Amniotes | Chapter 34 | HR |
| 1-Feb-2012 | Midterm I | | |
| 3-Feb-2012 | Metabolism in Animals | Chapter 40 | RR |
| 6-Feb-2012 | Animal Energetics - Cost of Living | Chapter 41 | RR |
| 8-Feb-2012 | Control Systems 1: Hormones | Chapter 45 | RR |
| 10-Feb-2012 | Control Systems 2: Neurons and synapses | Chapter 48 | RR |
| 13-Feb-2012 | Nervous Systems | Chapter 49 | RR |
| 15-Feb-2012 | Muscles and Movement | Chapter 50. 5 & 50. 6 | RR |
| 17-Feb-2012 | Nutrition and Digestion | Chapter 41 | RR |
| 20-Feb-2012 | Public Holiday | | |
| 22-Feb-2012 | Circulation and Circulatory Systems | Chapter 42 | RR |
| 24-Feb-2012 | Gas Exchange and Transport | Chapter 42 | RR |
| 27-Feb-2012 | Midterm II | | |
| 29-Feb-2012 | Osmoregulation | Chapter 44 | RR |
| 2-Mar-2012 | Plant diversity | Chapter 29 | RR |
| 5-Mar-2012 | Non-seed plants | Chapter 29 | RR |
| 7-Mar-2012 | Seed Plants | Chapter 30 | RR |
| 9-Mar-2012 | Plant Structure | Chapter 35 | HR |
| 12-Mar-2012 | Plant growth | Chapter 35 | HR |
| 14-Mar-2012 | Transport in Plants I | Chapter 36 | HR |
| 16-Mar-2012 | Transport in Plants II | Chapter 36 | HR |

IV. Math Courses

A. MATH 009A. First-Year Calculus (4)

Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 005 with a grade of "C-" or better or equivalent. Introduction to the differential calculus of functions of one variable. Credit is awarded for only one of MATH 008B, MATH 009A, or MATH 09HA.

➤ Math 009A Course Syllabus

- Textbook: David Guichard: Calculus, Late Transcendentals. (This is a free electronic book, available online at http://www.whitman.edu/mathematics/calculus_late/)

| |
|---|
| Analytic Geometry |
| 1.1 Lines |
| 1.2 Distance Between Two Points; Circles |
| 1.3 Functions |
| 1.4 Shifts and Dilations |
| Instantaneous Rate of Change: The Derivative |
| 2.1 The slope of a function |
| 2.2 An example |
| 2.3 Limits |
| 2.4 The Derivative Function |
| 2.5 Adjectives for Functions |
| Rules for Finding Derivatives |
| 3.1 The Power Rule |
| 3.2 Linearity of the Derivative |
| 3.3 The Product Rule |
| 3.4 The Quotient Rule |
| 3.5 The Chain Rule |
| Trigonometric Functions |
| 4.1 Trigonometric Functions |
| 4.2 The Derivative of $\sin x$ |
| 4.3 A Hard Limit |
| 4.4 The Derivative of $\sin x$, continued |
| 4.5 Derivatives of the Trigonometric Functions |
| 4.6 Implicit Differentiation |
| 4.7 Limits revisited |
| Curve Sketching |
| 5.1 Maxima and Minima |
| 5.2 The First Derivative Test |
| 5.3 The Second Derivative Test |
| 5.4 Concavity and Inflection Points |
| 5.5 Asymptotes and Other Things to Look For |
| Applications of the Derivative |
| 6.1 Optimization |

| |
|--------------------------------|
| 6.2 Related Rates |
| 6.3 Newton's Method (Optional) |
| 6.4 Linear Approximations |
| 6.5 The Mean Value Theorem |

B. MATH 009B. First-Year Calculus (4)

Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 008B with a grade of "C-" or better or MATH 009A with a grade of "C-" or better or MATH 09HA with a grade of "C-" or better. Introduction to the integral calculus of functions of one variable. Credit is awarded for only one of MATH 009B or MATH 09HB.

➤ **Math 009B Course Syllabus**

- Textbooks: David Guichard: Calculus, Late Transcendentals. This is a free electronic book, available at <http://mathdept.ucr.edu/pdf/Guichard-Complete.pdf>

| |
|---|
| Integration |
| 7.1 Two Examples |
| 7.2 The Fundamental Theorem of Calculus |
| 7.3 Some Property of Integrals |
| 7.4 Substitution |
| Application of Integration |
| 8.1 Areas between curves |
| 8.2 Distance, Velocity, Acceleration |
| 8.3 Volume |
| 8.4 Average value of a function |
| 8.5 Work |
| Transcendental Function |
| 9.1 Inverse function |
| 9.2 The natural logarithm |
| 9.3 The exponential function |
| 9.4 Other bases |
| 9.5 Inverse Trigonometric Functions |
| 9.6 Hyperbolic Functions |
| Techniques of Integration |
| 10.1 Powers of sine and cosine |
| 10.2 Trigonometric Substitutions |
| 10.3 Integration by Parts |
| 10.4 Rational Functions |
| 10.5 Additional exercises |
| More Applications of Integration |
| 11.1 Center of Mass |
| 11.2 Kinetic energy; improper integrals |
| 11.3 Probability |
| 11.4 Arc Length |
| 11.5 Surface Area |

C. MATH 009C. First-Year Calculus (4)

Lecture, 3 hours;discussion, 1 hour. Prerequisite(s): MATH 009B with a grade of "C-" or better or MATH 09HB with a grade of "C-" or better. Further topics from integral calculus, improper integrals, infinite series, Taylor's series, and Taylor's theorem. Credit is awarded for only one of MATH 009C or MATH 09HC.

➤ Math 009C Course Syllabus

- Textbooks: Stewart: Single Variable Calculus 6th Edition

| |
|--|
| Infinite Sequences and Series |
| 12.1 Sequences |
| 12.2 Series |
| 12.3 The Integral Test and Estimates of Sums |
| 12.4 The Comparison Test |
| 12.5 Alternating Series |
| 12.6 Absolute Convergence and the Ratio and Root Tests |
| 12.8. Power Series |
| 12.9 Representation of Functions as Power Series |
| 12.10 Taylor and Maclaurin Series |
| 12.11 Applications of Taylor Polynomials |
| Further Applications of Integration |
| 9.1 Arc Length |
| 9.2 Area of Surface of Revolution |
| Differential Equations |
| 10.1 Modeling with Differential Equations |
| 10.2 Direction Fields and Euler's Method |
| 10.3 Separable Equations |
| 10.4 Models for Population Growth |
| 10.5 Linear Equations |

D. MATH 010A. Calculus of Several Variables (4)

Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 009B with a grade of "C-" or better or MATH 09HB with a "C-" or better or equivalent. Topics include Euclidean geometry, matrices and linear functions, determinants, partial derivatives, directional derivatives Jacobians, gradients, chain rule, and Taylor's theorem for several variables.

➤ **Math 010A Course Syllabus (by Susan Colley)**

| |
|---|
| Chapter I, Vectors (6 lectures) |
| 1.1 Vectors in Two and Three Dimensions |
| 1.2 More about Vectors |
| 1.3 The Dot Product |
| 1.4 The Cross Product |
| 1.5 Equations for Planes: Distance Problems |
| 1.6 Some n---dimensional Geometry |
| 1.7 New Coordinate Systems |
| |
| Chapter 2, Differentiation in Several Variables (9 lectures) |
| 2.1 Functions of Several Variables; Graphing Surfaces |
| 2.2 Limits |
| 2.3 The Derivative |
| 2.4 Properties (of Derivatives); Higher order Partial |
| 2.5 The Chain Rule |
| 2.6 Directional Derivatives and the Gradient |
| |
| Chapter 3, Vector Valued Functions (6 lectures) |
| 3.1 Parameterized Curves |
| 3.2 Arclength |
| 3.3 Vector Fields, An Introduction |
| 3.4 Gradient, Divergence, Curl, and the Del Operator |
| |
| Chapter 4, Maxima and Minima in Several Variables (6 lectures) |
| 4.1 Differentiation and Taylor's Theorem |
| 4.2 Extrema of Functions |
| 4.3 Lagrange Multipliers |
| |

Note--Instructors are urged to consider assigning a substantial number of the true/false problems that appear as a separate section at the end of each chapter.

The following "optional" parts of sections have been "left out"

"2.4 Newton's Method", "3.1--Kepler's Laws", "3.2--Differential Geometry" The following "optional section" has been "left out"

4.4 Some Applications of Extrema

MATH 010B. Calculus of Several Variables (4)

Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 010A with a grade of "C-" or better or equivalent. Covers vectors; differential calculus, including implicit differentiation and extreme values; multiple integration; line integrals; vector field theory; and theorems of Gauss, Green, and Stokes.

➤ **Math 010B, Vector Calculus, Course Syllabus (by Susan Colley)**

| |
|---|
| Chapter 5, Multiple Integrals (10 lectures) |
| 5.1 Introduction: Areas and Volumes |
| 5.2 Double Integrals |
| 5.3 Changing the Order of Integration |
| 5.4 Triple Integrals |
| 5.5 Change of Variables |
| |
| Chapter 6, Line Integrals (7 lectures) |
| 6.1 Scalar and Vector Line Integrals |
| 6.2 Green's Theorem |
| 6.3 Conservative Vector Fields |
| |
| Chapter 7, Surface Integrals and Vector Analysis (10 lectures) |
| 7.1 Parameterized Surfaces |
| 7.2 Surface Integrals |
| 7.3 Stokes and Gauss's Theorem |
| 7.4 Further Vector Analysis; Maxwell's Equations |
| |
| |
| 5.6 Applications of Integration |

E. MATH 046. Introduction to Ordinary Differential Equations (4)

Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): MATH 009B with a grade of "C-" or better or MATH 09HB with a grade of "C-" or better or equivalent. Introduction to first-order equations, linear second-order equations, and Laplace transforms, with applications to the physical and biological sciences.

➤ **Math 046 Course Syllabus**

This is a course covering the standard basic material of differential equations. Topics covered include first order equations, linear second order equations, Laplace transforms and elementary applications to the physical and biological sciences.

- Textbooks: Schaum’s Outline of Differential Equations, 3ed, by Bronson and Costa.
- An ebook and a Kindle edition are also available.

| Topics | Suggested No. of Weeks Coverage |
|---|--|
| Introduction, First Order Equations | 3 |
| Chapters 1,2, 3, 4, 5, 6 | |
| Applications of First Order Equations | 2 |
| Chapter 7 | |
| Linear Differential Equations | 3 |
| Chapters 8, 9, 10, 11, 12 | |
| Initial Value Problems | 1 |
| Chapter 13 | |
| Application of Second-Order Linear Differential Equations | 1 |
| Chapter 14 | |

Appendix B – Faculty Vitae

Bahman Anvari
Professor II

Education

Ph.D., Bioengineering, Texas A&M University, 1993
M.S., Biomedical Engineering, California State University, Sacramento, 1988
B.A., Biophysics, University of California, Berkeley, 1985

Academic Experience

1993-1995. Postdoctoral Fellow, Beckman Laser Institute & Medical Clinic, UC Irvine.
1995-1996. Whitaker Research Fellow, Harvey Mudd College.
1996-1998. Research Assistant Professor, Harvey Mudd College.
1998-2003. Assistant Professor, Department of Bioengineering, Rice University .
2003-2006. Associate Professor, Department of Bioengineering, Rice University.
2006-2009. Professor I, Department of Bioengineering, UCR.
2008- . Cooperating Faculty, Department of Mechanical Engineering, UCR.
2008- . Participating Faculty, Division of Biomedical Sciences, UCR.
2009- . Professor II, Department of Bioengineering, UCR.

Current Memberships in Professional Organizations

American Association for the Advancement of Science (AAAS), American Chemical Society (ACS), American Society for Laser Medicine and Surgery (ASLMS), Biomedical Engineering Society (BMES), International Society for Optical Engineering (SPIE), Biophysical Society, Optical Society of America (OSA).

Honors and Awards

1996-2000. Principal Investigator, “*Cryogen spray cooling for spatially selective photocoagulation of biological tissues,*” National Science Foundation, Division of Bioengineering and Environmental Systems research grant (CBET-9634110).
1996-2000. Principal Investigator, “*Spatially selective photocoagulation of hypervascular lesions,*” The Whitaker Foundation, Biomedical Engineering Research Grant.
1997-2000. Principal Investigator, “*Spatially selective coagulation of vascular birthmarks,*” National Institute of Heart, Lung, and Blood, Academic Research Enhancement Award (R15-HL058215).
2000-2001. Principal Investigator, “*Spatially selective photocoagulation of hypervascular lesions,*” The Whitaker Foundation, Transitional Funding.
2001-2006. Principal Investigator, “*Spatially selective coagulation of hypervascular lesions,*” National Institute of Arthritis and Musculoskeletal and Skin Diseases, (1R01-AR47996).
2001-2006. Co-Principal Investigator, “*Mechanics of cochlear outer hair cells,*” National Institute of Deafness and Other Communication Disorders (2R01-DC02775).
2002-2004. Principal Investigator, “*Dermatological laser therapy: advancing the technology to treat patients of all skin types,*” Texas Higher Education Coordinating Board, Technology Development and Transfer grant.
2006-2007. Co-Principal Investigator, “*Modulation of Inner Ear Nanomechanics,*” Department of Defense/Alliance for NanoHealth.

2005-2009. Principal Investigator, “*Membranes as motors: investigating nanoelectromechanical characteristics*,” Biophotonics Partnership Initiative Program, National Science Foundation (CBET-0522862), \$330,000 (9/1/05–8/31/09).

2006-2012. Co-Principal Investigator, “*Outer hair cells electromechanics*,” National Institute of Deafness and Other Communication Disorders (2R01-DC02775).

2008, *Honorary Fellow*, American Institute for Medical and Biological Engineering (AIMBE)

2009-2012. Co-Principal investigator, “MRI: Acquisition of an Ultrafast Spectroscopy System for Biological and Engineering Research,” National Science Foundation (CBET-0923408).

2010, *Honorary Fellow*, American Association for the Advancement of Science (AAAS)

2011-2013. Principal Investigator, “*EAGER: Virus-resembling optical nano-materials for intraoperative ovarian cancer imaging*,” National Science Foundation (CBET-1144237).

Service Activities

Study section member, NIH Special Emphasis Panel for Small Business: Medical Imaging;
Study section member; Member, Biophotonics Panel, NSF; Panel Member, Ovarian Cancer Research Program Teal Innovator and Teal Leverage Award, Congressionally Directed Medical Research Programs, Department of Defense

Selected Publications, Past 5 Years

M. A. Yaseen, J. Yu, M. S. Wong, and B. Anvari, “Stability assessment of indocyanine green within dextran-coated mesocapsules by absorption spectroscopy,” *Journal of Biomedical Optics*, 12(6):064031, 2007.

M. A. Yaseen, J. Yu, M. S. Wong, and B. Anvari, “In-vivo fluorescence imaging of mammalian organs using charge-assembled mesocapsule constructs containing indocyanine green,” *Optics Express*, 16: 20577-20587, 2008.

M. A. Yaseen, J. Yu, B. Jung, M. S. Wong, and B. Anvari, “Biodistribution of encapsulated indocyanine green in healthy mice,” *Molecular Pharmaceutics*, 6: 1321-1332, 2009.

W. E. Brownell, F. Qian, and B. Anvari, “Cell membrane tethers generate mechanical force in response to electrical stimulation,” *Biophysical Journal*, 99: 845-852, 2010.

B. Jung, A. L. Rao, and B. Anvari, “Optical nano-constructs composed of genome-depleted brome mosaic virus doped with a near infrared chromophore for potential biomedical applications,” *ACS Nano*, 22: 1243-1252, 2011.

B. Bahmani, S. Gupta, S. Upadhyayula, V. I. Vullev, and B. Anvari, “Effect of polyethylene glycol coatings on uptake of indocyanine green loaded nanocapsules by human spleen macrophages in-vitro,” *Journal of Biomedical Optics*, 16: 051303, 2011.

B. Jung, and B. Anvari, “Synthesis and characterization of bovine serum albumin-coated nanocapsules loaded with indocyanine green as potential multi-functional nano-constructs,” *Biotechnology Progress*, DOI: 10.1002/btpr.732, 2011.

Selected Professional Development Activities

UC Export Control training, 2011.

Kaustabh Ghosh
Assistant Professor of Bioengineering
MSE 207, 900 University Ave., University of California, Riverside, CA 92521
kghosh@engr.ucr.edu
<http://www.engr.ucr.edu/~kghosh/>

Education

| | | | |
|--------|------------------------|---|------|
| Ph.D. | Biomedical Engineering | SUNY, Stony Brook, NY | 2006 |
| M.S. | Biomedical Engineering | SUNY, Stony Brook, NY | 2002 |
| B.Tech | Chemical Engineering | National Institute of Technology, Warangal, INDIA | 2001 |

Academic Experience

2011 - Assistant Professor II, Department of Bioengineering, UC, Riverside.
2006-2011 Research Fellow, Harvard Medical School and Children's Hospital, Boston

Current Memberships in Professional Organizations

American Heart Association (AHA)
Tissue Engineering and Regenerative Medicine International Society (TERMIS)

Selected Honors and Awards

2011 Lindbergh Lecturer, University of Wisconsin-Madison
2008 NIH/NIBIB T32 Postdoctoral Training Grant
2006 President's Award to Distinguished Doctoral Students, SUNY at Stony Brook
2004 Graduate Student Scholarship, New Jersey Center for Biomaterials
2004 Outstanding Mentor Award, Siemens Foundation

Service Activities

Editorial Board Member, *Journal of Regenerative Medicine and Tissue Engineering*
Ad Hoc Journal Reviewer, *Acta Biomaterialia*, *Journal of Biomedical Materials Research A*
Journal of Investigative Dermatology
Member, *Graduate Admissions Committee, Dept. of Bioengineering, UCR*

Selected Publications (Past 5 years)

Ghosh K, Khajavi M, Adini A (2012, *in press*). Quantitative study of *in vivo* angiogenesis and vasculogenesis using Matrigel-based assays. In: Cuttitta, F. & Zudaire, E. eds. *The Textbook of Angiogenesis and Lymphangiogenesis: Methods and Applications*, Springer Press

Ghosh K, Kanapathipillai M, Korin N, McCarthy J, Ingber DE. (2012) Polymeric nanomaterials for islet targeting and immunotherapeutic delivery. *Nano Letters*; Jan 11; 12(1): 203-8

Pan Z, Ghosh K, Liu Y, Nakamura T, Clark RAF, Rafailovich MH. (2009) Traction stresses and translational distortion of the nucleus during fibroblast migration on a physiologically relevant ECM mimic. *Biophysical Journal*; 96(10): 4286-4298

Ghosh K, Thodeti CK, Dudley AC, Mammoto A, Klagsbrun M, Ingber DE. (2008) Tumor-derived endothelial cells exhibit aberrant Rho-mediated mechanosensing and abnormal angiogenesis in vitro. *Proceedings of the National Academy of Sciences USA*; 105(32): 11305-11310.

Ghosh K, Pan Z, Guan E, Ge S, Liu Y, Nakamura T, Ren X-D, Rafailovich M, Clark RAF. (2007) Cell adaptation to a physiologically relevant ECM mimic with different viscoelastic properties. *Biomaterials*; 28(4): 671-679

Ghosh K and Ingber DE (2007). Micromechanical control of cell and tissue development. Implications for tissue engineering. *Advanced Drug Delivery Reviews*;59(13):1306-1318

Ghosh K, Ren X-D, Shu XZ, Prestwich GD, Clark RAF. (2006) Fibronectin functional domains coupled to hyaluronan stimulate adult human dermal fibroblast responses critical for wound healing. *Tissue Engineering*; 12 (3): 601-613

William H. Grover
Assistant Professor

1. Education –

Ph.D. in Chemistry, University of California, Berkeley, 2006

B.S. in Chemistry, University of Tennessee, Knoxville, 1999

2. Academic experience –

Massachusetts Institute of Technology, Department of Biological Engineering,
Postdoctoral Associate, 2006-2009 (full time).

Massachusetts Institute of Technology, Department of Biological Engineering, Research
Associate, 2009-2012 (full time).

3. Non-academic experience –

Independent consultant, Berkeley, CA and Medford, MA. Assisted several companies in
the design and control of microfluidic instruments. 2000-2009 (part time)

microFluent, Medford, MA. Cofounder of microFluent, a microfluidic device consulting
firm. Provider of device automation and software consulting services to microFluent's
clients. 2009-2012 (part time)

4. Certifications or professional registrations

5. Current membership in professional organizations

6. Honors and awards

Widmer Award for Best Student Poster, The Ninth International Conference on
Miniaturized Systems for Chemistry and Life Sciences (MicroTAS), Boston (2005).

Outstanding Teaching Award for Chemistry 125, University of California, Berkeley
(2001).

7. Service activities (within and outside of the institution)

Outreach coordinator, Physical Sciences-Oncology Center (National Cancer Institute) at
Massachusetts Institute of Technology (2010-2012).

