ABET
SELF-STUDY REPORT

for the

Department of
Biomedical Engineering

at

Illinois Institute of Technology

Chicago, IL

July 1, 2008

CONFIDENTIAL

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TABLE OF CONTENTS

BACKGROUND INFORMATION ........................................................................................................ 9-10
   Background Table 1.1 - BME Organizational Structure .....................................................11

CRITERION 1. STUDENTS
1.1 Student Admission
   1.1.1 Department of BME Admission ...........................................................................12
   Table 1.1 History of Admissions Standards for Freshmen
       Admissions for Past Six Years ...........................................................................12
1.2 Evaluating BME Student Performance .........................................................................12-13
1.3 Advising BME Students .................................................................................................13-14
   1.3.1 Medical School Advising .................................................................................14
   1.3.2 Grad School and Industry Advising ....................................................................14
1.4 Monitoring BME Student Progress ..............................................................................14-15
1.5 Transfer Students and Transfer Courses
   1.5.1 Institutional Policies ..........................................................................................15-16
   1.5.2 Specific Policies of the Department of BME .....................................................16
   Table 1.2 Transfer Students for Past Six Academic Years .......................................16
1.6 Graduation Requirements at IIT ..................................................................................16-17
1.7 Department of BME Enrollment and Graduation Trends ...........................................17-18
   Table 1.3 Enrollment Trends for Past Six Years ..........................................................18
   Table 1.4 Program Graduates .....................................................................................18-19
1.8 Student and Faculty Activities ......................................................................................19

CRITERION 2. PROGRAM EDUCATIONAL OBJECTIVES
2.1 Mission Statements
   2.1.1 University Mission .............................................................................................20
   2.1.2 Armour College of Engineering Mission ..........................................................20
   2.1.3 The Department of Biomedical Engineering Mission ........................................20
2.2 Program Educational Objectives
   2.2.1 The Department of Biomedical Engineering Program
       Educational Objectives ..........................................................................................19-20
   2.2.2 Discussion of Program Educational Objectives .................................................21-22
2.3 Consistency of the Department of Biomedical Engineering
       Program Educational Objectives with the University and
       the Armour College of Engineering Missions .......................................................22
2.4 The Department of Biomedical Engineering Constituencies .......................................22-23
2.5 Process for Establishing Program Educational Objectives
   2.5.1 The Department of Biomedical Engineering Program
       Educational Objectives Assessment Process .........................................................24
   2.5.2 Faculty Review ..................................................................................................24-25
   2.5.3 Student Advisory Board ..................................................................................25
2.5.4 Senior Exit Survey ................................................................. 25
2.5.5 Alumni Survey ................................................................. 25
2.5.6 External Advisory Board Review ........................................... 25-26
Table 2.1 Assessment Process ..................................................... 27
2.6 Achievement of Program Educational Objectives ....................... 28
  2.6.1 Senior Exit Survey ............................................................. 28
  2.6.2 Alumni Survey ................................................................. 28
  2.6.3 Employer Survey ............................................................... 28
Table 2.2 Pritzker Institute of Biomedical Sciences and Engineering/BME Advisory Committee ......................... 29-30

CRITERION 3. PROGRAM OUTCOMES
3.1 Process for Establishing and Revising BME Program Outcomes ................................................................. 31
3.2 BME Program Outcomes ........................................................ 31-32
  3.2.1 Relation of BME Program Outcomes to ABET Criterion 3 and 9 ......... 32
3.3 Relationship of BME Program Outcomes to BME Program Educational Objectives ................................................................. 32
  Table 3.1 Relationship Between Program Objectives and Outcomes ...... 33
3.4 Relationship of Courses in the BME Curriculum to the BME ................ 33
  3.4.1 Relationship of non-BME courses to the BME Program Outcomes ................................................................. 33-34
  Table 3.2 Math and Science Courses – Programs ............................ 34
  Table 3.3 Armour College Engineering Courses – Program Outcomes ................................................................. 35
  3.4.2 Relationship of the BME courses to the BME Program Outcomes ................................................................. 35-36
  Table 3.4 Relationship Between Program Outcomes and BME Courses ........................................................................ 36
3.5 Documentation of BME Program Outcomes Material ...................... 37
3.6 Achievement of BME Program Outcomes
  3.6.1 Direct Assessment of Program Outcomes ................................ 37-38
  Table 3.5 Performance Criteria for Outcomes Assessment ............... 38-42
  3.6.2 Indirect Assessment of Program Outcomes ....................... 42
  4.3.2.1 Exit Surveys ................................................................. 45
Table 4.2 Example of data from exit survey on skills achievement ........ 45
Table 4.3 Response to Alumni Survey .................................................. 45
4.3.2.2 Alumni Surveys ........................................................................ 45
4.3.2.3 Employer Surveys ..................................................................... 46
4.4 Program Educational Objectives
  4.4.1 Exit Surveys .................................................................................. 46
  4.4.2 Alumni Surveys ............................................................................ 46
Figure 4.2 Example of data obtained from Alumni Survey ............... 46
Figure 4.3 Perception of success in post-graduate study ....................... 47
  4.4.2.1 Placement Data ......................................................................... 47
  4.4.2.2 Achievement of Program Educational Objectives .................... 47
4.5 General Satisfaction with the Curriculum
  4.5.1 Exit Survey ................................................................................... 47
Figure 4.4 Placement data for 2007 graduates obtained from the Alumni
  Survey ..................................................................................................... 48
Table 4.4 Responses from Exit Survey regarding satisfaction with
  the program ............................................................................................. 48
4.6 Suitability of Program Outcomes and Program Educational
  Objectives .................................................................................................. 48-49
4.7 Actions Taken to Improve the Program
  4.7.1 Improvements Requiring Curricular Revision ............................... 49
    4.7.1.1 AY2002 revision to streamline curriculum ............................ 49
    4.7.1.2 AY2004 revision to engineering credits ................................. 49
    4.7.1.3 AY2004 revision to Neural Engineering and Medical
      Imaging .............................................................................................. 49-50
    4.7.1.4 AY2007-08 curricular revision to implement a MATLAB
      based engineering course .................................................................... 50
    4.7.1.5 AY2007-08 curricular revision to add a core biomaterials
      course .............................................................................................. 50-51
    4.7.1.6 AY2007 curricular revision to enhance design ....................... 51
    4.7.1.7 AY2008 curricular revision to enhance Physiology Lab ......... 51
  4.7.2 Actions to improve the program not requiring curricular revision
    4.7.2.1 Actions to improve the program from student and
      faculty course surveys ...................................................................... 51-54
    4.7.2.2 Actions to improve the program based on Exit
      Surveys ................................................................................................ 54-55
    4.7.2.3 Actions to improve the program based on direct
      program outcome assessment
      4.7.2.3.1 Actions taken to improve the assessment process ....... 55-57
Figure 4.5 Student satisfaction with laboratory courses and
  and capstone design from Exit Surveys from 2006-2008 .................... 56
Figure 4.6 Students’ perception of their potential success in post-
  graduate studies .................................................................................... 57
  4.7.2.3.2 Actions to improve achievement of program
    outcomes ............................................................................................. 57-59
Table 4.5 Percent achievement of specific Performance Criteria .......... 59
Table 4.6 Percent achievement of specific Performance Criteria .......... 59
4.7.2.4 Actions to improve the program based on Alumni Surveys .......................................................... 59-60
4.7.2.4.1 Planned placement compared to actual placement ........ 60
Figure 4.7 2006-2007 Senior Exit Profile ................................................. 60
Figure 4.8 Placement data from Alumni Survey for a) 2006 graduates and b) 2007 graduates .......................................................... 61
4.7.2.4.2 Alumni Ratings of Preparation vs. Importance of ABET Criteria .................................................................................. 62

4.8 Existing limitations and concerns
4.8.1 One-credit lab courses, enhanced capstone design, Additional core engineering courses ......................... 62-63
4.8.2 Multidisciplinary Teams ............................................................... 63
Table 4.7 Average responses of alumni to preparation vs. importance of program outcomes .................................................. 63-64

CRITERION 5. CURRICULUM
5.1 BME Program Curriculum ............................................................... 65
5.2 Curriculum ...................................................................................... 65-66
  5.2.1 Core Mathematics, Science, and Engineering Requirements ...... 66
  5.2.2 BME Core Engineering requirements ........................................ 66-68
  5.2.3 General Education .................................................................. 68
5.3 Preparation of Students for Engineering Practice ......................... 68
  5.3.1 Oral and Written Communication ........................................... 68-70
  5.3.2 Ethics and Professional Responsibility ..................................... 70-71
  5.3.3 Teamwork ................................................................................ 71
  5.3.4 Laboratory Experiences ......................................................... 71
  5.3.5 Design .......................................................... ................................. 71-72
5.4 Course Materials Notebook .............................................................. 72
  Table 5.1 Curriculum for the Department of Biomedical Engineering Cell and Tissue Engineering Track .................. 73
  Table 5.2 Curriculum for the Department of Biomedical Engineering Neural Engineering Track ............................................. 74
  Table 5.3 Curriculum for the Department of Biomedical Engineering Medical Imaging Track ................................................. 75
  Figure 5.1 BME Prerequisite Flow Chart ........................................ 76
  Table 5.4 Cell and Tissue Track Prerequisite Flow Chart .................. 77
  Table 5.5 Neural Engineering Tract Prerequisite Flow Chart ............. 78
  Table 5.6 Medical Imaging Track Prerequisite Flow Chart .................. 79
  Table 5.7 Course and Section Size Summary .................................... 80-82
  Table 5.8 BME Prerequisite Flow Chart Web Page .......................... 83-84

CRITERION 6. FACULTY
6.1 Leadership Responsibilities .............................................................. 85
6.2 Authority and Responsibility of Faculty ......................................................... 85
6.3 Faculty ........................................................................................................ 85-86
6.4 Faculty Competencies .................................................................................. 86
6.5 Faculty Size .................................................................................................. 86-87
6.6 Faculty Development ..................................................................................... 87-89
    Table 6.1. Faculty Workload Summary ......................................................... 90
    Table 6.2 Faculty Analysis ............................................................................. 91

CRITERION 7. BME PROGRAM FACILITIES
7.1 BME Space
    7.1.1 Offices ..................................................................................................... 92
    7.1.2 Classrooms ............................................................................................... 92
    7.1.3 Teaching Laboratory Space .................................................................... 92
        7.1.3.1 Measurements and Instrumentation Laboratory ........................ 92-93
        7.1.3.2 Ross Biofluids Laboratory ............................................................. 93-94
        7.1.3.3 Physiology Laboratory .................................................................... 94
        7.1.3.4 Design Laboratory ......................................................................... 94-95
        7.1.3.5 Computer Laboratory ................................................................. 95
    7.1.4 Research Facilities .................................................................................. 95

7.2 Resources and Support
    7.2.1 Computing Resources Used for Instruction
        7.2.1.1 Software available campus wide .................................................. 95-96
        7.2.1.2 Specialized Software Acquired by the BME Department ............ 96
    7.2.2 Limitations .............................................................................................. 96-97
    7.2.3 Plans for Maintaining and Upgrading Laboratories .............................. 97
    7.2.4 Support Personnel for Hardware, Software, and Networks ................. 97
    7.2.5 Support Personnel to Install, Maintain, and Manage Laboratory
        Equipment .................................................................................................... 97-98

7.3 Major Instructional and Laboratory Equipment ........................................... 98

CRITERION 8. SUPPORT
8.1 Program Budget Process and Sources of Financial Support ....................... 99
8.2 Sources of Support ....................................................................................... 99-100
8.3 Adequacy of Support ................................................................................... 100
8.4 Support of Faculty Professional Development ............................................. 100
8.5 Support of Facilities and Equipment ............................................................ 100-101
8.6 Adequacy of Support Personnel and Institutional Services ......................... 101

CRITERION 9. PROGRAM CRITERIA
    Included in Criterion 3. Program Outcomes .................................................. 102

APPENDIX A – COURSE SYLLABI ................................................................. 103

A. BME Courses ............................................................................................... 104-152
    BME 100 - Introduction to the Profession
    BME 200 - Biomedical Engineering Applications in MATLAB
BME 301 - Bio Fluids Mechanics
BME 309 - Imaging & Sensing
BME 310 - Biomaterials
BME 315 - Instrumentation Lab
BME 320 - Bio Fluids Lab
BME 330 - Analysis of Biosignals
BME 335 - Thermodynamics of Living Systems
BME 405 - Physiology Lab
BME 408 - Reaction Kinetics for BME
BME 419 - Introduction to Design
BME 420 - Design
BME 422 - Numerical Solutions to BME Problems
BME 425 - Tissue Engineering
BME 430 - Concepts of Medical Imaging
BME 433 - BME Stats
BME 438 - Neuroimaging
BME 443 - Biomedical Instrumentation & Electronics
BME 445 - Quantitative Neural Function
BME 452 - Control Systems for Biomedical Engineers
BME 475 - Neuromechanics of Human Movement
BME 482 - Mass Transport for BME
BME 490 - Senior Seminar

B. Armour College Engineering Courses .......................................................... 153-173
   CHE 202 - Material and Energy Balances
   ECE 211 - Circuit Analysis I
   ECE 212 - Analog & Digital Lab I
   ECE 213 - Circuit Analysis II
   ECE 214 - Analog & Digital Lab II
   ECE 218 - Digital Systems
   ECE 437 - Digital Signal Processing I
   ECE 481 - Image Processing
   MMAE 200 - Introduction to Mechanics
   MS 201 - Materials Science

C. Math & Science Courses ............................................................................. 174-205
   BIOL 115 - Human Biology
   BIOL 117 - Experimental Biology Lab
   BIOL 430 - Animal Physiology
   CHEM 124 - Principles of Chemistry I
   CHEM 125 - Principles of Chemistry II
   CHEM 237 - Organic Chemistry I
   CHEM 239 - Organic Chemistry II
   CS 105 - Introduction to Computer Programming I
   CS 115 - Object Oriented Programming I
CS 201 - Accelerated Introduction to Computer Science
MATH 151 - Calculus I
MATH 152 - Calculus II
MATH 251 - Multivariate & Vector Calculus
MATH 252 - Introduction to Differential Equations
MATH 333 - Matrix Algebra & Complex Variables
PHYS 123 - General Physics I: Mechanics
PHYS 221 - General Physics II: Electromagnetism & Optics
PHYS 224 - General Physics III: Thermal & Modern Physics

APPENDIX B – FACULTY RESUMES ......................................................... 206-232
Mark Anastasio, PhD, Assoc. Prof
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Eric Brey, PhD, Asst. Prof.
Jennifer Kang Derwent, PhD, Assoc. Prof.
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David Gatchell, PhD, Research Assist. Prof.
Connie Hall, PhD, Senior Lecturer
Derek Kamper, PhD, Assist. Prof.
David Mogul, PhD, Assoc. Prof.
Emmanuel Opara, PhD, Research Prof.
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Philip Troyk, PhD, Assoc. Prof.
Vincent Turitto, DEngSci, Prof., Chair

APPENDIX C – LABORATORY EQUIPMENT
Table C.1 – BME Laboratory Equipment ........................................ 233-238

APPENDIX D – INSTITUTIONAL SUMMARY ........................................ 239-275
Table D.1. Programs Offered by the Educational Unit
Table D.2. Degrees Awarded and Transcript Designations
by Educational Unit
Table D.3. Support Expenditures
Table D.4. Personnel and Students
Table D.5. Program Enrollment and Degree Data
Table D.6. Faculty Salary Data

APPENDIX E - DEPARTMENT OF BIOMEDICAL ENGINEERING
DOCUMENTATION ..............................................................................276-318
BME Program Planning Sheet (1 for each track)
BME Exit Interview Survey
BME Alumni Survey
BME Employer Survey
Student Course Survey
Faculty Course Survey
SELF-STUDY REPORT

DEPARTMENT OF BIOMEDICAL ENGINEERING
BS in Biomedical Engineering
Illinois Institute of Technology

BACKGROUND INFORMATION

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Program History

The Department of Biomedical Engineering entered its first undergraduate class in 2002. The Department evolved out of the Pritzker Institute of Biomedical Science and Engineering. The Institute received a Whitaker Foundation grant in 2000 to found the PhD program and then another in 2001 to found the undergraduate program; recruitment of faculty and work began that year. The current 3 tracks were founded and the supporting curriculum began to emerge as each class moved up. Refinement of the curriculum has been a continuous process.

Options

The Department of Biomedical Engineering has 3 tracks: cellular and tissue engineering, neural engineering, and medical imaging. There is a core math, science, and engineering (including BME courses) curriculum that all students take concurrent with a track specific biomedical engineering curriculum.

Organizational Structure

The Department of Biomedical Engineering depends upon two primary mechanisms within the departmental structure: the Undergraduate Curriculum Committee and the ABET Committee. Both collect and analyze data, assess information, make and recommend policy to the Department and the Chair. Both committees have the power to make certain routine decisions as well as the ability to make recommendations in curricular policy to the faculty and the chair.
Many of these decisions are within the purview of the Department and do not go up to the College.

Questions regarding student credit overload, late adds and drops, or any change of grade have to be approved by the Dean of Armour College of Engineering. New course forms also go through the Dean’s office.

Larger curricular issues, such as increasing total credit hours for the degree go to the University Undergraduate Curriculum Committee.

See Background Table 1.1 - BME Undergraduate Organizational Structure.

**Program Delivery Modes**

The Department of Biomedical Engineering offers its undergraduate courses predominately during the day, Monday through Friday. The traditional lecture and laboratory format is followed utilizing problems sets, writing assignments, laboratory reports, oral presentations, quizzes, examinations, programming assignments, and projects (e.g., design).

**Deficiencies, Weaknesses or Concerns Documented in the Final Report from the Previous Evaluation(s) and the Actions taken to Address them**

This is the initial application by the Department of Biomedical Engineering at IIT for ABET accreditation. There are no previous reports, etc.
BACKGROUND TABLE 1.1 – BME ORGANIZATIONAL STRUCTURE

BME UNDERGRADUATE ORGANIZATIONAL STRUCTURE

Undergraduate Committee → ABET Committee

BME Chair → BME Department

Dean of Armour College of Engineering → University Undergraduate Studies Committee
CRITERION 1. STUDENTS

1.1 Student Admission

Armour College of Engineering provides a rigorous education that prepares students to become qualified engineers. To satisfy this mission, its faculty have established a minimum set of academic standards and academic policies to which all continuing students must adhere. The processes used to evaluate, advise, and monitor students are described in this section. The advising process ensures that all students follow a designated curriculum, by track in the BME department, that leads to the achievement of the BME Program Outcomes, a-m as shown in Table 3.2 and then, ultimately, the students are prepared to achieve the Program Educational Objectives 1-5, as seen in Table 3.1.

1.1.1 Department of BME Admission

Students are typically accepted into the Department of Biomedical Engineering (BME) as freshman. Inter- and intra-university transfers are also accepted. The undergraduate admissions process is centralized at Illinois Institute of Technology. Admission requirements are based on a combination of secondary school grades, standardized test scores, co-curricular activities, and other indicators of the applicant's academic abilities. Although the BME Department does not formally participate in the admissions process, it is routinely consulted by admissions representatives to ensure that all applicants meet the standards for admission.

BME freshmen generally score slightly higher than other incoming freshmen in Armour College of Engineering and across the campus as a whole.

Table 1.1 History of Admissions Standards for Freshmen Admissions for Past Six Years

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>BME Composite ACT</th>
<th>BME Composite SAT</th>
<th>Campus Avg. w/o Armour</th>
<th>Armour Avg. w/o BME</th>
<th>Number of New Students Enrolled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN.</td>
<td>AVG.</td>
<td>MIN.</td>
<td>AVG.</td>
<td>ACT</td>
</tr>
<tr>
<td>2002-3</td>
<td>18</td>
<td>29</td>
<td>1110</td>
<td>1303</td>
<td>27</td>
</tr>
<tr>
<td>2003-4</td>
<td>22</td>
<td>29</td>
<td>1170</td>
<td>1370</td>
<td>28</td>
</tr>
<tr>
<td>2004-5</td>
<td>20</td>
<td>28</td>
<td>1150</td>
<td>1309</td>
<td>28</td>
</tr>
<tr>
<td>2005-6</td>
<td>21</td>
<td>29</td>
<td>1050</td>
<td>1325</td>
<td>28</td>
</tr>
<tr>
<td>2006-7</td>
<td>19</td>
<td>29</td>
<td>1090</td>
<td>1253</td>
<td>28</td>
</tr>
<tr>
<td>2007-F</td>
<td>15</td>
<td>29</td>
<td>1080</td>
<td>1297</td>
<td>27</td>
</tr>
</tbody>
</table>

*This graph was adjusted to include data that was available and place the BME program in perspective relative to the Armour College of Engineering and the IIT campus.

1.2 Evaluating BME Student Performance
Evaluation of the student’s progress and level of performance in coursework is conducted by use of metrics including homework, quizzes, projects, presentations and exams. The student’s progress is reflected by the letter grade earned in the course, which is documented on the student’s institutional transcript and is utilized in the calculation of the student’s Grade Point Average (GPA) on a maximum scale of 4.00. The academic status of every student in the Armour College of Engineering is reviewed at the end of each semester. Students who do not earn at least a 2.00 cumulative GPA, a 1.85 current GPA, and a 2.00 GPA in their major field are placed on academic probation. Degree-seeking students are also required to maintain a minimum of 12 credit hours per semester applicable to their degrees. The BME Department is notified by the Associate Provost of Undergraduate Affairs when students enter probation status, and such students are counseled by the Undergraduate Coordinator of the department and their advisor. Students on probation are not permitted to register for more than 15 credits per semester, hold office in any student organization, represent the university on any athletic team, or participate in the cooperative education program.

Undergraduate students who have completed at least 60 credit hours will receive an audit from the Office of Educational Services, which will provide a summary of the student’s academic status to date and lists the courses to be completed in order to receive a degree. At the end of each semester the names of all undergraduate students who have completed at least 12 credit hours without any D or E grades and who have a semester GPA of at least 3.50, will appear on the Dean’s List.

1.3 Advising BME Students

Each BME student is first advised by the Chair or an Undergraduate Curriculum Committee representative if the Chair is unavailable prior to matriculation. Each BME student is then assigned a faculty advisor in their first semester in the BME Department who remains associated with that student from the freshman year, or date of transfer, to graduation. Each student meets each semester with his/her faculty advisor to assist with course selection and discuss other educational and research opportunities as well as long-term career plans. The BME Department has three track areas – Cellular and Tissue Engineering, Neural Engineering, and Medical Imaging, each of which have specific curricular requirements in addition to the core BME courses. By the end of the freshman year, the students are required to select one of these three tracks in which they will specialize. Students in the BME Department are required to meet with their advisors at least once per semester to discuss course selection for the following term. The advisor monitors the student’s progress, and ensures that the selected courses adhere to the BME curriculum chosen by the student. The advisor signs a registration form containing the agreed upon coursework that is submitted to the Registrar’s Office, or, more commonly, provides an electronic authorization that permits the student to register using a web-based system called “Web-for-Students.” The advisor also maintains a program planning sheet that tracks the students progress toward the degree (see Appendix E).

As part of their first-year experience in the BME Department, all freshman and transfer students are required to complete the course BME 100 – Introduction to the
Profession. In addition to exposing them to an overview of the field of BME and instilling critical skills in writing and analyzing technical literature, this course provides an important forum in which the policies and expectations of the department are communicated to the students. Moreover, the instructor of this course often serves as an unofficial liaison between the new student and the BME department, which helps to ensure that the new student becomes properly integrated into the established advising system.

Exit interviews are conducted with all graduating seniors on an individual basis with the Department Chair twice during their senior year. The first interview takes place at an early stage during the fall semester in order to gain insight on the students’ plans after graduation and offer specific career suggestions. The second interview takes place at a latter stage in the spring semester where their plans are readdressed.

1.3.1 Medical School Advising

Approximate 30% of the BME graduates in the first two graduating classes attended medical school. In order to assist this large student group, additional advising for pre-med students is provided. BME faculty advisors are made aware of the additional requirements for medical school admission so that students are adequately informed. One major concern for these students is the fact that most medical schools will not accept Advance Placement Credit in the sciences. Students must complete one year each of biology, chemistry (both organic and inorganic) and physics with a laboratory component. Thus, it is not in the best interest of these students to accept AP credit for university science courses, particularly in inorganic chemistry (the standard first year chemistry sequence) because the choices of upper division inorganic chemistry courses are limited. In addition to BME faculty advising, there is a campus wide Premedical Studies Committee that advises these students. The BME Department is always represented on this committee.

1.3.2 Grad School and Industry Advising

Students meet with the BME Graduate Advisor in the Fall Semester of their senior year where a presentation on the nature of graduate work, requirements, professional preparation is made. Students also meet with their BME advisors regarding graduate applications and letters of recommendation.

IIT presents a Career Fair each semester where students have an opportunity to meet with industry representatives. In April 2008, The BME Department hosted the Midwest Biomedical Engineering Conference (MBEC). Students received assistance in planning academic and industrial careers, were introduced to companies based in the Midwest, and exposed them to innovative biomedical engineering research.

1.4 Monitoring of BME Student Progress
Student performance is monitored at the end of every semester during the academic year, as described above in Sections 1.2 and 1.3. Specifically, the Office of Undergraduate Affairs automatically monitors the current, cumulative, and major GPAs of all students, and notifies the Undergraduate Coordinator of BME which students are entering probation status. At the end of each semester, the Associate Provost of Undergraduate Affairs and the BME Undergraduate Curriculum Committee in consultation with the student’s faculty advisor will review all such cases and make decisions on any necessary actions. Actions range beyond placing the student on probation and include dismissing the student from the program and/or from IIT, or requiring an academic contract in which the student has to set specific expectations for this/her performance in upcoming semesters. Adherence to the contract terms is monitored by the Undergraduate Coordinator as well as the student’s academic advisor, who maintains a program of study that is reviewed and updated at the end of each semester. Finally, undergraduate students who have completed at least 60 credit hours will receive an audit from the Office of Educational Services which will provide a summary of the student’s academic status to date and lists the courses to be completed in order to receive a degree. Students may request additional audits up to one time per semester.

1.5 Transfer Students and Transfer Courses

1.5.1 Institutional Policies

The Office of Undergraduate Admissions is responsible for admissions decisions for full-time transfer students. Transfer students may apply for the fall or spring term, and admission decisions are made on a rolling basis. Transfer applicants must be in good academic standing at their previous colleges to be considered for admission to IIT. Admission is based on individual grades in all classes that apply to the major. Transfer applicants with less than 30 credit hours of transferable graded college coursework must submit high school transcripts and standardized test scores.

Official transfer credit evaluations are completed by the Office of Educational Services after a student is admitted to IIT. Courses may be acceptable for transfer from accredited colleges and universities, provided they are comparable in content and level to those offered by IIT. A course in which a grade lower than a ‘C’ was received is not eligible for transfer. A maximum of 68 credit hours is transferable from a two-year institution. In addition to the official transcript submitted for admission, the student is required to provide the Office of Educational Services with course descriptions and syllabi for all courses he/she wishes to have considered for transfer credit. All engineering upper-division transfer courses must be from an ABET accredited program and approved by the BME Department as described below. In the case of transfer of engineering credits from international institutions, courses are reviewed by the Educational Services and the Department. Upon admission and enrollment, transfer credits are incorporated into the permanent record in terms of semester hours. However, the GPA will only reflect grades from courses completed at IIT. The final 45
credit hours of work must be completed at IIT, and the student must complete a minimum of 45 credit hours at IIT in order to be eligible for a bachelor’s degree from IIT.

An existing student may request a review of academic status or university regulations by submitting an academic petition to the Office of Educational Services. An undergraduate student registered at IIT who wishes to enroll at another institution must submit an academic petition to the Office of Educational Services for approval prior to registration at the other institution. This includes registration at another institution for the summer term.

1.5.2 Specific Policies of the Department of BME

The BME Department must approve all transfer credit that seeks to satisfy 100 through 400 BME required or elective courses. A student may be permitted to apply transfer credit toward a 300 or 400-level BME course under specific conditions. Approval of the transfer credit by the IIT Office of Educational Services is a necessary but not sufficient condition for its application toward the BME degree. This establishes that the transfer credit must be from an ABET accredited institution. The course syllabus, including instructor contact information, and catalog description from the institution where the course will be or was taken must be submitted to the BME Department Undergraduate Curriculum Committee. This body will render the final decision indicating the applicability of the transfer credit to the BME degree.

Any request for course substitutions, e.g., double majors, must be reviewed and/or approved by the Undergraduate Curriculum Committee.

Table 1.2 Transfer Students for Past Six Academic Years

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>Number of Transfer Students Enrolled</th>
<th>Number of Transfer Students from within IIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002-3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>2003-4</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>2004-5</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>2005-6</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>2006-7</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>2007 F</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

1.6 Graduation Requirements at IIT

A student has the ultimate responsibility to fulfill all graduation requirements as specified in the IIT Bulletin in effect at the time of admission to IIT. This includes completing all the curriculum requirements for the degree and complying with all academic and administrative rules governing the specific degree program.

In the event that curriculum requirements change before a specific degree program can be completed, a student must have their department chair’s approval to make course substitutions or to follow an alternate curriculum.
Students must submit an Application for Graduation form to the Office of Educational Services at the beginning of the semester in which they plan to graduate. The specific deadlines to submit this form are found in the IIT calendar which is in the IIT Bulletin. Failure to meet the specific deadline will delay the date of graduation and the awarding of a diploma. The Application for Graduation form can be obtained in the Office of Educational Services. A $50.00 late fee will be assessed for applications received after the published deadline date.

Undergraduate students must complete the following in order to graduate:

* General education requirements.
* Curriculum requirements including required number of credit hours for the specific degree program.
* Academic Residence requirement. The final 45 semester hours towards a degree must be completed at IIT.
* A minimum cumulative grade point average of 2.00 and a minimum major grade point average of 2.00. In the event a student completes all curriculum requirements for a specific degree program but does not meet a minimum grade point average, written approval from both the student's department chair and academic dean is required prior to registering for additional courses.
* Completion of all the above within a period of eight calendar years from the semester of initial admission for full-time students or twelve calendar years for part-time students after achieving degree-seeking status. A student may petition the major department and the academic dean to have this period extended; if approved, this extension may involve additional compensating academic requirements.
* Payment of all financial obligations to the university.

NOTE:
If a student receives a grade of "I" (Incomplete) in the final semester, curriculum requirements are not completed. The student will not receive a diploma dated for that semester and must submit a new Application for Graduation form.

1.7 Department of BME Enrollment and Graduation Trends

New freshman enrollment in the Department of Biomedical Engineering from 2002-2006 has averaged approximately 35 students each year (Table 1.1). Added to this number are transfer students from other campuses, mostly junior colleges (Table 1.2). There are also a number of students who transfer to the BME Department from other IIT programs with the majority from engineering departments, but some from biology (Table 1.2). This enrollment pattern has proven steady as has the talent level of the students. The Department attracts high quality students (Table 1.1). BME freshmen on average enter with higher scores compared to the campus average SAT and are on par with the Armour College of Engineering. Table 1.3 shows enrollment trends for the past 7 academic years (since the inception of the Department).
The Department has been active in attracting students, both undergraduate and graduate. For example, Department personnel have visited several local high schools and the Illinois Math and Science Academy regularly. Also, the Department has had an exhibit booth at the Biomedical Engineering Society Annual Fall Meeting to recruit students for the past 6 years. Graduation rates are also displayed in Table 1.3.

Table 1.3 Enrollment Trends for Past Seven Academic Years

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time Students</td>
<td>40</td>
<td>65</td>
<td>101</td>
<td>121</td>
<td>135</td>
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<td>Part-time Students</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
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<tr>
<td>Student FTE¹</td>
<td>42</td>
<td>69</td>
<td>107</td>
<td>130</td>
<td>146</td>
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<tr>
<td>Graduates</td>
<td>21</td>
<td>27</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹FTE = Full-Time Equivalent (uses IITs Credit hour definition of 1FTE = 15 hrs
FTE data includes undergraduates only

Table 1.4 Program Graduates – Spring 2008 (+ 2 F07 & 2 Sum07)
(For Past Five Years or last 25 graduates, whichever is smaller)

<table>
<thead>
<tr>
<th>Numerical Identifier</th>
<th>Year Matriculated</th>
<th>Year Graduated</th>
<th>Prior Degree(s) if Master Student</th>
<th>Certification/Licensure (If Applicable)</th>
<th>Initial or Current Employment/Job Title/Other Placement</th>
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<tbody>
<tr>
<td>1 102-65-308</td>
<td>2005</td>
<td>2008</td>
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<td>N/A</td>
<td>Grad School</td>
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<tr>
<td>2 102-72-624</td>
<td>2004</td>
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<td>N/A</td>
<td>Med School</td>
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<tr>
<td>3 102-71-139</td>
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<td>4 102-46-463</td>
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<td>Industry</td>
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<tr>
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<td>N/A</td>
<td>Industry</td>
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<tr>
<td>6 104-05-179</td>
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<td>N/A</td>
<td>N/A</td>
<td>Grad School</td>
</tr>
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<td>7 103-72-395</td>
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<td>8 102-15-351</td>
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<td>N/A</td>
<td>N/A</td>
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<tr>
<td>9 103-89-897</td>
<td>2004</td>
<td>2008</td>
<td>N/A</td>
<td>N/A</td>
<td>Undecided</td>
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<tr>
<td>10 103-88-517</td>
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<td>Grad School</td>
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<td>11 102-23-222</td>
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<td>Grad School</td>
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<tr>
<td>12 103-88-352</td>
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<td>2008</td>
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<td>N/A</td>
<td>Undecided</td>
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<tr>
<td>13 103-87-828</td>
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<td>N/A</td>
<td>Industry</td>
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<td>14 102-48-162</td>
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<td>N/A</td>
<td>Grad School</td>
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<tr>
<td>15 102-42-888</td>
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<td>16 104-12-015</td>
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<td>N/A</td>
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<td>17 104-13-873</td>
<td>2006</td>
<td>2008</td>
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<td>N/A</td>
<td>Home/family</td>
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<tr>
<td>18 102-06-709</td>
<td>2004</td>
<td>2008</td>
<td>N/A</td>
<td>N/A</td>
<td>Grad School</td>
</tr>
<tr>
<td>19 104-05-988</td>
<td>2005</td>
<td>2008</td>
<td>N/A</td>
<td>N/A</td>
<td>Med School</td>
</tr>
</tbody>
</table>

18
### 1.8 Student and Faculty Interaction

BME students work closely with faculty both in and beyond classes. There is an active BMES student chapter at IIT that engages in a variety of professional development and social activities. Students attend sporting events according to season. The Department hosts a welcome cook-out each fall for all students and faculty but particularly to welcome the new freshmen. The Department also hosts a dinner for graduating seniors each spring. On a professional level, the chapter organizes and acts as an intermediary with Michael Reese Hospital for student volunteers. There have also been field trips to major biomedical companies and to medical centers. Two faculty members advise these students and aid in their fund-raising and other events.

Undergraduate students also play a role in research. On average, about 8-10 students work with faculty in a research capacity in their laboratories. Many of these students have presented at BMES and other professional society meetings. More undergraduates work in the faculty research laboratories over the summer months.
CRITERION 2. PROGRAM EDUCATIONAL OBJECTIVES

2.1 Mission Statements

2.1.1 University Mission

The Mission of Illinois Institute of Technology is (http://www.iit.edu/about/index.html):

To advance knowledge through research and scholarship, to cultivate invention improving the human condition, and to educate students from throughout the world for a life of professional achievement, service to society, and individual fulfillment.

2.1.2 Armour College of Engineering Mission

The Mission of the Armour College of Engineering is (http://www.iit.edu/engineering/about/mission.shtml):

Provide state-of-the art education and research programs; educate a new breed of engineers with a strong fundamental knowledge of engineering principles, the capability to apply their knowledge to broad interdisciplinary areas, and an understanding and appreciation of the economic, environmental, and social forces that impact intellectual choices; and enhance Armour's reputation as an internationally recognized engineering school.

2.1.3 The Department of Biomedical Engineering Mission

The Mission of the Department of Biomedical Engineering is (http://www.iit.edu/engineering/bme/programs/undergrad/overview.shtml):

To educate students in the fundamentals of biomedical engineering. This foundation consists of a broad exposure to the chemical, mathematical, physical and biological sciences, coupled with the appropriate technical and engineering skills to be able to fill diverse professional roles in industry, graduate school and the medical professions.

2.2 Program Educational Objectives

2.2.1 Department of Biomedical Engineering Educational Objectives

The Undergraduate Program is designed to meet the following specific objectives in order to fulfill the Departmental, College, and University Missions. These objectives describe the qualities and performance of our alumni and can be found at: http://www.iit.edu/engineering/bme/programs/undergrad/objectives.shtml
1. Our alumni possess the quantitative, analytic, and critical thinking skills necessary for solving biomedical engineering problems in industry, graduate or professional graduate programs.

2. Our alumni possess the ability to employ biomedical engineering laboratory skills in industry, graduate or professional graduate programs.

3. Our alumni possess the requisite written and oral communication skills necessary to interact with health care professionals, engineers or scientists in industry, graduate or professional graduate programs.

4. Our alumni possess the ability to work in teams in industry, graduate or professional graduate programs.

5. Our alumni possess the sense of responsibility and ethics of a professional engineer in industry, graduate or professional graduate programs.

2.2.2 Discussion of Program Educational Objectives

**Objective 1.** A central focus of our biomedical engineering program is for students to possess a matrix of necessary critical analytic skills that will eventually result in their ability to solve complex problems. This means a solid foundation in mathematics, physics, biology, chemistry, and engineering. Problem solving, creativity, and an ability to think critically are founded in both a knowledge base and a problem solving curriculum.

**Objective 2.** A guiding principle for the IIT BME program at is to train our students and equip them with the latest in laboratory and technical skills and the necessary accompanying analytic abilities that will make them competitive for entry into industry and the graduate/medical world. As such, we emphasize significant laboratory experiences that are integrated with the highest cognitive levels that hone their analytic and creative abilities.

**Objective 3.** The nature of the professional world, either in academia, industry, and the healthcare/medical professions requires that engineers effectively communicate with a wide range of professionals. Communication, either written or in presentation form, is an integral element in the BME curriculum. Students receive instruction the first freshman semester and that emphasis is reinforced throughout the Department until graduation. The students also take a variety of other courses in Humanities and the Social Sciences that further reinforce these skills. Central to our commitment is the simple but critical approach that clear critical thinking precedes a written paper or a poster presentation. Communication skills are not taught without the accompanying critical thinking skills.
**Objective 4.** Biomedical Engineering is of such a complex state the very nature of problem solving within industry, academic-based research, and medical school-based research are by their very definition team oriented. From their first class in the fall of the freshman year to the final design capstone course, BME students have a wide range of team experiences to make them aware of the nature of intellectual sharing and working towards common goals.

**Objective 5.** Students are immersed immediately in their freshman year and then throughout the breadth of BME curriculum about the responsibility that they will assume as biomedical engineers. Their actions as engineering scientists can ultimately have an impact on the health of patients. There is a code of conduct proffered by the Biomedical Engineering Society that is used as a basis for understanding their mission. An inherent aspect of this is an understanding of ethical behavior regarding their actions towards animal experimentation, patient privacy, patient needs, etc.

### 2.3 Consistency of the Department of Biomedical Engineering Program Educational Objectives with the University and the Armour College of Engineering Missions

The Mission of IIT is to advance knowledge through research and scholarship and serve the needs of human kind and the larger community with professional and individual achievement. The Armour College of Engineering further defines this for engineering with a focus on rigorous academic preparation and training students to broadly apply their knowledge and skills into an ever changing world.

The Department was founded upon the belief that biomedical engineering is an interdisciplinary major in which the principles and tools of traditional engineering fields, such as mechanical, materials, electrical, and chemical engineering are integrated with the chemical, physical and biological sciences, and applied towards a better understanding of physiological processes in humans or towards the solution of medical problems. Engineering will continue to play an increasingly important role in advancing medical treatment, developing biotechnology, and improving health-care delivery. By its very nature, biomedical engineering is expansive and requires a broad and integrated foundation in the physical, chemical, mathematical and biological sciences.

### 2.4 The Department of Biomedical Engineering Constituencies

The BME program relies primarily upon 3 groups of constituents: its faculty, students, and alumni, and secondarily from industry and professional graduate schools who have input into the program educational objectives. The assessment process depends upon contributions from all constituents. However, the role of implementing the assessment and revision process is a central faculty responsibility.

It should be noted that at another level, BME program educational objectives can be impacted. The Armour College of Engineering plays an important role in developing
undergraduate programs that meet the mission of the College and University as a whole. Their input includes external assessment and revision of program objectives and outcomes as well as their role in the delivery and assessment of engineering courses outside of BME.

Also, University administration can contribute to the program through the development, delivery, and assessment of a broad range of courses in the arts and sciences as well as ensuring that students have the tools and learning environment necessary to develop as students, engineers, and citizens.

The most immediate impact comes from:

**BME Majors:** This group represents the current students within the program. These students contribute to the assessment process through the use of data generated in courses, course evaluations, senior exit surveys, and the student advisory board.

**BME Alumni:** This group contains the graduates of the BME program. Their contributions will include completion of departmental alumni surveys, college and university surveys, representation on external review boards, and direct communications with the Department.

**BME Faculty:** The departmental faculty members are responsible for ensuring the success of the undergraduate BME program. These responsibilities include implementing the process of assessment and revision of program objectives and outcomes in collaboration with larger constituent body.

**Employers**

*Industry:* This group represents employers or potential employers of BME alumni at any point in their career, i.e., immediately after graduation from this institution or at any point later in their career. These employers may include industry, government, volunteer or charitable organizations, and academia. Their role is in the review of program objectives through discussions with faculty and on advisory boards. As the undergraduate program has graduated only 3 classes with only a few students going to industry, the ABET Committee has contacted those companies where are students have been placed.

*Professional/Graduate Schools:* This group generally represents the employers/faculty that are the direct recipients of the BME graduates, although in some cases BME alumni may be returning to graduate school following some industrial or service experience. These schools may include BME graduate programs, similar graduate training programs, e.g., biomedical sciences, medical school, engineering management programs, or other post-undergraduate training. Their role is in the review of program objectives through communication with departmental faculty.

The Pritzker/BME External Advisory board plays a prominent role in aiding the Department to gauge how best to approach both entities, industry and graduate schools, for insight on our graduates and determine if we are meeting student needs in their preparation.
2.5 Program Educational Objectives Assessment Process

2.5.1 The Department of Biomedical Engineering Program Educational Objectives Assessment Process

The assessment process relies upon feedback from all the constituent groups regarding the program objectives and outcomes. This is the first ABET evaluation for the BME program and currently we are conducting a two year feedback loop while outcomes and assessment methods are in actuality evaluated on an annual basis. Figure 2.1 illustrates the current process.

The BME program entered its first class in Fall 2002 largely through the efforts of Vincent Turitto, DEngSci, the Director of the Pritzker Institute of Biomedical Science and Engineering. With the aid of two Whitaker Grants, one to establish a PhD program in 2001 and the second for an undergraduate program, a core faculty was recruited and facilities were converted to BME use. The original proposed curriculum, designed by Dr. Turitto, began to evolve as new faculty more acutely addressed BME needs while working with other faculty and committees within Armour College. As the Department was so small both graduate and undergraduate curricular, objective, and outcome issues were discussed and determined within the context of regular department meetings. An Undergraduate Curriculum Committee was formally convened in 2004 as was an ABET Committee. There has been considerable refining of the specialty tracks as BME courses came on line and the nature of courses in other departments was better understood. Parallel to the curricular development was a growth in the understanding of where these efforts fit within an ABET matrix. Since that time the ABET Committee has endeavored to formalize the Department Mission, program outcomes, and program educational objectives. In pursuit of this effort, several members of the committee have attended ABET workshops. Dr. Turitto has also attended the Whitaker Education Summits. In addition, the Department held a faculty retreat in the summer of 2007 that focused on the ABET assessment process. Faculty presentations and discussions during the retreat promoted action plans for enhancing the assessment of program outcomes and mapping these to our educational program objectives. The assessment process in place, outlined in Figure 2.1, ensures the objectives remain relevant and meet the needs of constituents while continuously undergoing improvement.

The following assessment mechanisms are currently in place: Faculty Review, Student Advisory Board Review, Senior Exit Survey, Alumni Survey, External Advisory Board Review.

The ABET Committee solicits input and data from the faculty, and all other constituencies, reviews the material and information, and then makes recommendations back to the faculty and chair.

2.5.2 Faculty Review

The BME faculty have significant input in regard to the appropriateness of the Program Educational Objectives. They have extensive knowledge of the job market, graduate
school, and medical schools. They continually improve their understanding on their particular body of knowledge as presented in classes and through their research programs. We have an active research-oriented department that continually investigates into their respective areas. Based upon those changing knowledge bases, faculty critically evaluate the Program Educational Objectives on a bi-annual basis and assess if the Objectives are appropriate and need refining, etc. The ABET Committee solicits input from the faculty, incorporates the feedback, and then makes any recommendations back to the faculty for review and approval.

### 2.5.3 Student Advisory Board

In April of each academic year, a student representative for each class is selected by the BMES Chapter. These representatives relay student concerns to the Department Chair or the Chapter Faculty Advisors. Current board members are working with the ABET Committee to prepare a formal survey mechanism to assess how the BME curriculum addresses the Program Educational Objectives.

### 2.5.4 Senior Exit Survey

Graduating seniors have a 4 year perspective of the BME curriculum. All seniors fill out the exit survey and discuss that data with the Department Chair. The student commentary and completed forms are later assessed by the Chair and the ABET Committee. A specific question is directed to the Program Educational Objectives. Students are asked about the relevance of the Objectives to their post-BS career plans. See Appendix E.

### 2.5.5 Alumni Survey

The BME Alumni Survey, inaugurated in October 2007, contains 5 specific questions on the Program Educational Objectives, one for each objective. See Appendix E for the survey. These questions specifically ask if the Program Educational Objectives have prepared them for their current vocational needs. These data again go to the Chair and the ABET Committee.

### 2.5.6 External Advisory Board Review

An advisory board has been present from the beginning of the effort to create a BME graduate and undergraduate program at IIT. The first board existed for the Pritzker Institute of Medical Engineering and had oversight through the creation of the graduate and then the undergraduate program. The Board now has two advisory roles: one for the Pritzker Institute for Biomedical Science and Engineering and another for the Department of Biomedical Engineering. The membership of the Board reflects the post-BS career plans of the graduate and undergraduate student constituencies. The Board has: 4 medical, 5 industry, and 7 academic-based representative (5 of whom are biomedical engineers). There are a high number of students coming into BME that indicate medical school as their goal, on average 30-35%. The next significant group view graduate school as their goal, on average between 50 and 52%. The number of students who were interested in going directly into industry was on average about 18%. The Board usually meets on an annual basis with the Pritzker Institute and the Department. See Table 2.3 for current membership.
The Board members represent the larger constituencies of graduate school, professional school, and industry. These representatives provide feedback to the Department on the relevance and significance of the Program Educational Objectives to the student constituency and the constituency that they represent. Their knowledge of their own field allows them to make commentary on the needs of the student coming into that field. By knowing this, the Department can more acutely meet the needs of the students and meet the needs of the post-BS constituencies.

The ABET Committee has recommended that an alumnus be on the Advisory Board or alumni from the medical, professional/graduate, and industry areas.
TABLE 2.1 ASSESSMENT PROCESS

CONSTITUENTS

BME Department Mission and Goals

Program Objectives

Program Outcomes

Faculty

Course Outcomes

BME Undergraduate Committee

BME Program-Courses, faculty, Students

Graduation

Post-Grad Evaluation Tools

Pre-Grad Assessment Tools

Armour College Undergraduate Committee
2.6. Achievement of Program Educational Objectives

As stated in 2.5.1, the Department of Biomedical Engineering Program Educational Objectives Assessment Process, a process for assessment has been established utilizing input from the constituencies listed below.

2.6.1 Senior Exit Survey

The last portion of this survey asks students about where they are going in their post-BS career and provides the Department with information if they are prepared for acceptance into the medical, academic, and industrial professional worlds. The senior exit survey form can be found in the Appendix E. Exit interviews are conducted with all graduating seniors on an individual basis with the Department Chair twice during their senior year. The first interview takes place at an early stage during the fall semester in order to gain insight on the students’ plans after graduation and to offer specific career suggestions. The second interview takes place at a latter stage in the spring semester where their plans are readdressed. This survey is a preliminary assessment based on student placement success. The tacit assumption being that if students are successful in gaining entrance into graduate school, medical/professional school, or industry, then the Department has adequately prepared them to achieve our Program Educational Objectives in their chosen careers.

2.6.2 Alumni Survey

The first two BME undergraduate classes graduated in May 2006 and 2007 and provide the basis for the alumni survey. A survey has been designed and has been implemented on a web-based survey mechanism. The alumni survey has been posted on an Internet provider (Zoomerang). The survey was created, tested, and approved by the ABET Committee. Data has been garnered and has been analyzed by the ABET Committee. The third graduating class will be in May 2008 and will be surveyed a year from graduation.

A portion of the survey is designed specifically around the Program Educational Objectives and Outcomes, and asks a series of questions that indicate if and to what extent the student has achieved goals and accomplishments directly linked to the Program Educational Objectives. Students are asked to indicate, on a 1 (worst) through 5 (best) scale, the degree of importance and preparation for each Program Educational Objective and Outcomes. The mean of the responses are reviewed and any areas under 4 are examined more closely.

2.6.3 Employer Survey

A survey has been developed asking employers to evaluate BME graduates with respect to their achievements that are related to the Program Educational Objectives and Outcomes.

