ATTACHMENT 2B-2

PROPOSAL – 1
NEW CERTIFICATE OR DEGREE PROGRAM

1. **PROPOSED PROGRAM TITLE**

   Bachelor of Science in Biomedical Engineering

2. **CIP CODE REQUESTED**

   14.0501

3. **CONTACT PERSON**

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4. **PROPOSED STARTING DATE**

   July 1, 2012

5. **PROGRAM SUMMARY**

Biomedical engineering encompasses the creation, design, and operation, of processes / technology related to the broad field of human healthcare. The profession traditionally has focused on applications related to the development of instrumentation and diagnostic equipment, discovery of novel treatment options, production of new therapeutics, and the elucidation of underlying biophysical phenomena. Newer applications of bioengineering take advantage of the ever deepening understanding of human physiology and molecular genetics, as related to prevention, detection, and treatment of medical conditions. The program objectives of the Biomedical Engineering undergraduate program are to produce graduates who are capable of:

- succeeding in the practice of engineering or other professional activities, and
- succeeding in post baccalaureate studies.

Completion of the degree requirements provides for the following educational outcomes:

- 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 within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- an ability to function on multidisciplinary 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 global, economic, environmental, and societal contexts
- 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.

These educational outcomes are experienced within the context of biology and physiology appropriate to solving problems at the interface of engineering and biology.

Existing degree programs that support the proposed program:

Engineering
- Biological Engineering
- Chemical Engineering
- Electrical Engineering
- Mechanical Engineering
- Computer Science
- Industrial Engineering

Fulbright College of Arts and Sciences
- Biology
- Chemistry
- English
- Mathematics
- Physics
- Various other humanities and social science departments for State Core

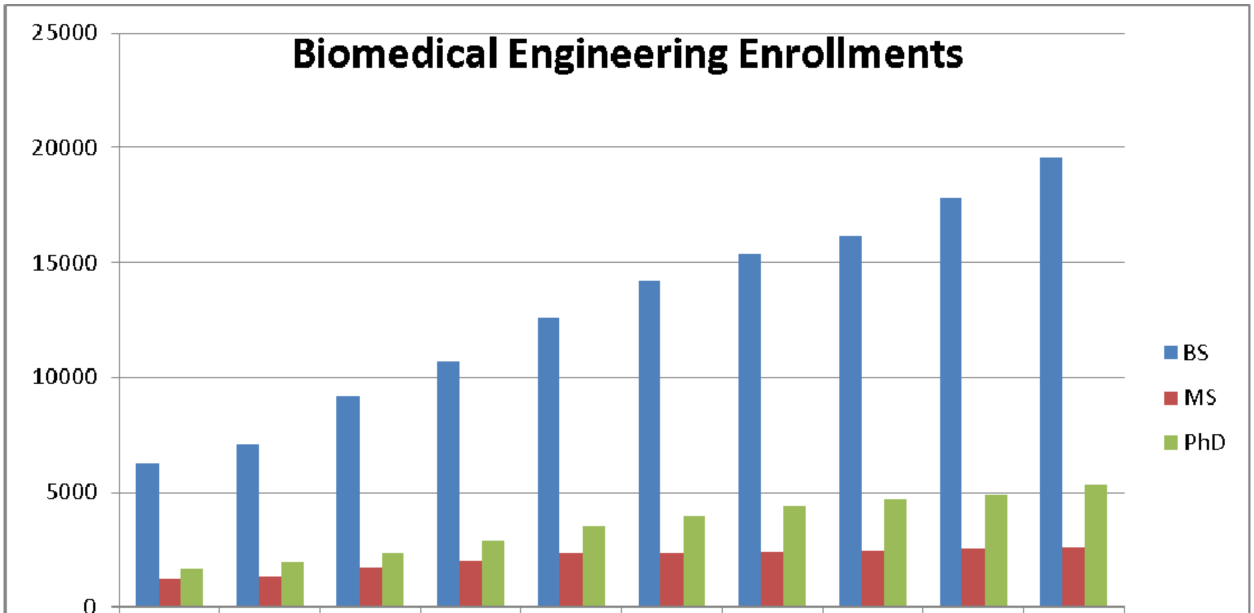
6. NEED FOR THE PROGRAM

The Biomedical education and research at the University of Arkansas is currently embedded within the department of Biological and Agricultural Engineering which reports to both the College of Engineering and to the Dale Bumpers College of Agriculture and Food and Life Sciences. Undergraduate students have the opportunity to choose Biomedical Engineering as a concentration within a BS degree in Biological Engineering. This stream produces approximately ten such graduates per year. A MS degree in Biomedical Engineering was initiated in 2004 and was accredited by ABET (the national engineering accreditation board) in 2009. The number of graduates in this program range from two to three per year. Doctoral students can choose Biomedical Engineering as a research area but their degree is recognized within the Biological Engineering PhD concentration.

The numbers of graduates at all degree levels with biomedical concentration at the University of Arkansas have been much lower than the national averages. In the past ten years, enrollments at the national level in Biomedical Engineering programs have increased by more than 200% (Fig. 1) while the overall engineering enrollment increases during the same period have only been at the level of approximately 20%. Similar impressive increases in students have also occurred at the MS and PhD levels (Fig. 1). Significantly larger numbers of female students and faculty are attracted to this discipline because of the exciting career opportunities in the health care field as seen in Fig. 2. The time is right for the University of Arkansas to re-examine its position on Biomedical Engineering and develop stand-alone degrees at all levels (BS, MS and PhD). This proposal is for creating a new Department of Biomedical Engineering. There are parallel proposals for creating a new undergraduate major in Biomedical Engineering and a new doctoral concentration in Biomedical Engineering within the existing PhD degree in Engineering. These two new degree programs will complement the existing MS degree and thereby create exciting educational opportunities in Biomedical Engineering for Arkansans at all levels.

Biomedical Engineering is a field at the interface of engineering, medicine and biological sciences. It combines the practical problem solving ability of engineering to diagnostic, monitoring, and therapy needs of medical sciences. Even though engineers have designed medical devices for a long time, Biomedical Engineering has only been established as a discipline within the past two decades.

The evolution of academic disciplines often follows the sequence of first being a multi-disciplinary program evolving into an interdisciplinary program and then becoming a discipline in itself with a variety of sub-disciplines. Biomedical Engineering has followed that path and is now widely recognized as a separate discipline within engineering. In the United States, an undergraduate degree in Biomedical Engineering is offered at 99 universities of which three are in the SEC, but none in Arkansas. The SEC schools offering Biomedical Engineering include the University of Tennessee, University of South Carolina and Vanderbilt.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
BS	6262	7093	9178	10716	12566	14213	15411	16153	17798	19558
MS	1218	1361	1718	2029	2314	2313	2390	2455	2568	2604
PhD	1643	1949	2348	2903	3546	3936	4411	4668	4894	5289

Fig. 1- A ten year history of national enrollment trends in Biomedical Engineering. The data are from the "The profiles of Engineering & Engineering Technology Colleges", ASEE 2009 Edition, American Sociey for Engineering Education, Washington, DC, 2010.

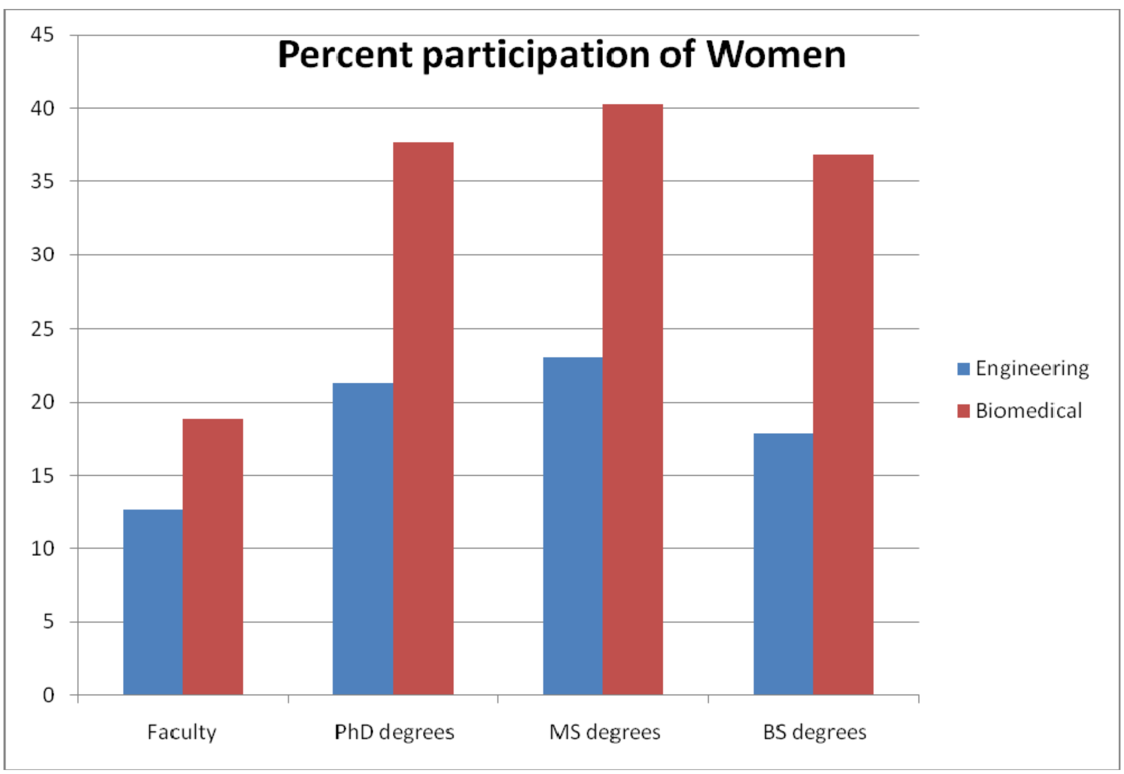


Table 1 presents the enrollment trend among Biomedical Engineering programs in our benchmark institutions that are ranked between 76 and 85 in the US News and World Report rankings and those institutions within the SEC that have Biomedical Engineering programs. Seven out of ten benchmark institutions and three out of twelve SEC institutions offer an undergraduate program in Biomedical Engineering. The enrollments range from 4% to 24% of all engineering enrollments in those institutions. The 24% number at Vanderbilt is unusual and likely due to the presence of an on-campus medical school. The median enrollment level in Biomedical Engineering is about 8% of the enrollment in the Engineering College. Using the median number and the current engineering enrollment at the University of Arkansas, the expected number of undergraduate students is 160 or approximately 40-45 graduates per year. If we use a more optimistic percentage of 10% and an expected undergraduate enrollment of 2500 in five years, we could have as many as 250 students enrolled in Biomedical Engineering or 55-60 graduates per year. The field attracts a large number of high ability students because it provides excellent preparation for entering medical school. Often, Biomedical Engineering programs are a bridge between engineering colleges and medical schools.