Regular referee for *Lab on a Chip*. Occasional referee for *ACS Nano*, *Analytical
Chemistry*, *Biomicrofluidics*, and *Sensors and Actuators A*.

8. Briefly list the most important publications and presentations from the past five years – title, co-authors if any, where published and/or presented, date of publication or presentation

A microfluidic “baby machine” for cell synchronization. Josephine W. Shaw, Kristofor Payer, Sungmin Son, William H. Grover and Scott R. Manalis, *Lab on a Chip*, in press.

Measuring single cell mass, volume, and density. Invited talk at Pittcon, Orlando, Florida, (2012).

Measuring single-cell density. Talk at the 15th International Conference on Miniaturized Systems for Chemistry and Life Sciences (MicroTAS), Seattle, Washington (2011).

Measuring single-cell density. William H. Grover, Andrea K. Bryan, Monica Diez-Silva, Subra Suresh, John M. Higgins, and Scott R. Manalis. *Proceedings of the National Academy of Sciences of the USA* **108** (27), 10992–10996 (2011).

Using buoyant mass to measure the growth of single cells. Michel Godin, Francisco Feijo Delgado, Sungmin Son, William H. Grover, Andrea K. Bryan, Amit Tzur, Paul Jorgensen, Kris Payer, Alan D. Grossman, Marc W. Kirschner, and Scott R. Manalis. *Nature Methods* **7** (5), 387–390 (2010).

Monolithic Membrane Valves and Pumps. William H. Grover and Richard A. Mathies. Chapter 18 of *Lab on a Chip Technology Vol. 1: Fabrication and Microfluidics*, Keith E. Herold and Avraham Rasooly, editors. Norwich, UK: Caister Academic Press (2009).

Teflon films for chemically- inert microfluidic valves and pumps. William H. Grover, Marcio G. von Muhlen, and Scott R. Manalis. *Lab on a Chip* **8**, 913–918 (2008).

Suspended microchannel resonators for ultra-low volume universal detection. Sungmin Son, William H. Grover, Thomas P. Burg, and Scott R. Manalis. *Analytical Chemistry* **80** (12), 4757–4760 (2008).

9. Briefly list the most recent professional development activities

NA

Jiayu Liao, Ph.D.
Assistant Professor

Education

Ph.D., Biological Chemistry, UCLA, 1999
B.S., Biochemistry, Peking University, 1988

Academic Experience

2006-2007. Assistant Professor II, Department of Bioengineering,UCR.
2007-2008. Assistant Professor III, Department of Bioengineering,UCR
2009-2012. Assistant Professor IV, Department of Bioengineering,UCR
2003-2012. Adjunct Professor, Chinese Academy of Science

Non-Academic Experience

2002-2003. Principle Investigator, Founding Scientist, GPCR platform, The Genomic Institute of
Novartis Research Foundation.
2006-2012. Founder and Director, Argusina Bioscience Inc.

Current Memberships in Professional Organizations

BMES Member
ACS Member
American Diabetes Association
Double Helix Professional Society
Translational Medicine Society

Honors and Awards

1988 Best Graduation Thesis. Department of Biology, Peking University
1988 National Protein Engineering Laboratory Award, P.R. China
1990 Department of Biology Fellowship, UCLA.
2004 Wang Kuan Chen Scholar, Chinese Academic of Science
2006 Outstanding Oversea Scholar, Chinese Natural Science Foundation
2006 UC Regent's Faculty Development Award
2011 Wang Kuan Chen Scholar, Chinese Academic of Science
2011 UCR Living the Promise Featured Faculty
2011 Highlighted in International Innovation Report, Research Media Ltd, UK.

Service Activities

2007 Session Chair, 2007 BMES annual meeting (Bioinformatics & Systems Biology)
2008 Session Chair, 9th UC Systemwide Bioengineering Symposium (2008) (Bioinformatics &
Genomics, Molecular & Cellular Engineering)
2009- Advisory Board, UCR Stem Cell Center
2009 Session Chair, the 10th UC Systemwide Bioengineering Symposium (Bioinformatics &
Genomics)
2009 IEEE EMBS annual meeting (Bioinformatics Algorithms for Genomics, Proteomics,
Metabolomics, and Lipidomics)
2009 NIH Special Emphasis Review Panel (Technology Centers for Networks and Pathways)

2009 Major Grant Final Review Panel of Natural Science Foundation of China
2010 Final Review Panel of Natural Science Foundation of China
2007- 2011 Review Panel of Biotechnology & Health Science, UC Discovery Grant
2010 NIH NIAID ZAI1 LG-M (C1 and C2) Review Panels
2011 NIH SBIR/STTR Review Panel.
2012 NIH SBIR/STTR Review Panel.

Selected Publications, Past 5 Years

1. Liu,Y., Song,Y., Madahar,V., and Liao,J. Quantitative Analysis for Kinetic determinations of SUMO-specific Protease 1. *Anal Biochem.* 2012 Mar 1;422(1):14-21. Epub 2011 Dec 24. PMID: 22244808
2. Zhao,Y.,Pirrung, MC., and Liao,J. A Fluorescent Amino Acid Probe to Monitor Efficiency of Peptide Conjugation to Glass Surfaces for High Density Microarrays. *Mol. Biosys.* 2012 Mar 1;8(3):879-87. PMID:22241083
3. Song,Y., and Liao,J. An in vitro FRET-based high-throughput screening assay for inhibitors of protein-protein interactions in the SUMOylation pathway. *Assay Drug Dev Technol.* 2011 Dec 22. [Epub ahead of print] PMID: 22192309
4. Liu,Y., Song,Y., Jiang,L., and Liao,J. Quantitative analysis of FRET assay in biology. *Frontier in Biology.*Feb. 7(1): 65-72. DOI: 10.1007/s11515-011-1164-0.
5. Liu Q., Li N., Yuan Y., Lu H., Wu X., Zhou C., He M., Su H., Zhang M., Wang J., Wang B., Wang Y., Ma D., Ye Y., Weiss HC., Gesing ER., Liao J. and Wang M. Cyclobutane derivatives as novel non-peptidic small molecule agonists of glucagon-like peptide-1 receptor. *J Med Chem.* 2011 Nov 21. PMID: 22103243
6. Zhao, Y., Liu Y., Lee I., Song Y., Qin X., Zaera F., Liao J.. (2011) Chemoselective fabrication of high density peptide microarray by hetero-bifunctional tetra(ethylene glycol) linker for click chemistry conjugation. *J Biomed Mater Res A.* 2012 Jan;100(1):103-10. Epub 2011 Oct 11. PMID: 21987481.
7. Zhao,Y., and Liao,J.(2011) Feasible Synthesis of the GPR40 Antagonist by Constructing 2-Thiouracil Ring via Acid Mediated Cyclization. *Heterocycles.* 83(5):1145-1151. PMID:21776181
8. Song,Y., Madahar,V., and Liao,J.(2010) Development of FRET assay into quantitative and high-throughput screening technology platforms for protein-protein interactions. *Ann Biomed Eng.* 2011 Apr;39(4):1224-34. Epub 2010 Dec 21. PMID: 21174150; PMCID: PMC3069323
9. Zhou, J., Su,P., Wang, L., Chen,J., Zimmermann,M., Genbaces,O., Afonja,O., Horne,M., Tanaka,T., Duan,E., Fisher, J.,Liao,J., SL., Chen, and Wang,F. (2009). mTOR supports long-term self-renewal and suppresses medoderm and endoderm activities of human embryonic Stem cells *Proc. Natl. Acad. Sci. USA.* 106:7840-7845. PMID: 19416884; PMCID: PMC2683106
10. He,M., Su,H., Gao,W., Johansson,S, Liu,Q., Wu,X.,Liao,J, Young,AA, Bartfai,T, Wang,M.(2010) Reversal of Obesity and Insulin Resistance by a Non-Peptidic Glucagon-Like Peptide-1 Receptor Agonist in Diet-Induced Obese Mice. *PLoS ONE.* 5(12): e14205 PMID:21151924; PMCID: PMC2997064

Selected Professional Development Activities

UCSD Clinical Trail Training 2005
UC Export Control training in 2011.

Huinan Liu
Assistant Professor

Education

Ph.D., Biomedical Engineering, Brown University, 2008
M.S., Materials Science and Engineering, Purdue University, 2005
B.S./M.S., Materials Science and Engineering, Materials Processing Specialty, University of Science and Technology Beijing, 2000

Academic Experience

2009-2010. Research Assistant Professor, Department of Bioengineering, University of Pittsburgh

2011-now. Assistant Professor II, Department of Bioengineering, Materials Science and Engineering, at UCR

Non-Academic Experience (Full Time)

2000-2003. Research Engineer, Laboratory of Titanium Alloys, Institute for Nonferrous Metals, Beijing, China

2008-2009. Senior Scientist, Principal Investigator of Biomedical Sector, NanoMech Corporation, Fayetteville, AR.

Certifications or Professional Registrations

Teaching Certificate I, II and III, The Harriet W. Sheridan Center for Teaching and Learning in Higher Education, Brown University, Providence, RI, 2006-2008

Current Memberships in Professional Organizations

Secretary/Treasurer of Nanomaterials Special Interest Group (Nano SIG), Society for Biomaterials, Elected 2011-.

Member of ASME (American Society of Mechanical Engineers), 2009-present

Member of Sigma Xi (The Scientific Research Society), 2008-present

Member of MRS (Materials Research Society), 2005-present

Member of BMES (Biomedical Engineering Society), 2005-present

Member of SFB (Society for Biomaterials), 2005-present

Recent Selected Honors and Awards

2011 National Science Foundation BRIGE Award.

International Journal of Nanomedicine Certificate of Merit Award, October, 2011. Presented at 2011 Biomedical Engineering Society Annual Meeting in Hartford, CT.

MARC/SRC Faculty Travel Award, Federation of American Societies for Experimental Biology (FASEB), September 2011.

Acta Annual Award for Primary Contributions to the Paper Published in Acta Biomaterialia, The Acta Journals, 2009.

Graduate Excellence in Materials Science (GEMS) Award, The American Ceramic Society, 2008.

The Joukowsky Family Foundation Outstanding Dissertation Award, Brown University, 2008.

Service Activities

Symposium co-Chair and Organizer. 46: Translating Emerging Biomaterials to Clinical Applications, *2012 World Bio materials Congress*, Chengdu, China, June 2012.

Track Organizer and Session Chair. Nanoengineering for Regenerative Medicine, *2011 ASME Annual Meeting*, Denver, CO, October 2011.

Symposium Organizer and Tutorial Instructor. Symposium YY: Compatibility of Nanomaterials, *2009 MRS Fall Meeting*, Boston, MA, December 2009.

Journal Manuscript Reviewer, JBMR, Biomaterials, Nanomedicine, etc.

Bioengineering Graduate Admission Committee, August 2011-.

MSE Academic Review Committee, member, June 2011-.

MSE Graduate Program Review, member, June 2011-

Contributing ideas to ALPHA center/Society of Women Engineers (SWE) NanoDays Public Educational Program, February 2011.

Served the Career Fair Booth for Bioengineering Faculty Recruitment at the BMES annual meeting, Hartford, CT, October 2011.

Served the Student Recruitment Booth at the BMES annual meeting, Hartford, CT, October 2011.

Recent Selected Publications (out of 22 Journal Articles, 2 books, 6 book chapters, 46 conference abstracts)

21. Guan R, Johnson I*, Cui T, Zhao T, Zhao Z, Li X, and **Liu H**. Electrodeposition of Hydroxyapatite Coating on Mg-4.0Zn-1.0Ca-0.6Zr Alloy and In Vitro Evaluation of Degradation, Hemolysis and Cytotoxicity. *Journal of Biomedical Materials Research Part A*. 100A: 999-1015, 2012.
20. Johnson I*, Perchy D*, **Liu H**. In vitro Evaluation of the Surface Effects on Magnesium-Yttrium Alloy Degradation and Mesenchymal Stem Cell Adhesion. *Journal of Biomedical Materials Research*. Available online (DOI: 10.1002/jbm.a.33290) 29 November 2011.
19. Lock JY*, **Liu H**. Nanomaterials Enhanced Osteogenic Differentiation of Human Mesenchymal Stem Cells Similar to a Short Peptide of BMP-7. *International Journal of Nanomedicine*. 6: 2769-2777, 2011.
18. **Liu H**. The Effects of Surface and Biomolecules on Magnesium Degradation and Mesenchymal Stem Cell Adhesion. *Journal of Biomedical Materials Research Part A*. 99A: 249-260, 2011.
17. **Liu H** and Webster TJ. Enhanced Biological and Mechanical Properties of Well-Dispersed Nanophase Ceramics in Polymer Composites: From 2D to 3D Printed Structures. *Materials Science and Engineering: C*. 31(2): 77-89, 2011.
16. **Liu H** and Webster TJ. Mechanical Properties of Dispersed Ceramic Nanoparticles in Polymer Composites for Orthopedic Applications. *International Journal of Nanomedicine*. 5: 299-313, 2010. (PMID: 20463945)
15. **Liu H** and Webster TJ. Ceramic/Polymer Nanocomposites with Tunable Drug Delivery Capability at Specific Disease Sites. *Journal of Biomedical Materials Research Part A*. 93(3): 1180-1192, 2010. Epub ahead of print, Sep 23, 2009. (PMID: 19777574)

Selected Professional Development Activities

UC Export Control training in 2011

UCR Proposal Workshop 01/2012

Julia Lyubovitsky
Assistant Professor

Education

Ph.D., Chemistry, Caltech, 2003

B.S., Chemistry, NYU, 1997

Transfer Credits, MS. Tech, Chemical Engineering, Moscow State Academy of Light Industry, Novosibirsk Institute of Technology, 1991 – 1994.

Academic Experience

1997 – 2003. Graduate Student, Caltech.

2003 – 2007. Hewitt Medical Fellow, Beckman Laser Institute, UCI.

2007– present. Assistant Professor, Department of Bioengineering UCR.

Non-Academic Experience

National Institutes of Health, NCRR, Biomedical Engineering and Instrumentation Program, Biomedical Engineer, summer research position; Surface Plasmon Resonance (SPR).

Certifications or Professional Registrations

N/A

Current Memberships in Professional Organizations

American Chemical Society (ACS), AIChE, Biophysical society, SPIE

Honors and Awards

UC Riverside Faculty

2009 – 2014 NSF CAREER Award

2009 – 2011 NSF BRIGE Grant

2009 – 2010 UC Regents' Faculty Fellowship

Postdoctoral

2005 Finalist in the 2005 Burroughs Wellcome Fund “Career Award at the Scientific Interface” competition

2004 Mauna Kea Technologies Young Investigator Travel Award, Society of Molecular Imaging

2003 – 2006 Hewitt Medical Fellowship, Beckman Laser Institute, UC Irvine

Predoctoral

2000 – 2002 NIH Traineeship, California Institute of Technology

1997 – 2000 NSF Graduate Fellowship Award

1999 Dow Travel Award, California Institute of Technology

Undergraduate

1996 NSF Undergraduate REU Fellow at University of Southern California

1996 – 1997 George Granger Brown Award in Chemistry for Academic Excellence

1995 NSF Undergraduate Fellow at New York University

1995 – 1997 New York University College of Arts and Science Merit Scholarship

1995 – 1997 Jewish Foundation for Education of Women Scholarship

A member of Phi Beta Kappa and Phi Lambda Upsilon Chemical Honor Society

Selected Service Activities

National Panel Review Service: NIH and NSF; Chair and Co-Char at the ACS Meetings, UC Wide Bioengineering Symposia; reviewer for *Annals of Biomedical Engineering*, *Journal of Biomedical Optics*, *Acta Biomaterialia*, *Biomacromolecules*, *Investigative Ophthalmology & Visual Science*; UCR panelist at the “Wow! That’s Engineering!” event, an invited speaker at the Bourns Space Science and Engineering Day hosted by the Society of Women Engineers, Development and Communications Committee, bioengineering graduate admissions committee

Selected Publications, Past 5 Years

Publications

- [1] Yu-Jer Hwang, Joseph Granelli and **Julia G. Lyubovitsky**, “The effects of zero- and non-zero length cross-linking reagents on the optical spectral properties and structures of collagen hydrogels,” *Applied Materials and Interfaces*, 4, 261–267 (2012)
- [2] Yu-Jer Hwang, Jillian Larsen, Tatiana B. Krasieva and **Julia G. Lyubovitsky**, “The effect of genipin crosslinking on the micro- and nano-structure of collagen hydrogels,” *Applied Materials and Interfaces*, 3, 2579-84 (2011)
- [3] Yu-Jer Hwang, Joseph Granelli and **Julia G. Lyubovitsky**, “Multiphoton Optical Image Guided Spectroscopy Method for Characterization of Collagen-Based Materials Modified by Glycation,” *Analytical Chemistry* 83 (1), 200–206 (2011)
- [4] Yu-Jer Hwang and **Julia G. Lyubovitsky**, “Collagen hydrogel characterization: multi-scale and multi-modality approach,” *Analytical Methods* 3,529-536 (2011), *featured on the inside cover*
- [5] Yu-Jer Hwang, Nomiki Kolletis, Miso Yang, Edgar Sanchez, Chung-ho Sun, Elizabeth R. Gillard, Bruce J. Tromberg, Tatiana B. Krasieva and **Julia G. Lyubovitsky**, “Multi-photon Imaging of Actin Filament Formation and Mitochondrial Energetics of Human ACBT Gliomas,” *Photochemistry and Photobiology*, 87, 408-417 (2011)

Presentations

Materials Research Society (MRS) Annual Meeting, Biomaterials, Boston, MA November 2011; Talk:” Effects of Different Length Cross-Linking Reagents on the Optical Spectral Properties and Structures of Collagen Hydrogels.

AIChE Annual Meeting, Materials Engineering and Sciences Division, Biomaterial Scaffolds for Tissue Engineering I, **Minneapolis, MN October 2011; Talk:” Characterizing Collagen Hydrogels for Tissue Engineering Applications”**

Beckman Laser Institute, LAMMP Seminar, UC Irvine, Irvine, CA, December 2010; Invited Talk: “Natural Materials Design: Engineering Materials that Work”

American Chemical Society Meeting (ACS), Philadelphia, PA 2008; Invited Talk: “Understanding Cellular Responses: Multi-photon imaging of actin filament formation and mitochondrial energetics of ACBT gliomas”; Invited Talk: “Dermal Structural Assembly in normal and pathological connective tissues by intrinsic signal multi-photon microscopy”

Selected Professional Development Activities

2011 UC Export Control training

Dimitrios Morikis
Professor of Bioengineering STEP III

Education

B.S., Physics, Aristotle University of Thessaloniki, Greece, 1983
M.S., Physics, Northeastern University, 1985
Ph.D., Physics, Northeastern University, 1990
Postdoctoral Fellow, Structural Biology, The Scripps Research Institute, 1990-1993
NIH Senior Postdoctoral Fellowship, Computational Chemistry, UCSD, 1999-2001

Academic Experience

2006- , Professor, Department of Bioengineering, UCR.
Other Appointments/Affiliations (2001-2012): 2008- , Faculty, Center for Bioengineering Research, UCR; 2008- . Faculty, Graduate Program in Biomedical Sciences, UCR; 2007- , Cooperating Faculty Member, Department of Chemistry, UCR; 2007- , Faculty Member, Materials Science and Engineering Program, UCR; 2007- , Faculty, Center for Research in Intelligent Systems (CRIS), Bourns College of Engineering, UCR; 2005- , Member, Center for Plant Cell Biology (CEPCEB), College of Natural and Agricultural Sciences, UCR; 2001- , Participating Researcher, Institute for Integrative Genome Biology (IIGB), UCR; 2003-2007, Adjunct Associate Professor, Division of Immunology and Department of Neurobiochemistry, Beckman Research Institute, City of Hope Medical Center, Duarte, CA; 2005-2006, Researcher, and 2001-2005 Associate Researcher, Department of Chemical & Environmental Engineering, UCR; 2001-2003, Visiting Scholar, Department of Chemistry & Biochemistry, UCSD.

Current Memberships in Professional Organizations

American Association for the Advancement of Science, American Institute for Medical and Biological Engineering, Biomedical Engineering Society, American Chemical Society, Biophysical Society

Selected Honors and Awards

2011, OCEC (Orange County Engineering Council) Distinguished Engineering Educator Award.
2008, AIMBE Fellow.
2006, AAAS Fellow.
2003-2004, Non-Senate Distinguished Researcher Award, UCR.
1999-2001, NIH National Research Service Award-Senior Fellowship, Department of Chemistry and Biochemistry, UCSD.
1993, The Scripps Society of Fellows Award for best presentation at the Scripps Society of Fellows Annual Research Symposium.
1983-1984, Fulbright Scholar to pursue graduate studies in physics in USA, Northeastern University, Boston, MA.

Service Activities

Editorial. 2011-, Co-Section Editor (Computational and Theoretical Biophysics Section), *BMC Biophysics*; 2008-, Contributing Faculty Member in “Faculty of 1000 Biology”; 2007-, Founding Faculty Advisory Board, *UCR Undergraduate Research Journal*; 2009-, Editorial Advisory

Board Member, *The Open Bioinformatics Journal*; 2009-, Editorial Board Member, *Molecular Biology International*.

