Student Handbook
2010-2011

Department of Biomedical Engineering
Tulane University
New Orleans, LA 70118 USA
(504) 865-5897
http://tulane.edu/sse/bme/

March 2011
Tulane University reserves the right to change any of its rules, courses, regulations and charges without notice and to make such changes applicable to students already registered as well as to new students. Although we make every effort to verify the accuracy of the information in this booklet, errors may still be present.
Dear Prospective or Current Student:

This booklet includes detailed descriptions of our department - the faculty, our research, the courses we teach, and the requirements for the degrees we offer.

The term “Biomedical Engineering” covers the application of engineering techniques and principles to problems and processes in biology or medicine. Our department was founded in 1977, so we are a relatively mature department in a new field - a field where the potential for making meaningful contributions is unlimited. Our backgrounds are diverse, covering the areas of biomechanics, biomaterials, bioelectronics, bioinformatics and tissue engineering. All of the faculty are actively engaged in research sponsored by federal, state and/or private organizations, and we believe that this enhances our teaching abilities by keeping us at the forefront of knowledge in our specialties. You will find that Tulane's Department of Biomedical Engineering is internationally recognized for our research and for the quality of our teaching and mentorship. Each of the faculty members is committed to helping you acquire the very best education.

At the undergraduate level, the emphasis chosen by our faculty is, first and foremost, to provide students with the opportunity to acquire a rigorous engineering education with an emphasis on scientific principles and interdisciplinary investigation. This foundation serves as a springboard to the study of biomaterials and tissue engineering, bioelectronics, biomechanics and design that will prepare our students for graduate school, medical school, or a position in industry.

At the graduate level we consider our students to be junior colleagues, and we furnish them with the advanced coursework, professional guidance, and equipment/facilities that are critical to their development as independent scholars. We have the resources, experience and energy that is required to mentor our students as they conduct independent research and pursue careers related to one of the major themes of biomedical engineering.

While written material and the information on our web site http://tulane.edu/sse/bme/ may be effective in answering general questions about study in biomedical engineering at Tulane, it cannot convey the enthusiasm that we feel for the work we are doing. If you are a prospective student, please feel free to write or e-mail; however, frequently a personal visit is the most effective way for you to decide whether you wish to join us. We will be happy to show you our facilities, introduce you to the faculty, and discuss the field of biomedical engineering with you if you make an appointment to visit us here in New Orleans.

I appreciate your interest in Tulane’s Department of Biomedical Engineering and hope you will decide to join us.

Sincerely,

Donald P. Gaver, Ph. D.
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1. Introduction

1.a. Departmental Mission Statement
Our mission is to inspire and work with students as we develop and apply engineering methods to confront health science challenges.

1.b. Departmental Vision
The Department of Biomedical Engineering is committed to being a global leader in biomedical engineering scholarship. Our faculty, staff, and students are all important parts of the team that provide distinctive opportunities for creative interdisciplinary solutions to biomedical engineering research and design problems. We aim for: excellence in undergraduate and graduate education; meaningful and innovative research; and service dedicated to advancing the field of Biomedical Engineering.

1.c. The Community
Tulane University is located in Uptown New Orleans, a beautiful residential section in one of America’s most distinctive cities. The area offers many cultural and recreational opportunities. Plays, concerts, and movies on campus are numerous. The city has long been known as the birthplace of jazz, and continues to be a major force in musical innovation and performance. Sailing, boating, and fishing are popular on Lake Ponchartrain (15 minutes from campus) and the beaches of the Mississippi Gulf Coast are less than an hour’s drive from New Orleans. The sports enthusiast can watch the Tulane Green Wave and the New Orleans Saints play in the Louisiana Superdome, attend basketball and baseball games on campus, and Zephyrs (minor league baseball), and New Orleans Hornets (NBA basketball) games off campus. There are many opportunities to participate in intramural sports, or to use the sports facilities of the Reily Center. Mardi Gras and its preliminary festivities offer pageantry unparalleled in the United States. The picturesque plantations and bayou country surrounding New Orleans provide many opportunities for pleasant weekend trips. Cajun and Creole food from Louisiana is world-renowned.

1.d. The University and the Department
Tulane is a private, nonsectarian university offering a wide range of undergraduate, professional, and graduate courses of study for men and women. Students are selected without regard to race, sex or religion. Tulane enrolls approximately 6,700 undergraduate and 4,400 graduate and professional students each year. About a third of the undergraduate student body is in the School of Science and Engineering.

Tulane’s Biomedical Engineering (BMEN) Department evolved from joint research efforts among faculty in the School of Science and Engineering and the Schools of Medicine at Tulane and the Louisiana State University Medical Center in New Orleans. Undergraduate BMEN degrees were first awarded in 1974, and in 1977 four tenured members of the Mechanical Engineering faculty, plus one new hire, formed the separate BMEN Department. In the past 30 years research in Tulane’s Department of Biomedical Engineering has matured from having a mechanics-oriented focus to a broader range of investigations that encompasses biotransport, biomechanics (fluid and solid), biomaterials and cell-tissue engineering. We have developed a strong expertise in computational modeling and analysis with specific foci on investigations of ocular biomechanics, microvascular research, pulmonary mechanics and biomaterials investigations of the neural system. The undergraduate program has been ABET accredited continuously since 1981, and is one of the largest majors in the School of Science and Engineering with approximately 150 undergraduates and 30 graduate students.

The Biomedical Engineering program represents one of Tulane’s areas of excellence, achieving national recognition in many periodic surveys.
2. Undergraduate Program

2.a. Undergraduate Program Objectives
Our undergraduate program provides students with the breadth required for participation in the interdisciplinary field of biomedical engineering and the depth required by engineers to advance the practice in our discipline. Our objective is to prepare graduates who are able to successfully pursue:
• advanced studies leading to research or professional practice in biomedical engineering
• advanced studies leading to research or professional practice in the health and medical sciences
• practice in biomedical engineering industries or related technical and professional fields.

2.b. Undergraduate Instructional Outcomes
By the time of graduation, our students are expected to have these skills, common to all engineers:
• an ability to apply knowledge of mathematics, science, and engineering.
• an ability to design and conduct experiments, as well as to analyze and interpret data.
• an ability to design a system, component, or process to meet desired needs.
• an ability to function on multi-disciplinary teams.
• an ability to identify, formulate, and solve engineering problems.
• an understanding of professional and ethical responsibility.
• an ability to communicate effectively.
• the broad education necessary to understand the impact of engineering solutions in a global and societal context.
• a recognition of the need for, and an ability to engage in life-long learning.
• a knowledge of contemporary issues.
• an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Furthermore, as Biomedical Engineers, we expect them to also possess:
• an understanding of Biology.
• an understanding of Physiology.
• the capability to apply advanced mathematics including differential equations to solve problems at the interface of engineering and biology.
• the capability to apply advanced mathematics including statistics to solve the problems at the interface of engineering and biology.
• the ability to make measurements on living systems.
• the ability to interpret data from living systems.
• the ability to address the problems associated with the interaction between living and non-living materials and systems.

2.c. Undergraduate Curriculum and Degree Requirements
The undergraduate program in Biomedical Engineering is built upon a rigorous engineering science foundation that is, in turn, based upon a broad curriculum of natural sciences, mathematics, electives in humanities and social sciences, and design. Although students are encouraged to concentrate their professional electives in a sub-field of interest in biomedical engineering (e.g., biomechanics, bioelectronics, bioelectricity, biomaterials, or tissue engineering) or medical sciences (for pre-med students), there are no formal “tracks” within the sequence. The undergraduate curriculum is designed primarily to prepare our undergraduates for advanced study. More than two-thirds of our BSE graduates continue on to graduate or professional training after graduation from Tulane. Our philosophy of ‘rigorous breadth’ in biomedical engineering can best be characterized by the undergraduate curriculum described below. This sample curriculum is applicable to the Class of 2014; exact programs of study for other class years are posted on the department website.
### Year 1

#### Semester One 18 Hours

<table>
<thead>
<tr>
<th>Course Title (Credit Hours)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1210 Calculus I (4)</td>
<td></td>
</tr>
<tr>
<td>CHEM 1070/1170 General Chemistry I &amp; Lab (4)</td>
<td></td>
</tr>
<tr>
<td>ENGL 1010 Writing (4)</td>
<td></td>
</tr>
<tr>
<td>PHYS 1310 General Physics I &amp; Lab (4)</td>
<td></td>
</tr>
<tr>
<td>TIDES Tulane Inter. Exp. Sem. (1)</td>
<td>*Service Learn (1) (1st or 2nd year)</td>
</tr>
</tbody>
</table>

#### Semester Two 18 Hours

<table>
<thead>
<tr>
<th>Course Title (Credit Hours)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1220 Calculus II (4)</td>
<td></td>
</tr>
<tr>
<td>CHEM 1080/1180 General Chemistry II &amp; Lab (4)</td>
<td></td>
</tr>
<tr>
<td>CULT Cultural Knowledge Elective (3)</td>
<td></td>
</tr>
<tr>
<td>PHYS 1320 General Physics II &amp; Lab (4)</td>
<td></td>
</tr>
<tr>
<td>ENGP 1410 Statics (3)</td>
<td></td>
</tr>
</tbody>
</table>

### Year 2

#### Semester One 17 Hours

<table>
<thead>
<tr>
<th>Course Title (Credit Hours)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 2210 Calculus III (4)</td>
<td></td>
</tr>
<tr>
<td>CELL 1010/2110 General Biology I &amp; Lab (4)</td>
<td></td>
</tr>
<tr>
<td>ENGP 2010 Electric Circuits (3)</td>
<td></td>
</tr>
<tr>
<td>ENGP 2430 Mechanics of Materials (3)</td>
<td></td>
</tr>
<tr>
<td>BMEN 2310 Product &amp; Experimental Design (3)</td>
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</tr>
</tbody>
</table>

#### Semester Two 18 Hours

<table>
<thead>
<tr>
<th>Course Title (Credit Hours)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 2240 Applied Math (Diff Eqns.) (4)</td>
<td></td>
</tr>
<tr>
<td>BMEN 2600 Intro Organic &amp; Bio-Chemistries</td>
<td></td>
</tr>
<tr>
<td>BMEN 2730 Biomedical Electronics &amp; Lab (4)</td>
<td></td>
</tr>
<tr>
<td>BMEN 3120 Materials Science &amp; Engr (3)</td>
<td></td>
</tr>
</tbody>
</table>

### Year 3

#### Semester One 16 Hours

<table>
<thead>
<tr>
<th>Course Title (Credit Hours)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMEN 3030/3035 Anat &amp; Physiol for Engr &amp; Lab (4)</td>
<td></td>
</tr>
<tr>
<td>BMEN 3440 Biofluid Mechanics (3)</td>
<td></td>
</tr>
<tr>
<td>BMEN 3710 BMEN Seminar (0)</td>
<td></td>
</tr>
<tr>
<td>BMEN 3xxx “Domain” class (3)</td>
<td></td>
</tr>
<tr>
<td>CULT Cultural Knowledge Elective(3)</td>
<td></td>
</tr>
<tr>
<td>**PELECT Professional Elective (3)</td>
<td></td>
</tr>
</tbody>
</table>