Employers are asked to indicate, on a 1 (worst) through 5 (best) scale, the degree of performance on specific tasks and skills related to Program Educational Objective and Outcomes. The mean of the responses are reviewed and any areas under 4 are examined more closely.
<table>
<thead>
<tr>
<th>Name</th>
<th>Title and Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maryellen L. Giger, PhD</td>
<td>Professor and Director, Graduate Program in Medical Physics</td>
</tr>
<tr>
<td></td>
<td>Department of Radiology</td>
</tr>
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<td></td>
<td>University of Chicago</td>
</tr>
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<td></td>
<td>Chicago, IL</td>
</tr>
<tr>
<td>Eric J. Guilbeau, PhD</td>
<td>Professor</td>
</tr>
<tr>
<td></td>
<td>Department of Bioengineering</td>
</tr>
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<td></td>
<td>Arizona State University</td>
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<tr>
<td>J. David Hellums, PhD</td>
<td>A. J. Hartsook Professor Emeritus and Research Professor</td>
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<tr>
<td>Jiang Hsieh, PhD</td>
<td>Chief Scientist, Applied Science Laboratory</td>
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<td>GE Healthcare</td>
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<tr>
<td>Mitchell Litt, DEngSci</td>
<td>Professor of Bioengineering and Chemical Engineering</td>
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<tr>
<td>Yale Nemerson, MD</td>
<td>Philip J. and Harriet L. Goodhart Professor of Medicine and</td>
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<td>Professor of Biochemistry</td>
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<td>The Mount Sinai Medical Center</td>
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<td>Philip S. Ulinski, PhD</td>
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<td>Department of Organismal Biology and Anatomy</td>
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<td>University of Chicago</td>
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</table>
Harvey J. Weiss, MD  
Columbia Medical School  
520 St. Nicholas Ave.  
Haworth, NJ 07641

Adrian Kantrowitz, MD  
L-VAD Technology, Inc.  
Detroit, MI

Brad Enegren  
VP and General Manager  
Medtronic Mini-Med  
Northridge, CA

David L Amrani, PhD, FAHA  
Senior Director  
Exploratory Research  
Baxter Corp.  
Deerfield, IL

Lewis B. Schwartz, MD  
Director of Research in Cardiovascular Applications  
Abbott Laboratories  
Abbott Park, IL

James Davidson, PhD  
Edwards Lifesciences  
One Edwards Way  
Irvine, CA 92614

IIT Members:  

Robert Arzbaecher, PhD  
Professor Emeritus  
IIT - Pritzker Institute of Biomedical Sciences and Engineering and Department of Biomedical Engineering

Vincent Turitto, DEngrSci  
Prof and Chair  
IIT - Pritzker Institute of Biomedical Sciences and Engineering and Department of Biomedical Engineering
CRITERION 3. PROGRAM OUTCOMES

3.1 Process for Establishing and Revising BME Program Outcomes

The current Program Outcomes were developed in the Department of Biomedical Engineering in 2004. These are the first outcomes for the undergraduate program. They were formulated in the ABET Committee and then brought to the Chair and Department for approval. They were directly adapted from the ABET outcomes with the addition of the specific program objectives for Biomedical Engineering. They were modified only slightly to include proper nomenclature linking the outcomes to biomedical engineering.

The Program Outcomes were again reviewed by the ABET Committee in 2007. They were determined to still meet the requirements of our students. The review included evaluation of data provided by exit surveys, alumni surveys, and input from the Advisory Board. Both surveys are contained in Appendix E. The outcomes will come under review again in 2009.

3.2 BME Program Outcomes

Graduates of the BME program at Illinois Institute of Technology will attain proficiency in the following program outcomes upon graduation. These outcomes are documented on: http://www.iit.edu/engineering/bme/programs/undergrad/objectives.shtml as well as in the IIT Undergraduate Bulletin 2006-08.

(a) an ability to apply knowledge of mathematics, science, and engineering to the solution of biomedical engineering problems

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

(c) an ability to design a biomedical engineering 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 multi-disciplinary teams

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

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively based upon analytical and critical thinking skills
(h) the 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 relevant to biomedical engineering

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

(l) an understanding of biology and physiology, and the capability to apply advanced mathematics, science, and engineering to solve the problems at the interface of engineering and biology

(m) 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

3.2.1 Relation of BME Program Outcomes to ABET Criterion 3 and 9

The Program Outcomes for the BME undergraduate program at IIT are directly correlated with the required ABET outcomes of Criterion 3 and Criterion 9. Specifically, program outcomes (a) through (k) correspond to Criterion 3 (a-k) while outcomes (l) and (m) correspond to sections of Criterion 9.

3.3 Relationship of BME Program Outcomes to BME Program Educational Objectives

The specific program outcomes that lead to fulfilling the program objectives and mission are outlined in Table 3.1. The first 2 objectives reflect the essential quantitative skills necessary for engineering practice and are supported by most of the program outcomes. The last 3 objectives, more specific, reflect non-technical skills that are complementary to the first two objectives and are vital to functioning in the professional engineering world.
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<th>Program Objectives</th>
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<td>3. Our alumni possess the requisite written and oral communication skills necessary to interact with health care professionals, engineers or scientists in industry, graduate, or professional graduate programs.</td>
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<td>4. Our alumni possess the ability to work in teams in industry, graduate or professional graduate programs.</td>
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<td>5. Our alumni possess the sense of responsibility and ethics of a professional engineer in industry, graduate, or professional graduate programs.</td>
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### 3.4 Relationship of Courses in the Curriculum to the BME Program Outcomes

The relationship of all required math, science and engineering courses to the BME Program Outcomes is delineated in this section according to Track.

#### 3.4.1 Relationship of non-BME courses to the BME Program Outcomes

BME students acquire basic math and science knowledge and skills in the first 2 years. The relationship to BME Program Outcomes is summarized in
Table 3.2. Math courses lay a basis for Program Outcomes a, e and l. Science lecture courses in chemistry, physics and biology lay an additional basis for Program Outcomes a and l. Accompanying lab courses contribute Program Outcome b, in addition to outcomes a and l. A lab course in human biology further contributes to knowledge required for Program Outcome m.

All students are also required by BME, in addition to the institution, to take an introductory computer science course. The course that BME students complete is track dependent with CS 105 in Cell and Tissue, CS 115 in Neural Engineering, and CS201 in Medical Imaging. Introductory computer science courses lay the groundwork for achievement of Program Outcome k (Table 3.2).

In these first two years, students also complete lower division engineering courses based on their Track selection. All students complete an introductory engineering course in circuits (ECE 211); Cell and Tissue Track students’ complete courses in mechanics (MMAE 200), materials science (MS201) and mass and energy balances (CHE202); Neural Engineering students complete additional courses in circuits and accompanying labs (ECE 212, 213, 214); Medical Imaging Track students take the one additional circuits course (ECE213). The Program Outcomes determined by the host department for each course was correlated to BME Program Outcomes and the relationship of these courses to BME Program Outcomes is noted in Table 3.3.

Table 3.2 Math and Science Courses – Program Outcomes

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Table 3.3. Armour College Engineering Courses – Program Outcomes

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3.4.2 Relationship of the BME courses to the BME Program Outcomes

In the first semester in the department, all BME students (new freshmen and all transfer students) take BME 100, *Introduction to the Profession*, which introduces BME laboratory skills (outcome b), ethics (outcome f), communication (outcome g), an appreciation of the breadth of biomedical engineering and its relationship to medicine, research and industry (outcome h) through presentations by outside speakers representative of these constituencies. In the 3rd or 4th semester all students take BME 200, *Engineering Applications of MATLAB* which introduces biomedical engineering problem solving (outcomes a and e), and the ability to use modern engineering tools (outcome k)(Table 3.4).

BME upper division core courses continue to provide a broader background in biomedical engineering with topics including signals (BME 330) and biomaterials (BME310) and biomedical engineering applications of statistics (BME 433). They also include a 3 semester sequence of laboratories: *Instrumentation and Measurements* (BME 315), *Bio-fluid Mechanics* (BME320), and *Quantitative Physiology* (BME 405). Together, this core contributes to all of the BME Program Outcomes and provides team-based experiences, although they are not strictly multidisciplinary (the students from each track are often in one team), and hence, do not strictly address outcome d. The 2 semester capstone design experience addresses multidisciplinary teams by requiring team members come from across tracks and by projects which entail broader engineering skills, e.g., electronics or signals in conjunction with materials. The sequence additionally addresses the realistic constraints of the design process (outcome c). BME 490 Senior Seminar emphasizes outcomes such as life-long learning (i) and understanding biomedical engineering in a broader context (outcome h), e.g., social.
Track requirements provide more depth in the areas of Cell and Tissue Engineering, Neural Engineering and Medical Imaging and further support all BME Program Outcomes.

Cell and Tissue Track courses focus on the engineering topics of thermodynamics (BME 335), fluid mechanics (BME301), reaction kinetics (BME 408), and mass transport (BME482) that are essential for cell and tissue engineering applications. These courses additionally address a range of Program Outcomes with an emphasis on biomedical engineering problem solving (outcomes a, e and l) and contemporary issues in cell and tissue engineering (outcome j) through analysis of current journal literature.

The Neural Engineering and Medical Imaging Tracks have 4 common courses that address biomedical imaging and sensing (BME309), instrumentation and electronics (BME 443), quantitative neural function (BME445) and Neuro-Imaging (BME 438). These courses also emphasize biomedical engineering problem solving (outcomes a, e and l) and the use of modern engineering tools with extensive application of MATLAB in addition to more specific software including PSplice, Neurons in Action, and SMP5.

Table 3.4 Relationship Between Program Outcomes and BME Courses

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<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
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</tr>
<tr>
<td>BME 490</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Cell and Tissue</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
<td>i</td>
<td>j</td>
<td>k</td>
<td>l</td>
<td>m</td>
</tr>
<tr>
<td>BME 301</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>BME 335</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>x</td>
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<tr>
<td>BME 408</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>BME 482</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neural Engineering/ Medical Imaging</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
<td>i</td>
<td>j</td>
<td>k</td>
<td>l</td>
<td>m</td>
</tr>
<tr>
<td>BME 309</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>BME 438</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>BME 443</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>x</td>
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<tr>
<td>BME 445</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
3.5 BME Documentation

The Department of Biomedical Engineering maintains a specific room solely for ABET materials (Wishnick Hall, Room 301C). There are labeled binders for each course with all relevant data, e.g., syllabi, samples of student work, (see list of materials collected for each course, each semester in Appendix E). These are termed “Course Binders” and include a copy of the syllabus that links student learning objectives (SLO) for the specific course to Program Outcomes and indirect assessment of SLOs (and hence Program Outcomes). There are also specific binders from each team in the Capstone Design course. There is another set of binders dedicated to each of the Program Outcomes termed “Direct Outcome Assessment Binders”. In each are complete sets of student achievement for targeted outcomes assessed as described in Section 3.6. There is in addition, a binder with pertinent Department policy, e.g., advising, etc., and ABET Committee and Faculty meeting minutes.

3.6 Achievement of BME Program Outcomes

3.6.1 Direct Assessment of Program Outcomes

Assessment of program outcomes occurs by applying specific performance criteria to each outcome. The BME Department established specific Performance Criteria that define measurable/quantifiable knowledge, skills or abilities for each of the Program Outcomes (see Table 3.5). The ABET Committee continued to refine the criteria and presented this final draft to the Chair and Department for approval. These criteria were used to assess achievement for all outcomes for academic years 2006-07 and 2007-08.

The Performance Criteria are directly applied to specific assignments similar to a grading rubric. Therefore, each instructor is assigned (by the ABET Committee) 2 or 3 Program Outcomes that are addressed in their junior or senior level course. The instructor selects an assignment (this can be a homework or test question(s), lab report (or portion), article analysis, term paper, etc.) in which the students are asked to demonstrate the knowledge, skills or abilities identified in the Performance Criteria. For this assignment, each student’s achievement is measured. Achievement for the first two academic years in which the Performance Criteria were implemented for all Program Outcomes was defined as a pass (1) or fail (0) evaluation based on the acceptable achievement level defined as average or better. In future versions of the Performance Criteria, levels of achievement will be more specifically defined and graded from 1-4 or 5 depending on complexity. In addition, as previously noted, they will only be applied to each outcome on a 3-year cycle.

Data from instructors are contained in spreadsheets by outcome and performance criteria for each student (see example in Appendix E). These data, in conjunction with copies of the assessment mechanism (homework, exam, etc)
are collected by the ABET Committee at the end of each academic year and maintained in the “Direct Outcome Assessment Binders”. The level of achievement for each student across Performance Criteria and the achievement of a given criteria across students are automatically tabulated in the spreadsheet. The ABET Committee reviews these data and provides a report to the Department Chair and faculty with specific concerns and any recommendations for improvement. These are then discussed by the full faculty and any decisions voted on.

Table 3.5 Performance Criteria for Outcomes Assessment

<table>
<thead>
<tr>
<th>OUTCOMES</th>
<th>PERFORMANCE CRITERIA</th>
</tr>
</thead>
</table>
| a: An ability to apply knowledge of mathematics, science, and engineering to the solution of biomedical engineering problems | 1. Converts physical problem into mathematical equations including initial/boundary conditions  
2. Transforms equations into a solvable format (e.g., Laplace Transforms, MATLAB)  
3. Solves equations  
4. Relates solution to relevant physical meaning |
| b: an ability to design and conduct experiments, as well as to analyze and interpret data | 1. Effectively uses a range of manual measurement instruments and computerized data acquisition based instruments  
2. The ability to apply basic statistics (mean, SD, t-test) to data sets and present data in a logical manner using both graphics and textual descriptions  
3. Student understands the limitations of the data and the statistical tests performed on the data. Provides rational explanations of data within the context of the relevant underlying concepts. Applies information from additional sources. Goes beyond mere error analysis  
4. The ability to design an experimental methodology to address a specific objective or test a hypothesis |
| c: An ability to design a biomedical engineering system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. | 1. Able to define needs  
2. Able to define constraints  
3. Offers alternative solutions  
4. Defines problem to be solved  
5. Defines project scope  
6. Compares alternative solutions  
7. Defends selection of final design |
|---|---|
| d: An ability to function on multidisciplinary teams | 1. Helps group develop team goals, defines criteria for conflict resolution, and communicate their decisions  
2. Completes tasks on time  
3. Monitors group’s progress  
4. Stays on tasks  
5. Initiates interactions with other team members and facilitates interactions between team members  
6. Evaluates work of peers  
7. Uses results of evaluation to improve performance of the team |
| e: An ability to identify, formulate and solve engineering problems | 1. Defines problem  
2. States assumptions, identifies unknowns, and an ability to estimate  
3. Develops model (mathematical or experimental)  
4. Solves problem or completes experiment and evaluates solution  
5. Applies knowledge of basic math and science throughout process |
| f: An understanding of professional and ethical responsibility | 1. Recognizes when ethical issues or dilemmas are present  
2. Discusses ethical concerns within the context of the relevant ethical standards  
3. Comprehends and critically assesses opposing arguments  
4. Uses ethical conduct in communication (using citations, acknowledging sources of info)  
5. develops and maintains a personal code of ethics |
| g: An ability to communicate effectively based upon analytical and critical thinking skills | 1. Conveys technical information effectively using graphics, tables, and charts  
2. Conveys information effectively in written and oral presentations  
3. Synthesizes technical/scientific information/content in order to present effectively to an audience  
4. Analyzes technical/scientific information in order to present effectively to an audience  
5. Recognizes background, needs, and characteristics of audience  
6. Communicates effectively using mathematics |
|---|---|
| h: the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context | 1. Identifies human needs and/or goals that technology or engineering research will serve  
2. Analyzes and evaluates the economic, social, environmental, and global impact of new research or technology |
| i: a recognition of the need for and an ability to engage in life-long learning | 1. Searches pertinent, professional literature  
2. Uses other information resources  
3. Evaluates how sources contribute to knowledge  
4. Able to discern when sufficient expertise or knowledge is reached for a particular task  
5. Assess the reliability of sources  
6. Attends seminars, workshops or other continuing education venues  
7. Pursues graduate or professional degrees following graduation |
| j: a knowledge of contemporary issues relevant to biomedical engineering | 1. Critically analyzes processes and theories addressed in current research or technological endeavors that impact biomedical engineering  
2. Comprehends assumptions and interprets key results of current research or technology based on knowledge of underlying engineering principles  
3. Draws relevant conclusions about current research or technology and proposes relevant future studies or improvements  
4. Is able to assess why a research finding or new technology is a significant contemporary topic |
|---|---|
| k: an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice | 1. Able to use software (e.g., Excel, Matlab, or Flowlab) to solve engineering problems  
2. Able to use instrumentation relevant to BME (viscometers, spectrophotometers, pumps, sensors, transducers, effectively)  
3. Able to use computerized data acquisition to acquire data (Powerlab) |
| l: an understanding of biology and physiology, and the capability to apply advanced mathematics, science, and engineering to solve the problems at the interface of engineering and biology | 1. Ability to quantitatively describe and explain biological/physiological processes and systems  
2. Utilizes appropriate assumptions when applying engineering solutions to biological or physiological systems  
3. Understand limitations of engineering solutions applied to biological and physiological systems |
m: 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

1. Handles animal subjects with proper technique and care
2. Handles tissue, cells or other anatomic components without inflicting unnecessary damage
3. Able to record relevant physiologic signals or apply appropriate stimuli
4. Able to analyze data and extract relevant parameters following data reduction
5. Connects results to and synthesizes results with general physiological principles
6. Ability to describe and explain nature of interactions between living and non-living materials and systems

3.6.2 Indirect Assessment of Program Outcomes

Student Learning Objectives (SLOs) are determined for each course and linked to Program Outcomes. The SLOs are assessed in every course, each semester by both students and faculty. The survey asks students to answer the following questions using a 4-point scale. 1) To which level do you feel this objective was addressed in this course? And 2) To what degree do you personally feel you achieved this objective? Additionally, each instructor completes a survey that indicates their own determination of the level of students’ achievement of SLOs. Instructors base their determination on the level of success in particular assignments as designated on the survey. Instructors also address specific aspects of the students’ achievement that includes their preparation in mathematics, basic sciences and the required prerequisite courses. The instructor is also asked to provide comment on any improvements to be made in future semesters. Finally, the students’ perception of SLO achievement, based on question 2 responses, is correlated with faculty determinations and entered into a spreadsheet that automatically generates a graphical comparison of student and faculty perceptions for each SLO and their correlative Program Outcomes. Examples of both surveys and the graphics are provided in Appendix E.

The data from the surveys are included in the “Course Binders” and submitted to the ABET Committee for review. Significant discrepancies between the student and instructor responses are discussed by the Committee and any recommendations presented to the full faculty. For example, if students indicate that a particular objective was not well addressed, or if students felt they were not able to achieve particular SLOs, these are identified and the relationship to Program Outcomes used in conjunction with Direct Assessment materials in Outcome assessment.
CRITERION 4. CONTINUOUS IMPROVEMENT

4.1  Information Used for Program Improvement

The BME Department garners important data from both indirect and direct assessment on the achievement of Student Learning Objectives, Program Outcomes, Program Educational Objectives and overall satisfaction with the curriculum. Data are also obtained regarding the suitability of Program Outcomes and Educational Objectives. The specific mechanisms used to assess achievement are as follows:

Student Learning Objectives
1) Student and Faculty Course Surveys

Program Outcomes
Direct Assessment based on Performance Criteria
Indirect assessment from 1) Student and Faculty Course Surveys (SLOs are linked to one or more POs), 2) Exit Surveys, 3) Alumni Surveys, 4) Employer Survey

Program Educational Objectives
1) Exit Survey, 2) Alumni Survey

Student Satisfaction with Curriculum
1) Exit Survey, 2) Alumni Survey

Mechanisms for assessing the suitability are as follows:

Program Outcomes
1) Advisory Board, 2) Alumni Survey

Program Educational Objectives
1) Advisory Board, 2) Alumni Survey

4.2  Student Learning Objectives (SLOs)

Specific learning objectives are determined for each course in the curriculum. These objectives are then linked to one or more Program Outcomes. Each semester students provide their perception of achievement of SLOs. Faculty members also submit a survey with their perception of student achievement. These responses are tallied and submitted in a spreadsheet that automatically graphs a comparison of student and faculty perceptions. An example for BME 100 (F07) is shown below (Figure 4.1). Significant variation (>20%) between student and faculty responses are summarized and reported to instructors. Instructors also provide commentary on strengths and weaknesses in the course.
4.3 Program Outcomes

4.3.1 Direct Assessment
Achievement of performance criteria were assessed over two academic years and the percent of all students achieving each outcome were summarized as in Table 4.1. Criteria with less than 70% achievement were reviewed closely by the ABET Committee and actions recommended.

Table 4.1 Program Outcome b

<table>
<thead>
<tr>
<th>Performance Criteria - b</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 315 – 25 students</td>
<td>19/25</td>
<td>Not assessed</td>
<td>14/25</td>
<td>19/25</td>
</tr>
<tr>
<td></td>
<td>76%</td>
<td>56%</td>
<td>76%</td>
<td></td>
</tr>
<tr>
<td>BME 320- 24</td>
<td>24/24</td>
<td>17/24</td>
<td>12/24</td>
<td>Not</td>
</tr>
</tbody>
</table>
4.3.2 Indirect Assessment
4.3.2.1 Exit Surveys
The second part of the Exit Survey queries students on how well they achieved competency in specific skills on a scale of 1 (worst) to 5 (best). The first generation of the Exit Survey relates to Program Outcomes a – m fairly well. This portion is currently under revision for 2008-09 academic year to more accurately address each aspect of every Program Outcome. The results from three years of graduates show that 75% or more of all graduates responded to skill questions with a 4 or 5 (with 5 indicating best). An example of responses for Outcome g is shown in Table 4.2.

Table 4.2 Example of data from exit survey on skills achievement

<table>
<thead>
<tr>
<th>SKILL</th>
<th>Worst</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Best</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to communicate (oral) (g)</td>
<td>1</td>
<td>7</td>
<td>34</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Ability to communicate (written) (g)</td>
<td>2</td>
<td>5</td>
<td>24</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Track</th>
<th>Class of 2006</th>
<th>Class of 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell and Tissue</td>
<td>18/27 67%</td>
<td>12/15 80%</td>
</tr>
<tr>
<td>Neural Engineering</td>
<td>1/3 33%</td>
<td>2/6 33.3%</td>
</tr>
<tr>
<td>Medical Imaging</td>
<td>0</td>
<td>1/1 100%</td>
</tr>
<tr>
<td>Overall (All Tracks)</td>
<td>19/30 63%</td>
<td>15/22 68%</td>
</tr>
</tbody>
</table>

Table 4.3 Response rate to Alumni Survey

4.3.2.2 Alumni Surveys
Alumni are asked to rate their perception of the level of preparation vs. the importance of Program Outcomes in their post-graduate employment or educational activities. Means and standard deviations are determined and any response under 4, as well as any difference in mean response between importance and preparation are examined by the ABET Committee and recommendations determined. An example of response data is shown in Figure 4.2. The response rate by graduating class and track is shown in Table 4.3.
4.3.2.3. Employer Surveys
Industry employers were asked to evaluate the performance of our students regarding their ability to perform the skills addressed by the Program Outcomes. To date we have responses from 2 employers regarding 5 graduates in industry. This is a high response rate as the majority of our graduates go on to postgraduate studies of some kind rather than enter industry. Responses are on a 1-5 scale as in other survey mechanisms.

4.4 Program Educational Objectives
4.4.1 Exit Surveys
Exit surveys yield placement data, and thus give an early indication of students’ achievement of Program Educational Objective 1. Students were queried about their chances of attending graduate school, medical school, or other professional school on a 1-5 scale. A summary of results from 3 years of surveys is given in Figure 4.3.

4.4.2 Alumni Surveys
Alumni surveys provide placement data and ask students to answer fact-based questions designed to evaluate their achievement of Program Educational Objectives.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Perception</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding of the business environment.</td>
<td>2.83</td>
<td>4</td>
</tr>
<tr>
<td>Understand the societal and global impact of engineering solutions.</td>
<td>3.58</td>
<td>4.17</td>
</tr>
<tr>
<td>Understanding of professional and ethical responsibility.</td>
<td>3.63</td>
<td>4.42</td>
</tr>
<tr>
<td>Knowledge of contemporary issues.</td>
<td>3.71</td>
<td>4.46</td>
</tr>
<tr>
<td>Design a system, component, or process to meet desired needs.</td>
<td>3.92</td>
<td>4.54</td>
</tr>
<tr>
<td>Use techniques, skills, and modern engineering tools necessary for engineering practice.</td>
<td>4.08</td>
<td>4.46</td>
</tr>
</tbody>
</table>

Figure 4.2 Example of data obtained from Alumni Survey. Comparison of students’ perception of achievement (upper bar) versus importance of Program Outcomes (lower bar).
4.4.2.1 Placement data
Placement information is summarized and categorized according to students’ current activity as Graduate School, Medical School, Industry or Other (Example for 2007 in Figure 4.4). Employment in areas other than companies (e.g. lab techs) is placed under Other.

4.4.2.2 Achievement of Program Educational Objectives.
A series of fact based questions, designed to determine the extent of achievement of Program Educational Objectives are compiled and evaluated. The responses are primarily in the form of a “yes” or a "no".

4.5. General satisfaction with the curriculum
4.5.1 Exit Survey
The exit survey given to seniors each of the last three years asks students to rate their overall satisfaction with the program, as well as their ability or knowledge in the specific areas of programming, hands-on expertise, written and oral communication and their perception of chances of pursuing post-graduate studies. Responses are divided among the three tracks and are on a scale from 1 to 5. The percent of responses at a level of 4 or 5 are summarized in Table 4.4 by track. Responses totaled 14-17 for NE, 45-50 for CT and 5 for MI.
Table 4.4  Responses from Exit Survey regarding satisfaction with the program

<table>
<thead>
<tr>
<th></th>
<th>CT</th>
<th>NE</th>
<th>MI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Was your education a positive experience?</td>
<td>83%</td>
<td>88%</td>
<td>80%</td>
</tr>
<tr>
<td>Quality and Effectiveness of the program.</td>
<td>74%</td>
<td>86%</td>
<td>40%</td>
</tr>
<tr>
<td>Your hands-on expertise now</td>
<td>71%</td>
<td>88%</td>
<td>80%</td>
</tr>
<tr>
<td>Your proficiency in</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer coding with any computer language</td>
<td>31%</td>
<td>65%</td>
<td>40%</td>
</tr>
<tr>
<td>MATLAB</td>
<td>38%</td>
<td>69%</td>
<td>80%</td>
</tr>
<tr>
<td>Any word processing software</td>
<td>98%</td>
<td>100%</td>
<td>80%</td>
</tr>
<tr>
<td>Oral presentations</td>
<td>92%</td>
<td>94%</td>
<td>60%</td>
</tr>
<tr>
<td>Writing reports</td>
<td>91%</td>
<td>88%</td>
<td>100%</td>
</tr>
<tr>
<td>Chances of attending graduate school in the near future for M.S. or Ph.D., Medical School, or other?</td>
<td>86%</td>
<td>81%</td>
<td>60%</td>
</tr>
</tbody>
</table>

4.6 Suitability of Program Outcomes and Program Educational Objectives

In addition to determining the achievement of outcomes and objectives,
their suitability for the Program will also be evaluated periodically and revised if necessary. Input from Faculty, the Advisory Board and the Alumni are the key sources of data. The capability of the alumni to achieve the objectives and outcomes also contributes to the decision to revise or update. Advisory Board input was obtained most recently in the Fall of 2007. Their commentary was recorded and will be evaluated in 2009 together with data from the Alumni Surveys and Faculty input.

4.7 Actions taken to improve the Program

4.7.1 Improvements Requiring Curricular Revision

A series of curricular revisions occurred since the Program inception in 2002. The curricular changes were made based on a compilation of faculty assessment, student feedback, the need to strengthen the engineering content and specific biomedical engineering outcomes I and m.

4.7.1.1 AY2002 revision to streamline curriculum

Initially the curriculum consisted of three tracks (Cell and Tissue Engineering, Medical Imaging and Neural Engineering) and 2 options (premed and biomaterials) that were slight variations of the Cell and Tissue curriculum. The curriculum was streamlined by eliminating the two options that only differed by one or two courses. This decision was primarily based on a review of the curriculum by the newly hired faculty (three at the time).

4.7.1.2 AY2004 revision to engineering credits

The number of engineering versus math/science credits for each track was determined based on ABET requirements. The Cell and Tissue track and the Medical Imaging track were slightly below the standard of 48 for engineering credits. As a result, the third semester of physics was replaced in all tracks with BME 330 Biomedical Signals and Systems. The requirement was implemented for all students that had not yet completed Physics III at the time of this decision.

4.7.1.3 AY2004 revision to Neural Engineering and Medical Imaging Tracks.

The Neural Engineering and Medical Imaging curricula were revamped substantially primarily as a result of student feedback. Due to the large number of courses taught in ECE and CS for these tracks, a large percentage of students that originally opted for them decided to move to the Cell and Tissue Engineering track (of the approximately 10 students that opted for NE, 7 opted to leave NE and move to C and T. The Department Chair met with these students and received detailed feedback regarding their concerns. The reason was that the
students felt there was not a significant biomedical component to their major. An additional factor in the decision to revise the curriculum was that these tracks were clearly less populated than the Cell and Tissue Engineering track. A large number of BME students plan to attend medical school and have a need for the Organic Chemistry classes that were not a part of the Neural Engineering and Medical Imaging curricula. The revised curricula offer an option to take organic chemistry classes and have more common core BME classes for the Neural Engineering and Medical Imaging tracks. The new BME courses implemented in the junior and senior years are:

BME 443 Biomedical Instrumentation and Electronics
BME 445 Quantitative Neural Function
BME 438 Neuroimaging

The success of this revision is demonstrated in the number of students selecting one of these tracks and ultimately graduating from that track. In 2006 there were 22, 3 and 0 graduates from CT, NE and MI, respectively. In 2007, it was 13, 7 and 1. In 2008 there were 10, 6 and 4, respectively.

4.7.1.4 AY2007-08 curricular revision to implement a MATLAB based engineering course.

Analysis of Exit Survey responses and faculty input revealed that students felt under qualified in computer programming, and specifically in the application of MATLAB. Responses over three years of graduates indicated that only 31, 65 and 40% of students in CT, NE and MI, respectively, indicated a strong (4 or 5 response) proficiency in programming in any language. Only 38% of Cell and Tissue Track, 69% of NE and 80% of MI students indicated a strong proficiency in MATLAB. However, the number of responses in MI was only 5. Additionally, several faculty members had implemented MATLAB based assignments (see section 7.2.1.1 under Criterion 7) and felt an introductory course in the use of MATLAB to solve open-ended engineering problems was highly desirable. This was also considered a desirable skill for industry and one that engineering students would find helpful in their careers. The lack of adequate MATLAB instruction for all BME students also came out in the interview portion of the exit survey. This problem was discussed and resolved at the department faculty retreat in July 2007. BME Applications of MATLAB (BME 200) became a 1 credit core requirement in Spring 2008 for sophomores. Therefore, complete implementation for all students will occur over 2 years. The total credit hours for the program was not increased by this addition due to a gain of a credit from a biology lab (BIOL 117) that was reduced from 2 to 1 credit the same year. The results of this change will be known at the end of the 2008-2009 academic year, at the earliest.

4.7.1.5 AY2007-08 curricular revision to add a core biomaterials course

Following the establishment of specific Performance Criteria for Program Outcome assessment, it was determined that students did not have sufficient
training in the interaction between living and non–living systems as indicated in outcome m, specifically performance criteria 6 "Ability to describe and explain nature of interactions between living and non-living materials and systems". Although students received some exposure to biomaterials in some required courses (BME 100, BME 405, BME 419), the extent of instruction was limited and informal and in many cases, specific assignments addressing this issue were not provided. The faculty felt that the ideal solution was to take an elective course in Biomaterials and make it a core requirement for all tracks. This was also decided at the Faculty Retreat in the summer of 2007. Implementation occurred over stages so that graduating seniors would not have to take an overload (over 18 credits in one semester) or delay their graduation. Seniors (graduating by summer 2008) were highly encouraged to enroll in the course as one of their BME electives. Students graduating beginning in the Fall of 2008 are required to take the course. In order to maintain the total number of credit hours in the program, the requirement for general biology with lab (BIOL 105 and BIOL 107) was removed as of Fall 2007. This opened up 4 credit hours, 3 of which were replaced with the biomaterials course.

4.7.1.6 AY2007 curricular revision to enhance Design
Instructor and student feedback following the first offering of the Design course (BME 419) led to a decision to increase the number of credit hours in the first semester from 1 to 2 such that the year-long course totaled 5 credits. In the first two offerings, the first semester was solely lecture and based on the underlying principles of design, but did not give students the opportunity to begin design projects. The projects were started and completed in the second semester only. Students did not feel they had sufficient time to complete the iterative process necessary for design. The instructor agreed. Simultaneous with this discovery, 2 credits were dropped from freshmen biology labs. Therefore, it was decided that one of these credits could be added to BME 419 without increasing the total number of credit hours in the program. In the Fall of 2007 students began their specific design projects in the first semester.

4.7.1.7. AY2008 curricular revision to enhance Physiology Lab
Based on student and instructor feedback, beginning in the Fall of 2008, the 1 credit physiology lab will have a lecture added and be increased to 2 credits.

4.7.2 Actions to improve the program not requiring curricular revision

4.7.2.1 Actions to improve the program from student and faculty course surveys.

Changes at the course level arise from data obtained from student and faculty surveys (indirect) and from direct assessment of outcomes. Instructors, in
conjunction with the ABET Committee determine specific action items for course and program improvement.

A review of student/faculty course surveys is done on a semester and annual basis for all BME courses by the ABET Committee. For example, based on comparisons between student and faculty responses on the level of achievement of student learning objectives, the following areas of significant disparity (over 20%) were identified for Core BME courses in Fall 2006-Spring 2007 and resulted in actions.

**Fall 2006**

**BME 100 - Introduction to the Profession**

SLO 2 “Students will have an understanding of professional ethics through discussion of the Code of Ethics of the Biomedical Engineering Society and presentations by professional engineers and physicians”, PO f.  
**Observation:** Students did not feel ethics were covered sufficiently (Handout of code of conduct and BMES Code of Ethics with some class discussion was insufficient.)  
**Action:** The instructor agreed and specific assignments that assessed students understanding of the codes of ethics have been developed for implementation in Fall 2007.  
**Result (from Fall 07 surveys):** Prior to the addition of specific ethics assignments, 39% of students indicated that they adequately achieved the SLO. After implementation of assignments, this number rose to 90%.

**SLO 3 “Students will experience an introduction to biomedical engineering labs through four hands-on experiences” (Program Outcomes b and m).**  
**Observation:** In hands-on exercises students had a greater perception of achievement than the instructor.  
**Action:** The instructor felt that the students were comfortable performing the labs and that the students based their assessment on this metric, whereas the instructor based the actual assessment on the lab reports. A grading rubric for lab reports was implemented to aid both students and instructor in articulating the requirements for the written lab reports.  
**Result (from Fall 07 surveys):** The instructor determined that the number of students adequately achieving SLO3 increased from 44% to 58%.

**BME 330 - Analysis of Biosignals and Systems**  
**Observation:** SLOs 5,6 and 7 were not addressed and this was reflected in faculty and student responses.  
**Action:** The instructor has determined that there is insufficient time in one semester to cover all topics of biomedical signals and biomedical systems. This problem was addressed at the July 18, 2007 Retreat. The SLOs will be limited to biomedical signals and subject matter relative to biomedical systems analysis will be considered a topic for an elective course.  
**Results (from Fall 07 surveys):** SLOs 5 and 7 were deleted while SLO 6 was maintained. Additionally, the topics removed from BME 330 were primarily the
“systems” related components. This topic area is now represented in a new BME elective course titled Control Systems for Biomedical Engineers (BME 452).

Spring 2007  
BME 320 - Biofluids Laboratory  
**Observation:** Students felt they achieved at a somewhat lower level on communication SLOs (PO g)  
**Action:** A grading rubric for lab reports is being implemented to aid both students and instructor in articulating the requirements for the written lab reports.  
**Results (from Spring 2008 surveys):** Students perceived a greater achievement of the communication SLO. The number responding that they did not achieve the objective, or needed improvement decreased from 20% to 4.6%. The faculty perception of achievement remained approximately the same. The implication is that there is still a disconnect between faculty and student expectations with regard to written communication. This issue will continue to be addressed. Data from direct assessment of Program Outcome g in the same course is presented below.

BME 420 - Senior Design  
SLOs  
1. To be able to identify design problems related to the construction of biomedical engineering devices. (Satisfies Program Outcomes a, e, h, j, l)  
2. To provide an understanding of the processes involved in planning, design and development in a team setting (Satisfies Program Outcomes a, c, d, e, j, l)  
3. To design and conduct experiments according to the team’s design plans and analyze the resulting data (Satisfies Program Outcomes a, b, c, d, e, l)  
4. To build a prototype biomedical device (Satisfies Program Outcomes a, b, c, d, k)  
5. To understand the ethical issues involved in testing the prototype devices (Satisfies Program Outcomes f)  
6. To develop professional communication skills (Satisfies Program Outcomes g)  
7. To use various software package (e.g. Matlab, LabView, PowerLab) to acquire and analyze data (Satisfies Program Outcomes a, b, e, k, l)  
8. To use Project Kickstart software to plan and document the design process (Satisfies Program Outcomes a, b, e, g, k, l)  

**Observation:** The instructor did not indicate any level of achievement for SLO 8 and student response corroborated by indicating “unacceptable” achievement.  
**Action:** SLO 8 has been removed from the course objectives. It was determined that use of this software package was not a key objective for a capstone design course.  
**Observation:** On SLO’s 1-7 the instructor indicated a greater percentage of students achieving at the “met expectations’ level than the students who indicated that they did not feel they had met the objectives of the course.
Action: The course objectives and the correlative program outcomes were reviewed by the instructor and members of the ABET committee. The objectives were streamlined. Essentially, objectives 1, 2, 3, 4 and 6 remained. In addition, a textbook was acquired for the course. There had been no text in previous years. Finally, students received a stronger introduction to the design process by the increase in credits in BME 419 as described in section 4.7.1.5.

Results (From Spring 2008 surveys): Every student indicated adequate or better achievement of all SLOs.

4.7.2.2 Actions to improve the program based on Exit Surveys

Data from Exit Surveys was divided into 4 areas. 1) Students perception of achievement of Program Outcomes (recall that the skill based survey questions corresponded to most Program Outcomes.); 2) Students satisfaction with laboratory courses (including capstone design); 3) Students perception of success in post-graduate study (early indicator of achievement of Educational Program Objective 1); 4) General satisfaction with the program and specific questions regarding proficiency in programming languages, specifically MATLAB and proficiency in oral and written communication.

1) Data from 3 years of graduates indicate that 75% or more of the students perceive that they achieved the aspects of Program Outcomes a-m addressed in the Exit Survey (see Appendix E for the survey). There was, however, an indication that students were not receiving sufficient knowledge about current societal and environmental issues that affect biomedical engineering. IIT requires that all students take 21 hours in social science and humanities courses and somewhere in this they would hopefully attain some knowledge that would help them to see the bigger picture. In Spring 2008 an effort to emphasize biomedical engineering within a larger context was made in BME 490, Senior Seminar. The direct assessment of Program Outcomes i and h from this course were very positive and are discussed in section 4.7.2.3. The responses in all other areas were at a level 3 or above; therefore, no action is currently planned based on these results. However, the Exit Survey is under revision to more closely align this portion of the survey with all aspects of the Program Outcomes and their respective Performance Criteria.

2) Graduating seniors were surveyed on their laboratory experiences on a sliding scale of 1-5, 1 (worst) and 5 (best). BME 315 is taken in fall of their junior year and BME 320 is taken in spring of their junior year; BME 405 is taken in fall of senior year, and BME 420 in spring. Results are displayed in the following 4 Figures.

For year 2006, generally less than 10% of students indicated dissatisfaction with laboratory experiences and 80-90% expressed satisfaction (Figure 4.5a).

In 2007 (Figure 4.5b), a greater dissatisfaction appeared with BME 315 and BME 320. There was some improvement in BME 405 and
BME 420. In the case of BME 320, there were significant instrumentation or equipment issues that contributed to the student dissatisfaction and have now been resolved. Regarding BME 315, this is under discussion with the instructor and the ABET Committee.

In 2008 (Figure 4.5c), there were no responses at the worst level (1) for any of the labs. There was considerable improvement in BME 420 responses in this year with all responses at 3 or above. As noted above in section 4.7.2.1, there were concerted efforts to improve students' perception of achievement of outcomes and as noted in section 4.7.1.5 the introductory design course was expanded to better prepare students for the final semester of BME 420.

3) Students were queried about their chances of attending graduate school, medical school, or other professional school after graduation. The student responses in 2006 are for 25 students (22 for C & T, and 3 for NE). Generally, C & T and MI students had an expectation of success in post-graduate study. One student or one/third of total in NE had poor expectations.

The student responses in 2007 are for 18 students (10 for C & T, 7 for NE, and 1 for MI). Generally, students in all tracks had expectations of success in post-graduate study.

The student responses for 2008 are for 20 students (10 for CT, 6 for NE and 4 for MI). There were only 2 responses, both in CT, that indicated a low expectation of success in post-graduate work.

The combined responses for the graduating classes from 2006 to 2008 are shown in Figure 4.6.

4) Analysis of the responses to this component of the Exit Survey resulted in a curricular change that is described in section 4.7.1.4.

4.7.2.3 Actions to improve the program based on direct program outcome assessment

4.7.2.3.1 Actions taken to improve the assessment process

Direct assessment of Program Outcomes first occurred in academic year 2006-2007. Previously, all assessment was indirect and survey based. An attempt was made to assess all outcomes (a-m) in junior and senior level courses based on the Performance Criteria. However, there were some areas in which direct assessment mechanisms for individual students had to be developed. These included outcomes c, d, h, i. Outcome c (design) was performed in teams and individual achievement could not be determined. This problem was addressed in Fall 2007. The instructors for BME 419 developed an individual exam based on the design process. In the case of outcome d, teams were evaluated as a whole, whereas individual students were not. This was addressed by the development of a peer-evaluation rubric. Outcomes h and i were not assessed because faculty did not have specific assignments that clearly addressed these outcomes. This was rectified by targeting these outcomes in the senior seminar course (BME 490). Seminar speakers that specifically addressed these outcomes and accompanying assignments asking students to consider these outcomes were
incorporated into the course in Spring 2008.

![Laboratory Survey 2006](image1)

![Laboratory Survey 2007](image2)

![Laboratory Survey 2008](image3)

**Figure 4.5** Student satisfaction with laboratory courses and capstone design from Exit Surveys from 2006-2008. a) responses from AY 2005-06; b) responses from AY2006-07; c) responses from AY2007-08.
The direct assessment process in 2006-2007 also identified specific performance criteria that could not be assessed because an adequate mechanism did not exist. For example, Program Outcome b is “An ability to design and conduct experiments as well as to analyze and interpret data”. The components of this outcome (design, conduct, analyze) are addressed by different Performance Criteria. It was determined that the ability to design experiments was not well covered. There was a practical exam (timed) given in BME 315 in which students were given an experiment to perform without being given a step-by-step protocol. This was used to assess this criteria, however, the ABET Committee felt this was not sufficiently open-ended and it had limitations due to the time constraint of the exam. Therefore, in BME 320 in Spring 2008, students were given an open-ended problem around which they designed an experiment from scratch.

In academic year 2007-2008, all program outcomes were directly assessed based on Performance Criteria.

4.7.2.3.2 Actions taken to improve achievement of program outcomes

Based on the 2006-2007 assessment data, the ABET Committee identified a set of Performance criteria (and respective Program Outcome) for which less than 70% of the students demonstrated minimal achievement. A pattern was recognized in that all of these criteria related to the ability of students
to evaluate or explain solutions to BME problems, or discuss data from experiments. The relevant Program Outcome (in bold) and the specific Performance Criteria (by number) were:

a: An ability to apply knowledge of mathematics, science, and engineering to the solution of biomedical engineering problems
   4. Relates solution to physical meaning

b: an ability to design and conduct experiments, as well as to analyze and interpret data
   3. Provides rational explanations of data within the context of the relevant underlying concepts. Applies information from additional sources. Goes beyond mere error analysis

e: An ability to identify, formulate and solve engineering problems
   4. Solves problem or completes experiment and evaluates solution

l: an understanding of biology and physiology, and the capability to apply advanced mathematics, science, and engineering to solve the problems at the interface of engineering and biology
   3. Understand limitations of engineering solutions applied to biological and physiological systems

In part, it is thought this is due to the students’ inability to apply knowledge and skills across the curriculum. For example, applying knowledge of human biology or physiology to understanding the physical significance of a solution. Individual instructors in courses addressing these outcomes were asked to make a concerted effort to focus on these Performance Criteria. For example, in BME 320 extra time was set aside to help students prepare discussion points for their lab reports and to understand how to go beyond error analysis. Additionally, in BME 315 and BME 320 the use of outside sources to prepare a discussion was emphasized, specifically, peer-reviewed literature only and not web sites. The results in the following year did not show improvement (Table 4.5). The ABET Committee is planning to address this problem in greater depth this summer by first examining each of the assessment mechanisms. The mechanisms (exam problem, lab report, etc.) were, in some cases, different each year. Additionally, to assess every student, a combination of assessments from two courses was employed. In some cases, the achievement was greater than 70% in one course, but only 40% in another. Therefore, a review of the consistency of the assessment process is first required. However, this does not mean that the data are irrelevant. It is clear by the commonality of the criteria that are a problem and from discussions with faculty that students are very limited in their abilities in this area. One source of the problem was also identified in the Exit Interviews. In the current curriculum, Statistics for Biomedical Engineers (BME 433) is taken in the senior year. This course is invaluable for data analysis and comprehending the significance of data. Additionally, the physiology lecture course (BIOL 430) is most often taken in the senior year making it difficult for students to understand physiologic relevance. Although there is a human biology course in the freshmen year, this does not deal with physiologic systems. The possibility of moving
these courses earlier in the curriculum will be under discussion at a department faculty retreat in August 2008.

Table 4.5 Percent achievement of specific Performance Criteria

<table>
<thead>
<tr>
<th>Year</th>
<th>a(4)</th>
<th>b(3)</th>
<th>e(4)</th>
<th>l(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-2007</td>
<td>50%</td>
<td>50%</td>
<td>70%</td>
<td>47%</td>
</tr>
<tr>
<td>2007-2008</td>
<td>63%</td>
<td>32%</td>
<td>55%</td>
<td>45%</td>
</tr>
</tbody>
</table>

A second area of concern is the application of basic mathematics across BME courses. This concern is often reported in the faculty course survey comment section and is apparent in the direct assessment of the following Performance Criteria

a: An ability to apply knowledge of mathematics, science, and engineering to the solution of biomedical engineering problems

3. Solves equations

e: An ability to identify, formulate and solve engineering problems

4. Solves problem or completes experiment and evaluates solution

Table 4.6 Percent achievement of specific Performance Criteria

<table>
<thead>
<tr>
<th>Year</th>
<th>a(3)</th>
<th>e(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-2007</td>
<td>50%</td>
<td>70%</td>
</tr>
<tr>
<td>2007-2008</td>
<td>28%</td>
<td>55%</td>
</tr>
</tbody>
</table>

Following the 2006-2007 and the 2007-2008 assessment cycles further evidence of a weakness in the application of mathematics to biomedical engineering problems was apparent. All faculty indicated that they spend some portion of their courses reviewing basic mathematics concepts needed for the course. For example, vector calculus for fluid mechanics, solution of differential equations for nearly all courses. As noted above, the assessment mechanisms used will be reviewed. In addition, it was proposed that each instructor prepare a list of example math problems that are relevant to their courses and give these to students at the beginning of each semester so they are made fully aware of the math skills they may need to review or, in some cases, relearn. This will be implemented in the 2008-2009 academic year. It should be noted that one reason for a decrease in achievement from 06-07 to 07-08 is that, in general, the 07-08 students were generally weaker in all areas.

Actions to improve the program based on Alumni Surveys

To date, alumni surveys have been received from graduates from 2006 to 2007 (see Table 4.3 for response rates). These data are to be reviewed in August 2008 at a faculty retreat. However, the placement data and student responses to the importance vs achievement of Program Outcomes will be presented here. The placement data will also be compared to similar data obtained from the Exit
Survey at the time of graduation in order to compare students’ goals/plans with their placement 1 or 2 years post graduation.

**Planned placement compared to actual placement**

At the time of graduation, 30% of our students planned on attending medical school, 34.6% on attending graduate school, and 13.5% planned to pursue industrial positions. Subsequent placement data obtained from 2006 Alumni Surveys shows a similar demographic for placement in medical school and industry with a movement from “other” (21.2% down to 5.3%) to graduate school (34.6% increases to 47.4%). Placement data for 2007 also shows a larger percentage of placement in graduate school (60%), but retains a larger “other” category (26.7%). Clearly, the placement is more stable (less in the “other” category) for students two years out. Overall, however, the data suggest great success for students entering graduate and medical school. The placement in industry is still somewhat low.

**2006-2007 Senior Exit Profile**

**Figure 4.7 54 Graduates**

18 Grad School  
16 Med School  
7 Industry  
11 Other:  
  Married, Looking for Job, Studying MCAT, Med School Prep, Time Off, Prep for GRE
Figure 4.8 Placement data from Alumni Survey for a) 2006 graduates and b) 2007 graduates.
4.7.2.4.2 Alumni Ratings of Preparation vs. Importance of ABET Criteria

Table 4.7 summarizes the responses of alumni to achievement and importance of Program Outcomes. In all cases the responses average a value greater than 4 on a 5-point scale for importance. The responses for preparation are generally above an average of 4. There are 3 outcomes with an average response slightly below 4. The perception of preparation in design was slightly below 4 at 3.94 (outcome c); the knowledge of contemporary issues was at 3.68 (outcome j); understanding of the societal and global impact of engineering (outcome h) was at 3.65; an understanding of professional ethical responsibility (outcome f) was 3.81. As described in previous sections, these outcomes were flagged by other sources of data including Exit Surveys and Student course surveys. Plans for improvement in these areas were put in place with some improvement observed from the 2006/07 to the 2007/08 academic year (see section 4.7.2); however, the success of these changes will only be apparent in future alumni surveys.

4.8 Existing limitations and concerns

4.8.1 One-credit lab courses, enhanced capstone design, additional core engineering courses

The originally established curriculum in 2002 devoted only 1 lab credit (3 hour lab) to laboratory courses and 4 credits to capstone design. Stand-alone laboratory courses are limited in that there is little time to present underlying concepts prior to laboratory work. Additionally, the design course was not a sufficient number of contact hours. In the past 6 years it has been possible to add one lecture credit (1 hour per week) to the Instruments and Measurements Lab (BME 315) and one additional credit to the first semester of design (BME 419). In the Fall of 2008 an additional lecture credit will be added to the physiology lab (BME 405). This was possible only when additional credits were obtained from two sources. Originally, there were 10 credits devoted to freshmen biology with labs (2-3 credit lectures and 2-2 credit labs). The biology labs were reduced to 1 credit each, leading to two open credits. Beyond this, the department opted to remove general biology lecture (3 more credits gained) in order to require a MATLAB course and a biomaterials course. We still wish to add one credit to the Biofluids Lab (BME 320) that remains a stand-alone lab. Finally, one more credit to capstone design for a total of 6 credits over the senior year is highly desirable. However, we cannot achieve this without increasing the total credit hours for the degree. With requirements of 131 to 133 total credit hours, we are already considered somewhat on the high side. The IIT requirement of 21 general education requirements in the humanities and social sciences is common. However, IIT also requires 6 credits (2 courses) of Interprofessional Project (IPRO) courses. These courses are project courses that require enrollment of students from multiple majors. However, they are often not engineering, math or science based and are considered part of the general
education requirement, making the total general education requirement 27 credit hours. There is a desire in many science and engineering departments to reduce this requirement from 6 to 3 credits so that additional courses in the major can be added to the curriculum. However, attempts to push this through the University system have not been successful.