Conference Organizations. 2003, Member of organizing committee for the “2nd Workshop on complement associated diseases, animal models, and therapeutics”, Myconos, Greece; 2005, Co-organizer (with AK Rizos) of the workshop “Immunophysics: dynamics and biomolecular function” at the 5th International Discussion Meeting on Relaxations in Complex Systems (5IDMRCS), Lille, France; 2008, Scientific Program Subcommittee Chair, 9th Annual University of California Systemwide Bioengineering Symposium, UCR; 2009, Co-organizer (with AK Rizos) of Special Focus Sessions “Frontiers In Biophysics I and II” at the 6th International Discussion Meeting on Relaxations in Complex Systems (6IDMRCS), Rome, Italy; 2009, Co-organizer (with L Mueller, C Larive, D Borchardt) of the Southern California Users of Magnets (SCUM) meeting, UCR.

Panels. NIH: 11/13/2006, Member, Biophysical and Biomedical Sciences Fellowship Panel ZRG1 F04BN 20; 8/8/2008, Member, Special Emphasis Panel, Scientific Review Group ZRG1 BST-Q (02), Special Reviews in Bioengineering; 7/21-22/2009, Chair, Review Panel of ARRA Competitive Revision Applications ZRG1 BST-N (96); 6/27-28/2011, Member, Scientific Review Group ZRG1 F04B-D 20 L, Fellowship, Biophysical and Biochemical Sciences. BIMR (Beckman Initiative for Macular Research): Panel Member for 3 years (2010-2012), The 2nd, 3^d, and 4th Annual Conferences, Beckman Center, Irvine, CA. Panels: Roles of complement system and other immune-mediated and immune-dependent pathways in the development and progression of age-related macular degeneration, and Inflammation.

Selected Recent Campus and System-Wide Service. 2005-2006, UCR Chancellor’s Advisory Committee on Non-Senate Academic Affairs, Chair in 2006; 2005-2006, Founding Faculty, Department of Bioengineering; 2006-2012, Member, Bioengineering Hiring Committee, Chair in 2007-2012; 2007-2012, Organizer, Department of Bioengineering Colloquium and Distinguished Speaker Series; 2008-2009, Member, College of Engineering Committee to evaluate the undergraduate math curriculum for engineering students; 2008-2009, Member, Steering Committee, Bioengineering Institute of California (BIC), a UC Multi-Campus Research Unit; Fall 2010, Acting Graduate Advisor; 2010-, Member, Graduate Admissions Committee; 2011-, Campus Scholarship of Teaching and Learning Committee.

Selected Publications, 5 recent publications out of a total of 105

1. Gorham RD Jr, Kieslich C, Morikis D (2012) Complement inhibition by *Staphylococcus aureus*: electrostatics of C3d-EfbC and C3d-Ehp association, *Cellular and Molecular Bioengineering*, In press – available online. DOI: 10.1007/s12195-011-0195-6.
2. Gorham RD Jr, Kieslich CA, Morikis D (2011) Electrostatic clustering and free energy calculations provide a foundation for protein design and optimization, *Annals of Biomedical Engineering* 39:1252-1263.
3. López de Victoria A, Gorham RD Jr, Bellows-Peterson ML, Ling J, Lo D, Floudas CA, Morikis D (2011) A new generation of potent complement inhibitors of the compstatin family, *Chemical Biology & Drug Design* 77:431-440.
4. Kieslich C, Vazquez H, Goodman GN, López De Victoria A, Morikis D (2011) The effect of electrostatics on Factor H function and related pathologies, *Journal of Molecular Graphics and Modeling* 29:1047-1055.
5. Hakkoymaz H, Kieslich CA, Gorham RD Jr, Gunopulos D, Morikis D (2011) Electrostatic similarity determination using multi-resolution analysis, *Molecular Informatics* 30:733-746.

Jin Nam
Assistant Professor II

Education

Ph.D., Materials Science and Engineering, The Ohio State University, 2006
M.S., Materials Science and Engineering, The Ohio State University, 2001
B.S., Ceramic Engineering, Yonsei University, 1999

Academic Experience

2008-2010. Research Assistant Professor, College of Dentistry, The Ohio State University
2011-present. Assistant Professor, Department of Bioengineering, University of California-Riverside

Current Memberships in Professional Organizations

Editorial board: *Journal of Regenerative Medicine and Tissue Engineering*
Associate Faculty Member of *Faculty of 1000 Medicine (F1000)*: Cartilage Biology and Osteoarthritis section
Member: *Tissue Engineering and Regenerative Medicine International Society (TERMIS)*
Member: *Society for Biomaterials (SFB)*
Member: *Osteoarthritis Research Society International (OARSI)*
Member: *Orthopaedic Research Society (ORS)*

Honors and Awards

Dean's Award for Excellence in Research – College of Dentistry, The Ohio State University (2011)
Young Investigator Award – *Osteoarthritis Research Society International* (2010)
Ruth L. Kirschstein National Research Service Award (2010)
Young Investigator Award – *Osteoarthritis Research Society International* (2007)
The Honor Society of Phi Kappa Phi (2004)
The International Honor Society of Alpha Sigma Mu (2001)

Service Activities

Reviewer for the journals *PLoS ONE*, *Biomaterials*, *Acta Biomaterialia*, *Annals of Biomedical Engineering*, *Journal of Orthopaedic Research*, *Nanotechnology*, *International Journal of Molecular Sciences*

Selected Publications, Past 5 Years

- J. Nam**, P. Perera, J. Liu, B. Rath, J. Deschner, R. Gassner, T. Butterfield and S. Agarwal, Regulation of transcriptome-wide gene expression during the progression of monoiodoacetate-induced arthritis, *PLoS ONE* 6(9), e24320 (2011)
- B. Rath*, **J. Nam***, J. Deschner, J. Schaumburger, M. Tingart, S. Grassel, J. Grifka and S. Agarwal, Biomechanical forces exert anabolic effects on osteoblasts by activation of SMAD 1/5/8 through type 1 BMP receptor, *Biorheology* 48(1), 37-48 (2011, *: contributed equally)
- J. Nam**, P. Perera, J. Liu, L. Wu, T. Butterfield and S. Agarwal, Transcriptome-wide gene regulation by gentle treadmill walking during the progression of monoiodoacetate induced arthritis, *Arthritis and Rheumatism* 63(6), 1613-25 (2011)-featured on journal cover
- J. Nam**, J. Johnson, J. Lannutti and S. Agarwal, Modulation of embryonic mesenchymal progenitor cell differentiation via control over pure mechanical modulus in electrospun nanofibers, *Acta Biomaterialia* 7(4), 1516-24 (2011)
- P. Perera, E. Wypasek, S. Madhavan, B. Rath-Deschner, J. Liu, **J. Nam**, B. Rath, M. Anghelina, Y. Huang, J. Deschner, N. Piesco, C. Wu and Agarwal S, Integrin-linked kinase, H-RAS, ERK 1/2-dependent mechanosignaling mechanisms control *Sox-9*, *Vegf* and *c-Myc* expression and cell proliferation in articular chondrocytes, *Arthritis Research and Therapy* 12(3), R106 (2010).
- J. Nam**, B. Aguda, B. Rath and S. Agarwal, Biomechanical thresholds regulating inflammation through the NF- κ B pathway: experiments and modeling, *PLoS ONE* 4(4) e5262 (2009).
- A. Veleva, D. Heath, J. Johnson, **J. Nam**, C. Patterson, J. Lannutti and S. Cooper, Interactions between endothelial cells and electrospun methacrylic terpolymer fibers for engineered vascular replacements, *Journal of Biomedical Materials Research A* 91A(4), 1131-1139 (2009).
- Y. Zhao, H. Zeng, **J. Nam** and S. Agarwal, Fabrication of skeletal muscle constructs by topographic activation of cell alignment, *Biotechnology and Bioengineering* 102(2), 624-31 (2009)-featured on journal cover.
- J. Nam**, B. Rath, T. Knobloch, J. Lannutti and S. Agarwal, Novel electrospun scaffolds for the molecular analysis of chondrocytes under dynamic compression, *Tissue Engineering* 15(3), 513-23 (2009).
- B. Rath, **J. Nam**, J. Lannutti and S. Agarwal, Compressive forces induce osteogenic gene expression in calvarial osteoblasts, *Journal of Biomechanics* 41(5), 1095-103 (2008).
- T. Knobloch, S. Madhavan, **J. Nam**, S. Agarwal Jr. and S Agarwal, Regulation of chondrocytic gene expression by biomechanical signals, *Critical Reviews in Eukaryotic Gene Expression* 18(2), 139-150 (2008).
- J. Nam**, Y. Huang, S. Agarwal and J. Lannutti, Materials selection and residual solvent retention in biodegradable electrospun fibers, *Journal of Applied Polymer Science*, 107(3), 1547-1554 (2008).
- J. Nam**, Y. Huang, S. Agarwal and J. Lannutti, Improved cellular infiltration in electrospun fiber via engineered porosity, *Tissue engineering*, 13(9), 2249-2257 (2007).

Selected Professional Development Activities

UC Export Control training in 2011.

B. Hyle Park
Assistant Professor

Education

- 2005 Ph.D., Physics, University of California, Irvine.
- 2000 M.S., Physics, University of California, Irvine, 2000
- 1996 B.S., Physics, California Institute of Technology, 1996

Academic Experience

- 2005-2007. Postdoctoral Fellow, Wellman Center for Photomedicine, Massachusetts General Hospital and Harvard Medical School.
- 2007-2008. Instructor, Wellman Center for Photomedicine, Massachusetts General Hospital and Harvard Medical School.
- 2009-present. Assistant Professor, Department of Bioengineering, University of California, Riverside.

Non-Academic Experience

- 1995-1996. Full time, Community service. AmeriCorps (Building Up LA).
- 1996-1997. Full time. Head Programmer. cdromnow (Manhattan Beach, CA).
- 1997-2000. Part time. Instructor. Elite Educational Institute (Irvine, CA).
- 2007. Part time. Mentor. HST Summer Institute in Biomedical Optics (Cambridge, MA).

Current Memberships in Professional Organizations

- Biomedical Engineering Society (BMES)
- International Society for Optics and Photonics (SPIE)

Honors and Awards

- NIH Pathway to Independence (PI) Award in 2007.
- Orange Country Engineering Council Outstanding Engineering Educator Award in 2012.

Service Activities

- Enrolled Graduate Student Advisor
- Ad hoc manuscript review for Journal of Biomedical Optics, Optics Express, Optics Letters, Annals of Biomedical Engineering
- Faculty Advisor for the local student chapter of the Biomedical Engineering Society Session Chair, 5th Frontiers in Biomedical Devices Conference & Exhibition of the American Society of Mechanical Engineers (ASME), Newport Beach, CA. Sept 21, 2010.

Selected Publications, Past 5 Years

1. Park BH, de Boer JF, "Polarization-Sensitive Optical Coherence Tomography," Optical Coherence Tomography: Technology and Applications, W. Drexler, J.G. Fujimoto (Eds.), 2008.
2. Kim KH, Park BH, Tu Y, Hasan T, Lee B, Li J, de Boer JF. Polarization-sensitive optical frequency domain imaging based on unpolarized light. Opt Express. 2011 Jan 17;19(2):552-61.

3. M. S. Islam, E. Freeman, Y. Wang, C. Oh, J. F. de Boer, B. H. Park, "Non-contact detection of functionally stimulated nerve activity using spectral domain optical coherence tomography," SPIE Photonics West 2010, San Francisco, CA, January 2010.
4. M. Oliveira, C.M. Oh, Y. Wang, A. Ortega, B. H. Park, "Endoscopic Optical Coherence Tomography and Structural Examination of Peripheral Nerves," Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) National Conference, Anaheim, CA, September 2010.
5. MS Islam, MC Oliveira, Y Wang, FP Henry, MA Randolph, BH Park, JF de Boer, "Extracting structural features of rat sciatic nerve using polarization-sensitive spectral domain optical coherence tomography," Journal of Biomedical Optics (under review).
6. Y Wang, MC Oliveira, CM Oh, MS Islam, A Ortega, BH Park, "GPU accelerated real-time multi-functional spectral-domain optical coherence tomography," Optics Express (under review).

Selected Professional Development Activities

- UC Export Control Training in 2011.

Victor G. J. Rodgers
Professor

Education

D.Sc., Chemical Engineering, Washington University, 1989
M.S., Chemical Engineering, University of Pittsburgh, 1985
B.S., Chemical Engineering, University of Dayton, 1980

Academic Experience

1989 – 1995 Assistant Prof., Dept. Chemical and Biochemical Engineering, Univ. of Iowa.
1995 – 2003 Associate Prof., Dept. Chemical and Biochemical Engineering, Univ. of Iowa.
2003 – 2005 Professor, Dept. Chemical and Biochemical Engineering, Univ. of Iowa.
2006 – Professor, Department of Bioengineering, University of California, Riverside
2011 – Chair, Department of Bioengineering, University of California, Riverside.

Non-Academic Experience

6/80 – 9/81 Engineer, Gulf Refining & Marketing Company, Philadelphia Refinery, Technical Services Department, Operations Department, Philadelphia, PA
9/81 – 9/82 Engineer, Gulf Research & Development Company, Refining Services Department, Hydrogenation Process Development, Pittsburgh, PA
9/82 – 8/83 Engineer, Gulf Research & Development Company, Systems and Controls Department, Pittsburgh, PA, Granted educational leave-of-absence

Current Memberships in Professional Organizations

1980 – Member, American Institute of Chemical Engineering, AIChE
2006 – Member American Association for the Advancement of Science, AAAS
2006 – Member, American Chemical Society
2007 – Member, Biomedical Engineering Society, BMES
2008 – Member, American Institute for Medical and Biological Engineering

Recent Honors and Awards

2007 AAAS Fellow (American Association for the Advancement of Science)
2009 AIMBE Fellow (American Institute for Medical and Biological Engineering)
2010 Faculty Mentor of the Year 2009-2010, University Honors Program
2010 Distinguished Engineering Educator Award presented by the Engineers Council

Service Activities

2007 – 2010 GAANN UCR Engineering: Outreach Coordinator with Mathew Gage Middle School, Riverside, CA
2010 Member, CWOC (Campus Wellness Oversight Committee), UCR

Selected Publications, Past 5 Years

- McBride D, Hsu MS, Rodgers VGJ, Binder DK, “Novel Hollow Fiber-Hydrogel Device Improves Survival Following Cerebral Edema”, accepted, *Journal of Neurosurgery* (2012).
- Buettner GR, Wagner BA, Rodgers VGJ, “Quantitative Redox Biology: An approach to understanding the role of reactive species in defining the cellular redox environment”, *Cell Biochemistry and Biophysics*, December (2011), Online.
- McBride D, Rodgers VGJ, “Obtaining Protein Solvent Accessible Surface Area (SASA) Using Osmotic Pressure”, *AICHE Journal*, (2011), Online.
- Wang Y, Rodgers VGJ, “Electrostatic Contributions to Permeate Flux Behavior in Bovine Serum Albumin Ultrafiltration”, *Journal of Membrane Science*, 366(1-2):184-191 (2011).
- Rajapaksa TE, Bennett KM, Stover-Hamer M, Lytle C, Rodgers VGJ Lo DD, “Intranasal M cell uptake of Nanoparticles is Independently Influenced by Targeting Ligands and Buffer Ionic Strength”, *J. of Biological Chemistry*, 285:23739-23746 (2010).
- Zhao A, Hunter SK, Rodgers VGJ, “Theoretical Prediction of Induction Period from Transient Pore Evolvement in Polyester-Based Microparticles”, *Journal of Pharmaceutical Science*, 99:11, 4477–4487 (2010).
- Wang Y, Rodgers VGJ, “Critical Flux in Protein Ultrafiltration: a New Definition through the Free-Solvent-Based (FSB) Model”, *AICHE Journal*, 56:10 2756–2759 (2010).
- Biglione N, Rodgers VGJ, and Peeples TL, “Determining Design and Scale-up Parameters for Degradation of Atrazine with Suspended *Pseudomonas* sp. ADP in Aqueous Bioreactors”, *Biotechnology Progress*, 24(3) 588-592 (2008).
- Wang Y, Rodgers VGJ, “Free-Solvent Model Shows Osmotic Pressure is the Dominant Factor in Limiting Flux during Protein Ultrafiltration”, *Journal of Membrane Science*, 320 335-343 (2008).
- Ng CF, Schafer FQ, Buettner GR, Rodgers VGJ, “Cellular hydrogen peroxide removal shows dependency on effective GPx activity: Mathematical insight into observed in-vivo behavior”, *Free Radical Research*, 41(11) 1201–1211 (2007).
- Tilakaratne HK, Andracki ME, Yang B, Hunter SK, Rodgers VGJ, “Can Myoglobin-Expression in Pancreatic Beta Cells Improve Insulin Secretion Under Hypoxia? An Exploratory Study with Transgenic Porcine Islets”, *Artificial Organs*, 31(7) 521-531 (2007).
- Tilakaratne HK, Hunter SK, Andracki ME, Benda JA, Rodgers VGJ, “Characterizing Short-Term Release and Neovascularisation Potential of Multi-Protein Growth Supplement from Alginate-Hollow Fiber Devices”, *Biomaterials*, 28(1), 89-98 (2007).

Selected Professional Development Activities

2011 UC Export Control Training.

Jerome S. Schultz, Ph.D.
Distinguished Professor of Bioengineering

Education

| | | |
|---------------------------|-------------------------|------|
| Ph.D. Biochemistry | University of Wisconsin | 1958 |
| M.S. Chemical Engineering | Columbia University | 1956 |
| B.S. Chemical Engineering | Columbia University | 1954 |

Academic Experience

| | | |
|-------------------------------|--------------|---|
| University of Michigan | 1964-1987 | Dept of Chemical Engineering (Chair 1980-87) |
| University of Pittsburgh | 1987-2003 | Director, Ctr. Biotechnology and Bioengineering |
| University of Pittsburgh | 1997-2003 | Chairman, Department of Bioengineering |
| Univ of California, Riverside | 2004-Present | Director, Center for Bioengineering Research |
| Univ of California, Riverside | 2004-2011 | Chair, Department of Bioengineering |

Non-Academic Experience

| | | |
|-----------------------------|-----------|---|
| Lederle Laboratories | 1958-1964 | Group Leader, Biochemical Research |
| National Science Foundation | 1985-1987 | Deputy Director, Div. Cross-Disciplinary Research |
| NASA | 2001-2002 | Div. of Fundamental Biology, Ames Research Ctr |

Current Memberships in Professional Organizations

National Academy of Engineering
American Chemical Society
American Institute of Chemical Engineering
American Institute of Medical and Biological Engineering
American Society of Engineering Education
Biomedical Engineering Society

Honors and Awards

Named one of "100 Chemical Engineers of the Modern Era" Amer. Inst. of Chemical Engineering, 2008
Fellow, Biomedical Engineering Society, 2005
Donald Katz Lectureship, University of Michigan, School of Engineering, 2002
Marvin J. Johnson Biotechnology Award, American Chemical Society, BIOT Division, 2000
University of Pittsburgh Distinguished Service Professor of Engineering, 1999
Fellow, American Association for the Advancement of Science, 1997
Whitaker Plenary Lecturer, American Society for Artificial Internal Organs, 1997
Career Achievement Award, Houston Society for Engineering in Medicine and Biology, 1995
National Academy of Engineering, Member 1994
Founding Fellow, American Institute for Medical and Biological Engineering, 1992
Bioengineering Award, American Institute of Chemical Engineers, 1984
Excellence in Research Award, Univ. of Michigan, College of Engineering, 1983
Ruth Symposium Lecturer, Iowa State University, 1979
NIH Research Career Development Award for Membrane Transport, 1970-1975

Service Activities

Member IOM Review Panel for Federal BioWatch System, 2009-2010
Chair NIH Special Study Section on Point of Care Technologies, 2007
NIH Biomaterials and Biointerfaces Study Section, 2003-2005
NRC Board of Life Sciences – Reviewer for reports, 2004, 2005
Chairman, NSF Panel to Review International Biosensing Research Trends; 2002-
Institute of Medicine, Comm on Response to Chem. and Biological Terrorism Incidents, 1997-9
National Research Council, Vice Chairman, Comm. Chemical and Biological Defense, 1995-8
American Institute for Medical and Biological Engineering, President, 1995
American Chemical Society, Biochemical Technology Division: Chairman, 1974-1975;
Amer. Inst. Chem. Eng., Food, Pharmaceutical and Bioengineering Div.: Chairman, 1969-1970;
NIH Surgery and Bioengineering Study Section, 1984-1988
Gordon Conference on Synthetic Membranes, Chairman 1988, Co-Chair 1986
American Society of Artificial Internal Organs, Program Committee, 1980-1984
NSF Ad-Hoc Committee: Structuring a Professional Society for Bioengineering, 1989-1990

Selected Publications, Past 5 Years

- D. Gao, N. McBean, J. S. Schultz, et al Fabrication of Antibody Arrays Using Thermally Responsive Elastin Fusion Proteins *J. Am. Chem. Soc.*, 128 (3), 676 -677, 2006
- J.S. Schultz. Inside the Cell – A New Paradigm for Unit Operations and Unit Processes? *Chemical Engineering Education*. 40(2): 126-139, (2006).
- J.S. Schultz. Optically-based Affinity Biosensors for Glucose. In *Topics in Fluorescence Spectroscopy*, Volume 11, Glucose Sensing. Springer. (2006), pp 283-310.
- K. Nagamine, S. Shimomura, K. Imai, J.S. Schultz. Probing magnetism in human blood by muon spin relaxation. *Physica B*, 374-375: 444-447 (2006)
- K. Nagamine, K. Shimomura, H. Miyadera, Y.-J. Ki, R.H. Scheicher, T. P. Das and J.S. Schultz. Hemoglobin Magnetism in Aqueous Solution Probed by Muon Spin Relaxation and Future Applications to Brain Research. *Proc. Jpn. Acad., Ser. B83*: 120-126 (2007).
- D. Gao, W. Chen, A. Mulchandani, and J.S. Schultz. (2007) Detection of Tumor Markers Based on Extinction Spectra of Visible Light Passing through Gold Nanoholes, *Applied Physics Letters* (90:073901).
- K. Nagamine, E. Torikai, K. Shimomura, Y. Ikedo, J.S. Schultz. Molecular radiation biological effect in wet protein and DNA observed in the measurements of labeled electron with muons. *Physica B* 404: 953–956 (2009)
- X. Huang, S. Li, J. S. Schultz, Q. Wang, Q. Lin A MEMS Affinity Glucose Sensor Using a Biocompatible Glucose-Responsive Polymer. *Sensors and Actuators B* 140 (2) 603-609, 16 July 2009
- J. Vasquez, A. Vu, J.S. Schultz, V. Vullev. Fluorescence Enhancement of Warfarin Induced by Interaction with β -Cyclodextrin. *Biotechnology Progress*, 25: 906-914 (2009).
- X. Huang; S. Li, J. Schultz, Q. Wang; Q. Lin A Capacitive MEMS Viscometric Sensor for Affinity Detection of Glucose *J. Microelectromechanical Systems*. 18: 1246-1254 (2009) DOI 10.1109/JMEMS.2009.2034869
- X. Huang; S.Li; J.S. Schultz; Q. Wang; Q. Lin. A dielectric affinity microbiosensor *Applied Physics Letters*. 96 (3) 033701 - 033701-3 (2010)

Selected Professional Development Activities UC Export Control training in 2011.