#### Semester Two 15 Hours

<table>
<thead>
<tr>
<th>Course Title (Credit Hours)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMEN 3070/3075 Quantitative Physiology &amp; Lab (4)</td>
<td></td>
</tr>
<tr>
<td>BMEN 3820 Math Modeling (3)</td>
<td></td>
</tr>
<tr>
<td>CULT Cultural Knowledge Elective (3)</td>
<td></td>
</tr>
<tr>
<td>BMEN 4900 Research &amp; Prof. Practice (2)</td>
<td></td>
</tr>
<tr>
<td>BMEN 3xxx “Domain” class (3)</td>
<td></td>
</tr>
</tbody>
</table>

### Year 4

#### Semester One 13 Hours

<table>
<thead>
<tr>
<th>Course Title (Credit Hours)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMEN 4030 Team Design I (2)</td>
<td></td>
</tr>
<tr>
<td>BMEN 4910 Research &amp; Prof. Practice II (2)</td>
<td></td>
</tr>
<tr>
<td>BMEN 6710 BMEN Seminar (0)</td>
<td></td>
</tr>
<tr>
<td>CULT Cultural Knowledge Elective (3)</td>
<td></td>
</tr>
<tr>
<td>CULT Cultural Knowledge Elective (3)</td>
<td></td>
</tr>
<tr>
<td>**PELECT Professional Elective (3)</td>
<td></td>
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</tbody>
</table>

#### Semester Two 12 Hours

<table>
<thead>
<tr>
<th>Course Title (Credit Hours)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMEN 4040 Team Design II (3)</td>
<td></td>
</tr>
<tr>
<td>BMEN 6720 BMEN Seminar (0)</td>
<td></td>
</tr>
<tr>
<td>CULT Cultural Knowledge Elective (3)</td>
<td></td>
</tr>
<tr>
<td>**PELECT Professional Elective (3)</td>
<td></td>
</tr>
</tbody>
</table>

127 Credit Hours

*Students must take a Service Learning class during their first two years (noted in credits for 1st semester of Year 1).

**Students take 4 Professional Electives. At least one must be a BMEN 6xxx graduate course as a follow-up to a BMEN 3xxx domain course.
2.c.1. Tulane Core Requirements

Several of the Tulane-Newcomb College Core Requirements are satisfied during completion of the Biomedical Engineering curriculum.

<table>
<thead>
<tr>
<th>Core Requirement:</th>
<th>Satisfied by:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Language</td>
<td>Not required for BSE degree</td>
</tr>
<tr>
<td>Writing (4 credits, first year)</td>
<td>ENGL1010 or equivalent</td>
</tr>
<tr>
<td>Quantitative Reasoning (3-4 credits)</td>
<td>MATH1210 or equivalent</td>
</tr>
<tr>
<td>Science (3-4 credits)</td>
<td>PHYS1310</td>
</tr>
<tr>
<td>Science with Lab (3-4 credits)</td>
<td>CHEM1070/1170</td>
</tr>
<tr>
<td>Cultural Knowledge (12 credits)</td>
<td>Satisfied through choice of CULT electives</td>
</tr>
<tr>
<td>Perspectives – European Tradition</td>
<td>Satisfied through choice of CULT electives</td>
</tr>
<tr>
<td>Perspectives – Outside European Tradition</td>
<td>Satisfied through choice of CULT electives</td>
</tr>
<tr>
<td>Service Learning – lower division</td>
<td></td>
</tr>
<tr>
<td>Service Learning – upper division</td>
<td>BMEN4030 &amp; BMEN4040</td>
</tr>
<tr>
<td>Interdisciplinary Scholarship (TIDES)</td>
<td></td>
</tr>
<tr>
<td>Capstone Experience</td>
<td>BMEN4030 &amp; BMEN4040</td>
</tr>
<tr>
<td>Writing Intensive</td>
<td>BMEN4900 &amp; BMEN4910</td>
</tr>
</tbody>
</table>

Table 1 - Undergraduate Core Requirements

Cultural Knowledge Electives

In the interest of making engineers more aware of their social responsibilities and better able to consider related factors in the decision-making process, coursework in humanities and social sciences is an integral part of our program. The BME curriculum requires a minimum of six courses of acceptable Cultural Knowledge electives in addition to satisfying the Freshman Year Writing requirement. Cultural Knowledge courses must be chosen to provide both breadth and depth and should not be a selection of unrelated introductory courses. The specific requirements for choice of these electives are determined by Newcomb-Tulane College, and Biomedical Engineering students are urged to consult with the Newcomb-Tulane College Advising Center.

While the School of Science and Engineering does not require a foreign language, it is highly recommended that students with a talent and background in languages consider using a language for some of the coursework to meet the Cultural Knowledge requirement. Engineering has become increasingly global, and a background in a foreign language and culture may be quite important to one's career.

2.c.2. Biomedical Engineering Degree Requirements

Domain Courses and Professional Electives

“Domain” courses from two different areas, plus four professional electives, must be completed. The professional electives must include at least one BMEN 600-level course. The other three professional elective courses may be any courses that meet the student's professional goals. Up to two ROTC courses may be used to meet this requirement. Domain courses, and the BMEN6xxx Professional Electives which follow them, are shown in the table below.
Table 2

<table>
<thead>
<tr>
<th>Design Domain Cell/Tissue and Biomaterials Domain</th>
<th>Biotransport Domain</th>
<th>Biomechanics Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMEN3xxx course</td>
<td>BMEN3xxx course</td>
<td>BMEN3xxx course</td>
</tr>
<tr>
<td>3500 Elements of BMEN Design</td>
<td>3400 Biomaterials &amp; Tissue Engineering</td>
<td>3420 Transport in Cells and Organs</td>
</tr>
<tr>
<td>3780 Projects in Embedded Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMEN6xxx courses</td>
<td>BMEN6xxx courses</td>
<td>BMEN6xxx courses</td>
</tr>
<tr>
<td>6680 Orthopedic Bioengineering</td>
<td>6430 Vascular Bioengineering</td>
<td>6020 Biosystems</td>
</tr>
<tr>
<td>6740 Data Acquisition and Control</td>
<td>6260 Molecular Principles of Functional Biomaterials</td>
<td>6330 Advanced Biofluid Mechanics</td>
</tr>
<tr>
<td>6760 Biomedical Microdevices</td>
<td>6680 Orthopedic Bioengineering</td>
<td>6800 Comp. Modeling of Biomedical Systems</td>
</tr>
<tr>
<td>6790 Design Studio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCEN6000 Engineering Entrepreneurship</td>
<td></td>
<td>6600 Comp. Modeling of Biomedical Systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6630 Cell Mechanics</td>
</tr>
</tbody>
</table>

Research and Design Experiences

Hallmarks of our curriculum are the research and design experiences that are coordinated through the two semester sequences in Professional Practice and Design (4900, 4910) and Team Design (4030, 4040). Every student participates in an individual research project as well as a team design project.

The team design projects, which are supported by the National Science Foundation and, are tailored to the needs of clients with disabilities who are referred to the department by several community agencies. The team designs are evaluated for safety and then presented and judged in a public design competition. Each class completes team projects (generally four students per team). A list and brief description is included in the Appendices. The team design experience of working for an extended period with a client with a disability—while having the opportunity to apply engineering foundations and real world design and construction skills to assist the client—has been extremely rewarding for our students.

In addition to the team design project, each student participates in an individual year-long research project generally with a biomedical engineering faculty member or with faculty in departments of the Tulane or LSU medical schools. The list of research projects completed by the each class covers an impressive range of activities. The students thus have substantial research experience, while still undergraduates that include writing a comprehensive thesis describing the research performed and an oral presentation of the work to the faculty and fellow students during the annual "Undergraduate Research Day Conference." A list of the recent undergraduate research projects is included in the Appendices.

2.c.3. Minor in Biomedical Engineering

Students in Chemical Engineering or Engineering Physics may earn a Minor in Biomedical Engineering through completion of the following courses:

- CELL 1010/2110 Cell Biology
- BMEN 2600 Intro. to Organic and Biochemistry
- BMEN 3030/3035 Anatomy and Physiology for Engineers, with lab
- BMEN 3070/3075 Quantitative Physiology, with lab

Plus 1 course selected from:

- BMEN 3300 Biomechanics
- BMEN 3400 Biomaterials and Tissue Engineering
- BMEN 3230 Biomaterials
- BMEN 3780 Projects in Embedded Control

2.d. Undergraduate Teaching Facilities

BME Design Studio, SSE Building, room 208:

Designed as a multipurpose classroom / meeting / studio environment, the Department of Biomedical Engineering at Tulane University offers students the opportunity to experience the engineering design process from napkin-sketch concept to finished product.

The studio is equipped with multiprocessor/twin-monitor workstations running the latest version of SolidWorks. CAD/CAM models can be molded in ABS plastic with the Dimension SST-1200 rapid prototyper, or milled in metal on the department’s CNC 1
\[3060/3160 \text{ prior to Fall '11}\]
milling machine. Tensile and compressive properties of the finished parts can then be analyzed on the MTS 1-kip capacity universal testing machine.

**BME Workshop, Mechanical Services Building, room 124B:**
The Department of Biomedical Engineering operates an extensive woodworking shop to aid in the development and production of research materials. Used extensively in the undergraduate Team Design curriculum, the shop has been utilized for projects including:
- Fine/finish woodworking
- Thermoforming of plastic and PVC
- Heavy/framing carpentry
- Light plastic and metalwork
- Vacuum-pressure GRP molding

**BME Computer Lab, Boggs 548:**
Supporting the capabilities of the electronics laboratory is a digital classroom that remains available to students around the clock. Incorporating new Windows 7 workstations with the latest software releases, this lab provides large 22” display screens for work with office productivity applications, CAD/CAM, finite element analysis, LabVIEW, and mathematical modeling software.

**Pendleton Lehde Electronics Laboratory, Boggs 441:**
The Department of Biomedical Engineering operates an electronics design and testing facility to support graduate and undergraduate coursework and research. 10 workstations offer oscilloscopes, power supplies, prototyping boards, and circuit analysis software. Highlights of the lab include:
- National Instruments LabVIEW and MultiSIM software
- NI BNC-2120 A-to-D breakout boxes
- National Instruments ELVIS II development boards
- Biopac hardware/software suite for Physiology
- Parallax Boe-Bot robot design package

Typical applications/projects performed in the electronics lab include:
- Design and construction of embedded controllers using MSP430 and BASIC Stamp hardware.
- Control of servo devices, robotics, display and sensor interfacing
- Work with rectifiers, filters, regulators and power supplies.
- Analog amplifiers and active filters of interest for medical devices.
- Combinational and sequential digital logic design techniques and circuits.

