The School of Science and Engineering

Biomedical Engineering (BMEN)

Biomedical Engineering consists of the application of engineering techniques and principles to problems and processes of biology or medicine. Such a broad class of study needs to be narrowed in order to achieve adequate depth, and the emphasis chosen by our faculty is—first and foremost—to provide students with the opportunity to acquire a rigorous engineering education. This basis then serves as a springboard to concentrated study of biomechanics, biomaterials, bioelectronics, bioelectricity, biotransport and cell and tissue engineering during the remaining undergraduate years.

Tulane's Department of Biomedical Engineering was founded in 1977, and therefore is a relatively mature department in a new field—a field in which the potential for making meaningful contributions is unlimited. Our backgrounds are diverse and our undergraduate and graduate teaching programs are extensive. All faculty members are actively engaged in research sponsored by federal, state or private organizations, and we believe that this enhances our teaching abilities by keeping each of us in the forefront of knowledge in our sub-specialties.

CREATIVITY, RESEARCH, DESIGN: CHARACTERISTICS OF TULANE'S UNDERGRADUATE PROGRAM

Hallmarks of our undergraduate curriculum are the research and design experiences that are coordinated through the two semester sequences in 'Research and Professional Practice' and 'Team Design' so that every biomedical engineering student participates in an individual research project as well as a team-design project.

Distinctive features of Tulane's undergraduate curriculum:

- First year course designed to: help students decide if biomedical engineering is the right career for them, help develop creativity, help students work together in teams, and explore the design process from idea generation to construction and testing a prototype
- Breadth in fundamentals: math, science, engineering sciences (statics, dynamics, mechanics of materials, materials science and engineering, circuits), professional practice
- Anatomy: A semester-long class that includes an active learning gross anatomy laboratory
- Quantitative Physiology: Taught by experts in the field faculty in Tulane's School of Medicine
- Depth in areas of interest: Domains of teaching and research include: bioelectronics, biomaterials, biomechanics bioelectricity and cell and tissue engineering
- Students are required, while still undergraduates, to take a graduate course as a follow-up to a 'domain' course
- Required team-design project: Teams of four biomedical engineering students each work with a disabled 'client' in the local community to design a device or process to assist the client; culminating with a design show in the spring
- Required year-long independent research project: During the senior year, students complete an individual research or design project with a faculty member in the department or in affiliated laboratories, commonly in the LSU or Tulane Schools of Medicine. This culminates with a thesis and a presentation during the department's Research Day conference.
- Required year-long independent research project: Students work from January of the junior year until December of the senior year on an individual research or design project with a faculty member in the department or from the LSU or Tulane Schools of Medicine
- The department has a very active five-year MS program. Students who demonstrate academic success (GPA > 3.4) can extend their senior projects towards a fifth year MS investigation. An MS is awarded after completion of coursework (24 credits) and an MS thesis.
- Our faculty members are active in research and teach both undergraduate and graduate courses. All of our faculty members are members of ASEE (American Society for Engineering Education) and all of our full professors have been elected as Fellows of AIMBE (American Institute for Medical and Biological Engineering).

DEPARTMENTAL MISSION

Our mission is to inspire and work with students as we develop and apply engineering methods to confront health-science challenges.

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 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.

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

UNDERGRADUATE INSTRUCTIONAL OUTCOMES

We give our students strong foundations in engineering, mathematics, and the life and basic sciences, in a coherent and coordinated curriculum. We provide our students with unique opportunities to conduct focused research or design projects in areas of individual interest, and we prepare our students for a successful transition to advanced study and professional careers. Specifically, students who obtain a bachelor's degree from our department will be able to:

1. Understand and apply principles and tools of mathematics, science, and engineering to formulate and analyze problems, specializing in issues found at the interface between biological and technological systems.

2. Compose and test hypotheses, and interpret resulting data.
3. Design systems, devices and processes to meet designatec specifications or open-ended objectives; evaluate and justify the resulting designs within contemporary cultural and broac societal contexts.
4. Work effectively in multidisciplinary teams.
5. Exemplify professionally and ethically responsible conduct.
6. Seek and value opportunities for extracurricular anc postgraduate education and development.
7. Communicate the short- and long-term challenges anc opportunities inherent in the field of biomedical engineering tc both technical colleagues and the general public.