Valentine I. Vullev
Assistant Professor of Bioengineering

Education

Ph.D., Chemistry, Boston University, 2001
B.S., Chemistry and Physics, Keene State College, 1993

Academic Experience

2001-2002, Research Associate, Department of Chemistry, Boston University
2002-2004, Postdoctoral Fellow, Department of Chemistry and Chemical Biology,
Harvard University
2004-2006, Research Associate, Photonics Center, Boston University
2006-present, Assistant Professor, Department of Bioengineering, UCR
2007-present, Assistant Professor, Materials Science and Engineering Program, UCR
2008-present, Cooperating Assistant Professor, Department of Biochemistry, UCR
2010-present, Cooperating Assistant Professor, Department of Chemistry, UCR

Non-Academic Experience

2004-2006, Senior Chemist, PhotoSecure, Inc., Boston, MA

Current Memberships in Professional Organizations

Biomedical Engineering Society, American Society for Microbiology, American Chemical Society, Biophysical Society

Selected Honors and Awards

1998 Boston University, Sugata Ray Award
2001 American Chemical Society, Northeastern Section, Philip L. Levins Memorial Prize
2009 University of California, Riverside, Medical School Program, Student Research Mentoring Recognition
2009 Regents of University of California, Faculty Development Award

Selected Service Activities

- Chaired and/or organized sessions for different scholarly meeting (e.g., 2010 Gordon Research Conference (GRC) on *Electron Donor-Acceptor Interactions*; 2011 GRC on *Photochemistry*; 2008 and 2010 UC Systemwide Bioengineering Symposium; 2007 National BMES Meeting);
- Invited talks (e.g., 2008 Department of Biomedical Engineering, UC, Davis; 2008 Department of Chemical & Nuclear Engineering, University of New Mexico; UCR; 2011 First International Congress on Bioinspired Materials for Solar Energy, Crete, Greece); 2011 Department of Mechanical and Aerospace Engineering, Princeton University);

- Reviewed research proposals for different agencies (e.g., participated in NSF review panels; ad hoc reviewer for NSF and for U.S. Army SBIR and STTR research proposals);
- Reviewed manuscripts for peer-reviewed journals (e.g., *J. Am. Chem. Soc.*, *J. Phys. Chem.*, *Ann. BME*, *Inorg. Chem.*, *Optics Express*). Ranked in the top 20% among the *J. Phys. Chem.* reviewers for 2009;
- Member of campus committees (e.g., BCOE Executive Committee, UCR Campus Biosafety Committee, Faculty Search Committees in Bioengineering and in Chemistry Departments).

Selected Recent Peer-Reviewed Journal Publications

- Upadhyayula, et al. *Journal of Physical Chemistry B* **2011**, *115*, 9473-9490.
- Vullev, V. I. *Journal of Physical Chemistry Letters* **2011**, *2*, 503-508 (**Journal cover**).
- Bahmani, et al. *Journal of Biomedical Optics* **2011**, *16*, 051303-1 – 051303-10.
- Xia, et al. *Journal of Clinical Microbiology* **2011**, *49*, 2966-2975.
- Chau, et al. *Microfluidics and Nanofluidics* **2011**, *10*, 907-917.
- Thomas, et al. *Langmuir* **2010**, *26*, 9756-9765.
- Thomas, et al. *Annals of Biomedical Engineering* **2010**, *38*, 21-32.
- Thomas, et al. *Langmuir* **2010**, *26*, 2951-2957.
- Lu, et al. *Advanced Science Letters* **2010**, *3*, 101-109.
- Bao, et al. *Journal of Physical Chemistry B* **2010**, *114*, 14467-14479.
- Vasquez, et al. *Biotechnology Progress* **2009**, *25*, 906-914.
- Ashraf, et al. *Biotechnology Progress* **2009**, *25*, 915-922.
- Hu, et al. *Journal of Physical Chemistry A* **2009**, *113*, 3096–3107.
- Wan, et al. *Annals of Biomedical Engineering* **2009**, *37*, 1190-1205.
- Bao, et al. *Journal of Physical Chemistry A* **2009**, *113*, 1259–1267.
- Hong, et al. *Langmuir* **2008**, *24*, 8439-8442.
- Wan, et al. *Journal Photochemistry and Photobiology A* **2008**, *197*, 364-374.
- Millare, et al. *Langmuir* **2008**, *24*, 13218-13224.
- Jones, et al. *Journal of Physical Chemistry B* **2007**, *111*, 6921-6929.
- Vullev, et al. *Journal of the American Chemical Society* **2006**, *128*, 16062-16072.

Selected Professional Development Activities

- Participated in workshops, such as the 3rd national Biomedical Engineering Education Summit (Chicago, IL, 2008), organized by the BMES;
- Presented at URM Principal Investigator Workshop (Arlington, VA, 2011), organized by NSF;
- Participated in the Research Frontiers on Bioinspired Energy Workshop (Washington, DC, 2011), organized by the National Academies.

Appendix C – Equipment And Safety

1. Safety

A. In the future each undergraduate will be required to take this online safety course:

Laboratory Safety Orientation (<http://ehs.ucr.edu/training/online/lso/indexlms.html>)

Introduction to safe practices in the laboratory / research environment. Topics include: Basic information about safety, hazards (identification), controls, hazardous materials, electrical safety, earthquake safety, fire extinguishers, emergency procedures, and ergonomics.

Length: 1 hour 20 min

B. At the beginning of each laboratory session specific safety instructions will be given that relate to that experiment. Here is an example for BIEN 130L:

Safety Training for Bioinstrumentation Lab (Spring 2012)
Lab 1: Introduction to Virtual Instrumentation and DC Analysis

Personal Protection requirement:

Closed-toe shoes

Lab coat required

No food or drink allowed

MS&E 154 is a biosafety level 1 lab

Don't touch any instrument which doesn't belong to this lab session.

Physical Hazards

UV light is on in the floor model shaker located in MS&E 158, teaching lab preparation room. Please don't enter this room without permission.

We will use weights and hangers in this lab. Make sure you stay away from the hanging weights during the lab.

Electrical Safety

We are going to make circuits on the prototyping board. Please turn off the power for the board while making the circuit.

Safety Contact

If you have any question or concerns regarding the safety of this lab, please contact Hong @ 951-827-7235 or hongxu@engr.ucr.edu. You can also come to Hong's office located in MS&E 205.

2. Equipment

Bioengineering Undergraduate Teaching Lab Location: MSE 154 &158

Funding Sources: Bioengineering start up fund (85lab) & instructional annual funding from Dean's office

Bioinstrumentation (BIEN130L): Spring Quarter

| Instrument/Manufacturer | Labs | Quantity | Unit Cost (\$) | Cost (\$) |
|---|--|-----------------|-----------------------|------------------|
| NI ELVIS by National Instrument | Lab 1-4: ECG circuit design and data acquisition | 10 | 2,300 | 23,000 |
| Dell Desktop & Monitor by Dell | Lab 1-4: ECG circuit design and data acquisition Lab 6: Biomechanical Lab | 12 | 1,000 | 12,000 |
| Labview Academic Site License by National Instrument | Lab 1-4: ECG circuit design and data acquisition | 1 | 5,000 | 5,000 |
| Rugged Multimeter by OMEGA | Lab 1-3: ECG circuit design | 11 | 67 | 737 |
| Universal Tester 100Q500 by Testresources, Inc. | Lab 6: Biomechanical Lab | 2 | 13,000 | 26,000 |
| Pasco Stress Strain Tester (Apparatus, sensors, USB links, Calipers) by Pasco | Lab 6: Biomechanical Lab | 9 | 1,500 | 13,500 |
| Gravity Convection Oven 3510FC by Fisher Scientific | Lab 6: Biomechanical Lab | 1 | 700 | 700 |
| Ocean Optical Spectrometer by Ocean Optics | Lab 7: Optical Methods for Hemoglobin Characterization and Blood Oxygen Provided by Professor Schultz | 1 | \$3,000 | |
| Mettler Balance 151G x0.001G by Mettler Toledo | Lab 7: Optical Methods for Hemoglobin Characterization and Blood Oxygen | 1 | 1,100 | 1,100 |
| Mettler New Classic MS Balance 0.001G by Mettler Toledo | Lab 7: Optical Methods for Hemoglobin Characterization and Blood Oxygen | 1 | 1,500 | 1,500 |
| Olympus Preamplifiers 5660B by Olympus | Lab 7: Ultrasonic Imaging Lab | 20 | 760 | 15,200 |
| Panametrics Immersion Transducers V318-SU by | Lab 7: Ultrasonic Imaging Lab | 20 | 430 | 8,600 |

| | | | | |
|---|--|----|--------------|------------------|
| Olympus | | | | |
| Tektronix Oscilloscope TDS 3054C by Tektronix | Lab 7: Ultrasonic Imaging Lab Professor Hyle Park's research instrument. Usage: 6hrs/Spring Quarter | 3 | \$11,400 | |
| Vernier Lab Quest by Vernier | Lab 8: Lung Capacity & Oxygen Measurements | 8 | 329 | 2,632 |
| Vernier Spirometer by Vernier | Lab 8: Lung Capacity & Oxygen Measurements | 9 | 199 | 1,791 |
| Vernior O2 sensor by Vernier | Lab 8: Lung Capacity & Oxygen Measurements | 12 | 188 | 2,256 |
| | | | total | \$114,016 |

Biotechnology Laboratory (BIEN155): Fall Quarter

| Instrument/Manufacturer | Labs | Quantity | Unit Cost (\$) | Cost (\$) |
|--|-------------------|-----------------|-----------------------|------------------|
| Pipettes sets (PR-10: 10ul, PR-200:200ul, PR-100: 1000ul) by Rainin | All labs | 11 | 630 | 6,930 |
| Eppendorf Easy Pet Motorized Pipet Dispenser by Eppendorf | All labs | 1 | 280 | 280 |
| Fisher Isotemp 210 Digital water bath by Fisher Scientific | All labs | 1 | 710 | 710 |
| Fisher Isotemp Forced Air Incubator 650F (4.5cu ft.) Fisher Scientific | All labs | 1 | 2,000 | 2,000 |
| Fisher Scientific Isotemp 20cu. Refrigerator -20C to -12C by Fisher Scientific | All labs | 2 | 1,300 | 2,600 |
| OHAUS Scout Pro Balance Accu622, 620g/0.01g by OHAUS | All labs | 1 | 1,000 | 1,000 |
| Bio-Rad DNA Engine with Dual Well by Bio Rad | PCR amplification | 1 | 6,300 | 6,300 |
| Thermo Fisher A1 large Gel | Cloning lab | 2 | 770 | 1,540 |

| | | | | |
|---|--|---|--------|--------|
| system by Thermo Fisher | | | | |
| Biospectrum System F4300 by UVP LLC | Cloning lab | 1 | 37,853 | 37,853 |
| Digital Dry Bath with Heating Block Modules (24x1.5ml) by Labnet International | Cloning lab | 1 | 400 | 400 |
| Transillum Fixed intensity 8" FBTI88A By Fisher Scientific | Cloning lab & protein purification | 1 | 1,100 | 1,100 |
| Eppendorf Electroporator 2510 Eppendorf | Transform fusion genes into pTOPO vector and transform into Top10 bacterial | 3 | 1,000 | 3,000 |
| Eppendorf Model 5424 Microcentrifuge by Eppendorf | Purify plasmid DNA from bacterial cells | 2 | 1,654 | 3,308 |
| Fermentation System BF0- 110 (heat jacket and water jacket vessels) by New Brunswick | Protein expression | 1 | 42,463 | 42,463 |
| Innova 44 Floor Model Shaker by New Brunswick | Protein expression | 1 | 15,333 | 15,333 |
| BioMate 3 UV-Vis Spectrophotometer by Thermo Scientific | Measure cell growth and protein concentration Professor Jiayu Liao's research instrument. Usage: 6hrs/Fall | 1 | 4500 | |
| Ultrasonic Liquid Processor by Misonix | Protein purification | 1 | 4,000 | 4,000 |
| S-4000 Dug 110V Sonicator by Fisher Scientific | Protein purification | 1 | 3,700 | 3,700 |
| Beckman J-E centrifuge with three rotors by Beckman | Protein purification | 2 | 30,839 | 61,678 |
| Digital Vortex Genie 2 By Scientific Industry | Protein Purification | 1 | 400 | 400 |
| Corning Hot Plate By Corning | Protein characterization | 2 | 1,000 | 2,000 |
| PowerPac Basic Power | Protein characterization | 2 | 350 | 700 |

| | | | | |
|---|---|---|---------|-----------|
| Supply 164-5050 by Bio Rad | | | | |
| Mini-Protean Tetra Cell by Bio Rad | Protein characterization | 2 | 410 | 820 |
| FLEX Station II 384R by Molecular Devices | Fluorescence Energy Transfer Assay Professor Jiayu Liao's research instrument. Usage: 6hrs/Fall Quarter | 1 | 151,518 | |
| | | | total | \$202,615 |

Bioengineering Departmental Support Instrument List

| Instrument/Manufacturer | Course | Quantity | Unit Cost (\$) | Cost (\$) |
|--|----------------------------------|-----------------|-----------------------|------------------|
| Rapid Prototyping System by Dimension Elite | Senior Design BIEN 175A&B | 1 | 30,200 | 30,200 |
| Desktop 3D Scanner by Nextengine | Senior Design BIEN 175A&B | 1 | 3,280 | 3,280 |
| Labconco Class II Type A2 6' Biosafety Cabinet by Labconco | Biotechnology Laboratory BIEN155 | 3 | 12,000 | 36,000 |
| Labconco Class II Type A2 4' Biosafety Cabinet by Labconco | Biotechnology Laboratory BIEN155 | 2 | 10,000 | 20,000 |
| Beta Star sterilizers 20"x20"x38" by Beta Star | Biotechnology Laboratory BIEN155 | 1 | 68,622 | 68,622 |
| Beta Star sterilizers 24"x36"x36" by Beta Star | Biotechnology Laboratory BIEN155 | 1 | 44,622 | 44,622 |
| | | | total | \$202,724 |

Bioengineering Computer Lab: Bourns Hall B256

Number of Computers: 34

Dell Vostro 460 Mini Tower with 21.5" monitor Manufacturer: Dell

Total cost of computers: \$34,000

Number of printer: 1

HP laserjet 4250 Printer Manufacturer: HP

Cost: \$400

List of Instructional Software Installed:

COMSOL 4.2a, latest version teaching license (**\$5821**)
Matlab; Solid Work, Mathematica, MS office 2010

The following is the list of free software installed for Professor Dimitrios Morikis's class

Deep View-Swiss-PDB Viewer (<http://spdbv.vital-it.ch/disclaim.html>)

Chimera (<http://www.cgl.ucsf.edu/chimera/download.html>)

R-base (<http://cran.r-project.org/bin/windows/base/>)

Modeller (http://salilab.org/modeller/download_installation.html)

DOCK (http://dock.compbio.ucsf.edu/Online_Licensing/index.htm)

APBS (<http://sourceforge.net/projects/apbs/>)

VMD (<http://www.ks.uiuc.edu/Development/Download/download.cgi?PackageName=3D3D>)

NAMD (<http://www.ks.uiuc.edu/Development/Download/download.cgi?PackageName=3D3D>)

MGL Tools (<http://mgltools.scripps.edu/downloads>)

Appendix D – Institutional Summary

1. The Institution

2. 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

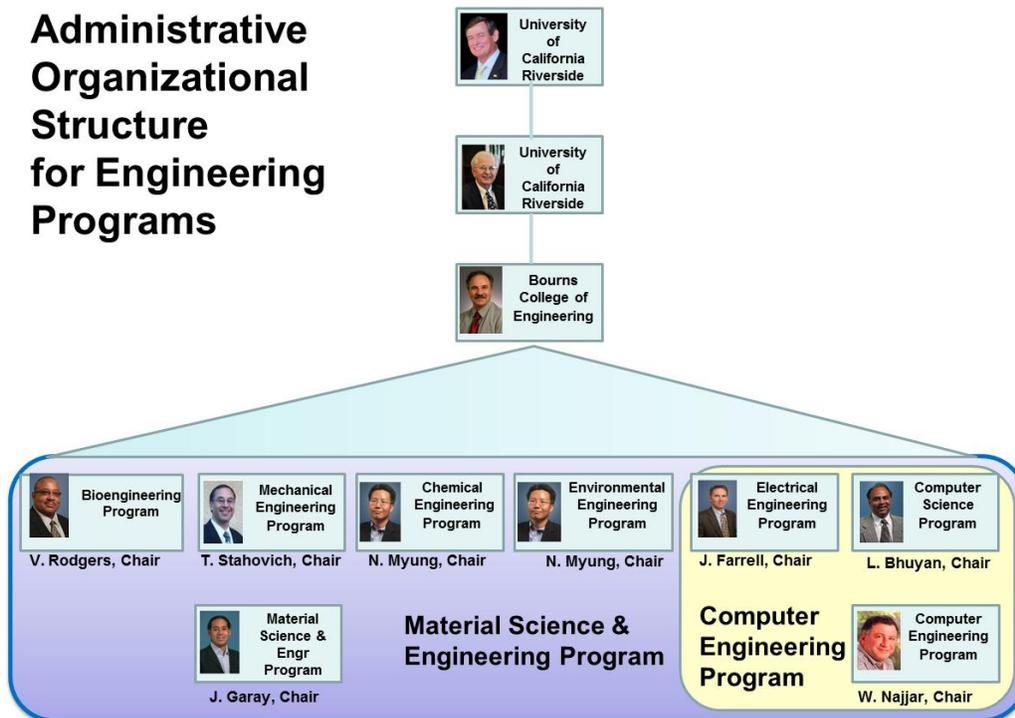
D Name the organizations by which the institution is now accredited and the dates of the initial and most recent accreditation evaluations. **Dennis**

2. Type of Control

The University is a state-controlled institution of higher education and an accredited Hispanic Serving Institution (HSI).

3. **Educational Unit** Describe the educational unit in which the program is located including the administrative chain of responsibility from the individual responsible for the program to the chief executive officer of the institution. Include names and titles. An organization chart may be included.

Administrative Organizational Structure for Engineering Programs



4. Academic Support Units

List the names and titles of the individuals responsible for each of the units that teach courses required by the program being evaluated, e.g., mathematics, physics, etc.

| 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: Randy Williams, Director

6. Credit Unit

It is assumed that one semester or quarter credit normally represents one class hour or three laboratory hours per week. One academic year normally represents at least 28 weeks of classes, exclusive of final examinations. If other standards are used for this program, the differences should be indicated.

