Board of Regents, State of Iowa

REQUEST TO IMPLEMENT A NEW BACCALAUREATE, MASTERS, DOCTORAL OR FIRST PROFESSIONAL DEGREE PROGRAM

Modified February 14, 2008

THE PURPOSE OF ACADEMIC PROGRAM PLANNING: Planning a new academic degree program provides an opportunity for a Regent University to demonstrate need and demand as well as the university's ability to offer a quality program that is not unnecessarily duplicative of other similar programs offered by colleges and universities in Iowa.

Institution: **Iowa State University**

Departments involved:

Aerospace Engineering
Agricultural and Biosystems Engineering
Chemical and Biological Engineering
Civil, Construction, and Environmental Engineering
Electrical and Computer Engineering
Industrial and Manufacturing Systems Engineering
Materials Science and Engineering
Mechanical Engineering

CIP Discipline Specialty Title: Bioengineering and Biomedical Engineering

CIP Discipline Specialty Number (six digits): 14.0501

Level:

Title of Proposed Program: Bioengineering Minor

Degree Abbreviation (e.g., Minor, B.S., B.A., M.A.): Minor

Approximate date to establish degree: Month August Year 2008

Contact person(s): (name, telephone, and e-mail)

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Please provide the following information (use additional pages as needed).

1. Describe the proposed new degree program, including the following:

   a. A brief description of the program and a statement of objectives including the student learning outcomes and how the learning outcomes will be assessed;

The Bioengineering Minor Program will be administered by the College of Engineering. The goal of this cross-disciplinary program is to educate undergraduate engineering students in sound engineering principles as they relate to the understanding and manipulation of biological systems at multiple scales starting from macromolecules to complex, interconnected biological systems. Students who complete the Minor in Bioengineering studies will be able to serve engineering needs in the bioeconomy, specifically in the areas of biorenewables, agriculture and health sciences. Such persons will be more capable workers and leaders in a society in which fundamental engineering principles are needed for designing and providing new and improved bio-based devices and products, and for the economic commercialization of biotechnology.

Students who complete this program successfully will be able to:

1. Get an overall perspective of the various subfields in bioengineering.
2. Understand the role of bioengineering in society and the interactions of biological systems with their major field of study.
3. Prepare for employment and further studies in this growth area with potential applications to biology, agriculture and health sciences.
4. Attain an understanding of the bioengineering design process.
5. Achieve an understanding of why particular materials and processes are used to produce new devices and products.
6. Attain an understanding of the analysis, synthesis and design related to the process of engineering a bio-based product
7. Understand the capabilities and limitations of basic manufacturing processes and biological systems.
8. Work and/or collaborate with multi-disciplinary groups of people.
9. Make informed decisions about the desirability of bioengineering activities by weighing the benefits of those activities against their environmental risks.

Assessment of whether students have met these learning outcomes will be made by the instructors of the individual courses involved in the minor.

b. The relationship of the proposed new program to the institutional mission and how the program fits into the institution's, college's, and department/program's strategic plan;

The VISION statement of the Iowa State University Strategic Plan states, "Iowa State University will be the best at advancing the land-grant ideals and putting science and technology to work. Students will become broadly educated, global citizens who are culturally informed, technologically adept, and ready to lead. The spirit of

Iowa State University will be evident in the integration of sciences and humanities and in the energy and creativity of its people."

The section of the University Strategic Plan headed "Priority: Education" states that the goals of the educational endeavors at the University include:

- Strengthen students' critical thinking, creative abilities, and communication skills.
- Create an environment that welcomes students to explore a variety of disciplines and career paths.
- Increase interdisciplinary and experiential learning opportunities.
- Leverage strengths in science and technology to enhance research and scholarly excellence with emphasis on interdisciplinary initiatives involving biological, materials, and information sciences.

A bioengineering minor for engineering students would strengthen the University's ability to meet each of the goals listed above.

c. The relationship of the proposed new program to other existing programs at the institution; describe how the proposed program will enhance other programs at the university.