FACILITIES

The Department of Biomedical Engineering is located in the Lindy Claiborne Boggs Center and includes more than 16,000 square fee of biomedical engineering office, laboratory, and classroom space Major items of research equipment include:

Computers - Biomedical Engineering Server: Apple Xserver *Various workstations:* PCs and Macintosh computers in researcl laboratories and the departmental computer/laboratory.

Imaging and Image Analysis: Epiflourescence microsopy suite, PC and Macintosh with frame grabbers, scanners, etc.

Physiology Laboratory: A physiology laboratory is equipped tc perform numerous physiology experiments and demonstrations.

Solid Mechanics: Digitally controlled MTS axial/torsiona universal testing system, console-mounted and portable strai gauge conditioners, ultrasonic testing apparatus.

Fluid Mechanics: TSI μPIV flow visualization apparatus Brookfield cone-plate viscometer, Cahn surface tension balance Electronetics pulsating bubble surfactometer, computational fluic diagnosis software.

Experimental and Computational Tissue Mechanics: Universa Cartilage Testing Device, High Resolution Imaging System ultrasound indentation probe, biosafety cabinet, centrifuge microscope, complete cell culture facilities.

Biomaterials: EG&G PAR computerized electrochemical and polarographic measurement systems, metallographic specimen preparation equipment, Azur Environmental toxicity analyzer.

Electronics: Full suite of GPIB connected test equipment to support development of HC11 and Basic Stamp microcontrollers. LabVIEW is used for algorithm and control loop development and prototyping of implant, telemedicine, and monitoring applications.

Pulmonary Function: Spirometers, flow and pressure instrumentation, data acquisition, acoustic measurement systems.

Tissue Engineering: This facility is fully equipped for cell/tissue culture and a range of chemistry and microscopy techniques. Major equipment includes biosafety cabinets, centrifuges, microscopes, incubators, microplate washer and reader, FTIR.

Undergraduate laboratories are available for experiments associated with required courses in medical sciences (BMEN 313/314), and bioelectronics (BMEN 273). These labs are also used in elective courses in biomechanics (BMEN 330), biomaterials (BMEN 323), and cell and tissue engineering (BMEN 340). A computer laboratory/classroom equipped with a SMARTboard and projector and 12 PCs, a printer and scanner are also available for undergraduates, particularly those taking BMEN 382 (required) and BMEN 361 (elective).

CURRICULUM

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 subfield of interest in biomedical engineering (*e.g.*, biomechanics, bioelectronics, bioelectricity, biomaterials, or tissue engineering) or biomedical sciences (for premed 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 graduates continue on to graduate or professional training after graduation from Tulane. We believe that this curriculum also prepares our students to enter directly into the workforce.*** We have a philosophy of 'rigorous breadth' in biomedical engineering which

can best be characterized by the undergraduate curriculun described below.

Tulane University BMEN Undergraduate Curriculum

The Biomedical Engineering curriculum is continuously evolving with the field. Below, we provide the curriculum for the Class o 2010. Up-to-date curricula for each class can be found a www.bmen.tulane.edu.

YEAR 1

Semester One		**18 hour**
	Course Title (Credit Hours)	
MATH 121	Calculus I (4)	
CHEM107/117	General Chemistry I and Lab (4)	
ENGL 101	Writing (4)	
PHYS 131	General Physics I and Lab (4)	
TIDES 100	Grand Challenges in Sci and Engr (2)	
Semester Two		**18 hour**
	Course Title (Credit Hours)	
MATH 122	Calculus II (4)	
CHEM 108/118	General Chemistry II and Lab (4)	
CPSC 101	Software Design and Programming (3)	
PHYS 132	General Physics II and Lab (4)	
ENGR 241	Statics (3)	