**Teaching / Tissue Lab, Boggs 241:**
This lab is a wet lab capable of holding large classes. It has a complete setup for cell culture work including laminar flow hoods, incubators, centrifuge, and water bath. It is also equipped for cell and molecular assessments, with phase/fluorescent microscopes, a gel imager, and fluorescent plate reader. This room is also equipped for tissue dissections and analysis. Multiple BME professors use this room for lab activities in a number of classes. In addition this room has significant bench top space and is ideal for large projects and group work.

**CAMS, Reily Center:**
The Center for Anatomical and Movement Sciences (CAMS) is one of eight specialized centers associated with the School of Science and Engineering. The Center is an independent SSE facility that allows faculty from associated departments to teach anatomy and physiology within their discipline utilizing an aggregate and centralized resource geared toward interdepartmental relationships. CAMS is an expansion of the former Human Anatomy Lab. Its main goal is to provide anatomical resources to departments across the uptown campus. CAMS main lab offers a unique human dissection experience to undergraduate and graduate students from the nine departments associated with the School of Science and Engineering (SSE). Additional labs provide hands-on experience with accelerometry, electromyography, metabolic assessment, and spirometry and other movement related physiology.

**2.e. Awards and Honors**

**Awards:**
There are many honors and awards that serve to recognize exceptional performance or service to a Department or the School of Science and Engineering. These awards are given annually in a special ceremony. Some of these awards are recognized by a plaque permanently placed in the Departmental offices and on the Department’s web site. Details of Departmental awards are found at http://tulane.edu/sse/bme/newsandevents/awards/index.cfm

**University Honors for Academic Excellence**
Complete details of the requirements for university honors may be found at http://honors.tulane.edu/web/. In summary, a student who at the time of graduation has achieved a cumulative grade-point average of at least 3.600 and has completed the Honors Program requirements will be awarded the degree magna cum laude. The degree summa cum laude is reserved for students who have achieved a cumulative grade-point average of at least 3.800 and have completed the Honors Pro-
The committee will consist of at least three members of an acceptable Senior Honors Thesis. For completion of the research project and presentation awarded at graduation following successful provisional project title. Departmental Honors will be named the committee members and provide a letter of application must be cosigned by the advisor, and guidelines of the Honors Program. The letter of recommendation must be submitted with the project to an honors project. Successful completion of this project will result in the degree being conferred “...with Departmental Honors in Biomedical Engineering.” To apply for candidacy for this honor, the student must identify a suitable research topic and advisor, select a research advisory committee, and submit a letter of application to the instructor of Research and Professional Practice by April 7th of the third year. The committee will consist of at least three members including the student's project advisor. Committee members must come from the academic, scientific, and professional community. At least one member of the committee must be a member of the departmental faculty. In order to receive University Honors (see above), students must comply with the guidelines of the Honors Program. The letter of recommendation must be cosigned by the advisor, and should name the committee members and provide a provisional project title. Departmental Honors will be awarded at graduation following successful completion of the research project and presentation of an acceptable Senior Honors Thesis. For participants in the fifth year program, the student's Honors Thesis requirements will be satisfied by the completed Master's Thesis.

2.f. Post-Graduation Career Paths
Every class is composed of outstanding individuals—BMEN students are typically some of the brightest students on campus, and each class seems to develop its own personality and interests. Thus, answering the frequent questions about expected post-graduation plans for beginning students is difficult. However, because biomedical engineering is a new and dynamic field, the questions about “what can I do with the degree” are frequent. The following observations are offered to give some insight, but these are generalizations and should be regarded as such.

Each year, approximately one half of the entering BMEN freshmen have—at least in the back of their minds—the idea that they may want to go to medical school to become a practicing physician. Typically, at the end of four years, slightly more than one third of the class members enter graduate school, and approximately 20% of the class members enter medical school. Of the remaining students, some begin their military commitment following ROTC training, and others (one-quarter of the class) enter the workforce. Jobs are typically available in government (e.g., FDA, NASA) or the medical device industry (e.g., orthopedic appliance companies, pacemaker companies). The high percentage of students who choose to continue their education is primarily driven by the students’ desire to participate in the discovery and innovation that characterizes the growing field of biomedical engineering. In addition, although there are approximately 10,000 medical device companies in the US, the companies tend to be quite small so that students seeking employment must aggressively seek job opportunities. Help is provided by the Career Services Center and by the informal network of industry links from faculty and alumni. Students are encouraged to work with Tulane’s Career Services Center (http://hiretulane.com) to find internships and employment opportunities. BMEN alumni who are willing to answer current students’ questions about employers and career paths can be found on our alumni web group, http://www.linkedin.com/groups?gid=1923837

Pre-Medical Information
Earning an undergraduate degree in Biomedical Engineering provides an excellent foundation for eventually becoming a practicing physician. The training in quantitative reasoning and problem solving is particularly valuable in forming diagnoses and treatment strategies. In addition, the required year-long Anatomy and Physiology sequence during the
junior year (taught by the medical school faculty), provides a solid introduction to physiology. The BMEN students have a fine record of acceptance into medical school—typically at least twice the national average. However, the rigorous engineering curriculum is a difficult pathway to medical school—especially if the student does not have a fundamental and driving interest in becoming an engineer. If a student really only wants to be a physician and does not have interests that are quantitative and technical, another choice of a pre-med major is recommended.

The standard biomedical engineering curriculum comes close to meeting the admission requirements for many medical schools. Each medical school establishes its own required sequence of courses and students need to check with the specific school of interest and also meet with Tulane’s pre-med advisor to carefully plan the appropriate courses (http://advising.tulane.edu). In general, pre-meds must supplement the Tulane BMEN standard curriculum in three areas:

English: Many medical schools require a year of college English, but BMEN requires only one semester. One of the Cultural Knowledge electives can be used for the second semester of English.

Biology: Most medical schools require a year of college Biology, with Lab. The BMEN curriculum requires one semester (with lab) supplemented by the year-long sequence of Anatomy and Quantitative Physiology. Although this standard sequence exceeds the Tulane Medical School requirements for “biological sciences” most other schools will require an additional course in general biology. A second biology course may be taken and counted as a professional elective.

Organic Chemistry: The standard BMEN curriculum does not require Organic Chemistry. All medical schools require a year-long sequence in Organic Chemistry, with Lab. Tulane BMEN students may use two professional electives to take Organic Chemistry. Many students find it advantageous to take Organic Chemistry during the summer between their Sophomore and Junior years. The required course, BMEN 2600, Introduction to Organic and Biochemistry, does not count toward the medical school requirements, but is required by all BMEN students in preparation for the Quantitative Physiology sequence. Students may elect to substitute a two-semester course in Organic Chemistry and a one-semester course in Biochemistry (e.g. CHEM3830) in lieu of BMEN 2600 if those courses are completed satisfactorily prior to taking Quantitative Physiology.
3. BSE-MS Program

An integrated five-year Bachelor’s -Master’s program is available in the School of Science and Engineering wherein students pursue both the BSE (Bachelor of Science in Engineering) and MS (Master of Science) degrees. Management of the program—including specific eligibility requirements—is determined by the various Departments subject to the approval of the School of Science and Engineering.

3.a. Options for Biomedical Engineering Students

The Biomedical Engineering Department has a program leading to both the BSE and MS degree in five years. Participation requires a current undergraduate student to apply and to be accepted.

The 5 year plan allows a student to elect not to receive a BSE until the end of the fifth year, then both degrees are awarded. This plan has two attractions:

1) The student maintains an undergraduate status with potential benefits of continued scholarships or other financing
2) A separate senior thesis is not required. Completing the Master’s thesis serves in lieu of a senior thesis.

Tuition for this program is 35% of the normal full undergraduate tuition during the fifth year.

3.b. Initial Eligibility Requirements

- Minimum 3.4 GPA at the conclusion of the 1st semester of the Junior year. For this GPA the student may include his or her transfer credits. Official transcripts do not always include transfer credits into the calculation of an individual’s GPA and may not be a complete representation of the total GPA for courses taken towards an individual’s degree.
- Identification of an advisor willing to supervise the student and a focused research plan, as indicated by a letter of intent to the instructor of Research and Professional Practice. This letter is needed by March 31st of the 3rd year. The letter of intent, co-signed by the advisor, should outline and briefly describe an appropriate research topic and project to be completed.
- Students not meeting the above requirements (individuals with a GPA between 3.0 and 3.4) may file a letter of intent along with a petition to the Department to participate in the five year program. This is due by March 31st of the 3rd year.

3.c. Continuation Requirements

- Formal application to the school’s graduate division is due in the Department by October 1st of the 4th year. The application must be complete and include a transcript, essay, and GRE scores (minimum combined total of Verbal and Quantitative of 1200). If the prospective MS thesis advisor is a member of the regular BMEN faculty, then the applicant only needs to submit a letter of support from his or her research advisor. Otherwise, three letters of recommendation are needed.
- An admission decision will be made by the Department by November 1st and the approved students will then be formally admitted to MS candidacy following the standard policies of the Graduate Division of the School of Science and Engineering.
- Students who have been approved for participation will then be required (or optional at advisor’s recommendation) to drop BMEN 4910 Research and Professional Practice II (without record) and add BMEN 4930 Advanced Undergraduate Research in order to meet undergraduate degree requirements. This schedule change will allow 5th Year students to more effectively concentrate on their research projects in lieu of completing the course requirements of BMEN 4910. The grade for BMEN 4930 will be listed as In Progress (IP) until such time as the master’s thesis is completed, whereupon the student’s advisor and thesis committee will assign a grade necessary to fulfill bachelor’s degree requirements.

3.d. Degrees

- Participation in commencement ceremonies is governed by the standard policies of the School of Science and Engineering.
- Upon successful completion of all BSE and MS degree requirements, assuming the student has not already received the BSE degree, the student graduates at the end of the term in which the re-
quirements have been fulfilled with both degrees (BSE and MS).

- If BSE requirements are not met (because the thesis is not complete), but if all undergraduate course requirements have been fulfilled, the student participates in commencement at the end of the 4th year by being recognized with a certificate of accomplishment, but does not receive a BSE degree.

3.e. Timing and Financial Support Considerations

- Tuition during the 5th year is discounted by the School of Science and Engineering to be 35% of the full-time undergraduate tuition. Note that scholarships and other financial aid will not normally be continued during the 5th year; financial need is most often met in the form of low-interest student loans.

- Students pursuing this program are strongly encouraged to spend the summer between the 4th and 5th years doing research on their project. Occasionally, summer funding may be available from the student’s advisor or other sources of support.