As part of the process in developing the Bioengineering Minor Program at ISU, meetings/conversations/email exchanges were held with several engineering faculty. These include Drs. Bastawros, A; Durbin, P; Hui, H; Anex, R; Bern, C; Raj Raman, D; Hillier, A; Mallapragada, S; Shanks, J; Russell, A; Frank, M; Salapaka, M; Vaswani, N; Dickerson, J; Pandey, S and Kim, J. Based on faculty interest at ISU, it was inferred that nearly all engineering departments have a growing interest in bioengineering research, and many of them have faculty working on different aspects of bioengineering directly related to their disciplinary interests. However, the degree of activity was found to vary widely across departments, with some departments having a relatively high degree of activity and others having modest to no activity. By offering to help realize synergies across multiple departments and to expand the biotechnological awareness of students in all engineering curricula at Iowa State University, this minor will provide students with a better understanding of the history, fundamental principles, potential, and limitations of bioengineering. This, in turn, can improve the students' appreciation of the interactions between biology and their major disciplines and

improve students' abilities to make informed decisions on issues involving engineering and technology factors.

d. The relationship of the proposed new program to existing programs at other colleges and universities in Iowa, including how the proposed program is different or has a different emphasis than the existing programs;

There are two state-supported engineering degree-granting programs in Iowa, one at Iowa State University (Ames) and the other at the University of Iowa (Iowa City). There are two private college engineering degree-granting programs in Iowa at Dordt College (Sioux Center) and Loras College (Dubuque). No program like the proposed Minor in Bioengineering is presently offered at any of the engineering schools in Iowa.

The University of Iowa does not offer a bioengineering minor (source: Alec Scranton, Associate Dean of Academic Programs in the College of Engineering at Iowa University). However, it has an established biomedical engineering (BME) program. They offer undergraduate and graduate degrees in BME. For undergraduates, they also offer specializations in

- Bioinformatics/Computational Biology
- Bioimaging
- Biomaterials
- Cardiovascular Biomechanics
- Musculoskeletal Biomechanics
- Tissue Engineering

Based on the courses listed under these specializations and faculty research, U of I appears to be especially strong in Biomechanics and Tissue engineering areas.

The Iowa State University program will have different focus areas and also offer concentration in areas of particular strength at Iowa State University such as engineering at the cellular level and bioengineering applications to biorenewable energy. The programs are founded on the individual and complementary strengths of these two major public institutions in the state of Iowa – the medical research focus of University of Iowa, and the agriculture and engineering focus of Iowa State University.

A Minor in Nondestructive Evaluation (NDE) and a Minor in Engineering Studies (ES) are the only engineering minors offered at Iowa State University; enrollment in NDE is restricted to students

with engineering major and ES is designed for non-engineering majors. Although the proposed Minor in Bioengineering is also designed for students who are majoring in engineering, there is no overlap of the proposed minor with either of the two engineering minors that already exist at Iowa State. Nondestructive evaluation relies on electromagnetic, acoustic and other noninvasive techniques to evaluate the state of materials or other systems. While it can be used to image biological systems such as imaging of a brain using CT scan, the bioengineering program's focus is on synthesis, multiscale understanding, and engineering of biological systems or engineering components that interface with them. Neither Dordt College (source: Ethan Brue, Professor of Engineering at Dordt) nor Loras College (source: Daniel Neebel, Division Chair for Engineering at Loras) offer any minors in bioengineering for engineering students.

e. Special features or conditions that make the institution a desirable, unique, or appropriate place to initiate such a degree program.

Iowa State University is a Land Grant Institution with one of the ten largest colleges of engineering in the United States. It also has a broad selection of bio-related majors, and some of the worlds leading research in science and technology. As such, it is well positioned to offer a Minor in Bioengineering to allow engineering students to better understand the history, fundamental principles, potential, and limitations of bioengineering. Bioengineering and its applications to agriculture and health is a field that is expected to grow in prominence over the coming decades. Training in this field is an essential part of preparing U.S. Citizens to take a lead role in 21st Century Science and Technology.

f. Does the proposing institution have personnel, facilities, and equipment adequate to establish and maintain a high quality program?