YEAR 2

Semester One		**17 hour**
MATH 221	Calculus III (4)	
CELL 101/211	General Biology I and Lab (4)	
ENGR 243	Mechanics of Materials (3)	
BMEN 201	Experiments & Experimental Design (3)	
ENGR 201	Electric Circuits (3)	

Semester Two **17 hours**

MATH 224	Applied Math (Diff Eqns.) (4)
BMEN 260	Intro Organic & Bio-Chemistries (3)
ENGR 312	Materials Science and Engr. (3)
BMEN 202	Human Anatomy Lab (1)
BMEN 273	Biomedical Electronics and Lab (4)
HUSL	Humanities/Social Sciences Elective (3)

YEAR 3

Semester One **16 hours**

BMEN 303/313	Anatomy and Physiology I and Lab (4)
HUSL	Human/Social Sciences Elective (3)
BMEN 3xx	3xx "Domain" class (3)
BMEN 3xx	3xx "Domain' class (3)
ENGR 344	Biofluids and Biotransport (3)
BMEN 371	BMEN Seminar (0)

Semester Two **15 hours**

BMEN 304/314	Quantitative Physiology and Lab (4)
HUSL	Human/Social Sciences Elective (3)
BMEN 382	Math Modeling (3)
BMEN 490	Research & Professional Practice I (2)

*PELECT/BMEN 6xx Professional Elective of Graduate Class (3)

YEAR 4

Semester One **14 hours**

*PELECT/BMEN 6xx	Professional Elective of Graduate Class (3)
HUSL	Human/Social Sciences Elective (3)
HUSL	Human/Social Sciences Elective (3)
BMEN 491	Research & Professional Practice II (2)
BMEN 403	Team Design I (2)

BMEN 405	Service Learning I (1)
BMEN 671	BMEN Seminar (0)

Semester Two **14 hour**

*PELECT/BMEN 6xx Professional Elective of Graduate Class (3)

*PELECT/BMEN 6xx Professional Elective of Graduate Class (3)

HUSL	Humanities/Social Science Elective (3)
BMEN 404	Team Design II (3)
BMEN 407	Service Learning II (1)
BMEN 672	Research Day Conference (1)

* Students take 3 Professional Electives and 1 BMEN 6XX graduate course as a follow-up to a BMEN 3XX domain course.

TULANE CORE REQUIREMENTS

The BMEN curriculum satisfies the Tulane University curriculun requirements of:

- Writing (4 hours): satisfied by ENGL 101
- Biomedical engineering majors are not required to satisfy the language requirement.
- Scientific inquiry (9 hours to 12 hours comprising quantitative reasoning, physical science and a life science, one of which contains a laboratory component): satisfied by MATH 121 MATH 122, MATH 221, MATH 224; PHYS 131, PHYS 132 CHEM 107/117, CHEM 108/118, CELL 101/211
- Cultural Knowledge: (18 credits) satisfied by six hours o humanities/fine arts and six hours of social sciences plus additional credits of humanities, fine arts, or social science.
- Public Service (2-3 hours): satisfied by BMEN 403/404
- Understanding interdisciplinary scholarship (1 hour–TIDES seminar)
- Capstone experience: satisfied by BMEN 490/491

DEPARTMENT OF BIOMEDICAL ENGINEERING REQUIREMENTS:

Continuation Requirements:
The BMEN curriculum is sequential and layered so that students can master prerequisite material prior to the study of engineering science and biomedical engineering domain material. Students that intend to major in biomedical engineering must have completed MATH 121, MATH 122; CHEM 107/117, CHEM 108/118; and PHYS 131, PHYS 132 (or equivalent) earning a "B" or better prior to the start of the second year of study. Students with a GPA below 3.000 in these courses must petition the BMEN faculty to seek approval if they want to continue in the program.

Professional Electives
The five professional electives listed in the BMEN curriculum include at least two of the BMEN 300-level elective "domain" courses and at least one BMEN 600-level course. The other 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.

Premedical students may use the professional electives in the junior year to take organic chemistry; however, many premedical students prefer to take organic chemistry during the summer. Some medical schools require a second English course, and this can be one of the humanities electives. Most medical schools also require an additional semester of biology with laboratory, and this is also considered as a professional elective.