- After the 5th year, students may, if necessary continue for an additional ½ academic year to complete the degree without additional charge. After this grace period, tuition would be charged at 35% of the graduate tuition rate per credit.
Discoveries emanating from Biomedical Engineering research programs have been a source of pride at Tulane for more than 50 years. The first doctorates for Biomedical Engineering research were awarded in the early 1970s, and our research labs continue to host a diverse group of undergraduate, Master’s, and Doctoral students working with faculty mentors.

4.a. Graduate Program Instructional Objectives
We enhance the academic preparation of our graduate students in engineering, mathematics, and the life and basic sciences. Our graduate students are our junior colleagues, and we furnish them with the advanced and current coursework, professional guidance, and equipment/facilities that are critical to their participation in biomedical engineering research and scholarship. We coach our students as they conduct independent research and pursue careers related to one of the major themes of biomedical engineering (e.g., biomechanics, bioelectronics, biomaterials, biotransport, bioelectricity, or cell/tissue engineering).

4.b. Programs of Study
The Department of Biomedical Engineering offers courses of study leading to the Master of Science (M.S.) with thesis and non-thesis options and the Doctor of Philosophy through the Graduate Division of the School of Science and Engineering. The Master's degree requires 24 semester hours of approved course work including at least one advanced mathematics course and at least one graduate-level course in each of the following subjects: biomechanics, bioelectronics or bioelectricity, and biomaterials or tissue engineering. Also required is an approved thesis, or, by petition to the faculty, 30 hours of approved course work for the non-thesis option. Tulane also has an integrated 5th year master's program to allow our best qualified undergraduates the opportunity to complete a two-year master’s level research project by building upon the undergraduate individual research project. Students may then be able to complete all requirements for the bachelor’s and master’s degree in five years (usually including the summers after the 4th and 5th years), although some take longer.

The doctoral degree requires 48 semester hours (including additional courses in biomechanics, bioelectronics or bioelectricity, biomaterials or cell and tissue engineering, and either the medical physiology course as taught to medical students or the two-semester sequence of Anatomy and Physiology — BMEN6030/6035 and Quantitative Physiology BMEN6070/6075 taught by the medical school faculty) and an approved dissertation. The course work for the doctorate generally requires two years, and most doctoral candidates spend about five to six years in residence.

4.b.1. Application and Admission
Applications for admission and financial aid are due by February 1 for the following Fall semester. Applications for admission only (without consideration for financial aid) may be submitted until July 15 for the Fall semester, or December 1 for the Spring semester. Applicants must hold a bachelor's degree to be admitted, and are required to submit transcripts of prior work and three recommendations. All applicants must take the Graduate Record Exam (GRE). Only the general test is required.

Information about the department, including application instructions, an application form and recommendation forms are available from https://app.applyyourself.com/?id=tulane-g

4.b.2. Tuition and Expenses
Tuition for the 2010-2011 academic year is $40,300; required fees in addition to tuition include the academic support services fee, activity fee, health center fee, Reilly Recreation Center Fee, and medical/hospitalization insurance, $1000 of which is subsidized for students supported through fellowships/TAS or RAs. Students who have completed their course work requirements are required to register for Master’s Research 9980 (3 credit hours) or Dissertation Research (BMEN 9990 (3 credit hours) in order to maintain continuous registration. Tuition equal to one 3 credit hour course and part time fees will be assessed for this registration. Living expenses for the single student are approximately $12,000. For international students, these fees are higher due to foreign travel costs, insurance, and initial household expenses. Graduate student housing is available in Tulane University apartments on a limited basis, though most students rent apartments near the university.
Tuition for both the Non-Thesis Masters, and Thesis program in the Department of Biomedical Engineering is offered at a rate of 50% of the undergraduate tuition. The tuition for this program is limited to one year of tuition if the student completes his/her coursework in less than 18 months. After that, additional tuition will be charged at one-half of the prevailing credit-hour rate (see [http://tulane.edu/sse/academics/graduate/ssegrad_tuition_fees.cfm](http://tulane.edu/sse/academics/graduate/ssegrad_tuition_fees.cfm)). Part-time students will be charged tuition at one-half of the prevailing credit-hour rate.

4.b.3. Financial Support

The Department of Biomedical Engineering provides merit-based aid to support our graduate students in paying for the cost of graduate education. Recipients of merit-based financial aid are chosen solely on the basis of academic qualifications. The stipend for incoming students entering in Academic Year 2010-2011 is $26,000 for 12-months in residence plus $500/semester credit for a Tulane-sponsored health insurance plan. Ph.D. students are given priority for merit-based aid, and students pursuing the non-thesis option Master's degree ineligible. The forms of merit-based aid are:

**Incoming Awards**

*Teaching assistantships (TA)*

The department’s primary method of support for incoming graduate students is through Teaching Assistantships. A Teaching Assistant is assigned to assist a faculty mentor and shares teaching responsibilities. TA duties may include discussions about upcoming lectures, feedback from lectures, and the preparation of handouts, grading, and laboratory instruction. The TA generally attends all class meetings.

*Fellowships*

These fellowships are primarily awarded by the Louisiana Board of Regents through Tulane University, and generally provide four-years of support plus a tuition waiver. Recipients must be U.S. citizens or resident aliens.

**Continuing Awards**

*Research assistantships (RA)*

These assistantships pay a stipend that is individually determined, and include a tuition waiver. These awards may be given to continuing graduate students who are performing research projects on a topic with extramural financial support.

4.c. Program for Students without an Engineering Degree

A special program has been developed for those with a B.S. or B.A. in non-engineering disciplines who wish to earn a degree in Biomedical Engineering. The entrance requirements are: (1) an undergraduate degree with substantial science content including a year of calculus, a year of physics, a year of biology, and a year of chemistry; (2) an undergraduate grade average of “B+” or better (e.g. 3.3). The program normally takes at least two years as follows:

**First Year:** The student enrolls in the undergraduate division of the School of Science and Engineering as a non-degree-seeking student. The courses taken during the first year are typically the following, although the specific selection may be tailored to the student’s background if some of the following have already been satisfied:

**Fall Semester**

- MATH 2210 Calculus III
- BMEN 2310 Experiments and Experimental Design
- ENGP 2010 Electric Circuits
- ENGP 2430 Mechanics of Materials

**Spring Semester**

- MATH 2240 Introduction to Applied Math
- BMEN 2730 Biomedical Electronics and Lab
- ENGP 1410 Statics
- BMEN 2020 Computational Concepts and Applications
- ENGP 3120 Materials Science and Engineering

These courses do not count for credit towards a graduate degree. Academic performance in these courses determines whether the student is admitted to the undergraduate or graduate division at the beginning of the second year.

**Second Year:** Students who complete the courses listed above with a grade point average of 3.00 or better may transfer into Graduate Division of the School of Science and Engineering to work on the M.S. degree. During the second year, the student must also pass BMEN 3440, Biofluid Mechanics, which does not count for graduate credit. Students who complete the courses listed above with a grade point average of less than 3.00 are given the option to apply to the undergraduate division of the School of Science and Engineering to complete the Bachelor’s degree as a transfer student.
4.d. Requirements for Advanced Degrees
The following curriculum is generally taken as an undergraduate prior to matriculation to Tulane’s BME graduate program (course numbers are equivalent Tulane courses satisfying each requirement)

1 year of college physics (PHYS 1310-1320)
1 year of college chemistry (CHEM 1070-1080)
1 semester of biology with lab (CELL 1010)
1 course in computer programming (BMEN 2020)
3 semesters of calculus (MATH 1210-1220, MATH 2210)
1 semester of differential equations (MATH 2240)
1 semester of statics (ENGP 1410)
1 semester of mechanics of materials (ENGP 2430)
1 semester of fluid mechanics (BMEN 3440)
1 semester of materials engineering (ENGP 3120)
1 semester of circuits (ENGP 2010)
1 semester of electronics (BMEN 2730)

Prior to commencing coursework at Tulane, an entering graduate student who is deficient in this preparation will prepare a proposed curriculum in conjunction with the Director of Graduate Studies.

4.d.1. Requirements for the Master’s Degrees
1.) Thesis Master of Science
The basic requirement for a Master of Science (MS) degree in Biomedical Engineering is completion of 24 hours of approved graduate level coursework that satisfy the distribution requirement (see below) and the writing of a scholarly thesis representing original research. The thesis committee must consist of at least three members, two of whom must be full-time members of Tulane’s faculty and a chairperson who is a full-time faculty member in the Department of Biomedical Engineering.

2.) Non-Thesis Master of Science
A non-thesis Master of Science degree (MS) is offered by the Graduate Division of the School of Science and Engineering upon the completion of 30 semester hours of approved graduate course work. This coursework must satisfy the distribution requirement (see below). Students receiving aid in the form of a teaching assistantship or a research assistantship are generally not eligible for a Master’s degree as their terminal degree. Doctoral students that have completed 30 semester hours of approved graduate credit and who have successfully defended their research prospectus may then petition the Department for a non-thesis MS degree.

Tuition is set at 50% of regular full graduate division for students in the terminal non-thesis MS program.

3.) Course Distribution Requirements for Master’s Degree
In order to prepare our students for careers in biomedical engineering, which is a rapidly evolving interdisciplinary field, we require all graduate students to complete a distribution of classes. These are:

a. Anatomy and Physiology
BMEN 6030/6035 Anatomy and Physiology for Engineers with Lab, and
BMEN 6070/6075 Quantitative Physiology with Lab.

b. Biomedical Engineering Domains
One course in three of the four domains, as described in Table 2.

c. Mathematics
One course in advanced mathematics (e.g., various 6000-level MATH courses)

4.d.2. Requirements for the Doctoral Degree
The Ph.D. is an academic degree that prepares students for careers in teaching and research. A Master’s degree is not required for students seeking the Doctoral degree. The specific requirements are as follows:

1.) Distribution Requirements
a. Anatomy and Physiology
BMEN 6030/6035 Anatomy and Physiology for Engineers with Lab, and
BMEN 6070/6075 Quantitative Physiology with Lab.

b. Biomedical Engineering Domains
One course in three of the four domains, as described in Table 2. Only one (1) of the domain requirements may be satisfied through the completion of a BMEN 3xxx/6xxx domain course

c. Mathematics
One course in advanced mathematics (e.g., various 6000-level MATH courses)

2.) Course-work
The student must demonstrate superior performance while completing 48-hours of graduate study with nine in-class “didactic” classes completed (see Table 3).
# Description of Requirement

<table>
<thead>
<tr>
<th>#</th>
<th>Description of Requirement</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>1</td>
<td>Anatomy and Physiology with Lab (BMEN 6030/6035)</td>
<td>3 + 1</td>
</tr>
<tr>
<td>2</td>
<td>Quantitative Physiology with Lab (BMEN 6070/6075)</td>
<td>3 + 1</td>
</tr>
<tr>
<td>3</td>
<td>Advanced mathematics</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Domain Distribution (see Table 2)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>• One course each in 3 of 4 domains</td>
<td></td>
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<tr>
<td>6</td>
<td>• Maximum of 1, 3xxx-6xxx cross-listed domain courses</td>
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Total credits required to petition to take PhD qualifying exam: **20**

7  Elective course 1 3
8  Elective course 2 3
9  Elective course 3 3

Minimum of elective course credits required: **9**

10 Research Seminar (BMEN 6710 – register every fall), *maximum* credits allowed 4

11 Remaining 15 credits may be satisfied by BMEN 7310-7320 Research in BME (graded), Directed Readings, or didactic courses 15

Total: **48**

Table 3: Course Requirements for a Ph.D. in Biomedical Engineering

Notes:
- All graduate students must register for, and attend, BMEN 6710 Research Seminar.
- A maximum of 15 of the 48 required credit hours may be taken as BMEN 7220 Directed Readings or BMEN 7310-7320 Research in BME Research. Students transferring to Tulane may transfer a maximum of 24 credits, and must complete at least 18 in-class credit hours of graduate study at Tulane University.