Current faculty in the degree granting departments of the College of Engineering collectively have the expertise to design and deliver bioengineering courses in the proposed program. The nine non-engineering courses (BIOL 301, BIOL 302, BBMB 301, ZOOL 155, BIOL 173, MICRO 302, GEN 308, FSHN 351, Ex Sp 355) that may be of interest to students taking the bioengineering minor are already taught at Iowa State, for which faculty, facilities, and equipment are adequate. Some tracks in the program require new facilities and equipment for laboratory development. These will be developed as needed to maintain a high quality program.

g. How does student demand for the proposed program justify its development?

National trends indicate the establishment of a growing number of bioengineering programs that are well populated. A survey conducted by ASEE reveals 15 bioengineering B.S. degree programs in the U.S. with an average student enrollment of 116 students. Current employment opportunities in this field coupled with faster than average expected growth in such opportunities augurs well for strong student demand in the coming years.

2. Describe the state and/or national workforce need and/or demand for graduates of the proposed program currently and in the near future (provide documentation about the sources of data used to estimate need and demand.)

While traditionally biology and engineering have been looked upon as separate disciplines, scientific advances over the past two decades have increasingly blurred this distinction. There is also an increasing realization of the critical need to integrate principles and knowledge of both disciplines to enable further advances at the leading edge of science and technology. It is expected that a good fraction of future engineers will be dealing with biological systems, be they related to agricultural or health sciences.

Although American Universities produced more than 70,000 engineering graduates in the past year, it was not nearly enough to meet the demand. In the bioengineering/biomedical engineering area itself, the demand for new bio-based products and devices is expected to fuel a 27% or higher increase in jobs through 2014. Employment for bioengineers is expected to grow much faster than the average for all occupations through 2014 (US News and World Reports, US Department of Labor).

According to the US Department of Labor Occupational Outlook Handbook, bioengineers held approximately 9,700 of the jobs in 2006. Manufacturing industries employed 38 percent of all bioengineers, primarily in the pharmaceutical and medicine manufacturing and medical instruments and supplies industries. Others were employed in universities, hospitals, research facilities of education and medical institutions, teaching, governmental regulatory agencies, or as independent consultants. The starting salaries for bachelor's degree candidates in bioengineering averages $48,503 and for master's degree graduates average around $ 60,000.

Therefore, the growing job market and financial reward provides a compelling need to train students to prepare for the future workforce needs and maintain U.S. competitiveness in critical areas at the frontiers of science and technology.

List all other public and private institutions of higher education in Iowa currently operating programs similar to the proposed new degree program. (For comparison purposes, use a broad definitional framework, e.g., such identification should not be limited to programs with the same title, the same degree designation, having the same curriculum emphasis, or purporting to meet exactly the same needs as the proposed program.)

No other Iowa institution offers a minor of this type. University of Iowa Offers an undergraduate and graduate degree programs in biomedical engineering. Dordt College offers an undergraduate degree in biotechnology, an interdisciplinary program with an option in biomedical engineering (http://www.dordt.edu/academics/programs/biotechnology/). Bionegineering is a global term that is applied to all life sciences and medicine while biomedical engineering focuses primarily on medicine and health care. The Bioengineering Minor Program at ISU will train students on using engineering skills and tools to analyze and solve problems not only in medicine, but also in other fields of biology including agriculture, and biorenewables.

If the same or similar program exists at another public or private institution of higher education in Iowa, respond to the following questions:

a. Could the other institution reasonably accommodate the need for the new program through expansion? Through collaboration?

b. With what representatives of these programs has there been consultation in developing the program proposal? Provide a summary of the response of each institution consulted.

c. Has the possibility of an inter-institutional program or other cooperative effort been explored? What are the results of this study? (Consider not only the possibility of a formally established inter-institutional program, but also how special resources at other institutions might be used on a cooperative basis in implementing the proposed program solely at the requesting institution.)

3. Estimate the number of majors and non-majors students that are projected to be enrolled in the program during the first seven years of the program.

a. Undergraduate

Undergraduate	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7
Non-Majors	NA	NA	NA	NA	NA	NA	NA
Majors	30	60	90	90	90	90	90

b. Graduate

Graduate	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7
Majors	NA	NA	NA	NA	NA	NA	NA
Non-Majors	NA	NA	NA	NA	NA	NA	NA

c. What are the anticipated sources of these students?