A strong doctoral program in Biomedical Engineering will open several collaborative opportunities with the medical school including potential joint faculty appointments and a joint MD/PhD program in medicine/engineering.

Table 1- Undergraduate Biomedical Engineering enrollments in benchmark institutions that have a separate degree in Biomedical Engineering*							2009 UGRD ENGR Enrollment	Biomed as % of UGRD Enrollment
	2005	2006	2007	2008	2009			
Arkansas	-	-	-	-	-		1,744	-
Clemson	0	19	66	130	157		3,621	4%
Houston	60	91	127	142	148		1,989	7%
Illinois Institute of Tech	124	136	123	136	131		1,217	11%
Mississippi St	-	-	-	-	-		2,252	-
New Mexico	-	-	-	-	-		1,179	-
Oregon State	105	110					3,685	0%
Syracuse	123	143	144	153	151		1,329	11%
Texas at Dallas	-	-	-	-	-		1,638	-
Tufts	0	9	20	29	39		738	5%
Washington State	72	72	58	65	71		1,859	4%
South Carolina	0	25	53	87	135		1,584	9%
Tennessee	174	163	170	151	164		2,202	7%
Vanderbilt	392	365	337	300	302		1,271	24%

* Enrollments determined from
ASEE Survey Data

The new Department of Biomedical Engineering will be created in the College of Engineering that will consist of its own core faculty and joint faculty from other departments in engineering, sciences and the medical school.

The program can be initiated with four core faculty for which there is already adequate budget in the College of Engineering. We expect that at least a dozen other faculty in the college will seek joint appointments in this unit. A model for joint faculty could be that the teaching load of the faculty member for one out of three semesters will be determined by the Biomedical Engineering program. This requirement may fully or partially be met by offering cross-listed course(s) that benefit both the Biomedical Engineering students as well as students from the home department of the faculty member.

As enrollments in Biomedical Engineering rise, it is expected that more positions will be allocated to the program from among the new lines allocated to Engineering. An estimate of those needs is shown in Table 2.

The following program space has been identified to serve the needs of the new department. Some minor renovation and reconfiguration of the space will be needed to make it suitable for the new programs.

I. Space available due to relocating faculty from Engineering Hall to the former Biobased Building on Cato Springs Road
II. Administrative and faculty offices can be located on 3rd floor of Engineering Hall
III. Undergraduate laboratories for Biomedical Engineering can be located in the southwest corner of Engineering Hall
IV. The research laboratories can be housed in the Engineering Research Center.

Table 2 - Expected growth in students and faculty in Biomedical Engineering

Fiscal Year	Expected UG enrollment	Expected Graduate Enrollment	Additional Faculty needed
FY 12	None	None	None
FY 13	60	20	0
FY 14	100	30	1 Senior position of Department Head or Program Coordinator
FY15	150	40	2
FY 16	200	40	1

7. **CURRICULUM OUTLINE**

Students admitted into the University of Arkansas are eligible for admission into this program.

Biomedical Engineering B.S.BM.E. **Eight-Semester Degree Program**
Fall Semester Year 1
3 ENGL 1013 Composition I 4 MATH 2554 Calculus I 3 CHEM 1103 University Chemistry I 4 PHYS 2054 University Physics I 0 PHYS 2050L University Physics I Lab 1 GNEG 1111 Introduction to Engineering I **15 Semester hours**
Spring Semester Year 1
3 ENGL 1023 Technical Composition II 4 Freshman Science Elective * 0 Freshman Science Elective Lab * 4 MATH 2564 Calculus II 3 Humanities/Social Science Elective 1 GNEG 1121 Introduction to Engineering II **15 Semester hours**
Fall Semester Year 2
3 BMEG 2613 Introduction to Biomedical Engineering 4 MATH 2574 Calculus III 4 Sophomore Science Elective ** 0 Sophomore Science Elective Lab ** 3 BIOL 1543 Principles of Biology 1 BIOL 1541L Principles of Biology Lab 3 CHEG 2313 Thermodynamics **18 Semester hours**
Spring Semester Year 2
3 BMEG 2813 Biomechanics 3 BMEG 2633 Biomaterials 4 MATH 3404 Differential Equations 3 BIOL 2533 Cell Biology 3 ELEG 3933 Circuits and Electronics **16 Semester hours**

Fall Semester Year 3	
3	Humanities/Social Science Elective
3	BMEG 3103 Biomedical Instrumentation
3	Organic Chemistry Elective
1	Organic Chemistry Elective Laboratory
3	BIOL 2213 Human Physiology
1	BIOL 2211L Human Physiology Laboratory
4	ELEG 3124 Systems and Signal Analysis
18	**Semester hours**
Spring Semester Year 3	
3	BMEG 3653 Biomedical Modeling and Numerical Methods
3	BMEG 3823 Biomolecular Engineering
1	BMEG 3811L Biomolecular Engineering Lab
3	CHEG 2133 Fluid Mechanics
3	Technical Elective
3	Humanities/Social Science Elective
16	**Semester hours**
Fall Semester Year 4	
3	BMEG 4813 Biomedical Engineering Design I
3	BMEG 4623 Biomedical Transport Phenomenon
3	BMEG Technical Elective
3	Science Elective
3	Humanities/Social Science Elective
15	**Semester hours**
Spring Semester Year 4	
3	BMEG 4923 Biomedical Engineering Design II
3	BMEG Technical Elective
3	Technical Elective
3	U.S. History
3	Humanities/Social Science Elective
15	**Semester hours**
128	**Total hours**

* The Freshman Engineering Science Elective must be chosen from either CHEM 1123/1121L or PHYS 2074.

** The Sophomore Science Elective must be PHYS 2074 (if CHEM 1123/1121L was chosen as the Freshman Engineering Elective) or CHEM 1123/1121L (if PHYS 2074 was chosen as the Freshman Engineering Science Elective.

New Courses

BMEG 2613 Introduction to Biomedical Engineering

Course Description: This is an introductory course for biomedical engineering undergraduate students. It covers topics such as recombinant DNA technologies, cell and tissue engineering, stem cell and organ regeneration, the design of tissue engineered products, biomaterial and tissue scaffolding, drug delivery, biomechanics, bioinstrumentation, engineering of immunity, and bio- and medical imaging, etc. The application of nano-biotechnology in developing clinical products such as tissue engineered products, drug delivery systems, etc. will be emphasized in the course. Lecture 3 hours per week.

Prerequisites by topic: None

Objective:

- Engage student interest in Biomedical Engineering, and broaden their view of Biomedical Science and Engineering to include emerging areas of stem cell engineering, organ regenerative medicine, medical imaging, and biomedical nanotechnology
- Reinforce engineering science through exposure to emerging applications for more in-depth understanding of engineering principles and methods specific to biomedical engineering
- Encourage undergraduate research in biomedical engineering

Outcome: After taking this course, students will be able to:

- Use and understand basic biomedical engineering technologies
- Identify potential career opportunities in biomedical engineering and medical fields
- Understand how engineering fundamentals can be applied toward real-world, complex problems involving medicine and human health
- Formulate and solve biomedical engineering problems using the engineering design process

Textbook:

- W. Mark Saltzman, “Biomedical Engineering: bridging medicine and technology” Cambridge University Press, New York, NY. ISBN 978-0-521-84099-6
- Handouts (in the form of draft textbook by Kaiming Ye)

Topics covered:

1. Introduction: What is Biomedical Engineering
2. Molecular and Cellular Principle: Cells in Their Society Context, cell junction, adhesion, and extracellular matrix
3. Cell Signaling and Differentiation
4. Engineering Balances: Respiration and Digestion
5. Circulation and Removal of Molecules from the body

6. Fundamentals of Tissue Engineering
7. Stem Cell Engineering and Organ Regenerative Medicine
8. Design of Tissue Engineered Products
9. The Modeling Process
10. Biomaterial and Tissue Scaffolding
11. Biomechanics, Biomaterial Design and Selection for Tissue Repair
12. Gene Therapy and Targeted Drug Delivery
13. Design of Nanomaterials for Disease Diagnosis & Treatment
14. Design of Biomedical Imaging Devices for Disease Diagnosis
15. Medical Imaging: MRI, Ultrasound, X-ray CT, Nuclear Medicine
16. Engineering of Immunity

Project Requirement

Student is required to undertake an independent design project applying biomedical engineering fundamentals to the design of a small project related to tissue engineering products.

Contribution of course to meeting the requirements of the Professional Component:

College level math and basic science	30%
Engineering Science	40%
Engineering design	30%
General education component	
Other (specify)	

This course contributes to the ABET criteria in the following ways.

ABET Criterion: student will be able to	**BMEG Contribution**
(a) Apply math, science, engineering	Use cell biology, molecular biology, math, physics to analyze and determine cellular and organ behaviors.
(b) Design, conduct experiments, analyze, interpret data	Mathematical modeling and computation
(c) Design system component, process to meet desired needs	Students will be required to design a tissue engineered product in a design project.
(d) Function on multidisciplinary teams	Students will team up for a design project
(e) Identify, formulate and solve engineering problems	Students will solve real world problems in homework that will be problem solving based.
(f) Understand professional and ethical problems	Heavy involvement in ethics of biomedical engineering including health care constraints, stem cell research, experiments on human subjects.
(g) Communicate effectively	Written report is required for the course project. Accurate and concise descriptions of solutions.
(h) Understand the impact of engineering on society and the world	Impacts of engineering on human health, modern health care system, rehabilitation, and sports medicine

(i) Recognize the need for and engage in life-long learning	
(j) Know contemporary issues	Students will be required to write several essays on emerging biomedical science and engineering technologies.
(k) Use modern techniques, skills, and tools for engineering practice	

BMEG 2633: Biomaterials

<u>Course Description</u>: Introduction to the engineering properties of materials used in biomedical devices and applications. Topics include: structure-property-processing relationships, bulk engineering properties, surface and interfacial properties and applications of materials in biology and medicine. Students will review the history of biomaterials as related to a specific biomedical device.