3.) Teaching Experience

In addition to the coursework and research requirements described in detail below, all students pursuing a Ph.D. in Biomedical Engineering must demonstrate teaching competence as part of their training toward the degree. **All doctoral students - regardless of their financial support package – must serve as a TA for at least one semester prior to completion of their Ph.D. program.**

Teaching Assistantships are regarded as “one-third-time” appointments and average about 12-15 hours per week of effort. TAs attend all classes taught by their faculty mentor, and are permitted to enroll in no more than 3 courses per semester.

4.) Qualifying Exam

The qualifying exam is usually taken after the fourth semester of graduate study, although students may request that it be taken earlier by written petition to the departmental faculty. The exam is a rigorous test of scholarly competence and knowledge, and is conducted as an oral examination.

The qualifying exam (QE) is given annually in May/June. In order to take the QE, the prospective PhD candidate must submit a petition to the Director of Graduate Studies by February 15. The petition should include:

1) A copy of the candidate’s transcript. Petitions will only be guaranteed for acceptance if the candidate demonstrates that they will, at the time of the exam, have completed course requirements #1-6 in Table 3, and that they have a cumulative GPA of 3.5 or above in these courses.

2) A document (no more than 1 page long) that describes the student’s PhD research area. This document should also list three relevant graduate courses that the student has completed and explain how the sub-disciplines related to these courses have prepared the student to begin independent advanced study in their PhD research area.

The Department’s Graduate Committee will review each petition. Upon acceptance of the petition the Graduate Committee, in concert with the student’s primary advisor, will assign a qualifying examination committee. At least three of the committee members must be department-affiliated full-time faculty.
The prospective PhD candidate is encouraged to initiate a meeting with his/her committee prior to the exam wherein a broad overview of the content areas will be discussed. This discussion will not provide an exclusive list of topics; rather, it will offer a framework for the student’s preparation.

The oral exam will commence with a brief (~5 minute) presentation by the prospective PhD candidate in which (s)he will present the content of the qualifier petition document (item 2). The exam will continue with questions by the committee that will be free-ranging, and will be used to identify a candidate’s strengths and weaknesses in his/her field of interest.

The criteria for passing the exam will include what the faculty determines to be the required minimum competence. The student will be informed the results of the exam by June 15, with the following possible outcomes:

a. Pass (and possibly recommendations)

b. Conditional Pass (with specific requirements)

c. Fail with encouragement to retake the exam

d. Fail with conversion to the MS

If the examination is failed, it may be retaken once only. A student who fails the exam twice will not be admitted to Ph.D. candidacy, although the student may then proceed with the Master’s Degree.

5.) Prospectus and Preliminary Examination

This is an oral examination in depth on specific topics of the candidate’s intended research, and includes the preparation of a written prospectus of the proposed dissertation research. It is administered after the student has passed the Qualifying Exam, and should be completed during the third year of study. In Biomedical Engineering, the student is required to satisfactorily prepare a complete proposal in the NIH format (PHS Form 398) on his/her dissertation topic in addition to the three-page prospectus required by the Graduate Division. The proposed prospectus should present an overall plan for the dissertation research, which may change during the progress of the dissertation with the approval of the thesis committee. The prospectus will be presented to the student’s 3-member (minimum) dissertation committee. At least three committee members must be full-time faculty members at Tulane and the committee chair must be a full-time member of the Department of Biomedical Engineering. Upon completion of this requirement, the student is admitted to candidacy for the doctoral degree.

6.) Dissertation and Defense

The dissertation is an original contribution to the field. The entire dissertation, or parts of the dissertation, should be of a quality suitable for publication. The candidate must pass the final, public oral examination, which is a primarily a presentation and a defense of the dissertation.

4.e. Research Domains

Tulane’s Department of Biomedical Engineering has a long history of studying a wide variety of research problems using traditional engineering expertise to analyze and solve problems in biology and medicine. Our program has particular expertise in the following biomedical engineering domains:

a.) **Biomaterials** include both living tissue and artificial materials used for implantation and to foster cell function. Understanding the properties and behavior of living material is vital in the design of implant materials. The selection of an appropriate material to place in the human body is a complex task, with newer biomaterials incorporating living cells in order to provide a true biological and mechanical match for the living tissue. Research in this area is conducted by Dr. Moore, who studies neuro-generation primarily of the optic nerve.

b.) **Biomechanics** applies classical mechanics (statics, dynamics, fluids, solids, thermodynamics, and continuum mechanics) to biological or medical problems. It includes the study of motion, material deformation and flows. These can influence the macro-scale and micro-scale stresses that can impact biological function at the organ, cell, and sub-cellular level. Research in this area is conducted by Drs. Ahsan, Anderson, Gaver, Khismatullin, Murfee, and Rice.

c.) **Biotransport** relates to physical and biological processes that govern molecular and convective transport of substances within biological systems. These transport processes may be passive (convection, diffusion) or active (such as with sodium-potassium pumps), wherein energy is expended to move material against a concentration gradient. Research in this area is conducted by Drs. Gaver, Khismatullin, Murfee and Shevkoplyas.
d.) Cell and Tissue Engineering utilizes the anatomy, biochemistry and mechanics of cellular and sub-cellular structures in order to understand disease processes and to intervene at very specific mechanical or electrical stimuli that can influence cellular processes at precise target locations. This can develop knowledge related to physiological processes in development and disease, or can lead to therapies in regenerative medicine to promote healing or inhibit disease formation and progression. Research in this area is conducted by Drs. Ahsan, Gaver, Murfee, Moore, and Shevkoplyas.

Microfluidics allows manipulation and analysis of minute amounts of biological samples, and thus enables the design and fabrication of low-cost, miniaturized devices for point-of-care clinical diagnostics. Research in this area is conducted by Professors Anderson, Walker, Rice and Shevkoplyas.

4.f. Research Laboratories

Stem Cell Lab – Dr. Taby Ahsan
The STEM Cell Laboratory uses Science, Technology, Engineering, and Medicine (STEM) to advance the positive impact of stem cells on public health. Ongoing stem cell research helps develop basic science models, in vitro diagnostic systems, methods for drug discovery, cell-based therapies, and cancer treatments. Our lab focuses on the effects of the physical microenvironment on stem cell fate utilizing engineered systems that control cellular configurations and apply mechanical forces. Our major areas of research include stem cell mechanobiology, stem cell-based therapies for regenerative medicine, and tissue engineering.

Artificial Heart Laboratory – Dr. Ravi Birla
Research at the Artificial Heart Laboratory (AHL) is focused on the development of 3D cardiovascular tissue constructs. AHL projects are focused on the development of heart muscle, blood vessels, tri-leaflet valves, cell based cardiac pumps and tissue engineered ventricles. In addition, projects are focused on the development of supporting technologies for 3D cardiovascular tissue constructs. These include perfusion systems for long term culture, bioreactors for electromechanical stimulation, bio-transportation modules, and systems for bio-exhibition at technology forums.

Biofluid Mechanics Laboratory- Dr. Donald Gaver
The Biofluid Mechanics Laboratory at Tulane University studies the interrelationships between fluid mechanical and physicochemical phenomena and the associated biological behavior of physiological systems. The main thrust of this research involves investigations of the pulmonary system, with the goal of developing improved therapies for pulmonary disease ARDS and the prevention of ventilator-induced lung injury (VILI). In addition, we investigate the design of optimized microfluidic devices for biosensor technology. These integrated studies bring together basic and applied scientists (including computational scientists), device developers and physicians to study problems of high clinical importance.

Cellular Biomechanics and Biotransport Laboratory - Dr. Damir Khismatullin
The Cellular Biomechanics and Biotransport Laboratory studies the mechanical properties of living cells and tissues and uses a combination of advanced experimental techniques and mechanistic models to develop novel, optimized approaches for treatment of cardiovascular disease and cancer. Some of the current projects in the laboratory include: 1) Quantitative biomechanical models of cellular interactions with applications in inflammation, atherosclerosis, and thrombosis; 2) Development of novel methods for rheological characterization of biological materials; 3) Liver tumor ablation by combination of percutaneous ethanol injection and high-intensity focused ultrasound; and 4) Development of computational tools for optimizing surgical treatment of intracranial aneurysms.

Micro- Neural Engineering Laboratory – Dr. Michael Moore
Our group utilizes tissue engineering and related technologies for the study of central nervous system (CNS) regeneration and development of treatments for CNS disorders. In particular, we are interested in the relationship between the three dimensional architecture of regenerating CNS tissue and its functionality. The major experimental goals in our laboratory are to: 1) design and fabricate biomaterial constructs with specified structural and molecular microarchitectures and employ 3D tissue culture preparations and 3D microscopic imaging for evaluation of constructs; 2) design and evaluate drug delivery systems for promotion of CNS axon regeneration; 3) develop implantable materials for CNS tissue engineering and evaluation in small mammals.
Microvascular Dynamics Laboratory – Dr. W. Lee Murfee
The overall goal of our laboratory is to better understand the cellular dynamics involved in adult microvascular remodeling. We apply in vivo, in vitro, and computational bioengineering approaches to investigate the regulation of vascular patterning and the functional relationships between microvascular remodeling and other processes such as neurogenesis, lymphangiogenesis and inflammation. In general, our work will provide valuable insight for the engineering of functional vascularized tissues and for understanding vascular dysfunction associated with multiple pathological conditions, including hypertension, tumor growth, and wound healing.

Pulmonary Function, Acoustics, and Devices – Dr. David A. Rice
Our work concentrates on the use of sound and vibration as a noninvasive tool for diagnostic and therapeutic applications. By identifying the mechanism for cat’s purr, we were led to a flow interrupting device that we are evaluating for treatment of cystic fibrosis. Focused ultrasound can selectively ablate polymer coated spheres to release drugs at specific sites. Measuring surgeon hand tremor helps to quantify fatigue and need for practice in laparoscopic surgery. We also develop and test concepts for affordable therapeutic or diagnostic devices. These include a glaucoma drainage implant, a heat treatment device for cutaneous Leishmaniasis, and a noninvasive diagnostic device for cerebral malaria.