7. Tables

Complete the following tables for the program undergoing evaluation.

Table D-1. Program Enrollment and Degree Data

Bioengineering program

| Bioengineering Enrollment and Degrees | New Students | | Total Enrollment | | | Degrees Granted | | |
|--|---------------------|-----------------|-------------------------|-------------|--------------|------------------------|-------------|--------------|
| | Freshmen | Transfer | UG | Grad | Total | UG | Grad | Total |
| | 2010-11 | 158 | 8 | 329 | 44 | 373 | 31 | 10 |
| 2009-10 | 84 | 7 | 228 | 24 | 252 | 23 | 3 | 26 |
| 2008-09 | 71 | 5 | 173 | 24 | 197 | 19 | 3 | 22 |
| 2007-08 | 46 | 5 | 125 | 12 | 137 | 6 | 1 | 7 |
| 2006-07 | 52 | 8 | 80 | 0 | 80 | | | 0 |

All Students are full-time

Table D-2. Personnel

Bourns College of Engineering, _____ Bioengineering _____

Year¹: _____ Fall 2011 _____

| | HEAD COUNT | | FTE |
|--|------------|----|-------|
| | FT | PT | |
| Administrative ⁴ | 0 | 0 | - |
| Faculty (tenure-track) | 11 | 0 | 11.00 |
| Other Faculty (excluding student Assistants) | 0 | 3 | 1.55 |
| Student Teaching Assistants ² | 3 | 6 | 6.00 |
| Student Research Assistants ³ | 15 | 16 | 23.00 |
| Technicians/Specialists | 1 | 3 | 1.20 |
| Office/Clerical Employees | 2 | 5 | 3.10 |
| Others ⁵ | 1 | 0 | 1.00 |

*Report data for the program being evaluated.

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.

dered appropriate, or leave blank.

Appendix E – Evaluation of Student Outcomes

EVALUATION OF STUDENT OUTCOME (a).

(a) an ability to apply knowledge of mathematics, science (*including biology and physiology (PCI)*), and engineering

Several core Bioengineering courses provide students with instruction that meets the characteristics of this required student capability.

In order to illustrate the range of materials and concepts that students were exposed to in our program we selected a few examples of student work that shows the depth and breadth of student abilities to apply these fundamental principles.

BIEN 115 – Quantitative Physiology

Students are challenged with quantitatively analyzing physiological phenomena. Various pharmacokinetic situations are covered in the course, for example in the mid-term exam they derive compartmental models to explain various types of drug distribution patterns.

Thermal effects are another aspect that is illustrated in this course; the mid-term exam shows an example of transient heat conduction in tissues.

BIEN 125 – Biotechnology

One of the areas covered in this course is the modeling of cell growth and metabolism. Illustrative examples from the midterm and final exams show that the students were challenged with modeling the growth of microorganisms in batch and continuous culture and the production of various products such as insulin.

89 percent of students answered these questions satisfactorily.
Average score = 45 Perform std = 36

BIEN 130 – Bioinstrumentation

Mathematical skills are emphasized in this course, especially as related to management of data from various instruments. An example problem in the final exam required students to derive the Fourier transform of a complex mathematical expression.

76 percent of the students answered this question satisfactorily.

BIEN 130L – Bioinstrumentation Laboratory

Hands-on utilization of biomedical instruments is a focus of this course. Students are required to assemble instruments and evaluate their behavior. An example report from a student illustrates

the in depth discussion of the circuitry of an electrocardiogram device and the thorough analysis of measurements made on a person.

63% of the students performed satisfactorily in this experiment.

BIEN 135 – Biophysics and Biothermodynamics

The fundamental principles of free energy considerations are applied to protein structure and function in this course. This homework example challenges the students to predict protein structural changes caused by hypothetical mutations of various amino acids.

92% of the students were able to able to satisfactorily apply thermodynamic principles to this situation.

BIEN 140A – Biomaterials

This course emphasizes the importance of certain chemical/biophysical properties of materials that tend to determine their behavior when placed in a biological milieu. One of the key materials often overlooked in discussing biomaterial behavior is the ubiquitous solvent – water. In this quiz students were challenged to show how the unique properties of water distinguish this solvent from others.

67% of the students were able to answer these questions satisfactorily.

BIEN 159 – Dynamics of Biological Systems

This course focuses on the modeling of kinetic behavior of biological systems. These particular exam questions challenge the students to explain oxygen binding to various proteins (such as hemoglobin) and how those binding characteristics affect oxygen exchange in the body.

54% of the students were able to answer these questions satisfactorily.

SUMMARY

Overall students in the Bioengineering program satisfactorily meet the Criteria (a) of Student Outcomes. The departmental goal is for at least 70% of the students to reach the level of satisfactory performance in the Student Outcome Criteria. Although we meet our goals if one averages student performance in the examples quoted above, there are some spots that will need attention in the future. In particular we will place emphasis on improving BIEN 130L, BIEN 140A, and BIEN 159.

EVALUATION OF STUDENT OUTCOME (b)

(b) An ability to design and conduct experiments, make measurements, analyze and interpret data from living systems addressing the problems associated with the interaction between living and non-living materials and systems.

Seven courses, BIEN 115 (Quantitative Physiology), BIEN 125 (Biotechnology), BIEN 130 (Bioinstrumentation), BIEN 140A (Biomaterials), BIEN 155 (Biotechnology Lab), BIEN 159 (Dynamics of Biological Systems), and BIEN 175 (Senior Design) include components aimed at meeting this SO.

In BIEN 115, particular quizzes constitute part of the course requirement aimed at meeting SO B. Under these quizzes, students apply pharmacokinetics analyses to characterize the biodistribution of various agents administered into the body. As such, these components of the course are mostly focused on interpretation of data from living systems.

In BIEN 125, specific questions on a midterm and a final are used to assess SO (b). The topics of these questions are related to protein expression systems and processes related to protein purification. SO B is met through these examples.(b) is met.

In BIEN 140A, a final exam is used to assess for SO (b). Under this exam, students are required to answer questions related to a journal paper that address the properties of a biodegradable material. This evaluates the students ability in data interpretation is provided.

In BIEN 155, three laboratory exercises related to performing fluorescent measurements, verification of DNA sequencing, and protein expression are used to asses SO (b). The emphasis is at molecular and cellular level.

In BIEN 159, an exam question related to binding of hemoglobin to oxygen is used to assess for SO(b). As such, the component of SO (b related to interpretation of data is met.

In BIEN 175, various student groups complete a senior design project over the course of two quarters. Overall the projects collectively address the various components related to SO (b). Most of the projects appear to be related to the faculty research areas.

EVALUATION OF STUDENT OUTCOME (c)

Student Outcome (c): an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, health and safety, manufacturability, and sustainability.

Overview

The following courses: BIEN 120, BIEN 130, BIEN 130L, BIEN 155, and BIEN 175, were all listed to contribute to Student Outcome (c). The examples given for BIEN 120, BIEN 130, BIEN 130L and BIEN 175 clearly provide support for demonstrating that the program meets this outcome. The example for BIEN 155 did not clearly meet the objectives for this outcome based on the example given.

Recommendation

The program is strong with respect to Student Outcome (c). It is recommended that BIEN 155 be removed from the list of courses that demonstrate proficiency in this outcome.

| Course No. | Summary of Assessment Method | Justification | % Meeting Standard |
|------------|--|---|--------------------|
| BIEN 120 | A term-long project to design a feedback control of a student prescribed process relevant to bioengineering. The control system design is analyzed within the limits of the process. | The design project has an objective and considers a realistic project. The students are asked to consider limitations. This course clearly meets SO (c). | 63.2 |
| BIEN 130 | A question on final exam asking to design iron suit armor to respond to various signals from the user. The students must design within limits of available equipment and pricing. | A well-defined question that requires students to design a specific device within economic and part-availability limitations. This course clearly meets SO (c). | 95.2 |
| BIEN 130L | A lab to acquire ECG signals from a human subject. | An important lab where the students are required to design a circuit to measure ECG signals. This course clearly meets SO (c). | 63.0 |
| BIEN 155 | A lab to conduct recombinant fluorescence protein production. | Although an important lab, the students need only follow instruction and provide no design components. The example does not give enough evidence to strongly meet SO (c). | 88 |
| BIEN 175 | A two-term project to design and build a device for specific | This senior design project is the quintessential representation of | - |

| | | | |
|--|--|---------|--|
| | applications with an economic, health and safety constraint. | SO (c). | |
|--|--|---------|--|

EVALUATION OF STUDENT OUTCOME (d)

Student Outcome (d): an ability to function on multidisciplinary teams.

Overview: This SO can be decomposed into two aspects: an ability to work in teams on multidisciplinary projects, and an ability to work on teams of a multidisciplinary composition. The undergraduate curriculum places an emphasis on working in teams on multidisciplinary projects, often with individuals or small subgroups specializing on different aspects of a larger project (e.g., a group of bioengineering students with assigned responsibility for physiology, theoretical design, and computation modeling working together to re-design a heart valve). The percentage of students/groups that met or exceeded set performance standards on assignments used to assess this SO was higher than 63% in all courses. While these marks are not a direct indicator of the ability of student to function on multidisciplinary teams, an inability to do so would have been reflected through lower marks such assignments.

The second aspect of this SO, an ability to work in teams of a multidisciplinary composition, has been somewhat lacking. However, we are currently addressing this issue, as noted in the Recommendation section below.

Recommendation: Possible improvements to the curriculum include:

- 1) A more direct assessment of SO (d) would be desirable in the future. While it is difficult to imagine a truly objective method for doing so, a subjective measure can be made through student feedback specifically asking to assess their ability to work in i) teams ii) of a multidisciplinary nature.
- 2) The examples provided clearly demonstrate the ability of our students to work in teams on projects of a multidisciplinary nature. However, they do little with regard to demonstrating an ability to work in teams composed of people with a background in different academic disciplines. This is currently being addressed through the recent integration of business students and material into BIEN 175A.

Summary of assessment data

BIEN 010: In this first-year course, students worked in groups of 3 on a multidisciplinary final project. The example provided was titled “Artificial Lungs,” and demonstrated a basic understanding of the biological/clinical motivation as well as a quantitative analysis of the required level of gas exchange for such a device.

BIEN 105: In this third-year course, students worked in groups of 3 on a multidisciplinary final project. The example provided was titled “Computational modeling of thrombi in the titanium Greenfield filter.” Presentation slides demonstrate an understanding of the biological/medical motivation behind removal of thrombi from circulation, a description of titanium Greenfield filter (TGF) for clots, and a detailed computational model of flow with and without spherical or conical clots in COMSOL.

BIEN 120: In this third-year course, students worked in groups of 3 on a multidisciplinary final project. The example provided was titled “Thermoregulatory sweat response of the human body due to a change in environmental conditions.” A comprehensive report demonstrates an understanding of physiology, feedback control mechanisms, and open and closed loop analysis of thermoregulation/sweat response using Matlab/Simulink.

BIEN 130L: In this third-year course, students worked in groups of 2 on different laboratory experiments every week. The example provided was titled “Biomechanical measurements.” The lab report demonstrates an ability to acquire and analyze data from compression testing of bone and tensile testing of skin.

BIEN 175: In this fourth-year course, students worked in groups of 3 or 4 students over the course of two quarters on highly multidisciplinary design projects. The example provided was titled “Utilization of inkjet technology to print cellular sheets.” The project required familiarity in a wide range of disciplines, with presentation slides demonstrating modification of an inkjet printer to print a layer of alginate, then cells, and then alginate in successive passes as well as SEM imaging to test printed sheets.

EVALUATION OF STUDENT OUTCOME (e)

Student Outcome (e): an ability to identify, formulate, and *apply advanced mathematics, science, and engineering to solve problems at the interface of engineering and biology.* (PC2)

Overview. In the following courses our undergraduate students have demonstrated ability to combine advanced mathematics, science, and engineering to solve bioengineering problems: BIEN 105, BIEN 110, BIEN 115, BIEN 120, BIEN 130, BIEN 135, and BIEN 140A. The assessments show that most of the students have met the performance standard in these classes.

Recommendation. Based on the presented course material, the following recommendations may be useful to strengthen SO (e) of our program:

- (i) Increase experimental and data analysis content. Emphasize statistical analysis of experimental data.
- (ii) Increase bioimaging and medical device content.

Summary of the contributions that each course offers to SO (e):

BIEN 105 – Circulation Physiology.

The students demonstrated understanding of the relationship between physical systems and mathematical models through the use of biosimulators (e.g. in COMSOL). They applied theoretical, computational and analytical, methods in designing fluid biomechanics models. They quantitatively analyzed their data and were able to recognize limitations in the approximations underlying their mathematical/physical models and design.

BIEN 110 – Biomechanics of the Human Body.

The students used computational tools to develop physical and mathematical models of bioengineering problems. The course focuses on solid mechanics problems and is complementary to BIEN 105, which focuses on fluid mechanics problems.

BIEN 115 – Quantitative Physiology.

The students demonstrated abilities to use differential equations to describe physical models useful in medical applications. Students learned how the diffusion equation is derived from energy balance principles and applied it to physiological heat and mass transfer applications.

BIEN 120 – Biosystems and Signal Analysis.

The students developed physical and mathematical models with the use of biosimulators (e.g. MATLAB) to model biological, biomedical, and bioengineering processes. They were able to use time-dependent differential equations to model real bioprocesses and they quantitatively analyzed their data. They were able to recognize limitations in the approximations underlying their mathematical/physical models and design and to translate the results from the modeled bioprocesses to outputs of real bioprocesses.

BIEN 130 – Bioinstrumentation.

The students demonstrated abilities to quantify physiological processes, using mathematical equations that describe physical models and chemical processes. They also demonstrated ability to apply statistical analysis to hypothetical data taken from a bioinstrument.

BIEN 135 – Biophysics and Biothermodynamics.

The students demonstrated abilities to apply thermodynamic principles to understanding the behavior of biological systems. They obtained knowledge on biophysical properties of biomolecules, and on using molecular and statistical thermodynamics to model biomolecular processes. The students used advanced mathematical methods to describe biomolecular structure and function at atomic detail and to understand the role of biomolecules in cellular and physiological processes. The students also obtained knowledge of a variety of physical methods applied in the study of biological molecules (e.g., spectroscopic, scattering, diffraction, microscopies, calorimetry, etc).

BIEN 140A – Biomaterials.

The students demonstrated abilities to analyze and explain data related to biomaterials and interactions between biomaterials and tissues. This course has strong statistical content for experimental data analysis.

EVALUATION OF STUDENT OUTCOME (f)

Student Outcome (f): ‘an understanding of professional and ethical responsibility

Overview. Three BIEN courses, 010, 140A and 175 were assessed to evaluate SO (f). The assessments show that most students met the expected performance for all classes.

Recommendation. SO Criterion (f) needs to be emphasized more in other courses, for example, those related to drug development, tissue engineering, etc.

Summary of the contributions that each course offers to SO (f):

BIEN010: the SO (avg. score of 92.3) exceeded the performance standard (70) meeting 100% of the standard. Group project and presentation were used as instructional and measuring methods to evaluate the SO Criterion (f). The students were asked to incorporate relevant aspects of ‘Code of Ethics for Professional Engineers’ and ‘Code of Ethics for Biomedical Engineers’ into their group projects. One of student presentation slides, in which the students correlated ‘Code of Ethics’ with their proposed hearing device is included as an example. The course materials and instructional method seem effective to instill the concept of the SO criterion (f) as an introductory course for bioengineering freshmen.

BIEN140A: the SO (avg. score of 93) exceeded the performance standard (85) meeting 100% of the standard. Students were asked to do literature review regarding professional and ethical problems in the bioengineering field. Several articles found from their literature review were included as examples. It appears that examples of students’ work, e.g. their presentation materials or term papers regarding those articles, would strengthen this SO.

BIEN175: for this senior design course, quantitative scores were not measured. The students were given a case study regarding bioethics and their responses in the form of essay were documented. Since ethical issues do not always have right answers, discussion and writing seem to be effective methods to instill the SO (f)

Overall, SO Criterion (f) needs to be stressed more in other courses, for example, in courses related to drug development, tissue engineering, etc.

EVALUATION OF STUDENT OUTCOME (g)

Student Outcome (g): The outcomes of several courses viz. BIEN 010, BIEN 105, BIEN 120, BIEN 130L, BIEN 155, and BIEN159 were assessed to evaluate the students' "ability to communicate effectively".

Summary

These courses require group projects involving several students. Students are required to write comprehensive reports on their projects. Also they make presentations that evaluated for effectiveness. Overall student performance is very good.

BIEN 010. Group projects and class presentations were used as metrics for evaluation of effective scientific communication. The students used lucid power point presentations to demonstrate their understanding of the key steps involved in the development of an artificial organ (skin). This included (1) the manufacturing steps (2) FDA regulatory issues for eventual marketing of the finished product, and (3) the ethical issues related to the use of autologous/allogeneous skin grafts. The average score (92.3) far exceed the performance standard (70) for this course, with all students meeting the standard criterion.

BIEN 105. This course introduces the physiological principles of blood flow. The students worked on group projects and gave PowerPoint presentations to communicate their ability to design flow-based biofluid mechanics process. Student presentations included results from their COMSOL modeling and simulations, which were particularly helpful in demonstrating their thorough understanding of subject matter. All students met the performance standard (70), with the average score of 94.35.

BIEN 120. This course provides an analytical understanding of the dynamic behavior of biological systems. Final project reports by student groups were used to evaluate their ability to effectively communicate their scientific understanding of the course material. Student reports included detailed illustrations, flow charts, data plots, and equations. 63.2% of the students met the performance standard (70), with the average score being 71.8.

BIEN 130L. In this Bioinstrumentation Laboratory course, student lab reports were used to evaluate their written communication skills. These lab reports, which included an abstract, introduction, methods, results and discussion sections, were structured according to the format used for preparing peer-reviewed journal manuscripts. Thus, this laboratory course gives students a first-hand experience of communicating their independent scientific findings for peer review. 63% of the students met the standard (≥ 80), with the average score being 89.

BIEN 155. This lab course provides hands-on experience with fundamental biochemistry and molecular-biology techniques. Student group lab reports and presentations were used to assess their interpretation and communication of the laboratory bench work. Both presentations and lab reports effectively described the experimental techniques and results obtained from each week's laboratory work, followed by conclusions and future directions. 86% of the students met the standard (14), with the average score being 16.6.

BIEN 159. In this course on the “Dynamics of Biological Systems”, a final problem set of 8 problems was used to determine the students’ understanding of subject matter. Although 66% of the students met the standard (80), with the average score being 81, this problem set may not represent an ideal criterion for evaluating student communication skills.

EVALUATION OF STUDENT OUTCOME (h)

Student Outcome (h): a broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

Overview. In a range of courses (BIEN 125 and 159), our undergraduate students have demonstrated the use of engineering solutions in an economic and societal context. For example, in BIEN125, students learned to compare a few approaches to characterize engineering protein products in an economic and societal context, that is, considering the cost of labor and time for each approach when making a decision on choice of engineering solution. The environmental and global context is less evident for both courses.

The assessments show that most of the students (75%) have met the performance standard for BIEN 125, and 54% met the performance standard for BIEN 159.

Recommendation. Based on the presented course materials, the following recommendations may allow us to strengthen SO (h) of our program:

1) *Widen the courses involving economic and societal context.* Out of the 2 courses providing SO (h), only one showed obvious economic and societal context. We need to develop more courses for SO (h). An introduction level “Engineering Ethics and Impacts on Global, Economic, Environmental, and Societal Context” will be beneficial.

2) *Demonstrating the global and environmental context.* None of the materials in the folder contained clear global and environmental context. More courses are certainly needed to demonstrate global and environmental context. Again, an introduction level “Engineering Ethics and Impacts on Global, Economic, Environmental, and Societal Context” will be beneficial.

Summary of the contributions that each course offers to SO (h):

BIEN 120. The students demonstrated how they would choose among multiple engineering solutions in protein purification and characterization in consideration of economic context (e.g. cost), and societal context (e.g. labor time involved). 75% students in the class have met the performance standard.

BIEN 159. 54% students met the performance standard. The connection to economic and societal context is less apparent.

Neither course has an apparent global and environmental context.

EVALUATION OF STUDENT OUTCOME (i)

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

Overview.

Our bioengineering students demonstrate a recognition of the need for (BIEN 10), and an ability (BIEN 125? and BIEN 140A) to engage in life-long learning. The assessments show that 100% of the students have met the performance standard for BIEN 10 and BIEN 140A classes.