<u>Prerequisites:</u>

- BMEG 2613
- CHEM 1123

<u>Pre or Co-requisites:</u>

- BIOL 1543/1541L

<u>Objectives</u>

- To familiarize students with a broad range of biomaterials and their applications in biology and medicine
- To demonstrate the roles of biomaterials in commonly used medical devices
- To explain structure-property-processing relationships of biomaterials as they relates to the fabrication of medical devices.
- To reinforce concepts in biomaterials characterization through hands-on learning experiences
- To appreciate the evolution of biomaterials in medical devices

<u>Outcomes:</u> After taking this course, students will be able to:

- Differentiate biomaterials from other materials
- Distinguish different classes of biomaterials
- Understand how structure and processing influence biomaterials properties
- Define commonly used engineering properties
- Differentiate analytical methods for biomaterials characterization
- Introduce the concept of biocompatibility

<u>Textbook:</u>

- <u>Materials Science and Engineering: An Introduction</u>, by W.D. Callister, Jr., Fifth Edition, Wiley, 2000.
- <u>Biomaterials Science</u>, by Ratner, Hoffman, Schoen, and Lemons. Third Edition, Academic Press, 2011.

<u>Topics covered</u>

1. Definitions; biomaterials in medicine
2. Atomic structure; Stress-strain relationships; Metals;
1. Failure mechanisms; Annealing/Hardening; Structure-Property-Processing
2. Conductivity; **LAB:** Tensile Testing
3. Biomedical alloys; Orthopaedic applications;
4. Ceramics; Osseointegration; Bioactive glasses;
5. Biomedical applications; **LAB:** Bone Cement

6. Synthetic Polymers; polymerization methods
7. Hydrogels; Smart polymers
8. Vascular grafts; ocular devices; drug delivery; **LAB:** silicone prosthesis
9. Natural Polymers (biopolymers); protein, DNA, collagen
10. Composites; **Mid-term Exam**
11. Surface characterization techniques;
12. Surface modification, **LAB:** contact angle
13. Biotic-Abiotic interface; biodegradation
14. Biocompatibility

Class / Laboratory schedule:
Current format is three 50 minute sessions per week with 4 labs spaced throughout the semester (3 semester credit hours)

Contribution of course to meeting the requirements of the Professional Component:

College level math and basic science	
Engineering Science	33%
Engineering design	67%

This course contributes to the ABET criteria in the following ways.

ABET Educational Outcome	How students are prepared to attain the outcome
(a) Apply math, science, engineering	Students use math, physics, chemistry and engineering to understand structure-property relationships for different classes of biomaterials.
(b) Design, conduct experiments, analyze, interpret data	Students design and conduct laboratory experiments to analyze and interpret biomaterials characterization data.
(c) Design system component, process to meet desired needs	
(d) Function on multidisciplinary teams	
(e) Identify, formulate and solve engineering problems	
(f) Understand professional and ethical problems	
(g) Communicate effectively	Students submit a written review of the history of biomaterials selection for a particular device. Students also submit written reports for laboratory and homework assignments.
(h) Understand the impact of engineering on society and the world	Students learn about the growing impact of biomaterials in enhancing the performance of countless life-sustaining and life-improving devices.
(i) Recognize the need for and engage in life-long learning	Students conduct literature review using PubMed and other databases for device review project.
(j) Know contemporary issues	Students understand the influence of modern

	economics on biomaterials selection.
(k) Use modern techniques, skills, and tools for engineering practice	

BMEG 2813 Biomechanics

***Course Description*:** This course introduces basic concepts and principles of biomechanics to biomedical and other engineering students. The course topics include mechanics and materials, viscoelastic properties, bone, cartilage, ligament, tendon, muscle, cardiovascular dynamics, clinical gait analysis, etc. After taking this course, students are expected to understand the application of engineering kinetics to describe motions of human body and mechanic properties of tissues. MATLAB will be used to write and solve biomechanical static and dynamic equations. Lecture 3 hours a week.

Prerequisites:

- MATH 3404
- MATH 2564
- PHYS 2074
- CHEM 1123
- BMEG 2613

Objectives

- Engage student interest in Biomechanical Engineering, and broaden their view of Biomedical Science and Engineering to include emerging areas of cellular biomechanics, mechanobiology, and sports medicine
- Reinforce engineering science through exposure to emerging applications for more in-depth understanding of engineering principles and methods specific to biomechanical engineering
- Encourage undergraduate research in biomechanical engineering

Outcome: After taking this course, students will be able to:

- Use and understand basic biomechanical engineering technologies
- Identify potential career opportunities in biomechanical engineering and medical fields
- Understand how physical forces interact with living cells and how these understands can help improve human health and disease treatment
- Formulate and solve biomechanical engineering problems using the engineering design process

Textbook:
Ethier, C.R. and Simmons, C.A. (2007) Introductory Biomechanics from Cells to Organisms, Cambridge University Press, ISSN 978-0-521-84112-2

Topics covered:
Introduction

1. Basic mechanics
    - 1.1. Vector mathematics
    - 1.2. Coordinate transformations: 3D direction cosines and Euler angles
    - 1.3. Static equilibrium
    - 1.4. Anthropomorphic mass moments of inertia
    - 1.5. Equations of motion
2. Mechanics of materials

3. Viscoelastic Properties
4. Bone and cartilage
   4.1. Blood circulation in bone
   4.2. Elasticity and strength of bone
   4.3. Viscoelastici properties of bone
   4.4. Functional adaptation of bone
   4.5. Cartilage
   4.6. Viscoelastic properties of articular cartilage
   4.7. The lubrication quality of articular cartilage surface
   4.8. Constitutive equations of cartilage according to a triphasic theory
   4.9. Ligament, tendon, and muscle
5. Clinical Gait Analysis
   5.1. The clinical gait model
   5.2. Kinematic data analysis
   5.3. Kinetic data analysis
   5.4. Clinical gait interpretation
6. Cardiovascular Dynamics
   6.1. Blood Rheology: laminar flow of blood in vessels and medical application of blood rheology
   6.2. Arterial vessels
   6.3. Heart mechanics
   6.4. Cardiovascular mechanics

Project Requirement

Student is required to undertake an independent design project applying biomechanical engineering fundamentals to the design of a small project related to biomechanics of organ system in human body.

Contribution of course to meeting the requirements of the Professional Component:

College level math and basic science	30%
Engineering Science	40%
Engineering design	30%
General education component	
Other (specify)	

This course contributes to the ABET criteria in the following ways.

ABET Criterion: student will be able to	**BMEG Contribution**
(a) Apply math, science, engineering	Use cell biology, anatomy, molecular biology, math, physics, fluid mechanics, statics, dynamics, thermodynamics, and solid mechanics to analyze and determine cellular and organ biomechanics.
(b) Design, conduct experiments,	Mathematical modeling and computation

analyze, interpret data	
(c) Design system component, process to meet desired needs	
(d) Function on multidisciplinary teams	
(e) Identify, formulate and solve engineering problems	Students will solve real world problems in homework that will be problem solving based.
(f) Understand professional and ethical problems	Heavy involvement in ethics of biomechanical engineering including health care constraints, stem cell research, experiments on human subjects.
(g) Communicate effectively	Written report is required for the course project. Accurate and concise descriptions of solutions.
(h) Understand the impact of engineering on society and the world	Impacts of engineering on human health, modern health care system, rehabilitation, and sports medicine
(i) Recognize the need for and engage in life-long learning	
(j) Know contemporary issues	Mechanobiology and use of new biomaterials for designing smart transplants for improving human health
(k) Use modern techniques, skills, and tools for engineering practice	Numerical solution techniques, exposure to modern engineering equipment used in biomechanics

BMEG 3103 Biomedical Instrumentation

Course Description: This course is designed for biomedical engineering undergraduate students to learn both theoretical and practical concepts of bioinstrumentation and their applications in modern life science and medicine. Analytical experiments will be practiced in the laboratory along with the lecture section. This course covers basic topics in circuits such as charge current, voltage, resistance, power, energy, linear network analysis, inductors, capacitors, operational amplifier, time-varying signals, active analog filters, bioinstrumentation design etc. The application of these principles and theories in bioinstrumentation design and development is particularly emphasized in this course. The lab section requires team work, planning, and data sharing. 3 credit hour lecture per week.

Prerequisite:

- BMEG 2613
- PHYS 2074
- MATH 3404

Objectives:

- Solve analog and digital circuitry problems
- Perform as a team member or leader in the pursuit of creative solutions to biomedical engineering problems.
- Engage student interest in bioinstrumentation, and broaden their view of biomedical science and engineering to include emerging areas of translational biomedical science and encourage students to engage in designing biomedical devices
- Reinforce engineering science through exposure to emerging applications for more in-depth understanding of engineering principles and methods specific to biomedical point-of-care testing, detection, and diagnosis.