Biomedical Microdevices Laboratory – Dr. Sergey Shevkoplyas
The research in the Biomedical Microdevices Laboratory is focused on gaining a better understanding of the mechanics of blood flow and of the traffic of circulating cells in networks of microvessels using microfluidic devices and systems. Additionally, we develop microfluidic devices for testing the mechanical properties of blood cells and other circulating cells and lab-on-a-chip technology for separating sub-populations of blood cells and rare circulating cells from small samples of whole blood for point-of-care diagnostics and other clinical applications.

Multiscale Bioimaging and Bioinformatics Laboratory – Dr. Yu-Ping Wang
The Multiscale Bioimaging and Bioinformatics Laboratory has three research themes: 1. Fundamental research on multiscale signal/image representation and analysis; 2. Multiscale bioimaging analysis from organ and tissue levels to molecular and cellular levels; and 3. Bioinformatics in human genomics and cytogenetics. Currently, we are working on information extraction and integration from multiscale and multimodality genomic imaging data. One of our goals is to bring the biomedical technique into commercial use. We are using an multidisciplinary approach and working closely with computational scientists, statisticians, medical geneticists and industrial engineers at Tulane Medical Center and all over the world.

4.g. Core Lab Facilities
In addition to the individual faculty research labs, the Biomedical Engineering Department maintains several shared facilities for use by the members of our department including:

Tissue Culture Core Lab, Boggs 636
The TCC Lab is fully equipped for cell/tissue culture and a range of cellular, molecular and chemical assays, as well as microscopy techniques. We maintain equipment including laminar flow hoods, refrigerated centrifuge, autoclave, incubators, vacuum aspiration systems, fluorescent microscope, water filtration systems, refrigerators and freezers.

Microscopy Suite, Boggs 510
The Microscopy Suite houses a Nikon TE-2000i fluorescent microscope with spinning disc confocal system. The semi-automated microscope utilizes a software program to help analyze the data captured. The room is stocked with other useful supplies like syringe pumps and a stereoscope to assist with your visualization needs.

Supply Center, Boggs 547
The Supply Center houses the department UltraLow Freezer, glassware washer, DI water source, and industrial sink. This room also houses the Invitrogen Supply Center and members of the Uptown Tulane campus come here to purchase common lab supplies as well as Invitrogen Products.

Teaching Lab, Boggs 241
The Teaching Lab is a large wet lab capable of holding large classes. It has a complete setup for cell work including laminar flow hoods, incubators, centrifuge, and water bath. All BME professors are able to use this room for lab activities in their classes. In addition this room has significant bench top space and is ideal for large projects and groups.
Appendix A. courses in Biomedical Engineering

A course with a four-digit number, such as 1010, lasts for one semester. A course with a double number, such as 1010-1020, lasts for both semesters. Courses with numbers from 1000 to 1990 are ordinarily open to freshmen; 2000 to 2990 are ordinarily open to sophomores; 3000 to 3990 are ordinarily open to juniors; 4000 to 4990 are ordinarily open to seniors; 6000 to 6990 are generally open to advanced undergraduate and graduate students unless marked with a § which indicates that the course is only open to graduate students; and 7000 to 7990, to graduate students only. An asterisk * denotes a less frequently offered class.

2020 Computing Concepts and Applications (4)
Dr. Shevkoplyas
This course introduces students to the foundations of algorithm development and programming, basics of matrix algebra and numerical analysis, solving ordinary differential equations.

2310 Product & Experimental Design (3)
Dr. Murfee; Dr. Oertling.
The objective of this course is to introduce students to the design process as they are starting their engineering studies. Through team projects geared toward translating bench research into product development, students will be challenged to begin thinking critically and applying physical fundamentals to complex systems. Weekly lectures will highlight phases of the design process, including problem identification, conceptual design, and early prototyping. Additionally, in the context of product and experimental design, students will gain experience with computer aided design and be provided an introduction to statistics. Course restricted to BMEN, ENGP, and PHYS majors, or by permission of the instructors. (Same as ENGP 2310.)

2600 Introduction to Organic and Bio-Chemistries (3)
Staff
Prerequisite: CHEM 1080 and CHEM 1180, or approval of instructor
This course introduces the main principles of Organic Chemistry and Biochemistry, preparing the student for BMEN 3030/3040. Topics include nomenclature of organic compounds and bio-molecules, major reactions of organic chemistry, relationship between chemical structures and biological functions, and the reaction pathways of major metabolic processes. Students will be introduced to the three-dimensional structure of organic compounds and biomolecules using molecular models and software tools.

2730 Biomedical Electronics with Lab (4)
Dr. Walker
Prerequisite: ENGP 2010

BMEN 3010/6010§ - The Physical Dimensions of Aging (3)
Pre-requisite: 1010/1110, CELL 1010 or instructor approval. This course is designed to introduce students to the physiological, behavioral, and cognitive changes associated with aging. In particular, we will focus on the effects of exercise on the aging human system. We will also discuss what it means to become older within a community, what can a person expect during the aging process, and what kind of control a person has over his/her aging body. (Same as SCEN 3010).

3030/6030§ Anatomy and Physiology for Engineers (3)
Dr. Dancisak
Prerequisite: either CELL 1010 or EBIIO 1010
Co-requisite: BMEN 3130 or BMEN 3035
This is a single-semester course in human structural anatomy. Course participants will examine both typical and pathological examples for the various subsystems including, body tissues; the musculoskeletal, neurological, cardiovascular, respiratory, digestive and reproductive systems.

3035/6035§ Anatomy and Physiology for Engineers Lab (1)
Dr. Dancisak
Co-requisite: BMEN 3030/6030§
This single-semester laboratory coordinates hands-on learning in human structural anatomy. Course participants will dissect and examine both typical and pathological examples for the various subsystems including, body tissues; the musculoskeletal, neurological, cardiovascular, respiratory, digestive and reproductive systems.

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2 6xxx courses marked with § are open ONLY to graduate students. All other 6xxx courses are open to graduate students and also to advanced undergraduate students.

3 Formerly 3130/7130
3070/6070§ Quantitative Physiology (3)
Tulane University Health Sciences Center Staff
Co-requisite: BMEN 3075/6075§
This course places emphasis upon the chemical basis of life; cells and cellular metabolism; histology and tissues; the endocrine, skeletal and nervous systems; respiratory, digestive, cardiovascular, lymphatic and reproductive systems; nutrition and metabolism; water, electrolyte and acid-base balance, and human growth and development.

3075/6075§ Quantitative Physiology Lab (1)
Tulane University Health Sciences Center Staff
Co-requisite: BMEN 3070/6070§
Subject matter will include blood, nutrition, and metabolism; and the cardiovascular, lymphatic, digestive, respiratory, urinary, and reproductive systems.

3230/6230§ Biomedical Engineering (3)
Dr. Moore
Prerequisites: ENGP 3120, ENGP 2430
The objective of this course is to deepen the student’s knowledge of phenomena that influence the success of surgical implants used in vivo. Building upon the introductory material covered in ENGR 3120, basic concepts of materials science and engineering relevant to this topic are discussed. In addition to engineering performance issues, fundamental factors affecting the biocompatibility of implant devices will also be covered. Laboratory experiments will be utilized, in a supplemental fashion, to illustrate selected aspects of this material and to provide an introduction to procedures used to evaluate biomaterials. This course will serve as a bridge for students who wish to take more advanced graduate level biomaterials courses in the future.

3300/6300 Biomechanics (3)
Dr. Anderson; Dr. Murfee; Dr. Ahsan
Prerequisite: ENGP 2430, BMEN 2600
This course introduces students to the various interdisciplinary fields in biomechanics - such as orthopaedic biomechanics, biofluid mechanics, soft tissue mechanics, and the biomechanics of human movement. Specific topics include: kinematics and energy/power during human activity; dynamics of human movement; the analysis of forces and stresses/strains in biological structures under loading; constitutive models for biological materials; and the relationship between structure and function in tissues and organs. Fulfills departmental “domain” requirement.

3400/6400§ Biomedical Engineering (3)
Dr. Moore, Dr. Ahsan
Prerequisites: ENGP 3120 and BMEN 2600, or permission of instructor.
This course will focus on fundamental materials science and biological principles that impact the engineering design of biomaterials and tissue-engineered products. Topics addressed will include structural hierarchies of materials and tissues, physical and chemical properties of surfaces, degradation of materials, and cell-surface, cell-cell, and cell-matrix interactions. The course will conclude with inflammatory, immunological, and pathological events associated with responses to such products. Laboratory exercises will be utilized to illustrate selected concepts, introduce assessment methods, and provide hands-on experiences with cells and materials. Fulfills departmental “domain” requirement.

3420/6420§ Transport in Cells and Organs (3)
Dr. Khismatullin
Fundamental principles of mass and momentum transport will be applied to physiological problems. The topics of this course will be the cardiovascular, respiratory and urinary systems, transmembrane and transvascular transport, transport within the cell, cell adhesion, drug transport and pharmacokinetics, and transport-related diseases (atherosclerosis, sickle cell disease, embolism, cancer metastasis, and urologic disease). Fulfills departmental “domain” requirement.

3440 Biomedical Engineering (3)
Dr. Gaver
Prerequisite: ENGP 1410, ENGP 2430, MATH 2240
This class focuses on fundamental concepts and properties of fluid mechanics with applications to the body. Topics to be covered include basic equations of fluid statics, dynamics and mass transport in differential and integral form using both system and control volume viewpoints. Rheological properties of biological fluids are studied as well as dimensional analysis and similarity. Advanced applications are investigated using the finite element method.

3500/6500§ Elements of Biomedical Engineering Design (3)
Dr. Anderson
This course develops the fundamental aspects of the mechanical performance of devices and components. Topics include a review of stress analysis, failure criteria, fatigue analysis and stress concentrations, as well as the mechanical behavior of fasteners, welded joints, spring selection, bearing design, and an introduction to finite element analysis; with applications to biomedical engineering. Fulfills departmental “domain” requirement.

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§ Formerly 3060/7060

§ Formerly 3160/7160
Projects in Embedded Control (3)
Dr. Walker
Prerequisite: BMEN 2730
Design and construction of embedded controllers using Texas Instruments and BASIC Stamp hardware. Control of servo devices, robotics, display and sensor interfacing, and data storage are considered. Assembly language is emphasized. In-lab and final projects. Fulfills departmental "domain" requirement.

Mathematical Modeling and Analysis of Biological Systems (3)
Dr. Gaver; Dr. Wang
Prerequisite: MATH 2240
The objective of this course is to teach basic mathematical modeling constructs and analysis techniques that are used for studying biological processes. Topics to be covered include ordinary differential equations, compartment systems, basics of dynamic systems, stability, statistical inference and model construction. These will be applied to study models of chemical kinetics, physiological control, AIDS transmission, population dynamics, and growth. Students will use Mathematica to develop and analyze models.