Recommendation. Based on the presented course materials, the following recommendations may allow us to strengthen SO (i) of our program:

- 1) *Introduce examples in the cognitive domain (analysis) that represent students' mastery of the skills as lifelong learners.* An example from BIEN10 course showing analysis of new information, concept, etc. by breaking it down, comparing and contrasting, recognizing patterns, interpreting information, etc. as appropriate. BIEN140A can include examples of students' skills to access information from variety of sources, to assess the quality of information and categorize/classify it. Widen the course selection and include courses at an upper level that show our students' skills to model, simplify, approximate, make and recognize assumptions as well as inquiring.
- 2) *Expand examples in the affective domain (attitudes and values) that represent students' development into the life-long learners.* This can be accomplished through a development of an *Engineering Ethics Course*. This self-standing course can help students to develop attitudes and values at the highest (ethical) level upon graduation and become lifelong learners. The development of the skills in the cognitive domain depends on the attitudes and values of the learners and our program will overall benefit from students gaining competence in the affective domain, which directs behaviors. The course will introduce the theory and practice of engineering ethics using a multidisciplinary and cross-cultural approach focusing on sciences and engineering case studies. This comprehensive course will introduce the professional attitudes and ethical values to help students recognize the need for lifelong learning beyond their engineering degree.
- 3) *Introduce students' periodic reflections on their learning process.* The students themselves identify their technical strengths and weaknesses and develop their own learning strategies to become lifelong learners.
- 4) *Introduce evidence of students' participation in professional organizations, conference presentations, publications or design competitions.*

Summary of the contributions that each course offers to SO (i):

BIEN 10. The students demonstrated the ability to reflect on their background

The Assignment 1 for the class required (1) reading the chapter introducing “the keys to success in engineering study” with discussions of the learning in the university environment, strategies for maximizing performance in engineering courses, studying, and models for what the student should expect from their engineering degree; (2) answering questions for example such as outlining personal goals, establishing a goal for the grade, etc.; (3) preparing 5 min PowerPoint presentations addressing answers to at least 3 questions in (2); 100% of students (with an 80 being an average score) meet the score of 70, which is a performance standard.

BIEN 125.

This course provides our students with an overview of biochemical process in cells and their use in developing new products and processes. There is no performance standard available for (i).

BIEN 140A. The students read the papers and discuss them during the quarter. This assignment is designed to make the students aware of the various publications in the field and help them see how the concepts they learn apply in more complex, real world problems.

EVALUATION OF STUDENT OUTCOME (j)

a knowledge of contemporary issues *related to bioengineering*

Summary: This outcome determines the knowledge of students acquired during the 4 years of Bioengineering program study about current scientific and social issues related to bioengineering. The outcome makes BIEN students aware of how bioengineering skills and knowledge could contribute to the contemporary issues in a very broad range. In the matrix table, the student outcome (j) should be contributed by courses BIEN10, BIEN115, BIEN125, BIEN140(A), and BIEN175. The current materials come from BIEN10 and BIEN140(A).

Two course materials are presented in this category,

1. BIEN10: Assignment 6A-Simple Mathematical Modeling Using Matlab

This assignment requires student to carry a project using Matlab to describe one of biological system and prepare a powerpoint presentation, such as Drug concentration in the Urine. The presentation covers the functions and regulations of kidney, mathematic modeling and calculation of drug concentration in urine.

Comments: This material covers the mathematic power of bioengineering in determining drug concentration, such as Marijuana, in urine. This is a good example from mathematic point in biological system. But this project seems focusing on a very specific question of drug concentration modeling. The background of the project and roles of bioengineering in this process are not very clearly presented in this project.

2. BIEN 140A: Quiz 2 last question-Do you know of any socioeconomic and /or environmental impact caused by usage of this material? (metal Coltan wire/fiber)

This question makes student aware of the Coltan is a main export of Congo and it is main financial income of Congo. This knowledge takes care of the metal Ta use in cell phone, computers and other electronic devices and recycles these machines after use.

Comment: This question is proper for this category. The BIEN students can gain knowledge of materials and biomaterials in socioeconomics impacts. But if biomaterials are used in this case, it would be even better for applications of transplant, medical devices and regenerative medicine.

Recommendations: This outcome is one of important criterion for B.S.degree of Bioengineering. The awareness of contemporary issues will not only make students more motivated but also clues for their future career and responsibilities. Many courses can contribute to this outcome. The example should come from higher level knowledge, other than a very specific example for a specific issue. We need to select at least one course from each category to contribute to this Student Outcome, e.g. BIEN125, BIEN130, BIEN120, BIEN135. This emphasis will also make students aware of scientific and social issues in various disciplines to their studies as bioengineering and their future careers.

EVALUATION OF STUDENT OUTCOME (k)

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

Overview. In a range of courses our undergraduate students have demonstrated the use of theoretical (e.g., BIEN 135), computational (e.g., BIEN 105) and experimental (e.g., BIEN 155) skills for bioengineering at various scales: i.e., from protein engineering (e.g., BIEN 155) to device engineering (BIEN 175). The assessments show that most of the students have met the performance standard for all classes.

Recommendation. Based on the presented materials course materials, the following recommendations may allow us to strengthen SO (k) of our program:

1) *Widen the courses involving experimental skills.* Out of the ten courses providing SO (k) only three involve the use of hands-on experimental skills. Concurrently, all of the ten courses involve the use of theoretical or computational abilities.

2) *Demonstrating the use of statistics.* According to the Program Criteria for Bioengineering, “The program must prepare graduates to have: an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology.” Having enough biology and physiology courses suffices to satisfy some of the program criteria. Regarding advanced math and statistics, however, the students have to demonstrate the use of these skills via SO (k). The lab courses are the best for allowing students to demonstrate skills in statistics (and just placing error bars will not be sufficient). Neither of the materials in the folder contained any concepts of statistical analysis. We might need to address this issue.

3) *Improve the connection with the strength of the department.* Imaging is one of the trademark strengths of our department. I might be wrong, but from the materials I’ve seen, our lab courses do not involve the use of imaging skills (taking photographs is not really advanced imaging). It might help to use some of the campus resources to allow students to develop and apply skills in imaging to their course projects.

Summary of the contributions that each course offers to SO (k):

BIEN 105. The students demonstrated the use of finite element analysis for fluid dynamics with physiological relevance. The final project for the class required: (1) designing the physiological models; (2) carrying the computational simulations with these models; and (3) analyzing the obtained results. All students in the class have met the performance standard.

BIEN 120. The students demonstrated the use of applied mathematics for signal analysis and system control at cellular and organ levels. The final project involved: (1) developing of mathematical models based, for example, on kinetics and mass transport; (2) carrying the

calculations; and (3) analyzing the results. More than half of the students have met the performance standard.

BIEN 125. This course introduces to students established and modern biochemistry and molecular-biology techniques, and their use in bioengineering. The students were tested on the ability to recognize these techniques and their use. More than 2/3 of the students have met the performance standard.

BIEN 130. This course introduces techniques and instrumentation for biomedical applications. The students are expected to understand not only the techniques, but also the technical limitations of the used instrumentation. They demonstrated the ability to code for accounting the shortcomings in the interface between state of the art medical equipment and a patient. More than 2/3 of the students have met the performance standard.

BIEN 135. This course introduces methods for approaching problems in macromolecular chemistry and biophysics of physiological and medical importance. The students demonstrated the use of basic physical chemistry / thermodynamics principles, along with 2D NMR data, for analysis of protein structural properties. Almost all students in the class have met the performance standard.

BIEN 155. This lab course provides hands-on experience with fundamental biochemistry and molecular-biology techniques. The students have demonstrated the use of these techniques for protein engineering, involving expression, isolation, and characterization of photoactive fused proteins. The student employed qualitative FRET theory (i.e., in a binary mode) to spectroscopic data for analyzing protein-protein interactions. More than 3/4 of the students have met the performance standard.

BIEN 175. This Senior Design course is perhaps the best example of SO (k). The students employ interdisciplinary technical skills toward designing a method and/or devices and testing their performance.

Appendix F – Bioengineering Survey of Alumni and Workplace

F.1 Bioengineering Survey of Alumni March 2012

1 What year did you earn your bachelor's degree in Bioengineering?

| Answer Options | Response Percent | Response Count |
|------------------------------|------------------|----------------|
| 2007 | 9.1% | 3 |
| 2008 | 15.2% | 5 |
| 2009 | 27.3% | 9 |
| 2010 | 30.3% | 10 |
| 2011 | 18.2% | 6 |
| <i>Answered Question: 33</i> | | |
| <i>Skipped Question: 2</i> | | |

2 Did you enter the program as a freshman?

| Answer Options | Response Percent | Response Count |
|------------------------------|------------------|----------------|
| Yes | 42.4% | 14 |
| No | 57.6% | 19 |
| <i>Answered Question: 33</i> | | |
| <i>Skipped Question: 2</i> | | |

3. The department of Bioengineering has established several objectives to serve as a base for your future career. We would like to know how well the undergraduate program prepared you to meet these goals. Please rate on a scale of one to five; five being very well, and one being minimally.

| Bioengineering Department Program Engineering Objectives | | | | | | | |
|---|----|----|---|---|---|----------------|----------------|
| Answer Options | 5 | 4 | 3 | 2 | 1 | Rating Average | Response Count |
| A strong foundation to apply science, engineering, and biological principles to meet the challenges at the interface of engineering, life sciences, and medicine. | 9 | 15 | 6 | 0 | 1 | 4.00 | 31 |
| A capability to pursue graduate studies, careers in the medical device or biotechnology industries, or entry into medical or | 14 | 11 | 5 | 0 | 1 | 4.2 | 31 |

| | | | | | | | |
|---|----|---|---|---|---|-----|----|
| other health related medical schools. | | | | | | | |
| Training to effectively work professionally as an individual and in teams and with skills to communicate effectively to integrate contributions from multiple disciplines to address biological and medical problems. | 18 | 9 | 2 | 1 | 1 | 4.3 | 31 |
| An appreciation of and sensitivity to a broad range of ethical and social concerns related to bioengineering | 16 | 4 | 8 | 2 | 1 | 4.0 | 31 |
| <i>Answered Question: 31</i> | | | | | | | |
| <i>Skipped Question: 4</i> | | | | | | | |

3 Do you have any suggestions that you would like us to consider modifying these objectives? If so please comment below.

| | |
|--------------------------|-----------|
| <i>Answered Question</i> | 13 |
| <i>Skipped Question</i> | 22 |

Response Text

- Focus more on applicable biology such as medicine/drugs and cell culture.
- The "capability" objective should be split into its three components so they can be rated individually. If so, I would give preparation for graduate studies a 5, preparation for industry a 3, and I cannot comment on the preparation for medical school.
- More opportunities to work with industry to prepare for non-academic careers.
- I think the university as a whole does a poor job in preparing us for the reality of the work world. Finding a job isn't easy, especially in entry level engineering and I feel like in a sense I was led to believe it wouldn't be that difficult of a task.
- i think there should be more pursue for helping in finding a career
- N/A
- Rather than having a biased curriculum towards chemistry and biochemistry, it would be nice to have a broader sense of what bioengineering really is. Students may be disinterested in chemistry and biochemistry, thus turning away their interest from the department.
- The integration of tracks so that bioengineering students can specialize and become more proficient in what sub-topics they enjoy. More bioengineering classes in lower division so that they know more about the careers path they've chosen.
- Maybe the department will be able to partner with local biotech or biomedical companies to help undergraduates attain some experience.
- None
- The program was good and it very well managed by the HOD and good program.

- Not enough emphasis is placed on the engineering perspective of the program. Several Professors lazily prepare for the lectures and good supplemental information cannot be found. It is understandable that Bioengineering is a new field of study, but obtaining information should not be as difficult as it is. Professors should be able to provide supplemental material so material can be learned and understood outside of the class. Also, assignments and projects usually had vague/unknown requirements. These processes need to be improved. Also, the program should have more than one "track" the program focuses far too much on the biology aspect and far too little on the engineering aspect. People with a background strong in biology may want to choose a track that contains more engineering classes in order to broaden their knowledge base.
- Please add a co-op program for the students. Thanks.

5 Has the education that you received at UCR been sufficient in breadth to prepare you for the work that you do? Please rate on a scale from one to five. One being minimally and 5 being very well.

| Answer Options | Response Percent | Response Count |
|----------------|------------------|------------------------------|
| 5 | 29.0% | 9 |
| 4 | 45.2% | 14 |
| 3 | 16.1% | 5 |
| 2 | 6.5% | 2 |
| 1 | 3.2% | 1 |
| | | <i>Answered Question: 24</i> |
| | | <i>Skipped Question: 4</i> |

6 Please indicate the category that best indicates your current position.

| Answer Options | Response Percent | Response Count |
|---|------------------|------------------------------|
| Graduate program | 38.7% | 12 |
| Bio-related professional program (medicine, pharmacy, etc.) | 12.9% | 4 |
| Another type of professional program (law, business, etc.) | 0.0% | 0 |
| Working in a bio-related industry | 25.8% | 48 |
| Working in another type of industry or business | 3.2% | 1 |
| Other (please specify) | 19.4% | 6 |
| | | <i>Answered Question: 31</i> |
| | | <i>Skipped Question: 4</i> |

Other:

- Program management at an electrical engineering (power supply) manufacturer
- graduate program/ working in a bio related industry
- Master Program in Tissue Engineering fall 2012
- Medical school

- Working in Aviation Industry
- Quality Engineer

7 Rank the success of the teams that you have worked with, on a scale of one to five; five being the best.

| Answer Options | Response Percent | Response Count |
|-----------------------|-------------------------|------------------------------|
| 5 | 29.0% | 9 |
| 4 | 58.1% | 8 |
| 3 | 6.5% | 2 |
| 2 | 0.0% | 0 |
| 1 | 0.0% | 0 |
| N/A | 6.5% | 2 |
| | | <i>Answered Question: 31</i> |
| | | <i>Skipped Question: 4</i> |

8 Have you had supervisory responsibilities?

| Answer Options | Response Percent | Response Count |
|-----------------------|-------------------------|------------------------------|
| Yes | 61.3% | 19 |
| No | 38.7% | 12 |
| | | <i>Answered Question: 31</i> |
| | | <i>Skipped Question: 4</i> |

9 Do you belong to any professional societies?

| Answer Options | Response Percent | Response Count |
|-----------------------|-------------------------|------------------------------|
| Yes | 29.0% | 9 |
| No | 71.0% | 22 |
| | | <i>Answered Question: 31</i> |
| | | <i>Skipped Question: 4</i> |

If yes, which organizations?

- Tau Beta Pi
- ASQ
- Biomedical Engineering Society
- Current member of: International Society for Eye Research; Previous affiliation: Biophysical Society Optical Society of America
- Tau Beta Pi, SHPE, SACNAS

10 Do you read any professional publications or journals?

| Answer Options | Response Percent | Response Count |
|------------------------------|-------------------------|-----------------------|
| Yes | 58.1% | 18 |
| No | 41.9% | 13 |
| <i>Answered Question: 31</i> | | |
| <i>Skipped Question: 4</i> | | |

If yes, how many?

- One a week
- I read about five to ten
- 1
- 1
- 2 per week
- About 25 kinds of journals
- 10
- A lot
- 20-30
- 1 or 2
- Nature Reviews
- Varies
- 2
- 5 per week
- Every week one since 2009 January to 2009 December
- Hundreds
- Three

11 Have you collaborated on any projects involving the development of intellectual property or innovations?

| Answer Options | Response Percent | Response Count |
|------------------------------|-------------------------|-----------------------|
| Yes | 19.4% | 6 |
| No | 80.6% | 25 |
| <i>Answered Question: 31</i> | | |
| <i>Skipped Question: 4</i> | | |

If yes, please list:

- A biosensor device for the detection of stress markers and a nanoscale device for gas detection. I am unsure if either of these will be developed further
- Magnetic nano-biosensor with IBM
- Not at liberty to say.

- Novel ureteral stent device
- Device to treat cerebral edema.
- Device to optimize osmotic pressure measurements. Device to measure streaming potential.

12 Have you collaborated in reports or published articles in professional journals?

| Answer Options | Response Percent | Response Count |
|------------------------------|-------------------------|-----------------------|
| Yes | 32.3% | 10 |
| No | 67.7% | 21 |
| <i>Answered Question: 31</i> | | |
| <i>Skipped Question: 4</i> | | |

13 Have you received any awards (include graduate school fellowships, professional or community awards, etc.) if applicable.

| Answer Options | Response Percent | Response Count |
|------------------------------|-------------------------|-----------------------|
| Yes | 29.0% | 9 |
| No | 71.0% | 22 |
| <i>Answered Question: 31</i> | | |
| <i>Skipped Question: 4</i> | | |

If yes, please specify:

- My-Best
- Graduate Dean Fellowship
- Howard Hughes Medical Institute Fellowship
- Center for Complex Biological Systems (CCBS) Opportunity Award / Collaborative Grant"
- Research funding to undertake a thesis as a Masters student.
- Dean's fellowship
- National Science Foundation Graduate Research Fellowship Program
- Eugene Cota-Roble Awards"
- Summer research fellowship
- NSF Honorable Mention
- Poster Awards
- Travel Grants
- Research Grant
- GAANN Fellowship"
- Dean's fellowship. Graduate school at UC Riverside

14 Since your graduation from UCR, have you earned any other degrees?

| Answer Options | Response Percent | Response Count |
|------------------------------|-------------------------|-----------------------|
| Yes | 19.4% | 6 |
| No | 80.6% | 25 |
| <i>Answered Question: 31</i> | | |
| <i>Skipped Question: 4</i> | | |

If so, in what field and what year were you awarded your advanced degree:

- Chemical Engineering (expected Spring 2013)
- Bioengineering MS UCR 2011
- masters in biotech 2013
- Master in Biomedical Engineering (03/2012)
- Bioengineering 2011
- M.S. Bioengineering from UC Riverside

15 The Bioengineering program was designed to provide you with certain capabilities called "Student Outcomes." To what extent did your UCR courses assist you in possessing these attributes.

| Answer Options | 5 | 4 | 3 | 2 | 1 | Response Count |
|---|----------|----------|----------|----------|----------|-----------------------|
| a) an ability to apply knowledge of mathematics, science, (including biology and physiology) and engineering. | 9 | 1 | 3 | 1 | 1 | 28 |
| b) an ability to design and conduct experiments, make measurements, analyze and intrerpret data from living systems addressing the problems associated with the interaction between living and non-living materials and systems. | 9 | 1 | 4 | 0 | 1 | 28 |
| c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. | 9 | 9 | 8 | 1 | 1 | 28 |
| d) an ability to function on multidisciplinary teams. | 1 | 6 | 2 | 1 | 1 | 28 |
| e) an ability to identify, formulate, and apply advanced mathematics, science, and engineering to solve problems that are at the interface of engineering and biology. | 1 | 1 | 4 | 1 | 1 | 28 |
| f) an understanding of professional and ethical responsibility. | 1 | 4 | 6 | 2 | 1 | 28 |
| g) an ability to communicate effectively | 1 | 9 | 1 | 1 | 1 | 28 |
| h) a broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, | 1 | 7 | 7 | 0 | 2 | 28 |

| | | | | | | |
|---|---|---|---|---|---|----|
| and societal context. | | | | | | |
| i) a recognition of the need for, and an ability to engage in life-long learning. | 1 | 6 | 3 | 1 | 1 | 28 |
| j) a knowledge of contemporary issues related to bioengineering | 1 | 7 | 5 | 1 | 1 | 28 |
| k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. | 9 | 1 | 3 | 1 | 1 | 27 |
| <i>Answered Question: 28</i> | | | | | | |
| <i>Skipped Question: 7</i> | | | | | | |

16 Our program is designed to enable a Bourns College of Engineering alumnus to be successful either in pursuing a higher degree or in starting a career in engineering or a related field. Based on your experience, what comments do you have on our program and our objectives?

| | |
|--------------------------|-----------|
| <i>Answered question</i> | 17 |
| <i>Skipped question</i> | 18 |

Response to text:

- When I was a part of the program, I felt the main objective was to prepare students for research or graduate school. Industry was almost always an afterthought and there was very little offered in the way of internships or industry experiences.
- none
- More preparation for careers outside of academics.
- I feel like the program heavily discourages going into industry and puts too much emphasis on graduate studies. When I graduated I felt embarrassed to not be going on for a phd.
- i think there should be more focus on starting a career
- The actual curriculum is good as is, and shouldn't be changed.
- It would be nice to see some faculty members put in effort that involve the improvement of the infant department rather than excusing and only looking out for themselves. It would also be nice if there was an inclusion of broader range of classes which involve other aspects of bioengineering other than chemistry and biochemistry.
- More application of the learning we have obtained as it relates to the work force. I think most of the context of the material I learned was for Research/Graduate School work and not so much for the practicality of the work force.
- The training was comprehensive to allow transfer to a very wide range of fields
- The only drawback I've felt regarding the program is how broad it is. At the end of the degree, I felt that I knew of a lot of topics, but not enough about any particular one. It was a great position to be in for graduate school, but made me feel unprepared to start an engineering job. In short, about the right amount of theory, not quite enough hands on experience.
- The program is very well diversified. Faculty are involved in different areas of bioengineering which reflects on the courses taught. This allows the students to be

exposed to different topics and allows them to broaden their knowledge. This ultimately leads to an opportunity of pursuing a higher education, not only in bioengineering but any other related fields, as well as starting a career with the different skills acquired.