4.8.2 Multidisciplinary Teams

The BME department is aware that, although, team based work is common in our department, and that it occurs across tracks, it is not truly multi-disciplinary. There is a general belief that the Interprofessional Project courses fulfill this requirement. However, we are concerned that the projects completed are not necessarily engineering based. The Chemical and Biological Engineering Department addressed this concern by basically merging their capstone design with IPRO. That is, chemical engineering students are required to take an IPRO that is run by their department. Discussions with administration have indicated to the BME department that this merging is no longer an option and will not be allowed. Secondly, teaching multiple sections of IPRO in our department would require additional instructors. Therefore, the BME department supports a different approach to this issue that enables team based work in courses across engineering departments. For example, in sophomore level courses such as Circuits or Static and Dynamics. However, this is not supported outside of the department and BME does not have the manpower to open our courses to other departments.

Table 4.7 Average responses of alumni to preparation vs importance of Program Outcomes

<table>
<thead>
<tr>
<th>Program Outcome</th>
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<tbody>
<tr>
<td>Importance</td>
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<tr>
<td>Preparation</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Program Outcome 1: An ability to apply knowledge of mathematics, science, and engineering to the solution of biomedical engineering problems.</td>
</tr>
<tr>
<td>4.65</td>
</tr>
<tr>
<td>Program Outcome 2: An ability to design and conduct experiments, as well as to analyze and interpret data.</td>
</tr>
<tr>
<td>4.55</td>
</tr>
<tr>
<td>Program Outcome 3: An ability to design a biomedical engineering system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.</td>
</tr>
<tr>
<td>4.42</td>
</tr>
<tr>
<td>Program Outcome 4: An ability to function on multi-disciplinary teams.</td>
</tr>
<tr>
<td>4.74</td>
</tr>
<tr>
<td>Program Outcome 5: An ability to identify, formulate, and solve engineering problems.</td>
</tr>
<tr>
<td>4.40</td>
</tr>
<tr>
<td>Program Outcome 6: An understanding of professional and ethical responsibility.</td>
</tr>
<tr>
<td>4.52</td>
</tr>
<tr>
<td>Program Outcome 7: An ability to communicate effectively based upon analytical and critical thinking skills.</td>
</tr>
<tr>
<td>4.90</td>
</tr>
<tr>
<td>Program Outcome</td>
</tr>
<tr>
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<td>13</td>
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CRITERION 5: CURRICULUM

5.1 BME Program Curriculum

The BME curriculum provides training in the basic sciences and mathematics, engineering topics and general education. Students are trained for a professional career and further study. The structure and content of the BME curriculum, including the design experience, provided to students, is consistent with the Program Educational Objectives and Program Outcomes. Beginning with the first freshman BME course, BME 100 and throughout the BME curriculum, students are exposed to all aspects of the Program Educational Objectives. Freshman are introduced to PowerLab computerized data acquisition and other sophisticated equipment; later in the junior and senior years BME students go through extensive laboratory experiences in state of the art facilities. BME students also have extensive team-based activities in BME 100, all the lab classes, and in the year-long capstone design sequence. BME 100 students are exposed to ethical issues and are assessed in two individual exercises on ethical considerations. In the senior capstone design courses ethical issues associated with research on humans and animal testing are discussed. In addition, students are reminded each semester of the importance of intellectual honesty as a student and subsequently as a professional engineer. In many of the BME courses students, again beginning with BME 100 and ending with the senior capstone courses, are required to critically read professional literature and write analyses, write lab reports, and short papers. Oral presentations are an important component as well. BME students acquire the skill to solve biomedical engineering problems by acquiring the component skills of each course and then applying them in the senior capstone design sequence.

The BME curriculum, as evidenced in Criterion 3, reflects the required a-k outcomes and l and m in Criterion 9. Students follow an orchestrated process of development through the four years with relevant skills introduced, reinforced, refined, and finally brought together in the senior year design sequence. The BME curriculum is rigorous and demands the best from each student. BME students must devote considerable time to their classes. Such rigor trains students to: have strong self-discipline, learn to prioritize their time, coordinate their responsibilities, and work with other students. These attendant skills have proved to serve our students well in medical school, graduate school, and industry.

5.2 Curriculum

The BME curriculum offers three tracks with 11 BME core classes, 6-7 BME Track specific classes and a balance of mathematics, science, and general education classes. The program requires a minimum of 131-133 credit hours. Sections that follow describe required mathematics, sciences and engineering classes needed for the BS degree. The detailed curriculum and course categories are found in Tables 5.1 through 5.3.

Math, science, and engineering courses follow a prescribed route with key classes directly linked to those that follow. These are outlined in the pre- and co-
requisite flow charts that show an overview of the curriculum (Figure 5.1), and each track specific curriculum (Tables 5.4, 5.5, 5.6, 5.7, and 5.8). The required general education courses are placed in the curriculum to fill out 16-18 credit hours per semester over 8 semesters.

The BME curriculum comprises 104-106 total credits in math, science, and engineering. There are 41 credits of core math and science plus an additional 6-7 credits of math and/or science specific to each Tracks. There are core BME engineering credits for all students (24 credits), and one external (provided by other engineering departments) engineering requirement for a total of 27 core engineering credits. BME courses and external engineering requirements specific to each track contribute an additional 27-29 credits of engineering for a total of 54-56 engineering credits.

5.2.1 Core Mathematics, Science, and External Engineering Requirements

The BME curriculum requires 44 hours of coursework in mathematics, the sciences, and engineering for all students.

Mathematics:
- MATH 151 - Calculus I (5)
- MATH 152 - Calculus II (5)
- MATH 252 - Differential Equations (4)
- MATH 251 - Multivariate and Vector Calculus (4)

Science:
- CHEM 124 - Principles of Chemistry I (4)
- CHEM 125 - Principles of Chemistry II (4)
- BIOL 115 - Human Biology (3)
- BIOL 117 - Experimental Biology (1)
- PHYS 123 - General Physics I (4)
- PHYS 221 - General Physics II (4)
- BIOL 430 - Animal Physiology (3)

Engineering:
- ECE 211 - Circuit Analysis I (3)

5.2.2 BME Core Engineering Requirements

The BME Engineering requirement is divided into core classes and track-required classes.

Core Engineering:
- BME 100 - Introduction to the Profession (3)
- BME 200 - Biomedical Engineering Applications of MATLAB (1)
- BME 310 - Biomaterials (3)
BME 330 - Analysis of Biosignals (3)
BME 315 - Instrumentation and Measurement Laboratory (2)
BME 320 - Biofluids Laboratory (1)
BME 405 - Physiology Laboratory (2)
BME 419 - Introduction to Design Concepts (2)
BME 420 - Design Concepts in BME (3)
BME 433 - BME Statistics (3)
BME 490 - Senior Seminar (1)

In addition to the above 24 credits of core BME classes, each track requires the following engineering and science classes.

**Cell and Tissue Engineering**

**Engineering (27 credits):**
- MMAE 200 - Introduction to Mechanics (3)
- MS 201 - Material Science (3)
- CHE 202 - Material and Energy Balances (3)
- BME 301 - Biofluid Mechanics (3)
- BME 335 - Thermodynamics (3)
- BME 408 - Reaction Kinetics (3)
- BME 482 - Mass Transport (3)
- Two BME electives (6 credits total)

**Science (7)**
- CHEM 237 - Organic Chemistry I (4)
- CHEM 239 - Organic Chemistry II (3)

**Computer science (2 credits)**
- CS 105 - Introduction to Programming (2)

**Neural Engineering**

**Engineering (29 credits):**
- ECE 212 - Analog and Digital Laboratory (1)
- ECE 218 - Digital Systems (3)
- ECE 213 - Circuit Analysis II (3)
- ECE 214 - Analog and Digital Laboratory II (1)
- BME 309 - Biomedical Imaging and Sensing (3)
- BME 443 - Biomedical Electronics (3)
- BME 445 - Quantitative Neural Function (3)
- BME 438 - Neural Imaging (3)
- Three BME electives (9 credits total)

**Math or science (6/7 credits)**
- MATH 333 - Complex Variables and Linear Algebra (3) or CHEM 237 – Organic Chemistry I (4)
- Technical Elective or CHEM 239 - Organic Chemistry II (3)
Computer science (2 credits)
   CS 115 - Object-Oriented Programming I (2)

Medical Imaging
Engineering (27 credits):
   ECE 213 - Circuit Analysis II (3)
   ECE 437 - Digital Signal Processing I (3)
   ECE 481 - Image Processing (3)
   BME 309 - Biomedical Image and Sensing (3)
   BME 443 - Biomedical Electronics (3)
   BME 445 - Quantitative Neural Function (3)
   BME 438 - Neural Imaging (3)
   Two BME Electives (6 credits total)

Math or science (6/7)
   PHYS 224 - General Physics III (3) or CHEM 237 - Organic Chemistry I (4)
   MATH 333 - Complex Variables and Linear Algebra (3) or CHEM 237 - Organic
       Chemistry II (3)

Computer science (4 credits)
   CS 201 - Introduction to Computer Science (4)

5.2.3 General Education

IIT, and subsequently the BME curriculum, requires 21 hours (7 classes) of coursework
in general education comprised of 12 credits of humanities, 12 credits of social science
and an additional 3 credits in either area. There are an additional 6 credit hours of
coursework considered Interprofessional Projects 1 and 2 (IPRO 1 and IPRO 2). These
courses are team based courses that can be in any subject and require participation of
students from multiple majors on each project.

5.3 Preparation of Students for Engineering Practice

In addition to the basic math, science and engineering topics, preparation for
professional engineering practice requires competency in the following areas:
   Oral and written communication
   Ethical and Professional responsibility
   Teamwork
   Laboratory/hands-on experiences
   Design

5.3.1 Oral and Written Communication
Program Education Objective #3 states that our graduates will “possess the requisite written and oral communication skills to interact with health care professionals, engineers or scientists in industry, graduate or professional graduate programs.” Therefore, extensive opportunities to learn written and oral communication skills are integrated into BME courses. This integration allows our students to practice these skills in the proper context of science, engineering, and medicine. The process begins in BME 100, *Introduction to the Profession for Biomedical Engineering* majors taken in the first semester of the freshman year.

This first course undergraduates complete in BME (BME 100) lays the groundwork for the Program’s emphasis on written and oral communication skills. The ITP course has been taught for the past 5 years by an engineering professor, Dr. Connie Hall (Asst. Prof., BME) and a historian of science and engineering, Dr. Paul Fagette (Historian in Residence and Senior Lecturer, BME). The unique combination of a historian and an engineer has led to the development of a process by which the students are introduced to the professional literature and taught to critically analyze scientific/engineering journal articles and present the key concepts in focused two page essays. Additionally, the students are introduced to laboratory exercises with required written laboratory reports that are in the form of a scientific article. A tutorial with Excel introduces students to basic numerical manipulation and graphics. There is also a final project that the students prepare for over the last 6-7 weeks of the semester. The students, having been introduced to MEDLINE and other journal databases, are given a topic related to one of the three tracks (Cell and Tissue Engineering, Neural Engineering, Medical Imaging) and are asked to find 3-5 peer-reviewed articles in order to address the topic (e.g., the key issues related to biocompatibility of mechanical heart valves). The students submit an individual written analysis and prepare a poster presentation in teams of three for presentation to the entire BME faculty on the last day of class. The team members have different aspects of the same topic so that they can present a broader view in the poster component. Dr. Hall and Dr. Fagette have reiterated the process of article analysis in junior level courses, such as BME 301. Additional courses incorporate a significant component requiring analysis of professional literature (BME 408, BME 309, BME 310, and BME 335 among others).

The junior level laboratory courses, BME 315 and BME 320, follow a consistent writing and oral communication component. The students are required to write formal laboratory reports in the style of peer-reviewed journal articles. BME 315 requires 5-6 reports that are submitted by teams of three. In BME 320, the students are transitioned from group reports to individual reports. The initial instructors of BME 315 (Dr. Jennifer Kang Derwent) and BME 320 (Dr. Connie Hall) developed consistent requirements that enable the students to progress to the submission of individual lab reports at the end of the junior year. In addition, BME 315 and BME 320 require the students to present their work in oral presentations. Each laboratory team will give on average of 1-2 oral presentations using PowerPoint during the semester. All of the laboratory courses (BME 315, BME 320, and BME 405) require extensive laboratory notebook record-keeping.
In the senior design sequence (BME 419 and BME 420), teams of seniors generate several written design documents including problem statements, executive summaries, design specifications, risk analyses, intellectual property issues, economic and financial models, and discussions of safety and ethical considerations. In addition, teams participate in weekly meetings with the design faculty. Design teams orally defend their design solutions in front of the faculty at the end of BME 419 and BME 420.

Lastly, all BME seniors are required to take BME 490, Senior Seminar. Students attend a weekly series of seminars by professionals in and related to the biomedical engineering field. Representatives from industry, academia, and the healthcare industry will make presentations on research, translational development and research, clinical problems, and aspects of biomedical engineering regarding ethics and the role of the discipline in a broader economic/global context. Students write a one-page essay that explains the essential points of the each presentation. The main focus of the course is on life-long learning and a broader understanding of biomedical engineering.

5.3.2 Ethics and Professional Responsibility

Program Educational Objective #5 states that our graduates will “possess the sense of responsibility and ethics of a professional engineer in industry, graduate or professional graduate programs.” Therefore, ethics and professional responsibility are introduced in BME 100, the first course students take as incoming freshmen. The students are informed of the IIT Academic Code of Conduct and the Biomedical Engineering Society Code of Ethics. Specific discussions are directed toward ethics in communication and plagiarism during the introductory module on reading and analyzing a peer-reviewed journal article. Also, freshman BME students are required to complete a 2 hour certification process on Human Participant Protections Education by the National Cancer Institute prior to their first laboratory: http://cme.cancer.gov/clinicaltrials/learning/humanparticipant-protections.asp.

Additional instruction is provided in the laboratory courses as students’ laboratory notebooks are monitored for complete record keeping and truthfulness in data collection and presentation of results. There is also an emphasis on the strict use of peer-reviewed literature for references and no acceptance of web sites. The application of statistics in biomedical engineering presents ethical dilemmas arising from data analysis.

The capstone design course sequence, BME 419 and BME 420, requires a component on medical device safety and on the use of human and animal subjects in research. In addition, at least one lecture is delivered on medical ethics and relevant case studies. Students in BME 420 are asked to consider the ethical ramifications of their proposed design solutions and to include appropriate ethical discussions in their final team notebooks. An understanding of professional and ethical responsibility (Program Outcome f) is assessed according to the Performance Criteria presented under Criteria 3.
In the BME 490 Senior Seminar, students listen to current biomedical engineering research in connection with appropriate clinical issues, translational attempts to bring biomedical engineering research to the market place, and relative clinical needs, with attention paid to: placing this work within the pertinent global, national, economic, environmental, or societal context and appropriate professional and ethical issues. A written assignment follows each presentation.

5.3.3 Teamwork

Program Educational Objective #4 states that our graduates will “possess the ability to work in teams in industry, graduate or professional graduate programs.” Therefore, teamwork activities are dispersed across the curriculum. The first team experiences begin in BME 100. Students perform laboratory experiments and one written report in teams of 3. They also complete the poster portion of the final project as a 3-person team. Teamwork activities continue through the laboratory sequence (BME 315, 320 and 405) culminating in team design projects in BME 419 and BME 420. The ability to function in teams is evaluated based on the Performance Criteria delineated for Program Outcome d. In BME 419 and BME 420, students assess their peer’s abilities to perform within teams using an online survey instrument developed within the Department. Students are assessed twice during BME 419 and twice during BME 420.

5.3.4 Laboratory Experiences

Program Education Objective #2 states that our graduates will have “the ability to employ laboratory skills in industry, graduate or professional graduate programs.” This objective is supported by the entire curriculum with a specific emphasis in the laboratory courses and the capstone design sequence. The laboratory courses offer excellent laboratory experiences in high-quality facilities.

The core BME curricular component includes three laboratory courses: BME 315, BME 320 and BME 405. The laboratory classes offer an opportunity for hands-on learning. The laboratory modules in BME 315 target measurements of electrical, chemical or mechanical signals. BME 320 emphasizes fluid properties and transport. BME 405 is engineering-based physiology and incorporates measurements from both humans and animals. Safety training is introduced in each class prior to experimentation. In addition to these courses, there are several laboratory projects embedded in BME core and elective courses (e.g., BME 100 and BME 445).

5.3.5 Design

Design is first introduced to students in the BME 100 course. Concepts of design and how engineers and physicians have to take into account a variety of realistic constraints in the creative process are presented to freshman. Subsequent to BME 100, design is applied in a specific manner for several classes in the BME curriculum. For example, students are asked to design a unique imaging modality in BME 309, Imaging and
Sensing. In another case, students have to design a novel bioreactor in BME 408, Reaction Kinetics.

In the senior design sequence (BME 419 and 420), seniors rely on their BME skills and knowledge to engineer solutions to real-world biomedical problems. In BME 419, students learn about the design process, and work in teams to brainstorm plausible solutions, establish design constraints and metrics, and use decision matrices to help guide the construction of an initial mock-up solution. Teams submit reports and meet with design faculty weekly to discuss their ideas. The class culminates with oral presentations delivered by each team which are assessed by all department faculty. In addition, each team generates a team notebook comprising the aforementioned weekly reports, meeting agendas and minutes, sketches, results from brainstorming sessions, RAM and Gannt charts, decision matrices, etc. In BME 420, students continue this process, concentrating on the generation of multiple mock-ups. The ultimate objective of BME 420 is to have students generate a prototype to solve the engineering problem originally defined in BME 419. All teams present their prototypes to the BME faculty, graduate students, and undergraduates, in a poster session at the end of the semester.

Introduced in the 2007-'08 school year, BME 419 and 420 students were assigned a client from outside of IIT. In 2007, the clients for the design sequence came from Michael Reese Hospital. Students were asked to work with these clients (all MDs) to design solutions in following medical areas: 1) pressure ulcers; 2) telemetry; 3) EKG monitoring and defibrillation; 4) continuous glucose monitoring; 5) biodegradable stents.

### 5.4 Course Materials Notebooks

In the ABET record room in Wishnick, 301C, along with the outcomes and policy notebooks, a notebook for each course is stored containing syllabi, samples of student work, student and faculty course survey forms.
Table 5.1  Curriculum for the Department of Biomedical Engineering Cell and Tissue Engineering Track

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<thead>
<tr>
<th>Year; Semester or Quarter</th>
<th>Course (Department, Number, Title)</th>
<th>Math &amp; Basic Sciences</th>
<th>Engineering Topics</th>
<th>General Education</th>
<th>Engr Design(^1)</th>
<th>Other</th>
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<td>Semester 7</td>
<td>BME 408 – Reaction Kinetics for BME</td>
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\(^1\) Place an “X” in this column if the course contains significant engineering design content
### TABLE 5.2 Curriculum for the Department of Biomedical Engineering Neural Engineering Track

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<th>Year; Semester or Quarter</th>
<th>Course (Department, Number, Title)</th>
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<th>Engineering Topics</th>
<th>General Education</th>
<th>Eng Design</th>
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Total Credit Hours Required for Completion of the Program: 132/133

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Total Credit Hours Required for Completion of the Program: 132/133

1 Place an “X” in this column if the course contains significant engineering design content.
Figure 5.1 PREREQUISITE FLOW CHART – BME

Prerequisite: 
Co-requisite: 

CELL AND TISSUE TRACK
- MATH 252
- CS 105
- CHEM 237
- CHEM 239

- MATH 251
- MMAE 200
- CHE 202
- MS 201

BME CORE COURSES
- BME 200
- BME 315
- BME 330
- ECE 211

MEDIcal imaging track
- ECE 213
- CS 201
- ECE 437
- ECE 481

- BME 309
- PHYS 221
- PHYS 224 or CHEM 237

- BME 443
- BME 438
- MATH 333 or CHEM 239
- 2 BME Electives

MATH 251
- PHYS 224
- MATH 152
- BIOL 117
- BIOL 115

CHEM 125
- MATH 151

- MATH 252
- PHYS 123
- BIOL 115

- BME 445
- BME 438
- CHEM 239
- 2 BME Electives
### Table 5.7 Course and Section Size Summary

#### Biomedical Engineering

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<th>Course No.</th>
<th>Title</th>
<th>Responsible Faculty Member</th>
<th>No. of Sections Offered in Current Year</th>
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<th>Lecture</th>
<th>Laboratory</th>
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<td>Greg Fasshauer</td>
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<td>2- Spring</td>
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<tr>
<td>MMAE 200</td>
<td>Introduction to Mechanics (3-0-3)</td>
<td>J. Kallend</td>
<td>50</td>
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<tr>
<td>MS 201</td>
<td>Materials Science (3-0-3)</td>
<td>J. Kallend</td>
<td>85</td>
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<tr>
<td>CHEM 237</td>
<td>Organic Chemistry I (3-4-4)</td>
<td>Rong Wang</td>
<td>23</td>
<td>4</td>
<td>43%</td>
<td>57%</td>
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</tr>
<tr>
<td>CHEM 239</td>
<td>Organic Chemistry II (3-4-4)</td>
<td>Rong Wang</td>
<td>45</td>
<td>2</td>
<td>43%</td>
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<tr>
<td>CHE 202</td>
<td>Materials and Energy Balances (3-0-3)</td>
<td>S. Parulekar</td>
<td>26</td>
<td>2</td>
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<tr>
<td>BME 301</td>
<td>Bio-Fluid Mechanics (3-0-3)</td>
<td>C. Hall</td>
<td>18</td>
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<tr>
<td>BME 335</td>
<td>Thermodynamics of Living Systems</td>
<td>G. Papavasiliou</td>
<td>18</td>
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<tr>
<td>BME 408</td>
<td>Reaction Kinetics for BME</td>
<td>G. Papavasiliou</td>
<td>18</td>
<td></td>
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<td></td>
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<tr>
<td>BME 482</td>
<td>Mass Transport for Biomedical Engineers (3-0-3)</td>
<td>E. Brey</td>
<td>18</td>
<td>1</td>
<td>100%</td>
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</tr>
<tr>
<td><strong>Two (2) BME Electives (6 credit hours)</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Neural Engineering (37/38 cr. hours)</strong></td>
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<tr>
<td>CS 115</td>
<td>Object-Oriented Programming I (2-1-2)</td>
<td>Matt Bauer</td>
<td>30</td>
<td>6</td>
<td>67%</td>
<td>33%</td>
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<tr>
<td>ECE 212</td>
<td>Analog and Digital Laboratory I (0-3-1)</td>
<td>Jafar Saniie</td>
<td>18</td>
<td></td>
<td></td>
<td>100%</td>
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<tr>
<td>ECE 213</td>
<td>Circuit Analysis II (3-0-3)</td>
<td>Jafar Saniie</td>
<td>49</td>
<td></td>
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<td>100%</td>
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<tr>
<td>ECE 214</td>
<td>Analog and Digital Laboratory II (0-3-1)</td>
<td>Jafar Saniie</td>
<td>20</td>
<td></td>
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<td>100%</td>
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<tr>
<td>ECE 218</td>
<td>Digital Systems (3-0-3)</td>
<td>Jafar Saniie</td>
<td>46</td>
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<td>Biomedical Imaging and Sensing (3-0-3)</td>
<td>K. Arfanakis</td>
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<td>BME 438</td>
<td>Neuroimaging (3-0-3)</td>
<td>K. Arfanakis</td>
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<tr>
<td>BME 443</td>
<td>Biomedical Instrumentation and Electronics (3-0-3)</td>
<td>P. Troyk</td>
<td>9</td>
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<tr>
<td>BME 445</td>
<td>Quantitative Neural Function (3-0-3)</td>
<td>J. Derwent</td>
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<tr>
<td>MATH 333</td>
<td>Matrix Algebra and Complex Variables (3-0-3)</td>
<td>Greg Fasshauer or Rong Wang</td>
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<tr>
<td>OR CHEM 237</td>
<td>OR Organic Chemistry I (3-4-4)</td>
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### Technical Elective OR CHEM 239
- Technical Elective OR Organic Chemistry II (3-4-4)

<table>
<thead>
<tr>
<th>Course</th>
<th>Instructor</th>
<th>Credits</th>
<th>Grade</th>
<th>Grade</th>
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<tbody>
<tr>
<td>Rong Wang</td>
<td></td>
<td>4</td>
<td>30</td>
<td>43%</td>
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</table>

Three (3) BME Electives (9 credit hours)

**Medical Imaging** (37/38 cr. hours)

- Medical Imaging
  - General Physics III Lecture: Thermal and Modern Physics (3-0-3) OR Organic Chemistry I (3-4-4)
  - Howard Rubin or Rong Wang
  - 4 each
  - 30
  - 100% OR 43% 57%

- Organic Chemistry I (3-4-4)

<table>
<thead>
<tr>
<th>Course</th>
<th>Instructor</th>
<th>Credits</th>
<th>Grade</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 224 OR CHEM 237</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Two (2) BME Electives (6 credit hours)

- Enter the appropriate percent for each type of class for each course (e.g., 75% lecture, 25% laboratory).
## 5.8 BIOMEDICAL ENGINEERING COURSES - PREREQUISITES

<table>
<thead>
<tr>
<th>BME CORE COURSES</th>
<th>SEMESTER</th>
<th>PREREQUISITES</th>
<th>CO-REQUISITE</th>
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<tbody>
<tr>
<td>BME 100-ITP</td>
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<td>BME Major</td>
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<tr>
<td>BME 200-MATLAB</td>
<td>Spring</td>
<td>BME 100, ECE 211</td>
<td>CS 105, 115, or 201</td>
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<tr>
<td>BME 310-Biomaterials</td>
<td>Spring</td>
<td>BME 100</td>
<td></td>
</tr>
<tr>
<td>BME 315-Instrum Lab</td>
<td>Fall</td>
<td>BME 200, ECE 211</td>
<td>BME 330</td>
</tr>
<tr>
<td>BME 320-Bio Fluids Lab</td>
<td>Spring</td>
<td>BME 315, BIOL 115</td>
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</tr>
<tr>
<td>BME 330-Signals</td>
<td>Fall</td>
<td>BME 200, ECE 211</td>
<td></td>
</tr>
<tr>
<td>BME 405-Physio Lab</td>
<td>Fall</td>
<td>BME 315</td>
<td></td>
</tr>
<tr>
<td>BME 419-Intro Design</td>
<td>Fall</td>
<td>BME 315, 320, 330</td>
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<tr>
<td>BME 420-Design</td>
<td>Spring</td>
<td>BME 419</td>
<td></td>
</tr>
<tr>
<td>BME 433-BME Stats</td>
<td>Spring</td>
<td>BME 315</td>
<td></td>
</tr>
<tr>
<td>BME 490-Seminar</td>
<td>Spring</td>
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<td>BME 420</td>
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### CELL AND TISSUE REQUIRED TRACK COURSES

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<th>SEMESTER</th>
<th>PREREQUISITES</th>
<th>CO-REQUISITE</th>
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</thead>
<tbody>
<tr>
<td>BME 301-Bio Fluids Lect</td>
<td>Spring</td>
<td>MMAE 200, MATH 251, BIOL 115</td>
<td>BME 320</td>
</tr>
<tr>
<td>BME 335-Thermo</td>
<td>Spring</td>
<td>CHE 202, MATH 251</td>
<td>BME 320</td>
</tr>
<tr>
<td>BME 408-React Kinetic</td>
<td>Fall</td>
<td>BME 301, MATH 252, BME 335</td>
<td>BME 482</td>
</tr>
<tr>
<td>BME 482-Mass Trans</td>
<td>Fall</td>
<td>BME 301, CHE 202</td>
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### NEURAL ENGINEERING REQUIRED TRACK COURSES

<table>
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<tr>
<th>COURSES</th>
<th>SEMESTER</th>
<th>PREREQUISITES</th>
<th>CO-REQUISITE</th>
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<tbody>
<tr>
<td>BME 309-Imaging &amp; Sensing</td>
<td>Fall</td>
<td>PHYS 221</td>
<td>BME 330</td>
</tr>
<tr>
<td>Course</td>
<td>Semester</td>
<td>Prerequisites</td>
<td>Co-requisite</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------</td>
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</tr>
<tr>
<td>BME 438-Neuro Imag</td>
<td>Spring</td>
<td>BME 315, PHYS 221</td>
<td></td>
</tr>
<tr>
<td>BME 443-Instrum &amp; Elect</td>
<td>Spring</td>
<td>BME 315, ECE 213</td>
<td></td>
</tr>
<tr>
<td>BME 445-Quant Neural Func</td>
<td>Spring</td>
<td>BME 315</td>
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**MEDICAL IMAGING REQUIRED TRACK COURSES**

<table>
<thead>
<tr>
<th>Course</th>
<th>Semester</th>
<th>Prerequisites</th>
<th>Co-requisite</th>
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</thead>
<tbody>
<tr>
<td>BME 309-Imaging &amp; Sensing</td>
<td>Fall</td>
<td>PHYS 221</td>
<td>BME 330</td>
</tr>
<tr>
<td>BME 438-Neuro Imag</td>
<td>Spring</td>
<td>BME 315, PHYS 221</td>
<td></td>
</tr>
<tr>
<td>BME 443-Instrum &amp; Elect</td>
<td>Spring</td>
<td>BME 315</td>
<td></td>
</tr>
<tr>
<td>BME 445-Quant Neural Func</td>
<td>Spring</td>
<td>BME 315</td>
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</table>

**BME ELECTIVES**

<table>
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<th>Course</th>
<th>Semester</th>
<th>Prerequisites</th>
<th>Co-requisite</th>
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<tbody>
<tr>
<td>BME 422-Numerical Solut to BME Problems</td>
<td>Fall</td>
<td>BME 330</td>
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<tr>
<td>BME 425-Tissue Eng</td>
<td>Spring</td>
<td>BME 310</td>
<td></td>
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<tr>
<td>BME 430-Concepts of Medical Imaging</td>
<td>TBA</td>
<td>BME 315, PHYS 221</td>
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<tr>
<td>BME 475-Neuromech</td>
<td>Spring</td>
<td>BME 330, BIOL 115</td>
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</table>
CRITERION 6. FACULTY

6.1 Leadership Responsibilities

Dr. Vincent T. Turitto is the Chairman of the Department of Biomedical Engineering. He is the founding Chair and was appointed when the Department was created in 2002. He has been responsible for the initial hiring of all faculty and the delineation of the three track areas with BME. He currently supervises the tenure track faculty within the department, the departmental administrative assistant (D'Amico), the laboratory coordinator (Dhar) and the Senior Lecturers (Fagette and Hall) and two research faculty (Gatchell and Opara), both of whom’s salary is paid by the Pritzker Institute (non-departmental funds.) He is responsible for establishing and allocating the departmental budget, for developing and modifying the curriculum together with the faculty and reviewing the performance of the faculty yearly and evaluating their suitability for tenure and promotion at the departmental level.

6.2 Authority and Responsibility of Faculty

A curriculum committee consisting of a representative from each track area reviews all new course offerings. The curriculum in each track was determined by the faculty for each track and their recommendations were submitted to the faculty as a whole for approval. The curriculum is reviewed on an ad hoc basis for modifications by the faculty in the respective track. Review is occasioned by comments and observations arising out of student exit interviews or from Advisory Board recommendations. Faculty who wish to develop a new course can propose such a course to the curriculum committee and, if approved, to the faculty as a whole. Changes in the core curriculum would require approval of the ABET Committee to ensure compliance with such considerations. Courses are reviewed at least every three years by the faculty as a whole to ensure consistency, modernity and quality of the courses. The Dean or Provost may suggest to the Chairs course areas which are interdisciplinary in nature, i.e., those that might cross traditional departmental or college boundaries. Courses of this nature would require the approval of all faculties involved with the teaching of such courses.

6.3 Faculty

There are 8 tenure track faculty within the Department of Biomedical Engineering: one full professor (Turitto), five tenured associate professors (Derwent, Troyk, Mogul, Anastasio, and Arfanakis) and two tenure track assistant professors (Brey, Papavasiliou.) In addition, there are four non-tenure track faculty that contribute to undergraduate teaching (Hall, Opara, Fagette and Gatchell.) All faculty have doctoral degrees; all have been teaching in the department for a minimum of 4 years. Tenure track faculty teaching loads vary from 30% to 45% of their time. All tenure track faculty have their own research
labs and are expected to conduct research and perform scholarly work for at least 50% of their time. All tenure track faculty (except the most recent hire Papavasiliou who has been tenure track for 1 year) currently hold external funding from various sources, including NSF, NIH, industry and several foundations. The faculty publish at least two manuscripts per year in peer reviewed journals and attend national and international meetings on a yearly basis, normally related to their specialty, such as BMES, EMBS or IEEE.

6.4 Faculty Competencies

There are three track areas in the Department of Biomedical Engineering: Cell and Tissue Engineering, Medical Imaging, and Neural Engineering. Cell and Tissue Engineering is chemical/mechanical based. Faculty that teach courses in this area are Drs Papavasiliou (PhD in Chemical Engineering), Hall (PhD in Biomedical Engineering) and Brey (PhD in Chemical Engineering) and Turitto (PhD in Chemical Engineering). Neural Engineering is more electrically based and faculty who teach courses in this area are Troyk (PhD in Biomedical Engineering), Derwent (PhD in Biomedical Engineering), Mogul (PhD in Electrical Engineering) and Kamper (PhD in Biomedical Engineering.) Medical Imaging is taught primarily by two faculty with training in that specific area, Drs. Anastasio (PhD in Medical Physics) and Arfanakis (PhD in Medical Physics.)

6.5 Faculty Size

The current faculty size of 8 tenure track faculty (7 effective since the Chair does not teach undergraduate courses presently) is minimally capable of delivering the undergraduate courses in the three track areas, given that faculty are expected to also deliver graduate level courses in these three areas, perform externally funded research for more than 50% of their time and contribute to the service requirements of the department, institution and profession (typically about 10% of a faculty member’s time). In order to meet the course requirements in the three track areas, we have relied on four additional non-tenure track personnel. Dr. Hall is a Senior Lecturer and delivers the BME fluids course and lab ans parts of BME100. Dr. Fagette is appointed in the Department and contributes to the ITP and IPRO courses; Dr. Gatchell and Dr. Opara are appointed to and salaried by the Pritzker Institute and contribute to the teaching of two design courses, a MatLab course and some IPRO courses. Even with the additional non-tenure faculty positions, it is difficult to meet the requirements of graduate level courses in the three track areas. Currently, first year graduate students often take classes with senior year undergraduate students in order to help meet their curricular needs.

All students that enter the undergraduate program are advised by the Chair initially. After spending a semester in the program, they are then assigned a faculty member as a permanent advisor for their remaining academic life, unless the student request’s a change of advisor. Faculty are assigned according to the student’s interest (track) where possible. However, given the large amount
of students that are interested in Cell and Tissue Engineering, relative to the other two tracks, such a matching is not always possible. All faculty, both tenure and non-tenure advise students; the typical number of students assigned is 10-15 per faculty.

Faculty are actively involved in undergraduate research with the students. In the freshman year students who have been awarded a Biomedical Research Scholarship (upon entering IIT) work in the labs of several faculty. Generally, this has been in association with an NSF REU grant in diabetes. Students in subsequent years have been designated as Ross Scholars and work with faculty on research projects. Typically, 10 - 15 undergraduates per year conduct research in BME faculty labs.

Faculty service varies among the faculty. Faculty service assignments are usually made by the Chair with the philosophy of spreading the service load. However, some faculty have service to the college and/or institution too. Because the faculty are relatively young professionally (the Chair is the only full professor in the department), service activities are probably excessive for faculty. For example, Dr. Hall, an untenured faculty member, has been given the primary responsibility for the ABET activities. Dr. Kang Derwent, an Associate Professor tenured in 2007 has been assigned to coordinate the teaching laboratories; Dr. Brey, also untenured, has significant responsibilities with respect to undergraduate research through the REU program for which he is the PI and for developing and heading a university-based undergraduate research program at IIT. The various departmental committees and the faculty assigned to them are listed below:

ABET: Hall, Papavasiliou, Kang Derwent, Gatchell, Fagette, Anastasio
Safety: Brey, Arfanakis, Kang Derwent
Undergraduate: Hall, Papavasiliou, Kang Derwent, Gatchell, Fagette, Anastasio
Graduate: Mogul, Arfanakis, Brey
Advising: all faculty
Pre-med Advisor: Arfanakis
Animal Users: Kang Derwent, Mogul

6.6 Faculty Development

The BME undergraduate program was begun in 2002. Vincent Turitto has been the Chair since the beginning of the department. He has hired all the BME
faculty, except for Phil Troyk, who was already a tenured faculty member at IIT in the Department of Electrical and Computer Engineering. Phil Troyk transferred his tenure to BME in 2003. The Chair has mentored the BME faculty through the tenure and promotion process. The following faculty, Anastasio (early consideration), Derwent, Mogul and Arfanakis, thus far have received tenure and are Associate Professors. Hall has been transferred from tenure track to Senior Instructor where she will also act as an Assistant to the Chair. Kamper, Brey and Papavasiliou are proceeding in a satisfactory manner toward tenure. The only faculty hire that has not been retained is Viji Balasubramanian who developed a chronic medical problem and had to leave IIT for medical reasons 3 years after her hire.

All faculty are counseled regularly with respect to what they need to accomplish in order to receive tenure in BME. Their letter of offer when each faculty member is hired delineates specifically the minimal expectations with respect to research, teaching and service that each is expected to meet. Informal meetings with the Chair are held in order to advise them on their progress in meeting such goals and to suggest specific opportunities for them with respect to teaching or research. Faculty have been encouraged to be aggressive with respect to the recruiting of graduate students and undergraduates to assist them in their research work and to persevere in trying times with respect to re-submitting grant applications. The Chair has offered to assist faculty financially (through monies from the department or Institute) and has developed a system of seed grants to foster interdisciplinary research which has considerably assisted younger faculty members. The Chair meets frequently with individual faculty members to offer specific suggestions with respect to research and grant applications. In addition, faculty in various tracks have also received mentorship from more senior faculty with secondary appointments in BME, such as Miles Wernick (primary appointment ECE) in imaging and Ali Cinar (primary ChBE.) The Chair meets formally with each faculty member once a year, usually in April. They present the Chair with a Faculty Activity Report (FAR) that delineates their past year’s progress and their plans for the upcoming year. The Chair prepares a critical evaluation of their teaching, research and service plans, both past and present. This evaluation is then signed by the faculty member and sent to the Dean.

To further assist in their development, faculty with their graduate and undergraduate students are encouraged to attend meetings in their respective professional areas, such as BMES, SPIE and EMBS and to organize sessions of their colleagues at these meetings. Funds have been made available through departmental allocations, university resources and the Institute endowment to help defray the faculty and student expenses for travel and lodging. Departmental funds, while not formally budgeted, have been available in the past through “buy out” of faculty academic year time from grants. Typically, $30-60K per year has been available in BME and this money is generally returned to faculty for development purposes. With respect to development of faculty teaching, the Dean has regularly held a day long session, at least once a year, to
discuss teaching and its improvement. Faculty who attend educational meetings, such as ASEE, are compensated for their costs by the Dean.
# Table 6-1 Faculty Workload Summary

## Department of Biomedical Engineering

<table>
<thead>
<tr>
<th>Faculty Member (name)</th>
<th>FT or PT</th>
<th>Classes Taught (Course No./Credit Hrs.) Term and Year¹</th>
<th>Total Activity Distribution²</th>
<th>Other³</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Teaching</td>
<td>Research/Scholarly Activity</td>
</tr>
<tr>
<td>Mark Anastasio</td>
<td>FT</td>
<td>BME 330/3cr fall 2007; BME 540/3cr sp 2008</td>
<td>33</td>
<td>57</td>
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<tr>
<td>Konstantinos Arfanakis</td>
<td>FT</td>
<td>BME 309/3cr fall 2007; BME 438/3cr sp 2008</td>
<td>33</td>
<td>63</td>
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<tr>
<td>Eric Brey</td>
<td>FT</td>
<td>BME 482/3cr fall 2007; BME 310/3cr sp 2008</td>
<td>33</td>
<td>52</td>
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<tr>
<td>Jennifer Derwent</td>
<td>FT</td>
<td>BME 419/2cr fall 2007; BME 445/3cr sp 2008; BME 420/3cr sp 2008</td>
<td>42</td>
<td>48</td>
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<tr>
<td>Paul Fagette</td>
<td>FT</td>
<td>BME 100/3 cr; BME 490/1 cr; HIST 380 F &amp; HIST 388 S/6 cr</td>
<td>33</td>
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<tr>
<td>David Gatchell</td>
<td>FT</td>
<td>BME 200/1cr sp 2008</td>
<td>50</td>
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<tr>
<td>Connie Hall</td>
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<td>Derek Kamper</td>
<td>PT</td>
<td>BME 315/1cr fall 2007; BME 475/3cr sp 2008</td>
<td>22</td>
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<tr>
<td>David Mogul</td>
<td>FT</td>
<td>BME 433/3cr sp 2008; BME 552/3cr sp 2008</td>
<td>33</td>
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<tr>
<td>Emmanuel Opara</td>
<td>FT</td>
<td>BME 497/3cr sp 2008, IPRO 2 semesters</td>
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<tr>
<td>Georgia Papavasiliou</td>
<td>FT</td>
<td>BME 435/3cr fall 2007; BME 335/3cr sp 2008</td>
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<tr>
<td>Phil Troyk</td>
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<td>Vincent Turitto</td>
<td>FT</td>
<td>BME 500/3cr fall 2007</td>
<td>11</td>
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</table>

¹ Indicate Term and Year for which data apply (the academic year preceding the visit).
² Activity distribution should be in percent of effort. Members' activities should total 100%.
³ Indicate sabbatical leave, etc., under "Other."

FT=Full Time Faculty       PT=Part Time Faculty
<table>
<thead>
<tr>
<th>Name</th>
<th>Rank</th>
<th>Type of Academic Appointment</th>
<th>FT or PT</th>
<th>Highest Degree and Field</th>
<th>Institution from which Highest Degree Earned &amp; Year</th>
<th>Years of Experience</th>
<th>Level of Activity (high, med, low, none) in:</th>
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<td>TT, T, NTT</td>
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<td>FT</td>
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<td>Georgia Papavasiliou</td>
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<td>Phil Troyk</td>
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<td>FT</td>
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Column 3 Code: TT = Tenure Track, T = Tenured, NTT = Non Tenure Track
CRITERION 7. BME PROGRAM FACILITIES

7.1 BME Space

7.1.1 Offices
The Department of Biomedical Engineering currently occupies about 15,000 sq. ft. in Wishnick Hall not including classrooms. The departmental office space, and 12 faculty offices are located in space that was specifically renovated for BME on the 2nd and 3rd floors of Wishnick Hall at a cost in excess of $3M, excluding the costs of the laboratories. The departmental administrative offices include space for two administrative staff, the chair, a copying room, storage capability and a conference room/library for faculty meetings. Faculty offices are typically 150 sq. ft. and are equipped with standard power, phone outlets and internet connectivity.

7.1.2 Classrooms

Classrooms are not controlled by departments, but are assigned according to the teaching needs in a given semester. Students take course in various buildings, depending on the nature of the courses. All BME teaching labs are in Wishnick Hall. All classroom space on campus was completely renovated in 2006 with funds from a $50M bond allocation. Most classrooms throughout the campus have new furniture, dry erase whiteboards, internet connectivity and overhead projection. The typical classroom seats 25-30 students and there are larger lecture rooms (auditorium-like) that seat several hundred. The classrooms are state of the art in communication and condition.

7.1.3 Teaching Laboratory Space

BME has 4 teaching laboratories and one computer lab on the 3rd floor of Wishnick Hall. The space was renovated as part of the 15,000 sq ft noted above. Additional funding was provided to outfit the 4 BME teaching laboratories that are equipped with state of the art experimental equipment, together with data acquisition and processing capability. The laboratories are designed for groups of 2-3 students to work on experimental modules in a team based setting. Other than the Design Lab, which is configured for larger teams and for design, brainstorming as well as experimental and electronics fabrication, the labs have 10 stations each. An additional student computer lab (8 stations) is available to students throughout the working day for offline data analysis. Each BME laboratory is described in more detail below.

7.1.3.1 Measurements and Instrumentation Laboratory

The Instrumentation and Measurement Laboratory class is designed to give undergraduate students in BME the ability of acquiring quantitative biological measurements and analyzing and presenting the results in oral and written form. The objectives of this course are to: understand and utilize data collection and analysis; use appropriate instruments to acquire measurements; present results in both oral and written
The course consists of six experimental units:

1) Spectrophotometry: Determine the relationship between protein concentrations and optical density through use of a spectrophotometer.
2) Microscopy: Learn the basics of optics and microscopy as an imaging tool, and examine a biological sample using both a microscope and imaging software.
3) Biorheology: Determine the viscosity of various biological fluids.
4) Data acquisition: Learn the basic principles of data collection and use of basic data acquisition instruments.
5) Computed Tomography (CT): Learn the basics of CT. You will be able to collect artificial images using a simple CT setup and optimize the images using software tools.
6) DNA and protein gel electrophoresis: Utilize the basic gel electrophoresis technique to analyze unknown DNA and protein samples.

The laboratory space and accompanying equipment enable up to 10 workstations to complete experimental units 2, 3, 4, 5 and 6. Each of the 10 stations is equipped with 4 channel data acquisition units (PowerLab 4/25T), necessary amplifiers or signal conditions (termed “pods”) and a networked Dell desktop computer. There are also specific transducers such as cardio-microphones and pressure pulse detectors. For unit 4, each station has a function generator and a digital oscilloscope. There are 10 Brookfield cone and plate viscometers (stand-alone) for unit 3, and 10 microscopes with image capture hardware and software for unit 2. Ten computed tomography setups were designed and built by ECE and BME faculty and post-docs. 10 Gel electrophoresis trays, power supplies and related accessories are available for unit 6. Five spectrophotometers, shared by lab groups are available to complete unit 1.

Common equipment available in this laboratory includes a refrigerated centrifuge (Eppendorf 5810R), several water baths, top-loading and analytical balances, stir/hot plates, microwave (for melting agarose for gels) and a refrigerator.

7.1.3.2 Ross Biofluids Laboratory

The Biofluids Laboratory introduces all of the BME undergraduates (regardless of track) to basic principles of biological fluid properties (interfacial tension, rheology) and two major modes of transport, osmosis and diffusion. There are 5 modules and one experimental design module. The modules are:

1) Surface tension of fluids: the role of surfactants
2) Interfacial tension between liquids and solids: the role of contact angle in biomaterials
3) Blood rheology as a function of hematocrit and type of viscometer (tube vs cone and plate)
4) The role of osmosis in cellular homeostasis: the red blood cell and a perfect osmometer
5) Diffusion and convection in a capillary dialyzer: the effect of dialysis flow rate on the transport of small molecules from “blood” (saline) to “dialysate” (water) in the absence of convection.

6) Experiment Design: will be variable by year and based on the previous 5 modules. Spring 2008 students were asked to design an experiment to examine the effects of blood flow rate differences in the dialysis of a child versus adult.

Each of the 10 stations is equipped with 4 channel data acquisition units (PowerLab 4/25T), necessary amplifiers or signal conditions (termed "pods") and a networked Dell desktop computer. Additional computer controlled equipment per stations includes a pump controller with a Gilsen Minipuls roller pump and Brookfield cone and plate viscometers with Rheocalc software. Additional stand-alone station equipment insluces Masterflex roller pumps, Cannon Fenske tube viscometers of several sizes, conductivity probes and pressure gauges. For modules 1 and 2 there are four Micro-Cam™ contact angle devices (Tantec) and 4 Tensiomat™ tensiometers (Fisher Scientific). Students perform these labs on alternate weeks.

Common equipment includes a refrigerated centrifuge (Eppendorf 5810R), 4 micro-Critspin™ micro-hematocrit centrifuges, water purification system (Barnstead, E-Pure™), icemaker and refrigerator.

7.1.3.3 Physiology Laboratory

The Physiology Laboratory is a hands-on laboratory course aimed primarily at Senior-level BME undergraduates. Laboratories are divided into two basic types: those that make noninvasive measurements in humans (e.g., respiratory function, cardiac ECG, urine production) and invasive measurements in animals (e.g., smooth muscle receptor pharmacology, nerve conduction velocity). Virtually all measurement information is input and controlled by a computerized data acquisition system (AD Instruments) that permits real-time plotting and analysis using the software packages Chart and Scope. Cellular analysis has been provided by lab microscopes coupled with inexpensive CCD cameras for image capture. All labs have both the instructing professor and one graduate-level teaching assistant available to help during dissections and experimentation. Post-lab data analysis is performed off-line by the students. Both the Scope and Chart programs are available to students for their own personal computers because of site-license agreements with AD Instruments. Frequently, Excel and Matlab are also employed for other forms of signal or discrete data analysis.

7.1.3.4 Design Laboratory

The focus of the BME Senior Design class is to introduce strategies and fundamental biomedical design criteria for the development of biomedical devices in a team setting. The designs vary from medical devices such as a blood glucose meter targeting a specific client, e.g. children, a dual EKG/defibrillator electrode, to telemetric systems for data sharing in a hospital environment. The projects change each year. The students are
teamed up with medical staff and the staff serves as consultants/clients.

The laboratory is arranged with sections equipped for varied design needs and is available to students by card-key entrance. There is a “wet lab” section where biological or chemical aspects of projects can be designed or tested. This section includes Zeiss microscopes (upright, inverted and stereo), a spectrophotometer, a microplate reader (Versamax™, Molecular Devices), water-jacketed incubator, laminar flow hood, refrigerated centrifuge (Eppendorf 5810R), ultra-low temperature freezer and a cryogenic storage unit. There is an electronics/testing area with various electronics components for designs or testing, 6 computerized data acquisition stations similar to the other laboratories. There are also large spaces with tables and work-space for team meetings, consultations, etc. Additional common equipment including pumps (roller, syringe, vacuum), printers (color and black and white), function generators and oscilloscopes are also available to teams.