Students from all engineering departments at Iowa State University may enroll in this program.

4. If there are plans to offer the program away from the campus, briefly describe these plans, including potential sites and possible methods of delivery instruction.

No off-campus program delivery is anticipated at this time.

5. Has the proposed program been reviewed and approved by the appropriate campus committees and authorities? List them:

Engineering College Curriculum Committee – approved Dec 5, 07

Faculty Senate Curriculum Committee –

Faculty Senate Academic Affairs Council -

Provost's Office -

6. List date the program proposal was submitted to the Iowa Coordinating Council for Post High School Education (ICCPHSE) and the results of listserv review.
(THIS WILL BE COMPLETED BY THE PROVOST OFFICE.)

7. Will the proposed program apply for accreditation? When?

No

8. Will articulation agreements be developed for the proposed program? With whom?

No

9. Describe the faculty, facilities, and equipment that will be required for the proposed program.

The faculty, facilities, and equipment for the proposed program will be those already supporting the degree-granting departments of the Engineering College and those of other colleges now used to support the nine existing non-Engineering courses being taught at Iowa State (BIOL 301, BIOL 302, BBMB 301, ZOOL 155, BIOL 173, MICRO 302, GEN 308, FSHN 351, ExSp 355).

10. From where will the financial resources for the proposed program come (list all that apply, e.g., department reallocation, college reallocation, grants, new to the university)

College reallocation, differential tuition funds, NSF-CCLI and other grants

11. Estimate the total costs/total new costs <u>(incremental increases each year in expenditures</u>) that will be necessary for the next seven years as a result of the new program:

The costs for delivering the minor are based on the following assumptions:

a. Development of a new course is a one-time cost of $10-15k

b. Delivery of a course is recurring cost of $10-15k.

c. For the launching of the minor, of the 8 new courses and 2 laboratories, 6 new courses will be developed (Introduction to Bioengineering I, Introduction to Bioengineering II, Systems biology for engineers , Molecular, cellular and tissue biomechanics, Biomedical image processing and Bioprocessing and Bioproducts) in the first year.

d. 2 additional BioE courses and 2 labs will be developed in the next year.

e. A one-time cost of $ 100K will be required to set up labs (BioMEMs and Nanotechnology Lab and Biosensing Lab)

f. Fixed cost of $20k/year for director.

	New Courses	**Sections**	**Director**	**TOTAL COSTS**	**TOTAL <u>NEW</u> COSTS**
Year 1	6	6	$20k	$140-200K	$140-200K
Year 2	4 (2C and 2L)	10	$20k	$160-230K	$20-30k
Year 3	0	10	$20k	$120-170K	Decrease of $40-60K
Year 4	0	10	$20k	$120-170K	0
Year 5	0	10	$20k	$120-170K	0
Year 6	0	10	$20k	$120-170K	0
Year 7	0	10	$20k	$120-170K	0

C- course, L-laboratory

13. Program requirements, including:
a. prerequisites for prospective students;

The program is for engineering undergraduate students at Iowa State. The prerequisites for courses supporting the Bioengineering Minor taught within the College of Engineering are set by the offering departments. Some courses that are already being taught at the university by departments outside the College of Engineering may be of interest to students taking the Bioengineering Minor; for these courses, the prerequisites are set by the offering department, and these vary from course to course. However, none of these non-engineering courses are required for the Bioengineering Minor.

b. language requirements;

None

c. courses and seminars presently available for credit toward the program;

This information is included in the response to Item 13.d. below.

d. proposed new courses or modifications of existing courses;

The Bioengineering Minor is structured so that no undergraduate engineering student at ISU will be excluded due to insufficient prior preparation in life sciences. Thus the program is specifically designed to offer a range of courses such that students from all engineering disciplines could find coursework that would support an accessible and intellectually stimulating program of study. The courses offered for the Bioengineering Minor bearing the designation “BioE” (as described below) are closed to students whose major curriculum is not in the College of Engineering.