"Domain" classes – BMEN 3xx

BMEN 323 Biomaterials

BMEN 361 Bioelectricity

BMEN 330 Biomechanics

BMEN 340 Cell and Tissue Engineering

BMEN 6xx courses are graduate courses, one of which is required as a follow-up to one of the selected BMEN 3xx domain classes.

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 (490, 491) and

Team Design (403, 404). Every student participates in an *individual research project* as well as a *team design project*.

The team design projects, which recently have been supported by the National Science Foundation and the Joe W. and Dorothy Dorsett Brown Foundation, are tailored to the needs of individuals 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. The team design experience of working for an extended period with a handicapped client—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. Participation in the team design experience satisfies the Tulane University public service requirement.

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 class of 2005, available at http:www.bmen.tulane.edu, covers an impressive range of activities. The students thus have substantial research experience - *while still undergraduates* -- that includes 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. Participation in the individual research project satisfies the Tulane University capstone experience requirement.

MINORS

Biomedical engineering students may also elect to pursue a major or minor offered by another department. Students should contact the appropriate department chair and work out a program of study.

Since many engineering students elect to add a minor in mathematics or business, these programs are listed:

Mathematics Minor
A mathematics minor or major is awarded for the following coursework.

MATH 121, 122, 221 Calculus I, II, III

MATH 224 Introduction to Applied Math or

MATH 217 Discrete Math

MATH 309 Linear Algebra

Plus: One additional course at the 300 level or above.

Business Minor
An undergraduate business minor is awarded for the following coursework.

ECON 101 Microeconomics

ACCT 203 Financial Accounting

And any four of the following:

ACCT 301 Managerial Accounting

FINC 352 Financial Management

OBHR 331 Organization Behavior

PSOM 371 Operations Management

MKTG 382 Marketing Management

Plus:

One additional course from the A. B. Freeman School of Business.

MINOR IN BIOMEDICAL ENGINEERING

Students in chemical and biomolecular engineering may earn a Minor in biomedical engineering through completion of the following courses:

CELL 101/211 Cell Biology, with Lab

BMEN 303/313 Anatomy and Physiology, with lab

BMEN 304/314 Quantitative Physiology II, with lab

1 course selected from:

BMEN 330 Biomechanics (Note: requires ENGR 241 and ENGR 243 prerequisites)

BMEN 340 Cell and Tissue Engineering

BMEN 361 Bioelectricity

BMEN 323 Biomaterials (Note: requires ENGR 312 as a prerequisite)

FACULTY AND COURSE DESCRIPTIONS

Office: Suite 500, Lindy Claiborne Boggs Center

Phone: 504-865-5897

Fax: 504-862-8779

e-mail: bme-info@.tulane.edu

url: http://www.bmen.tulane.edu

PROFESSORS

Nicholas J. Altiero, Professor and Dean, Ph.D., The University o Michigan at Ann Arbor, 1974.
Research interests: Computational mechanics, fracture mechanics, biomechanics.

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, biocomputing.

Cedric F. Walker P.E., Professor and Director, Freshman Programs; Ph.D., Duke University, 1978.
Research interests: Telemedicine, neural stimulation implantable monitoring devices.

ASSOCIATE PROFESSORS

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

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 signa processing.

Jun-Kyo Francis Suh, Associate Professor; Ph.D., Rensselaer Polytechnic Institute, 1989.
Research interests: Mechanics of collagen based connective tissues, cartilage tissue engineering, repair of articula cartilage defects, brain injury, computational biomechanics

ASSISTANT PROFESSORS

Yuefeng Han, Assistant Professor, Ph.D. The City College of New York, 2006.

Research Interests: Mechanotransduction and cellular signaling.

Michael J. Moore, Assistant Professor, Ph.D. Mayo Clinic College of Medicine, 2005.

Research Interests: Tissue engineering, biomaterials, central nervous system regeneration.

Darryl R. Overby, Assistant Professor; Ph.D. Massachusetts Institute of Technology, 2002.