7.1.3.5 Computer Laboratory

A separate computer lab with networked 8 desktop computers and a common printer is available to BME students by card key entrance between 8 am and 7 pm. The computers are loaded with software such as Microsoft Office, Chart and Scope for offline analysis of data obtained during laboratory courses, MATLAB, FLOWLAB, etc.

7.1.4 Research Facilities

BME faculty welcome undergraduates into their research laboratories and on average, there are 15-20 undergraduates participating in research activities. The BME faculty research laboratories are located in the Engineering Research Building (ERB) and Technology Park (formerly the Chemistry Research Building.) The ERB building has been renovated and made available for faculty over the period 2002 - 2005. Each faculty member has an individual research laboratory with space ranging from 500 - 2500 sq. ft, depending on needs. The costs for renovating these research laboratories were in excess of $5M. In addition, all faculty at hire received startup funds ranging from $200K to $350K, with the amount depending on their areas of expertise and need for computational versus wet lab facilities. In general, laboratories are clustered with respect to their focus area, with Cell and Tissue wet labs being in the central section of the ERB, the wet labs for neural engineering being in the northern section of ERB and the medical imaging facilities being in the Medical Imaging Research Center (MIRC) located in Technology Park, a newly developed facility that is contiguous to the southern section of ERB. Technology Park is a $50M renovation of the Chemistry Research Building (CRB) developed primarily for incubator and graduate companies to develop. A 20,000 sq. ft. section is assigned to IIT for state of the art research centers, such as the MIRC.

7.2 Resources and Support

7.2.1 Computing Resources used for Instruction
7.2.1.1 Software available campus wide

A complete list of software available in campus computer labs can be found at http://ots.iit.edu/computer_classrooms/software/software_master_list.php. If a teaching computer lab room is required for a BME course, or if an instructor requires the use of a campus computer lab, the necessary software can be installed by OTS at the instructor’s request. For planning purposes, a notice soliciting instructor software and computer lab needs is distributed by OTS each semester for the subsequent semester. The BME department has also purchased licenses for the software listed below and it is installed in all BME labs. The courses which employ the software for instruction are listed in parentheses.

MATLAB with various tool boxes is used extensively (BME 200, 310, 315, 408, 422, 438, 452, 475, 482)
LABVIEW (BME 419, 420)
MS EXCEL (any course requiring data analysis, graphing)
MS Word (throughout curriculum)
MS Powerpoint (BME 315, 320, 419, 420)

7.2.1.2 Specialized Software Acquired by the BME Department

Several faculty employ specialized software for instructions. For example, FLOWLAB for flow visualization and computational fluid dynamics, Neurons in Action for neuroscience oriented simulations, Project Kickstart for design projects, Pspice for circuit simulation, SPM5 for imaging. These are installed in BME labs, campus labs (if requested by the instructor as explained above in section 7.2.1a) or, in some cases, provided to or downloaded by students for individual use.

ORCAD Pspice circuit simulation software (BME 443)
Neurons in Action (BME 445)
FLOWLAB (ANYSYS, Inc.) (BME 301)
Project KICKSTART (BME 419, 420)
ADInstruments Chart and Scope for computerized data acquisition (BME 315, 320, 405, 419, 420)
SPM5 (Statistical Parametric Mapping, ver. 5) is a free software available to the imaging community (BME 438).

7.2.2 Limitations

Currently, there are no significant limitations regarding computer and software resources. BME students are exposed to computing in a large number of courses and in the past academic year (2007-2008) a MATLAB application course was introduced as a required core course in order to adequately prepare students for the significant number of upper division courses that employ MATLAB. The extensive use of computerized simulation, analysis, data acquisition in the program is reflected by the designation of Program Outcome k (use of modern engineering tools) in seven BME
core courses, 3 of 4 C and T track courses and 4 of 4 NE/MI BME courses. The only limitations noted by instructors is the lack of a computer classroom in the department's home building and the small size of the BME computing laboratory. However, instructors can use computer classrooms in several other buildings when needed and they can have specialized software installed in campus computer labs when more workstations are necessary.

7.2.3 Plans for Maintaining and Upgrading Laboratories

The teaching laboratories are currently state of the art as they were developed and implemented in the years, 2004-2006. They are highly adequate for meeting the needs of the students in the three track areas. Under consideration is the development of an electronics lab for those primarily in Neural Engineering; however, this is in the early discussion stages. A lab fee of $100 per student per lab is part of the student's registration fee and that fee is returned to the department for helping maintain the current supplies and equipment in the labs. The equipment in the labs is maintained on an as needed basis. The maintenance and parts replacement information for equipment is noted in TABLE C.1 in Appendix C. Major equipment replacement or repair is currently not budgeted in the department, but must be requested from the Dean of Engineering. Major lab renovation would be handled by central administration through the facilities office. Major overhauls (which are currently not anticipated for the BME labs) have been handled in the past through a combination of philanthropy and central administrative budgeting. For example, all of the undergraduate teaching labs in engineering and sciences (except BME) were completely renovated in the past two years with $1M from donations that were matched by $1M from the central administration. The Ross Biofluid Dynamics Lab was recently named for Ed Ross through a $1M donation.

7.2.4 Support Personnel for Hardware, Software, and Networks

The BME Department employs a part-time student worker (most often a computer science major) to install and maintain software and security on all instructional lab computers. Software or security problems that cannot be solved by this individual are referred to the institutional Office of Technology Support (OTS). Most hardware problems are referred to the Office of Technology Support (OTS). The first 30 minutes of service is free with each subsequent hour costing $25. If OTS is unable to complete repairs, and external service provider is contacted. For example, OTS will not service printers. The BME department has a recommended service company to contact. OTS maintains the network (both wired and wireless). Requests beyond maintenance, e.g., new network ports, can be installed for a charge. More details about OTS can be found in Appendix D, Institutional Summary.

7.2.5 Support Personnel to Install, Maintain, and Manage Laboratory Equipment
The Department employs a full time undergraduate instructional laboratory coordinator (Promila Dhar, Ph.D.). She maintains the laboratory equipment and supplies with the assistance of 3-4 BME work-study students. When needed, she arranges for outside service or repair of equipment. She additionally supervises the part-time student employee that maintains the computer software and security (see Section 7.2.3). The current instructor and the assigned teaching assistant for a given laboratory course also contribute some effort to managing laboratory equipment used in that semester.

7.3 Major Instructional and Laboratory Equipment

Instructional equipment model information and quantity are provided in Table C.1 in Appendix C
CRITERION 8. SUPPORT

8.1 Program Budget Process and Sources of Financial Support

The final budget for the Armour College of Engineering is negotiated between the Dean of Engineering and the Provost. The BME Chair meets regularly every two weeks with the Dean and the other Chairs to discuss the state of the College and various initiatives which are ongoing. The Chair is asked to develop a strategy for the upcoming year consonant with the 5 year plan of the College. This strategy may include various items, such as faculty salaries and raises, additional faculty, new initiatives, resources for labs, etc. From this strategy, the Dean develops the BME budget for the following year. Modifications to this strategy, based on overall university needs and availability of funds, are discussed with the Chair and the yearly budget is determined. Budgets run from June 1st to May 31st.

The new BME program recently (2007) obtained a permanent home in Wishnick Hall where the faculty offices (12), departmental offices and teaching labs are located. The research labs for the BME faculty are located in the Engineering Research Building (ERB) and have been developed gradually as needed by the hiring of faculty. Monies to renovate and equip the BME department and the undergraduate teaching laboratories in Wishnick Hall were obtained from a combination of budgetary resources and fund raising conducted by the central administration. Monies to renovate the BME laboratories in ERB were obtained from a combination of sources, such as central administration and the state. The initial hiring of faculty and their startup funding was provided by two $1M Special Opportunity Awards from the Whitaker Foundation awarded to Dr. Turitto.

8.2 Sources of Support

The main source of support for BME comes from its annual budget. Being a new program, the department has no endowed Chairs and no gift accounts that would help sustain its activities. Under the present arrangement, the Chair of BME, Dr. Turitto, is also the Director of the Pritzker Institute for Biomedical Science and Engineering. The Pritzker Institute is a separate entity with an endowment that generates over $500K per year. The endowment benefits the Department indirectly, in that expenses, such as startup funds, support of students, etc., can be provided on a timely basis, in cases where the funds are not readily available through the university or the dean’s office. The endowment also pays for more than 50% of Dr. Turitto’s salary, and Dr. Gatchell’s and Opara’s salaries, who have been hired in part to help with the teaching load. The endowment has also benefitted the faculty in the department by providing over $500K in interdisciplinary seed grants which help support new research initiatives. Another source of funds is obtained from faculty buyout (payment of part of the faculty academic year salary) from research grants. In a new department with a very
young faculty (only one full professor), the source has been limited and quite variable. While all faculty are funded from outside sources, the grants are not large and salary monies typically are used for providing summer salary support. The amounts of buyout have varied from $0 to as much as $60K in a given year. Such funds are used for emergency needs or are offered to faculty to purchase teaching or research equipment. They are also used to help support travel of faculty and students to meetings.

8.3 Adequacy of Budget

The budget is currently adequate for providing faculty salaries and benefits, a departmental secretary, an undergraduate lab coordinator, teaching assistants, telephone and computer line costs and a very limited amount of miscellaneous activities, such as, departmental supplies and travel to meetings. However, the Department Chair is not fully salaried and the position of Chair and Director of the Pritzker Institute may be separated in the future. The department is small with a significant faculty teaching load which has been primarily been shifted to undergraduate teaching, rather than graduate teaching, which is not desirable in the long run. There is a particular shortage in the cell and tissue area with only two tenure track faculty and a senior instructor. The needs in this area have been supplemented by the hiring of faculty on a non-tenure track basis, such as Dr Papavasiliou (recently hired to tenure track position), and Drs. Gatchell and Opara both of whom have been salaried by the Pritzker Institute.

8.4 Support of Faculty Professional Development

Development of faculty teaching and research capabilities have been encouraged by both the Chair and the Dean. The Dean has offered to pay part of the costs of travel of junior faculty to educational meetings and the Chair has supplemented the funds available to do so. The initiative to travel to such meetings has been left to the individual faculty members and the participation has been limited, in part, due to the lack of funds available. In addition, the Dean has sponsored day-long educational meetings on campus for the faculty to improve their teaching skills. The Chair has a designated ABET coordinator (Dr. Hall) who has been supported for travel to training sessions for ABET. Faculty and students have been strongly encouraged to participate in research meetings in their respective disciplines and the Chair has supported in part costs to attend such meetings.

8.5 Support of Facilities and Equipment

The departmental budget is adequate for supporting the normal activities of the department. A laboratory fee of $100 per credit hour per student currently maintains and upgrades the undergraduate teaching labs (ca. $12K per year). Replacing major equipment would necessitate a request to the dean's office for the needed funds; however, most of the equipment in the undergraduate labs is
not high cost and maintenance with the lab fee has been satisfactory. New labs or initiatives would have to be developed from requests through the Dean’s office or through a grant proposal. With respect to research equipment, there is no yearly budget available for purchasing state of the art research equipment and such equipment must come from special requests, grant applications or funds available from the Pritzker Institute. Occasionally, funds are received from outside philanthropy. A $1M gift from Ed Ross to BME allowed the naming of the BME Fluid Lab, support of UG research activities over several summer periods and the purchase of some research equipment.

8.6 Adequacy of Support Personnel and Institutional Services

A lab manager budgeted in the department is available for helping faculty conduct the 4 BME undergraduate teaching laboratories. The department currently has budgeted funds for a departmental administrative assistant (D’Amico) who balances the departmental activities, the grants administration, and the activities of the Pritzker Institute. There are monies for a half time position to help the departmental assistant and a person is currently being sought. Institutional services, such as Admissions, help with undergraduate enrollment. Graduate enrollment in BME is quite limited, having only a doctoral degree program. Much of the recruiting is performed by the department itself. There are limited interactions with institutional advancement (fund-raising), marketing, the office of institutional information, etc.
CRITERION 9. PROGRAM CRITERIA
Included in Criterion 3. Program Outcomes
APPENDIX A: COURSE SYLLABI

A. BME Courses

B. Armour College Engineering Courses

C. Math & Science Courses
A. BME COURSES

BME 100 - Introduction to the Profession
BME 200 - Biomedical Engineering Applications in MATLAB
BME 301 - Bio Fluids Mechanics
BME 309 - Imaging & Sensing
BME 310 - Biomaterials
BME 315 - Instrumentation Lab
BME 320 - Bio Fluids Lab
BME 330 - Analysis of Biosignals
BME 335 - Thermodynamics of Living Systems
BME 405 - Physiology Lab
BME 408 - Reaction Kinetics for BME
BME 419 - Introduction to Design
BME 420 – Design
BME 422 - Numerical Solutions to BME Problems
BME 425 - Tissue Engineering
BME 430 - Concepts of Medical Imaging
BME 433 - BME Stats
BME 438 - Neuroimaging
BME 443 - Biomedical Instrumentation & Electronics
BME 445 - Quantitative Neural Function
BME 452 – Control Systems for Biomedical Engineers
BME 475 - Neuromechanics of Human Movement
BME 482 - Mass Transport for BME
BME 490 - Senior Seminar
BME 100–Introduction to the Profession - Required

2006 Course Instructor: Connie Hall, PhD and Paul Fagette, PhD

Catalog Data: BME 100 Introduction to the Profession—Biomedical Engineering Credit hours: 3

Course Description: Introduction to the Profession Introduces the student to the scope of the biomedical engineering profession and its role in society, and develops a sense of professionalism in the student. Provides an overview of biomedical engineering through lectures, presentations by outside speakers, hands-on exercises and scientific literature analyses. Develops professional communication and teamwork skills. (3-0-3) (C)

Topics Covered:
1. How to read a scientific paper and how to use critical thinking skills to analyze and synthesize scientific (engineering, medical and basic sciences) knowledge.
2. Hemodialysis as an example of engineering design
3. The mechanical and electrical function of the heart and heart valve replacement
4. Neural engineering of brain and vision
5. Introduction to imaging modalities including x-ray, ultrasound, MRI, SPECT and PET

Prerequisites: BME major

Textbook: No text required. Instructor Handouts

Course Schedule: This course meets twice per week for 75 minutes

Student Learning Objectives:

This course is designed as the students’ first look into the broad arena of biomedical engineering. At the end of the semester:

1. The student will possess a greater appreciation for the breadth of studies and career options in biomedical engineering and an understanding of the applications of biomedical engineering in the three Department tracks (Program Outcome h).
2. Students will have an understanding of professional ethics through discussion of the Code of Ethics of the Biomedical Engineering Society and presentations by professional engineers and physicians (Program Outcome f).
3. Students will experience an introduction to biomedical engineering labs through four hands-on experiences (Program Outcomes b, m).
4. Students will gain experience in reading technical literature, critical thinking, technical writing and in oral communication of technical subject matter (Program...
Outcome g).
5. Students will apply the basic physiology of three major organ systems (cardiovascular, renal, neural and vision) to the interpretation and analysis of peer-reviewed articles in biomedical engineering (Program Outcome g and l).

Prepared by: Connie L. Hall, Ph.D. Date: 07/20/2007

Criterion 5:

Required course for all BME students, prerequisite for BME 200, fulfills 3 credits of engineering, and fulfills IIT introduction to the profession requirement
BME 200 – Biomedical Applications of MATLAB - Required

Course Instructors: David Gatchell, Ph.D.

07-08 Catalog Data: BME 200 – Biomedical Engineering Applications of MATLAB
Credit hours: 1

Catalog Description: BME 200, Biomedical Engineering Applications of MATLAB, will provide students an opportunity to learn how to use the MATLAB programming environment to solve biomedical engineering problems. Students will learn basic MATLAB functions for analyzing and plotting data, as well as computational techniques for modeling and solving relevant biomedical engineering problems. Examples will be taken from the three areas of specialization offered in the biomedical engineering department: cellular & tissue engineering, neural engineering, and medical imaging.

Topics Covered: There is no formal lecture associated with this class. However, the students will apply basic biology, physiology, mathematics and engineering in order to mathematically and computationally model relevant biomedical engineering systems.

Prerequisites: BME 100 – ITP; ECE 211 – Circuit Analysis I;

Co-requisites: CS 105, CS 115, or CS 201

Textbook: None Assigned (handouts distributed)

Course Schedule: The course meets once a week for two hours and forty minutes. The first section will meet on Tuesdays from 1:50PM – 4:30PM, and the second group will meet on Thursdays from 1:50PM – 4:30PM. The course is offered in the Spring semester.

Student Learning Objectives (SLOs):
1. To develop knowledge of mathematics, science and engineering and apply this knowledge in solving complex biomedical engineering problems (satisfies ABET Program Outcomes: a, e, k)

2. To develop the ability to perform research, define constraints, and seek out answers to open-ended, ill-defined problems (satisfies ABET Program Outcomes: e, i)

3. To understand conditional logic (e.g., FOR loops, IF-THEN statements), and use this logic to model real biomedical engineering problems and scenarios (satisfies ABET Program Outcomes: k)
4. To improve graphical communication skills through the use of MATLAB functions, for example, to improve one’s ability to create and interpret graphical representations of data (satisfies ABET Program Outcomes: g, k)

5. To improve understanding of contemporary biomedical engineering problems comprising the three tracks offered at IIT: cell & tissue engineering; neural engineering; medical engineering (satisfies ABET Program Outcomes: j)

Prepared by: David W. Gatchell       Date: 1/15/2008

Criterion 5:

Required for all BME majors and prerequisite for BME 315 and BME 330, fulfills 1 engineering credit
BME 301 BIO-FLUID MECHANICS – Required for Cell & Tissue Track

Course Instructor: Connie Hall, Ph.D.

2006 Catalog Data: BME 301 Biofluid Mechanics
Credit hours: 3

Catalog Description: Basic properties of fluids in motion. Lagrangian and Eulerian viewpoints, material derivative, streamlines. Continuity, energy, angular and linear momentum equations in integral and differential forms. Applications in biofluids and biomedical devices; Rheology of biological fluids.

Topics Covered:
2. Fluid statics and kinematics
3. Tensors and review of vector calculus
4. Constitutive relations for Newtonian and non-Newtonian fluids
5. Properties of biological fluids
6. Conservation Laws and control volume approach
7. Differential form of Conservation of Mass and Momentum (Navier-Stokes Equations)
8. Dimensional analysis and scaling
9. Friction Factors
10. Integral form of conservation of mass and momentum

Prerequisites: BIOL 115, MMAE 200, MATH 251

Textbook: Transport Phenomena in Biological Systems by Truskey, Yuan and Katz

Course Schedule: This course meets twice per week for 75 minutes.

COURSE DESCRIPTION

Student Learning Objectives:

1. Students will have experience in reading, analyzing and writing about peer-reviewed journal articles in biomedical fluid mechanics (Program Outcomes g, j).
2. Solve 2-dimensional and axisymmetric problems by developing a mass and momentum balance over a control volume (Program Outcomes a, e)
3. Understand Newtonian and non-Newtonian constitutive relations, particularly for blood (Program Outcomes a, e, l)
4. Apply the Buckingham Pi theorem to develop dimensionless groups (Program Outcomes a, e)
5. Apply the Navier-Stokes equations to 2-dimensional and axisymmetric problems by simplification of terms (Program Outcomes a, e).

6. Understand the significance of the terms in the Navier Stokes equations through non-dimensionalization (Program Outcomes a, e).

Prepared by: Connie L. Hall, Ph.D. Date: 7/20/2007

Criterion 5:

Required course for Cell and Tissue Track, fulfills 3 credits of engineering, prerequisite for BME 408 and BME 482
BME 309 - Biomedical Imaging and Sensing

Required for Medical Imaging Track

Course Instructor: Konstantinos Arfanakis, Ph.D.

Catalog Data: BME 309 – Biomedical Imaging and Sensing.
Credit hours: 3

Catalog Description: An introduction to concepts of imaging and sensing that underlie a wide range of biomedical imaging modalities. Topics covered include transcutaneous near-infrared light power/information transmission for implantable medical devices, cell and nanosurgical operation with light, manipulation of living bodies with light, physiological function analysis of the human body, electrochemical biosensors, measurements of neural activity, microneurography, control of artificial organs and limbs, X-ray imaging, nuclear medicine, and ultrasound imaging.

Topics Covered: Biological imaging and sensing, bioanalyses using electrochemical and electrophysiological methods, X-ray imaging, nuclear medicine, ultrasound imaging.

Prerequisites: PHYS 221 General Physics II: Electromagnetics and Optics

Corequisites: BME 330 Analysis of Biosignals and Systems

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Course Schedule: The course meets twice a week for sessions that last one hour and fifteen minutes each. The course is offered in the Fall semester.

Student Learning Objectives (SLOs):

1) To provide students with an introduction to the physics and mathematics that support various biomedical imaging and sensing techniques. (Satisfies Program Outcomes a, e, g, j, k, l).
2) To evaluate the advantages and limitations of various imaging and sensing modalities. (Satisfies Program Outcomes a, e, j, l).
3) To familiarize students with the clinical applications of the imaging and sensing modalities presented. (Satisfies Program Outcomes a, c, g, j, k, l).
4) To learn the latest developments in medical imaging industry and research by attending the largest medical imaging and radiology conference in the world (Radiological Society of North America, RSNA) (Satisfies Program Outcomes i, j).

5) Analyze technical articles from the medical imaging literature. (Satisfies Program Outcomes g, i, j).

Prepared by: Konstantinos Arfanakis, Ph.D. Date: 6/15/2006

Criterion 5:

Required course for Medical Imaging Track and fulfills 3 credits of engineering
BME 310: Biomaterials - Required

Course Instructor: Eric M. Brey, Ph.D.

2006 Catalog Data: BME 310 – Biomaterials
Credit hours: 3

Catalog Description: Applications of biomaterials in different tissue and organ systems. Relationship between physical and chemical structure of materials and biological system response. Choosing, fabricating and modifying materials for specific biomedical applications. (3-0-3)

Topics Covered:

1. Syllabus, introduction to biomaterials and types of chemical bonds
2. General Classes and Structure of Biomaterials
3. Physical properties of Biomaterials
4. Mechanical properties of Biomaterials
5. Biomaterial Degradation
6. Biomaterial Processing
7. Surface Properties of Biomaterials
8. Protein Interactions with Biomaterials
9. Cell Interactions with Biomaterials
10. Biomaterial Implantation and Acute Inflammation
11. Wound Healing and the Presence of Biomaterials
12. Immune Response to Biomaterials

Prerequisites: BME 100

Textbook Biomaterials: The Intersection of Biology and Materials Science
Temenoff and Mikos

Course Schedule: The course meets twice a week for sessions that last one hour and fifteen minutes each. The course is offered in the Spring semester.

Student Learning Objectives (SLOs):

1. Describe the types of materials used in medicine and their properties important to biological application. (Program Outcomes: a, e, k, m)

2. Describe mechanical and physical parameters used in the characterization of biomaterials. (Program Outcomes: a, e, k)

3. Apply quantitative techniques to determine physical properties of materials from experimental data. (Program Outcomes: a, b, e, k, l)
4. Describe specific materials currently used clinically and strategies for improving their properties. (Program Outcomes: a, e, k, l, m)

5. Explain fundamental biological principles underlying the response of cells and tissues to biomaterials. (Program Outcomes: a, l, m)

6. Describe material interactions with host tissues. (Program Outcomes: a, e, m)

7. Apply knowledge about biomaterials to the assessment of research published in literature. (Program Outcomes: a, e, g, k, m).

Prepared by: Eric M. Brey, Ph.D. Date: 1/22/2008

Criterion 5:

Required course for all BME majors and fulfills 3 credits of engineering
BME 315: Instrumentation and Measurement Laboratory - Required

Course Instructor: Derek Kamper, Ph.D.

2005 Catalog Data: BME 315-Instrumentation and Measurement Laboratory
Credit hours: 2

Catalog Description: BME 315 is a junior-level course which the main focus is on data collection, analysis method and presentations as well as instrumentation and equipment used in BME.

Topics Covered: 1. Measurements in Physiology
2. Microscopy and Image processing
3. Spectrophotometry
4. Computed Tomography
5. Viscoity
6. Gel electrophoresis

Prerequisites: ECE 211 and BME 200

Textbook: There is no required text, but a laboratory manual is provided. Additional handouts and reading materials are provided.

Course Schedule: The course meets twice a week: a 50 minute lecture class and 150 minute laboratory time. The course is offered in the Fall semester.

Student Learning Objectives (SLOs):

1. To provide an understanding of the basic concepts of data collection and analysis. (Program Outcomes a, b)

2. To perform and analyze electrical/image oriented experimental modules. (Program Outcomes a, b, k)

3. To perform and analyze chemical oriented experimental modules. (Program Outcomes a, b, k)

4. To develop critical thinking and professional oral and written communication skills. (Program Outcome g)
Laboratory or Other Technical Skills Acquired:

Computerized data acquisition. Use of technical instrumentation including oscilloscope, function generator, sensors, microscope, CT setup, micropipets, spectrophotometer, viscometer, centrifuge, gel electrophoresis as well as MATLAB software.

Prepared by: Derek Kamper, Ph.D. Date: 7/19/2007

Criterion 5:

Required course for all BME majors, fulfills 3 credits of engineering, and prerequisite for BME 320, BME 405, BME 419, BME 430, BME 433, BME 438, BME 443, and BME 445
BME 320- Fluids Laboratory - Required

Course Instructor: Connie L. Hall, Ph.D.

2005 Catalog Data: BME 320 Fluids Laboratory.
Credit hours: 1

Catalog Description: Laboratory experiments in thermodynamics, biological fluid flow and mass transfer. Emphasis is placed on current methods, instrumentation, and equipment used in biomedical engineering; oral presentation of results; and on the writing of comprehensive reports.

Topics Covered: 1. Surface tension and contact angle
2. Blood rheology
3. Osmosis
4. Pressure/flow/resistance
5. Diffusion
6. Dialysis

Prerequisites: BME 315, BIOL 115

Textbook: There is no required text, however a laboratory manual is provided in addition to handouts and reading relevant to each experimental module.

Course Schedule: The course meets weekly for either laboratory sections of 150 minutes. The course is offered in the Spring semester.

Student Learning Objectives (SLOs):
1. The student will develop the ability to apply knowledge of the fundamentals of fluid mechanics and biology to experiments using biological fluids (Program outcomes a, e).
2. Students will develop the ability to perform and analyze measurements of fluid properties (viscosity, density, surface tension) using manual and automated data acquisition systems (Program outcomes a, b, k).
3. Students will develop the ability to perform and analyze basic measurements in fluid mechanics (pressure, flow) using manual and automated data acquisition systems (Program outcome a, b).
4. Students will gain experience in technical writing and in oral communication of technical subject matter (Program outcome g).

Prepared by: Connie L. Hall, Ph.D. Date: 3/20/2006

Criterion 5:
Required course for all BME majors, fulfills 1 engineering credit, prerequisite for BME 419, and co-requisite for BME 301 and BME 335
BME 330 - Analysis of Biosignals and Systems - Required

Course Instructor: Mark A. Anastasio, Ph.D.

2005 Catalog Data: BME 330 – Analysis of Biosignals and Systems. Credit hours: 3

Catalog Description: BME 330 is a junior-level introduction to the theoretical and practical aspects of signal processing and dynamical systems behavior as they relate to physiological, biological, and biomedical systems. The topics covered will include sampling theory, continuous and discrete Fourier transforms and series, Laplace transforms, Linear systems theory, signal filtering, models of biological and physiological systems.

Topics Covered: Continuous and discrete Fourier transforms and series, sampling theory, Laplace and z-transforms, and linear systems theory

Prerequisites: BME 100 – Introduction to the Profession
Math 252 – Differential Equations
ECE 211 – Circuit Analysis I


Course Schedule: The course meets twice a week for sessions that last one hour and fifteen minutes each. The course is offered in the Fall semester.

Student Learning Objectives (SLOs):

1. Describe and categorize different types of biosignals. (Satisfies Program Outcomes a, b, e)
2. Describe and categorize different types of systems that are relevant to problems in biomedical engineering. (Satisfies Program Outcomes a, e)
3. Explain how continuous-time signals can be processed by use of discrete-time systems by use of sampling theory. (Satisfies Program Outcomes a, c, e, k)
4. Determine the output of a linear time-invariant system given the input signal and impulse response of the system. (Satisfies Program Outcomes a, c, e, k)
5. Use MATLAB for implementation of biomedical systems and biosignal processing. (Satisfies Program Outcomes a, c, e, k)

Prepared by: Mark A. Anastasio, Ph.D. Date: 8/23/2007
Criterion 5:

Required course for all BME students, fulfills 3 engineering credits, prerequisite for BME 419, BME 422, BME 475, and co-requisite for BME 309 and BME 315
BME 335 – Thermodynamics of Living Systems – Required for Cell & Tissue Track

Course Instructor: Georgia Papavasiliou, Ph.D.

Catalog Data: BME 335 – Thermodynamics of Living Systems
Credit hours: 3

Catalog Description: BME 335 is a junior-level course which focuses on the principles of thermodynamics. The topics covered include conservation of mass applied to living systems and biomedical devices, macroscopic material balances, the first and second laws of thermodynamics, phase and chemical equilibrium, metabolic stoichiometry and energetics.

Topics Covered:
1. Introduction and Basic Thermodynamic Concepts
2. Gas Laws and Equations of State
3. Energy, Energy Transfer and General Energy Analysis
4. Total and Partial Differentiation
5. First Law of Thermodynamics
6. Second Law of Thermodynamics
7. Thermodynamic Property Relations
8. Gibbs and Helmholtz Energies and Physical Equilibria
9. Chemical Equilibrium

Prerequisites: CHE 202: Material and Energy Balances
MATH 251: Multivariable and Vector Calculus

Co-Requisites: BME 320: Fluid Laboratory

Textbook:

Course Schedule: The course meets twice a week for sessions that last one hour and fifteen minutes each. The course is offered in the Spring semester.

Student Learning Objectives (SLOs):
1. Understand basic thermodynamic concepts such as reversible versus irreversible paths, state functions (or exact differentials, e.g. internal energy, enthalpy) versus path functions (or inexact differentials, e.g. heat and work), and cycles. (Program Outcome e)
2. Determine thermodynamic properties of pure substances from thermodynamic data tables (Program Outcome e)

3. Apply the first law of thermodynamics to both open and closed systems and/or cycles in order to solve energy balance problems involving heat and work interactions for pure substances, ideal gases and incompressible substances. (Program Outcomes a, e, l)

4. Apply the second law of thermodynamics to open and closed systems, and calculate entropy changes that take place during processes for pure substances, ideal gases and incompressible substances (Program Outcomes a, e, l)

5. Develop fundamental relations between commonly encountered thermodynamic variables (e.g. internal energy, enthalpy and entropy) and express properties that cannot be measured directly in terms of easily measurable properties (e.g. temperature, pressure and volume) by use of partial derivatives and Maxwell relations. (Program Outcome a, e)

6. Apply the concept of Gibbs free energy and/or chemical potential to analyze chemical reactions at equilibrium and predict the spontaneity. Understand the importance of coupled biochemical reactions in metabolic pathways (Glycolysis coupled with the ATP/ADP reaction) (Program Outcomes a, e, l)

7. Apply the concept of Gibbs free energy and/or chemical potential to analyze the thermodynamics of phase equilibria. Examples include active and passive transport of molecules and ions across cell membranes (Program Outcomes a, e, l)

8. Apply the above-mentioned knowledge in an analysis of technical articles from biomedical engineering literature. (Program Outcomes a, e, j)

Prepared by: Georgia Papavasiliou, Ph.D. Date: 1/21/2008

Criterion 5:

Required course for Cell & Tissue Track, fulfills 3 credits of engineering, prerequisite for BME 408
BME 405 – Physiology Laboratory -Required

Course Instructor:  David J. Mogul, Ph.D.

Catalog Data: BME 405 Physiology Laboratory.
Credit hours: 1

Catalog Description: A laboratory course which demonstrates basic concepts of bioengineering design through experimental procedures involving humans and experimental animals. Statistical principles of experimental design. Study of possible errors. Experiments include nerve action, electrocardiography, mechanics of muscle, membranes, and noninvasive diagnostics in humans.

Topics Covered:
1. Cardiac electrophysiology and circulation
2. Respiratory physiology
3. Muscle physiology & stimulation
4. Receptor pharmacology
5. Nerve conduction and electrophysiology
6. Renal physiology

Prerequisites: BME 315

Textbook: There is no textbook for this class. A laboratory manual is supplied to the students containing relevant background information.

Course Schedule: The course meets weekly for a laboratory for 160 minutes in the Fall semester.

Student Learning Objectives (SLOs):
1. The students will gain a practical understanding of the essential fundamentals of animal and human physiological systems (Program outcomes I).
2. Students will learn how to make experimental measurements of physiological phenomena (Program outcomes b and m).
3. Students will learn how to acquire physiological data in a number of different animal systems (Program outcomes b and m).
4. Students will gain insight into mechanisms underlying physiological disease states (Program outcomes j, l).

Laboratory or Other Technical Skills Acquired:
1. Animal dissection
2. Physiological equipment used to make measurements common in a medical setting.
3. Statistical analysis of data.
Criterion 5:

Required course for all BME majors and fulfills 2 credits of engineering
BME 408 - Reaction Kinetics for Biomedical Engineers – Required for Cell & Tissue Track

Course Instructor: Georgia Papavasiliou, Ph.D.

Catalog Data: BME 408 – Reaction Kinetics for Biomedical Engineers
Credit hours: 3

Catalog Description: This course is an introduction to the fundamentals of chemical kinetics. Analysis of rate data; single and multiple reaction schemes. Biomedical Topics include: biological systems, enzymatic pathways, enzyme and receptor–ligand kinetics, pharmacokinetics, heterogeneous reactions, microbial cell growth and product formation, and the design and analysis of biological reactors.

Topics Covered:
1. The General Mole Balance Equation and Ideal Reactors
2. Collection and Analysis of Rate Data
3. Basic Kinetic concepts
4. Multiple reaction schemes
5. Enzymes and Enzyme Kinetics
6. Receptor-Ligand Kinetics
7. Microbial Cell Growth
8. Bioreactors
9. Heterogeneous Reactions

Prerequisites:
BME 335, BME 301, MATH 252. Co requisite: BME 482

Textbook: As this course is a union of several areas, no specific textbook is required. The course will rely exclusively on classroom lectures. Lecture notes will be posted at the end of each week on Blackboard. Classroom attendance although not required is strongly recommended.

Course Schedule: The course meets twice a week for sessions that last one hour and fifteen minutes each. The course is offered in the Fall semester.

Student Learning Objectives (SLOs):
1. To provide students with a clear understanding of the definition of the reaction rate law. (Program Outcomes b, e,)
2. Develop dynamic and steady state equations to model reactive processes by applying material balances to open and closed systems (reactors). (Program Outcomes a, e, l)
3. Determine rate law parameters using differential, integral and half-life methods by analyzing experimental data. (Program Outcomes a, b, e, k)
4. Develop equations necessary to model multiple reaction schemes and understand the differences between series and parallel reaction pathways as applied to physiological reactions. (Program Outcomes a, e, k, l)

5. Provide students with an understanding of concepts such as rate limiting step, quasi steady state approximation and employ these to obtain rate expressions for enzymatic reaction pathways. (Program Outcomes a, b, e, l)

6. Use of kinetic analysis to understand bimolecular rate processes such as enzyme kinetics and receptor ligand interactions. (Program Outcomes a, b, e)

7. Formulate rate laws used to describe microbial cell growth and its stoichiometry. (Program Outcomes a, e, l)

8. Design and analyze various bioreactor operation modes and understand their importance in producing a variety of products. (Program Outcomes a, e, j, l)

9. Understand the difference between mass transfer-limited and reaction rate-limited reactions. (Program Outcomes a, e)

10. Use MATLAB in order to simulate and understand steady state and dynamic behavior for various reaction systems. (Program Outcomes a, b, e, j, k)

11. Apply the above-mentioned knowledge in an analysis of technical articles from biomedical engineering literature. (Program Outcomes a, e, j, l)

Prepared by: Georgia Papavasiliou, Ph.D. Date: 6/4/2008

Criterion 5:

Required for Cell & Tissue Track and fulfills 3 credits of engineering
BME 419 – Introduction to Design Concepts in BME - Required

Course Instructor: Jennifer J. Kang Derwent, PhD

Catalog Data: BME 419 – Introduction to Design Concepts in BME
Credit hours: 2

Catalog Description: This course aims to educate students on project definition, and on the design, development, and technology transfer of potential biomedical products in the context of the student's major capstone project. Students will learn best practices for designing a marketable medical device, including the design process from the clinical problem definition through prototype and clinical testing to market readiness.

Topics Covered:
1. User-centered design
2. Product development process
3. Specifications
4. Intellectual property
5. Prototyping and testing
6. Biomaterials
7. Safety, reliability, liability
8. Regulatory
9. Ethics
10. Design for manufacturing and assembly
11. Project planning
12. Proposal writing

Prerequisites: BME majors with senior standing, BME 315, BME 330, BME 320

Textbook: Product Design and Development, Karl T. Ulrich and Steven D. Eppinger

Course Schedule: This course meets once a week for a session that lasts one hour and forty minutes. The course is offered in the Fall semester.

Student Learning Objectives (SLOs):
1. To identify design problems related to the construction of biomedical engineering devices. (Satisfies Program Outcomes a, e, h, j, l)
2. To understand the processes involved in project planning, design, and development in a team setting. (Satisfies Program Outcomes a, c, d, e, j, l)
3. To identify user needs and product constraints, and to use these to formulate design specifications. (Satisfies Program Outcomes c, e, j, m)
4. To develop an initial prototype that will be the basis for refining their product in the following semester. (Satisfies Program Outcomes a, b, k)
5. To communicate through a written project proposal and oral presentation the project goals, detail the project plans, and development of prototype. (Satisfies Program Outcome g)

Prepared by: Jennifer J. Kang Derwent, Ph.D. Date: 7/19/2007

Criterion 5:

Required course for all BME majors, fulfills 2 credits of engineering, first semester of capstone design sequence, and prerequisite for BME 420
BME 420 - Design Concepts in Biomedical Engineering - Required

Course Instructors: Jennifer J. Kang Derwent, Ph.D.  
David Gatchell, Ph.D.

2005 Catalog Data: BME 420 - Design Concepts in Biomedical Engineering.  
Credit hours: 3

Catalog Description: BME 420 is a senior-level design laboratory class. The focus is to introduce strategies and fundamental biomedical design criteria for the development of biomedical engineering systems and devices. Students will be required to complete a team-oriented design project.

Topics Covered: There is no formal lecture associated with this class. However, the students will apply basic biology, physiology, mathematics and engineering in order to design and build prototype biomedical devices.

Prerequisites: BME 419 - Introduction to Design Concepts in Biomedical Engineering

Textbook: Product Design and Development, Karl T. Ulrich and Steven D. Eppinger

Course Schedule: The course meets twice a week that last one hour and fifteen minutes each. The course is offered in the Spring semester.

Student Learning Objectives (SLOs):
1. To be able to identify design problems related to the construction of biomedical engineering devices. (Satisfies Program Outcomes e, h, j, l)
2. To understand the processes involved in project planning, design and development in a team setting. (Satisfies Program Outcomes c, d, e, j, l)
3. To identify user needs and product constraints and to use these to formulate design specifications. (Satisfies Program Outcomes c, e, j, m)
4. To build a prototype biomedical device (Satisfies Program Outcomes b, k)
5. To develop professional communication skills (Satisfies Program Outcome g)
6. To understand the ethical issues involved in testing the prototype devices (Satisfies Program Outcome f)
Criterion 5:

Required course for all BME students, fulfills 3 engineering credits, second semester of capstone design sequence, and co-requisite for BME 490
BME 422/522 – Mathematical Methods in Biomedical Engineering - Elective

Course Instructor: Derek Kamper, Ph.D.

Catalog Data: BME 422 – Mathematical Methods in Biomedical Engineering. Credit hours: 3

Catalog Description: The purpose of this course is to introduce a number of mathematical concepts that are important in solving problems related to biomedical engineering. The mathematical topics will include matrix manipulation, eigenvalues, linear and nonlinear differential equations, numerical solutions of differential equations, Laplace transforms, and numerical integration and differentiation. Applications will be drawn from image processing, diffusion, fluid flow, and neural conduction. MATLAB techniques will be introduced in conjunction with analytical techniques.

Topics Covered: Linear algebra
Ordinary differential equations
Partial differential equations
Numerical methods
Biomedical applications

Prerequisite: BME 330


Course Schedule: This course meets twice a week for sessions that last one hour and 15 minutes each. This course is offered in the spring semester.

Student Learning Objectives (SLOs):
1. Apply matrix operations, such as transpose, inverse, and determinant, to compute coordinate transforms and statistical quantities (Satisfies Program Outcomes: a, e).
4. Use MATLAB (Mathworks, Inc.) to perform the mathematical procedures defined in the course (Satisfies Program Outcomes: k).
5. Employ numerical methods in developing simulations of biological processes (Satisfies Program Outcomes: a, e, l).
Criterion 5:

Elective course for BME majors and fulfills 3 credits of engineering
BME 425 – Concepts of Tissue Engineering - Elective

Course Instructor: Eric M. Brey, Ph.D.

Catalog Data: BME 425 – Concepts of Tissue Engineering
Credit hours: 3

Catalog Description: An introduction to the strategies and fundamental bioengineering design criteria behind the development of cell-based tissue substitutes. Topics include biocompatibility, biological grafts, gene therapy-transfer, and bioreactors.

Topics Covered:
1. Introduction to the Field of Tissue Engineering (Chapter 1 and 17.1-17.3)
2. Tissue Organization and Morphogenesis (Chapters 2 and 3)
3. Cell therapy (Chapters 5 and 6)
4. Inductive factors (Chapters 7 and 11)
5. Biomaterials (Chapters 15 and 16)
6. Bioreactors/Scale up (Chapter 13)
7. Clinical Limitations (18)
8. Market limitations (Chapter 19)
9. Ethical Considerations
10. Case Studies

Prerequisites:


Course Schedule: The course meets twice a week for sessions that last one hour and fifteen minutes each. The course is offered in the Spring semester.

Student Learning Objectives (SLOs):

1. Discuss the breadth of tissue engineering applications and the clinical need driving the development of alternatives to conventional organ transplantation and tissue reconstruction (j, h).
2. Apply quantitative techniques for use in the study of cell function and evaluation of potential tissue engineering strategies (a, e, l).
3. Discuss possible sources of cells for tissue engineering therapies and limitations of each (j, l).
4. Identify scientific issues related to the use of stem cells for therapies (l).
5. Discuss properties important for characterizing biomaterials (k).
6. Explain the advantages and disadvantages of natural vs. synthetic biomaterials for tissue engineering (l).
7. Identify approaches and technologies for tailoring biomaterial properties for specific applications (e).
8. Discuss the advantages and disadvantages of proteins versus genes as inductive factors in tissue engineering (I).
9. Evaluate methods for delivery genes and proteins to target tissues (I).
10. Understand molecular approaches for improving protein/gene therapies (e, I).
11. Quantitatively characterize nutrient and oxygen exchange in bioreactor systems (a, e, I).
12. Identify translational issues for the successful clinical application of tissue engineered products (e, j, h).
13. Apply tissue engineering principals to design an intervention based on a specific clinical need (a, c, d, e, I).
14. Effectively convey research ideas in formal presentation and written report/disclosure (d, g).
15. Understand the ethical considerations of tissue engineering interventions, including stem cell therapies and therapeutic cloning (f).

Prepared by: Eric M. Brey, Ph.D.   Date: 8/18/2006

**Criterion 5:**

Elective course for all BME majors and fulfills 3 credits in engineering
# BME 430 - Concepts of Medical Imaging - Elective

**Course Instructor:** Konstantinos Arfanakis, Ph.D.

**Catalog Data:** BME 430 – Concepts of Medical Imaging. Credit hours: 3

**Catalog Description:** This course is an introduction to the basic concepts in medical imaging, such as: receiver operating characteristics, the rose model, point spread function and transfer function, covariance and autocovariance, noise, filters, sampling, aliasing, interpolation and image registration.

**Topics Covered:** Sampling theory, noise properties of medical imaging systems, receiver operating characteristics, point spread function and point transfer function, covariance and autocovariance, filters, image reconstruction approaches.

**Prerequisites:** BME 315 Instrumentation Laboratory
PHYS 221 General Physics II: Electromagnetics and Optics


**Course Schedule:** The course meets twice a week for sessions that last one hour and fifteen minutes each. The course is offered in the Fall semester.

**Student Learning Objectives (SLOs):**

1) To provide students with a clear understanding of the basic concepts of imaging science such as image noise, resolution, sampling theory, etc. (Satisfies Program Outcomes a, e, k).

2) To explain how medical images can be used for the detection of abnormalities in living tissue, and what is involved in differentiating abnormalities from normal variations (receiver operating characteristics, the rose model) (Satisfies Program Outcomes a, b, c, e, j, k, l, m).

3) To combine the knowledge acquired and discuss the steps required to reconstruct images from the raw data in more complex medical imaging modalities such as CT and MRI. (Satisfies Program Outcomes a, c, e, i, j, k, l).

4) Analyze technical articles from medical imaging literature. (Satisfies Program Outcomes d, f, g, i, j).

**Prepared by:** Konstantinos Arfanakis, Ph.D.  
**Date:** 8/15/2006

**Criterion 5:**
Elective course for all BME majors and fulfills 3 credits in engineering
BME 433
BIOMEDICAL ENGINEERING APPLICATIONS OF STATISTICS

Course Instructor: David J. Mogul, Ph.D.

2007 Catalog Data: BME 433 Biomedical Engineering Applications of Statistics.
Credit hours: 3

Catalog Description: This course is designed to cover the tools and techniques of probability and statistics with specific applications to biomedical engineering. Both parametric and non-parametric analysis will be presented. Emphasis is on inferential statistics and experimental design.

Topics Covered:
1. Sampling and estimation theory
2. Basic probability and probability distributions
3. Hypothesis testing
4. Analysis of variance
5. Simple and multiple regression; correlation
6. Chi-square analysis
7. Distribution-free statistics

Prerequisites: BME 315


Course Schedule: The course meets twice a week for sessions that last one and one-quarter hours each. The course is offered in the Spring semester.

Student Learning Objectives (SLOs):
1. Understand the fundamental principles underlying statistical testing (Program outcome a).
2. Be able to critically evaluate statistical decisions and findings reported in scientific and popular literature (Program outcomes f, h).
3. Ability to employ the tools, techniques, and underlying assumptions to effectively use statistics in biomedical research (Program outcomes b).
4. Analyze when parametric or nonparametric statistical analysis is required (Program outcomes a, b).
5. Be able to design an experiment based on criteria of statistical confidence and minimization of errors (Program outcomes b, c).
Criterion 5:

Required course for all BME majors and fulfills 3 credits in engineering

BME 438 - Neuroimaging – Required for Neural Engineering and Medical Imaging Tracks
BME 438 - Neuroimaging – Required for Neural Engineering and Medical Imaging Tracks

Course Instructor: Konstantinos Arfanakis, Ph.D.

2007 Catalog Data: BME 438 – Neuroimaging. Credit hours: 3

Catalog Description: This course describes the use of different imaging modalities to study brain function and connectivity. The first part of the course deals with brain function. It includes an introduction to energy metabolism in the brain, cerebral blood flow, and brain activation. It continues with an introduction to magnetic resonance imaging (MRI), perfusion-based functional MRI (fMRI), blood oxygen level dependent (BOLD) fMRI, fMRI paradigm design and statistical analysis, introduction to positron emission tomography (PET) and studying brain function with PET, introduction to magnetoencephalography (MEG) and studying brain function with MEG. The second part of the course deals with brain connectivity. It includes an introduction to diffusion tensor MRI, explanation of the relationship between the diffusion properties of tissue and its structural characteristics, and white matter fiber tractography.

Topics Covered: Human brain anatomy and physiology, imaging brain function with MRI, PET and MEG, experimental design and statistical analysis, white matter fiber tractography by means of diffusion tensor MRI.

Prerequisites: BME 315 Instrumentation Laboratory
PHYS 221 General Physics II: Electromagnetics and Optics


Course Schedule: The course meets twice a week for sessions that last one hour and fifteen minutes each. The course is offered in the Spring semester.

Student Learning Objectives (SLOs):

1) To provide students with a clear understanding of the processes that take place during brain activation. (Satisfies Program Outcome I).
2) Describe imaging techniques that can be used to probe brain function (primarily functional MRI, which is the most widely used method for imaging brain function due to the fact that it combines relatively high spatial and temporal resolution). (Satisfies Program Outcomes a, b, e, j, k, l).
3) Provide an introduction to brain anatomy, and describe techniques that can be used to image brain anatomy and connectivity. (Satisfies Program Outcomes a, b, e, j, k, l).
4) Become familiar with the analysis of functional imaging data through lab-based homework assignments. (Satisfies Program Outcomes a, b, e, j, k, l).
5) Analyze technical articles from neuroimaging literature. (Satisfies Program Outcomes i, j).

Prepared by: Konstantinos Arfanakis, Ph.D. Date: 1/15/2007

Criterion 5:

Required course for Neural Engineering and Medical Imaging Tracks, and fulfills 3 credits of engineering
BME 443  - Biomedical Instrumentation –Required for Neural Engineering and Medical Imaging Tracks

Course Instructor: Philip R. Troyk, Ph.D.

Catalog Data: BME 443 –Biomedical Instrumentation  Credit hours: 3

Catalog Description: This course will cover basic principles of Biomedical Instrumentation from the standpoint of a circuits approach. Various types of transducers will be examined with an emphasis on the means of transduction, and the implications for interfacing to an amplifier. Amplifier circuits will be detailed, covering different configurations, grounding techniques, D.C. behavior, Frequency response, and noise. An introduction to active filters will be studied. Typical models for transducers and amplifiers will be used to examine their combined behavior in Biomedical Engineering-type measurements.

Topics Covered: Passive network circuit theory, Loop/mesh analysis, the RC/RL circuit, circuit analysis techniques, Active network theory, Basic transistor analysis, biasing techniques, use of transistors in amplifiers, Amplifiers, Characteristics, use of operational amplifiers, amplifier topologies, frequency response, Principles of physiologic transducers, Resistive, Capacitive, and Inductive transducers, Biopotentials, Nature and origin of biological based signals, Electrodes, Electrode types, nature of the electrode tissue interface, recording electrodes, stimulating electrodes, Other Bioelectric transducers, Flow, pressure, acoustic, and chemical transducers, System design, Combining transducers and amplifiers in complete systems, design techniques.