The proposed minor would require that a student complete a total of 15 course credits; 6 from the core curriculum and 9 from the non-core curriculum:

- Courses in the Core Curriculum (described on the following pages) are required courses.
- 9 additional credits are to be earned from the list of Tracks.
- The proposed program will comply with all university requirements for minors, including the requirement that a minimum of 6 credits in a minor be 300-level or above courses taken at Iowa State University and the requirement that a minimum of 9 credits used to satisfy the course credits required for the minor may not be used to satisfy any other department, college, or University requirement.

Thus, the requirements for the proposed Bioengineering Minor would be:

Total Credits Required for the Bioengineering Minor = 15

1) Required course #1: Introduction to Bioengineering I (3 cr.)
2) Required course #2: Introduction to Bioengineering II (3 cr.)
3) Nine additional credits in courses that bear the designation "BioE" (as described below) or courses offered by engineering departments and expressly approved by that department's curriculum committee and the bioengineering committee for use in the Bioengineering Minor program, or other courses on an approved list maintained by the bioengineering committee.

The following is a partial listing of courses for the Bioengineering Minor. The designation "BioE" is an abbreviation for "Bioengineering" and indicates that the course will be administered by the Engineering College to serve students who are majoring in engineering. A bioengineering section will be added to the university catalog as a separate section clearly delineating these courses from other engineering courses. That section of the catalog will list the

program objectives for the minor and will contain language that explains the role of the minor relative to other engineering programs.

Additional courses may be added to this list by action of the individual Engineering College department curriculum committees, designating courses offered by their departments deemed suitable for inclusion on the approved course listing.

The Bioengineering Minor program is made of a core curriculum and a non core curriculum. Courses listed under the core curriculum are required for the minor.

The core curriculum is designed to achieve the following objectives:

- Give students an introduction to various subfields of bioengineering to give them an overall perspective.
- Provide basic training in biology in conjunction with engineering applications that can serve as the foundation on which advanced courses can be planned.
- Help students in choosing areas of specialization and/or select further topics for completing the minor.
- Give students not minoring in bioengineering access to bioengineering fundamentals.

This core is structured as the following two courses with a total of 6 credits:

BioE 201. Introduction to Bioengineering I **[new course].** F. Prereq: *Chem 167, engineering classification.* An exploration of cell structure and function, cellular metabolism, types of life forms, energy transport and use, biomolecule structure and function, and enzyme structure, function, and kinetics, with strong mathematical emphasis.

BioE 202. Introduction to Bioengineering II [**new course]** S. Prereq: *BioE 201.* Feedback loops in biological systems, cell and microbial growth patterns, fermentation kinetics, and use of biotechnology in everyday living such as diseases, wastewater treatment, genetic engineering of bacteria, fungi, plants, and animals, and biosensor operation. Strong mathematical emphasis.

Additional courses to complete the minor are listed under organized tracks. Tracks are provided to a) to guide the student in selecting subfields for more in-depth study and b) to realize synergies across multiple subsets of departments. The students can either choose to specialize in a

particular track or choose a set of courses from all tracks as a list of electives to draw from.

The following is a list of tracks and courses in the tracks. The tracks are listed in alphabetical order.

Track1: Bioinformatics and Systems Biology

BCB 211: Introduction to Bioinformatics and Computational Biology (3 cr) S. Overview of bioinformatics and computational biology. Database searching, sequence alignment, gene prediction, RNA and protein structure prediction, construction of phylogenetic trees, comparative and functional genomics.

BioE 325. Systems Biology for Engineers (3 cr) **[new course].** *Prereq: Math 267, BioE 201, 202*. Review of systems approaches for modeling. Introduction or review of methods for gene regulation in cells and how to model them. Auto regulation of gene networks. Feedforward modeling, timing considerations. Feedback Mechanisms. Kinetic and rate-limiting steps.

BCB 401. Fundamentals of Bioinformatics and Computational Biology I (3 cr). F. *Prereq: BCB 211, Com S 228.* Biology as an information science. Generative models for sequences. String algorithms. sequence alignment. Algorithmic and statistical aspects of database search. Basic methods in molecular phylogeny/phylogenomics. Genome sequence assembly.