Outcome: After taking this course, students will be able to:

- Integrate electronic, circuits, life sciences and engineering in a biomedical design application
- Demonstrate an appreciation for ethics, intellectual property, entrepreneurship, licensing, society membership and other professional responsibilities
- Communicate findings to peers and clients in both technical and plain language

Textbook:

- Enderle, J., Blanchard and S., Bronzino, J. (3^{nd}) (2012) “Introduction to Biomedical Engineering”, Elsevier Academic Press, Oxford, UK. ISBN: 978-0-12-374979-6
- Webster, J.G. (2004) “Bioinstrumentation”, John Wiley and Sons, New York, ISBN: 0471-263273

Topics

1. Introduction
2. Basic bioinstrumentation systems
3. Charge current, voltage, resistance, power, and energy

4. Linear network analysis
5. Linearity and superposition
6. Thevenin's theorem
7. Inductors and capacitors
8. A general approach to solving circuits involving resistors, capacitors, and inductors
9. Discontinuities and initial conditions in a circuit
10. Operational amplifiers
11. Time-varying signals and active analog filters
12. Bioinstrumentation design
13. Biomedical sensors.
14. Biopotential measurements
    - 14.1. Electrolyte/metal electrode interface
    - 14.2. ECG electrodes
    - 14.3. EMG electrodes
    - 14.4. EEG electrodes
    - 14.5. Microelectrodes
    - 14.6. Nanoelectrodes
15. Physical measurements
    - 15.1. Displacement transducers
    - 15.2. Electromagnetic flow transducer
    - 15.3. Potentiometer transducers
    - 15.4. Elastic resistive transducers
    - 15.5. Strain gauge transducers
    - 15.6. Capacitive transducers
    - 15.7. Piezoelectric transducers
    - 15.8. Microelectromechanical system transducers
    - 15.9. Airflow transducers
    - 15.10. Temperature transducers
16. Bioanalytic sensors
    - 16.1. Enzyme-based sensors
    - 16.2. Microbial biosensors
    - 16.3. Optical sensors

<u>Contribution of course to meeting the requirements of the Professional Component:</u>

College level math and basic science	20%
Engineering Science	30%
Engineering design	50%
General education component	
Other (specify)	

<u>This course contributes to the ABET criteria in the following ways.</u>

ABET Criterion: student will be able to	**BMEG Contribution**
(a) Apply math, science, engineering	Use electronics, circuits, physics to analyze and determine living systems.
(b) Design, conduct experiments, analyze, interpret data	Mathematical modeling and computation
(c) Design system component, process to meet desired needs	Design biomedical devices
(d) Function on multidisciplinary teams	
(e) Identify, formulate and solve engineering problems	Students will solve real world problems in homework that will be problem solving based.
(f) Understand professional and ethical problems	
(g) Communicate effectively	Lab section requires team work, planning and data sharing
(h) Understand the impact of engineering on society and the world	Impacts of engineering on human health, modern health care system, rehabilitation, and sports medicine
(i) Recognize the need for and engage in life-long learning	
(j) Know contemporary issues	
(k) Use modern techniques, skills, and tools for engineering practice	Learn the principle of point-of-care testing

BENG 3653: Biomedical Modeling and Numerical Methods.

***Course Description*:** Application of mathematical techniques to physiological systems. The emphasis will be on cellular physiology and cardiovascular system. Cellular physiology topics include models of cellular metabolism, membrane dynamics, membrane potential, excitability, wave propagation and cellular function regulation. Cardiovascular system topics include models of blood cells, oxygen transport, cardiac output, cardiac regulation, and circulation. Lecture 3 hours per week.

Prerequisite:

- BMEG 2613
- MATH 2574
- MATH 3404

Course Objectives: Students will learn to

1. Apply engineering principles to solve physiological problems
2. Integrate human physiology with realistic mathematical models and their analysis.
3. Integrate principles of physiology, biology, biochemistry, mathematics and engineering.
4. Use Matlab.
5. Describe and analyze human body function at the organ and systems levels.

Outcome: After taking this course, students will be able to:

- Use and understand basic biomedical engineering modeling and numerical methods
- Identify potential career opportunities in biomedical engineering and medical fields
- Understand how engineering fundamentals can be applied toward real-world, complex problems involving medicine and human health
- Formulate and solve biomedical engineering problems using numerical approaches

Textbook:

- Keener, J. and J. Sneyd. Mathematical Physiology. Springer-Verlag. 1998. ISBN# 0-380-98381-3.
- Other materials including class notes, reference materials and book chapters.

Topics:

1. Introduction to biomedical engineering modeling and numerical methods
2. ODE, PDE, Soling DE with MatLab
3. Biochemical reaction
4. Diffusion models
5. Calcium dynamics (Ch 5), Project 1

6. Intercellular Communications or Calcium Waves
7. Regulation of Cellular Function
8. Cardiovascular System
9. Respiratory System

Contribution of course to meeting the requirements of the Professional Component:

College level math and basic science	40%
Engineering Science	10%
Engineering design	50%
General education component	
Other (specify)	

This course contributes to the ABET criteria in the following ways.

ABET Criterion: student will be able to	BMEG Contribution
(a) Apply math, science, engineering	Use cell biology, molecular biology, math, physics to analyze and determine living systems.
(b) Design, conduct experiments, analyze, interpret data	Mathematical modeling and computation
(c) Design system component, process to meet desired needs	
(d) Function on multidisciplinary teams	
(e) Identify, formulate and solve engineering problems	Students will solve real world problems in homework that will be problem solving based.
(f) Understand professional and ethical problems	
(g) Communicate effectively	
(h) Understand the impact of engineering on society and the world	Impacts of engineering on human health, modern health care system, rehabilitation, and sports medicine
(i) Recognize the need for and engage in life-long learning	
(j) Know contemporary issues	
(k) Use modern techniques, skills, and tools for engineering practice	

BMEG 3823 BIOMOLECULAR ENGINEERING

Course description: Biomolecular Engineering is to design and produce biomolecules, especially proteins, for uses ranging from pharmaceuticals, materials, sensors, transducers, to functional interfaces with conventional engineering materials. The course begins with an introduction to the tools and techniques of molecular biology that are used for protein engineering. Additional topics include recombinant DNA techniques, biochemical kinetics, cell growth reaction and kinetics, bioreactors, membrane processes, and bioproduct purification. There is an associated laboratory with exercises related to lecture topics. Lecture 3 hours and lab section 1 hour a week.

Prerequisites by topic:

- CHEM 1123
- BIOL 2533

Course objectives: This course introduces technologies for designing and engineering bioactive molecules for use in healthcare and disease treatment. The following objectives will be achieved through the course:

- Engage student interest in biomolecular engineering, and broaden their view of life science and engineering by including the emerging techniques used in designing and engineering biomolecules for improving human health and life quality
- Reinforce engineering and science through exposure to contemporary molecular biology techniques, methods, and instrumentations, as well as emerging nanotechnology for designing and engineering biomolecules
- Provide hands-on experience to encourage undergraduate research in biomolecular engineering

Outcome: By the end of the course, students should be able to:

- Understand basic principles and concepts of biomolecular engineering
- Design a bioprocess for producing biomolecules
- Formulate mathematical models and use these models to design and optimize bioprocesses for biomolecule production
- Identify potential career opportunities in biomocleular engineering, pharmaceutical engineering, and medical fields

Textbook

- Handouts (in the form of draft textbook by the instructor)

Topics Covered in Lecture Section

1. Introductions
2. Basic Concepts and Principles
    - 2.1. Background and scope
    - 2.2. Dimensions & units

2.3. Equilibria and rates
2.4. Batch v.s. continuous operation
2.5. Material balance
2.6. Energy balance

3. Biochemical Kinetics
   3.1. Fundamental Biochemical Reaction Kinetics
   3.2. Elementary biochemical reaction & equilibrium
   3.2. Temperature dependence of reaction rate constant
   3.3. First and second-order reaction rates
   3.4. Rates of enzyme reactions
   3.5. Kinetics of enzyme reactions
   3.6. Evaluation of kinetic parameters in enzyme reactions
   3.7. Inhibition and regulation of enzyme reactions
4. Recombinant Protein Engineering
   4.1. Fundamentals of recombinant DNA techniques
   4.2. Construction of DNA vectors for production of recombinant proteins
   4.3. Selection of hosts for efficient expression and production of recombinant proteins
   4.4. Development of humanized microbial organisms for production of pharmaceutical and therapeutic proteins.
   4.5. Recombinant DNA proteins for vaccine development
5. Cell Growth Reaction and Kinetics
   5.1. Cell growth kinetics in batch culture
   5.2. Cell growth kinetics in continuous culture
   5.3. Metabolic flux analysis for identifying factors affecting cell growth kinetics
   5.4. Modeling of cell growth reaction kinetics
   5.5. Population balances based on cell number
   5.6. Mass transfer
   5.7. Optimization of cell growth for recombinant protein production
6. Bioreactors
   6.1. Fundamental concepts
   6.2. Batch v.s. continuous operation
   6.3. Effects of mixing on cell growth and recombinant protein production in bioreactors
   6.4. The steady-state chemostat
   6.5. Chemodynamics
   6.6. Fed-batch operation
   6.7. Plug flow bioreactors
   6.8. Microbioreactors
   6.9. Disposable bioreactors
   6.10. Bioreactor modeling and design
   6.11. Scale-up and modeling of industrial process
7. Membrane processes and bioproduct purification
   7.1. Dialysis
   7.2. Ultrafiltrations
   7.3. Microfiltrations
   7.4. Reverse Osmosis
   7.5. Membrane modules
   7.6. Flat and Tubular membrane

Topics Covered in Laboratory Session

Exp 1. General aspects of DNA isolation and purification

Exp 2. Kinetics of receptor-ligand binding
Exp 3. Kinetics of enzyme reaction
Exp 4. Preparation of genomic DNA from bacteria
Exp 5. Isolation of plasmid DNA
Exp 6. Agarose gel electrophoresis of DNA
Exp 7. DNA cloning-general consideration
Exp 8. DNA cloning-experimental procedures
Exp 9. PCR analysis
Exp 10. DNA sequencing
Exp 11. Isolation and purification of RNA
Exp 12. Cell growth kinetics
Exp 13. Metabolism of animal cell culture
Exp 14. Production of proteins
Exp. 15. Protein purification, dialysis, and quantification

Contribution of course to meeting the requirements of the Professional Component:

College level math and basic science	40%
Engineering Science	50%
Engineering design	10%
General education component	
Other (specify)	

This course contributes to the ABET criteria in the following ways.

ABET Criterion: student will be able to	BMEG Contribution
(a) Apply math, science, engineering	Use cell molecular biology, recombinant DNA technique, protein engineering, biochemical engineering principles and techniques, math, physics, statics, and thermodynamics to analyze and design bioprocesses for biomolecule production.
(b) Design, conduct experiments, analyze, interpret data	Hands-on training in enzyme reaction, recombinant DNA techniques, protein engineering techniques, bioreactor design, etc; Analyze data collected from experiments Modeling and optimizing bioprocesses for biomolecule production
(c) Design system component, process to meet desired needs	Hands-on training in experimental design and data analysis.
(d) Function on multidisciplinary teams	
(e) Identify, formulate and solve engineering problems	Students will solve real world problems in homework that will be problem solving based.
(f) Understand professional and ethical problems	
(g) Communicate effectively	A written report is required for every experiment performed by students.