Prerequisites: BME 315 – Instrumentation Laboratory

Textbook: No one textbook is used for the course, lecture material is drawn from Basic Engineering Circuit Analysis (Irwin), Engineering Circuit Analysis (Hayt, Kemmerly), Microelectronics Circuits (Sedra, Smith), Medical Instrumentation (Webster).

Course Schedule: The course meets twice a week for sessions that last one hour and fifteen minutes each. A consistent schedule of offering has not yet been established. To-date, it has been taught once, in the Spring '06, semester.

Student Learning Objectives (SLOs):
1. To provide a theoretical knowledge base to the student that facilitates a fundamental understanding of electrical and electronic circuits commonly encountered in biomedical engineering. (a)
2. To establish proficiency in using computer-based simulation methods in order to sophisticate the design and analysis capacity of the student. (k)
3. To establish an intuitive application-based understanding of circuits, transducers, and systems that allows the student to analyze the behavior of existing designs as well as to conceptualize new designs. (e)

Prepared by: Philip R. Troyk, Ph.D. Date: 06/05/2006

Criterion 5:

Required course for Neural Engineering and Medical Imaging Tracks and fulfills 3 credits of engineering
BME 445: Quantitative Neural Function – Required for Neural Engineering and Medical Imaging Tracks

Course Instructor: Jennifer J. Kang Derwent, Ph.D.

2005 Catalog Data: BME 445-Quantitative Neural Function
Credit hours: 3

Catalog Description: BME 445 is a junior- and senior-level course which the main focus of BME 445 is quantitatively approach to basic structure and function of the human nervous system including cable theory, ion channels and as well as the organizations of neural systems.

Topics Covered:
1. Organization of the nervous system
2. Ion channels
3. Resting membrane potential
4. Passive membrane properties
5. Action potential
6. Synaptic transmission
7. Spinal cord & development of the brain
8. Pain
9. Visual system
10. Auditory system
11. Motor system

Prerequisites: BME 315


Course Schedule: The course meets twice a week that last one hour and fifteen minutes each. The course is offered in the Spring semester.

Student Learning Objectives (SLOs):

1. To provide an understanding of structure and electrical properties of the neurons and communication between neurons. (Program Outcome a)

2. To provide a mathematical understanding of ion channels, membrane potentials, action potential (including cable theory). (Program Outcomes a, e)

3. To provide computer stimulator laboratory exercises (Neurons in Action) to enhance self-learning of neural function. (Program Outcomes b, g, k)
4. To design and perform experiments to demonstrate visual and motor systems. (Program Outcomes b, f, g)

5. To develop critical thinking and professional written communication skills. (Program Outcome g)

**Prepared by:** Jennifer J. Kang Derwent, Ph.D.  **Date:** 7/19/2007

**Criterion 5:**

Required course for Neural Engineering and Medical Imaging Tracks and fulfills 3 credits of engineering
Control Systems for Biomedical Engineers
BME 452/552

Course Instructor: David Mogul, Ph.D.

Catalog Description:
Control Systems for Biomedical Engineers Prerequisites: BME 330
Control systems design and analysis in biomedical engineering. Time and
frequency domain analysis, impulse vs step response, open vs closed
loop response, stability, adaptive control, system modeling. Emphasis is
on understanding physiological control systems and the engineering of
external control of biological systems

Text: Modern Control Systems – 11th edition
Dorf & Bishop (Pearson Prentice-Hall)

Reserve Texts:
Physiological Control Systems: Analysis, Simulation, and Estimation

Endogenous and Exogenous Regulation and Control of Physiological
Systems, Robert B. Northrop (CRC Press, 1999)

Prerequisites:
BME 330

Course Schedule:
The course meets twice a week for sessions that last one and one-quarter
hours each. This course is offered in the Spring semester.

Student Learning Objectives (SLOs):

1. A firm understanding of basic principles and methods in order to be able to
critically evaluate any feedback control system. (Program outcome a)
2. Be able to assess error in a feedback circuit (Program outcome b)
3. Be able to model a physiological system using electrical analogs (Program
outcome b, l)
4. Perform stability analyses using Root Locus and Nyquist Plots (Program
outcome c, e)
5. Examine frequency domain analysis using Bode plots (Program outcome b)
6. Understand adaptive control (Program outcome b)
7. Model nonlinear processes and perform nonlinear analysis (Program outcome a, 
e)
Topics Covered:

1. Simulink
2. Distributed vs. lumped parameters
   Linear vs. Nonlinear systems
   State space analysis
   Impulse response
   Open vs. Closed loops
3. Steady State
   Static analysis
   Time domain analysis
   Transient responses
   First vs. Second order
4. Impulse vs. Step responses
   Open vs. Closed loop dynamics
   Frequency domain analysis
5. Sinusoidal input
   Bode & Nyquist Plots
   Stability analysis
6. Identification methods
   Parameter estimation
7. Identification of physiological systems
   Optimization
   Constrained optimization
8. Adaptive control
9. Nonlinear Analysis
10. Nonlinear Control

Laboratory or Other Technical Skills Acquired:
Students learn to construct mathematical models of physiological systems and then analyze them using Simulink and Matlab using the BME Computer Lab.

Prepared by:    David J. Mogul, Ph.D.          Date:  1/15/08

Criterion 5: Elective class for all BME majors and fulfills 3 engineering credits
BME 475/575 – Neuromechanics of Human Movement - Elective

Course Instructor: Derek Kamper, Ph.D.

Catalog Data: BME 475 – Neuromechanics of Human Movement.
Credit hours: 3

Catalog Description: This course will explore how we control movement of our extremities, with concepts drawn from mechanics and neurophysiology. The progression from neurological signals to muscle activation and resulting movement of the hand or foot will be modeled, starting at the periphery and moving back toward the central nervous system. Biomechanics of the limbs will be modeled using dynamic simulation software (Working Model) which will be driven by a neural controller, implemented in MATLAB. Issues related to sensory feedback and redundancy will be addressed.

Topics Covered: Muscle physiology
Limb biomechanics
Lagrangian dynamics
Neural feedback control
Redundancy

Pre-requisite: BME 330


Course Schedule: This course meets twice a week for sessions that last one hour and 15 minutes each. This course is offered in the fall semester.

Student Learning Objectives (SLOs):
1. Model muscle mechanics and the conversion of neural activation into joint torque production (Satisfies Program Outcomes: a, e, l).
2. Use Lagrangian dynamics to describe the conversion of joint torques into limb movement (Satisfies Program Outcomes: a, e).
3. Use Simulink and the dynamics software Working Model to simulate human movement (Satisfies Program Outcomes: a, e, k).
4. Describe how feedback affects system control (Satisfies Program Outcomes a, e, l).

Prepared by: Derek Kamper, Ph.D. Date: 7/23/07
Criterion 5:

Elective course for all BME majors and fulfills 3 credits in engineering
BME 482: Mass Transport for Biomedical Engineers – Required for Cell & Tissue Track

Course Instructor: Eric M. Brey, Ph.D.

2006 Catalog Data: BME 482 – Mass Transport for Biomedical Engineers. Credit hours: 3

Catalog Description: This course seeks to provide students with an introduction to advanced concepts of mass transport with an emphasis on biological systems. Students will be exposed to derivation of the conservation equations for heat, mass, and momentum. Following derivation of these laws, focus will be placed on mass transport applications, including diffusion, convection-diffusion, diffusion with reactions, and facilitated diffusion. Students will be able to apply mass transport equations to solve problems in biological systems.

Topics Covered:

1. Conservation of Mass (Continuity Equation)
2. Derivation of convective-diffusion equation
3. Diffusion – Random Walk
4. Diffusion coefficient – chemical potential, Stokes-Einstein
5. Reaction-diffusion
6. Brief review of Fluid Mechanics
7. Convection-diffusion
8. Dimensionless groups
9. Boundary Layer Theory
10. Transport in porous media (Darcy’s Law)
11. Facilitated diffusion/Blood oxygenator
12. Membranes/Artificial Kidney

Prerequisites: CHE 202 - Material and Energy Balances
BME 301 – Bio-fluid Mechanics


Course Schedule: The course meets twice a week for sessions that last one hour and fifteen minutes each. The course is offered in the Fall semester.

Student Learning Objectives (SLOs):

1. To recognize mass-transport based problems and formulate appropriate mathematical constructs for their solution based on the physical system (Program Outcomes: a, e, g, k, l).
2. Approximate the diffusion coefficient for a given solute based on its thermodynamic and/or physical properties (Program Outcomes: a, e, k, l).
3. Derive the continuity equation for Cartesian, spherical, and cylindrical geometries (Program Outcomes: k).
4. Understand the assumptions required for application of the convective-diffusion-reaction equation and then apply it to appropriate biological problems (Program Outcomes: a, e, g, k, l).
5. Solve simple PDEs and ODEs using basic separation and combination of variables approaches (Program Outcomes: e, k).
6. Understand dimensionless groups and apply them towards the simplification of mass transport problems (Program Outcomes: e, k).
7. Use order of magnitude analysis to predict relative sizes of momentum and mass transfer boundary layers (Program Outcomes: e, k).
8. Apply equations describing mass transfer across membranes (Program Outcomes: a, e, g, k, l).
9. Develop and apply equations describing solute flow in biological tissues modeled as porous media (Program Outcomes: a, e, g, k, l).
10. Apply the above knowledge to the analysis of technical articles from biomedical engineering literature (Program Outcomes: a, e, g, k, l).

Prepared by: Eric M. Brey, Ph.D. Date: 8/17/2006

Criterion 5:

Required course for Cell & Tissue Track, fulfill 3 credits of engineering, co-requisite for BME 408
**BME 490 - SENIOR SEMINAR - Required**

**Course Instructors:** Paul Fagette, PhD and David Gatchell, PhD

**2006 Catalog Data:** BME 490 Senior Seminar
Credit hours: 1

**2006 Course Description:** Students will attend a series of seminars by professionals in and related to the biomedical engineering field. Representatives from industry, academia, and the healthcare industry will make presentations on research, translational development and research, and clinical problems. Students will write a one page essay that explains the essential points of each presentation. (1-0-1) C.

**Topics Covered:** Current biomedical engineering research in connection with appropriate clinical issues, translational attempts to bring biomedical engineering research to the market place, and relative clinical needs, with attention paid to: placing this work within the pertinent global, national, economic, environmental, or societal context and appropriate professional and ethical issues.

**Co-requisites:** BME 420

**Textbook:** No text required.

**Course Schedule:** This course meets once per week for 75 minutes.

**Student Learning Objectives:**

1. The student will possess a greater appreciation for the breadth of studies and career options in biomedical engineering and an understanding of the applications of biomedical engineering in professional settings (Program Outcome h).

2. Students will have an understanding of professional and ethical responsibility by presentations by professional engineers and physicians (Program Outcome f and i).

3. Students will gain experience in critical thinking and technical writing (Program Outcome g).

4. Students will gain an understanding of contemporary issues relevant to biomedical engineering (Program Outcome j).

5. Students will have an opportunity to apply their undergraduate BME skills to understanding a wide range of biomedical, clinical, and industrial speakers as in a post-BS world (Program Outcome i).
Criterion 5:

Required course for all BME majors and fulfills one credit of engineering
B. Armour College Engineering Courses
   CHE 202 - Material and Energy Balances
   ECE 211 - Circuit Analysis I
   ECE 212 - Analog & Digital Lab I
   ECE 213 - Circuit Analysis II
   ECE 214 - Analog & Digital Lab II
   ECE 218 - Digital Systems
   ECE 437 - Digital Signal Processing I
   ECE 481 - Image Processing
   MMAE 200 - Introduction to Mechanics
   MS 201 - Materials Science
Course: ChE 202 Materials and Energy Balances

Required course for Cell & Tissue Track

Description: Material and energy balances for engineering systems subjected to chemical and physical transformations. Calculations on industrial processes. Prerequisites: CS 105, MATH 152, and one year of chemistry. (3-0-3)

Course Goals:
1. To provide students a basic understanding of units, physical properties, kinetics, and thermodynamics and to apply them to solve engineering problems.
2. To provide students necessary skills required for drawing a process flowchart in terms of its components, establishing the relationship between known and unknown process variables based on descriptive information, and solving for the unknowns to obtain the desired solution.
3. To provide students the basic concepts to formulate and solve material balances, energy balances, and both simultaneously.
4. To develop systematic problem solving skills and improve confidence.
5. To learn how to deal with complex material and energy balances and work in a team environment to solve these complex problems.

Students Learning Objectives:
Upon completing the course, the student will be able to
1. Describe SI and American Engineering systems of units and carry out the conversions between units.
2. Describe basic laws of the behavior of gases, liquids, and solids.
3. Describe the difference between ideal and real gases, use compressibility factor and appropriate charts to predict P-V-T behavior of a gas.
4. Describe multiphase systems and use appropriate equations to calculate partial pressure, vapor pressure, humidity, etc.
5. Describe the difference between an open and a closed system and write material and energy balance for such systems.
6. Describe reactive and nonreactive processes and write material and energy balances for such systems.
7. Draw a process flow chart for a complex chemical system and solve for material and energy balances.

Course Relationship to CHE program Educational Objectives:
This introductory level course contribute to the CHE program objectives & outcomes as follows:

Outcome II: Students apply their knowledge of mathematics and science to understand systems of units, behavior of gases, liquids, and solids in single and multi-phase systems. Students learn to identify chemical engineering problems, represent them graphically using flow charts, formulate materials and energy balances and solve them. This outcome is supported by SLOs 1, through 7.
Outcome IX: The entire ChE curriculum is designed to instill in the students a yearning for the pursuit of “Life Long Learning”, and the skills necessary for it. Each course achieves this goal by various means. The assessment plan for this outcome is currently under development, data are continually being collected to assess the whole range of methodologies that are used in this regard. All data collected will be used by the outcome IX assessment committee (in Year 3) to formulate future metrics.

Prepared by: S. Parulekar, August 2006

Criterion 5:
Required course for Cell & Tissue Track, fulfills 3 credits of engineering, prerequisite for BME 335 and BME 482

Program Outcomes:
CHE program outcome II corresponds to BME program outcomes a and e
CHE program outcome IX corresponds to BME program outcomes b, i, and k
ECE 211 – Circuit Analysis I - Required
Fall Semester 2007

Catalog Data: ECE 211: Circuit Analysis I. Credit 3. Ohm’s Law, Kirchhoff’s laws, and network element voltage-current relations. Application of mesh and nodal analysis to circuits, superposition, Thevenin’s and Norton’s theorems, maximum power transfer theorem. Transient circuit analysis or RC, RL, and RLC circuits. Introduction to Laplace transforms. Concurrent registration in ECE 212 and ECE 218 is strongly encouraged. Co-requisite: MATH 252. (3-0-3)

Enrollment: Required course for CPE and EE majors.


Coordinator: J. Pinnello, Lecturer of ECE

Course objectives:
After completing this course, the student should be able to do the following:
1. Derive and apply the relevant equations of DC circuit analysis.
2. Draw the symbols for active and passive circuit components.
3. Given a resistive network with multiple nodes and loops, containing both independent and dependent sources, use a variety of appropriate methods to find all unknown variables.
4. Given a resistive network with multiple nodes and loops, containing both independent and dependent sources, determine the load resistance that allows the source to deliver maximum power to the load; calculate the maximum power that is transferred.
5. Given resistors (or capacitors or inductors) connected in series or in parallel, find the equivalent resistance (or capacitance or inductance).
6. Given a series or parallel RL (or RC or RLC) circuit excited by a constant voltage or current, write the response equation, and find the solution.
7. List the possible modes of response for a second-order circuit.
8. Given a linear ordinary differential equation with constant coefficients with a “well-behaved” engineering function as input, apply Laplace transforms to solve for the unknown function of time.

Prerequisites by topic:
1. Algebra, trigonometry, integration, differentiation
2. Corequisite: First and second order linear ordinary differential equations

Lecture schedule: Two 75-minute sessions per week.
Laboratory schedule: None.

Topics:
1. Introduction and basic concepts—element, circuit, charge, current, voltage, energy, power, independent sources, active/passive elements (1.5 weeks)
2. Resistive circuits—resistors and the color code, Ohm’s law, KVL, KCL, current and voltage division (2 weeks)
3. Dependent sources and operational amplifiers (1 week)
4. Analysis methods—nodal and mesh analysis (2 weeks)
5. Linear circuit theorems—superposition, Thevenin and Norton equivalent circuits, source transformation, maximum power transfer (2 weeks)
6. Capacitors and inductors (1 week)
7. First order RC and RL circuits (1.5 weeks)
8. Transient analysis of second order circuits (1.3 weeks)
9. Introduction to Laplace transforms (2 weeks)
10. Quizzes and tests (1.7 weeks)

### Relationship of ECE 211 Course to ABET Outcomes:

<table>
<thead>
<tr>
<th>OUTCOME:</th>
<th>Course Objective(s)</th>
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<tbody>
<tr>
<td>3a Apply knowledge of math, engineering, science</td>
<td>1,3,4,5,6,7</td>
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<tr>
<td>3b Design and conduct experiments / Analyze and Interpret Data</td>
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<tr>
<td>3c Design system, component, or process to meet needs</td>
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<tr>
<td>3d Function on multi-disciplinary teams</td>
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<tr>
<td>3e Identify, formulate, and solve engineering problems</td>
<td>1,3,4,5,6,7</td>
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<tr>
<td>3f Understand professional and ethical responsibility</td>
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<td>3g Communicate effectively</td>
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<td>3h Broad education</td>
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<td>3i Recognize need for life-long learning</td>
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<tr>
<td>3j Knowledge of contemporary issues</td>
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<tr>
<td>3k Use techniques, skills, and tools in engineering practice</td>
<td>2,3,4,5,6,7</td>
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<tr>
<td>4 Major design experience</td>
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</tbody>
</table>

**Prepared by:** J. Pinnello  
**Date:** May 14, 2008

### Criterion 5:

Required course for all BME majors, fulfills 3 credits in engineering, and pre-requisite for ECE 213 and BME 315

**Program Outcomes:**

ECE outcomes a, e, k correspond to BME outcomes a, e, k
ECE 212 - Analog and Digital Laboratory I
Spring Semester 2008 – Required for Neural Engineering Track

Catalog Data: ECE 212: Analog and Digital Laboratory I. Credit 1.
Basic experiments with analog and digital circuits. Familiarization with test and
measurement equipment; combinational digital circuits; familiarization with
latches, flip-flops, and shift registers; operational amplifiers; and transient effects
in first-order and second-order analog circuits; PSpice software applications.
Corequisites: ECE 211, ECE 218. (0-3-1) (C)

Enrollment: Required course for CPE and EE majors.

Textbook: ECE 212 Laboratory Manual
S. Wolf and R. F. M. Smith, Student Reference Manual for Electronic

Coordinator: A. Khaligh, Assistant Professor of ECE

Course objectives:
After completing this laboratory course, the student should be able to do the
following:
1. Utilize the digital multimeter in making measurements of voltage, current, and resistance.
2. Set up the function generator to obtain sinusoidal and square waves of required amplitudes.
3. Determine the value and tolerance of a resistor by its color code.
4. Understand the principle of operation of the oscilloscope. Use the oscilloscope to display a waveform
   and make measurements on a signal with the oscilloscope.
5. Construct and troubleshoot simple circuits on a breadboard.
6. Implement simple analog functional circuits with the operational amplifier.
7. Implement digital functional circuits using logic gates and programmable logic devices.
8. Measure the time constant of a first-order circuit.

Prerequisites by topic:
1. DC and transient linear circuit theory (Co-requisite)
2. Digital circuit analysis (Co-requisite)

Lecture schedule: None.
Laboratory schedule: One 150-minute session per week.

Computer usage:
1. Students use PSpice simulation for several pre-laboratory assignments.
2. Students prepare reports using word-processing software.

Laboratory topics:
1. Introduction to PSpice (1 week)
2. Digital Meters and Loading Effects (Digital multimeters, power supplies) (1 week)
3. The Oscilloscope (Oscilloscope, function generator) (1 week)
4. Frequency Measurements with the Oscilloscope (Oscilloscope, function generator) (1 week)
5. Introduction to Digital Circuits (Digital manifold) (1 week)
6. The River-Crossing Game (Logic and Digital Circuit Construction) (Digital manifold) (1 week)
7. Operational Amplifiers (Oscilloscope, power supply, function generator) (1 week)
8. Code Conversion (Digital manifold, PAL programmer) (1 week)
9. Seven-Segment Display Drivers (Digital manifold) (1 week)
10. Adders, Subtractors, and Comparators (Digital manifold) (1 week)
11. Transients in First-Order Circuits (Oscilloscope, function generator, power supply) (1 week)
12. Latches, Flip-Flops, and Shift Registers (Digital manifold) (1 week)
13. Practical Midterm and Final Examinations (2 weeks)

Professional components as estimated by faculty member who prepared this course description:

- Engineering Science: 0.25 credits or 25%
- Engineering Design: 0.25 credits or 25%
- Other (Lab skills): 0.50 credits or 50%

Relationship of ECE 212 Course to ABET Outcomes:

<table>
<thead>
<tr>
<th>OUTCOME</th>
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<tbody>
<tr>
<td>3a</td>
<td>1,2,3,4,5,6,7,8</td>
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<tr>
<td>3b</td>
<td>5,8</td>
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<td>3c</td>
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<td>3k</td>
<td>1,2,3,4,5,6,7,8</td>
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</table>

Prepared by: A. Khaligh
Date: Jan, 2008

Criterion 5:

Required course for Neural Engineering Track and fulfills 1 credit in engineering

Program Outcomes:

ECE program outcomes a, b, e, g, k correspond to BME a, b, e, g, k
ECE 213 – Circuit Analysis II
Spring Semester 2008- Required for Neural Engineering and Medical Imaging Tracks

Catalog Data: ECE 213: Circuit Analysis II. Credit 3. Sinusoidal excitation and phasors. AC steady-state circuit analysis using phasors. Complex frequency, network functions, pole-zero analysis, frequency response, and resonance. Two-port networks, transformers, mutual inductance, AC steady-state power, RMS values, introduction to three-phase systems and Fourier series. Concurrent registration in ECE 214 is strongly encouraged. Prerequisite: Grade of "C" or better in ECE 211. (3-0-3)

Enrollment: Required course for CPE and EE majors.


Coordinator: T. Wong, Professor of ECE

Course objectives: After completing this course, the student should be able to do the following:
1. Demonstrate ability to analyze circuits using both phasor notation and sinusoidal functions of time.
2. Demonstrate ability to apply all essential circuit analysis techniques to the analysis of AC circuits.
3. Demonstrate ability to calculate instantaneous power, average power, and complex power in AC circuits; to determine RMS values of voltage and current; to apply the maximum power transfer theorem; and to correct the power factor in a circuit.
4. Demonstrate ability to work with three-phase circuits.
5. Demonstrate ability to analyze circuits containing mutual inductances and transformers.
6. Demonstrate ability to use Laplace transforms to solve AC circuits in the time and frequency domains.
7. Given a two-port network, calculate its admittance, impedance, hybrid, and transmission parameters.

Prerequisites by topic:
1. Calculus
2. Differential equations
3. DC time-domain circuit analysis techniques
4. Complex algebra

Lecture schedule: Two 75-minute sessions per week.
Laboratory schedule: None.

Topics:
1. Sinusoidal excitation and phasors (1.5 weeks)
2. AC steady-state analysis using phasors (2 weeks)
3. AC steady-state power (1.5 weeks)
4. Three-phase circuits (1 week)
5. Mutual inductance and linear transformers (1 week)
6. Complex frequency and network functions (1 week)
7. Frequency response and filters (2 weeks)
8. Laplace transform applications (1.5 weeks)
9. Introduction to Fourier series applied to circuit analysis (1 week)
10. Two-port networks (1.5 weeks)

Computer usage: None
Laboratory topics: None
Professional components as estimated by faculty member who prepared this course description:

Engineering Science: 3 credits or 100%
Engineering Design: 0 credits or 0%

Relationship of ECE 213 Course to ABET Outcomes:

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<td>3c</td>
<td>Design system, component, or process to meet needs</td>
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<td>3d</td>
<td>Function on multi-disciplinary teams</td>
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<td>3e</td>
<td>Identify, formulate, and solve engineering problems</td>
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<td>3f</td>
<td>Understand professional and ethical responsibility</td>
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<td>3g</td>
<td>Communicate effectively</td>
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<td>3h</td>
<td>Broad education</td>
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<tr>
<td>3i</td>
<td>Recognize need for life-long learning</td>
</tr>
<tr>
<td>3j</td>
<td>Knowledge of contemporary issues</td>
</tr>
<tr>
<td>3k</td>
<td>Use techniques, skills, and tools in engineering practice</td>
</tr>
<tr>
<td>4</td>
<td>Major design experience</td>
</tr>
</tbody>
</table>

Prepared by: T. Wong Date: February 29, 2008

Criterion 5:

Required course for Neural Engineering and Medical Imaging Tracks, fulfills 3 credits in engineering, co-requisite for ECE 214

Program Outcomes:

ECE program outcomes a and e correspond to BME program outcomes a and e
ECE 214 - Analog & Digital Lab II
Spring Semester 2008- Required for Neural Engineering Track

Catalog Data: ECE 214: Analog & Digital Lab II. Credit 1.
Design-oriented experiments including counters, finite state machines, sequential logic design, impedances in AC steady-state, resonant circuits, two-port networks, and filters. A final project incorporating concepts from analog and digital circuit design will be required. Prerequisite: ECE 212. Corequisite: ECE 213. (0-3-1) (C)

Enrollment: Required course for CPE and EE majors.

Textbook: ECE 214 Laboratory Manual


Coordinator: A. Khaligh, Assistant Professor of ECE

Course objectives:
After completing this laboratory course, the student should be able to do the following:
1. Design and implement basic analog and digital circuits.
2. Construct and troubleshoot basic analog and digital electronic experiments.
3. Utilize the logic analyzer and oscilloscope to test and debug digital circuits.
4. Use various software tools (PSpice, Excel) for analysis and simulation.

Prerequisites by topic:
1. Boolean Algebra, Combinational Logic Design
2. Sequential Logic Design: Latches, Flip-Flops, Finite State Machines
3. Basic Circuit and Network Theory

Lecture schedule: None.
Laboratory schedule: One 150-minute session per week.

Computer usage:
1. Students use PALASM software to program and simulate Programmable Logic Devices in several lab assignments.
2. Students use PSPICE to simulate analog circuits.

Laboratory topics:
1. Oscilloscope review (1 week)
2. Counters (1 week)
3. Logic Analyzer Familiarization (1 week)
4. Finite State Machines (1 week)
5. Sinusoidal Steady State Analysis (2 weeks)
6. Power and Power Factor Correction (1 week)
7. Sequential Logic Design with PLDs (1 week)
8. Frequency Response of Active Networks (1 week)
9. Transformers (1 week)
10. Practical Final Exam (2 weeks)
Professional components as estimated by faculty member who prepared this course description:

Engineering Science: 0.50 credit or 50%
Engineering Design: 0.25 credit or 25%
Other (Lab Skills): 0.25 credit or 25%

Relationship of ECE 214 Course to ABET Outcomes:

<table>
<thead>
<tr>
<th>OUTCOME</th>
<th>Objective (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a Apply knowledge of math, engineering, science</td>
<td>1,2,3,4</td>
</tr>
<tr>
<td>3b Design and conduct experiments /Analyze and Interpret Data</td>
<td>2,3</td>
</tr>
<tr>
<td>3c Design system, component, or process to meet needs</td>
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<tr>
<td>3d Function on multi-disciplinary teams</td>
<td></td>
</tr>
<tr>
<td>3e Identify, formulate, and solve engineering problems</td>
<td>2,3,4</td>
</tr>
<tr>
<td>3f Understand professional and ethical responsibility</td>
<td></td>
</tr>
<tr>
<td>3g Communicate effectively</td>
<td>5</td>
</tr>
<tr>
<td>3h Broad education</td>
<td></td>
</tr>
<tr>
<td>3i Recognize need for life-long learning</td>
<td></td>
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<tr>
<td>3j Knowledge of contemporary issues</td>
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<td>3k Use techniques, skills, and tools in engineering practice</td>
<td>1,3,4</td>
</tr>
<tr>
<td>4 Major design experience</td>
<td></td>
</tr>
</tbody>
</table>

Prepared by: A. Khaligh Date: Jan, 2008

Criterion 5:

Required course for Neural Engineering Track, fulfills 1 credit in engineering, co-requisite for ECE 213

Program Outcomes:

ECE program outcomes a, b, e, and k correspond to BME a, b, e, and k
ECE 218 - Digital Systems
Spring Semester 2008 – Required for Neural Engineering Track

Catalog Data: ECE 218: Digital Systems. Prerequisites: Sophomore standing, Credit 3. Number systems and conversions, binary codes, and Boolean algebra. Switching devices, discrete and integrated digital circuits, analysis and design of combinational logic circuits. Karnaugh maps and minimization techniques. Counters and registers. Analysis and design of synchronous sequential circuits. Concurrent registration in ECE 211 and ECE 212 is strongly encouraged. (3-0-3)

Enrollment: Required course for CPE and EE majors.


Coordinator: S.R.Borkar, Senior Lecturer of ECE

Course objectives: After completing this course, the student should be able to do the following:
1. Perform arithmetic in bases 2, 8, and 16.
2. Demonstrate the ability to apply Boolean algebra to digital logic problems.
3. Implement Boolean functions using Karnaugh maps.
4. Simplify Boolean functions using Karnaugh maps.
5. Design logic circuits from verbal problem descriptions.
6. Describe situations where medium-scale integration circuits are useful.
7. Analyze and design logic circuits containing flip-flops.
8. Design and analyze synchronous sequential circuits.
9. List various types of memories and programmable logic devices.

Prerequisites by topic: None.

Lecture schedule: Two 75-minute sessions per week.
Laboratory schedule: None.

Topics:
1. Number Bases, Conversion (1 week)
2. Signed Numbers, Complements, Codes (1 week)
3. Boolean Algebra (1 week)
4. Logic Gates (0.5 week)
5. Karnaugh Map Method (0.5 week)
6. Don't-Care Terms (0.5 week)
7. Two-Level Logic Implementations (0.5 week)
8. Don't-Care Terms (0.5 week)
9. Exclusive OR (0.5 week)
10. Design and Analysis Procedures (1 week)
11. MSI Circuits: Adders, Comparators, Decoders, Encoders, Multiplexers (2 weeks)
12. Flip-Flops, Triggering (1 week)
13. Clocked Sequential Circuits (1 week)
14. State Reduction (0.5 week)
15. Excitation Tables (0.5 week)
16. Design of Registers and Counters (1 week)
17. Random Access Memory (1 week)
18. Programmable Logic: ROMs, PLAs, PALs (1 week)
19. Tests (1 week)

Computer usage: None

Laboratory topics: None.
Professional components as estimated by faculty member who prepared this course description:

Engineering Science:  1.5 credits  or  50%
Engineering Design:  1.5 credits  or  50%

Relationship of ECE 218 Course to ABET Outcomes:

<table>
<thead>
<tr>
<th>OUTCOME</th>
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</thead>
<tbody>
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</tr>
<tr>
<td>4 Major design experience</td>
<td></td>
</tr>
</tbody>
</table>

Prepared by:  S. R. Borkar  Date:  Feb 20, 2008

Criterion 5:

Required course for Neural Engineering Track and fulfills 3 credits in engineering

Program Outcomes:

ECE program outcomes a, c, and e correspond to BME program outcomes a, c, and e
Catalog Data: ECE 437: Digital Signal Processing I. Credit 3. Discrete-time system analysis, discrete convolution and correlation, Z-transforms. Realization and frequency response of discrete-time systems, properties of analog filters, IIR filter design, FIR filter design. Discrete Fourier Transforms. Applications of digital signal processing. Credit will be given for either ECE 436 or ECE 437, but not for both. Prerequisite: ECE 308. (3-0-3) (P)

ECE 436: Digital Signal Processing I with Laboratory. Credit 4. Discrete-time system analysis, discrete convolution and correlation, Z-transforms. Realization and frequency response of discrete-time systems, properties of analog filters, IIR filter design, FIR filter design. Discrete Fourier Transforms. Applications of digital signal processing. Credit will be given for either ECE 436 or ECE 437, but not for both. Prerequisite: ECE 308. (3-3-4) (P)(C)

Enrollment: Elective course for CPE and EE majors.


Coordinator: Y. Yang, Associate Professor of ECE

Course objectives: After completing this course, the student should be able to do the following:
1. Conduct fundamental time analyses of discrete-time signals and systems.
2. Analyze linear, time-invariant discrete-time system behavior using the Z-transform.
3. Conduct frequency analyses of discrete-time signals and systems using the discrete-time Fourier transform.
4. Apply the DFT (Discrete Fourier Transform) in the analysis of discrete-time signals.
5. Implement DFTs efficiently via FFT (Fast Fourier Transform) algorithms.
6. Design structures for the implementation of discrete-time systems.
7. Design basic digital filters.
8. Use computer-based analysis and design tools (such as MATLAB, TI C6x DSK) in the analysis of digital signals and systems and in the analysis and design of DSP systems.

Prerequisites by topic:
1. Engineering mathematics
2. Fourier and Laplace transforms
3. Linear system analysis, including time and frequency domain representation of signals and systems

Lecture schedule: Two 75-minute sessions per week.
Laboratory schedule: ECE 437: None.
ECE 436: One 150-minute session per week.

Topics:
1. Discrete-Time Signals and systems, Applications, Convolution and correlation (1 week)
2. Fourier Analysis and Sampled Data Signals (2 weeks)
3. Z Transform, Frequency Response and Realization (2 weeks)
4. Design and Properties of Analog Filters (2 weeks)
5. IIR Filter Design (2 weeks)
6. FIR Filter Design (2 weeks)
7. Discrete Fourier Transform and Properties (2 weeks)
8. Fast Fourier Transform, FFT Convolution and Correlation (1 week)
9. Exams (1 week)

**Computer usage:**
Students use computers, MATLAB software, and TI C6x DSK to implement and test their projects.

**Laboratory topics (ECE 436):**
1. Introduction to lab tools and digital signals
2. Signal sampling and reconstruction
3. Real-time digital signal processing systems
4. Frequency selectivity of LTI systems
5. FIR filter design and implementation
6. IIR filter design and implementation
7. Quantization effects in digital signal processing systems
8. Digital image processing using C6713 DSK
9. Real time spectral analysis of signals and systems
10. Design project: Real time signal processing system design

Professional components as estimated by faculty member who prepared this course description:
ECE 437
Engineering Science: 2 credits or 67%
Engineering Design: 1 credit or 33%

**Relationship of ECE 437/436 Course to ABET outcomes:**

<table>
<thead>
<tr>
<th>Course Objective (s)</th>
<th>ECE 437</th>
<th>ECE 436</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a Apply knowledge of math, engineering, science</td>
<td>1,2,3,4,5,6,7,8,9</td>
<td>1,2,3,4,5,6,7,8,9</td>
</tr>
<tr>
<td>3b Design and conduct experiments/ Analyze and Interpret Data</td>
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</tr>
<tr>
<td>3c Design system, component, or process to meet needs</td>
<td>6,7,8</td>
<td>6,7,8,9</td>
</tr>
<tr>
<td>3d Function on multi-disciplinary teams</td>
<td></td>
<td></td>
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<tr>
<td>3e Identify, formulate, and solve engineering problems</td>
<td>1,2,3,4,5,6,7,8,9</td>
<td>1,2,3,4,5,6,7,8,9</td>
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<tr>
<td>3f Understand professional and ethical responsibility</td>
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<td></td>
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<tr>
<td>3g Communicate effectively</td>
<td></td>
<td>10</td>
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<tr>
<td>3h Broad education</td>
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<td>3i Recognize need for life-long learning</td>
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<td>3j Knowledge of contemporary issues</td>
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<tr>
<td>3k Use techniques, skills, and tools in engineering practice</td>
<td>8</td>
<td>8,9</td>
</tr>
<tr>
<td>4 Major design experience</td>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>

**Program Outcomes:**

ECE program outcomes a, c, e, and k correspond to BME program outcomes a, c, e, and k

Prepared by: Y. Yang  Date: Mar 10, 2008

Criterion 5:
Required course for Medical Imaging Track, fulfills 3 credits in engineering, pre-requisite for ECE 481
ECE 481 - Image Processing
Spring Semester 2008 – Required for Medical Imaging Track

Catalog Data: ECE 481: Image Processing, Credit 3.
Mathematical foundations of image processing, including two-dimensional discrete Fourier transforms, circulant and block-circulant matrices. Digital representation of images and basic color theory. Fundamentals and applications of image enhancement, restoration, reconstruction, compression, and recognition. Prerequisite: ECE 437. Corequisite: ECE 475 or MATH 475. (3-0-3) (P)

Enrollment: Elective course for CPE and EE majors.
Required course for BME (Medical imaging track).


Coordinator: J. G. Brankov, Assistant Research Professor of ECE

Course objectives:
After completing this course, the student should be able to do the following:
1. Understand the basic elements of the color theory, including hue, saturation, and luminance; the basic principles of color matching, the RGB color system.
3. Perform digital image enhancement by intensity transformations, histogram operations, smoothing, sharpening, etc.
4. Perform digital image restoration using the Wiener and pseudoinverse filters.
5. Perform digital image reconstruction from projections (Computed tomography).
7. Understand basic of "Protections for Human Subjects" in medical imaging research.
8. Recognize and design appropriate image processing methods based on the observed image degradation.
9. Understand the fundamentals of image coding and compression.

Prerequisites by topic:
1. Signal Processing: 1D convolution, sampling and Fourier transform.
2. Basic Probability.

Lecture schedule: Two 75-minute sessions per week.
Laboratory schedule: None.

Topics:
1. Introduction to image processing (1.5 week)
   Images and image processing defined, image representations, applications
2. Mathematical foundations (3 week)
   Linear systems, Fourier transform and its properties, Discrete Fourier transform (DFT), linear and circular convolution, vector representation of images, circulant matrices
3. Image enhancement (2 week)
   Intensity transformations, histogram operations, smoothing, sharpening, edge detecting, median filter
4. Image restoration (3 week)
   Degradation model, inverse filtering, Wiener filter
5. Image reconstruction (tomography)  (2.5 week)
   Radon transform, central-slice theorem, filtered backprojection, Basics of Human Subject Protections
6. Image compression     (1.5 week)
   Types of redundancy, variable-length coding, transform coding, JPEG, MPEG
7. Exams     (1.5 weeks)

**Computer usage:**
Students will write software to perform:
1. denoising and edge enhancement of images;
2. restoring blurred noisy images using the Wiener and pseudoinverse filters;
3. reconstructing images from projections (Computed tomography);
4. apply Karhunen-Loeve transformation;
5. analyze the image processing methods performance.

**Laboratory topics:** None.

**Professional components as estimated by faculty member who prepared this course description:**
- Engineering Science: 2.4 credits or 80%
- Engineering Design: 0.6 credits or 20%

**Relationship of ECE 481 Course to ABET Outcomes:**

| 3a | Apply knowledge of math, engineering, science | 1,2,3,4,5,8,9 |
| 3b | Design and conduct experiments | 8 |
| 3c | Analyze and interpret data | 3,4,5,6,8,9 |
| 3d | Design system, component, or process to meet needs | 8 |
| 3e | Function on multi-disciplinary teams | |
| 3f | Identify, formulate, and solve engineering problems | 1,2,3,4,5,8,9 |
| 3g | Communicate effectively | 6 |
| 3h | Broad education | |
| 3i | Recognize need for life-long learning | |
| 3j | Knowledge of contemporary issues | 1,2,3,4,5,6,7,8,9 |
| 3k | Use techniques, skills, and tools in engineering practice | 3,4,5,6,8,9 |
| 4 | Major design experience | |

**Prepared by:** J. G. Brankov  **Date:** February 29, 2008

**Criterion 5:**
Required course for Medical Imaging Track and fulfills 3 credits in engineering. BME 433 fulfills the prerequisites along with ECE 437

**Program Outcomes:**

ECE program outcomes a, b, c, e, f, g, j, and k corresponds to BME program outcomes a, b, c, e, f, g, j, and k
MMAE 200: Statics and Dynamics – Required for Cell & Tissue Track

Catalog Data:

Prerequisites: PHYS 123, MATH 152, CS 105. Corequisite: MATH 252.


Course Objectives:
To introduce the concept of static equilibrium as applied to simple structural problems and provide an understanding of distributed forces, center of gravity, and centroids. To introduce the concept of dynamic motion as applied to simple moving objects, including effects of friction, centrifugal forces, and analysis of motion from an energy balance perspective and momentum perspective.

Topics:
1. Force Vectors
2. Equilibrium of a Particle
3. Force System Resultants
4. Midterm 1
5. Equilibrium of a Rigid Body
6. Friction and Center of Gravity
7. Kinematics of a Particle
8. Kinetics of a Particle Force and Acceleration
9. Midterm 2
10. Kinetics of a Particle: Work and Energy
11. Kinetics of a Particle: Impulse and Momentum
12. Final Exam (Comprehensive)

Computer Usage:
Limited to excel spreadsheets and plots

Relationship of Course to ABET Outcomes:

<table>
<thead>
<tr>
<th>ABET Criterion</th>
<th>Program Outcome</th>
<th>Status</th>
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</thead>
<tbody>
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<td>3a</td>
<td>Apply knowledge of math, engineering, science</td>
<td>4</td>
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<tr>
<td>3b</td>
<td>Design and conduct experiments</td>
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</tr>
<tr>
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<td>3e</td>
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<td>3</td>
</tr>
<tr>
<td>3f</td>
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<tr>
<td>3g</td>
<td>Communicate effectively</td>
<td>1</td>
</tr>
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</tbody>
</table>
Program Outcomes:

MMAE program outcomes a, c, e, g, h, and i correspond to BME program outcomes a, c, e, g, h, and i
MS 201 Materials Science – Required for Cell & Tissue Track

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


Objectives:
1. Distinguish different solid types according to bonding
2. Solve elementary problems in crystal geometry
3. Relate intrinsic properties to bonding and crystal structures
4. Describe crystal defects and predict their effects on properties
5. Solve problems involving stiffness, strength, toughness of engineering materials
6. Solve problems involving creep and fatigue of engineering materials
7. Solve problems involving electrical properties of engineering materials
8. Solve simple phase transformation problems

Prerequisite by Topic: General chemistry, elementary mechanics.


Schedule: Classes are 1 hr. 20 min. long, 2 sessions per week
Relationship of Course to ABET Outcomes:

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Criterion 5: Required for Cell & Tissue Track and fulfill 3 credits of engineering

Program Outcomes:

MMAE program outcomes a, b, h, i and j correspond to BME program outcomes a, b, h, i, and j
APPENDIX C: Math & Science Courses

BIOL 115 - Human Biology
BIOL 117 - Experimental Biology Lab
BIOL 430 - Animal Physiology
CHEM 124 - Principles of Chemistry I
CHEM 125 - Principles of Chemistry II
CHEM 237 - Organic Chemistry I
CHEM 239 - Organic Chemistry II
CS 105 - Introduction to Computer Programming I
CS 115 - Object Oriented Programming I
CS 201 - Accelerated Introduction to Computer Science
MATH 151 - Calculus I
MATH 152 - Calculus II
MATH 251 - Multivariate & Vector Calculus
MATH 252 - Introduction to Differential Equations
MATH 333 - Matrix Algebra & Complex Variables
PHYS 123 - General Physics I: Mechanics
PHYS 221 - General Physics II: Electromagnetism & Optics
PHYS 224 - General Physics III: Thermal & Modern Physics
Biology 115: Human Biology- Required  
Department of Biological, Chemical, and Physical Sciences

Course Description:

This course covers selected topics in biology of particular relevance to humans and to human health and disease. Topics include biology of human cells and selected organ systems; neurobiology including psychoactive drugs and drug addiction; development and birth defects; genetics and genetic diseases; toxicology; the immune system and immunologic diseases such as AIDS; human nutrition and nutritional effects; microbial human diseases.  
Instructor: T.C. Irving,  
Class Hours: Tuesday and Thursday, 5:00 - 6:15 pm Life Sciences 111  
Office Hours: Tuesday and Thursday, 6:30 -7:30 pm  Life Sciences 166C

All course class notes, and other relevant materials will be available on the Biol 115 Blackboard web site. Please check it frequently for updates.

Reaching Prof Irving:  
The best way to reach me is by e-mail irving@iit.edu. I am very responsive to e-mail. Optimists may try and reach me at my office LS 166 C (312), 567-3489 or my lab LS 356, (312) 567-3486. Voice mail is generally a less reliable way to reach me.

Course text:  
Sylvia S. Mader, Human Biology, 10th Edition (McGraw-Hill) and accompanying CD-ROM.  
Other recent editions should also be useful.

Course Notes:  
Only the text portion of the lecture notes are provided on Blackboard. Students are expected to use them as a “road map” guide to the text as to what parts to study. The notes themselves will not necessarily contain everything you could be expected to know. It should also be noted that there is not always a one to one correspondence of lecture topics to chapters in any given edition. Ability to use the index in the text is assumed.

Course goals:  
Students will acquire familiarity (at the level of the text) with:  
1) Introductory Biochemistry and Cell Biology  
2) Anatomy and Physiology I: Organization and regulation of body systems  
3) Anatomy and Physiology II: Movement, support and senses  
4) Human Genetics, Development and Biotechnology  
5) Introduction to human pathogens and disease  
6) Human Ecology and Human Evolution

Topics Covered:
See course description

**Grading plan:**

1) Two midterms, each worth 25% percent of the grade
2) One comprehensive final, worth 40% of the grade
3) Eight quizzes worth collectively 10% of the grade (1.25% each)

There will be no make up exams. Any exams or quizzes missed due to illness or other reasons acceptable to the instructor will be ignored and the remainder of the grade pro-rated. Requests to do so must be done by e-mail.

Prepared by: T.C. Irving, 2/11/08

**Criterion 5:**

Required course for all BME students and fulfills 3 credits of math/science requirements

**Program Outcomes:**

a and I
BIOL 117 Human Biology Laboratory- Required

Catalogue Data:

A biology laboratory course to accompany BIOL 115. Laboratories will include the identification of body structures and the application of experimental methods for the understanding of the relationship between cell structure and function. 0-3-1 (C)

Co-requisite:

BIOL 115

Class Schedule:

LS-306: Section 021-Tuesday 8:35-11:15am; Section 022-Tuesday 1:50-4:30pm; Section 023-Thursday 1:50-4:30pm

Instructor
Kathryn Spink, Ph.D.
LS-146C, 312-567-3441, spink@iit.edu
Office Hours: Wednesday 11:30am-1:00pm and Thursday 9-11am or by appointment

Teaching Assistants
Ismael Muhamed, imuhamed@iit.edu; Sai Ravi Shankar, sravish@iit.edu; Xiangyu Deng, xdeng7@iit.edu; Tony Sanny, sannton@iit.edu; Eric Valesio, evalesio@iit.edu

Textbooks:
Lab Manuals: Human Biology Laboratory, Kathryn Spink (this is a lab manual created for this lab and will only be available in the IIT bookstore) and A Dissection Guide & Atlas to the Fetal Pig, Second Edition, David G. Smith & Michael P. Schenk

Course Objectives:

1) to learn tests for chemical components of cells
2) to be able to identify various human body tissues
3) to recognize body structures
4) to learn proper data recording and reporting

Topics Covered:

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Topic</th>
<th>Spink</th>
<th>Smith</th>
<th>Assignments</th>
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<tr>
<td>1</td>
<td>Jan. 22, 24</td>
<td>No Lab</td>
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<td>2</td>
<td>Jan. 29, 31</td>
<td>Check In Human Body Tissues (8pts)</td>
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<td>3</td>
<td>Feb. 5, 7</td>
<td>Chemical Composition</td>
<td>3</td>
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177
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<tr>
<th>#</th>
<th>Dates</th>
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<th>Credits</th>
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<tr>
<td>4</td>
<td>Feb. 12, 14</td>
<td>Cell Structure and Function (8pts)</td>
<td>4</td>
<td>Lab Report on Exercise 3</td>
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<td></td>
<td></td>
<td></td>
<td>(25pts)</td>
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<td>5</td>
<td>Feb 19, 21</td>
<td>External Anatomy Muscular System (10pts)</td>
<td>1, 3</td>
<td>Quiz #1 (12.5pts)</td>
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<td>6</td>
<td>Feb. 26, 28</td>
<td>Muscular System (10pts)</td>
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<td>7</td>
<td>Mar. 4, 6</td>
<td>Muscular System (10pts)</td>
<td>3</td>
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<td>Mar. 11, 13</td>
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<td>Mar. 18, 20</td>
<td>Spring Break</td>
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<td>10</td>
<td>Mar. 25, 27</td>
<td>Chemical Aspects of Digestion (6pts)</td>
<td>9</td>
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<td>11</td>
<td>Apr. 1, 3</td>
<td>Digestive System Respiratory System (10pts)</td>
<td>4, 6</td>
<td>Lab Report on Exercise 9</td>
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<td>(25pts)</td>
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<td>12</td>
<td>Apr. 8, 10</td>
<td>Circulatory System (10pts)</td>
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<td>Apr. 15, 17</td>
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<td>14</td>
<td>Apr. 22, 24</td>
<td>Urinary System Reproductive System Endocrine System (10pts)</td>
<td>8</td>
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<td>15</td>
<td>Apr. 29, May 1</td>
<td>Nervous System and Senses Skeletal System (12pts)</td>
<td>13, 14</td>
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<td>16</td>
<td>May 6, 8</td>
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</table>

**Prepared by:**

Kathryn Spink, Ph.D, 1/22/08

**Criterion 5:**

Required course for all BME students and fulfills 1 credit of math/science requirements

**Program Outcomes:**

a, b, l, and m
BIOL 430 Animal Physiology - Required

ALL MATERIALS ARE AVAILABLE ON BLACKBOARD

Instructor: Chunbo Zhang
Life Science 392 Ph. 312-567-3575 (office)
E-mail: zhangc@iit.edu
Office Hours: after class or by appointment.


Catalogue Data:

Respiration; circulation; energy metabolism; temperature regulation; water and osmotic regulation; digestion and excretion; muscle and movement; nerve excitation; information control and integration; and chemical messengers. Emphasis on general principles with examples drawn from various animal phyla. Same as BME 450. 3-0-3

Introduction to Biology 430

Animal physiology focuses on the function of tissues, organs, and organ systems in multicellular animals. Knowledge about natural history, morphology, behavior, and environment of an animal will allow you to fully appreciate the importance of the physiological mechanisms. It is expected that you get these information through reading the text book and other sources such as the internet, scientific articles and reference books.