BCB 402: Fundamentals of Bioinformatics and Computational Biology II (3 cr) S. *Prereq: BCB 401.* Genome annotation. DNA and protein motifs. DNA microarrays. Introduction to gene expression studies. Protein, DNA and RNA structure. Structure representation, comparison and visualization. Biological networks and systems.

BCB 442: Bioinformatics Tools and Techniques (cr 1 per module) F S SS. *Prereq: BCB 211.* Workshops in basic bioinformatics tools and techniques. Offered on a satisfactory-fail grading basis only. Sections A - F.

Track 2: Biomaterials and Biomechanics

BioE 352. Molecular, Cellular and Tissue Biomechanics (3 cr) [**new course**]: *Prereq: EM324, MatE272, BioE201*. Introduction to the anatomy of the musculoskeletal system and connective tissue. Range of movement, joint dislocation, bone deformity and fracture.

Application of continuum mechanics (statics and dynamics) to both living and non-living systems. Laws of motion, free-body diagrams and simple force analysis of musculoskeletal system. Biomechanical response of soft and hard tissues with emphasis on microstructure and mechanical properties (field equations, constitutive material response and boundary conditions). Applications to bioengineering design.

Mat E 456X. Biomaterials (3 cr) *prereq*: *Mat E 211 or Mat E 272*. Presentation of the basic chemical and physical properties of biomaterials, including tissues, metals, ceramics, and polymers, and composites as they are related to their manipulation by the engineer for incorporation into living systems. Role of microstructure and properties in the choice of biomaterials and in the design of artificial organs, implants, and prostheses.

Ch E 440. Biomedical Applications of Chemical Engineering. (Dual-listed with 540.) (Cr. 3) *Prereq:* Ch E *210, Math 266, Phys 222*. Applications of material and energy balances, transport phenomena, chemical reaction engineering, and thermodynamics to problems in biomedical engineering and applied physiology; survey of biomedical engineering; biomaterials; biomedical imaging. Nonmajor graduate credit.

Ex Sp 355. Biomechanics. (Cr. 3) *Prereq: Phys 106 or 111*. Mechanical basis of human performance; application of mechanical principles to exercise, sport and other physical activities. Nonmajor graduate credit.

Track 3: Bio Micro Systems

BioE 341. BioMEMs and Nanotechnology. (Cr 3) [**new course**] F. *Prereq: BioE201 and 202*. Overview of Micro-Electro-Mechanical-System (MEMS) technologies for bioengineering, fundamentals of microfluidic device design, fabrication, and characterization, survey of microfluidic functional building blocks for lab-on-a-chip applications including mixers, valves, channels, and chambers. Topics of nanotechnology in bioengineering, nanoscale building block technologies for bioengineering including self-assembling, surface chemical treatment, nano-imprinting, nano-particles, nano-tubes, nano-wires, and stimuli-responsive biomaterials.

BioE 341L. BioMEMs and Nanotechnology Lab. (Cr 1) [**new course**] F. *Prereq: BioE 201 and 202*. Laboratory course

accompanying BioE 341. Must be taken with BioE341. BioE341L is not a necessary corequisite with BioE341. Introductory laboratory course on the design, fabrication, and characterization of BioMEMS lab-on-a-chip devices and nanoscale techniques for bioengineering. It will include student projects in groups of maximum four students.

BioE 450. Biosensing. (Cr 3) [**new course**] F. *Prereq: BioE 201 and 202*. Overview of biosensors and bioanalytical challenges; designing for performance including various analytical problems, ion-selective membranes, characteristics of enzymes and basics of bioaffinity sensing; fundamentals of bioselective layers including depositing films and membranes, surfaces for immobilization and bioselective agents; survey of different biosensing technologies including electroanalytical, biomembrane, optical, and acoustic-wave based sensors.

BioE 450L. Biosensing Lab. (Cr 1) [**new course**] F. *Prereq: BioE 201 and 202*. Laboratory course accompanying BioE450. Must be taken with BioE450. BioE450L is not a necessary corequisite with BioE450. The lab comprises the design, fabrication, and characterization of various electrical, chemical, polymer, optical and acoustic sensors.