(h) Understand the impact of engineering on society and the world	Impacts of engineering on human health and the improvement of life quality will be discussed during class.
(i) Recognize the need for and engage in life-long learning	
(j) Know contemporary issues	Exposure to emerging biomolecular engineering techniques and experimental approaches.
(k) Use modern techniques, skills, and tools for engineering practice	Exposure to modern life science equipment in lab section.

BMEG 3811L BIOMOLECULAR ENGINEERING Lab

Course Description: Biomolecular Engineering is to design and produce biomolecules, especially proteins, for uses ranging from pharmaceuticals, materials, sensors, transducers, to functional interfaces with conventional engineering materials. The course begins with an introduction to the tools and techniques of molecular biology that are used for protein engineering. Additional topics include recombinant DNA techniques, biochemical kinetics, cell growth reaction and kinetics, bioreactors, membrane processes, and bioproduct purification. There is an associated laboratory with exercises related to lecture topics. Lecture 3 hours and lab section 1 hour a week.

Prerequisites by topic:
- CHEM 1123
- BIOL 2533

Course objectives: This course introduces technologies for designing and engineering bioactive molecules for use in healthcare and disease treatment. The following objectives will be achieved through the course:
- Engage student interest in biomolecular engineering, and broaden their view of life science and engineering by including the emerging techniques used in designing and engineering biomolecules for improving human health and life quality
- Reinforce engineering and science through exposure to contemporary molecular biology techniques, methods, and instrumentations, as well as emerging nanotechnology for designing and engineering biomolecules
- Provide hands-on experience to encourage undergraduate research in biomolecular engineering

Outcome: By the end of the course, students should be able to:
- Understand basic principles and concepts of biomolecular engineering
- Design a bioprocess for producing biomolecules
- Formulate mathematical models and use these models to design and optimize bioprocesses for biomolecule production
- Identify potential career opportunities in biomocleular engineering, pharmaceutical engineering, and medical fields

Textbook
- Freshney, R. I. (2000) “Culture of Animal Cells, A Manual of Basic Technique” John Wiley and Sons, New York, ISBN: 0-471-34889-9
- Handouts (in the form of draft textbook by the instructor)

Topics Covered in Laboratory Session

Exp 1. General aspects of DNA isolation and purification
Exp 2. Kinetics of receptor-ligand binding
Exp 3. Kinetics of enzyme reaction
Exp 4. Preparation of genomic DNA from bacteria
Exp 5. Isolation of plasmid DNA

Exp 6. Agarose gel electrophoresis of DNA
Exp 7. DNA cloning-general consideration
Exp 8. DNA cloning-experimental procedures
Exp 9. PCR analysis
Exp 10. DNA sequencing
Exp 11. Isolation and purification of RNA
Exp 12. Cell growth kinetics
Exp 13. Metabolism of animal cell culture
Exp 14. Production of proteins
Exp. 15. Protein purification, dialysis, and quantification

Contribution of course to meeting the requirements of the Professional Component:

College level math and basic science	40%
Engineering Science	50%
Engineering design	10%
General education component	
Other (specify)	

This course contributes to the ABET criteria in the following ways.

ABET Criterion: student will be able to	BMEG Contribution
(a) Apply math, science, engineering	Use cell molecular biology, recombinant DNA technique, protein engineering, biochemical engineering principles and techniques, math, physics, statics, and thermodynamics to analyze and design bioprocesses for biomolecule production.
(b) Design, conduct experiments, analyze, interpret data	Hands-on training in enzyme reaction, recombinant DNA techniques, protein engineering techniques, bioreactor design, etc; Analyze data collected from experiments Modeling and optimizing bioprocesses for biomolecule production
(c) Design system component, process to meet desired needs	Hands-on training in experimental design and data analysis.
(d) Function on multidisciplinary teams	
(e) Identify, formulate and solve engineering problems	Students will solve real world problems in homework that will be problem solving based.
(f) Understand professional and ethical problems	
(g) Communicate effectively	A written report is required for every experiment performed by students.
(h) Understand the impact of engineering on society and the world	Impacts of engineering on human health and the improvement of life quality will be discussed during class.
(i) Recognize the need for and engage	

in life-long learning	
(j) Know contemporary issues	Exposure to emerging biomolecular engineering techniques and experimental approaches.
(k) Use modern techniques, skills, and tools for engineering practice	Exposure to modern life science equipment in lab section.

BMEG 4243: Advanced Biomaterials and Biocompatibility

Course Description: **Advanced Biomaterials and Biocompatibility (Sp)** From Absorbable sutures to Zirconium alloy hip implants, biomaterials science influences nearly every aspect of medicine. This course focuses on the study of different classes of biomaterials and their interactions with human tissues. Topics include: biocompatibility; biofouling; hemocompatibility; wound healing response; foreign body response; design of orthopedic, dental and cardiovascular implants; opthalmological and dermatological materials; degradable polymers for drug delivery; nanobiomaterials; smart biomaterials and the regulation of devices and materials by the FDA. Prerequisite: BMEG 2633, Pre- or Corequisite: BMEG 4623

Objectives

- To demonstrate the importance of biocompatibility in the performance of biomedical devices
- To integrate engineering and life sciences
- To contextualize coursework with clinical needs
- To review and analyze recent developments in biomaterials via independent literature research

Outcomes: After taking this course, students will be able to:

- Explain the concept of biocompatibility
- Identify failure mechanisms for common biomedical devices
- Explain the critical aspects of biomaterial design
- Explain methods of surface modification to improve biocompatibility of biomedical devices
- Identify critical biocompatibility limits for biomedical devices
- Explain how biomaterials are regulated by the FDA

Text:

- Biomaterials Science, by Ratner, Hoffman, Schoen, and Lemons. Third Edition, Academic Press, 2011.

Topics

- Course introduction; definitions; project orientation
- Metals, Polymers Ceramics Review; Nanobiomaterials
- Bioinspired and biomimetics materials
- Wound Healing Response; Coagulation and Protein adsorption
- Foreign Body Response
- Device related infections and surface treatments
- Immuno-engineering of biomaterials
- Biocompatibility of tissue-contacting devices
- Biocompatibility of blood-contacting devices
- Othopedic device design; Dental device design
- Opthalmological Device design; Artificial Blood

- Wound closure devices; Biosensor design
- Student Presentations
- Student Presentations
- Drug Delivery
- FDA regulation

<u>Contribution of course to meeting the requirements of the Professional Component:</u>

College level math and basic science	
Engineering Science	33%
Engineering design	67%
General education component	
Other (specify)	

<u>This course contributes to the ABET criteria in the following ways.</u>

ABET Criterion: student will be able to	**BMEG Contribution**
(c) Design system component, process to meet desired needs	In a semester long design project, students identify the failure mechanism of a current biomedical device, propose a redesign involving an existing or novel biomaterial and fabricate/generate relevant data to evaluate engineering properties and biocompatibility characteristics as appropriate.
(e) Identify, formulate and solve engineering problems	Students use knowledge of engineering properties to identify and overcome device failure due to biomaterials.
(g) Communicate effectively	Written and oral presentation skills are evaluated in multiple formats: formal literature review; NIH/NSF-style specific aims proposal; oral white paper proposal; formal manuscript; oral conference-style presentation.
(h) Understand the impact of engineering on society and the world	Students learn about the growing impact of biomaterials in enhancing the performance of countless life-sustaining and life-improving devices.
(i) Recognize the need for and engage in life-long learning	Students review current literature using PubMed and other databases for a semester long design project.
(j) Know contemporary issues	Students understand the influence of modern economics and clinical needs on biomaterials selection.

BMEG 4413 TISSUE ENGINEERING

Course Description: This course introduces Tissue Engineering approaches at genetic and molecular, cellular, tissue, and organ levels. Topics include cell and tissue in vitro expansion, tissue organization, signaling molecules, stem cell and stem cell differentiation, organ regeneration, biomaterial and matrix for tissue engineering, bioreactor design for cell and tissue culture, dynamic and transportation in cell and tissue cultures, clinical implementation of tissue engineered products, and tissue-engineered devices. Lecture 2 hours, lab 3 hours per week.

Prerequisite:
- BIOL 2533
- BMEG 3823

Objective:
- Provide students with in-depth training in tissue engineering and broaden their view of regenerative medicine, especially stem cell-based therapies
- Reinforce engineering concepts in medical applications
- Encourage students to pursue biomedical research

Outcome: After completing this course, students should be able to:
- understand basic principles of tissue engineering and organ regenerative medicine
- formulate and solve biomedical engineering problems using tissue engineering design processes
- design and fabricate tissue engineered products
- identify potential career opportunities in biomedical engineering
- master skills for life-long learning in biomedical engineering

Textbook:
- Ulrich Meyer et al. (2009) Fundamentals of Tissue Engineering and Regenerative Medicine, Springer, Germany.
- Freshney, R.I. (2000) Culture of Animal Cells, (4th ed.) Wiley-Liss, Inc. ISBN: 0-471-34889-9
- Handouts (In the form of draft textbook prepared by the Instructor)

Topics Covered
- Introduction to tissue engineering
- Ethical issues of Tissue Engineering (TE)
- Organogenesis
- TE at genetic and molecular level I: genetically designed tissues for regenerative medicine
- TE at genetic and molecular level II: posttranscriptional gene silencing, signaling molecules, and kinetics of molecular interaction
- Tissue remodeling and regeneration I: Fetal stem cell, embryonic stem cell, and adult stem cell
- Tissue remodeling and regeneration II: Mathematical modeling for stem cell proliferation and apoptosis
- Bioreactor design for cell and tissue culture

- Biophysical stimulation, dynamic and transportation, microenvironmental determinants in bioreactor
- Design of tissue engineered devices: artificial skin, heart valves, artificial liver, and artificial pancreas
- Biomaterial in TE: scaffold design, cell-biomaterial interaction, and matrix effects
- TE at tissue level: Bone engineering, Cartilage engineering, Neural TE

Topics Covered in Laboratory Session:

- Introduction to Tissue Culture-1: Design and layout of tissue culture room, Biosafety and risk assessment
- Introduction to Tissue Culture-2: Preparation, sterilization, and aseptic techniques
- Introduction to equipment required for tissue culture: Basic cell culture techniques: Cell counting and medium preparation
- Aseptic Techniques and safety: Recover cells from their nitrogen stocks
- Culture Vessels and Media: Cell proliferation, passage, and cryopreservation
- Cell lines: Cell counting by hemocytometer and live cell microscopy
- Cloning-1: Gene transfection and detection of green fluorescent protein expression in transduced cells
- Cloning-2: Isolation of gene transduced colonies
- Preparation of primary cells-bone marrow stem cells: Preparation of hematopoietic stem cells
- Cell separation: Separate cells by density gradient
- Cell separation: Immunostaining and flow cytometric analysis
- Gene delivery-1: Preparation of retrovirus vectors for gene delivery
- Gene delivery-2: Virus infection and gene delivery
- Differentiation of stem cells: *In vitro* stimulation of stem cell differentiation and forming of colonies under control of stem cell growth factors
- Contamination: Detection of mycoplasma in the contaminated cell cultures

Contribution of course to meeting the requirements of the Professional Component:

College level math and basic science	10%
Engineering science	60%
Engineering design	30%
General education component	
Other (specify)	

This course contributes to the ABET criteria in the following ways:

ABET Criterion: student will be able to	Course Contribution
(a) Apply math, science, engineering	**Accomplishment:** Use physics, fluid mechanics, statics, and dynamics to analyze and design tissue engineered products.
(b) Design, conduct experiments, analyze, interpret data	**Accomplishment:** Design bioreactors and scaffolds for tissue engineering; analyze data collected from lab practice and prepare lab report.
(c) Design system component, process to meet desired needs	.
(d) Function on multidisciplinary teams	**Accomplishment:** Perform experiments involving team work.
(e) Identify, formulate and solve engineering problems	**Accomplishment:** Students solve engineering problems in homework that is problem solving based. Assignments are given to students to train them to identify and solve biomedical engineering problems.
(f) Understand professional and ethical problems	
(g) Communicate effectively	
(h) Understand the impact of engineering on society and the world	**Accomplishment:** Impacts of engineering on human health and modern health care system.
(i) Recognize the need for and engage in life-long learning	
(j) Know contemporary issues	**Accomplishment:** Students learn latest achievement in health care, experimental medicine, stem cell research, and new treatment for curing diseases.
(k) Use modern techniques, skills, and tools for engineering practice	

BMEG 4623: Biomedical Transport Phenomena

Course Description: An introduction to the modeling of complex biological systems using principles of transport phenomena and biochemical kinetics. This course will cover molecular transport due to velocity, concentration and thermal gradients. Topics include the conservation relations; rheology of Newtonian and non-Newtonian physiological fluids; regulation of blood flow; steady and transient diffusion in reacting systems; dimensional analysis; transport in biological tissues and transport processes in disease pathology.

Prerequisites by topic:

- MATH 3404
- CHEG 2133 or similar
- CHEG 2313 or similar
- BMEG 3653

Objectives

- To model mass and energy transport processes relative to human biology
- To distinguish Newtonian and non-Newtonian biological fluids
- To identify pathways for biological transport
- To appreciate dimensional analysis in simplifying transport problems
- To apply classical transport equations to human physiological systems

Outcomes: After taking this course, students will be able to:

- Identify, formulate and solve steady and unsteady one-dimensional diffusion problems
- Understand and explain the interaction between diffusion and biochemical reactions
- Determine relative importance of convection, diffusion, or chemical reaction in biological mass transport processes.
- Identify relevant dimensionless parameters in transport phenomena
- Use Matlab to solve complex problems and interpret results.

Textbook:

- Transport Phenomena in Biological Systems, by Truskey, Yuan and Katz, Second Edition, Pearson, 2009.
- Fundamentals of Heat and Mass Transfer, by Incropera, DeWitt, Bergman and Levine, Sixth Edition, Wiley, 2006.

Topics covered

1. Transport in physiological systems; conservation of mass
2. Conservation of momentum; Viscosity; Blood Rheology
3. Regulation of Blood Flow; Navier-Stokes Equations
4. Dimensional Analysis; Low Reynolds number flow; Pressure drop across heart valves
5. Stokes Law; Settling and centrifugation of cells and biologics;
6. Diffusion flux and conservation relations; Constitutive equations; molecular basis of diffusion

7 Estimation of Diffusion Coefficients in Solution; Steady 1-D Diffusion
8 Unsteady 1-D diffusion; Diffusion in cells; diffusion with binding
9 Steady-state diffusion w/convection; Mass transport equations;
10 Mass transfer coefficients; hemodialysis design; Transport in porous tissue
11 Reactions and Kinetics; Receptor-ligand interactions;
12 Diffusion w/chemical reaction; Oxygen Transport;
13 Conservation of Energy; Fick's Law; Heat Equation
14 Steady 1-D and 2-D conduction
15 Unsteady conduction; heat transfer with phase change: evaporation of sweat
16 Metabolism and Regulation of body temperature; cryopreservation

Contribution of course to meeting the requirements of the Professional Component:

College level math and basic science	
Engineering Science	100%
Engineering design	

Contribution of course to meeting the requirements of the Professional Component:

ABET Educational Outcome	How students are prepared to attain the outcome
(a) Apply math, science, engineering	Students use math (ordinary and partial differential equations), science and engineering properties to solve mass and energy transport problems.
(b) Design, conduct experiments, analyze, interpret data	
(c) Design system component, process to meet desired needs	
(d) Function on multidisciplinary teams	
(e) Identify, formulate and solve engineering problems	Students set-up and solve open-ended, steady and unsteady, 1-dimensional and 2-dimensional transport problems.
(f) Understand professional and ethical problems	
(g) Communicate effectively	Homework assignments and exams require accurate and concise written solutions to complex, open-ended problems
(h) Understand the impact of engineering on society and the world	Students understand how mass transport calculations influence pharmaceutical formulations, laboratory and medical procedures.
(i) Recognize the need for and engage in life-long learning	
(j) Know contemporary issues	
(k) Use modern techniques, skills, and tools for engineering practice	Students apply numerical methods to solve complex equations. Students use Matlab and Excel to solve homework problems and interpret results.

BMEG 4743: Drug and Gene Delivery

Course Description: An advanced course covering important issues in drug and gene delivery in tumor and normal tissues. The course emphasizes quantitative analysis of molecule and nanoparticle transport through mathematical modeling and computer simulation. Various engineering-related topics on drug and gene delivery are discussed. These topics include physiologically-based pharmacokinetic analysis, transvascular transport, interstitial transport, transport across cell membrane, drug and gene carriers, targeted delivery of drugs, oxygen transport, delivery of effector cells and genes.

Pre or co requisites

- BMEG 4623

Objectives

- To familiarize students with pharmacological mechanisms at the molecular, cell, tissue and systems level
- To demonstrate the influence of delivery systems on spatiotemporal drug distribution
- To appreciate the need for multiple routes of administration and delivery platforms

Outcomes: After taking this course, students will be able to:

- Apply mathematical models to study drug absorption, distribution, metabolism and excretion
- Rationally design a delivery system for a clinical indication
- Evaluate the advantages/disadvantages of current delivery systems
- Understand the barriers to gene delivery and current methods to overcome them

Textbook:

- TBD

Topics covered

1. Definitions; Biologicals vs. Pharmaceuticals
2. Pharmacokinetics/Pharmacodynamics
3. One-compartment models; Two-compartment models
4. Transmembrane transport; Multidrug Resistance
5. Transvascular Transport; Interstitial Transport
6. Passive Targeting; Active targeting
7. Interstitial hypertension; Controlled release
8. Triggered Release; Interstitial Transport
9. Delivery of effector cells; prodrug delivery
10. Transdermal drug delivery; Pulmonary drug delivery
11. Opthalmic drug delivery; renal clearance
12. Transport in the reproductive system; targeted drug delivery
13. Liposomes and polymeric drug delivery
14. **Project Presentations**

15 Barriers to gene delivery; viral/non-viral gene delivery
16 Vaccination and immunotherapy delivery

Class / Laboratory schedule:
Current format is three 50 minute sessions per week (3 semester credit hours)

Contribution of course to meeting the requirements of the Professional Component:

College level math and basic science	33%
Engineering Science	33%
Engineering design	34%

Contribution of course to meeting the requirements of the Professional Component:

ABET Educational Outcome	How students are prepared to attain the outcome
(a) Apply math, science, engineering	Students use math, chemistry and engineering to model delivery of drugs within and between compartments.
(b) Design, conduct experiments, analyze, interpret data	Students develop a mathematical simulation to analyze the effects of different parameters on spatiotemporal drug distribution.
(c) Design system component, process to meet desired needs	A design project requires teams of students to develop a Matlab model to optimize a drug delivery platform for a given clinical indication.
(d) Function on multidisciplinary teams	Students work in teams to complete design project. Most students are within the BMEG program however they self-distribute into different disciplinary tasks, i.e. literature review, modeling, programming, writing, etc.
(e) Identify, formulate and solve engineering problems	In the design project and homework assignments, student will solve open-ended problems germane to the biopharmaceutical field
(f) Understand professional and ethical problems	Lectures primarily focus on issues of professionalism and include: project management, business conduct, research ethics, intellectual property, professional licensing and society membership.
(g) Communicate effectively	Students present the results of a design project with both written and oral components. Homework assignments and exams require accurate and concise written solutions to complex, open-ended problems.
(h) Understand the impact of engineering on society and the world	
(i) Recognize the need for and engage in life-long learning	
(j) Know contemporary issues	Students evaluate and debate the strengths and weaknesses of contemporary drug and gene delivery platforms.
(k) Use modern techniques, skills, and tools for engineering practice	Students apply numerical methods to solve complex equations. Students use Matlab and Excel to solve homework problems and interpret results.

BMEG 4813: Biomedical Engineering Design I

Course Description: First semester of a two semester capstone biomedical engineering design class covered from the perspective of FDA design mandates. Students will design and prototype a medical device using Food and Drug Administration (FDA) requirements for Design Control. The course is designed as a partnership between end users (clinicians and patients) and student engineering teams. The users supply the ideas and clinical relevancy while the student teams develop requirements, build prototypes and conduct testing. The course is designed to mirror the FDA regulated product design approach that is taken by industry thereby exposing students to current best practices. All projects will be planned, managed and executed using FDA Design Control Requirements. To accomplish this, projects will utilize customer driven inputs to motivate the development of product specifications. Prototypes will be fabricated based on these specifications. The prototypes will be tested and evaluated to ensure the specifications are met. All projects will be implemented using a planned, multidisciplinary, ethics-based team approach.