- again form a partnership with a company because not a lot of companies know what we do and what we know so exp will be much needed
- I think it would have been nice if we had speakers from industry as well.
- TERRIBLE, MOST PEOPLE BREEZE THROUGH CLASS EVEN WHEN THEY WERE SCORING 5-10% ON THEIR MIDTERMS!!!! THE AVG SCORE WAS 5%! WE DID NOT LEARN ANYTHING USEFUL!!!!!! WASTED 4 YEARS OF MY LIFE HERE.
- Many skills above I had ranked low because I was able to achieve those prior to the program, or through other means.
- I think this was achieved for even the first graduating class
- ok

17 Please give us your suggestions on how to better serve our students as well as alumni.

| | |
|--------------------------|-----------|
| <i>Answered question</i> | 16 |
| <i>Skipped question</i> | 19 |

- If the program has not taken an approach that also prepares students for industry, it should. Create industry friendly alternatives in the program. Examples: Elective credit could be given for internships. Instead of working on a senior design project, some students may instead be part of a Co-Op and report their experience at the end.
- During senior design, let the undergrads have time in the labs. Stop giving the grad students the power to cut our time to nothing. We can't learn and achieve if we are never given the chance.
- More effort to work with companies.
- When I entered the program I was under the impression that UCR's Bioengineering program made certain disciplines much more accessible than they actually were. I was given a two page list of "Technical Electives", however, very few of these classes were available.
- Keep an open mind to other opportunities within the engineering discipline.
- Resources to finding careers/ graduate programs
- It would be nice to have a team that focuses on finding collaborative projects between the university and the industry. This will open the door to co-op programs and internships, and better connect recent graduates and alumni to job search in the industry.
- Have classes on Bioethics and Applying their skills to the workforce.
- Networking for alumni and career opportunities within bioengineering
- The departments' faculty and staff is very approachable and I feel this is a very precious asset that UCR Bioengineering should keep. As the department grows in

size, both student and professional, it will be difficult to retain the close knit community. Informal gatherings after finals should help in retaining that.

- Maybe the email newsletter or something similar would be nice.
- DO A BETTER JOB HELPING THEM FIND WORK AFTER GRADUATION!!!!!!!!!!!!!! OUR DEGREES ARE USELESS IN THE REAL WORLD!
- Expanding the faculty will greatly improve the process. Also, more effort should be made to assign the correct faculty to the correct class. Some professors that taught some of the bioengineering courses did not understand the course content themselves. They needed their notes to figure out the problems and could not solve problems correctly without their notes. Undoubtedly, the professor has his strong suits, he was just assigned the wrong class to teach.
- Keep improving all aspects.
- Need better internship/Co-Op programs specifically for bioengineers. However, this will naturally come with time as the field is still young.
- Ok

F.2 Bioengineering Survey of Workplace – March 2012

| Workplace Survey of Bioengineering program Educational Objectives | | | | |
|--|----------|----------|---|---|
| Your workplace | Academia | Industry | | |
| Response | 4 | 0 | | |
| <p>We would like to have your evaluation of our how our students are meeting the objectives of our undergraduate program and, if needed, how we might implement improvements.</p> <p>We would like to know how well the UCR undergraduate program prepared the bioengineer(s) that you supervise to meet the goals of our undergraduate program.</p> <p>Please provide your evaluation on a scale of one to five;</p> <p>5 = Very well; 3 = Satisfactory; 1 = Poorly</p> <p>UCR Bioengineer(s) have demonstrated:</p> | | | | |
| An ability to apply science, engineering, and biological principles to meet the challenges at the interface of engineering, life sciences, and medicine | | | | |
| Response | 5 | 4 | 3 | 2 |
| | 2 | 2 | | 1 |
| <p>Using of advanced spectroscopy for understanding the dynamics of bacterial staining, essential for the development of novel assays for pathogens.</p> <p>The two students had excellent preparations in molecular-level bioengineering. Specifically, they had good grasp of the role of structure, dynamics, and thermodynamics in biomolecular stability and interactions, and in protein and drug design.</p> <p>The graduates have a strong background for preparation of our research. In fact, their additional knowledge they bring helps us obtain insights to our research that we would normally ask collaborators to do.</p> <p>My student from UC Riverside is very good at multiple science disciplines.</p> | | | | |
| A capability to pursue graduate studies, careers in the medical device or biotechnology industries, or entry into medical or other health related medical schools. | | | | |
| Response | 5 | 4 | 3 | 2 |
| | 3 | | 1 | 1 |
| <p>All undergraduates who worked in my lab have successfully pursued graduate or medical degrees; or landed jobs in biotech industry.</p> <p>After finishing their work in my lab, one student continued for graduate studies in bioengineering at UCR and she received an NSF Fellowship, and the other student is admitted for graduate studies in mechanical engineering at University of Vancouver, Canada, where he will perform bioengineering-related research.</p> <p>The UCR graduates are highly competitive. One of them is an NSF Graduate Research Fellowship recipient.</p> <p>I think it is more her style, but she has a difficult time maintaining her focus on key</p> | | | | |

| | | | | | |
|--|---|---|---|---|---|
| experimental details. | | | | | |
| An ability to effectively work professionally as an individual and in teams and with skills to communicate effectively to integrate contributions from multiple disciplines to address biological and medical problems. | | | | | |
| Response | 5 | 4 | 3 | 2 | 1 |
| | 4 | | | | |
| Most of the projects in my lab are extensively cross disciplinary. | | | | | |
| They worked well individually and in teams, collaborated with other bioengineers and biological scientists, and delivered high quality presentations at conferences and group meetings. | | | | | |
| The UCR graduates naturally take to performing scientific presentations and serve as role models for others. | | | | | |
| Excellent team player. | | | | | |
| An appreciation of and sensitivity to a broad range of ethical and social concerns related to bioengineering. | | | | | |
| Response | 5 | 4 | 3 | 2 | 1 |
| | 3 | 1 | | | |
| The research projects in which the undergraduates are involved, are in the general areas of energy and infectious agents. Because of it, at group meetings, the students often discuss socioeconomic and ethical issues related these areas of research. | | | | | |
| Ethical and social concerns related to bioengineering are addressed frequently in our lab group meetings and casual discussions. | | | | | |
| No doubt, the diverse training in bioengineering at UCR was very helpful for them to see a wide range of areas in the discipline. | | | | | |
| Always asking questions about ethical implications | | | | | |

Appendix G – Annual Course Reviews for Continuous Improvement

BIEN 10

BIEN 10 Fall 2009

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

Included a text in bioengineering, *Biomedical Engineering: Bridging Medicine and Technology*, W. Mark Saltzman, Cambridge University Press, ISBN:978-0-521-84099-6.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

The Pass/Fail structure of this course does not allow an appropriate structure for assessment.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

This course has been changed to a Letter Grade course so that its success relative to the Student Outcomes can be better assessed.

PERSON(S) WHO PREPARED THIS DESCRIPTION

Victor G. J. Rodgers

AND DATE OF PREPARATION: July 20, 2010

SIGNATURE BY INSTRUCTOR:

BIEN 10 Fall 2010

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

Included **the additional textbook** *Biomedical Engineering: Bridging Medicine and Technology*, W. Mark Saltzman, Cambridge University Press, ISBN:978-0-521-84099-6.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

Overall the students' performance exceeded the course performance measures in every area.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

Keep the course focused on bioengineering while continuing to provide emphasis on learning strategies.

PERSON(S) WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:

Victor Rodgers - February 27, 2012

BIEN 105

COURSE: BIEN 105:

ACADEMIC TERM: Fall 2009

INSTRUCTOR: V. G. J. Rodgers

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

None

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

From the assessment, the students could benefit from a more rapid training on the coupling of mathematical modeling, and transport phenomena relative to biomedical engineering.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

In response to the assessment, we will be substituting the textbook with Transport Phenomena in Biological Systems, G. Truskey, F. Yuan, D.F. Katz, Pearson Prentice Hall, New Jersey, 2004, ISBN: 0-13-042204-5. This text provides a more complete discussion of the conservation laws and their relationship to actual systems.

PERSON(S) WHO PREPARED THIS DESCRIPTION

Victor Rodgers -

AND DATE OF PREPARATION: 22-Jul-10

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

Year, we have included an additional exam (three closed-book exams in this case, to help students continuously focus on mathematical techniques. The results are most prevalent in the final projects where it appears that this year's performance was particularly satisfying.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

Overall, the final design project remains the capstone representation of student performance in all critical categories. The design project requires a solid ability to apply knowledge of mathematics, and engineering to related biological topics [SO(a)]. In addition, the project is a group activity fostering team communication [SO(d), SO(g)] However, these students are all bioengineering students so the interdisciplinary component is not directly resolved. Because the project requires the students to identify, formulate and apply advanced mathematics, science and engineering to solve problems at the interface of engineering and biology [SO(e)], this is strongly satisfied by the successful performance of the students at the final project. Finally, because the students must learn computations tools such as COMSOL, they have successfully

developed the ability to use techniques, skills and modern engineering tools for engineering practice [SO(k)].

The students met or exceeded the Course Outcomes well this year. This is primarily because the latter evaluation tools are used to determine their performance while the initial examinations are used to help identify deficiencies.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

The course should continue in its form for the upcoming class however, with the class size beginning to increase, the number of 3-member groups will be substantial. It does not appear that BIEN 105 can satisfy the interdisciplinary component of SO d so it may be necessary to relax the contribution of BIEN 105 in fulfilling this Student Outcome.

PERSON(S) WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:

Victor Rodgers - February 22, 2012

BIEN 110

DATE OF PREPARATION: April 28, 2010

COURSE: BIEN 110: Biomechanics of the Human Body. 4 units

ACADEMIC TERM: Winter 2010

INSTRUCTOR: B. Anvari

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

Added more information related to cellular level mechanics.

—

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

Students seem to feel comfortable in performing literature search and writing reports.

Concept of viscoelasticity and the models associated with it seem challenging to many students

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

Add more biological examples related to hard tissue mechanics. Add more content and assessment related to program outcome c.

PERSON(S) WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:

Bahman Anvari - April 28, 2010

DATE OF PREPARATION: August 1, 2011

COURSE: BIEN 110: Biomechanics of the Human Body. 4 units

ACADEMIC TERM: Winter 2011

INSTRUCTOR: B. Anvari

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

—

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

Students seem to feel comfortable in performing literature search and writing reports.

Concept of viscoelasticity and the associated models as well as membrane mechanics continue to be challenging to many students

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

Add more biological examples related to whole body mechanics and clinical applications.

PERSON(S) WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:

Bahman Anvari - August 1, 2011

BIEN 115

DATE OF PREPARATION: July 8, 2010
COURSE: BIEN 115: Quantitative Physiology. 4 units
ACADEMIC TERM: Spring 2010
INSTRUCTOR: B. Anvari

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:
Added more information related to other physiological systems.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:
Students seem to feel comfortable in performing literature search and writing reports.
Concept of diffusion and the models associated with it seem challenging to many students

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:
Add more biological examples related to hard tissue mechanics. Add more content and assessment related to program outcome c.

PERSON(S) WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
Bahman Anvari - July 8, 2010

DATE OF PREPARATION: October 6, 2011
COURSE: BIEN 115: Quantitative Physiology. 4 units
ACADEMIC TERM: Spring 2011
INSTRUCTOR: B. Anvari

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:
Added more information related to a few other physiological systems.

—

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:
Students seem to feel comfortable in performing literature search and writing reports.
Concept of diffusion and the models associated is somewhat of a challenge to some students.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

PERSON(S) WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
Bahman Anvari - October 7, 2011

BIEN 120

DATE OF PREPARATION: July 20, 2010

COURSE: BIEN 120: Biosystems and Signal Analysis. 4 units

ACADEMIC TERM: Winter 2010

INSTRUCTOR: V. G. J. Rodgers

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:
None

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

The results of this assessment indicate that the students can benefit from earlier evaluation of mathematical skill development and understanding of the relationship between mathematical models and designing.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

1) With reference to the assessment, it will be beneficially if an additional text is used to supplement this current limitation. We are considering several texts that might be helpful. 2) It is clear that this design-based course provides extensive mathematical preparation and training for the engineer. Thus, it is appropriate to include BIEN120 when assessing Student Outcome (a) in the Student Outcomes.

PERSON(S) WHO PREPARED THIS DESCRIPTION

Victor G. J. Rodgers

AND DATE OF PREPARATION: July 20, 2010

BIEN 120 Winter 2011

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:
In the last assessment, it was recommended that additional mathematical supplements are provided to support the students' grasp of the mathematical material. As a result additional course material on mathematical modeling analysis was added.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

Overall, the final design project remains the capstone representation of student performance in all critical categories. The design project requires a solid ability to apply knowledge of

mathematics, and engineering to related biological topics [SO(a)] although BIEN 120 is not considered a major contribution to this Student Outcome. In addition, the project is a group activity fostering team communication [SO(d), SO(g)]. However, these students are all bioengineering students so the interdisciplinary component is not directly resolved. Because the project requires the students to identify, formulate and apply advanced mathematics, science and engineering to solve problems at the interface of engineering and biology [SO(e)], this is strongly satisfied by the successful performance of the students at the final project. Finally, because the students must learn computations tools such as Matlab and its Control Toolbox, they have successfully developed the ability to use techniques, skills and modern engineering tools for engineering practice [SO(k)].

The students' for 2011 as a class only resulted in a lackluster performance in BIEN 120 with only 63.2% meeting the program performance standard via the above Student Outcomes. This may be the result of an unusual class as this class also had the highest failure rate for BIEN 120 than any in our program since its inception.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

The course should continue in its form for the upcoming class however additional mathematical supplements should be further increased. It might be useful to increase the number of short quizzes that are not graded.

PERSON(S) WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:

Victor Rodgers - February 26, 2012

BIEN 125

DATE OF PREPARATION: February 6, 2012

COURSE: BIEN 125: Biotechnology and Molecular Bioengineering 4 units

ACADEMIC TERM: Winter 2011

INSTRUCTOR: Jiayu Liao

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

We continue emphasizing mathematic applications in enzymatic kinetics, cell growth and fermentation process. We also put more efforts on experimental design and biotechnology social impacts.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

The overall outcomes are above average of expectations. Students have exposed to real biotechnology techniques, products, bioengineering industrial opportunities and direct impact on their career in the future.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

We still need to emphasize mathematic applications and give more examples in cell growth calculations and specific protein engineering examples. At the same time, we should give more clear directions for future directions of biotechnology and bioengineering.

PERSON(S) WHO PREPARED THIS DESCRIPTION

Jiayu Liao

AND DATE OF PREPARATION: Feb, 2012

BIEN 130

DATE OF PREPARATION: July 15, 2010
COURSE: BIEN 130 (Bioinstrumentation)
ACADEMIC TERM: Spring 2010
INSTRUCTOR: B. Hyle Park

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:
Significant effort was made to introduce material in this lecture course prior to its use in the co-requisite laboratory course (BIEN 130L). Integration between the two courses was greatly enhanced this year as both were taught by the same instructor.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

This quarter went fairly smoothly with the exception of 1 student, who failed to take advantage of extra credit and optional work offered to bolster their grade. While it might be expected that the percentage of students meeting performance standards increased with repetition, this was not seen as the difficulty level of similar problems was raised each time a particular topic was presented.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

The course will be improved through increased emphasis on statistics and statistical analysis, incorporation of more challenging problem sets, and increased utilization of computational software (e.g., Matlab).

PERSON(S) WHO PREPARED THIS DESCRIPTION Hyle Park

DATE OF PREPARATION: July 5, 2011
COURSE: BIEN 130 (Bioinstrumentation)
ACADEMIC TERM: Spring 2011
INSTRUCTOR: B. Hyle Park

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:
Significant effort was still put into introducing concepts in the lecture course before students encountered them in the concurrent laboratory course. Statistics, especially as related to interpretation of results obtained with bioinstrumentation, was added to the course curriculum. In addition, a greater emphasis was placed on the use of Matlab to solve practical problems related to course material.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

This quarter went fairly smoothly. While it might be expected that the percentage of students meeting performance standards increased with repetition, this was not seen as the difficulty level of similar problems was raised each time a particular topic was presented.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

It was assumed that students had a better working knowledge of Matlab than they actually did, and this shortcoming will be addressed in next year's curriculum.

PREPARER Hyle Park PREPARATION: July 3, 2011

BIEN 130L

DATE OF PREPARATION: July 15, 2010

COURSE: BIEN 130L (Bioinstrumentation Laboratory)

ACADEMIC TERM: Spring 2010

INSTRUCTOR: B. Hyle Park

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:
Significant effort was made to introduce material in the co-requisite lecture course (BIEN 130) prior to its use in this laboratory course. Integration between the two courses was greatly enhanced this year as both were taught by the same instructor.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

This quarter went fairly smoothly with the exception of 2 students, who failed to submit acceptable lab reports. Students felt the last two labs (hemoglobin and respiratory analysis) were a bit too scattered and random in nature, and that there was too much emphasis on circuitry through the first half of the class.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

The course will be improved through increased emphasis on statistics and statistical analysis, a reworking of all labs to move away from a “cookbook” type environment where students simply follow direction in favor of one in which they understand why certain steps and analysis are necessary and replacement of the hemoglobin lab with one on ultrasound imaging.

PERSON(S) WHO PREPARED THIS DESCRIPTION Hyle Park

AND DATE OF PREPARATION: July 15, 2010

DATE OF PREPARATION:

August 10, 2011

COURSE:

BIEN 130L (Bioinstrumentation Laboratory)

ACADEMIC TERM:

Spring 2011

INSTRUCTOR:

Huinan Liu

EVALUATION BY INSTRUCTOR

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:
Significant efforts were made to encourage students' pre-lab preparation. The following three elements were added to facilitate students' learning:

(1) added pre-lab introduction in the discussion two weeks before the lab;

- (2) added pre-lab review in the discussion before the lab;
- (3) added the pre-lab quizzes in the discussion to further involve students in pre-lab preparation.

Through developing these three elements, students were much better prepared for the labs. Students read and understood the lab objectives and guidelines before entering the lab. Better prepared students were naturally moved away from a “cookbook” type of lab environment and they followed the lab guideline after they actually understood the concepts, steps and analysis done in the lab.

Communicate with the instructor (Dr. Hyle Park) for the co-requisite lecture course (BIEN 130) regularly to ensure the pace of 130 and 130L matches. As a result, the integration between the two courses was greatly enhanced.

Syllabus

Completed the lab policy in the course syllabus to improve transparency and fairness.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

This quarter went smoothly except 1 student complained about grading on the circuit test. The standard point-by-point grading sheet was used throughout the test. However, due to the large size of the class, the instructor had to split the TAs to grade different sections using the same standard grading sheet. The correct answers are always the same, but the mistakes made by different students are always different. Instructor had to make a final judgment. Students commented:

“This course really taught me about the importance of bio instruments and I now have a much better understanding of the electrical elements that make up bio sensors.”

“I have been able to improve my circuit skills remarkably.”

“Great course was able to learn a lot.”

PROPOSED ACTION FOR COURSE IMPROVEMENT:

The course can be further improved if more instruments can be added to the teaching lab to accommodate more students concurrently for Lab 6, 7, 8.

BIEN 135

DATE OF PREPARATION: 07/22/2010

COURSE: BIEN 135 – Biophysics and Biothermodynamics

ACADEMIC TERM: Fall 2009

INSTRUCTOR: Dimitrios Morikis

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

1. Course Assessment for 2008-2009 AY

Homework problems were a significant medium for the comprehension of sometimes abstract concepts.

Discussion sessions were taught by the professor and were highly interactive.

Introduction of clickers with assessment of each question during discussion contributed to lively class interactions.

2. Recommendations for 2009-2010 AY

Change the textbook from van Holde, Johnson and Ho to Jackson.

Since the incoming class is bigger, introduce weekly quizzes for better student assessment.

Administer quizzes using clickers.

Add a second in-class midterm exam.

Request a Teaching Assistant.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

As in previous year, homework problems were a significant medium for the comprehension of sometimes abstract concepts.

Introduction of a second midterm was helpful in keeping the students alert and contributed in the continuity of the students' engagement with the class material.

Given the class size, Teaching Assistant was helpful for running highly interactive discussion sessions.

Some discussion sessions were taught by the professor, who had the opportunity to communicate with the class in a more relaxed and interactive setting.

Grading was performed jointly between the Teaching Assistant and the Professor.

Use of clickers for quizzes, with assessment of each question during discussion, contributed to lively class interactions.

Quizzes with clickers were a great learning medium. Although students were not performing well in quizzes, they were knowledgeable when they subsequently encountered individual quiz questions during class or in exams.

New textbook was not welcomed by the students. Although it covers a large variety of contemporary topics, it is more of a reference book rather than a self-contained textbook. In many topics the textbook referred to other books, instead of presenting first principles or working out examples.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

Change the textbook back to van Holde, Johnson and Ho.

Increase thermodynamics content in line with the textbook.