Topics covered include respiration, circulation, energy metabolism, temperature regulation, water and osmotic regulation, digestion and excretion, muscle and movement, nerve excitation, information control and integration, and chemical messengers. Emphasis will be on general principles with examples drawn from various animal phyla

Goals and Objectives

Upon completion of the lecture portion of this course, students will be expected to:
1. Understand the cellular and molecular events involved in normal physiological function.
2. Understand structures and functions of the integrated systems in animals.
3. Understand the relationship among individual organ systems.
4. Know the basis of neurophysiology, including conductance, signal propagation, transmission and sensory mechanism.
5. Understand the importance and complexity of hormonal regulation.
6. Learn scientific skills.
### Topics Covered

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Topics</th>
<th>Text Chapter</th>
</tr>
</thead>
</table>
| 01   | January 22 | Introduction
Biological molecules
Experimental methods | 1-2          |
| 02   | January 29 | Cells and Organelles: Structure and Function | 3            |
| 03   | February 5 | Cell membranes: Permeability and Transport | 4            |
| 04   | February 12| Gastrointestinal Physiology: Nutrition and Digestion | 15           |
| 05   | February 19| Endocrinology: Hormonal Regulation of Metabolism | 9            |
| 06   | February 26| Endocrinology and Reproduction | 9            |
| 07   | March 4    | Respiratory Physiology: Ventilation and Gas Exchange | 13           |
| 08   | March 11   | Mid-term Examination |                          |
| 09   | March 18   | Spring Break |                          |
| 10   | March 25   | Renal Physiology: Osmoregulation and Excretion | 14           |
| 11   | April 1    | Neurophysiology I: Molecular Electrophysiology | 5            |
| 12   | April 8    | Neurophysiology II: Signal Propagation and Transmission | 6            |
| 13   | April 13   | **Term-paper submitted before 23:59, to the Blackboard will received 5% bonus points.** |             |
| 13   | April 15   | Neurophysiology III: Sensory Mechanism
Basics of the Central Nervous system | 7            |
| 14   | April 20   | **Deadline for Term-paper (due at 23:59) to be submitted to the blackboard. Reference materials may be submitted before the beginning of the class on April 18.** |             |
| 14   | April 22   | Muscle Physiology | 10           |
| 15   | April 29   | Cardiovascular Physiology and Circulation | 12           |
| 16   | May 6      | TBA |                          |
| 17   | May 12-17  | Final examination (May 13, 7:30 -9:30 pm) |              |

**Criterion 5:**

Required course for all BME students and fulfills 3 credits of math/science requirements

**Program Outcomes:**

a and l
CHEM 124: Principles of Chemistry I - Required

Catalog Data: Foundations of chemistry, atoms and molecules, stoichiometry of chemical reactions, thermochemistry, properties of gases, states of matter, chemical solutions, and kinetics. Molecular basis for chemical reactivity, atomic structure, periodicity, chemical bonding. (3-3-4) (C)

Prerequisite(s) None

Textbook(s) and/or other required material


Course Objectives:
Emphasis is placed on developing and understanding important principles and concepts of the atomic world and on utilizing this understanding to solve specific problems based on those principles using well-organized approaches. Memorizing equations and descriptive facts are de-emphasized. Students gain a fundamental knowledge of molecular structure and how it relates to macroscopic properties of materials used in engineering science and medicine.

Class/laboratory schedule Two 75 minute lectures and one 170 minute (nominally) laboratory per week

Lecture Topics: Matter and Measurement; Atoms, Molecules and Ions; Stoichiometry; Reactions in Aqueous Solutions; Thermochemistry; Electronic Structure of Atoms; The Periodic Table; The Chemical Bond; Molecular Geometry; Gases; Liquids and Solids.


Prepared by: Rong Wang April 14, 2008

Criterion 5: Required science course that fulfills 4 credits of math/science, required for Chemistry 125, and for MS 201

Program Outcomes: Preparation for outcomes a, b, and l
CHEM 125- Principles of Chemistry II

Instructor - Dr. Mohamed El-Maazawi
Life Sciences 383
Office Hours: Tuesday & Thursday 1:00-2:00 PM
Phone: 312-567-5882
Electronic mail: elmaazawi@iit.edu

Catalog Description:
Chemical equilibria, the chemistry of acids and bases, solubility and precipitation reactions. Introduction to thermodynamics and electrochemistry. Chemistry of selected elements and their compounds. 3-3-4 (C)

Schedule:
Meets twice a week for 75 minutes lecture and once a week for 3 hour lab

Course Objectives:
1. Recognize the different intermolecular forces and their role in phase changes.
2. Identify the types and properties of mixtures, and perform calculations involving the conversion between the different units of concentration.
3. Recognize transition metal coordination compounds.
4. Perform calculations involving reaction rates, identify reaction mechanisms and derive rate laws.
5. Write the expression for the equilibrium condition of a reaction. Identify acids and bases, their equilibrium, and ionic equilibrium.
6. Categorize standard functions of enthalpy, entropy, and free energy and their applications to different systems including electrochemistry.

Required Text -

Prerequisites: CHEM 124

Topics covered

<table>
<thead>
<tr>
<th>Dates</th>
<th>Chapter</th>
<th>HW Problem Sets</th>
<th>HW Due Date</th>
<th>Quizzes</th>
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<tr>
<td>Jan. 22</td>
<td>Intermolecular Forces 12</td>
<td>HW 1</td>
<td>01-29-08 11:59 M</td>
<td>Quiz 1 01-29-08</td>
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<td>4, 6, 10, 15, 17, 20, 22, 27, 29, 38, 40, 46, 50, 55, 62, 63, 85, 93, 113</td>
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<td>Jan. 29</td>
<td>The Properties of Mixtures: Solutions and Colloids 13</td>
<td>HW 2</td>
<td>02-10-08 11:59 PM</td>
<td>Quiz 2 02-05-08</td>
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<td>8, 10, 14, 22, 24, 28, 33, 39, 41, 45, 51, 52, 59, 61, 69, 71, 83, 86, 89, 91, 95, 97, 99, 104, 106, 139</td>
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<td>Date</td>
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<td>HW Set</td>
<td>Quiz Date</td>
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<td>Feb. 07</td>
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<td>Feb. 21</td>
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<td>Equilibrium</td>
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<td>Acid-Base Equilibria</td>
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<td>Mar 17-22</td>
<td>Spring Break – No Classes</td>
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<td>Ionic Equilibria</td>
<td>HW 6</td>
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<td>Apr. 01</td>
<td>Thermodynamics</td>
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<td>Apr. 08</td>
<td>Exam 2 – Chapters 17, 18, and 19</td>
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<td>Thermodynamics</td>
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<td>Electrochemistry</td>
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<td>Apr. 29</td>
<td>Exam 3 – Chapters 20 and 21</td>
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<td>May. 01</td>
<td>Transition Metals</td>
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<td>May. 06</td>
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<td>May 08</td>
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<td>Monday</td>
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<td>May 12</td>
<td>Cumulative Chapters 12-13, 16-21 &amp; 23</td>
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</table>

**Prepared by:** Mohamed El-Maazawi, PhD, 1/20/2008

**Criterion 5:**

Required class for all BME majors, fulfills 4 credits of math/science requirement, and prerequisite for CHEM 237

**Program Outcomes:**

Program outcomes a, b, and I
CHEM 237 - ORGANIC CHEMISTRY I

Required course for Cell & Tissue Track; alternative course Neural Engineering (or MATH 333) and Medical Imaging (or PHYS 224) Tracks

Catalogue Description:

The constitution and properties of the different classes of organic compounds, with considerable attention to stereochemistry, reaction mechanisms, synthetic organic and bio-organic chemistry, and spectroscopy. The laboratory work involves an introduction to the major synthetic and analytical techniques of organic chemistry including the preparation of representative organic compounds and the isolation of compounds from natural sources. 3-4-4 (C)

Instructor: Professor Hyun-Soon Chong, , LS 398, Chong@iit.edu, 312-567-3235
Chemistry Division, BCPS Dept, IIT

Prerequisite: CHEM 125

Course Hours: TR 5:00 PM to 6:15 PM in Stuart Bldg 113


Course Objectives
1. Write mechanisms of organic chemical reactions leading to or involving ethers, epoxides, sulfides, aromatics, carbonyl compounds, carboxylic acid derivatives, and amines.
2. Draw structures of products of organic chemical reactions involving ethers, epoxides, sulfides, aromatics, carbonyl compounds, carboxylic acid derivatives, and amines.
3. Devise short synthetic sequences leading to organic molecules.
4. Elucidate the structure of organic molecules by interpretation of ultraviolet, infrared, nuclear magnetic resonance and mass spectra.
5. Demonstrate proficiency in organic nomenclature and other topics related to ethers, epoxides, sulfides, aromatics, carbonyl compounds, carboxylic acid derivatives, and amines.
6. Identify the structure and understand the biosynthesis of carbohydrates, nucleic acids, amino acids, peptides, proteins, lipids and synthetic polymers.

Major topics:

See course description


Criterion 5:
Required course for Cell & Tissue Track, alternative course for Neural Engineering Tracks (or MATH 333) and Medical Imaging (PHYS 224) Tracks, fulfills 4 credits of math/science requirement.

Program Outcomes:

a, b, and l
CHEM 239 – Organic Chemistry II

Required course for Cell & Tissue Track; alternative course for Neural Engineering (or a technical elective) and Medical Imaging Tracks (or MATH 333)

Peter Johnson, PhD, Room 298, LS

Course Description:

Sequel to Organic Chemistry I. Constitution and properties of organic compounds at a fundamental level. Introduction to biological materials and synthetic polymers. 3-0-3

Prerequisite:

CHEM 237

Schedule:

1:50 to 3:05 PM, Wed/Fri, RM 111 LS

Textbooks:


Supplies:

Molecular Model Set for Organic Chemistry, Prentice Hall, optional

Major Topics:

See course description

Prepared by P. Johnson, PhD, 1/20/2007

Criterion 5:

Required course for Cell & Tissue Track, alternative course for Neural Engineering (or a technical elective) and Medical Imaging (or MATH 333) Tracks, fulfills 3 credits of math/science requirement

Program Outcomes:

a and I
CS 105 Introduction to Computer Programming I

Required course for Cell and Tissue Engineering Track

Catalog Data:

Introduces the use of a high-level programming language as a problem-solving tool—including basic data structures and algorithms, structured programming techniques, and software documentation. Designed for students who have had little or no prior experience with computer programming. (2-1-2) NOT FOR COMPUTER SCIENCE MAJORS, SERVICE COURSE

Textbook:

Or similar if different language is used

Student Learning Objectives:

Students should be able to:
Analyze and explain the behavior of simple programs involving the following fundamental programming constructs: assignment, I/O (including file I/O), selection, iteration, functions
Write a program that uses each of the following fundamental programming constructs: assignment, I/O (including file I/O), selection, iteration, functions
Break a problem into logical pieces that can be solved (programmed) independently.
Develop, and analyze, algorithms for solving simple problems.
Use a suitable programming language, and development environment, to implement, test, and debug algorithms for solving simple problems.
Write programs that use each of the following data structures (and describe how they are represented in memory): strings, arrays, and class libraries including strings and vectors

Class Schedule:

Two 50 minute class meetings and one 50 minute lab each week

Major Topics Covered in the Course:

1. Development Environment, Program Elements 3 hours

2. Data Types, Expressions, Basic I/O, Data Type Conversion, Library Functions, Strings (introduction) 3 hours

3. Selection 6 hours
4. Stream File I/O, Output Manipulators  4 hours
5. Iteration  8 hours
6. Functions (scope, pass by reference, overloading)  3 hours
7. Arrays, Vector Class  9 hours
8. Project 5 hours
Quiz #1, Midterm Exam, Quiz #2 4 hours
Final Exam

Prepared by  Matt Bauer 3 June 2008

Criterion 5:

Required course for Neural Engineering Track, fulfills 2 credits of math/science requirements, fulfills IIT CS requirement, and co-requirement for BME 200

Program Outcomes:
k
CS 115 Object-Oriented Programming I

Required Course for Neural Engineering Track

Catalog Data:

Introduces the use of a high-level object-oriented programming language as a problem-solving tool – including basic data structures and algorithms, object-oriented programming techniques, and software documentation. Designed for students who have had little or no prior experience with computer programming. For students in CS and CS related degree programs. (2-1-2)

Textbook:


Student Learning Objectives:

Students should be able to:
- Analyze and explain the behavior of simple programs involving the following fundamental programming constructs: assignment, I/O (including file I/O), selection, iteration, methods
- Write a program that uses each of the following fundamental programming constructs: assignment, I/O (including file I/O), selection, iteration, methods
- Break a problem into logical pieces that can be solved (programmed) independently.
- Develop, and analyze, algorithms for solving simple problems.
- Use a suitable programming language, and development environment, to implement, test, and debug algorithms for solving simple problems.
- Write programs that use each of the following data structures (and describe how they are represented in memory): strings, arrays
- Explain and apply object-oriented design and testing involving the following concepts: data abstraction, encapsulation, information hiding
- Use a development environment to design, code, test, and debug simple programs, including multi-file source projects, in an object-oriented programming language.
- Implement basic error handling
- Apply appropriate problem-solving strategies
- Use APIs (Application Programmer Interfaces) and design/program APIs

Class Schedule:

Two 50 minute class meetings and one 50 minute lab each week

Major Topics in the Course:

1. Fundamental data storage and manipulation (types and variables, statements and expressions)
   6 hours
2. Functions  4 hours

3. Classes (classes and objects, instance variables and instance methods, and encapsulation).  6 hours

4. Flow of control (Boolean expressions, conditional statements, and loops).  12 hours

5. Vectors  6 hours

6. Problem Solving approaches (This section is dispersed appropriately throughout the semester to illustrate the above techniques.)  3 hours

7. Software Engineering – design, testing, debugging (This section is dispersed appropriately throughout the semester to illustrate the above techniques.)  6 hours

Exams  2 hours

Final Exam

**Prepared by Matt Bauer 3 June 2008**

**Criterion 5:**

Required course for Neural Engineering Track, fulfills 2 credits of math/science requirements, fulfills IIT CS requirement, co-requisite for BME 200

**Program Outcomes:**

k
CS 201- Accelerated Introduction to Computer Science

Required course for Medical Imaging Track

Catalog Data:

Problem-solving and design using an object-oriented programming language. Introduces a variety of problem solving techniques, algorithms, and data structures in object-oriented programming. Prerequisites: CS105 or CS 115 or experience using any programming language. (3-2-4)

Textbook:


Student Learning Objectives:

Students should be able to:

Analyze and explain the behavior of simple programs involving the following fundamental programming constructs: assignment, I/O (including file I/O), selection, iteration, methods
Write a program that uses each of the following fundamental programming constructs: assignment, I/O (including file I/O), selection, iteration, methods
Break a problem into logical pieces that can be solved (programmed) independently.
Develop, and analyze, algorithms for solving simple problems.
Use a suitable programming language, and development environment, to implement, test, and debug algorithms for solving simple problems.
Write programs that use each of the following data structures (and describe how they are represented in memory): strings, arrays
Explain the basics of the concept of recursion.
Write, test, and debug simple recursive functions and procedures.
Explain and apply object-oriented design and testing involving the following concepts: data abstraction, encapsulation, information hiding, inheritance, polymorphism
Use a development environment to design, code, test, and debug simple programs, including multi-file source projects, in an object-oriented programming language.
Implement basic error handling
Solve problems by creating and using sequential search, binary search, and quadratic sorting algorithms (selection, insertion)
Determine the time complexity of simple algorithms.
Apply appropriate problem-solving strategies
Use APIs (Application Programmer Interfaces) and design/program APIs

Class Schedule:
Three 50 minute lectures and 2 hours of lab per week

**Major Topics Covered in the Course:**

1. Fundamental data storage and manipulation (types and variables, statements and expressions) 5 hours
2. Functions 3 hours
3. Classes (classes and objects, instance variables and instance methods, and encapsulation). 5 hours
4. Flow of control (Boolean expressions, conditional statements, and loops). 10 hours
5. Vectors 5 hours
6. Review of CS115 material 10 hours
7. Inheritance (subclasses, dynamic binding, abstract classes, and interfaces). 5 hours
8. Strings 3 hours
9. Introduction to recursion. 3 hours
10. Searching and sorting algorithms (linear and binary search, selection sort, insertion sort, and quick sort - introduced via recursive versions). 5 hours
11. Algorithm analysis. 2 hours
12. Problem Solving approaches (This section is dispersed appropriately throughout the semester to illustrate the above techniques.) 5 hours
13. Software Engineering – design, testing, debugging (This section is dispersed appropriately throughout the semester to illustrate the above techniques.) 10 hours

Exams 4 hours
Final Exam

Prepared by Matt Bauer 3 June 2008

**Criterion 5:**

Required course for Medical Imaging Track, fulfills IIT CS requirement; fulfills 4 credits of math/science requirements, and co-requisite for BME 200

**Program Outcomes:**

K
MATH 151: Calculus I - Required

Course Description from Bulletin: Analytic geometry. Functions and their graphs. Limits and continuity. Derivatives of algebraic, trigonometric and inverse trigonometric functions. Applications of the derivative. Introduction to integrals and their applications. (4-1-5) (C)

Enrollment: Required for AM majors and all engineering majors


Other required material: Maple

Prerequisites: Must pass departmental pre-calculus placement exam

Objectives:
1. Students will understand and be able to apply the concept of limit, continuity, differentiation, and integration (all single variable).
2. Students will learn to distinguish between definitions and theorems and will be able to use them appropriately.
3. Students will know and be able to apply laws/formulas to evaluate limits, derivatives, and (some) integrals.
4. Students will interpret the basic calculus concepts from both algebraic and geometric viewpoints.
5. Students will be able to use calculus in basic applications, including related rate problems, linear approximation, curve sketching, optimization, Newton's method, volume and area.
6. Students will use Maple for visualization and calculating exact and approximate solutions to problems.
7. Students will do a writing project.

Lecture schedule: Three 67 minute lectures and one 75 minute TA session (Maple computer lab and recitation) per week

Course Outline: Hours
1. Elementary analytic geometry, functions, trigonometry 3
2. Limits, continuity, tangent lines 7
3. The derivative, differentiation of algebraic and trigonometric functions, implicit functions, related rates of change 18
4. Applications of the derivative 6
5. Theory of inverse functions and their derivatives, inverse trigonometric functions and their derivatives 3
6. Anti-derivatives, definite and indefinite integrals, Fundamental Theorem of Calculus 13
7. Applications of the Integral 5
Assessment: Homework/Quizzes 10-20%
            Maple Lab/Recitation 5-15%
            Tests 40-50%
            Final Exam 25-30%

Syllabus prepared by: Michael Pelsmajer and Dave Maslanka
Date: 01/10/06 (Last updated: Oct.23, 2007)

Criterion 5:

Required math course for all BME majors that fulfills 5 credits in math/science requirements, required for 200 level math courses, and for Physics 123

Program Outcomes:

Preparation for Outcomes a, e, k, and l
MATH 152: Calculus II - Required

Course Description from Bulletin: Transcendental functions and their calculus. Integration techniques. Applications of the integral. Indeterminate forms and improper integrals. Polar coordinates. Numerical series and power series expansions. (4-1-5) (C)

Enrollment: Required for AM majors and all engineering majors


Other required material: Maple

Prerequisites: Grade of "C" or better in MATH 151 or MATH 149 or Advanced Placement

Objectives:
1. The student should acquire a sound understanding of the common transcendental functions.
2. The student should become proficient in the basic techniques of integration for the evaluation of definite, indefinite, and improper integrals.
3. The student should learn to solve first-order separable and linear differential equations with initial values.
4. The student should learn parametric curves and polar curves and their calculus.
5. The student should learn infinite series, power series and Taylor polynomial and series, and their convergence properties.
6. The student should be able to utilize the computer algebra system Maple to explore mathematical concepts, illustrate them graphically, and solve problems numerically or symbolically.
7. The student should become a more effective communicator by developing his/her technical writing skills in the preparation of several Maple lab reports.

Lecture schedule: Three 67 minute lectures and one 75 minute TA session (Maple computer lab and recitation) per week

Course Outline:          Hours
1. Inverse Functions and their derivatives; Exponential and logarithmic functions; Indeterminate forms and L'Hospital's rule  12
2. Techniques of integration; Improper integrals                        12
3. Differential equations: Euler's method; 1st order separable DE's, exponential growth and decay; The logistic equation; 1st order linear DE's 8
4. Parametric equations and polar coordinates for plane curves 10
5. Sequences; Numerical series; Convergence tests; Power series; Taylor series; Applications of power/Taylor series 12
6. Complex numbers                                                      3
**Assessment:**  
- Homework/Quizzes: 10-20%  
- Maple Lab/Recitation: 5-15%  
- Tests: 40-50%  
- Final Exam: 25-30%

**Syllabus prepared by:** Xiaofan Li and Dave Maslanka  
**Date:** 12/15/05 (Last updated: Oct.23, 2007)

**Criterion 5:**  
Required math course for all BME majors that fulfills 5 credits of math/science requirements and required for 200 level math courses

**Program Outcomes:**  
Preparation for Outcomes a, e, k, and l
MATH 251: Multivariate and Vector Calculus - Required


Enrollment: Required for AM majors and some engineering majors


Prerequisites: Math 152

Objectives:

1. Students will learn to solve problems in three-dimensional space by utilizing vectors and vector-algebraic concepts. This includes representation in Cartesian, cylindrical and spherical coordinates.
2. Students will be able to describe the path, velocity and acceleration of a moving body in terms of vector-valued functions, and to apply the derivative and integral operators on space curves in order to characterize the length, curvature and torsion of a smooth curve.
3. Students will learn to extend the notion of continuity and differentiability to functions of several variables, and be able to interpret partial and directional derivatives as rates of change.
4. Students will be able to use partial differentiation to solve optimization problems. This includes being able to solve constrained optimization problems via Lagrange multipliers.
5. Students will learn to extend the notion of a definite integral from a one-dimensional to an n-dimensional space, and be able to describe and evaluate double and triple integrals in Cartesian and curvilinear coordinates.
6. Students will be able to work with vector-valued functions of several variables (i.e., vector fields) and be able to compute line and surface integrals.
7. Students will be able to use the theorems of Green, Stokes, and Gauss to solve classical physics problems.

Lecture schedule: 3 75 minute lectures per week

Course Outline:

<table>
<thead>
<tr>
<th>Hours</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1. Vectors and the Geometry of Space</td>
</tr>
<tr>
<td></td>
<td>A. Vectors in the plane</td>
</tr>
<tr>
<td></td>
<td>B. Cartesian coordinates and vectors in space</td>
</tr>
<tr>
<td></td>
<td>C. Dot products and cross products</td>
</tr>
<tr>
<td></td>
<td>D. Lines and planes in space</td>
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<tr>
<td></td>
<td>E. Cylinders and quadric surfaces</td>
</tr>
<tr>
<td></td>
<td>F. Cylindrical and spherical coordinates</td>
</tr>
<tr>
<td>6</td>
<td>2. Vector Functions and their Derivatives</td>
</tr>
<tr>
<td></td>
<td>G. Vector-valued functions and motion in space</td>
</tr>
<tr>
<td></td>
<td>H. Space curves</td>
</tr>
</tbody>
</table>
I. Arc length and the unit tangent vector

3. Partial Derivatives 12
   J. Functions of several variables
   K. Limits and continuity, partial derivatives, differentiability
   L. Linearization and differentials
   M. Chain rule
   N. Gradient vector, tangent planes, directional derivatives
   O. Extreme values and saddle points,
   P. Lagrange multipliers
   Q. Taylor's formula

4. Multiple Integrals 13
   R. Double integrals
   S. Areas, moments, and centers of mass
   T. Double integrals in polar form
   U. Triple integrals in rectangular coordinates
   V. Masses and moments in 3-D
   W. Triple integrals in cylindrical and spherical coordinates
   X. Substitutions in multiple integrals

5. Vector Calculus 13
   Y. Integration in vector fields
   Z. Line integrals
   AA. Vector fields
   BB. Work, circulation, and flux
   CC. Path independence, potential functions, and conservative fields
   DD. Green's theorem in the plane
   EE. Surface area and surface integrals
   FF. Parameterized surfaces
   GG. Stokes' theorem
   HH. Divergence theorem and a unified theory

Assessment: Homework/Quizzes 10-25%
Tests 40-50%
Final Exam 25-30%

Syllabus prepared by: Andre Adler and Greg Fasshauer
Date: 12/15/05

Criterion 5:
Required math course for all BME majors that fulfills math/science credits and required
for entry into BME and other engineering courses

Program Outcomes:
Preparation for Outcomes a, e, k, and l
MATH 252: Introduction to Differential Equations - Required


Enrollment: Required for AM majors and some engineering majors


Other required material: None

Prerequisites: Math 152

Objectives:
1. Students will be able to classify and solve first-order DEs and IVPs of various types: especially separable, exact, linear, and others reducible to them.
2. Students will be able to solve higher-order linear DEs and IVPs having constant coefficients via the method of undetermined coefficients and variation of parameter.
3. Students will be able to obtain power series solutions (about regular points) of second-order linear DEs having variable coefficients.
4. Students will be able to manipulate Laplace transforms and to solve linear IVPs using them.
5. Students will be able to solve systems of first-order linear DEs.
6. Students will be able to solve a variety of physical problems modeled by first-order and linear second-order IVPs.

Lecture schedule: 3 75 minute lectures per week

Course Outline: Hours
1. Linear Equation of Higher Order 12
   a. Initial-value and boundary-value problems
   b. Linear dependence and linear independence
   c. Solutions of linear equations
   d. Homogeneous linear equations with constant coefficients
   e. Undetermined coefficients
   f. Variation of parameters
2. Application 4
   a. Free undamped motion
   b. Free damped motion
   c. Driven motion
   d. Power series solutions, solutions about ordinary points
3. Laplace Transforms 15
   a. Laplace transform and inverse transform
b. Translations theorems and derivatives of a transform
c. Transforms of derivatives, integrals and periodic functions
d. Applications
e. Systems of linear equations

4. Introduction to Matrices
   a. Basic definitions and theory
   b. Gaussian elimination
   c. Eigenvalues

5. Systems of Linear First-Order Differential Equations
   a. Preliminary theory
   b. Homogeneous linear systems
   c. Distinct real eigenvalues, repeated eigenvalues, complex eigenvalues
   d. Variation of parameters

Assessment:
Homework: 10-25%
Quizzes/Tests: 40-50%
Final Exam: 25-30%

Syllabus prepared by: Andre Adler and Warren Edelstein
Date: 12/15/05

Criterion 5:
Required math course for all BME majors that fulfills 4 credits in math/science requirements and required for entry into BME and other engineering courses

Program Outcomes:
Preparation for Outcomes a, e, k, and l
MATH 333 – Matrix Algebra and Complex Variables

Math 333 or Chem 237 are required for the Neural Engineering Track Math 333 or Chem 239 are required for the Medical Imaging Track

Course Description from Bulletin: Vectors and matrices; matrix operations, transpose, rank, inverse; determinants; solution of linear systems; eigenvalues and eigenvectors. The complex plane; analytic functions; contour integrals; Laurent series expansions; singularities and residues. (3-0-3)

Enrollment: Not applicable for Math majors; Required course for EE majors; Math elective for CPE majors


Other required material:

Prerequisites: MATH 251

Objectives:
1. Students will be able to evaluate, determine domains, and ranges (conformal mappings of regions), compute derivatives, anti-derivatives of standard complex functions.
2. Students will be able to determine harmonic conjugates, check for analyticity by Cauchy-Riemann equations.
3. Students will be able to expand analytic functions in Taylor and Laurent series.
4. Students will be able to apply Cauchy's Theorem and the Cauchy Integral Formulas to evaluate complex integrals.
5. Students will be able to find residues, zeros, and evaluate real integrals of rational and trigonometric functions by Cauchy’s residue theorem.
6. Students will be able to solve systems of equations by Gauss-Jordan elimination, compute nullity and rank of linear transformations/matrices.
7. Students will be able to represent linear transformations by matrices and vice-versa.
8. Students will be able to compute eigenvalues and eigenvectors of a matrix.

Lecture schedule: 3 50 minute (or 2 75 minute) lectures per week

Course Outline: Hours
1. Linear Algebra: Matrices, Vectors, Determinants 8
   a. Basic concepts, matrix addition, scalar multiplication, matrix multiplication
   b. Inverse of a matrix
   c. Determinants
   d. Systems of linear equations
   e. Gauss elimination
   f. Eigenvalues, eigenvectors, and applications
   g. Symmetric, skew-symmetric, and orthogonal matrices

201
h. Hermitian, skew-Hermitian and unitary matrices
i. Properties of eigenvalues, diagonalization

2. Complex Numbers, Complex Analytic Functions
   a. Complex numbers, complex plane, polar form
   b. Powers and roots
   c. Curves and regions in the complex plane
   d. Limit, derivative, and analytic functions
   e. Cauchy-Riemann equations
   f. Exponential functions, trigonometric functions, hyperbolic functions
   g. Logarithm, general power

3. Complex Integration
   a. Line integrals in the complex plane
   b. Cauchy’s integral theorem
   c. Existence of indefinite integrals
   d. Cauchy’s integral formula
   e. Derivatives of analytic functions

4. Power Series, Taylor Series, Laurent Series
   a. Review of power series
   b. Taylor series
   c. Uniform convergence
   d. Laurent series
   e. Singularities and zeroes

5. Residue Integration Method
   a. Residues
   b. Residue theorem
   c. Evaluation of real integrals

**Assessment:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>20-30%</td>
</tr>
<tr>
<td>Quizzes/Tests</td>
<td>40-50%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>20-30%</td>
</tr>
</tbody>
</table>

**Syllabus prepared by:** Warren Edelstein and Greg Fasshauer

**Date:** 9/18/06

**Criterion 5:**
Required math course (or Chem 237) that fulfills math/science credits for the Neural Engineering Track
Required math course (or Chem 239) that fulfills math/science credits for the Medical Imaging Track

**Program Outcomes:**
Preparation for Outcomes a, e, and l
**PHYS 123: General Physics I: Mechanics – Required**

**Catalog Data:**

Vectors and motion in one, two, and three dimensions. Newton’s Laws; particle dynamics, work and energy. Conservation laws and collisions. Rotational kinematics and dynamics, angular momentum and equilibrium of rigid bodies. Simple harmonic motion. Gravitation. (3-3-4)

**Co-requisite:**

MATH 149, MATH 151, or MATH 161

**Textbooks:**


**Course Objectives and Material Covered:**

See Catalog Description for material description. The purpose of the laboratory is to familiarize the student with the physical phenomena being studied, and to teach techniques in experimental observation and data analysis.

**Schedule:**

PHYS 123 meets in either 2 75-minute lecture sessions per week. The laboratory meets for 3-hour sessions on alternate weeks, alternating with recitations conducted by the class lecturer.

**Prepared by:** H. A. Rubin, Associate Chair for Physics, 4/04/08

**Criterion 5:**

Required course for all BME majors that fulfills 4 credits of math/science requirements and required for Physics 221

**Program Outcomes:**

Preparation for Outcomes a and l
PHYS 221: General Physics II: Waves, Electricity and Magnetism – REQUIRED

Catalog Data:


Prerequisite: PHYS 123.

Co-requisite: MATH 152 or MATH 162

Textbooks:

Physics for Engineers and Scientists, Third Edition, Ohanion & Markert, Physics Division and General Physics Laboratory Manual

Course Objectives and Material Covered:

See Catalog Description for material description. The purpose of the laboratory is to familiarize the student with the physical phenomena being studied, and to teach techniques in experimental observation and data analysis.

Schedule:

PHYS 221 meets in 2 75-minute lecture sessions per week. The laboratory meets for 3-hour sessions on alternate weeks, alternating with recitations conducted by the class lecturer.

Prepared by: H. A. Rubin, Associate Chair for Physics, 4/04/08

Criterion 5:

Required course for all BME majors that fulfills 4 credits of math/science requirements, required for Physics 224, and required for BME 309 and BME 443.

Program Outcomes:

Preparation for Outcomes a and I
PHYS 224: General Physics III: Thermodynamics and Modern Physics

Physics 224 or Chemistry 237 are required for the Medical Imaging Track to fulfill required math and science credits


Textbooks: “Physics for Engineers and Scientists,” Third Edition, Ohanion & Markert

Course Objectives and Material Covered: See Catalog Description for material description.

Schedule: PHYS 224 meets in either 2 75-minute lecture sessions per week.

Contribution to Professional Components:
PHYS 224 contributes 3/32 of a year of college level basic science. PHYS 224 contributes to program outcomes by promoting proficiency in science.

Prepared by: H. A. Rubin, Associate Chair for Physics, 4/04/08

Criterion 5:
Required science course (or CHEM 237) for the Medical Imaging Track

Program Outcomes:
Preparation for Outcomes a and l
APPENDIX B: FACULTY RESUMES

Mark Anastasio
Konstantinos Arfanakis
Eric Brey
Jennifer Kang-Derwent
Paul Fagette
David Gatchell
Connie Hall
Derek Kamper
David Mogul
Emanuel Opara
Georgia Papavasiliou
Phil Troyk
Vincent Turitto
Mark A. Anastasio
Associate Professor

Degrees:
Illinois Institute of Technology  Electrical Engineering  B.S.  1992
University of Pennsylvania  Electrical Engineering  M.S.E  1993
University of Illinois at Chicago  Physics  M.S.  1995
The University of Chicago  Medical Physics  Ph.D.  2001

Current Appointment:
2006-present  Associate Professor of Biomedical Engineering

Other Related Experience:
2001-2006  Assistant Professor of Biomedical Engineering
1995-July 2001  Research Assistant, Radiology, The University of Chicago

Consulting, Patents, etc.:
None

Professional License or Certification:
None

Publications:
C-Y Chou, M. A. Anastasio, J.B. Brankov, M.W. Wernick, E. Brey, D. Connor and Z. Zhong: An Extended DEI Method for Implementing Multiple-Image Radiography, 52,


**Professional Societies:**

Optical Society of America (OSA)
Institute for Electrical and Electronic Engineers (IEEE)
International Society for Optical Engineering (SPIE)

**Honors and Awards:**

2003-2006   Whitaker Foundation Investigatorship Award
2006       NSF CAREER Award - Development of Biomedical X-ray Phase-Contrast Tomography
2006       IIT Sigma Xi Award for Excellence in Research, Junior faculty category

**Institutional and Professional Service:**

2007-present  Associate Director, Medical Imaging Research Center (MIRC)
2007-present  BME Department Representative on the Armour College Committee on Education
2006-2007    BME Chairman Search Committee
2006-present BME Department Representative on the Campus Committee on Promotion and Tenure (CAMCOPT)
2006-present Undergraduate Coordinator for BME Department
2006-present BME representative for the IIT Undergraduate Studies Committee
2004-present ABET committee member for BME Department
2002-2007    Graduate Recruitment Chairman for BME Department
2002-present BME representative on the IIT High Performance Computing Task Force
2001-present Grant reviewer for NIH, NSF and reviewer for over 15 journals

**Research or Scholarly Activity Percentage:** 57%
BME Program Percentage: 100%
KONSTANTINOS ARFANAKIS  
Assistant Professor

Degrees:
University of Athens, Greece  Physics  BS  1997  
University of Wisconsin, Madison  Medical Physics  MS  1999  
University of Wisconsin, Madison  Medical Physics  Ph.D.  2002

Current Appointment:
2003-present  Assistant Professor of Biomedical Engineering

Other Related Experience:
March 1998- June 2002, Research Assistant in the Department of Medical Physics, University of Wisconsin-Madison, Medical School.  
July 2002-January 2003, Research MR Physicist for Philips Medical Systems in the Radiology Department of Miami Children's Hospital.  
January 2003 - present, Assistant Professor in the Department of Biomedical Engineering at the Illinois Institute of Technology (IIT), Director of the MRI Laboratory.  
November 2006 - present, Visiting Professor in the Department of Diagnostic Radiology and Nuclear Medicine at Rush University Medical Center.

Consulting, Patents, etc.:
Gerson Lehrman Group Councils Member (2003-present)  
Miami Children's Hospital, Miami, FL. (2004-present). ACR accreditation tests.  
Dartmouth Medical School, Hanover, NH. (2001-2007). Development of diffusion tensor imaging and functional MRI protocols at the Advanced Imaging Center.  
Riken Brain Science Institute, Wako, Japan. (2005-present). Combination of diffusion tensor imaging (DTI) and magnetoencephalography (MEG) data.

Professional License or Certification:
None

Publications:
K. Arfanakis, B.P. Hermann, B.P. Rogers, J.D. Carew, M. Seidenberg, M.E. Meyerand. Diffusion


**Professional Societies:**

**Honors and Awards:**
2001 Vilas Fellowship.
1999-2002 ISMRM student stipend.
2002 Magna Cum Laude, Radiological Society of North America (RSNA)
2002 Excellence in Design of Education Exhibit, Radiological Society of North America (RSNA)
2007 Sigma Xi Award for Excellence in University Research.

**Institutional and Professional Service:**
Graduate program committee (2004-present)
Premedical studies advisor (2005-present)
Rush Alzheimer’s Disease Center Executive Committee Member (July 2006-present)
Armour College of Engineering Dean Search Committee (2007-2008)
Undergraduate Laboratory Planning and Safety Committee (2007-present)
Member of the Editorial Board of the Journal “Brain Imaging and Behavior” published by Springer. (2006-present)

**Research or Scholarly Activity Percentage:** 63%
**BME Program Percentage:** 100%
ERIC M. BREY

Assistant Professor

Degrees:
University of Louisville  Chemical Engineering  BS  1996
University of Louisville  Chemical Engineering  MEng  1997
Rice University   Chemical Engineering  PhD  2003

Current Appointments:
2007-Current   Assistant Dean of Undergraduate Research, IIT
2004-Current  Assistant Professor of Biomedical Engineering, IIT
2006-Current  Research Health Scientist, Department of Research, Hines V.A. Hospital

Other Related Experience:
2003-2005 Research Associate, Department of Surgery, Loyola University Medical
Center, Maywood, IL
2003-2005 Research Associate, Department of Research, Hines V.A. Hospital,
Hines, IL

Consulting, Patents, etc.:
1. Brey E.M., Lalani Z., Patrick Jr. C.W., Wong M. Automated Feature Extraction & Analysis of
DAB-stained Antigens (invention disclosure, IDR01-189).
Membrane Hydrogels from Human and Animal Tumors and Tissue (Application filed
10/30/06).

Professional License or Certification:
None

Tissue Engineering.  In Press
The Role of Adipose Protein Derived Hydrogels in Adipogenesis.  Biomaterials.  Accepted.
3. Papavasiliou G.P., Songprawat P., Perez-Luna V.H., Hammes E.H., Morris M., Chiu Y.C.,  
Brey E.M. Three Dimensional Patterning of Poly(ethylene glycol) Hydrogels Through 
Surface Initiated Photopolymerization.  Tissue Engineering, Part C.  Accepted.
W.A., Velander W.H., Burgess W.H., Greisler H.P. Construction and Characterization of a 
Zhong Z. An extended diffraction-enhanced imaging method for implementing multiple-


**Professional Societies:**

Biomedical Engineering Society, International Society of Applied Cardiovascular Biology, Tissue Engineering and Regenerative Medicine International Society

**Honors and Awards:**

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>Visiting Prof., Dept. of Plastic and Reconstructive Surg., Chang Gung Memorial Hospital, Taiwan</td>
</tr>
<tr>
<td>2007-2008</td>
<td>Coleman Faculty Scholar</td>
</tr>
<tr>
<td>2004</td>
<td>International Society of Applied Cardiovascular Biology Young Investigator Award</td>
</tr>
<tr>
<td>2003-2006</td>
<td>National Institutes of Health (NIH) National Research Service Award</td>
</tr>
</tbody>
</table>

**Institutional and Professional Service:**

Assistant Dean of Undergraduate Research, Campus Entrepreneurship Committee, Chair Search Committee, Safety Committee, Campus Code of Ethics Focus Group, Heat/mass committee, Baxter internship coordinator, Graduate Program Committee, Journal reviewer

**Research or Scholarly Activity Percentage:** 52%

**BME Program Percentage:** 100%
PAUL H. FAGETTE, JR.
Historian in Residence and Senior Lecturer

Degrees:

California State University, Fullerton  History  BA  1974
California State University, Fullerton  History  MA  1975
University of California, Riverside  History  PhD  1985

Current Appointment:
2001- present: Historian in Residence and Senior Lecturer, Biomedical Engineering, Department of Biomedical Engineering, Illinois Institute of Technology

Other Related Experience:
1999-Present  Historian, Biomedical Engineering Society
1991-2001  Associate Professor, History, Department of History, Arkansas State University, Jonesboro, AR
1991-1996  Director, Social Studies Program, Department of History, Arkansas State University, Jonesboro, AR
1982-87  Lecturer, History, Department of History, California State University, San Bernadino, San Bernadino, CA

Consulting Patents, etc.:
N/A

Professional License or Certification:
Lifetime Teaching Credential (Fisher), Secondary, California, 1976

Publications:
Editor, *A Tribute to the Whitaker Foundation*, Biomedical Engineering Society, October 2005.
2000:142.

Professional Societies:

Biomedical Engineering Society
American Society for Engineering Education

Honors and Awards:
N/A

Institutional and Professional Service:

Historian for the Biomedical Engineering Society.
Work within the Department of Biomedical Engineering as an interdisciplinary contact to reach out to multiple disciplines and groups to expand the understanding and importance of biomedical engineering with others such as the Department of Math and Science Education.
Teach 2 semester course in the History of Artificial Organs for the College of Science and Letters. Team-teach the Introduction to the Profession for Biomedical Engineering Course, BME 100. Teach BME 490, Senior Seminar, Teach BME 497, Special Problems: various topics that include building historic artificial organs.
Co-advisor for the Biomedical Engineering Society Student Chapter at IIT.
Advisor for the Hawaiian Students Club at IIT.
Working with other biomedical engineering faculty to incorporate historic/critical thinking elements into curriculum.
Developed working relationship with the Museum of Science and Industry to develop prototype exhibits integrating engineering, basic science, and medicine. Two years ago, a team of undergraduate engineering students built a full-scale working model of the original Kolff rotating drum dialysis device, 1943-44.

Percentage of Time available for research or scholarly activities:
20%

Percentage of time committed to the program:
100%
David W. Gatchell

Research Assistant Professor

Degrees:

Bowdoin College    Physics   AB  1993
Boston University    Biomedical Engineering  PhD  2002

Current Appointment:

2007-present    Research Assistant Professor of Biomedical Engineering
2007-present    Assistant Director of the Pritzker Institute of Biomedical Science and Engineering

Other Related Experience:

2005-2007    Research Associate, VaNTH ERC, Northwestern University, Evanston, IL
2003-2004    Postdoctoral Research Fellow, Northwestern University, Evanston, IL
2002-2003    Postdoctoral Research Fellow, Boston University, Boston, MA

Consulting, Patents, etc.:

None

Professional License or Certification:

None

Publications:


Comeau SR, Gatchell DW, Vajda S, Camacho CJ. ClusPro: an automated docking and


**Professional Societies:**

Biomedical Engineering Society
American Society of Engineering Education

**Honors and Awards:**

Recipient, Teaching Grants for Innovative Faculty, Illinois Institute of Technology
BME Graduate Teaching Fellow of the Year, Boston University
Governmental Areas of National Need (GANN) Doctoral Fellow

**Institutional and Professional Service:**

Associate Editor, Engineering Pathways, Bioengineering and BME Education Division
Member, BME ABET Committee, Undergraduate Curriculum Committee
Co-chair, Educational Symposium, “What is a Biomedical Engineer?” BMES Annual Meeting, October, 2006, Chicago, IL.

**Research or Scholarly Activity Percentage:**

15%

**BME Program Percentage:**

100%
CONNIE L. HALL
Senior Lecturer

Degrees:
University of California, San Diego  Bioengineering  BS  1986
University of California, San Diego  Bioengineering  MS  1987
University of Memphis  Biomedical Engineering  Ph.D.  1996

Current Appointment:
2001-present  Assistant Professor of Biomedical Engineering

Other Related Experience:
1987-1989  Research Associate I, University of California, San Diego
1989-1990  Research Associate II, University of California, San Diego
1990-1991  Associate Scientist, Corvas International, Inc., San Diego, CA
1992-1995  Herff Research Fellow in Biomedical Engineering, Memphis, TN
1996-1999  NIH Research Service Award Fellow, The University of Memphis,
            Memphis, TN
1999-2001  Assistant Professor, Biomedical Engineering, The University of Memphis

Consulting, Patents, etc.:
Consultant, Hearten Inc., 1994 – Developed 2D and 3D computational models (using Fluent, Inc.) for anastamoses of vascular bypass grafts

Professional License or Certification:
None

Publications:
Mast, A. E., Acharya, N., Malecha, M. J., Hall, C. L., and Dietzen DJ Characterization
of the Association of Tissue Factor Pathway Inhibitor with Human Placenta.

Dietzen, Dennis J., Jack Garnet G., Page, Keith L., Tetzloff, Tina, A., Hall, Connie L.,
Mast Alan E., Localization of tissue factor pathway inhibitor to lipid rafts is not required
for inhibition of factor VIIa/tissue factor activity. Thrombosis and Haemostasis, 89:65-73,
2003.

Raybagkar, Deepti, Patchipulusu, Sirisha, Mast Alan E., Hall, Connie L., In vitro flow
evaluation of recombinant tissue factor pathway inhibitor immobilized on collagen


**Professional Societies:**

Biomedical Engineering Society  
American Society of Engineering Education  
American Society of Artificial Internal Organs

**Honors and Awards:**

Herff Research Fellow, University of Memphis, 1991-1995  
NIH Research Service Award Fellow, 1996-1999  
Whitaker Foundation Investigator Award, 2000-2004  
ASAIO Young Investigator Award, 2008

**Institutional and Professional Service:**

BME Undergraduate Coordinator, BME ABET Coordinator, BME Cell and Tissue Track Director, IIT Radiation Safety Committee, IIT Institutional Animal Care and Use Committee, IIT Undergraduate Studies Committee

**Research or Scholarly Activity Percentage:** 35%

**BME Program Percentage:** 100%
DEREK G. KAMPER

Assistant Professor

Degrees:

Dartmouth College Electrical Engineering AB,BE 1989
Ohio State University Biomedical Engineering MS 1992
Ohio State University Biomedical Engineering PhD 1997

Current Appointment:

2005-present Assistant Professor of Biomedical Engineering
2002-present Research Scientist, Rehabilitation Institute of Chicago

Other Related Experience:

1997-2000 Postdoctoral Fellow, Rehabilitation Institute of Chicago/ Northwestern University
2000-2002 Associate Director, Sensory Motor Performance Program, Chicago, IL
2000-2005 Assistant Research Professor, Northwestern University, Chicago, IL
2002-2003 Managing Editor, IEEE Transactions on Neural Systems and Rehabilitation Engineering

Consulting, Patents, etc.:

None

Professional License or Certification:

None

Publications:


Cruz EG, Kamper DG. Kinematics of point-to-point finger movements. Exp Brain Res 2006; 174: 29-34.


Professional Societies:

IEEE Engineering, Medical, and Biological Society
IEEE Robotics and Automation Society
Society for Neuroscience

Honors and Awards:

Whitaker Foundation Investigator Award
Individual NRSA Award for Postdoctoral Fellows, Rehabilitation Institute of Chicago
Institutional NRSA Award for Postdoctoral Fellows, Northwestern University
Ohio State University Presidential Fellowship
Ohio State University Alumni Fellowship

Institutional and Professional Service:

Finance Chair, IEEE International Conference on Rehabilitation Robotics, Chicago, IL, 2005; Ad hoc Associate Editor for IEEE Transactions on Neural Systems and Rehabilitation Engineering; Reviewer for over 15 journals including Annals of Biomedical Engineering, Journal of Biomechanics, and Journal of Biomechanical Engineering; Session Chair, Motor Control, Sophia, Bulgaria, 2005.

Research or Scholarly Activity Percentage:
28% at IIT

BME Program Percentage: 50%
JENNIFER J. KANG DERWENT

Associate Professor

Degrees:
Northwestern University Mathematics BA 1994
Northwestern University Applied Mathematics MS 1996
Northwestern University Biomedical Engineering Ph.D. 1999

Current Appointment:
2007-present Associate Professor of Biomedical Engineering

Other Related Experience:
1999-2001 Postdoctoral Research Associate, Department of Ophthalmology and Visual Sciences, University of Illinois at Chicago
2001-2007 Assistant Professor, Department of Biomedical Engineering, Pritzker Institute of Biomedical Science and Engineering, IIT

Consulting, Patents, etc.:
None.

Professional License or Certification:
None

Publications:


**Professional Societies:**

**Honors and Awards:**
Walter P. Murphy Fellowship, Graduate Fellowship, Northwestern University General Electric Faculty of the Future Intern Fellowship, General Electric National Eye Institute Travel Fellowship Grant, ARVO and National Eye Institute Committee on Institutional Cooperation Women in Science and Engineering Nelson Fellowship Award, Nelson Foundation Whitaker Foundation Fellow

**Institutional and Professional Service:**
BME Undergraduate Studies Committee, BME ABET Committee, Director of BME Undergraduate Laboratory, IIT Animal User Advisory Committee, Director of Neural Engineering, BMES faculty officer, Retention Committee, Tenure and Promotion Committee

**Research or Scholarly Activity Percentage:** 48%
**BME Program Percentage:** 100%
DAVID J. MOGUL  
Associate Professor

Degrees:

Cornell University  Electrical Engineering  BS  1979  
Northwestern University  Electrical Engineering  MS  1984  
Northwestern University  Electrical Engineering  PhD  1988  
Northwestern University  International Marketing  MBA  2000

Current Appointment:

2002-present  Associate Professor of Biomedical Engineering

Other Related Experience:

1979-1981  Systems Engineer, ADT, Inc. New York, NY  
1988-1991  Postdoctoral Fellow, Pharmacol/Physiol, University of Chicago  
1991-1992  Instructor, Pharmacol/Physiol, University of Chicago  
1992-1999  Assistant Professor, Biomedical Engr, Northwestern University  
1999-2002  Consultant, ZS Associates, Evanston, IL

Consulting, Patents, etc.:

Scientific Consultant, 2003-2005, NewNeural LLC, Lisle, IL  
President, 2007-present, Neurintech LLC, Chicago, IL

Professional License or Certification:

None

Publications:


Colpan, M.E., Sekerci, Z., Hekimmoglu, B. & MOGUL, D.J. Computer-assisted intra-


**Professional Societies:**

Institute for Electrical and Electronics Engineers
Engineering in Medicine and Biology Society
Society for Neuroscience
Biomedical Engineering Society

**Honors and Awards:**

McMullen Scholarship, Cornell University 1976-1979
Murphy Fellowship, Northwestern University 1981-1982
General Electric Scholarship, Northwestern University 1984-1985
Reingold Fellowship, Northwestern University 1984-1988
Neuroimmunology Training Grant, University of Chicago 1988-1990
NIH NRSA Fellowship Award, University of Chicago 1990-1992

**Institutional and Professional Service:**

BME Graduate Coordinator, IIT Animal Care and Use Advisory Committee, IIT Research Council, IIT BME Graduate Admissions, Center for Integrative Neuroscience & Neuroengineering Executive board member.