Objective:

- Students will design and prototype a medical device using FDA requirements for Design Control.
- Students will formulate project ideas by interacting with potential customers (clinicians and patients).
- Students will assemble into multidisciplinary teams.
- Students will create a project plan and implement their design project based on this plan.
- Students will present their design work in written form by means of team reports and the Design History File.
- Students will present their design work in oral form by means of Design Reviews.
- Students will explore and analyze projects for ethical issues and potential solutions will be proposed.

Outcome: After taking this course, students will be able to:

- Explain and describe Design Control within the overall structure of FDA-QSR (Quality System Requirements) and other international regulatory requirements.
- Explain tools and concepts of design management including how to deal with people of different backgrounds (engineers, physicians, and patients).
- Apply the QSR design process including appropriate written documentation and oral presentations.
- Identify engineering constraints and considerations including economic, environmental, sustainability, manufacturability, health, safety, social, and political.
- Students will be able to identify the elements of QSR project planning and
- implementation that are important to all design projects (medical and non-medical).

Prerequisites by topic:

- BMEG Major Status

Textbook:

- Design Controls for the Medical Device Industry, Marie B. Teixeira and Richard Bradley, Marcel Decker, Inc. 2002. ISBN:0-8247-0830-X
- FDA 21CFR820: Title 21--Food and Drugs, Subchapter H - Medical Devices, Part 820 Quality System Regulation (available on the web)

Topics covered:

- Food and Drug Administration (FDA)
- FDA Quality System Regulation and Design Control
- Determining customer needs
- Translating customer needs into design requirements and product specifications
- Safety and Reliability
- Materials Selection and Biocompatibility Testing
- Sketching and Solid Modeling
- Patents and Intellectual Property
- Designing medical devices for third world applications

Class / Laboratory schedule:
Lecture: 2 hours and Lab: 3 hours.

Contribution of course to meeting the requirements of the Professional Component:

College level math and basic science	
Engineering science	
Engineering design	3 hr. Application of concepts and techniques as related to the design or manufacture of biomedical devices
General education component	
Other (specify)	

Contribution of course to meeting the requirements of the Professional Component:

ABET Educational Outcome	How students are prepared to attain the outcome
(a) Apply math, science, engineering	Course exercises will draw upon prerequisite content
(b) Design, conduct experiments, analyze, interpret data	
(c) Design system component, process to meet desired needs	Students will solve open-ended problems by choosing a particular product and develop a scheme to produce the device (device is used as a generic term)
(d) Function on multidisciplinary teams	Each student will bring their own unique perspective and talents to team-based project(s)
(e) Identify, formulate and solve engineering problems	Product design concepts will be discussed during class
(f) Understand professional and ethical problems	

(g) Communicate effectively	Students will prepare oral and written accountings of their work
(h) Understand the impact of engineering on society and the world	
(i) Recognize the need for and engage in life-long learning	Understanding up to date laws and requirements for medical products
(j) Know contemporary issues	
(k) Use modern techniques, skills, and tools for engineering practice	

BMEG 4873: Bionanotechnology

Course Description: This is an introductory course relevant to bionanotechnology. The topics covered in this course include nanobiomaterials, nanoparticles, nanowires, nanobiochips, nanobiosensors, and nanobiodevides. The applications of these nanomaterials and devices in clinical diagnostics, disease treatment, point-of-care test and/or point-of-care diagnostics, tele-medical cares, controlled and targeted drug delivery, etc. will be particularly emphasized in the lecture. Lecture 3 hours a week.

Prerequisites by topic:

- BMEG 3823/BMEG 3811L
- BMEG 2813
- CHEG 2133

Course objectives: The objective of this course is to teach the basic principles of fabrication, characterization, and utilization of biologically-derived materials ordered at the nanoscale. The following objectives will be achieved through the course:

- Engage student interest in nanobiotechnology, and broaden their view of material science and engineering by illustrating their applications in modern medicine
- Reinforce engineering and science through exposure to contemporary nanomaterial fabrication and nano-scale bioproducts and medical devices
- Encourage undergraduate research in nanomedicine

Outcome: By the end of the course, students should be able to:

- Understand basic principles and concepts of nanobiomaterial science and engineering
- Master techniques and skills required for designing and fabricating nanobioproducts, nano-therapeutic products, and nano-scale medical devices
- Identify potential career opportunities in nanomedicine and nanobioproduct development fields

Textbook

- Goodsell, D.S. (2004) BioNanotechnology, Wiley-Liss, Inc. ISSN 0-471-41719-X

Topics Covered

1. Technologies for visualization of biological structure at nanoscale
2. Nanoparticles
3. Nanoshells, carbon nanotubes, nanowires
4. Nanomaterials for biolabeling
5. Applications of nanotechnology in life sciences
6. Nanomolecular diagnoses
7. Nanobiosensors
8. Pharmaceutical applications of nanodiagnostics

9. Clinical applications of nanodiagnostics
10. Nanotechnology for controlled and targeted drug delivery
11. Nanotechnology for telemedicines
12. Nanotechnology for point-of-care test/point-of-care diagnosis

Contribution of course to meeting the requirements of the Professional Component:

College level math and basic science	10%
Engineering Science	60%
Engineering design	30%

This course contributes to the ABET criteria in the following ways.

ABET Criterion: student will be able to	BEMG Contribution
(a) Apply math, science, engineering	
(b) Design, conduct experiments, analyze, interpret data	Fabrication and synthesis of nanostructured biomaterials
(c) Design system component, process to meet desired needs	Design nano-scale scaffolds, drug delivery systems, biosensors, and smart biomedical devices for biomedical application.
(d) Function on multidisciplinary teams	
(e) Identify, formulate and solve engineering problems	
(f) Understand professional and ethical problems	Students are required to write an essay about the potential environmental impact of nanomaterials.
(g) Communicate effectively	
(h) Understand the impact of engineering on society and the world	The application of nanomaterials in development of new therapies is particularly emphasized in this class.
(i) Recognize the need for and engage in life-long learning	
(j) Know contemporary issues	Students are informed with emerging nanotechnologies.
(k) Use modern techniques, skills, and tools for engineering practice	Exposure to nanomaterial synthesis and characterization, and nanobioproduct development; exposure to modern instruments for characterization of nanomaterials such as TEM, SEM, and AFM.

BMEG 4923: Biomedical Engineering Design II

Course Description: Continuation of BMEG 4813. Initial designs will be prototyped before going through a design review. Design verification issues and improvements will then be solved in a redesign phase following a design process based on Food and Drug Administration Quality System Regulation (FDA-QSR). Projects will be team oriented and lead to increased project management skills. In addition, discussions on design considerations will continue. A final written design document and an oral presentation of the working prototype will culminate the class.

Objective:

- Students will design and prototype a medical device using FDA requirements for Design Control.
- Students will formulate project ideas by interacting with potential customers (clinicians and patients).
- Students will assemble into multidisciplinary teams.
- Students will create a project plan and implement their design project based on this plan.
- Students will present their design work in written form by means of team reports and the Design History File.
- Students will present their design work in oral form by means of Design Reviews.
- Students will explore and analyze projects for ethical issues and potential solutions will be proposed.

Outcome: After taking this course, students will be able to:

- Explain and describe Design Control within the overall structure of FDA-QSR (Quality System Requirements) and other international regulatory requirements.
- Explain tools and concepts of design management including how to deal with people of different backgrounds (engineers, physicians, and patients).
- Apply the QSR design process including appropriate written documentation and oral presentations.
- Identify engineering constraints and considerations including economic, environmental, sustainability, manufacturability, health, safety, social, and political.
- Students will be able to identify the elements of QSR project planning and implementation that are important to all design projects (medical and non-medical).

Prerequisites by topic:

- BMEG 4813

Textbook:

- Design Controls for the Medical Device Industry, Marie B. Teixeira and Richard Bradley, Marcel Decker, Inc. 2002. ISBN:0-8247-0830-X
- FDA 21CFR820: Title 21--Food and Drugs, Subchapter H - Medical Devices, Part 820 Quality System Regulation (available on the web)

Topics covered:

- FDA Quality System Regulation and Design Control
- Prototyping

- Packaging and Labeling
- Design for Manufacture and Assembly
- Design of mechanical, optical, and electrical systems
- Clinical Trials
- Ethics and Ethical Design
- Effective oral and written presentation skills

Class / Laboratory schedule:

- Lecture: 1 hour and Lab: 3 hours + 3 hours arranged.

Contribution of course to meeting the requirements of the Professional Component:

College level math and basic science	
Engineering science	
Engineering design	3 hr. Application of concepts and techniques as related to the design or manufacture of biomedical devices
General education component	
Other (specify)	

Contribution of course to meeting the requirements of the Professional Component:

ABET Educational Outcome	How students are prepared to attain the outcome
(a) Apply math, science, engineering	Course exercises will draw upon prerequisite content
(b) Design, conduct experiments, analyze, interpret data	
(c) Design system component, process to meet desired needs	Students will solve open-ended problems by choosing a particular product and develop a scheme to produce the device (device is used as a generic term)
(d) Function on multidisciplinary teams	Each student will bring their own unique perspective and talents to team-based project(s)
(e) Identify, formulate and solve engineering problems	Product design concepts will be discussed during class
(f) Understand professional and ethical problems	
(g) Communicate effectively	Students will prepare oral and written accountings of their work
(h) Understand the impact of engineering on society and the world	
(i) Recognize the need for and engage in life-long learning	Understanding up to date laws and requirements for medical products
(j) Know contemporary issues	
(k) Use modern techniques, skills, and tools for engineering practice	

BMEG 4973 Advanced Tissue Engineering and Regenerative Medicine

Course Description: This is an advanced course focusing on tissue engineering and regenerative medicine. Topics include stem cell tissue engineering, cell signaling, transport and kinetics, biomaterials and scaffolds, surface interactions, viral and nonviral-based gene delivery, tissue engineered organs, organ transplantation, nanomedicine, cell replacement therapy, and organ regenerative therapy. Technologies used to grow clinical relevant cells and tissues in lab will also be discussed in this course. Lecture 3 hours a week.