Keep the format of two midterms, one final, and several quizzes and homework problems.

PERSON(S) WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:

NAME: Dimitrios Morikis DATE: 07/22/2010

DATE OF PREPARATION: 08/06/2010

COURSE: BIEN 135 – Biophysics and Biothermodynamics

ACADEMIC TERM: Fall 2010

INSTRUCTOR: Dimitrios Morikis

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

1. Course Assessment for 2009-2010 AY

As in previous year, homework problems were a significant medium for the comprehension of sometimes abstract concepts.

Introduction of a second midterm was helpful in keeping the students alert and contributed in the continuity of the students' engagement with the class material.

Given the class size, Teaching Assistant was helpful for running highly interactive discussion sessions.

Some discussion sessions were taught by the professor, who had the opportunity to communicate with the class in a more relaxed and interactive setting.

Grading was performed jointly between the Teaching Assistant and the Professor.

Use of clickers for quizzes, with assessment of each question during discussion, contributed to lively class interactions.

Quizzes with clickers were a great learning medium. Although students were not performing well in quizzes, they were knowledgeable when they subsequently encountered individual quiz questions during class or in exams.

New textbook was not welcomed by the students. Although it covers a large variety of contemporary topics, it is more of a reference book rather than a self-contained textbook. In many topics the textbook referred to other books, instead of presenting first principles or working out examples.

2. Recommendations for 2010-2011 AY

Change the textbook back to van Holde, Johnson and Ho.

Increase thermodynamics content in line with the textbook.

Keep the format of two midterms, one final, and several quizzes and homework problems.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

Topics in Biophysical methods were not covered to the extent of previous years because of more emphasis on problem solving and consequent time constraints.

Homework on drug design was not given because of time constraints, although the subject was well covered.

Teaching Assistant, who had taken the class as an undergraduate at UCR, was helpful for running interactive discussion sessions. As this was the fourth time the class was taught and the class material had become more standardized, the discussion sessions were the responsibility of the Teaching Assistant.

As in previous years:

Homework problems were a significant medium for the comprehension of sometimes abstract concepts.

Two midterm exams were helpful in keeping the students alert and contributed in the continuity of the students' engagement with the class material.

Quizzes were a great learning medium. Use of clickers for quizzes, with discussion following each question, contributed to lively class interactions.

Grading was performed mainly by the very meticulous Teaching Assistant and was checked by the Professor.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

Increase time spent on the survey of biophysical methods. This will increase % Meeting Standard of FE 3 of Table 2.

Introduce a homework set on drug design. This will populate % Meeting Standard of FE 7 of Tables 1 and 2.

Re-introduce a homework set in reading a paper and writing an essay in conjunction with Homework 4 (hands-on work on computational protein modeling and analysis). This will increase % Meeting Standard of FE 8 of Table 2.

Keep the format of two midterms, one final, and several quizzes and homework problems.

PERSON(S) WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:

NAME: Dimitrios Morikis DATE: 08/06/2010

BIEN 140A

DATE OF PREPARATION: March 8, 2010

COURSE: BIEN 140A: Biomaterials I. 4 units

ACADEMIC TERM: Spring 2010

INSTRUCTOR: V. I. Vullev

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

During some of the lectures through the quarter, included a series of brief reviews on applying statistics to problems related to biomaterials. Statistical analysis was included in the last two quizzes

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

Include in the quizzes material from the discussion topics.

PERSON(S) WHO PREPARED THIS DESCRIPTION

Valentine Vullev

AND DATE OF PREPARATION: July 23, 2010

DATE OF PREPARATION: March 25, 2010

COURSE: BIEN 140A: Biomaterials I. 4 units

ACADEMIC TERM: Spring 2011

INSTRUCTOR: V. I. Vullev

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

During some of the

1. Included materials from the discussions in the quizzes: e.g., from the "dental materials" discussion in Quiz 6, and from the discussion on FDA regulations in Quiz 7.
2. Included program outcome G.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

The students' assessment of the course still varied between about 4 and 5, which showed that the quality of the course did not deteriorate with the increase in the size of the class, which was a big concern of mine in the beginning of the quarter.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

1. Increase the discussion time (one hour a week is not enough). Include more controversial topics on ethics and contemporary science and engineering related to materials.

PERSON(S) WHO PREPARED THIS DESCRIPTION

Valentine Vullev AND DATE OF PREPARATION: June 22, 2010

BIEN 155

DATE OF PREPARATION: Sep.28th, 2009
COURSE: BIEN 155 Biotechnology Lab. 2 units
ACADEMIC TERM: Fall 2009
INSTRUCTOR: Jiayu liao
ACADEMIC TERM: Fall 2009

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

Based on previous two years outcomes and assessment, we have changed our experimental objective of expression and characterizations from Interferon alpha to two fluorescence proteins-CyPet-SUMO1 and Ypet-Ubc9 in order to increase the contents of modern bioengineering contents this year.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

Students have developed and gained various abilities in a multidisciplinary team to conduct a series of bioengineering experiments to measure protein interactions using modern fluorescence technology-Förster Energy Transfer (FRET). Students have been able to understand and design a system including various components, such as DNA, bacterial cells, fluorescence proteins, electroporation apparatus, fluorescence imaging machine, spectroscopy, and high-throughput fluorescence plate reader, in order to detect protein interactions with the understandings of various realistic constraints. Students have developed effectively written and oral communication skills through experimental procedure discussion, four written lab reports and final oral presentation. Students have gained completely understandings and practice with skills and techniques for a modern bioengineering project

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

Because the second experiment of pET28(b) expression vector cloning is too challenging and cloning techniques cannot be learned in just one experiment, we will remove this experiment. We will focus more on fluorescence protein characterizations, which have a widely applications in both academic and industry.

PERSON(S) WHO PREPARED THIS DESCRIPTION

Jiayu Liao

AND DATE OF PREPARATION:15-Jul-10

BIEN 155 Fall 2010

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

Based on previous two years outcomes and assessment, we have changed our experimental objective of expression and characterizations from Interferon alpha to two fluorescence proteins-CyPet-SUMO1 and Ypet-Ubc9 in order to increase the contents of modern bioengineering contents this year.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

Students have developed and gained various abilities in a multidisciplinary team to conduct a series of bioengineering experiments to measure protein interactions using modern fluorescence technology-Förster Energy Transfer (FRET). Students have been able to understand and design a system including various components, such as DNA, bacterial cells, fluorescence proteins, electroporation apparatus, fluorescence imaging machine, spectroscopy, and high-throughput fluorescence plate reader, in order to detect protein interactions with the understandings of various realistic constraints. Students have developed effectively written and oral communication skills through experimental procedure discussion, four written lab reports and final oral presentation. Students have gained completely understandings and practice with skills and techniques for a modern bioengineering project

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

Because the second experiment of pET28(b) expression vector cloning is too challenging and cloning techniques cannot be learned in just one experiment, we will remove this experiment. We will focus more on fluorescence protein characterizations, which have a widely applications in both academic and industry.

PERSON(S) WHO PREPARED THIS DESCRIPTION

Jiayu Liao

AND DATE OF PREPARATION:6-Oct-11

BIEN 159

DATE OF PREPARATION: July 11, 2010

COURSE: BIEN 159: Dynamics of Biological Systems. 4 units

ACADEMIC TERM: Fall 2009

INSTRUCTOR: J.G. Lyubovitsky

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

To achieve the learning outcomes more effectively, more emphasis will be placed on group/class interactions and 'in-class' learning. More class time and emphasis will be placed on preparation for exams with examples specifically focused on what will be tested during the exam. The project requirement will be removed. The course will be restructured and consist of series of power point presentations.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

The students did not have prior exposure to the fundamental concepts of dynamic/thermodynamic processes. To match the rate of learning, the amount of material presented to the students was reduced. Per students' assessment regarding meeting these reduced course outcomes (100% student responded at the last class of the quarter), about 35 % of students disagree/strongly disagree that they were able to achieve 3 out of 5 outcomes. Out of 75% of students that responded to the numerical online evaluations, 50% had a low understanding of the course content.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

Require a course in thermodynamics or physical chemistry with thermo content as a prerequisite

PERSON(S) WHO PREPARED THIS DESCRIPTION

Julia Lyubovitsky - AND DATE OF PREPARATION: Jul-10

DATE OF PREPARATION: July 11, 2011

COURSE: BIEN 159: Dynamics of Biological Systems. 4 units

ACADEMIC TERM: Fall 2010

INSTRUCTOR: J.G. Lyubovitsky

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

n/a

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

To achieve the learning outcomes more effectively, more emphasis was placed on group/class interactions and 'in-class' learning. More class time as well as additional time and emphasis was placed on preparation for exams with examples specifically focused on what was tested during

the exam. The course was restructured and consisted of series of power point presentations. Majority of students felt that they achieved the course outcomes.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

There is a need for a course with thermodynamics content prior to taking BIEN159

PERSON(S) WHO PREPARED THIS DESCRIPTION Julia Lyubovitsky -
AND DATE OF PREPARATION: Jul-11

BIEN 165

DATE OF PREPARATION: 07/25/2010

COURSE: BIEN 165 – Biomolecular Engineering

ACADEMIC TERM: Spring 2010

INSTRUCTOR: Dimitrios Morikis

EVALUATION BY INSTRUCTOR:

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

N/A. This is a new course.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

Hands-on computer projects were a significant medium for understanding and extending material taught in class.

Discussion sessions, taught by the TA, included tutorials on the computer software used for the projects.

Invited lectures were an excellent medium to provide detailed research examples, which were elaborations on material taught in class.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

Change pre-requisites to BIEN 125 and BIEN 135. These include lower-division pre-requisites.

Increase content on de novo protein design using computational methods.

Include a sixth project on protein-ligand docking.

Spend more time on QSAR methods for drug design.

PERSON(S) WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:

NAME: Dimitrios Morikis DATE: 07/25/2010

BIEN 175

BIEN 175A & B (8) Senior Design Winter and Spring
Instructor: Jerome S. Schultz
Spring 2010

EVALUATION.

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

Project concepts provided to students in the Fall Quarter before Course starts in Winter Quarter
Add specific lecture and reading material on ethics

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

More time needed for projects, no lectures during lab periods
Include guest lectures from various bioengineering and biotechnology industries

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

Better definition of project goals and benchmarks
Spread lectures over two quarters so that more lab time is available during first quarter
Give quizzes to maintain student involvement with course material

BIEN 175A & B (8) Senior Design Winter and Spring
Instructor: Jerome S. Schultz
Spring 2011

EVALUATION.

CHANGES MADE THIS QUARTER BASED ON PREVIOUS ASSESSMENT RESULTS:

Required teams to maintain a Gantt chart to keep up with goals and benchmarks.
Lectures were distributed over 15 week period so that students could get a good start on their design project
Team reports were required each week, report writer was distributed among team members and report grades were factored into final grade for each student.

SUMMARY OF ASSESSMENT RESULTS FOR THIS QUARTER:

A method of requiring individual teams to meet with their faculty mentors on a weekly basis is needed. Several teams did not meet with their mentors frequently enough to avoid pitfalls in planning and implementing their projects.

A multidisciplinary component should be added to the course.

PROPOSED ACTIONS FOR COURSE IMPROVEMENT:

Make team meetings with mentors part of the grade for the team to encourage students to arrange these meetings.

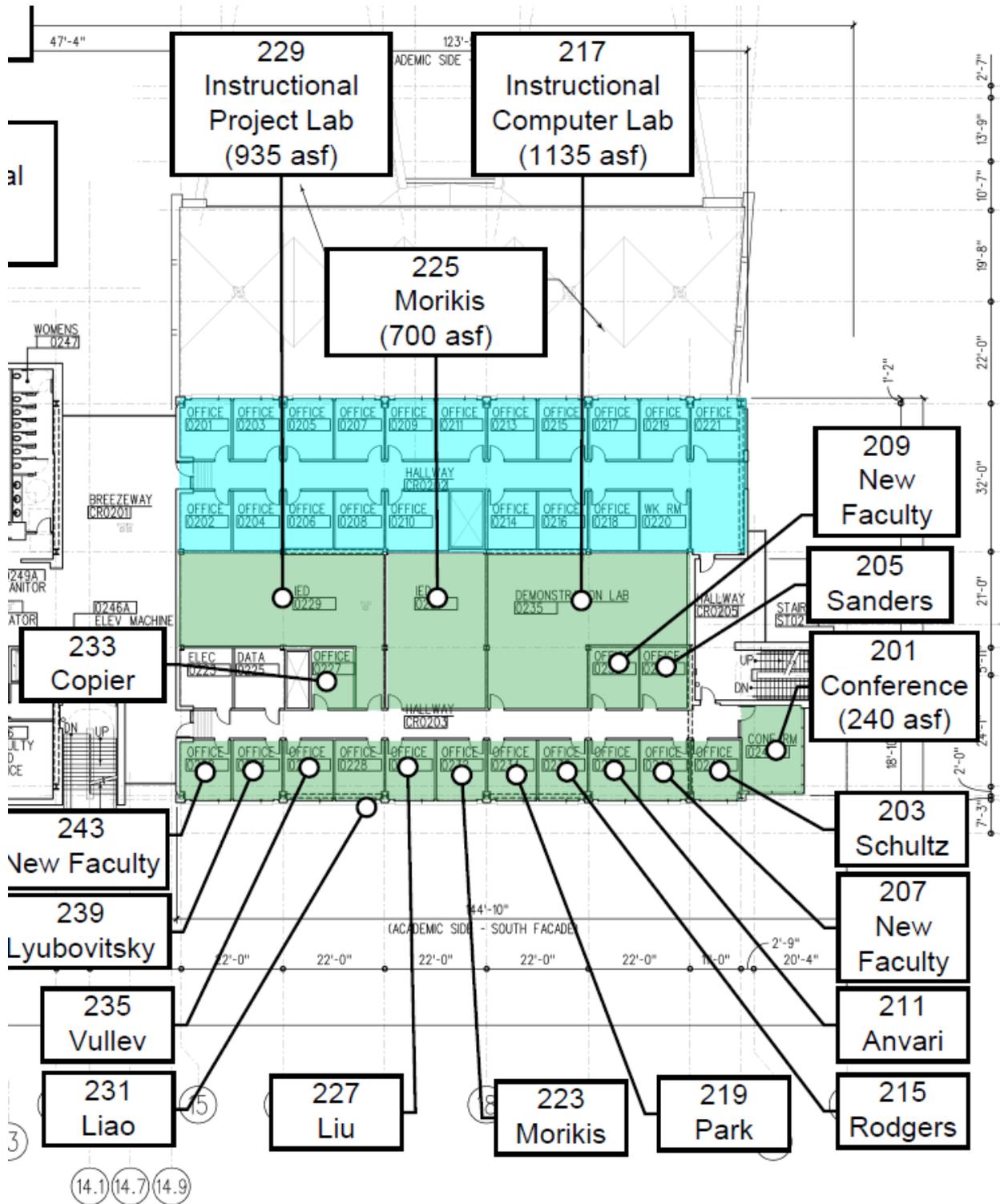
Connect the course with business students to provide multidisciplinary context and a better understanding of business aspects of bioengineering projects.

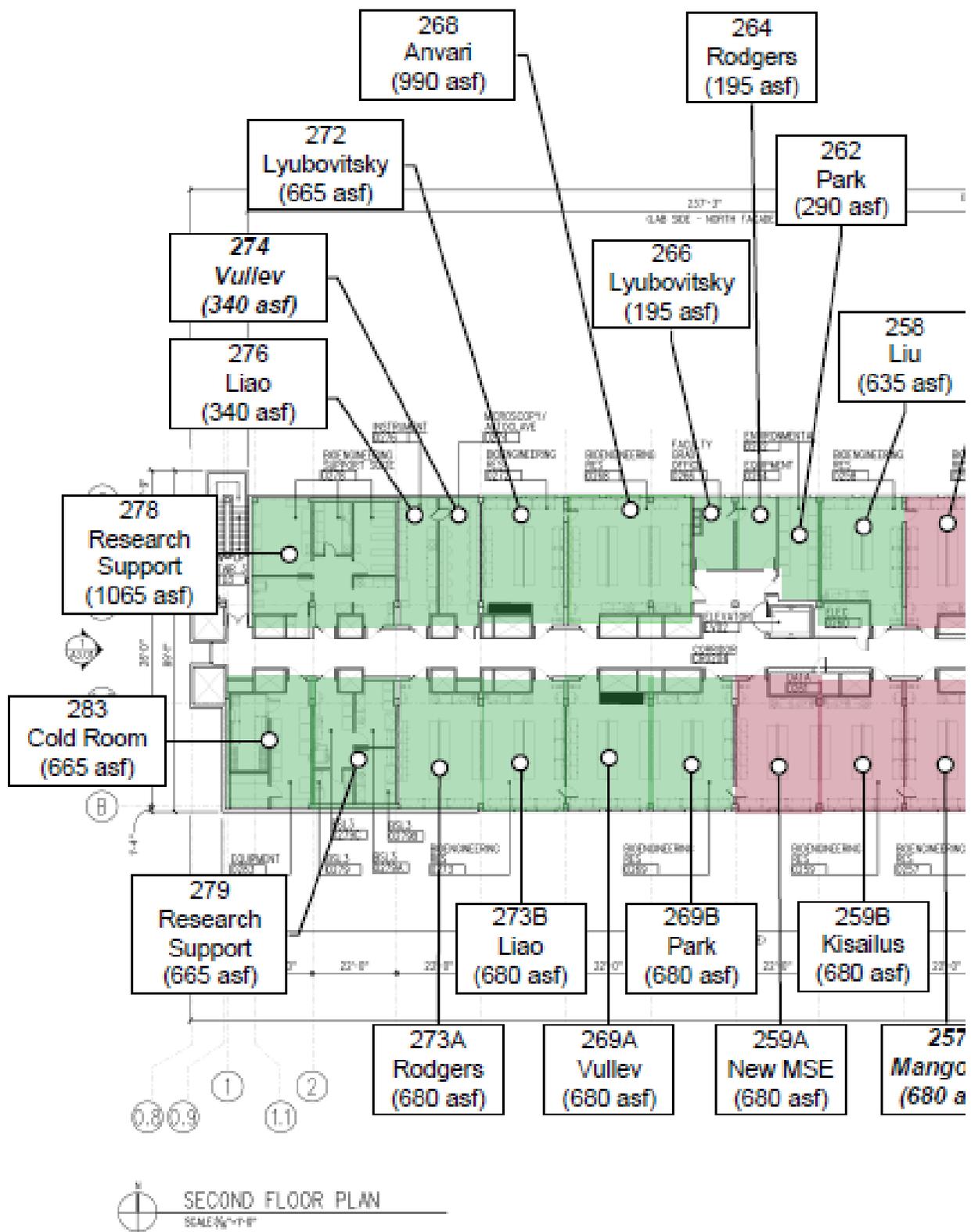
Enhance the coverage of ethics and global aspects of bioengineering in the course.

Appendix H Bioengineering Office and Laboratory Facilities

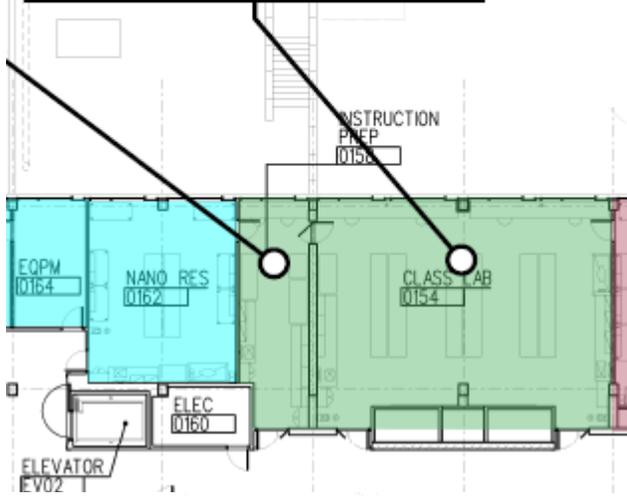
New Material Science and Engineering Building home of the Bioengineering Department







154
BIEN Instructional
Wet Lab
(1365 asf)



158
BIEN Instructional
Lab Prep
(345 asf)

Appendix I Computer and Library Facilities

Computer and Communications Overview

- Support Services
- Facilities and Infrastructure
- Other Services and Support

C&C (which includes the Instructional Technology Group, Computing Infrastructure and Security, the Computer Support Group, and Communications) is under the direction of the Associate Vice Chancellor and CIO who reports 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.
- Based on the academic discipline, sound systems and data projection resolution requirements may drive certain classroom minimum standards.

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)
- Coax 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. Their 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&C's Multimedia Technologies Group for operation 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 with C&C

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”.

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 provides licensed access to all of the current Springer books online, many of the e-books from the CRC EngNetBase, the Knovel Collection, the Wiley Online collection and many more.

Recently, through a special competitive initiative, the UCR Libraries has 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.

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.

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.

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.

Signature Attesting to Compliance Dean

By signing below, I attest to the following:

That the Department of Bioengineering 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