Team Design Projects I and II (2,3)
Dr. Rice
Prerequisite: Senior standing
Techniques and experience in the solution of constrained and open-ended design problems. Lecture topics include all aspects of the design process, including goal setting, idea generation, prototyping, fabrication, and product evaluation. Also included are technical presentation, project planning and management. Included as needed are other topics such as standards, fastening and joining, motors and control, esthetics and finish. Each team will design and construct a device or system to assist an individual with a disability. These designs are presented in a public show during the second semester.

Special Problems in Biomedical Engineering (1-4)
Staff
Independent study and investigation of special problems in biomedical engineering. Details to be arranged with individual biomedical engineering faculty members.

Service Learning: Beyond Design (1)
Dr. Rice
Prerequisite: Approval of instructor
Required co-requisite: BMEN/ENGR 4030 or 4040
The required BMEN 4030/4040 design sequence is centered on the design and construction of a device or system to assist an individual with a disability or a group servicing such individuals. As an option, students may choose to supplement their interaction with their clients with a service learning component that follows Tulane's guidelines for service learning courses and specifically requires: Completing at least 40 hours in a community setting during the semester; keeping a journal of weekly activities that will allow the student to describe and evaluate his/her experiences with the activity; and creating a product that can be evaluated as part of the course grade (e.g., a review paper on an issue relevant to the service activity, or some product of value to the site).

Biomedical Research and Professional Practice I and II (2,2)
Dr. Birla
This course introduces the tools, techniques, and rules necessary to function professionally as a researcher or engineer. Topics include economic analysis, ethics, professional communication including writing and oral presentation, research techniques including literature searching, citation, and the structure of a scientific paper. An integral part of the course is a year-long research or design project under the direction of a faculty member or other scientist or professional. This culminates in a Senior Thesis and a presentation in Departmental Seminar.

Advanced Undergraduate Research (2)
Dr. Anderson
Prerequisite: Approval of instructor; admission to 5th year BS-MS program
In order to meet undergraduate degree requirements, this course will allow 5th Year students to more effectively concentrate on their research projects in lieu of completing the course requirements of BMEN 4910. The grade for BMEN 4930 will be listed as In Progress (IP) until such time as the masters thesis is completed, whereupon the student's advisor and thesis committee will assign a grade necessary to fulfill bachelors degree requirements.

Biologysystems (3)
Dr. Rice
Prerequisite: BMEN 3070 or equivalent
This course gives students the skills to interpret or predict the behavior of physiologic systems in order to study normal and pathologic phenomena. The body uses many feedback control mechanisms to maintain homeostasis, the keeping of a constant interior environment e.g. pH, temperature, blood pressure, balance, bone stress, muscle length. Transfer functions characterize organ physiology. These functions are the building blocks of an organ system model. By studying these models, complex behavior can often be easily interpreted. Further, these models often suggest ways to make noninvasive physiologic measurements. Applications include: vicious cycles, such as hyperventilation syndrome, and how to break them; hierarchical, parallel, and other redundant systems; causes of instabilities such as Cheyne-Stokes breathing; open and closed loop control of anesthesia and artificial organs. Reference will be made to several common mechanisms such as the thermostat. Lecture demonstrations include pulmonary and cardiovascular measurement. A term paper on a topic of the student's
choice is required.

6060 Biomedical Acoustics (3)
Dr. Rice
Prerequisite: BMEN3070, MATH 2210, knowledge of MATLAB
Introduction to sounds in the physiological and medical arena. Topics include: physics of sound propagation, sources and mechanisms of cardiac and respiratory sound production, sound transmission, auscultation and stethoscope evaluation, psychoacoustics and auditory perception, speech production and structure of the speech signal, medical ultrasound applications and safety.

6260 Molecular Principles of Functional Biomaterials (3)
Dr. Moore
Prerequisite: BMEN 3230/6230§
Functional biomaterials are non-viable materials that have been designed or modified in order to elicit specific biological responses when interacting with human fluids, cells, tissues, or organs. This course will focus on chemical principles utilized in endowing polymeric materials with biological functionality for medical applications. Following a brief review of polymer properties with a focus on hydrogels, topics addressed will include attachment of proteins to materials, induction of cell-binding and differentiation, responsive polymers, and spatial and temporal control of material properties for biological signaling. Unifying concepts will be introduced by directed reading and discussion of landmark papers in the biomaterials literature. Supplemental laboratory exercises will be utilized to illustrate selected concepts and introduce experimental procedures.

6310 Continuum Models in Biomedical Engineering (3)
Dr. Anderson
Prerequisites: ENGP 2430, BMEN 3440, BMEN 3300/6300§
The course begins with a presentation of the kinematics of continuous media and elementary tensor manipulations. We will then cover the conservation principles of mass, linear momentum, angular momentum, and energy. Additional topics will include the formulation of constitutive laws, continuum models in electrodynamics, and simple descriptions of piezoelectric materials. These concepts will be applied to fundamental problems in bio-solid mechanics, bio-fluid mechanics, and bio-electromagnetism.

6330 Advanced Biofluid Mechanics (3)
Dr. Gaver
Prerequisites: ENGP 2430, BMEN 3440
This course will cover general intermediate/advanced fluid mechanics, and will provide a foundation from which to base one's studies of biofluid mechanics. Issues pertinent to the study of biofluid mechanics will be emphasized. Topics to be studied include kinematic principles, the Navier-Stokes equations, boundary conditions for viscous flows, basic solutions to steady and unsteady Navier-Stokes equations, turbulence, analysis of the vorticity equation, and interfacial phenomena. Whenever possible, problems of a biological nature will be used as examples.

*6340 Soft Tissue Mechanics (3)
Staff
Prerequisite: ENGP 2430, BMEN 3300
This course provides an introduction to the various approaches used in modeling soft tissues, with particular attention paid to those of the musculoskeletal system (e.g. ligament, tendon, cartilage). Particular emphasis will be placed on the theoretical and experimental consequences of the large deformation behavior of these tissues. An important objective of this class is to enable the student to develop a sense for the physical and mathematical relationships between the many types of models (and the associated experiments) currently being utilized in soft tissue mechanics.

6360 Introduction to Finite Element Analysis (3)
Staff
Prerequisite: BMEN 3300 or equivalent
Matrix structural analysis techniques as applied to frames, problems in plane strain, plane stress, and axisymmetric and 3-D structures. Development of the isoparametric family of finite elements. Use of user written and packaged software.

6430 Vascular Bioengineering (3)
Dr. Murfee
Prerequisite: BMEN 3070, BMEN 3400/6400§
The objectives of this graduate-level course are to familiarize students with contemporary research areas that cover the field of vascular biology, and to provide an understanding of bioengineering principles related to physiological function and therapeutic modalities. Example topics include smooth muscle cell and endothelial cell lineage, leukocyte-endothelial cell interactions, angiogenesis, drug targeting via the microcirculation, neural vascular control, atherosclerosis, and hypertension. These topics will be presented in the context of four over-arching sections: 1) Vascular Cell Biology; 2) Principles of Vascular Function and Design; 3) Vascular Pathophysiology, and 4) Therapeutic Design. For each section of the course students will be required to read, critically analyze, and present relevant articles. As indicated by the section titles, the course will culminate by highlighting how our basic understanding of physiological function/dysfunction can be translated to therapeutic design.

*6460 Cellular Mechanotransduction (3)
Staff
Prerequisites: ENGP 2430, BMEN 3030, BMEN 3440/6440§ or instructor’s approval.
This course reviews cellular mechanotransduction in a variety of tissues that adapt to physiological loading. A partial list of mechanosensing cells sells in these tissues include hair cells in inner ears, chondrocytes in cartilage, osteocytes in bone, endothelial cells in blood vessels, etc. In particular, this course emphasizes the role of mathematical modeling in solving biological problems. Hands-on mathematical modeling will be assigned as homework and projects.

6600 Computational Modeling of Biomedical Systems (3)
Dr. Khismatullin
The objective of this graduate course is to provide students with the skills and knowledge necessary for computational modeling of biological and physiological systems. The first half of the course will cover introduction to UNIX, elements of programming (Matlab and FORTRAN), and numerical methods commonly used in biomedical research. The second half will immerse the students in specific biomedical applications including hemodynamics, respiratory flow, cellular mechanobiology, and neural dynamics. Most lectures will be accompanied by computer labs.

6610 Introduction to Computational Biomechanics (3)
Dr. Khismatullin
This course covers fundamentals of computational methods with the emphasis in biomechanics applications. The computational methods include finite element methods and finite difference methods at the introductory level. The course will use MATLAB to implement these methods. The underlying theories of these numerical methods will be taught, and example problems will be discussed during the lecture. Example problems will include those from implant design, bone biomechanics, soft tissue biomechanics, etc. in static and dynamic conditions. The course will also discuss some special issues such as the stability/convergence criteria and the error estimation. The student will work on a term project to exercise these issues on a biomechanics problem of his/her choice.

*6620 Multiscale Modeling of Biophysical Systems (3)
Drs. Gaver, Bishop and Adhangale
This course is an introduction to multi-scale modeling from the atomistic- to continuum-levels. This course will begin with an introduction to molecular modeling with an emphasis on biomolecules and applications related to membranes, proteins and DNA. Continuum mechanics models of DNA and membranes will be developed, including equations of state describing the large-scale influence of atomistic structures in fluid systems. Students will learn to perform continuum mechanics calculations that will link to these atomistic structures, and thus model dynamic systems that span many scales.

6630 Cell Mechanics (3)
Dr. Khismatullin
Fundamental principles of continuum mechanics will be applied to problems of biomechanics at the cellular level. Topics covered include structure of mammalian cells, cell membrane mechanics, mechanics of the cytoskeleton, models of cell viscoelasticity, cell adhesion, active cell processes, flow-induced deformation of blood cells, and experimental techniques (micropipette aspiration, biointerface probe, atomic force microscopy, magnetic twisting cytometry, optical tweezers, and flow chamber assays).

*6670 Pulmonary Mechanics (3)
Dr. Gaver
Prerequisites: MATH 2240, BMEN 6330 or equivalent
This is a survey course in which mechanical models of the pulmonary system are discussed. Topics to be addressed include mucous transport, airflow/diffusion in the pulmonary airways, ventilation/perfusion relationships, flow through collapsible airways and interfacial phenomena.

*6680 Orthopaedic Bioengineering (3)
Dr. Anderson
Prerequisites: ENGP 1410, ENGP 2430, ENGP 3120
Concentration on various engineering aspects of the human knee and the treatment of its common orthopaedic pathologies. Topics include histophysiology of wound healing, synovial joint anatomy and tissue biomechanics, knee biomechanics, osteochondral and ligamentous graft reconstruction, prosthetic ligaments, and knee arthroplasty with emphasis on the design issues involved and the integration of clinical practice.