**Research or Scholarly Activity Percentage:**

57%

**BME Program Percentage:**

100%
EMMANUEL C. OPARA

Research Professor

Degrees:

University of Nigeria, Nsukka  Biochemistry  BS  1976
University of Surrey, Guildford, UK  Clinical Biochemistry  MS  1981
University of London, UK  Medical Biochemistry  Ph.D.  1984

Current Appointment:

2003-present  Research Professor of Biomedical Engineering

Other Related Experience:

1976-1977  Laboratory Scientist on National Youth Service, State Hospital, Ado Ekiti, Nigeria
1977-1978  Food and Drug Inspecting Officer, Federal Ministry of Health, Nigeria
1978-1980  Clinical Biochemist, Epsom Hospital Laboratories, Epsom Surrey, England
1980-1983  Demonstrator (Instructor) in Biochemistry, Chelsea College, University of London
1984-1986  W.H.O. Fellow in Endocrinology & GI Res, Mayo Clinic, Rochester, MN
1986-1988  Visiting Fellow, NIDDK, NIH, Bethesda, MD
1988-1993  Research Associate, Dept. of Surgery, Duke Univ Med Center, Durham, NC
1991-2003  Member, Stedman Center for Nutritional Studies, Duke Univ Med Center,
1994-1999  Assistant Research Professor, Department of Surgery, Duke Univ Med Center,
1996-2003  Assistant Research Professor, Dept. of Cell Biology, Duke Univ Med Center,
2000-2003  Associate Research Professor, Department of Surgery, Duke Univ Med Center,

Patents:


Professional License or Certification:

None

Publications:


El-Shewy H, Kendall Jr. WF, Darrabie MD, Collins BH, Opara EC. Polyvinylpyrrolidone:


Professional Societies:

American Diabetes Association
American Pancreatic Association
American Federation for Medical Research
Society of Black Academic Surgeons
American Gastroenterological Association
Transplantation Society

Honors and Awards:

World Health Organization Fellowship Award
Mayo Foundation Fellowship Award
John E. Fogarty Fellowship Award
NIH Scientific Review Study Sections

Institutional and Professional Service:

Member, IIT IPRO (Interprofessional Courses) Proposals Selection Committee
Co-Director, IIT Engineering Center for Diabetes Research & Education (ECDRE)

Research or Scholarly Activity Percentage:
30%

BME Program Percentage:
100%
GEORGIA PAPAVASILIOU

Assistant Professor

Degrees:
Illinois Institute of Technology, Chicago Chemical Engineering BS 1996
Illinois Institute of Technology, Chicago Chemical Engineering Ph.D. 2003

Current Appointment:
2007-present Assistant Professor of Biomedical Engineering

Other Related Experience:
2003 Research and Development Post-Doctoral Intern, Johnson Polymer, Sturtevant, WI
2003-2004 Adjunct Professor, Chemical and Environmental Engineering, Illinois Institute of Technology, Chicago, IL
2004-2007 Senior Lecturer and Assistant Director, Biomedical Engineering, Illinois Institute of Technology, Chicago, IL
2007-Present Assistant Professor, Biomedical Engineering, Illinois Institute of Technology, Chicago, IL

Consulting, Patents, etc.:
None

Professional License or Certification:
None

Publications:


**Professional Societies:**

Biomedical Engineering Society  
American Institute of Chemical Engineers  
American Society of Engineering Education  
Society for Biomaterials

**Honors and Awards:**

Outstanding Undergraduate Teaching Recognition,  
Armour College of Engineering, IIT  
University Teaching Assistant of the Year Award, IIT  
W. M. Langdon Excellence in Teaching in Chemical Engineering Award, IIT  
Graduate Research Fellow, Illinois Institute of Technology  
AIChE Chicago Section Harry McCormack Award Recipient

**Institutional and Professional Service:**

BME Undergraduate Curriculum Committee, BME ABET Committee,  
IIT Laser Safety Committee BME Representative

**Research or Scholarly Activity Percentage:**  
57%

**BME Program Percentage:** 100%
Philip R. Troyk  
Associate Professor

Degrees:
University of Illinois, Urbana  Electrical Engineering  BS  1974
University of Illinois, Chicago  Bioengineering  MS  1980
University of Illinois, Chicago  Bioengineering  Ph.D.  1983

Current Appointment:
2001-present  Associate Professor of Biomedical Engineering

Other Related Experience:
7/75 - 1/94  Northrop Corporation Defense Systems Division, Engineering Specialist, Technical Advisor
1978 - 1983  University of Illinois, Chicago, Teaching Assistant, Research Fellow
5/83 - 6/91  Pritzker Institute of Medical Engineering, IIT, Assistant Professor
1/85 - 6/91  Department of Neurosurgery, Rush Presbyterian-St. Luke's Medical Ctr, Chicago, IL, Adjunct Assistant Professor
1/88 - 6/91  Department of Electrical and Computer Engineering, IIT, Assistant Professor
6/91 - Present  Department of Neurosurgery, Rush Presbyterian-St. Luke's Medical Ctr, Chicago, IL, Adjunct Associate Professor
6/91 – 6/2001  Pritzker Institute of Medical Engineering, Department of Electrical and Computer Engineering, IIT, Associate Professor
12/2000 - Present  President Sigenics, Inc.

Consulting, Patents, etc.:
Composite Polymer Coatings for IC Encapsulation #4,939,014
Composite polymer/Desiccant coatings for IC Encapsulation #4,977,009 & #5,108,784
Self-regulating Class E Resonant Power Converter Maintaining Operation in a Minimal Loss Region #5,179,511
Electromagnetic Energy Transmission and Detection Apparatus #5,012,236
Method and apparatus for modulating and detecting a subcarrier signal for an inductively coupled transponder #5,095,309
Method and apparatus for producing a subcarrier signal for transmission by an inductively coupled transponder #5,198,807
Automated method for the manufacture of small implantable transponder devices #5,025,550 & #5,050,292
Implantable microstimulator #5,193,539 & #5,324,316
Suspended carrier modulation of high-Q transmitters #5,697,076
Numerous Industry and Funding agency consultation positions

Professional License or Certification:
None
Publications:

Professional Societies:
IEEE EMBS, ARVO

Honors and Awards:
2007 A.E. MANN Foundation Scientific Achievement Award

Institutional and Professional Service:

Research or Scholarly Activity Percentage:
68%

BME Program Percentage:
100%
VINCENT TURITTO

Professor

Degrees:

Columbia University  9/66-2/72  Sc.D. Chemical Engineering
University of Massachusetts  9/65-6/66  None
Manhattan College  9/61-6/65  B. Chemical Engineering

Current Appointment:

2001-  Director, Pritzker Institute of Biomedical Science and Engineering
2002-  Chairman, Department of Biomedical Engineering

Other Related Experience:

1993-2000  U of Memphis  Chairman, Department of Biomedical Engineering
1990-2000  Memphis State  Herbert Herff Professor of Biomedical Engineering

Publications:


Professional Societies:

Biomedical Engineering Society
American Institute of Medical and Biological Engineering, Founding Fellow
American Society of Engineering Education
International Society for Rotary Blood Pumps
International Society for Thrombosis and Hemostasis
American Society for Hematology
American Heart Association

Honors and Awards:

Biomedical Engineering Society, Inaugural Fellow
American Institute of Medical and Biological Engineering, Founding Fellow
Herbert Herff Endowed Chair of Excellence in Biomedical Engineering
American Heart Association, "Established Investigator"

Institutional and Professional Service:

Director, Pritzker Institute 2001- present
Chairman, Biomedical Engineering Department 2002- present
Chair, Academic Council, AIMBE 2007-2008
co-Organizer and co-Program Chair National BMES meeting 2006
Secretary and Treasurer, Academic Council, AIMBE 2004-2006

Research or Scholarly Activity Percentage:

20%

BME Program Percentage:

75%
### BME UG Labs

#### List of Major equipment

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Service</th>
<th>Replacement of parts</th>
<th>Replacement of Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra low temp freezer (Revco, ULT2186)</td>
<td>1</td>
<td>Once in two years</td>
<td>As needed</td>
<td></td>
</tr>
<tr>
<td>Ice makers (Hoshizaki)</td>
<td>2</td>
<td>Once in two years</td>
<td></td>
<td>Thermostat, Steam Pressure Gauge</td>
</tr>
<tr>
<td>Water distillation plant (Barnstead, e-pure)</td>
<td>2</td>
<td>Every six to nine months</td>
<td>Cartridges every year</td>
<td></td>
</tr>
<tr>
<td>Vacuum pressure station</td>
<td>2 low pressure and house</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerator</td>
<td>3</td>
<td>As needed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microwave oven</td>
<td>2</td>
<td>As needed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytical balance (Fisher, accu-series 224)</td>
<td>4</td>
<td>Once in two years*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic balance (Fisher, accu-series 2202)</td>
<td>1</td>
<td>Once in two years*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic balance (Ohaus, adventurer pro)</td>
<td>4</td>
<td>Once in two years*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic balance (Mettler Toledo, PG2002-S)</td>
<td>2</td>
<td>Once in two years*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal weighing balance (Scientech, SL3100D)</td>
<td>1</td>
<td>Once in two years*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weights, (Troy, 8,10,12lb)</td>
<td>8 of each weight</td>
<td>As needed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water bath (Fisher, models: isotemp 200 Series, isotemp 2100 Series, Isotemp 3016HS)</td>
<td>25</td>
<td>Thermostat, circulator</td>
<td>Once in three years*</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>Quantity</td>
<td>Maintenance</td>
<td>Frequency</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>----------</td>
<td>------------------------------------------</td>
<td>---------------------------</td>
<td></td>
</tr>
<tr>
<td>Touch mixer (Fisher, Model 232)</td>
<td>2</td>
<td></td>
<td>Once in three years*</td>
<td></td>
</tr>
<tr>
<td>Hotplate (Fisher, Isotemp)</td>
<td>9</td>
<td></td>
<td>Once in three years*</td>
<td></td>
</tr>
<tr>
<td>Oven (Fisher, Isotemp 516G)</td>
<td>1</td>
<td>Thermostat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunsen Burner (Fisher)</td>
<td>10</td>
<td></td>
<td>As needed, almost every year</td>
<td></td>
</tr>
<tr>
<td>Incubator (Fisher, Isotemp series)</td>
<td>1</td>
<td>Thermostat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autoclave (Marketforce)</td>
<td>1</td>
<td>Once in two years</td>
<td>parts as needed</td>
<td></td>
</tr>
<tr>
<td>Desktop computer (Dell, Optiplex GX270, GX280)</td>
<td>32</td>
<td>Software Maintenance</td>
<td>Every 5 years</td>
<td></td>
</tr>
<tr>
<td>Desktop computer (Dell, Optiplex GX620)</td>
<td>8</td>
<td>Software Maintenance</td>
<td>Every 5 years</td>
<td></td>
</tr>
<tr>
<td>Powerlab system (AD Instruments, 4/25T ML865)</td>
<td>36</td>
<td>Accessories as needed</td>
<td>As needed</td>
<td></td>
</tr>
<tr>
<td>BridgeAmp Amplifier (AD Instruments, ML110)</td>
<td>36</td>
<td></td>
<td>As needed</td>
<td></td>
</tr>
<tr>
<td>Powerlab ultimate teaching kit Incl. Software (AD Instruments, PTB401)</td>
<td>21</td>
<td></td>
<td>As needed</td>
<td></td>
</tr>
<tr>
<td>Powerlab flow meter (AD Instruments, ML191)</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Powerlab pump controller (AD Instruments, ML175)</td>
<td>10</td>
<td>Once in two years</td>
<td>cartridges</td>
<td></td>
</tr>
<tr>
<td>Large centrifuge (Eppendorf, 5810R)</td>
<td>3</td>
<td>Every year</td>
<td>As needed</td>
<td></td>
</tr>
<tr>
<td>Hematocrit microcentrifuge (StatSpin, CritSpin)</td>
<td>4</td>
<td></td>
<td>Once in three years*</td>
<td></td>
</tr>
<tr>
<td>Microcentrifuge (Costar, 10 MVSS)</td>
<td>1</td>
<td></td>
<td>Once in three years*</td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Quantity</td>
<td>Frequency</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>----------</td>
<td>--------------------</td>
<td>----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Light microscope (Zeiss, axioskop 40)</td>
<td>1</td>
<td>once in two years</td>
<td>objective lenses, eye piece, light source as needed</td>
<td></td>
</tr>
<tr>
<td>Inverted light microscope (Zeiss, axiovert 40C)</td>
<td>1</td>
<td>once in two years</td>
<td>objective lenses, eye piece, light source as needed</td>
<td></td>
</tr>
<tr>
<td>Stereoscope (Zeiss, Stemi DV4)</td>
<td>1</td>
<td>once in two years</td>
<td>objective lenses, eye piece, light source as needed</td>
<td></td>
</tr>
<tr>
<td>Light microscope (Fisher, micromaster)</td>
<td>20</td>
<td></td>
<td>Objective lenses, Eye Piece lenses, adaptor assembly for Camera</td>
<td></td>
</tr>
<tr>
<td>Microscope Camera incl. Lens and software (The Imaging Source, DMK21F04)</td>
<td>10</td>
<td></td>
<td>updating Software Every year</td>
<td></td>
</tr>
<tr>
<td>Histology Slides (Carolina Biological)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissection pans and instruments</td>
<td>11</td>
<td>as needed</td>
<td>Tools as needed</td>
<td></td>
</tr>
<tr>
<td>DC regulated power supply (BK Precision, 1670A)</td>
<td>6</td>
<td></td>
<td>As needed</td>
<td></td>
</tr>
<tr>
<td>Digital storage oscilloscope (Tektronix, TDS 1002)</td>
<td>16</td>
<td></td>
<td>As needed</td>
<td></td>
</tr>
<tr>
<td>Function generator (BK Precision, 4010A)</td>
<td>16</td>
<td>as needed</td>
<td>As needed</td>
<td></td>
</tr>
<tr>
<td>Circuit etching process kit (MG Chemicals)</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-C Circuit boxes</td>
<td>16</td>
<td>Each semester</td>
<td>As needed</td>
<td></td>
</tr>
<tr>
<td>Small electronic components</td>
<td></td>
<td>inventory yearly</td>
<td>As needed</td>
<td></td>
</tr>
<tr>
<td>Soldering station (Weller, WESS1)</td>
<td>2</td>
<td>inventory solder</td>
<td>As needed</td>
<td></td>
</tr>
<tr>
<td>Peristaltic pump (Cole Palmer, Masterflex L/S)</td>
<td>10</td>
<td>as needed</td>
<td>Once in 5 years</td>
<td></td>
</tr>
<tr>
<td>Peristaltic pump (Gilson, Minipuls 3)</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infusion pump (Cole Palmer)</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Quantity</td>
<td>Inspection Frequency</td>
<td>Replacement Frequency</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
<td>----------</td>
<td>----------------------</td>
<td>-----------------------</td>
<td></td>
</tr>
<tr>
<td>Manual hydrometer (Fisher)</td>
<td>80</td>
<td>Breakable, Once in two years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opaque-Type Capillary Viscometer (Cannon)</td>
<td>12</td>
<td>Breakable, Once in two years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fenske-Type Capillary Viscometer (Cannon)</td>
<td>33</td>
<td>Breakable, Once in two years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viscometer (DVII+, Brookfield Engineering)</td>
<td>18</td>
<td>Every year</td>
<td>Once in five years*</td>
<td></td>
</tr>
<tr>
<td>Micropipettes (Fisher, Finnpipette)</td>
<td>7</td>
<td>Every year</td>
<td>Once in three years</td>
<td></td>
</tr>
<tr>
<td>Micropipettes (Rainin)</td>
<td>78</td>
<td>Every year</td>
<td>Once in three years</td>
<td></td>
</tr>
<tr>
<td>Electrophoresis chamber (Carolina Biological)</td>
<td>10</td>
<td>combs, Every year</td>
<td>Once in three years</td>
<td></td>
</tr>
<tr>
<td>Electrophoresis power supply (Carolina Biological)</td>
<td>10</td>
<td>fuse as needed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDS-PAGE electrophoresis chamber (Carolina Biological)</td>
<td>9</td>
<td>Every year</td>
<td>Once in three years</td>
<td></td>
</tr>
<tr>
<td>Hollow Fiber dialysis cartridges and associated accessories (Fresenius, Optiflux)</td>
<td>10</td>
<td>Every year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sphygmomanometers</td>
<td>25+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact angle meter and associated accessories (Tantec, Cam Plus Micro)</td>
<td>4</td>
<td>Glass syringe assembly, UV light bulb, Every year</td>
<td>Once in five years*</td>
<td></td>
</tr>
<tr>
<td>Spectrophotometer (Thermo Electron Corp., Genesys 5)</td>
<td>10</td>
<td>Once in two years</td>
<td>Tungsten-halogen lamp, deuterium lamp, Fan filter, fuse, Dust cover, power cord</td>
<td>Once in five years*</td>
</tr>
<tr>
<td>Tensiometer (Fisher, Surface Tensiomat 21)</td>
<td>5</td>
<td>Every year</td>
<td>Torsion shaft assembly, platinum rings once in two years</td>
<td>Once in five years*</td>
</tr>
<tr>
<td>Equipment Description</td>
<td>Quantity</td>
<td>Maintenance Details</td>
<td>Maintenance Schedule</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>----------</td>
<td>----------------------------------------------------------</td>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td>pH meter (Denver Instrument, UB-10)</td>
<td>7</td>
<td>Electrode solution,</td>
<td>Once in three years*</td>
<td></td>
</tr>
<tr>
<td>pH meter (Fisher, Acumet AB15)</td>
<td>2</td>
<td>Electrode solution,</td>
<td>Once in three years*</td>
<td></td>
</tr>
<tr>
<td>Microplate reader (Molecular Devices, Versamax)</td>
<td>1</td>
<td>Every year</td>
<td>software upgrade every year</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>As needed</td>
<td></td>
</tr>
<tr>
<td>CT phantoms</td>
<td>10</td>
<td></td>
<td>Every three years</td>
<td></td>
</tr>
</tbody>
</table>

* This equipment is extensively used by undergraduate students, replacement of at least one set is strongly recommended.
INSTITUTIONAL SUMMARY

The Institution

Illinois Institute of Technology
Chief Executive Officer: John L. Anderson, President

Type of Control

Illinois Institute of Technology is an independent non-sectarian, co-educational, urban university. It is governed by a board of trustees drawn from diverse groups representing the public interest.

History of Institution

Armour Institute opened in 1893; the institute offered professional courses in engineering, chemistry, architecture and library science. IIT was created in 1940 by the merger of Armour Institute with Lewis Institute (est. 1895), a West Side Chicago college that offered liberal arts as well as science and engineering courses. The Institute of Design, founded in 1937, merged with IIT in 1949.

In 1969, IIT became one of the few technology-based universities with a law school when the Chicago Kent College of Law, founded in 1887, became an integral part of the university. Stuart School of Business was added in 1969, with a gift from the estate of Lewis Institute alumnus and Chicago financier Harold Leonard Stuart. The school became the Stuart School of Business in 1999. Midwest College of Engineering, founded in 1967, joined the university in 1986, forming the nucleus for IIT's west suburban campus.

Today, IIT is a private, Ph.D.-granting university with programs in engineering, science, psychology, architecture, business, design and law. It is one of the 16 institutions that comprise the Association of Independent Technological Universities (AITU).

Student Body

Please see included tables. The IIT student body is exceptionally diverse; students are drawn from all 50 states of the USA, and from over 90 nations.

Admissions Process

Students may be admitted directly into an engineering major or as “undeclared engineering”. Admission decisions are based on academic performance, standardized test scores, teacher/counselor recommendations and evidence of promise to succeed, which includes co-curricular activities, interests and hobbies, and personal maturity.
Students must have attended an accredited high school (although we do accept home schooled students) and have completed a minimum of 16 units of high school work and a minimum of 3½ units of mathematics that must include 2 units of algebra through pre-calculus, 1 unit of geometry and ½ unit of trigonometry. Calculus is strongly recommended but not required. Additionally, students must have completed 2 units of laboratory science (preferably physics and chemistry). Students are encouraged to take an additional laboratory science. Additional requirements include 4 units of English, and 2 units of History or Social Studies.

It is expected that students select a rigorous high school program that includes AP, IB or honors courses when they are available at the student's school. Students are encouraged to take college courses to supplement their education while they are enrolled in high school.

Students with unweighted grade point averages greater or equal to 3.0 and ACT test scores greater or equal to 24 math and 24 composite, or SAT scores greater or equal to 1150 may be admitted without a faculty committee review. Students who fall below these floors are generally denied admission, but may be, on an individual basis, selected for admission by a faculty review committee.

IIT recognizes and grants credit for students who have satisfactory scores for Advanced Placement or International Baccalaureate examinations. IIT also will grant transfer credit for college course work taken while a student was in high school provided a grade of “C” or above was earned.

IIT does not have an “upper division” per se. Students admitted as “Undeclared Engineering” are subject to the same requirements as all other admits. They are expected to declare a major by the end of the first year of study.

The Office of Educational Services is responsible for verifying all courses transferred from other colleges. Transfer applicants must be in good academic standing at their previous colleges to be considered for admission to IIT. Applicants with less than 30 hours of transferable college course work must submit high school transcripts and SAT or ACT scores as part of their application. Admission is based upon a cumulative GPA and individual grades in all classes that apply to the selected major. A minimum cumulative GPA of 3.0 is expected for transfer consideration. However, a transfer applicant who has special circumstances will be reviewed by a faculty committee.

Transfer credit is granted only for courses completed at schools listed in Transfer Credit Practices of Designated Educational Institutions, American Association of Collegiate Registrars and Admissions Officers. For engineering students, transfer credit for the equivalent of engineering and professional electives is given only for courses completed at schools accredited by the EAC of ABET.

Transfer credit is granted on a course equivalency basis, i.e., the nature,
content, level and prerequisites of the course must be comparable to those offered at IIT. Students may transfer a maximum of 68 applicable credits from a 2-year college. Transfer students must complete their last 45 credits at IIT with at least 50% of the course work at the 300 and 400 level in their major discipline. Transfer credit will be accepted for courses completed with the equivalent of a grade of “C” or better.

Joint programs with specific articulation agreements have been established with Benedictine University, DePaul University, Dominican University, University of St. Francis, Elmhurst College, and Wheaton College. Depending on the specific partner institution, students may receive a degree in Aerospace Engineering, Architectural Engineering, Chemical Engineering, Civil Engineering, Computer Engineering, Electrical Engineering, or Mechanical Engineering and a Bachelor’s degree in an approved discipline from their host school. Students are considered full-time at their host institution while completing requirements for both degrees. Admission into the Joint Program at another institution does not guarantee admission to IIT. Students must meet IIT admission requirements. Grades of “D” are acceptable for transfer credit for general education courses only. Programs of study have been produced for all engineering curricula available at each specific partner institution.

Regional or Institutional Accreditation

Illinois Institute of Technology has had continuous accreditation from the North Central Association of Colleges and Schools since 1941; the last accreditation visit was in 2006.

Personnel and Policies

(a) Promotion and tenure policies

Tenure track and tenured ranks are: assistant professor, associate professor, and professor. Decisions on promotion and tenure are, by authority of the Board of Trustees, vested in the President of the university. For each candidate, the Provost is expected to make recommendations to the President based on consideration of university needs, plans, and resources, and on the recommendations submitted by the following faculty committees and individuals:

1. The Academic Unit Committee on Promotion and Tenure (AUCOPT);
2. The Campus Committee on Promotion and Tenure (CAMCOPT);
3. The University Committee on Promotion and Tenure (UCOPT); and
4. The head of the academic unit and, in the case of a college with departments, the dean of the candidate’s department.

The recommendations of the faculty committees as to any candidate are the result of the consideration of the portfolio of the candidate and any additional information or recommendations provided at the request of the committees
by appropriate persons, including the candidate, professional peers from outside IIT, fellow faculty members, the Provost, the academic unit head, and students.

Evaluation of candidates for tenure appointments and for promotions to the rank of professor are based on clearly defined standards of academic quality. Inasmuch as there may be significant differences in the spirit and traditions of the individual disciplines comprising IIT, standards may vary from one profession to another. While each academic unit is expected to formulate its own standards and guidelines for the evaluation of its faculty, the following criteria are common to all academic units: performance in teaching, advising and the promotion of student learning; scholarly activities appropriate to the discipline; and service to the university, the profession, and the community at large. The standards are drafted by the unit’s Committee on Promotion and Tenure, and academic unit heads supply copies of these standards with any amendments and revisions to the Provost for approval. A copy of the appropriate set of standards is given to each faculty member by the Office of the Provost at the time of the faculty member’s initial appointment.

(b) The process used to determine faculty salaries

The available salary adjustment funds are allocated to the deans by the provost. In Armour College of Engineering the dean meets with the department heads who propose a distribution of these funds to their faculty according to the faculty activities and evaluations for the preceding year, and the needs of the departments/programs. The proposed adjustments are approved by the provost.

(c) Faculty Workload

The official workload for a full-time faculty member is 9 contact hours or equivalent per semester over a 2 semester academic year. This requirement can be met through: teaching of regularly scheduled courses; advising either or both undergraduate and graduate students; serving as research mentor for undergraduate or graduate students with a project, thesis, or dissertation outcome with the general rule that ten student credit hours is equivalent to one contact hour; developing new or redesigning existing courses and/or laboratories; or teaching courses with a large enrollment or highly intensive laboratory or project component.

Other activities that carry equivalent teaching credit include: serving as chair or associate chair of academic units, acting in other defined administrative roles within academic units, or providing extensive committee service for the academic unit, college, or university. In general, research funds can be used to reduce a faculty member's teaching load with the general guideline that approximately one month of academic year salary is equivalent to two contact hours.
In addition, varying contact hour credit is given in certain special cases such as teaching a course for the first time, teaching a distance learning course, or supervising seminar courses.

Untenured faculty members on the tenure track are provided with a minimum credit per academic year of six contact hours reduction in their teaching loads and may receive up to twelve contact hours of reduced teaching at the discretion of their academic unit head.

(d) Supervision of Part-time Faculty

Part-time faculty are hired by the academic units after an interview process and evaluated on a semester-by-semester basis by the unit head or a designee. Student teaching evaluations identical to those used for full-time faculty are conducted for each course taught by a part-time faculty member. These evaluations, along with other inputs, are used by the unit head to determine the teaching performance of part-time faculty. On occasion, the academic unit head or a designee will attend one or more classes taught by part-time instructors to evaluate their performance directly. The course outline and textbook selection is made by the cognizant full-time faculty member who normally teaches the specific course.

(e) Faculty Benefits

Faculty benefits include: mandatory individual and family health insurance program (Blue Cross/Blue Shield); life and permanent injury insurance; university matched 503(b) retirement program; optional dental insurance; and a tuition remission program for family members of the faculty. Faculty are eligible to apply for sabbatical leave after each 6 years of service.

Educational Unit

Administration and Mission

The Armour College of Engineering is one of eight academic units that comprise the educational core of Illinois Institute of Technology. These units are: Armour College of Engineering, The College of Science and Letters, The Institute of Psychology, The Institute of Design, The College of Architecture, The Stuart School of Business, The Center for Professional Development, and Chicago Kent College of Law.

Administrative Heads - Engineering

<table>
<thead>
<tr>
<th>Head, Title</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacant, Dean</td>
<td>Armour College of Engineering</td>
</tr>
<tr>
<td>F. Teymour, Chairman</td>
<td>Chemical and Biological Engineering</td>
</tr>
</tbody>
</table>
Position of Engineering Educational Programs in the Organization

The Dean of the Armour College of Engineering reports to the Provost, who is the Chief Academic Officer and Senior Vice President. The office of Provost is currently vacant. See attached organizational chart.

Mission Statement

The mission of the engineering unit at the undergraduate level is to offer Bachelor of Science programs in the main engineering disciplines that are recognized by the profession for their quality. Specifically, the purposes of these programs are to:

- Prepare individuals for rewarding careers in the engineering profession and for advanced study at graduate level.
- Equip their graduates with the potential to maintain currency in their fields.

Credit Unit

One semester credit hour represents one class hour or three laboratory hours per week. One academic year represents 30 weeks of classes, exclusive of final examinations.

Instructional Modes

Non-traditional modes of instruction are not employed in the undergraduate engineering programs as a general rule.

Grade-Point Average and Graduation Requirements

A four point grading scale is used, with “A” = 4, “B” = 3, “C” = 2, “D” = 1 and “E” (fail) = 0. A grade point average of 2.0 cumulative and a 2.0 average in courses designated as major courses is required to graduate.

Requirements for Graduation

The Office of Educational Services is responsible for certifying that an individual student has satisfied the prescribed curriculum for a Bachelor of Science degree in engineering. When necessary, the associate chair of the individual engineering department provides assistance in the verification process.
An academic audit provides a summary of a student’s academic status to date and lists the courses to be completed in order to receive a degree. Engineering students who have completed at least 60 semester hours (including applicable transfer credit) will receive an audit from the Office of Educational Services. After receiving their first audit, students may request periodic updates. Faculty advisors have access to the same database of student information that is used by the Office of Educational Services.

After a student submits an application for graduation, a graduation audit is completed and a letter, which indicates the remaining requirements for the degree, is sent to the student. The final audit is completed when the grades for the semester are recorded and, if all requirements are completed, the degree is awarded.

Academic Supporting Units

The Department of Applied Mathematics teaches required courses in calculus and differential equations. The department head is Dr. F. Hickernell.

The Department of Biological, Chemical and Physical Sciences teaches required courses in Physics and Chemistry. The department head is Dr. J. Zasadzinski.

The Department of Computer Science teaches required courses in computer science. The department head is Dr. B. Korel.

Non-Academic Supporting Units

The Academic Resource Center (ARC)

The ARC supports many required undergraduate courses in mathematics, physics, and chemistry, and many lower division engineering courses.

The ARC hires 22-30 tutors per semester, depending on how many hours each tutor works. For tutors to work in the ARC, they must be a rising junior or senior, with a 3.5 GPA in the major they wish to tutor. Tutors are recruited by faculty referral, current tutor recommendations, advertising in IIT Today, or by running GPA reports of students by major and year. After students turn in a faculty letter of recommendation and application, they interview with both the director and a subject-specific tutor, who asks them to answer questions in a mock-tutoring session that are representative of the questions we get in the ARC.

In addition to one-on-one and group tutoring, the ARC also runs examination reviews by student or professor request. This past school year, the ARC ran review sessions in PHYS 123 and 221, as well as MMAE305 and MMAE320. During the fall 2008 semester, the ARC had 4,000 visits.

There is one permanent staff member:

Dr. Elizabeth Lyons, Director, Academic resource Center (2007)
Education: MFA in Creative Writing, Purdue University, 2006  
BA in English, College of Charleston, 2003

Prior Employment History:  
Assistant Director, Academic Resource Center (2006-2007)  
Graduate Instructor, Purdue University, 2003-2006  
Writing Lab Coordinator and Tutor, Purdue University, 2004-2006

IIT Writing Center

Individual assistance for writing assignments is available in the IIT Writing Center, which provides guidance with assignments in engineering, science, and technical communication courses as well as courses in the humanities (literature, history, art & architecture history, philosophy) and social sciences.

One-on-one instruction focuses on the specific needs of the individual student. Typically, a student takes a project or paper assignment to the Writing Center, where a tutor assists with the writing process:

by helping to interpret the goals and requirements of the assignment

by guiding the processes of information gathering, analyzing, evaluating, synthesizing, organizing, and documenting

by helping to address "local" issues such as grammar, punctuation, spelling, conventions of typing, etc.

The Writing Center is opened four days a week, Monday through Thursday, with a typical daily schedule of 9:30 AM to 3:30 pm on Mondays and Wednesdays, and 10:00 am to 5:00 pm on Tuesdays and Thursdays. Weekly student sign-up sheets were posted on the faculty offices of 232 and 233, allowing visitors to make their own appointments. Most appointment lasted from one half to one hour. Students may bring in any form of writing, from an undergraduate first-year composition assignment to a PhD project.

The total number of Spring 2008 visitors was 98. Non-native speakers totaled 67, native English speakers 31. Undergraduates totaled 69 and graduates 29. Total tutoring sessions numbered 236. More that one third (31 of 98 total) of the students were native English Speakers.

There is one permanent staff member:  
James Dabbert, Director, IIT Writing Center, 1997-2008  
Senior Lecturer, Lewis Department of Humanities, Illinois Institute of Technology, 2000-2007
Education: B.A., English, Indiana University, Bloomington, Indiana, 1967
M.S., Linguistics, Indiana University, Bloomington, Indiana, 1977

Prior Appointments:
Instructor, Lewis Department of Humanities, Illinois Institute of Technology, 1989-2000

Office of Technology Services (OTS)

Main Campus Infrastructure

(a) Academic Buildings

From 2006 to 2008, OTS has upgraded technology at Engineering 1 (E1), Stuart, Metals, Siegel Hall, Life Sciences, Perlstein, and Crown Hall buildings. These recent upgrades include:

- Fiber connection into the buildings
- Fiber raiser between floors
- New teledata closets
- New network switches
- Infrastructure for Distance Learning
- A/V equipped classrooms/labs
- Full wireless coverage
- Replacement of CAT3 cables with CAT6 cables
- UPS in teledata

Engineering and computer science classroom and lab work activities are usually conducted in the following buildings: Stuart, E1, Alumni Hall, and Siegel Hall, each of which benefited from these upgrades.

(b) Classrooms

IIT offers three levels of technology enhanced classrooms:
Basic A/V classroom, which is equipped with a network connection, a projector and screen, an ELMO and a VHS/DVD deck. All components are controlled through a single Crestron Control Panel on the instructor's desk.

Distance Learning Classroom has all the equipment of a basic A/V classroom, plus one or two video cameras, instructor and student microphones, plasma TV monitor, connections to broadcasting and digitizing devices for TV and/or Internet delivery. These classrooms also broadcast via television and the Internet.
Video Conferencing Classroom, which is similar to Distance Learning Classroom but also allows for real-time collaboration with a remote classroom location.

In addition, a PC Classroom is an OTS computer lab that is equipped with a PC and projector for the instructor and individual computers for each student. This arrangement provides students with a hands-on learning experience.

The following buildings are equipped with technology-enhanced learning classrooms:

Stuart Building:
8 basic A/V classrooms
8 distance learning classrooms (2 of which are videoconferencing classrooms)
4 PC classrooms

E1:
14 basic A/V classrooms
3 distance learning classrooms
1 PC classroom

Alumni Hall:
2 basic A/V classrooms
1 PC classroom

Siegel Hall:
1 basic A/V classrooms
2 PC classrooms

(c) OTS Computer Labs:

OTS operates 12 labs in the Main Campus. The Stuart Building, E1, Alumni Hall and Siegel Hall computer labs were the focus of technology upgrades in 2006-2007 or are scheduled for upgrades within the next year. The Engineering and computer science student community usually use the labs in the following buildings:

The E1 building computer lab in room 029 has 21 workstations.
E1 029:
Equipped with basic A/V System in Summer 2006.
The 21 PCs that were refreshed in 2007 are due to be refreshed in Summer 2010.

The Stuart Building has four computer labs, with a total of 109 workstations.
Stuart 112J:
Equipped with basic A/V System in Summer 2006.
The 46 PCs were refreshed in 2005 are due to be refreshed Summer 2008.
Stuart 112E:
The 22 PCs that were refreshed in 2006 are due to be refreshed in Summer 2009.
Stuart 112F:
The 22 PCs that were refreshed in 2006 are due to be refreshed in Summer 2009.
Stuart 112X: (An open work area)
The 19 PCs that were refreshed in 2006 are due to be refreshed in Summer 2009, with the addition of 4 new workstations.

Alumni Hall has one computer lab with 29 workstations:
Alumni 218:
The 29 PCs that were refreshed in 2007 are due to be refreshed Summer 2010.

Siegel Hall has two computer labs with 52 workstations:
Siegel 237:
The 31 PCs that were refreshed in 2006 are due to be refreshed Summer 2009.
Siegel 236:
The 21 PCs that were refreshed in 2007 are due to be refreshed Summer 2010.

The MTTC Night Owl Lab, opened in February 2006:
The 50 laptops are due to be refreshed Summer 2008.

(d) Software
OTS PC labs offer 81 current software titles that specifically address engineering students' needs, and 49 titles that are geared toward Computer Science students. These titles are reviewed every semester by the IIT Software Committee, and are updated after thorough testing for compatibility with existing lab hardware/software.

(e) Distance Learning
IIT Online provides technology and procedural training for all new distance learning faculty. This is primarily utilized in Masters and certificate programs and will not be described here.

(F) Blackboard
Since 2003, the number of courses utilizing the Blackboard course management system has increased six fold. The Blackboard system hosts a website for every course offered at IIT and serves as a portal to IIT Online streaming media, which can be accessed by students in both online and live course sections. Instructors post notes, lectures and assignments on the course page, which also features a discussion board and chat room.

In Fall 2008, 161 of the 579 (27.8%) Engineering courses use the Blackboard management system.

Each Fall, OTS conducts group Blackboard training for new professors. New professors arriving in Spring and Summer are offered either group or individual Blackboard training. Advanced Blackboard training sessions are also available for faculty currently using the system.

OTS operates under the direction of:

Ophir Trigalo, Chief Information Officer, 2003 – 2008

Education: M.B.A. Information Systems, Tel Aviv University, 1990
B.A. Economics and Statistics, Ben Gurion University, 1983

Prior appointments
Vice President for Information Services, Depaul University, 1997-2003

University Libraries

IIT libraries provide access to an extensive collection of print and digital resources in support of the institution’s academic disciplines including architecture, design, engineering, computer science, business, and law. There are six libraries at IIT located on four campuses. The Paul V. Galvin Library serves as the main library for the Illinois Institute of Technology and provides primary support for all programs in the fields of engineering and computer science. The Downtown Campus Library serves IIT’s Chicago-Kent College of Law and the Stuart Graduate School of Business. Branch and departmental libraries include the Graham Resource Center serving the College of Architecture, the Louis W. Biegler Library on IIT’s Rice Campus, the Center for the Study of Ethics in the Professions Library, and the National Center for Food Safety and Technology Library.

Collections
Collectively, the libraries’ collections consist of over 1.8 million volumes, including books, journals, videos, DVDs, maps, microform, and government documents. In
addition, the libraries provide 24/7 access to a broad range of digital resources including over 100 online databases, more than 24,000 full-text scholarly journal titles, and over 7,000 full text e-book titles in computer science and technology related fields.

A founding member of the Consortium of Academic and Research Libraries in Illinois (CARLI), IIT libraries also provide access to more than 32 million library items from 75 additional academic libraries statewide. Along with extensive resource sharing, IIT’s membership in CARLI enables IIT libraries to develop partnerships with over 140 Illinois libraries and take advantage of innovations in teaching, research, technology, and services as well as opportunities to enhance its collections. In 2007, IIT libraries were awarded several cooperative collection development grants in conjunction with other Illinois university libraries that have been used to enrich the libraries collections particular in the fields of science and technology. These specialized areas include “Applied Mathematics in Support of Homeland Security”, “Computer Science Mathematics and Computer Algorithms”, “Internet Telephony and Computer Crimes Investigation”, and a collection partnership in Green Manufacturing Technology.

While the Galvin Library supports the university’s core curriculum and all subject disciplines, IIT branch and departmental libraries also provide specialized collections of resources that directly and indirectly support science, technology, and engineering. In addition to its rapidly growing architecture collection, the library also contains materials of interest to those in related engineering fields. The Ethics Center Library has a growing collection of materials on practical and professional ethics including items related to ethical issues and activities in areas across the disciplines including computer science, engineering, and the sciences, as well as items addressing cross disciplinary issues relating to the professions such as confidentiality, conflicts of interest, and professional concerns such as self-regulation and continuing education. The Ethics Center Library also maintains the most comprehensive online collection of codes of ethics in the world as well as a variety of print and online resources, including the “NanoEthicsBank”, an online, annotated bibliography of materials developed by IIT’s Center for the Study of Ethics in the Professions, that includes reports, regulatory documents, codes of ethics, research and development, and other resources related to nanotechnology and nanoparticles.

IIT libraries are actively engaged in the ongoing assessment of the quality and currency of its print and digital collections in order to meet the increasing demand of the growing student population as well as support emerging curriculum needs. In 2004 and 2006, the Galvin Library participated in LibQUAL, a library service and quality assessment process, in order to evaluate faculty, staff, and student satisfaction with IIT libraries’ collections, services, and facilities, as well as to monitor the impact changes made in response to the 2004 assessment had on current user satisfaction.
As a result of the assessment and additional collection analysis that identified potential areas requiring additional attention, the IIT libraries began an initiative to review and reconstitute its core monograph collections which includes five-year goals for the development of the print and online collections. In response to user assessment, the book acquisitions funding formula for the main library was also redesigned to increase expenditure in various disciplines such as the basic sciences and mathematics in order to more adequately support programs that are part of the undergraduate core curriculum.

Due to the renewed focus on the collections and the significant increase in funding allocated for monograph acquisitions, the Galvin Library’s print collection has substantially improved over the last five years particularly in the areas of science, technology, and engineering. The number of computer science titles purchased in FY2007 was almost twice the amount purchased in FY2003. The number of titles purchased overall in the fields of science, technology, and engineering in FY2007 was three times the amount purchased in FY2003.

IIT libraries also created new collection development policies to foster the development of more contemporary monograph collections and shift away from a focus heavily weighted towards the development of traditional programs to also include new disciplines as well. With additional support from the university and this new direction, Galvin Library was able to build foundation collections to support IIT’s new Biomedical Engineering program. To identify the unique collection needs across the disciplines, all libraries also employ an active departmental liaison program, staffed with subject specialists having skills unique to each program, and these liaisons consult with faculty on resources that will contribute to the development of library collections in support of their curriculum.

IIT libraries also have undertaken a comprehensive review of current print journal subscriptions, resulting in a transition at the main library from a primarily print-based journal collection of a few thousand titles to a primarily online journal collection of over 24,000 full-text titles, 8,400 of which are in the sciences and technology. These titles not only include individual subscriptions but also include multiple titles provided through publisher “bundles” including ACM, ACS, ASCE, ASME, and IEEE. Online database access has also shifted from providing numerous small, lower quality services to selecting the “best of class” in each discipline, resulting in subscriptions to INSPEC, CSA Technology Research Database, COMPENDEX, Web of Science, and SciFinder Scholar. In 2007, the SIAM Locus Journal Archive, Institute of Mathematics Statistics Journals, and Wiley Interscience Electronic Journals were also added to the collection of electronic resources available to the IIT community.

Services/Innovative Technology
IIT libraries are particularly well known for their use of innovative technology to support student learning and effective teaching. The libraries were among the
first in the country to implement an electronic reserves system; web-based
document delivery for interlibrary loan; remote access to a diverse collection of
digital resources; wireless networking; and a laptop loaner program. The libraries
provide ongoing support for digital resources and information technology through
a long-term commitment of library personnel, technology, and technological
expertise which contributes to the development and expansion of resources and
information technology centered services unique to libraries and the communities
they serve. In addition to financial support provided by the university, IIT libraries
– particularly Galvin Library – have received several state and federal grants in
support of library technology initiatives and continue to seek additional funding
for the development of emerging technologies and technology-based services to
better serve the changing needs and expectations of its users for less traditional
methodologies of information access, retrieval, and dissemination.

IIT libraries also continue to offer innovative services that use new
technologies to facilitate communication between students and librarians. Along
with in-person consultations, Galvin Library offers access to reference librarians
through email and instant messaging which has become a popular and efficient
way of getting expert assistance quickly. In 2007, over 18% of Galvin Library’s
total reference transactions occurred electronically through IM or email contact. The Galvin Library also introduced a library blog in 2007 to keep library users
informed of new resources, collections, and services available to them as they
become available.

Over the last several years, the libraries have also significantly increased
public computing resources in response to user demand. The Galvin Library, in
particular, has experienced a significant growth in on-site use of library resources
over the past several years and has continued to add additional public
workstations to meet this demand as illustrated by the estimated 20% increase in
public workstation logins at the main library between 2006 and 2007. Annual
visitors to the Galvin Library was over 205,000 in 2007 which represents a 48%
increase over the 139,000 total visitors in 2003.

Instruction
Emerging technologies have also been employed by IIT libraries to promote
innovative and interactive instruction in support of the curriculum. The Library
Learning Center (LLC), a state-of-the-art learning resource center on the lower
level of the Galvin Library that opened in 2000, continues to foster a highly
adaptable and collaborative teaching and interactive learning environment by
employing the latest information resources and technology. The LLC is used
extensively for traditional bibliographic and library skills instruction on the main
campus as well as increasingly more collaborative, problem-based information
literacy instruction that focuses on developing skills that will more fully support
students’ academic growth as well as their long-term professional development.
This collaborative instruction approach, in which librarians work with faculty to create contextual, course-specific assignments and instruction materials, was developed to fill a need for students in engineering programs to possess information literacy skills that are developed in the classroom, improved through their research, and then continued on into the profession.

Galvin Library’s role in this development within the academic environment is to provide resources that will aid and services that will instruct students in identifying, locating and effectively using information. The senior engineering librarian, as well as other subject specialists in engineering and the sciences, present instruction in library resources during Introduction to the Profession (ITP) classes that are mandated for all students in the engineering disciplines and for other classes upon request. ITP classes expose students to concepts that are part of the training necessary to acquire information literacy skills that will lead them through their early formative academic years, and create an acknowledgement of the need to engage in life-long research and learning in their profession. In addition, a regular variety of library workshops are offered that expand upon ITP classes and are more specific in the content presented, such as patents, standards and technical reports. These sessions are attended by both graduate and undergraduate students alike.

In Fall 2007, a new structure for collaborative or blended instruction was put into practice for CAEE classes. Librarians worked with faculty in designing three assignments weeks apart and with library instruction in between that were context specific to course materials and therefore more meaningful to the student. Assessment showed that the students agreed the instruction was effective in improving the quality of their research and assignments. Additional collaborative opportunities in other courses will be pursued by librarians and further assessment of library instruction will be conducted.

IIT Libraries operate under the direction of:

Christopher Stewart,  Dean of Libraries, 2006 - 2008

Education: BA, Political Science, University of Illinois at Chicago, 1989
MLS, Dominican University, 1995
MBA, Illinois Institute of Technology, 2004
Ed.D, University of Pennsylvania (expected, 2009)

Prior Appointments
2004-2006, Acting Dean of Libraries, Illinois Institute of Technology
2002-2004, Associate Dean of Libraries, Illinois Institute of Technology
2000-2002, Associate Dean for Library Technology, Illinois Institute of Technology
1999-2000, Associate Dean for Network Services, Paul V. Galvin Library, IIT
1998-1999, Assistant Dean for Network Services, Paul V. Galvin Library,
Career Management Center

The Career Management Center (CMC) at Illinois Institute of Technology serves the critical function of providing the linkage between students and graduates with local, national and international employers. The CMC’s mission is to engage students and alumni to develop and practice lifelong career management skills to realize their career goals. Students are strongly encouraged to register with the CMC during their freshman year in order to begin developing their careers as soon as possible. The CMC also seeks to develop lasting partnerships with employers by providing employers with the opportunity to participate in key programs to identify, and hire skilled and technically prepared individuals. The Director of CMC is Bruce Mueller, and CMC has a professional staff of eight.

CMC Programs

Career Fairs: IIT Career Fairs are open to all local, national and international employers seeking quality hires from all disciplines. The Illinois Institute of Technology is a prime institution targeted by many employers. The Career Management Center sponsors two Career Fairs each school year.

On-Campus Interviewing: On-Campus Interviewing (OCI) is a program allowing employers can use to interview and hire IIT graduates, alumni, and undergraduates seeking full-time, co-op or internship positions on IIT’s campuses. The Career Management Center holds OCI during the fall and spring semesters. The fall session runs from mid-September through early December and the Spring session runs from mid-February through early May.

Job Listings: Employers may post job listings on the CMC’s eRecruiting website.

Resume Development: CMC provides workshops and one-on-one advising on resume writing throughout the year. Students and alumni may post their resumes on eRecruiting, where they are made available to potential employers.

Cooperative Education & Internship Programs: CMC provides monitoring and administrative services for students in approved Cooperative Education & Internship positions. Assistance in obtaining Curricular Practical Training (CPT) Work Authorization for these positions is also provided to international students by the CMC in partnership with International Center.
Tracking Reports: CMC tracks graduating students’ progress in finding employment or enrollment in post-graduate programs, and provides a regular summary report to the academic units.

Web Site: CMC maintains a comprehensive web site with online resources for students, alumni and employers at www.cmc.iit.edu

Professional Development Programs & Workshops: CMC provides several programs and workshops to help students develop professionally. The programs include one-on-one career advising with a Career Counselor who specializes in the student’s field, mock interviews, and resume and cover letter critiques. Workshops include the Getting a Job three-part series, Making a Positive First Impression, Marketing Yourself Effectively and Transitioning from Student to Professional, Etiquette Lunches or Dinners, and Dress for Success.

The CMC operates under the direction of:


Education: BBA (1968), MBA (1974)

Prior Appointments
ACS-Managing Director, Global Human Resources Outsourcing (2002-2005)
Motorola-Corporate Vice President, Human Resources Infrastructure and Technology (1983-2003)

The Interprofessional Projects (IPRO) Program Office

The IPRO Program Office is responsible for administering and coordinating all aspects of The IIT Interprofessional Projects (IPRO) Program. This office was established in 1995 in order to plan for and eventually implement the general education requirement that all undergraduates complete two interprofessional project courses in order to graduate, with each course representing three credit hours. There are two prominent functions that achieve this result:

1. Since the interprofessional course, by design, encompasses all professional disciplines and programs, the IPRO Program Office has the responsibility to coordinate and integrate faculty, sponsors and students in order to identify, organize, promote, implement and assess approximately 90 IPRO project course sections (i.e., project teams) each year so that our students can fulfill their interprofessional project requirement. This serves on the order of 1,000 students each year (producing on the order of 3,000 credit-hours), with an average team size of eleven students from any level (sophomore through graduate) and any
discipline and professional program at IIT, although the vast majority of students have junior or senior standing. The disciplines involved across all IPRO course sections encompass all undergraduate degree programs: applied mathematics, architecture, business, computer science, engineering (aerospace, architectural, biological, biomedical, chemical, civil, computer, electrical, environmental, materials, mechanical), the sciences (biology, chemistry, physics), humanities (internet communication, journalism, technical communication), industrial technology and management, information technology and management, math and science education, psychology and social sciences (political science, public administration). Graduate students may also participate and receive credit toward their degrees, depending on their field of study, including, in addition to those previously mentioned, law, design, and food safety and technology.