Research interests: Cellular mechanotransduction, ocular biomechanics, and cell and tissue bio-engineering.

PROFESSOR OF PRACTICE

Annette B. Oertling, Ph.D. , Mechanical Engineering, Tulane University, 2001.

PROFESSORS EMERITI

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.

Courses in Biomedical Engineering (Undergraduate and Graduate)

A course with a three-digit number, such as 101, lasts for one semester. A course with a double number, such as 101-102, lasts for both semesters. Courses with numbers from 100 to 199 are ordinarily open to first-year students; 200 to 299 are ordinarily open to sophomores; 300 to 399 are ordinarily open to juniors; 400 to 499 are ordinarily open to seniors; 600 to 699 are open to advanced undergraduate and graduate students; and 700 to 799, to graduate students only.

REGULARLY SCHEDULED COURSES

201 Experiments & Experimental Design (3)
Prof. Anderson, Oertling. Prerequisite: BMEN 102
This course investigates measurement, error analysis and the treatment of uncertainties in biomedical engineering. Students will be provided an introduction to statistics, including probability and distributions, confidence intervals, sampling and hypothesis tests on the mean. Sources of potential bias (and how to avoid them) and various experimental designs commonly utilized in biomedical engineering will also be explored. Useful computational tools will be introduced and utilized throughout the course.

BMEN 241 Statics (3) Lecture
Prerequisites: PHYS 131. Statics of particles and rigid bodies. Concepts of force, moments, free body diagrams, equilibrium and friction with engineering applications. Same as ENGP 241.

BMEN 243 Mechanics of Materials (3) Lecture
Prerequisites:BMEN/ENGP 241, MATH 122. Concepts of stress and strain. Generalized Hooke's Law. Mohr's circle. Formulations for axial, shear, bending, torsion, and combined stresses applied to tension members, pinned points, symmetric and unsymmetric beams, and shafts. Euler buckling criteria for columns. Same as ENGP 243.

260 Introduction to Organic and Bio-Chemistries (3)
Staff. Prerequisite: CHEM 108 and CHEM 118, or approval of instructor. This course introduces the main principles of organic chemistry and biochemistry, preparing the student for BMEN 303/304. Topics include nomenclature of organic compounds and biomolecules, 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.

273/773 Biomedical Electronics with Lab (4)
Prof. Walker. Prerequisite: ELEN 201 or ENGR 201. 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. Brief overview of modulation, encoding, and interfacing. Electrical safety. Extensive weekly lab projects.

303/703 Anatomy and Physiology I (3)
Prof. Dancisak. Prerequisites: MATH 224, BMEN 260, CELL 101 Co-requisite: BMEN 313/713. This course is taught by the Structural and Cellular Biology department at the Tulane Medical School's Human Anatomy Lab. The course objectives are to learn to identify the principal components of the musculosketeal, peripheral nervous, central nervous, visual and auditory systems and to be able to relate the structures and their functions.

304/704 Quantitative Physiology II (3)
Tulane University Health Sciences Center Staff. Prerequisite: BMEN 303; Corequisite: BMEN 314
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.

BMEN 312 Materials Science and Engineering (3) Lecture
Prerequisites: CHEM 107, CHEM 108, PHYS 131, PHYS 132, MATH 221. The structure and properties of engineering materials are considered. Coverage includes basic atomic and microscopic structure, testing methods, phase relationships, and strengthening techniques. Emphasis is placed on common industrial materials. Thermodynamics and kinetics aspects of material science are discussed. Same as CENG 312 and ENGP 312.

313/713 Anatomy and Physiology Lab (1)
Prof. Dancisak. Co-requisite: BMEN 303/703. This course involves students in learning the principles and applications of anatomy and physiology. Dissection and exploration of preserved animals and cadavers are integral components of the lab. Computer software is used to explore the three-dimensional aspects of human anatomy. Physiological instruments will be used to demonstrate the interaction of physiological systems through electrocardiography, Spirometry, pO2 and pCO2, and for body composition analysis. Subject matter will include levels of organization, metabolism, histology, and the integumentary skeletal, muscular, neurological and endocrine systems.