BioE 428/528. Biomedical Image Processing (Cr 3) [**new course**] *Prereq: E E 324.* Review of Signal Processing, Linear Algebra, Probability. Image Sampling and Quantization. Image Transforms. Image Enhancement. Image Denoising/Restoration. Tomographic Reconstruction. Segmentation and Registration. Recognition and Shape Analysis and Applications in Computer Aided disease Detection (CAD).

Track 4: Biosystems and Environmental Engineering

BioE 402/502. Bioprocessing and Bioproducts. (Cr 3) [**new course**] Prereq: *AE 216 or equivalent, Math 160 or 165; one of Chem 167 or higher, Biol 101 or higher, or BRT 501; completion of at least 3y of full-time equivalent studies.* Sustainability, cleaner production, water conservation. Microbial taxonomy, metabolism, kinetics and cultivation, special purpose organisms, aerobic and anaerobic fermentation. Biofuels, bioenergy and coproducts. Mass and energy balances, process integration, pretreatment of raw materials, waste reutilization and new byproducts, separation. Dry-grind and wet corn milling, lignocellulosic ethanol, food-grade fermentation, membrane reactors, nanotechnology, mutagenesis, genetic engineering, microbial fuel cells and bioelectrolysis. Cost

and environmental factors and market forces. Term project required for graduate credit.

Ch E 415. Biochemical Engineering. (Dual-listed with 515.) (Cr. 3). *Prereq: Ch E 357 and 382 recommended, Chem 331*. Application of basic chemical engineering principles in biochemical and biological process industries such as enzyme technology and fermentation. Nonmajor graduate credit.

Ch E 427. Biological Engineering Laboratory. (0-4) Cr. 2. *Prereq: Credit in Ch E 325, 358, 382 and BBMB 301*. Experiments on biological applications in chemical engineering. Nonmajor graduate credit.

A E 216. Fundamentals of Agricultural and Biosystems Engineering. (Cr. 3) *Prereq: A E110, Engr 160, credit or enrollment in Math 166*. Application of mathematics and engineering sciences to energy and mass balances in agricultural and biological systems. Emphasis is on solving engineering problems in the areas of air and water vapor systems; electrical systems, grain systems; food systems, hydrologic systems, and bioprocessing.

A E 480. Engineering Quantification of Biological Processes. (Dual-listed with 580.) (Cr. 3) *Prereq: A E 216, Math 266; Biol 101 or 211 or 212; M E 330*. Prediction of biological systems behavior by computer simulation of mathematical system models. Focus on mathematical representation of biological processes including population dynamics, growth, development, diffusion, bioenergetics, enzyme kinetics. Flow diagrams for representing systems and constructing mathematical models. Finite difference techniques for continuous system simulation including examples of plant growth and soil water balances. Students enrolled in A E 580 will be required to answer an additional final exam question, to report on two journal articles, and to complete a more comprehensive class project than students enrolled in A E 480.

C E 421. Environmental Biotechnology. (Dual-listed with 521.) (Cr. 3) *Prereq: C E 326*. Fundamentals of biochemical and microbial processes applied to environmental engineering processes, role of microorganisms in wastewater treatment and bioremediation, bioenergetics and kinetics, metabolism of xenobiotic compounds, waterborne pathogens, parasites, and disinfection.

The following is a list of related courses offered by non-engineering departments that may be of interest to students taking the Bioengineering Minor. Note that a course can be taken only after its prerequisites, if any, are satisfied.

Biol 155. Introduction to the Human Body. (Cr. 3) A survey course of the human body including principal structures and functions of the body systems and the diseases and disorders associated with them. Designed to meet general education requirements in natural science. Not recommended for those seeking a career in the allied health professions or for students majoring in life science.

Biol 173. Environmental Biology. (Same as Env S 173.) (Cr. 3). An introduction to the structure and function of natural systems at scales from the individual to the biosphere and the complex interactions between humans and their environment. Discussions of human population growth, biodiversity, sustainability, resource use, and pollution. Non-majors only.

Biol 313. Principles of Genetics. (Same as Gen 313.) (Cr. 3). *Prereq: 211L and 212 L*, credit or enrollment in organic chemistry. Introduction to the principles of transmission and molecular genetics of plants, animals, and bacteria. Recombination, structure and replication of DNA, gene expression, cloning, quantitative and population genetics. Students may receive graduation credit for no more than one of the following: 313 and 313L, Gen 260, Gen 313, Gen 320, and Agron 320.