6710-6720 Seminar, Research Day Conference (0)
Each week, a one-hour seminar on research within or outside the department is presented. During the Spring semester, all seniors are required to give a presentation on their project or internship. Attendance of all graduate students is required in the Fall semester.

6740 Data Acquisition and Control (3)
Dr. Walker
Prerequisite: BMEN 2730
Acquisition, digital processing, and output of signals of biomedical interest. Closed loop control applications for medical devices. Programming in the National Instruments LabVIEW environment. In-lab and final projects.

6760 Biomedical Microdevices (3)
Dr. Shevkoplyas
This graduate level course will focus on design and fabrication of biomedical microdevices for basic biomedical research and clinical diagnostics. Students will learn from examples in recent medical literature how to approach the design of biomedical devices. The course will emphasize two basic engineering concepts – simplicity and biomimetics. It often pays (figuratively and literally) to spend the time to engineer the simplest
device with needed functionality, because simple devices are often more robust, inexpensive and user-friendly, and therefore are easier to commercialize. The biomimetic approach to engineering of devices could save a lot of effort simply because nature has already spent the time to try out nearly every possible design, and has often (but not always) arrived at the optimal solution. As an exercise in this course, students will be asked to propose a solution to a medical problem of their choice (from contemporary literature) and explain why they chose the specific design. A goal of this course will be to stimulate students to think creatively and to integrate their knowledge across a wide spectrum of subjects in BMEN curriculum for solving real problems related to human health. This course will specifically emphasize the development of point-of-care diagnostic devices for remote, rural areas, developing world and other resource-poor settings.

6790 Biomedical Engineering Design Studio (3)
Dr. Anderson
Prerequisites: BMEN Graduate or BMEN Senior Undergraduate standing.
This course is intended to provide students with a realistic design experience from virtual design, to rapid prototype fabrication, to testing, through redesign. It will focus on the practical application of leading commercial design software, including the creative extension of this software to innovate research applications. The course will be project intensive with commensurate report submissions and future design recommendations. Projects will include analyses of existing clinical problems, as well as research development of cell scaffolds and cell mechanotransduction.

6930 Cell Interactions and Signaling (3)
Staff
Prerequisites: CELL 1010, MATH 2240, BMEN 2600, BMEN 3440 or instructor approval.
This course teaches the modeling of cell dynamics using biological kinetics. In this course, students will learn to build kinetic mathematical models and apply quantitative analysis to cellular and biomolecular phenomena such as ligand-receptor binding, protein trafficking, signaling, cell growth and death, and cell migration.

7100 Current Topics in Biomedical Engineering (3)
This course focuses on state-of-the-art technologies and scientific discoveries in biomedical engineering. Experimental design/analysis topics will include proper controls, statistics, data presentation, and data interpretation. These types of technologies to be included are in the areas of epigenetics and genetics, molecular and cellular biology, proteins, mechanics and materials science, modeling and simulation, high-throughput omics, and/or imaging. Seminal articles from top-tier journals in the field of biomedical engineering will also be selected and discussed in class. The chosen articles will span a wide range of topic areas including articles that focus on basic science as well as funda-

7210-7220 Directed Readings in Biomedical Engineering (1-6)
Taught on a tutorial basis, this course allows a student to make an in-depth study in an area of expertise of members of the department. Some recent and current topics include non-Newtonian fluid mechanics; the mechanics of the inner ear; the mechanics of bone; the mechanics of soft tissue; ceramics engineering; physical metallurgy; laser applications in medicine; and modeling of neural networks.

*7410 Research Methods (3)
Dr. Rice
Methods and resources for experimental studies in engineering science are introduced. Topics include the nature of scientific inquiry, literature search and writing techniques, experimental design and control, data analysis and presentation, and statistical methods. An original proposal is required.
Appendix B. Faculty

Full-Time Faculty

Nicholas J. Altiero, Professor and Dean of the School of Science and Engineering; Ph.D., University of Michigan, 1974
Research interests: Computational mechanics, fracture mechanics and biomechanics.

Taby Ahsan, Assistant Professor; Ph.D., University of California, San Diego, 1998
Research Interests: Tissue engineering, stem cell research, mechanotransduction, biomanufacturing

Ronald C. Anderson, Associate Professor; Ph.D., Tulane University, 1987.
Research interests: Biomechanics, orthopedic materials.

Ravi K. Birla, Paul and Donna Flower Assistant Professor; Ph.D., University of Michigan, 2004.
Research interests: Cardiac tissue engineering, bioreactors, entrepreneurship.

Michael Dancisak, Senior Professor of the Practice and Director of the Center for Anatomical and Movement Science; Ph.D., University of Minnesota, 2000.
Research Interests: performance enhancement for individuals working in extreme environments.

Donald P. Gaver, Alden J. 'Doc' Laborde Professor and Department Chair, Director of Graduate Studies; Ph.D., Northwestern University, 1988.
Research interests: Biofluid mechanics, pulmonary mechanics, bioremediation, bio-computing.

Damir Khismatullin, Associate Professor; Ph.D., Bashkir State University, 1998.
Research interests: Modeling the mechanical behavior of biological systems at cellular and tissue levels, biomechanics.

Michael J. Moore, Assistant Professor; Ph.D., Mayo Clinic College of Medicine, 2005.
Research interests: Tissue engineering, biomaterials, central nervous system regeneration.

Walter Lee Murfee III, Assistant Professor; Ph.D., University of Virginia, 2005.
Research interests: Microvascular biology, cell-tissue engineering

David A. Rice P.E., Associate Professor and Director of Undergraduate Studies; Ph.D., Purdue University, 1974.
Research interests: Physiologic modeling, cardiopulmonary mechanics, bioacoustics, instrumentation and signal processing.

Sergey S. Shevkoplyas, Assistant Professor; Ph.D., Boston University, 2005.
Research interests: Microvascular blood flow, microfabrication, microfluidics, lab-on-a-chip, biomimetics.

Cedric F. Walker P.E., Professor; Ph.D., Duke University, 1978.
Research interests: Telemicine, neural stimulation, implantable monitoring devices.

Yu-Ping Wang, Associate Professor; Ph.D., Xi’an Jiaotong University, P. R. China, 1996.
Research interests: Medical imaging, bioinformatics, genomic signal processing and systems biology.

Emeritus Faculty

Paul L. Nunez, Professor; Ph.D., University of California at San Diego, 1969.
Research interests: Electroencephalography, signal processing, neocortical dynamics.

William C. Van Buskirk P.E., Professor and Chair Emeritus of Biomedical Engineering, Dean Emeritus of Engineering; Ph.D., Stanford University, 1970.

Affiliated Faculty

San Aung, Professor of the Practice, SSE; Ph.D., Tulane University, 2000.

Ming Li, Associate Professor, Department of Physiology; Ph.D. University of Iowa, 1989.

Annette Oertling P.E., Professor of the Practice, SSE; Ph.D. Tulane University, 2001.
Adjunct Faculty


James T. Bennett, Professor, Professor of Orthopaedics, Clinical Professor of Pediatrics, Tulane University; M.D., Tulane University, 1978. Spine Mechanics. Appointment through 12/31/2013

Hong-Wen Deng, Department of Biostatistics, School of Public Health and Tropical Medicine, Tulane University; Ph.D., 1995, University of Oregon. Appointment through 12/31/2013

David Halpern, Professor, Department of Mathematics, University of Alabama, Tuscaloosa. Ph.D. University of Arizona, Biomechanics, Computational Fluid Dynamics, Applied Mathematics. Appointment through 12/31/2013

Jean T. Jacob, Department of Ophthalmology, LSU Eye Center; Ph.D., Tulane University, 1988. Biomedical research. Appointment through 12/31/2013


Bahram Khoobehi, Department of Ophthalmology, LSU Eye Center; Ph.D., Yale, 1982. Laser-liposome techniques for studying retinal blood flow. Appointment through 12/31/2013

Jian Li, Department of Biostatistics, School of Public Health and Tropical Medicine, Tulane University; Ph.D., 2005, North Carolina State University. Appointment through 12/31/2013

Janet C. Rice, Associate Professor, Biostatistics, Tulane University Health Sciences Center; Ph.D., Purdue University, 1974. Statistical analysis and experimental design. Appointment through 12/31/2013

Note: Adjunct appointments are generally made for three-year terms
Appendix C. Undergraduate projects

Undergraduate Team Design Projects 2010-2011
These projects are supported by the National Science Foundation.

Team Victorious Secret
Martin Sosa, James Barrios, Amaris Genemaras, Miko Altenberg
We are designing a rocking system that allows wheelchair using grandparents to rock with their grandkids.

Team Pudding
Renee Huval, Bau Pham, Lydia Barrett, Teddy Brown
Our system includes both physical and psychologic systems to calm and reduce manic/self-abusive behavior in an autistic student.

Team SoundByte
John Pitre, Joan Lien, Hudson Chien
We are working with a congenital below-the-elbow amputee to develop a prosthesis that would enable her to play and maintain a violin.

Team Teamocil
Seth Figueroa, Tyler Humphrey, Lindsey Shepard, Christina Yee
We are working with a school for autistic children to develop a system that provides support and control of the reins during equestrian therapy.

Undergraduate Research Projects 2011

Amaris Genemaras  Analysis of the Effect of Cyclic Strain on the Age-Related Biological Properties of Human Adipose-Derived Stem Cells
Lindsey Shepard  The Effects of Shear Stress on Mouse Embryonic Stem Cells in Hypoxic Conditions
Bau N. Pham  Feasibility of the Use of Stem Cells as a Treatment for Early Stage Diabetic
Christina A. Yee  Computational Model of a Flagellum Swimming in a Brinkman Flow
Renee M. Huval  Localization of Biomolecules for Directing Neurite Outgrowth in 3D Dual-Hydrogel Systems
Seth A. Figueroa  A Computational Model of Axon Guidance
Theodore P. Brown  Quantification of Platelet Aggregation on Histamine Stimulated Endothelial Cells
Lydia L. Barrett  Liposomal Nanocarriers: Delivery of Short chain Ceramide to Decrease Viability of Breast Cancer Cells.


Jose M. Sosa  Design and Fabrication of an Artificial Micro Vascular Network to Determine

Mikolai J. Altenberg  Investigation of Optimization Methods of a Finite Element Analysis Software Package

Xavier B. Alvarez  Measuring Level of Ischemia in Kidney during Partial Nephrectomies Using Image Analysis Techniques and MATLAB

Joan Lien  Wear Analysis of Pyrolytic Carbon on Ultra-High Molecular Weight Polyethylene

James G. Barrios  A Novel Design Using Mylar Sheets for a Liquid Cooling/Warming Garment

Tyler J. Humphrey  Digital Valve Control Interface for Liquid Cooling/Warming Garment