314/714 Quantitative Physiology Lab (1)
Staff. Co-requisite: BMEN 304. Subject matter will include blood, nutrition, and metabolism; and the cardiovascular, lymphatic, digestive, respiratory, urinary, and reproductive systems.

323/723 Biomaterials (3)
Prof. Moore. Prerequisite: ENGR 312. The objective of thi course is to deepen the student's knowledge of phenomena tha influence the success of surgical implants used *in vivo*. Buildin upon the introductory material covered in ENGR 312, basi concepts of materials science and engineering relevant to this topi are discussed. In addition to engineering performance issues fundamental factors affecting the biocompatibility of implan devices will also be covered. Laboratory experiments will b utilized, in a supplemental fashion, to illustrate selected aspects o this material and to provide an introduction to procedures used t evaluate biomaterials. This course will serve as a bridge fo students who wish to take more advanced graduate leve biomaterials courses in the future.

330/730 Biomechanics (3)
Prof. Suh, Anderson. Prerequisite: ENGR 243. This cours introduces students to the various interdisciplinary fields i biomechanics, such as orthopaedic biomechanics, bioflui mechanics, soft tissue mechanics, and the biomechanics of huma movement. Specific topics include: kinematics and energy/powe during human activity; dynamics of human movement; the analysi of forces and stresses/strains in biological structures under loading constitutive models for biological materials; and the relationshi between structure and function in tissues and organs.

340/740 Cell and Tissue Engineering (3)
Prof. Overby. Prerequisite: BMEN 260. This course addresses th complex interactions between living tissues, implant biomaterials and the extracellular microenvironment, stressing the importanc of cellular- and molecular-level phenomena in macroscopic, tissue level events. After taking this course, students will be able t explain the roles of cells/tissues and biomaterials in coagulatio and fibrinolysis, inflammation, wound healing, hypersensitivity and foreign-body responses, and carcinogenesis. In this class students will also be exposed to current technologies of cell an molecular biology used to control the behavior of living cells an tissues. Current cell and tissue engineering research topics will b incorporated into class discussions and laboratory projects.

BMEN 344 Fluid Mechanics (3) Lecture
Prerequisites: ENGR 241, MATH 224. Fundamental concepts an properties of fluids. Basic equations of fluid statics and dynamics in differential and integral form using both system and control

volume viewpoints. Topics and applications include dimensional analysis and similitude; ideal, viscous and compressible flows; pipe and boundary layer flow. Same as ENGP 344.

361/761 Bioelectricity (3)
Prof. Staff. Prerequisite: ELEN 201 or ENGR 201. The objective of this course is to introduce the student to bioelectricity of excitable cells from a quantitative perspective. Topics include membrane transport phenomena, the ionic basis of action potentials, the Hodgkin - Huxley model, propagation of action potentials down excitable fibers, the response of cells to external stimuli, and the current flow in the medium surrounding the electrically active cell. The course also incorporates virtual bioelectricity labs designed to familiarize the student with the concepts presented in lecture.

382/782 Mathematical Modeling and Analysis of Biological Systems (3)
Prof. Gaver. Prerequisite: MATH 224. 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 or MATLAB to develop and analyze models.

403-404 Team Design Project I and II (2,2)
Prof. 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 and 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.

405 Service Learning: Beyond Design (1)
Prof. Rice. Prerequisite: Approval of instructor. Required co-requisite: BMEN/ENGR 403 or BMEN/ENGR 404. The required BMEN 403/404 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 thei clients with a service-learning component that follows Tulane' 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 students to describe and evaluate their experiences with the activity; and must create a product that can be evaluated as part o the course grade (e.g., a review paper on an issue relevant to the service activity or some product of value to the site).

409-410 Special Problems in Biomedical Engineering (1-4)
Staff. Independent study and investigation of special problems in biomedical engineering. Details to be arranged with individua biomedical engineering faculty members.