Prerequisites by topic:

- BMEG 4413
- BIOL 2533
- BMEG 3823/BMEG 3811L
- BMEG 2813

Objectives:

- Engage student interest in Tissue and Organ Engineering, and broaden their view of Tissue and Organ Engineering and Science to include emerging areas of stem cell engineering, organ regenerative medicine, medical imaging, and biomedical nanotechnology;
- Provide students with specific skills required in biomedical industry, including tissue engineering process design and organ regeneration approaches;
- Reinforce engineering science through exposure to emerging applications for more in-depth understanding of engineering methods specific to tissue engineering;
- Encourage undergraduate research in biomedical engineering.

Outcome: After taking this course, students will be able to:

- Use and understand basic tissue engineering technologies;
- Identify potential career opportunities in the biomedical engineering and medical fields for further study;
- Understand how engineering fundamentals can be applied toward real-world, complex problems involving medicine and human health;
- Formulate and solve biomedical engineering problems using the tissue engineering design process.

Textbooks

1. Liu, S.Q. (2007) "Bioregenerative Engineering Principles and Applications", John Wiley & Sons, Inc. ISBN978-0-471-70907-7
2. Handouts (in the form of draft textbook by the instructor)

Topics covered

1. Objective of Tissue Engineering & Elements of Tissue Development
2. Cell signaling pathways and mechanisms
3. Functional cellular function and developmental aspects of tissue and organ engineering
4. Embryonic organ development
5. Adult cells, tissues, and organ regeneration

6. Molecular aspects of tissue and organ engineering
7. Biomaterial aspects of tissue and organ engineering
8. Application of tissue and organ engineering
9. Nerve regenerative engineering
10. Cardiac regenerative engineering
11. Vascular regenerative engineering
12. Pulmonary regenerative engineering
13. Liver regenerative engineering
14. Gastrointestinal regenerative engineering
15. Pancreatic regenerative engineering
16. Urinary regenerative engineering
17. Skeletal muscle regenerative engineering
18. Bone and cartilage regenerative engineering
19. Ocular regenerative engineering
20. Skin regenerative engineering
21. Regenerative medicine for cancer treatment
22. Prostheses and artificial organs

Contribution of course to meeting the requirements of the Professional Component:

College level math and basic science	30
Engineering science	50
Engineering design	20
General education component	
Other (specify)	

This course contributes to the ABET criteria in the following ways.

ABET Criterion: student will be able to	BMEG Contribution
(a) Apply math, science, engineering	Use cell molecular biology, material science, math, physics, fluid mechanics, statics, dynamics, and thermodynamics to analyze and design therapeutic products for cell replacement therapy and tissue repair and regeneration.
(b) Design, conduct experiments, analyze, interpret data	
(c) Design system component, process to meet desired needs	
(d) Function on multidisciplinary teams	
(e) Identify, formulate and solve engineering problems	
(f) Understand professional and ethical problems	Ethical concerns over the use of embryonic stem cells for tissue repair and regeneration, biosafety concerns of gene and cell replacement therapy are discussed

	during class.
(g) Communicate effectively	
(h) Understand the impact of engineering on society and the world	Impacts of tissue engineering on disease treatment, human health, and modern health care system.
(i) Recognize the need for and engage in life-long learning	
(j) Know contemporary issues	Human embryonic and induced stem cells for cell replacement therapy, gene therapy, nanomaterials for three-dimensional tissue and organ generation, and mechanical biology.
(k) Use modern techniques, skills, and tools for engineering practice	

8. **FACULTY**

List the names and credentials of all faculty teaching courses in the proposed program. **(For associate and above: A minimum of one full-time faculty member with appropriate credentials is required.)**

1. Dr. Kaiming Ye, Associate Professor
2. Dr. David Zaharoff, Assistant Professor
3. Dr. Sha Jin, Assistant Professor
4. Dr. Robert Beitle, Professor
5. Dr. Ashok Saxena, Distinguished Professor
6. Dr. Magda El-Shenawee, Professor
7. Dr. Jin-Woo Kim, Professor
8. Dr. Christa Hestekin, Assistant Professor
9. Dr. Shannon Servoss, Assistant Professor
10. Dr. Ranil Wickramasinghe, Professor
11. Dr. Lalit Verma, Professor
12. Dr. Julie Carrier, Professor
13. Dr. Vasundara Varadan, Distinguished Professor
14. Dr. Vijay K. Varadan, Distinguished Professor
15. Dr. Simon Ang, Professor
16. Dr. Steve Tung, Associate Professor
17. Dr. Russell Deaton
18. Dr. Uche Wejinya
19. Dr. Ron Rardin, Distinguished Professor
20. Dr. Keith Roper, Associate Professor

Total number of faculty required (number of existing faculty, number of new faculty).

In the fall of 2012, the proposed Department of Biomedical Engineering is expected to have five full-time faculty members. They will consist of three existing faculty and two that we are currently recruiting as follows:

1. Dr. Kaiming Ye, Associate Professor
2. Dr. David Zaharoff, Assistant Professor
3. Dr. Sha Jin, Assistant Professor
4. A PhD in Biomedical Engineering or a related discipline to start in the fall of 2011
5. A PhD in Biomedical Engineering or related discipline to start in the fall of 2012

In addition to the above five faculty, we expect 10 to 12 other faculty from the earlier list in this section to have one-third of their teaching assignments in support of Biomedical Engineering undergraduate and graduate degrees.

9. DESCRIPTION OF RESOURCES

Both the IEEE and ASME journals packages include well ranked journals that support biomaterials for medical applications, biomechanical devices and systems, and tissue engineering. Our consortia agreements with the UAMS libraries, especially the Elsevier/Science Direct titles, provide journal literature in medical fields. There are a few IEEE conference materials that support this engineering discipline. The databases that we currently offer will support literature search in these areas. Our purchases to support the current master's program in this area have focused on the book literature in the area of tissue engineering at the advanced level. Our purchases to support the senior design projects in bioengineering will partially support the biomechanical devices at the undergraduate level. The Knovel resource, purchased jointly by the library and five engineering departments provides access to a few important titles in this area and the Morgan and Claypool's Synthesis product has several series that may be used by upper division students within the program. With strong undergraduate and graduate programs in the biological sciences, the Libraries have a well-developed collection of materials in physiology and basic cell biology.

There are sufficient classrooms with instructional equipment available in the College of Engineering for the new classes required for this program. No additional classrooms will be needed.

Existing undergraduate instructional laboratories will be used for this program with some modifications. These laboratories are located on the southwest corner of the first floor of the Engineering Hall. These laboratories are being vacated by electrical engineering because of moving some of their research laboratories into the newly acquired facility on Cato Springs Road. The funds for modification/renovation, estimated to be at approximately $250,000, will be from a combination of sources ranging from University renovation funds and from the College of Engineering maintenance budget.

10. NEW PROGRAM COSTS – Expenditures for the first 3 years of program operation

New administrative costs
$50,000/year X 3 = $150,000

Number of new faculty (full-time and part-time) and costs
$600,000/year X 3 = $1,800,000

New library resources and costs
$43,250

New/renovated facilities and costs
$250,000

Other new costs (graduate assistants, secretarial support, supplies, faculty development, faculty/students research, etc.)
$100,000/year X 3 = $300,000

11. **SOURCES OF FUNDING – Income for the first 3 years of program operation**

Reallocation the Department of Biological and Agricultural Engineering
$533,000/year X 3 = $1,599,000

Tuition/fees from new students
$1,775,715

External Grants and Contracts
$4,500,000

Endowment and Gifts
$60,000

12. **ORGANIZATIONAL CHART REFLECTING NEW PROGRAM**

The degree will be housed in the new Department of Biomedical Engineering in the College of Engineering.

13. **SPECIALIZED REQUIREMENTS**

Accreditation from the Engineering Accreditation Commission of ABET will be pursued after graduates have been matriculated.

14. **BOARD OF TRUSTEES APPROVAL**

15. **SIMILAR PROGRAMS**

There are no other institutions in Arkansas offering this program.

16. **DESEGREGATION**

State the total number of students, number of black students, and number of other minority students enrolled in related degree programs (if applicable).

	Non-Minority	Black	Other Minority	Total
Biological Engineering	80	8	14	102
Computer Engineering	54	5	12	71
Chemical Engineering	146	0	20	166
Civil Engineering	178	6	18	202
Electrical Engineering	107	3	16	126
Freshman Engineering	416	44	77	537
Industrial Engineering	110	12	20	142
Mechanical Engineering	237	10	26	273
Undeclared Engineering	2	2	1	5
Total	1330	90	204	1624

17. INSTITUTIONAL AGREEMENTS/MEMORANDUM OF UNDERSTANDING (MOU)

None

18. ADDITIONAL INFORMATION REQUESTED BY ADHE STAFF

This budget is for creating a new Department of Biomedical Engineering. This new department will incorporate a new Bachelor of Science degree in Biomedical Engineering, an existing Master of Science degree in Biomedical Engineering, and a new Biomedical Engineering concentration for the PhD in Engineering.

Resource Requirements

	1st Year (in dollars)	2nd Year (in dollars)	3rd Year (in dollars)
Staffing (Number)			
Administrative/Professional	50,000	50,000	50,000
Full-time Faculty	460,000	570,000	690,000
Part-time Faculty	300,000	300,000	300,000
Graduate Assistants	300,000	350,000	400,00
Clerical	25,000	25,000	25,000
Fulbright College Faculty			
Equipment & Instructional Materials	40,000	40,000	40,000
Library	18,250	12,000	13,000
Other Support Services			
Supplies/Printing	10,000	10,000	10,000
Travel	40,000	40,000	40,000
Distance Technology	0	0	0
Other Services (Research Expenditures)	$600,000	$750,000	$900,000
TOTAL	**$1,843,250**	**$2,147,000**	**$2,468,000**

Planned Funding Sources

	1st Year (in dollars)	2nd Year (in dollars)	3rd Year (in dollars)
New Student Tuition and Fees #students*15 hrs/sem*(tuition+fees($257.35))*2 semesters	$231,615 30 students	$386,025 50 students	$1,158,075 150 students
New State General Revenue	$0	$0	$0
Redistribution of State General Revenue From the Department of Biological and Agricultural Engineering To the Department of Biomedical Engineering	$533,000	$533,000	$533,000
External Grants/Contracts	$1,200,000	$1,500,000	$1,800,000
Other Funding Sources (Endowment and Gifts)	$20,000	$20,000	$20,000
TOTAL	**$1,984,615**	**$2,439,025**	**$3,511,075**