2. Since the purpose of the interprofessional course is to provide students with experiences that emulate the workplace, an important aspect of the IPRO Program is the involvement of workplace organizations that identify viable “real world” complex topics, and provide financial support and professional advice to our IPRO teams throughout the semester. One-third of projects are currently sponsored, with a long-term goal of achieving two-thirds sponsorship, although many projects already benefit from informal collaboration with a range of business, non-profit, entrepreneurial and public sector organizations.

The roles and responsibilities of The IPRO Program Office are thus summarized as follows:

- Facilitate review and implementation of policies and procedures that define the learning objectives and govern the fulfillment of the two-IPRO project course general education requirement.
- Implement and maintain an efficient and effective system for creating, delivering and assessing project courses consistent with the learning objectives established for an interprofessional project experience.
- Develop and maintain sponsor relationships that are compatible with our faculty expertise and offer interesting and challenging learning experiences for our students, and that provide financial resources to help support the costs of coordinating and delivering the interprofessional project experience in a professional manner.
- Manage an operating budget and various grant and unrestricted donation accounts that support the delivery of the interprofessional course.
- Organize various events that support the learning objectives, including workshops (e.g., teambuilding, communication, project management, ethical decision-making, business planning).
- Organize and participate in various events that support the development and advancement of the interprofessional curriculum, including faculty orientation sessions, faculty development workshops and other education conference opportunities that help to promote information exchange between IIT faculty and
colleagues at other institutions, particularly in the field of team project based learning modalities.

- Participate in open houses for prospective students and organize presentations and conferences related to interprofessional education (e.g., Best Practices of Interdisciplinary Team Project Programs, presentations to sponsors and trustees)
- Coordinate the end-of-semester IPRO Projects Day Conference (held three times each year) that provides a venue for all IPRO teams to present their work via formal oral presentations and interactive exhibits, and includes a judging process (with working professionals, faculty members and graduate students) that is linked to assessment of learning objectives, and offers a showcase event for IIT alumni, trustees, sponsors, employers, high school and junior high school students, parents of IIT students and prospective students, and the general public.
- Support the information needs of and be responsive to the Interprofessional Studies Committee, a committee established via the University Faculty Council to provide academic oversight of the IPRO course.
- Coordinate the IPRO proposal review process each semester that leads to the review of candidate IPRO projects for the subsequent semester, with on the order of half of the IPRO projects continuing and half new each semester.
- Identify and encourage the use of best practices by IPRO instructors that have value in enhancing the effectiveness of IPRO teams (e.g., peer evaluation, grading guidelines (team performance and individual performance on the team).
- Encourage academic units and faculty to collaborate across disciplines and programs, recognize innovative approaches and support scholarship, publication and presentation at national conferences.
- Encourage graduate students to participate on interprofessional project teams and seek ways to adapt the IPRO course model to support graduate research and commercialization activities across professional boundaries and build competency of graduate students to team teach and teach in teams.
- Integrate and coordinate the process for students to enroll in interprofessional courses as part of the regular course registration schedule and provide timely information about IPRO course topics at http://ipro.iit.edu, giving particular attention to constraints that help to control the size of the team and the mix of students from various disciplines on a team.
- Provide a syllabus template that offers a generic framework and semester schedule for IPRO instructors to use in planning and implementing an IPRO project course.
- Coordinate IPRO team tools that facilitate communication and recordkeeping, including http://igroups.iit.edu and http://iknow.iit.edu.
- Coordinate the submittal and review of deliverables by IPRO teams, including: project plan, code of ethics, mid-term review, web site (optional), final oral presentation, exhibit/poster, abstract, final report and team work product.
- Coordinate surveys and evaluation tools that provide feedback to the IPRO Program Office from students, faculty, sponsors and alumni.
- Provide IPRO stipends to support the assignment of IIT faculty members in serving as an IPRO instructor as part of their regular teaching load, support part-
time IPRO instructors who offer specialized expertise and capacity and support IPRO team expenses on an as-needed basis.

- Coordinate with IIT’s director of entrepreneurship and the Jules F. Knapp Entrepreneurship Center to encourage student and faculty ideas for Entrepreneurial IPRO (EnPRO) projects that meet all of the requirements of a typical interprofessional project and encompass venture development and opportunity analysis that can lead to a business plan, prototype and user testing.
- Coordinate with the IIT Leadership Academy in delivering various teambuilding and leadership seminars and workshops.
- The IPRO Program Office is supported as follows: Director of Interprofessional Studies and The IPRO Program (full time), Associate Provost for Undergraduate Affairs (20%), IPRO Administrative Assistant/Coordinator (full time) and part-time graduate and undergraduate students.

Thomas M. Jacobius, Director, Interprofessional Studies & The IPRO Program, 2000-2008

Education: BS, Mechanical Engineering, IIT, 1971
MBA, Northwestern University, 1978

Prior appointments:

1995-2000  Director, Industrial Liaison & Technology Transfer; Co-Director, The IIT Interprofessional Projects (IPRO) Program, IIT.
1991-1995  Director, Office of Research Admin and Office of IP Management, IIT.
1988-1989  Program Manager, Rail Simulation & Training Group, IIT Research Institute.
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<th>Administrative Head</th>
<th>Administrative Unit or Units (e.g. Dept.) Exercising Budgetary Control</th>
<th>Submitted for Evaluation</th>
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Table D-1. Programs Offered by the Educational Unit – Graduate
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<td>Chemical and Biological Engineering</td>
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<td>Computer Systems Engineering (M.S.)</td>
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<td>Gas Engineering (M.S.)</td>
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<td>Mechanical, Materials and Aerospace Engineering</td>
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<td>Electrical and Computer Engineering</td>
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<td>Power Engineering (M.S.)</td>
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<td>Civil, Architectural and Environmental Engineering</td>
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<td>Transportation Engineering and Planning (M.S.)</td>
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### Table D-2. Degrees Awarded and Transcript Designations by Educational Unit

#### Undergraduate

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<th>Off Campus</th>
<th>Alternative Mode</th>
<th>Name of Degree Awarded</th>
<th>Designation on Transcript</th>
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### Table D-4. Personnel and Students
#### All Engineering Departments
**Fall 2007**

<table>
<thead>
<tr>
<th>Headcount Description</th>
<th>FT</th>
<th>PT</th>
<th>FTE</th>
<th>Ratio to Faculty</th>
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<td>Executive</td>
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<td>Other Faculty (excluding Student Assistants)</td>
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<td>0.13</td>
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<td>Research Assistants</td>
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<td>0.21</td>
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</table>

*Includes all classes (freshmen, sophomore, junior, senior, etc)*

FTE calculation:
- Undergraduate=Hours/15
- Graduate=Hours/9
Table D-4. Personnel and Students  
Biomedical Engineering  
Fall 2007

<table>
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<td>Technicians/Specialists</td>
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</table>

*Includes all classes (freshmen, sophomore, junior, senior, etc)

FTE calculation:  
  Undergraduate=Hours/15  
  Graduate=Hours/9
Table D-4. Personnel and Students  
Chemical and Biological Engineering  
Fall 2007

<table>
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<th>Ratio to Faculty</th>
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</table>

*Includes all classes (freshmen, sophomore, junior, senior, etc)

FTE calculation:
Undergraduate=Hours/15
Graduate=Hours/9
Table D-4. Personnel and Students
Civil, Architectural and Environmental Engineering
Fall 2007

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<th>Ratio to Faculty</th>
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*Includes all classes (freshmen, sophomore, junior, senior, etc)

FTE calculation:
  Undergraduate=Hours/15
  Graduate=Hours/9
Table D-4. Personnel and Students  
Electrical and Computer Engineering  
Fall 2007

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<td>Professional</td>
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<td>Research Assistants</td>
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<td>0.08</td>
</tr>
<tr>
<td>Technicians/Specialists</td>
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*Includes all classes (freshmen, sophomore, junior, senior, etc)

FTE calculation:
  - Undergraduate=Hours/15
  - Graduate=Hours/9
### Table D-4. Personnel and Students
#### Mechanical, Materials and Aerospace Engineering
Fall 2007

<table>
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<th>Ratio to Faculty</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

*Includes all classes (freshmen, sophomore, junior, senior, etc)*

FTE calculation:
- Undergraduate=Hours/15
- Graduate=Hours/9
### Table D-5. Program Enrollment and Degree Data

#### Aerospace Engineering

<table>
<thead>
<tr>
<th>Enrollment counts in Fall of AY</th>
<th>Undergraduate Enrollment by Class</th>
<th>Total Undergrad</th>
<th>Total Grad</th>
<th>Degrees Conferred Between July 1 and June 31 Of Academic Year</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td>2nd</td>
<td>3rd</td>
<td>4th</td>
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<td></td>
<td>PT</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Give official fall term enrollment figures (head count) for the current and preceding five academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the fall visit.

**FT**--full time
**PT**--part time

*Degree conferred as of June 10, 2008*
Table D-5. Program Enrollment and Degree Data

**Architectural Engineering**

<table>
<thead>
<tr>
<th>Enrollment counts in Fall of AY</th>
<th>Undergraduate Enrollment by Class</th>
<th>Total Undergrad</th>
<th>Total Grad**</th>
<th>Degrees Conferred Between July 1 and June 30 Of Academic Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
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Give official fall term enrollment figures (head count) for the current and preceding five academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the fall visit.

FT--full time  
PT--part time

*Degree conferred as of June 10, 2008  
**Includes Master’s and Doctoral degrees
### Table D-5. Program Enrollment and Degree Data

**Biomedical Engineering**

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Give official fall term enrollment figures (head count) for the current and preceding five academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the fall visit.

FT--full time  
PT--part time  

*Degree conferred as of June 10, 2008  
**Includes Master’s and Doctoral degrees
### Table D-5. Program Enrollment and Degree Data

#### Chemical Engineering

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Give official fall term enrollment figures (head count) for the current and preceding five academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the fall visit.

FT--full time
PT--part time

*Degree conferred as of June 10, 2008
**Includes Master of Science in Computer Science/Master of Chemical Engineering dual degree
***Includes Master’s and Doctoral degrees; includes Master of Science in Computer Science/Master of Chemical Engineering dual degree
**Table D-5. Program Enrollment and Degree Data**

*Civil Engineering*

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Give official fall term enrollment figures (head count) for the current and preceding five academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the fall visit.

FT—full time
PT—part time

*Degree conferred as of June 10, 2008
**Includes Master’s and Doctoral degrees
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Give official fall term enrollment figures (head count) for the current and preceding five academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the fall visit.

FT--full time
PT--part time

Other Class includes one-year visiting, foreign exchange, joint program post-baccalaureate visiting and special students.

*Degree conferred as of June 10, 2008
**Includes Master of Electrical and Computer Engineering
***Includes Master's and Doctoral degrees; includes Master of Electrical and Computer Engineering
### Table D-5. Program Enrollment and Degree Data

#### Electrical Engineering

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Give official fall term enrollment figures (head count) for the current and preceding five academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the fall visit.

- FT—full time
- PT—part time

Other Class includes one-year visiting, foreign exchange, joint program post-baccalaureate visiting and special students.

*Degree conferred as of June 10, 2008

**Includes Master of Electrical and Computer Engineering

***Includes Master’s and Doctoral degrees; includes Master of Electrical and Computer Engineering
Table D-5. Program Enrollment and Degree Data

*Materials Science and Engineering*

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Give official fall term enrollment figures (head count) for the current and preceding five academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the fall visit.

FT--full time
PT--part time

*Degree conferred as of June 10, 2008*
### Table D-5. Program Enrollment and Degree Data

#### Mechanical Engineering

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Give official fall term enrollment figures (head count) for the current and preceding five academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the fall visit.

FT--full time
PT--part time

*Degree conferred as of June 10, 2008
Table D-6. Faculty 9-Month Salary Data  
For Academic Year 2007-2008

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### TABLE D.2. Degrees Awarded and Transcript Designations by Educational Unit

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#### Graduate

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<td>Ph.D. in Biomedical Engineering</td>
</tr>
<tr>
<td>Program</td>
<td>Degree</td>
<td>Specialization</td>
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<tr>
<td>-------------------------------</td>
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</tr>
<tr>
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<td>M.S.</td>
<td>M.S. in Biological Engineering</td>
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<tr>
<td>Chemical Engineering</td>
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<td>Ph.D. in Chemical Engineering</td>
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</tr>
<tr>
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<td></td>
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<tr>
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<td>Ph.D. in Civil Engineering</td>
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</tr>
<tr>
<td>Computer Engineering</td>
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<td>MS in Computer Engineering</td>
<td></td>
</tr>
<tr>
<td>Computer Engineering</td>
<td>Ph.D.</td>
<td>Ph.D. in Computer Engineering</td>
<td></td>
</tr>
<tr>
<td>Computer Engineering and</td>
<td>M.S.</td>
<td>M.S. in Computer Engineering and Electrical</td>
<td></td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td></td>
<td>Engineering</td>
<td></td>
</tr>
<tr>
<td>Computer Science and</td>
<td>M.S.</td>
<td>MS in Computer Science and Chemical Engineering</td>
<td></td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Systems Engineering</td>
<td>M.S.</td>
<td>MS in Computer Systems Engineering</td>
<td></td>
</tr>
<tr>
<td>Construction Engineering and</td>
<td>M.S.</td>
<td>MS in Construction Engineering and Management</td>
<td></td>
</tr>
<tr>
<td>Management</td>
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<tr>
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<td>MS in Computer Engineering</td>
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<td>Engineering</td>
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<td>MS in Electrical Engineering</td>
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<td></td>
</tr>
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<td>Food Process Engineering</td>
<td>M.S.</td>
<td>MS in Food Process Engineering</td>
<td></td>
</tr>
<tr>
<td>Gas Engineering</td>
<td>M.S.</td>
<td>MS in Gas Engineering</td>
<td></td>
</tr>
<tr>
<td>Geoenvironmental Engineering</td>
<td>M.S.</td>
<td>MS in Geotechnical Engineering</td>
<td></td>
</tr>
<tr>
<td>(M.S.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geotechnical Engineering</td>
<td>M.S.</td>
<td>MS in Geotechnical Engineering</td>
<td></td>
</tr>
<tr>
<td>Manufacturing Engineering</td>
<td>M.S.</td>
<td>MS in Manufacturing</td>
<td></td>
</tr>
<tr>
<td>Program</td>
<td>Degree</td>
<td>Program Name</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>---------</td>
<td>--------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Materials Science and Engineering</td>
<td>M.S.</td>
<td>MS in Materials Science and Engineering</td>
<td></td>
</tr>
<tr>
<td>Materials Science and Engineering</td>
<td>Ph.D.</td>
<td>Ph.D. in Materials Science and Engineering</td>
<td></td>
</tr>
<tr>
<td>Mechanical and Aerospace Engineering</td>
<td>M.S.</td>
<td>MS in Mechanical and Aerospace Engineering</td>
<td></td>
</tr>
<tr>
<td>Mechanical and Aerospace Engineering</td>
<td>Ph.D.</td>
<td>Mechanical and Aerospace Engineering</td>
<td></td>
</tr>
<tr>
<td>Network Engineering</td>
<td>M.S.</td>
<td>MS in Network Engineering</td>
<td></td>
</tr>
<tr>
<td>Power Engineering</td>
<td>M.S.</td>
<td>MS of Power Engineering</td>
<td></td>
</tr>
<tr>
<td>Public Works Administration</td>
<td>M.S.</td>
<td>MS in Public Works Administration</td>
<td></td>
</tr>
<tr>
<td>Structural Engineering</td>
<td>M.S.</td>
<td>MS in Structural Engineering</td>
<td></td>
</tr>
<tr>
<td>Telecommunication and Software Engineering</td>
<td>M.S.</td>
<td>MS in Telecommunication and Software Engineering</td>
<td></td>
</tr>
<tr>
<td>Transportation Engineering and Planning (M.S.)</td>
<td>M.S.</td>
<td>MS in Transportation Engineering and Planning</td>
<td></td>
</tr>
<tr>
<td>VLSI and Microelectronics</td>
<td>M.S.</td>
<td>MS in VLSI and Microelectronics</td>
<td></td>
</tr>
</tbody>
</table>
### Table D.3 Support Expenditures

**Armour College Total**

<table>
<thead>
<tr>
<th>Expenditure Category</th>
<th>2006-2007¹</th>
<th>2007-2008²</th>
<th>2008-2009³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations (not including staff)⁴</td>
<td>902,426</td>
<td>937,245</td>
<td>368,929</td>
</tr>
<tr>
<td>Travel⁵</td>
<td>155,282</td>
<td>194,733</td>
<td>174,600</td>
</tr>
<tr>
<td>Equipment⁶ (a) Institutional Funds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Grants and Gifts⁷</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate Teaching Assistants</td>
<td>392,989</td>
<td>696,042</td>
<td>534,513</td>
</tr>
<tr>
<td>Part-time Assistance⁸ (other than teaching)</td>
<td>62,911</td>
<td>81,423</td>
<td>74,042</td>
</tr>
<tr>
<td>Faculty Salaries</td>
<td>7,475,081</td>
<td>7,794,908</td>
<td>8,092,786</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expenditure Category</th>
<th>2006-2007¹</th>
<th>2007-2008²</th>
<th>2008-2009³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations (not including staff)⁴</td>
<td>47,455</td>
<td>58,191</td>
<td>48,254</td>
</tr>
<tr>
<td>Travel⁵</td>
<td>13,280</td>
<td>18,889</td>
<td>16,000</td>
</tr>
<tr>
<td>Equipment⁶ (a) Institutional Funds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Grants and Gifts⁷</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate Teaching Assistants</td>
<td>14,500</td>
<td>27,015</td>
<td>32,000</td>
</tr>
<tr>
<td>Part-time Assistance⁸ (other than teaching)</td>
<td>7,480</td>
<td>13,820</td>
<td>8,000</td>
</tr>
<tr>
<td>Faculty Salaries</td>
<td>858,102</td>
<td>993,923</td>
<td>1,162,585</td>
</tr>
</tbody>
</table>

*Report Department Level and Program Level data for each program being evaluated. Updated tables are to be provided at the time of the visit.*

¹ Provide the statistics from the audited account for the fiscal year completed year prior to the current fiscal year.

² This is your current fiscal year (when you will be preparing these statistics). Provide your preliminary estimate of annual expenditures, since your current fiscal year presumably is not over at this point.

³ Provide the budgeted amounts for your next fiscal year to cover the fall term when the ABET team will arrive on campus.

⁴ Categories of general operating expenses to be included here.

⁵ Institutionally sponsored, excluding special program grants.

⁶ Major equipment, excluding equipment primarily used for research. Note that the expenditures (a) and (b) under “Equipment” should total the expenditures for Equipment. If they don’t, please explain.

⁷ Including special (not part of institution’s annual appropriation) non-recurring equipment purchase programs.

⁸ Do not include graduate teaching and research assistant or permanent part-time personnel.
Table D.4. Personnel and Students
All Engineering Departments
Fall 2007

<table>
<thead>
<tr>
<th>Headcount</th>
<th>FT</th>
<th>PT</th>
<th>FTE</th>
<th>Ratio to Faculty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive</td>
<td>1</td>
<td>1</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>Faculty (tenure-track)</td>
<td>63</td>
<td>63</td>
<td></td>
<td>0.62</td>
</tr>
<tr>
<td>Graduate Assistants</td>
<td>240</td>
<td>80</td>
<td></td>
<td>0.79</td>
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<tr>
<td>Office/Clerical Employees</td>
<td>10</td>
<td>10</td>
<td></td>
<td>0.10</td>
</tr>
<tr>
<td>Other Faculty (excluding Student Assistants)</td>
<td>13</td>
<td>31</td>
<td>23</td>
<td>0.23</td>
</tr>
<tr>
<td>Professional</td>
<td>13</td>
<td>13</td>
<td></td>
<td>0.13</td>
</tr>
<tr>
<td>Research Assistants</td>
<td>21</td>
<td>21</td>
<td></td>
<td>0.21</td>
</tr>
<tr>
<td>Technicians/Specialists</td>
<td>7</td>
<td>7</td>
<td></td>
<td>0.07</td>
</tr>
<tr>
<td>Administrative</td>
<td>15</td>
<td>15</td>
<td></td>
<td>0.15</td>
</tr>
<tr>
<td>Undergraduate Student Enrollment*</td>
<td>1091</td>
<td>75</td>
<td>1171</td>
<td>11.55</td>
</tr>
<tr>
<td>Graduate Student Enrollment</td>
<td>737</td>
<td>484</td>
<td>1021</td>
<td>10.08</td>
</tr>
</tbody>
</table>

*Includes all classes (freshmen, sophomore, junior, senior, etc)

FTE calculation:
Undergraduate=Hours/15
Graduate=Hours/9
Table D.4. Personnel and Students  
Biomedical Engineering  
Fall 2007

<table>
<thead>
<tr>
<th>Headcount</th>
<th>FT</th>
<th>PT</th>
<th>FTE</th>
<th>Ratio to Faculty</th>
</tr>
</thead>
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<tr>
<td>Faculty (tenure-track)</td>
<td>9</td>
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<td>9</td>
<td>0.68</td>
</tr>
<tr>
<td>Graduate Assistants</td>
<td></td>
<td>31</td>
<td>10</td>
<td>0.78</td>
</tr>
<tr>
<td>Other Faculty (excluding Student Assistants)</td>
<td>3</td>
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<td>3</td>
<td>0.25</td>
</tr>
<tr>
<td>Professional</td>
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<td>0.08</td>
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<tr>
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<td></td>
<td>2</td>
<td>0.15</td>
</tr>
<tr>
<td>Technicians/Specialists</td>
<td>1</td>
<td></td>
<td>1</td>
<td>0.08</td>
</tr>
<tr>
<td>Administrative</td>
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<td></td>
<td>1</td>
<td>0.08</td>
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<tr>
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<td>125</td>
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<tr>
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<td>17</td>
<td>18</td>
<td>24</td>
<td>1.78</td>
</tr>
</tbody>
</table>

*Includes all classes (freshmen, sophomore, junior, senior, etc)

FTE calculation:  
Undergraduate=Hours/15  
Graduate=Hours/9
Table D.5  Program Enrollment and Degree Data

**Biomedical Engineering**

<table>
<thead>
<tr>
<th>Enrolment counts in Fall of AY</th>
<th>Undergraduate Enrollment by Class</th>
<th>Total Undergrad</th>
<th>Total Grad**</th>
<th>Degrees Conferred Between July 1 and June 31 Of Academic Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
<td>3rd</td>
<td>4th</td>
</tr>
<tr>
<td>CURRENT 2007-8*</td>
<td>FT</td>
<td>24</td>
<td>36</td>
<td>26</td>
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<tr>
<td></td>
<td>PT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 2006-7</td>
<td>FT</td>
<td>45</td>
<td>23</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>PT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 2005-6</td>
<td>FT</td>
<td>31</td>
<td>27</td>
<td>28</td>
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<tr>
<td></td>
<td>PT</td>
<td>1</td>
<td>1</td>
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<tr>
<td>3 2004-5</td>
<td>FT</td>
<td>29</td>
<td>36</td>
<td>26</td>
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<tr>
<td></td>
<td>PT</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4 2003-4</td>
<td>FT</td>
<td>26</td>
<td>28</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>PT</td>
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<td></td>
</tr>
<tr>
<td>5 2002-3</td>
<td>FT</td>
<td>34</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>PT</td>
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<td></td>
</tr>
</tbody>
</table>

Give official fall term enrollment figures (head count) for the current and preceding five academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the fall visit.

FT--full time
PT--part time

Other Class includes one-year visiting, foreign exchange, joint program post-baccalaureate visiting and special students.

*Degree conferred as of June 10, 2008
**Includes Master's and Doctoral degrees
### Table D-6. Faculty 9-Month Salary Data
For Academic Year 2007-2008

<table>
<thead>
<tr>
<th>Department</th>
<th>Rank</th>
<th>Number</th>
<th>High</th>
<th>Mean</th>
<th>Low</th>
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<tr>
<td>Biomedical Engineering</td>
<td>Assistant Professor</td>
<td>5</td>
<td>$77,443</td>
<td>$75,279</td>
<td>$71,050</td>
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<td></td>
<td>Associate Professor</td>
<td>5</td>
<td>$88,518</td>
<td>$77,349</td>
<td>$48,347</td>
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<td>$54,671</td>
<td>$54,671</td>
<td>$54,671</td>
</tr>
<tr>
<td></td>
<td>Professor</td>
<td>2</td>
<td>$157,671</td>
<td>$114,127</td>
<td>$70,583</td>
</tr>
<tr>
<td>Chemical and Biological Engineering</td>
<td>Assistant Professor</td>
<td>2</td>
<td>$77,761</td>
<td>$75,297</td>
<td>$72,833</td>
</tr>
<tr>
<td></td>
<td>Associate Professor</td>
<td>5</td>
<td>$98,700</td>
<td>$86,176</td>
<td>$77,236</td>
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<tr>
<td></td>
<td>Lecturer</td>
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<td>$63,355</td>
<td>$63,355</td>
<td>$63,355</td>
</tr>
<tr>
<td></td>
<td>Professor</td>
<td>13</td>
<td>$153,450</td>
<td>$102,594</td>
<td>$73,196</td>
</tr>
<tr>
<td>Civil, Architectural and Environmental Engineering</td>
<td>Assistant Professor</td>
<td>3</td>
<td>$76,482</td>
<td>$72,675</td>
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<tr>
<td></td>
<td>Associate Professor</td>
<td>3</td>
<td>$76,381</td>
<td>$71,642</td>
<td>$67,384</td>
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<td></td>
<td>Lecturer</td>
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<td>$67,821</td>
<td>$61,251</td>
<td>$55,931</td>
</tr>
<tr>
<td></td>
<td>Professor</td>
<td>3</td>
<td>$112,063</td>
<td>$100,214</td>
<td>$84,137</td>
</tr>
<tr>
<td>Electrical and Computer Engineering</td>
<td>Assistant Professor</td>
<td>10</td>
<td>$88,000</td>
<td>$83,951</td>
<td>$80,800</td>
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<tr>
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<td>Associate Professor</td>
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<td>$102,692</td>
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<tr>
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<td>$53,000</td>
<td>$53,000</td>
<td>$53,000</td>
</tr>
<tr>
<td></td>
<td>Professor</td>
<td>7</td>
<td>$143,514</td>
<td>$112,980</td>
<td>$88,344</td>
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<tr>
<td>Mechanical, Materials and Aerospace Engineering</td>
<td>Assistant Professor</td>
<td>4</td>
<td>$83,894</td>
<td>$79,172</td>
<td>$75,000</td>
</tr>
<tr>
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<td>9</td>
<td>$97,795</td>
<td>$87,743</td>
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<tr>
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<td>Lecturer</td>
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<td>$36,828</td>
<td>$36,828</td>
<td>$36,828</td>
</tr>
<tr>
<td>Professor</td>
<td>8</td>
<td>$154,195</td>
<td>$111,867</td>
<td>$89,661</td>
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</tr>
</tbody>
</table>

*Salary figures do not include salary portions assigned to administrative duties.*
APPENDIX E: DEPARTMENT OF BIOMEDICAL ENGINEERING
SUPPLEMENTARY DOCUMENTATION

BME Program Planning Sheet (1 for each track)
BME Exit Interview Survey
BME Alumni Survey
BME Employer Survey
Student Course Survey
Faculty Course Survey
### CELL AND TISSUE TRACK

<table>
<thead>
<tr>
<th>TRACK COURSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 100 (3)</td>
</tr>
<tr>
<td>MS 201 Material Science (3)</td>
</tr>
<tr>
<td>MMAE 200 Intro. to Mech (3)</td>
</tr>
<tr>
<td>MATH</td>
</tr>
<tr>
<td>MATH 151 Calc I (5)</td>
</tr>
<tr>
<td>CHEM 237 Organic Chem/Lab (3)</td>
</tr>
<tr>
<td>MATH 152 Calc II (5)</td>
</tr>
<tr>
<td>CHEM 239 Organic Chemistry (3)</td>
</tr>
<tr>
<td>MATH 252 Diff Eqs (4)</td>
</tr>
<tr>
<td>BME 301 Fluid Mechanics (3)</td>
</tr>
<tr>
<td>MATH 251 Vector Calc (4)</td>
</tr>
<tr>
<td>BME 335 Thermo in Living Syst (3)</td>
</tr>
<tr>
<td>CHEMISTRY</td>
</tr>
<tr>
<td>CHEM 124 (with lab) (4)</td>
</tr>
<tr>
<td>BME Elective (300 level or above) (3)</td>
</tr>
<tr>
<td>CHEM 125 Chem II (with lab) (4)</td>
</tr>
<tr>
<td>BME Elective (300 level or above) (3)</td>
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<td>BIOLOGY</td>
</tr>
<tr>
<td>BIOL 115 Human Biology (3)</td>
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<tr>
<td>BIOL 117 Experimental Biology Lab (2)</td>
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<td>PHYSICS</td>
</tr>
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<td>PHYS 123: Mechanics (4)</td>
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<tr>
<td>PHYS 221 Electromag &amp; Optics (4)</td>
</tr>
<tr>
<td>COMPUTER SCIENCE</td>
</tr>
<tr>
<td>CS 105 Intro to Computers (2)</td>
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<td>BME 320 Fluid Laboratory (1)</td>
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<td>BME 405 Physiology Laboratory (1)</td>
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<td>BME 419 Intro to Design Concepts (2)</td>
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<td>BME 420 Design Concepts in BME (3)</td>
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<td>BME 433 BME App of Stats (3)</td>
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<tr>
<td>BME 490 Senior Seminar (1)</td>
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<tr>
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* 6 credits of 9 in same area, 3 of 9 in different area
### TRACK COURSES

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<td>(3)</td>
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<tr>
<td>ECE 213</td>
<td>Circuit Analysis II</td>
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<td>ECE 214</td>
<td>Analog/Digital Lab II</td>
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<td>(4)</td>
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<td>OR Math 333</td>
<td>Matrix and Complex</td>
<td>(3)</td>
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<tr>
<td>Chem 239</td>
<td>Orgo II</td>
<td>(3)</td>
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<tr>
<td>OR Technical Elective</td>
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<td>Biomed Imaging and Sensing</td>
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<td>NeuroImaging</td>
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<td>Biomed. Instr. &amp; Electronics</td>
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<td>BME 445</td>
<td>Quantitative Neural Function</td>
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<td>Chem 239</td>
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<td>BME 438</td>
<td>NeuroImaging</td>
<td>(3)</td>
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<td>BME 443</td>
<td>Biomed. Instr. &amp; Electronics</td>
<td>(3)</td>
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<td>BME 445</td>
<td>Quantitative Neural Function</td>
<td>(3)</td>
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<td>BME Elective 300</td>
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### COMPUTER SCIENCE

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### CORE

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<th>Course Name</th>
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<td>BME 200 BME App of Matlab</td>
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<td>BME 310 Biomaterials</td>
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<td>BME 330 Anal. Biosignals</td>
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<td>(2)</td>
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<tr>
<td>BME 419 Intro. To Design</td>
<td>(2)</td>
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<tr>
<td>BME 420 Design Concepts in BME</td>
<td>(3)</td>
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<td>BME 433 BME App of Stats</td>
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<tr>
<td>BIOL 430 Animal Physiology</td>
<td>(3)</td>
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<tr>
<td>BME 490 Senior Seminar</td>
<td>(1)</td>
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### GENERAL EDUCATION

Writing Proficiency

Humanities 100 level | (3) |
Humanities 300 level or above | (3) |
Humanities 300 level or above | (3) |
*Social Science 100 level or above | (3) |
*Social Science 300 level or above | (3) |
*Social Science 300 level or above | (3) |
Humanities or Social Science | (3) |

### IPRO

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<td>Interprof Project</td>
<td>(3)</td>
</tr>
<tr>
<td>IPRO 497</td>
<td>Interprof Project</td>
<td>(3)</td>
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- 6 of 9 credits in same area; 3 in different area
## MEDICAL IMAGING

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<td>ECE 213 Circuit Analysis II (3)</td>
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<td>MATH</td>
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<td>MATH 151 Calc I (5)</td>
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<td>MATH 333 Matrix Algebra (3)</td>
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<td>MATH 152 Calc II (5)</td>
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<td>OR CHEM 237 Orgo I (4)</td>
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<td>MATH 252 Diff Eqs (4)</td>
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<td>PHYS 224 Modern Physics (3) OR Chem 237 Orgo I. (4)</td>
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<td>MATH 251 Vector Calc (4)</td>
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<td>BME 443 Biomed Instr. &amp; Electronics (3)</td>
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<td>CHEMISTRY</td>
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<td>BME 309 Biomed Imaging and Sensing (3)</td>
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<td>CHEM 124 (with lab) (4)</td>
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<td>CHEM 438 NeuroImaging (3)</td>
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<tr>
<td>CHEM 125 Chem II (with lab) (4)</td>
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<td>ECE 437 Digital Signal Processing (3)</td>
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<td>PHYS 224 Modern Physics (3) OR CHEM 237 Orgo I. (4)</td>
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<td>BME 445 Quantitative Neural Function (3)</td>
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<td>BME Elective (300 level or above) (3)</td>
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### COMPUTER SCIENCE

| CS 201 Acc. Intro to CS (4) |

### PHYSICS

| PHYS 123: Mechanics (4) |
| PHYS 221 Electromag & Optics (4) |

### CORE

| ECE 211 Circuit Analysis (3) |
| BME 200 BME App of Matlab (1) |
| BME 310 Biomaterials (3) |
| BME 315 Instrumentation Lab (2) |
| BME 320 Fluid Laboratory (1) |
| BME 330 Anal. Biosignals (3) |
| BME 405 Physiology Laboratory (2) |
| BME 419 Intro to Design Concepts (2) |
| BME 420 Design Concepts in BME (3) |
| BME 433 BME App of Stats (3) |
| BIOL 430 Animal Physiology (3) |
| BME 490 Senior Seminar (1) |

### GENERAL EDUCATION

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<th>Writing Proficiency</th>
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<tr>
<td>Humanities or Social Science (3)</td>
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### IPRO

| IPRO 397 Interprof Project (3) |
| IPRO 497 Interprof Project (3) |

*6 of 9 credits in same area; 3 credits in different area*
EXIT INTERVIEW
Department of Biomedical Engineering

Please bring this completed when you come in for your exit interview with Professor Turitto (schedule with Ms. D’Amico, damico@iit.edu). YOU MUST COMPLETE BOTH THE WRITTEN AND ORAL EXIT INTERVIEWS IN ORDER TO GRADUATE.

A. Faculty Evaluation:

Please fill out the following information for faculty (listed alphabetically) you have had. Grade each instructor on how well he is doing his job as a teacher. Give each one a grade as follows: A = upper third among the most effective you have ever had; B = middle third among the most effective you have ever had; C = lower third among the most effective you have ever had; We will appreciate comments on both the good and bad characteristics of each. Note that faculty does not have to be rank ordered (all could receive the same grade, for example, if you evaluate them that way). Don’t list your name, except at the place where we request your forwarding address. Your name will not be associated with any of the data you provide in this survey.
<table>
<thead>
<tr>
<th>Name</th>
<th>No. of classes you had from him/her</th>
<th>Ave. of grades you received from him/her</th>
<th>Overall rating of instructor (A-C)</th>
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<tbody>
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Comments:
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Hall: ___________________   ____________________   _______________

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<th>Overall rating of instructor (A-C)</th>
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### B. Labs:

Quality of your experiences with the BME lab courses. This includes both the quality of the equipment and usefulness of lab personnel.

(Rate based on 1 to 5 scales. 1 = worst and 5 = best)

**BME 315, Instrumentation Lab:**

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<tr>
<td>Worst</td>
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Comment:

**BME 320, Fluids Lab:**

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<td>4</td>
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Comment:

**BME 405, Physiology Lab:**

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<td>Worst</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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</table>

Comment:
**General Comments about our Program**

Your Track: Cell and Tissue, Neural Engineering, Medical Imaging  *(circle one)*

Please answer the following questions about our program/department (use additional paper if necessary): (Rate based on 1 to 5 scale.  **1 = worst and 5 = best**).

<table>
<thead>
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<th>Best</th>
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<td>1 2 3 4 5</td>
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<tr>
<td>Elaborate</td>
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Quality and Effectiveness of the program.

What are the strengths of the program?

What are the weaknesses of the program?
How can we improve the program?

Your hands-on expertise now

<table>
<thead>
<tr>
<th></th>
<th>Worst</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<td>Comment:</td>
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Computers/Software: Your proficiency in

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<th>3</th>
<th>4</th>
<th>Best</th>
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<tr>
<td>a) Computer coding with any computer language</td>
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<td>4</td>
<td>5</td>
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<td>b) MATLAB</td>
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<td>4</td>
<td>5</td>
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<td>d) Any word processing software</td>
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<td>3</td>
<td>4</td>
<td>5</td>
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<td>e) Oral presentations</td>
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<td>5</td>
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<td>f) Writing reports</td>
<td>1</td>
<td>2</td>
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<td>4</td>
<td>5</td>
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</table>

Comment on any software you think should be added.

Did you have an internship as an undergraduate? What is the name of the company? Was the work related to your major? How many hours per week did you work?

Did you have a research experience as an undergraduate? With which faculty member did you work and what was the research topic? How many hours per week did you spend on the project?
Chances of attending graduate school in the near future for M.S. or Ph.D., Medical School, or other?

Comment:                      Worst  Best
                                      1   2   3   4   5

If high, answer the following questions. Mark the exam/s you took and provide percentile scores

GRE____                      Score: verb____; Quan____; Anal____;
MCAT____                      Score: Biology____, Physics____ Verbal____ Essay____

If accepted to a graduate or medical program, state where and with or without assistantship
## Skills Survey

<table>
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<th>Skill</th>
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<th>2</th>
<th>3</th>
<th>4</th>
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<tr>
<td>Ability to work independently</td>
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<td>Ability to work in teams</td>
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<td>Ability to manage time efficiently</td>
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<td>Ability to communicate (oral)</td>
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<td>Ability to complete a task</td>
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<td>Ability to use modern engineering tools</td>
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<td>(These include computer-based software tools and instrumentation)</td>
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<td>Ability to understand problems associated with the interaction of</td>
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<td>living and non-living materials and systems.</td>
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<td>Sense and knowledge of professional ethics issues</td>
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<td>Sense and knowledge of current societal and environmental issues</td>
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<td>Awareness of need for life long learning</td>
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<td>Ability to comprehend a biomedical engineering problem</td>
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<td>Ability to formulate a biomedical engineering problem</td>
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<td>Ability to solve a biomedical engineering problem</td>
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<td>Ability to analyze and interpret the solution</td>
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<tr>
<td>Ability to design and conduct experiments on living and non-living</td>
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<td>Ability to design, build and test components</td>
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Job Prospects:

Any other comments:

As part of our accreditation requirements, we would like to keep in touch with our alumni. Please give us a contact address and also keep in touch, write to us regarding your experience in the "real world."

Contact Information:
Your name:
BME Alumni Survey

Alumni Survey, 2007
Department of Biomedical Engineering
Illinois Institute of Technology

As part of the BME Department's process for continuous assessment of its educational program objectives we are requesting your input as a recent graduate with a BS in Biomedical Engineering. Please take a few minutes to complete this survey.

1. Please complete the contact information below.
   - Name:
   - Address #1:
   - Address #2:
   - State/Zip:
   - Email:

2. Month/Year of Graduation:

3. BME Track Specialization:

4. Are you currently employed? If in graduate school, enter "No".
   - YES
   - NO

5. Please indicate the following:
   - Company name
   - Job Title
   - Job
   - Responsibilities

6. How long have you been with your current employer?
7. List previous employers (Name/Dates):

8. Are you a practicing biomedical engineer?
   - YES  
   - NO

9. Have you been promoted in the past two years?
   - YES  
   - NO

10. Have you received any honors or awards within the past two years from your employer?
    - YES  
    - NO

   If YES, briefly list awards/honors:

   SUBMIT

BME Alumni Survey

11. Have you applied for graduate or professional study since you obtained your undergraduate BME degree from IIT?
    - YES  
    - NO

12. If YES, have you completed your graduate or professional studies?
    - YES
    - NO
    - IN PROGRESS
    - Other, please specify
13 If YES or IN PROGRESS indicate:

Degree
Institution
Department

14 Have you received any honors or awards within the past two years from your program?

YES  NO

If YES, briefly list awards/honors:


BME Alumni Survey

Program Objective 1: Our alumni possess the quantitative, analytic, and critical thinking skills necessary for solving biomedical engineering problems in industry, graduate or professional graduate programs.

15 Has your undergraduate experience prepared you to conduct research and/or development in your vocation?

YES  NO

If YES, give example(s):


16 If NO, what in the BME undergraduate program needs to be improved (give examples e.g., specify courses, describe experiences, etc.)?
17 Does your current position require you to solve quantitative problems?
   YES  NO

18 If YES, do you feel that the IIT BME program adequately prepared you to do this?
   YES  NO

   If you do not feel prepared, can you recommend changes to the undergraduate program?

19 Have you applied for and/or received a patent?
   YES  NO

   If YES, give example(s):

20 Have you published in scientific journals since your graduation from IIT?
   YES  NO

   If YES, how many and in which journals (specify those for which you were first author)?
Program Objective 2: The ability to employ biomedical engineering lab skills in industry, graduate or professional programs.

21 Have you applied any BME laboratory experience/skills in your vocation since graduation?

YES  NO

If YES, list some examples of skills used:

22 Do you feel that the knowledge and experience gained in your undergraduate BME lab courses has provided you with the skills to:

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<tr>
<td>1</td>
<td>Yes</td>
<td>No</td>
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Design experiments?

If NO, what do you feel needs improvement?

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<td>1</td>
<td>Conduct experiments?</td>
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If NO, what do you feel needs improvement?

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<td>1</td>
<td>Analyze and interpret Data?</td>
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If NO, what do you feel needs improvement?
BME Alumni Survey

Program Objective 3. Our alumni possess the requisite written oral communication skills necessary to interact with health care professionals, engineers or scientists in industry, graduate or professional graduate programs.

23 Do you deliver oral and/or poster presentations in your current vocation?
   YES  NO

24 Do you prepare written reports and proposals in your current vocation?
   YES  NO

25 Have you presented at professional society meetings and seminars since you graduated from IIT?
   YES  NO

If YES, indicate professional organizations:

---

26 List other examples where you currently practice written and/or oral communication in your current vocation.

---

27 Do you feel that your undergraduate experience in BME has prepared you in written and oral communication?
   YES  NO

If NO, why not? What could be improved?
BME Alumni Survey

Program Objective 4. Our alumni possess the ability to work in teams in industry, and graduate or professional graduate programs.

28 Have your past/current positions required teamwork?
   YES  NO

29 If you answered YES above, what levels of responsibility have been required of you in your vocation? What roles have you played? Give examples.

30 If you answered YES above, do you feel that your training at IIT adequately prepared you to work within a team-based environment?
   YES  NO

If NO, what in the BME program do you feel needs to be improved?

BME Alumni Survey

Program Objective 5. Our alumni possess the sense of responsibility and
ethics of a professional engineer in industry, and graduate or professional graduate programs.

31 Are you aware of the Biomedical Engineering Society Code of Conduct?
   YES   NO

32 Do you maintain the Biomedical Engineering Society Code of Conduct?
   YES   NO

33 Are environmental, global, and societal considerations an important part of your current position?
   YES   NO

34 Has your undergraduate experience in BME prepared you for handling ethical issues?
   YES   NO

If YES, give examples of ethical issues you have encountered since graduating from IIT.

35 If you answered NO to question 34, what in the BME program could be improved? Give examples.

BME Alumni Survey

Relevance of ABET Program Outcomes
Below you are asked to rate the importance of a list of skills to your occupation and career goals. In addition, you are to rate the preparation that you received in each area while at IIT. Please select one value from the five-point Likert scale for each question.

### 36 Criterion One: Your ability to apply knowledge of mathematics, science, and engineering.

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<tr>
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<th>1 Not Important</th>
<th>2 Somewhat Important</th>
<th>3 Not Important</th>
<th>4</th>
<th>5 Very Important</th>
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</table>

### 37 Criterion Two: Your ability to design and conduct experiments, as well as analyze and interpret data.

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### 38 Criterion Three: Your ability to design a system, component, or process to meet desired needs.

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<td>Importance</td>
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### 39 Criterion Four: Your ability to function on multi-disciplinary teams.

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<td>1</td>
<td>2</td>
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</table>
40 **Criterion Five**: Your ability to identify, formulate, and solve engineering problems.

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<th>Importance</th>
<th>Preparation</th>
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<td>Not Important</td>
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<td>Somewhat Important</td>
<td>2</td>
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<tr>
<td>Very Important</td>
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41 **Criterion Six**: Your understanding of professional and ethical responsibility.

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<th>Importance</th>
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<td>Very Important</td>
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42 **Criterion Seven**: Your ability to communicate effectively.

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<td>Very Important</td>
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43 **Criterion Eight**: Your ability to understand the societal and global impact of engineering solutions.

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</table>
44 **Criterion Nine:** Your recognition of the need to engage in life-long learning, e.g., additional education, training, attending professional workshops and conferences, etc.

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45 **Criterion Ten:** Your knowledge of contemporary issues.

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46 **Criterion Eleven:** Your ability to use techniques, skills, and modern engineering tools necessary for engineering practice.

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47 **Criterion Twelve:** Your understanding of the business environment.

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</table>

48 Please use the space below to share any additional feedback that could be used to improve the undergraduate BME program at IIT.
The faculty and staff of the Biomedical Engineering Department at IIT thank you for taking the time to complete this survey. Your feedback is invaluable to the success and improvement of the undergraduate BME program.
**IIT Industry Evaluation – Dept of Biomedical Engineering**  
**Employer Appraisal of IIT BME Graduate**

<table>
<thead>
<tr>
<th>Student Name:</th>
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<table>
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<tr>
<th>Company Name:</th>
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<tr>
<th>Supervisor Name/Division:</th>
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<th>Dates of Employment:</th>
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**Note to supervisor:** the information provided below will be distributed to members of the biomedical engineering undergraduate committee at IIT and used to improve the undergraduate learning experience in Biomedical Engineering (BME).

Please evaluate the above employee’s performance along each of the dimensions listed below using the following five-point Likert scale:

1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A: Not applicable

**Section I: Engineering Content**

1) The ability to apply knowledge of mathematics, science and engineering.

   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

2) The ability to design and conduct experiments.

   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

3) The ability to analyze and interpret data.

   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

4) The ability to design a system, component or process to meet desired needs.

   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

5) The ability to identify, formulate and solve engineering/technical problems.

   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

6) The ability to use techniques, skills and modern tools necessary for engineering/technical practice.

   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A
Section II: Professional Skills

1) The ability to function on multi-disciplinary teams.
   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

2) The ability to demonstrate an understanding of professional and ethical responsibility.
   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

3) The ability to communicate effectively in writing.
   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

4) The ability to communicate orally.
   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

5) The ability to demonstrate an understanding of the impact of engineering solutions in a global and societal context.
   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

6) A demonstrated recognition of the need for continuous learning.
   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

7) A demonstrated knowledge of contemporary issues.
   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

8) The ability to schedule and organize work efficiently.
   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

9) The ability to initiate appropriate, independent action with a minimum of supervision.
   1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

10) The ability to work well with people of diverse backgrounds and styles.
    1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A

11) A demonstrated maturity in judgment and concern for the welfare of others.
    1-Poor  2-Fair  3-Average  4-Very Good  5-Excellent  N/A
Section III: Overall assessment of the employee’s performance

1) Please comment on your overall assessment of the employee’s performance:

2) Responsibilities (please be specific):

3) Deliverables (please be specific)
Section IV: Supervisor Feedback

1) What factors most impress you about this employee?

2) What are some specific suggestions for student improvement and growth?

Evaluated By:

Title:

Date:
Evaluation of Student Learning Objectives

Course: BME-____  Instructor: _____________  Semester: ___ Fall ___ Spring  20___

Please refer to student learning objectives for this course listed in the attached syllabus and rate each objectives on a scale of 1-4 in each column.

<table>
<thead>
<tr>
<th>Objective</th>
<th>1</th>
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Additional Comments:
Please comment on the ratings given above:
Illinois Institute of Technology  
Department of Biomedical Engineering  

FACULTY COURSE ASSESSMENT

Course: BME-____  Instructor:_____________  Semester: Fall ___ Spring ___  20___

Student Enrollment: ___

1. How many students earned each grade?  A ___  B ___ C ___ D___ E ___

2. In the table below indicate the percentage of student achievement for each student learning objective (SLO) addressed in your course. Specify the example used (i.e. Exam #, problem #, Hwk #, problem #, course project, etc…) for your assessment. Also indicate the equivalent program outcome(s) for each SLO in the table provided.

<table>
<thead>
<tr>
<th>Student Learning Objective (SLO)</th>
<th>Example used for assessment (i.e., Exam 1, problem1)</th>
<th>Equivalent Program Outcome(s) (Indicate a-m)</th>
<th>No understanding/achievement of Objective (%)</th>
<th>Need improvement (%)</th>
<th>Achieved objective (%)</th>
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3. In your opinion were the students adequately prepared in Mathematics? If not, what deficiencies did you identify?
   ____________________________________________________________

4. In your opinion were the students adequately prepared in the basic sciences? If not, what deficiencies did you identify?
   ____________________________________________________________

5. Do you feel that the students were adequately prepared based on the course pre-requisites? If not, what deficiencies did you identify?
   ____________________________________________________________

316
6. If you were to teach the course again, what modifications would you make? (Use additional pages if needed).

7. Please attach a graphical comparison of SLO achievement based on student surveys and faculty assessment. An example is provided below.
ABET Program Outcomes:

(a) an ability to apply knowledge of mathematics, science, and engineering to the solution of biomedical engineering problems
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a biomedical engineering 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 multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively based upon analytical and critical thinking skills
(h) the 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 relevant to biomedical engineering
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
(l) an understanding of biology and physiology, and the capability to apply advanced mathematics, science, and engineering to solve the problems at the interface of engineering and biology;
(m) 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.