490-491 Biomedical Research and Professional Practice I and II (2,2)
Prof. Anderson. This course introduces the tools, techniques, and rules necessary to function professionally as a researcher o engineer. Topics include economic analysis, ethics, professiona communication including writing and oral presentation, researcl 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 membe or other scientist or professional. This culminates in a senior thesis and a presentation in departmental seminar.

493 Advanced Undergraduate Research (2)
Prof. Anderson. Prerequisite: Approval of instructor; admission to fifth year BS-MS program. In order to meet undergraduate degree requirements, this course will allow fifth year students to more effectively concentrate on their research projects in lieu o completing the course requirements of BMEN 491. The grade fo BMEN 493 will be listed as In Progress (IP) until such time as the master's thesis is completed, whereupon the student's adviser and thesis committee will assign a grade necessary to fulfill the bachelor's degree requirements.

611 Cardiac Electrophysiology (3)
Staff. Prerequisite: BMEN 361. An engineering perspective on the electrical behavior of the heart. Topics include the norma electrical excitation of the heart, membrane ionic channels contraction, the basics of electrocardiography, arrhythmias and

mechanisms of arrhythmogenesis, sudden cardiac death, and the electrical therapies for disturbances in cardiac rhythm. Virtual labs are also included to aid the learning process.

627 Biomaterials and Biocompatibility (3)
Prof. Moore. Prerequisite: BMEN 323 or equivalent. Building upon the fundamental material presented in BMEN 323, this course discusses structure-property relationships for the metallic, polymeric, ceramic, and composite materials used in surgical implants. Factors involved in the design of implants and processes used in their manufacture are also presented. Various aspects of biocompatibility are discussed in terms of effects (such as corrosion and wear) that the host environment has on implant materials, effects that species released by degradation processes have on the host tissues, and test methods for the study of these effects.

631 Continuum Models in Biomedical Engineering (3)
Prof. Suh. Prerequisite: ENGR 243, ENGR 344, BMEN 330. The course begins with a presentation of the kinematics of continuous media and elementary tensor manipulations. We then cover the conservation principles of mass, linear momentum, angular momentum, and energy. Additional topics 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.

633 Biofluid Mechanics (3)
Prof. Gaver. Prerequisites: ENGR 243, ENGR 344. 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 are used as examples.

634 Soft Tissue Mechanics (3)
Prof. Suh. Prerequisite: ENGR 243, BMEN 330. 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.

635 Advanced Soft Tissue Biomechanics (3)
Prof. Suh. Prerequisite: BMEN 634, BMEN 636. The class is designed to provide students with advanced modeling topics in musculoskeletal soft-tissue biomechanics. The course material consists of an introduction to the anatomical structure of various musculoskeletal soft tissues such as ligament, tendon, and cartilage, followed by fundamentals and general principles in mechanics necessary to understand mathematical modeling of these tissues. The main focus is placed on various viscoelastic modeling of soft tissues, such as linear, nonlinear and quasi-linear viscoelastic modelings. A viscoelastic model based on mixture theory, such as biphasic poroelastic model and biphasic poroviscoelastic model is also introduced. The models are studied mostly using typical simple loading conditions. They include creep, stress relaxation, and cyclic loading of such models.

636 Introduction to the Finite Element Method (3)
Staff. Prerequisite: ENGR 330 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.

642: Transport Phenomnena in Biological Systems (3)
Prof. Overby. The objectives of this course are i) to understand the physical factors governing the transport of momentum, mass and heat; ii) to develop the ability to quantify the transport of these quantities using the basic equations of fluid mechanics and heat and mass transfer, and iii) to relate these transport processes to the function of biological systems.

646: Cellular Mechanotransduction (3)
Prof. Han. This course reviews cellular mechanotransduction in a variety of tissues that adapt to physiological loading. A partial list of mechanosensing cells in these tissues include hair cells in the inner ear, 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.

661 Introduction to Computational Biomechanics (3)
Prof. Suh. 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 as the official computational tool to implement these methods. The underlying theories of these numerical methods are taught, and example problems are discussed during the lecture. Example problems include those from implant design, bone biomechanics, soft tissue biomechanics, etc. in static and dynamic conditions. The course also discusses some special issues such as the stability/convergence criteria and the error estimation. The student works on a term project to exercise these issues on a biomechanics problem of the student's choice.

671-672 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.

674 Data Acquisition and Control (3)
Prof. Walker. Prerequisite: ELEN 303, BMEN 373. 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.

721-722 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.

LESS FREQUENTLY SCHEDULED COURSES

602 Biosystems (3)
Prof. Rice. Prerequisite: BMEN 373 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 often can 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.

606 Biomedical Acoustics (3)
Prof. Rice. Prerequisite: BMEN 304, MATH 221. 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.

616 Neural Augmentation (3)
Prof. Walker. Prerequisite: BMEN 373. Implantable and external electrical stimulation devices and technology for the control of pain, functional electrical stimulation, and other neural prostheses are discussed. Additionally, the anatomy of the central nervous system is taught through the use of a programmed learning sequence.

618 Electrodiagnosis (3)
Prof. Walker. Prerequisite: BMEN 373. Application of medical instrumentation in clinical diagnosis including EKG, EMG, multimodality-evoked potentials, stress tests, ultrasound, and computed tomography. The lectures cover the system design of the instruments and review the conditions they are designed to detect. The lab consists of an applications demonstration in one of the local medical facilities.

626 Biomaterials Research Problems and Methodology (3)
Staff. Prerequisite: BMEN 323. This course emphasizes a detailed consideration of selected topics that are currently the focus of biomaterials research, as well as consideration of experimental and theoretical methodology used to approach these and other biomaterials problems. The specific topics will change from year to year as the field of biomaterials develops.

628 Surgical Applications of Biomaterials (3)
Staff. Prerequisite: BMEN 627 or equivalent. This course emphasizes specific uses of biomaterials in various branches of surgery, specific materials used, and problems that may be a consequence of such use. Topics discussed include orthopædic, cardiovascular, dental, and other applications.

639 Advanced Finite Element Methods (3)
Staff. Prerequisite: BMEN 636. This is the second course in finite element analysis that expands upon the introductory course, BMEN 636. Included in the topics to be addressed are the theory and application of weighted residual methods, dynamic mode shape and time series analyses, geometric and material nonlinearities, contact problems, and thermal and electric field problems. The BMEN Origin 2000 is used for running ABAQUS and/or ABAQUS/EXPLICIT to solve all application problems.

664 Bone Mechanics (3)
Staff. Prerequisite: BMEN 636 and approval of instructor . The objective of the course is to provide students with an opportunity to pursue an in-depth examination into current methods and results in bone mechanics research. Of particular interest is the study of the anatomy and physiology of bone tissue, the stress-strain behavior of cortical and cancellous bone, the fatigue behavior of bone, and the response of living bone to disease, foreign materials, and to mechanical loading. Both the methods and the results of bone mechanics research are studied, and computer simulations of bone adaptation to mechanical loads are performed.

665 Structure-Function Relationships in Biological Tissues (3)
Staff. Prerequisites: BMEN 634 or ENGR/BMEN 631. This course provides a review of the mechanics of finitely deformable structures and thermomechanics with applications to the study of biological tissues. The focus of the course is on the development of mathematical models describing fluid-solid interactions in biological tissues, nutrient transport, damage repair, and discontinuities. In particular, we cover mixture theory,

poroelasticity, microstructural models of cortical and cancellous bone, tendon, ligament, and other tissues, transient and steady-state nutrient transport, and continuum damage theories.

666 Cardiovascular Biomechanics (3)
Prof. Gaver. Prerequisites: MATH 224, BMEN 633 or equivalent This course provides an advanced discussion of the fluid mechanical principles underlying the operation of the heart and circulatory system. It completes the sequence intended to provide the necessary course background for students pursuing research in biofluid mechanics. Topics covered include blood rheology mechanics of circulation, arterial wave propagation and transport of suspended solutes.

668 Orthopaedic Bioengineering (3)
Prof. Anderson. Prerequisites: ENGR 241, ENGR 243, ENGR 312 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.

741 Research Methods (3)
Prof. 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.