Biol 314. Principles of Molecular Cell Biology and Biochemistry. (Cr. 3).*Prereq: Biol 313*. Integration of elementary principles of metabolism, bioenergetics, cell structure and function to develop a molecular view of how the cell works.

BBMB 301. Survey of Biochemistry. (Cr. 3) *Prereq: Chem 231 or 331*. A survey of biochemistry: structure and function of amino acids, proteins, carbohydrates, lipids, and nucleic acids; enzymology; metabolism; biosynthesis; and selected topics. Not acceptable for credit toward a major in biochemistry or biophysics.

FSHN 351. Unit Operations in Food Processing. (Cr 3) *Prereq: a course in calculus and Phys 106*. Introduction to material and energy balances. Fluid flow, physical and thermal properties of food

materials. Fundamentals of heat and mass transfer. Application of momentum and heat transfer to unit operations in food processing. Calculations and computer applications in food processing. Nonmajor graduate credit.

Gen 308. Biotechnology in Agriculture, Food, and Human Health. (Cr. 3). *Prereq: Biol 211 and 212*. Scientific principles and techniques in biotechnology. Products and applications in agriculture, food, and human health. Ethical, legal, and social implications of biotechnology.

Micro 302. Biology of microorganisms. (Cr 3). *Prereq*: *Biol 211, credit or enrollment in 212*. Basic cell biology physiology, metabolism gentics and ecology of microorganisms, with an emphasis on prokaryotes and viruses, as well as the role of microorganisms in the environment, disease, agriculture and industry.

The requirements and list of courses applicable for the Bioengineering Minor Program are summarized in Table 1.

An Update on the Bioengineering Minor Curriculum:

The following summarizes progress made since the initial draft of the proposal was circulated at the beginning of summer 2007:

Based on faculty feedback, the proposed 1 credit introductory course “Topics in Bioengineering” and credit (3 credits) for prerequisites were eliminated from the curriculum. Students are now required to complete 15 credits (originally 19 credits) of course work; 6 credits from the core curriculum and 9 credits from carefully organized tracks to provide in depth exposure to targeted areas of specialization – 1) Bioinformatics and Systems biology, 2) Biomaterials and Biomechanics, 3) Bio Micro Systems, and 4) Biosystems and Environmental engineering.

The Bioengineering proposal was forwarded to all engineering department chairs for review by their respective department curriculum committees. Some of the department curriculum committees have processed the proposal and provided their feedback. To date, ECpE and IMSE have approved the minor. CCEE has indicated that they have no negative feedback regarding the curriculum and support the program. Although MSE and ABE do not have issues with the planned curriculum, they would like an academic home in a department that has the budget to support the program. CBE, ME and AE have yet to provide their approval on the bioengineering proposal.

There are however, some concerns regarding department-ownership of the program at the college level. Mainly that 1) department-ownership may reduce the scope of the program and make it more focused towards students from those department(s), 2) tracks other than those closely aligning with the departments may not be fully developed and hence, other departments and students from those departments may lose interest in the program, 3) expertise from several engineering departments is needed to develop different Tracks in the minor, and 4) long term success of the program depends on participation from all departments and broad student participation and enrollment.

Because of these concerns, the following administrative structure that combines management at the college level with a committee of faculty representatives from all departments to monitor the curriculum and advise on proper functioning of the program was proposed:

1. Minor administered at the college level.
2. Program director to oversee the minor.
3. A bioengineering committee with representation from all departments.
4. Funding and incentives to be given for teaching courses in the program and for hiring new faculty working in the area.

This administrative plan was discussed by the Engineering Dean and Department Chairs, and a College level administration for the Bioengineering Minor was informally agreed upon by all parties involved. A **Memorandum of Understanding** (MOU) is being routed for their signatures.

A call for proposals to develop and teach new BioE courses was sent to all engineering faculty, the deadline for which was October 31, 2007. In response to the CFP, we received proposals for all new BioE courses proposed in the curriculum (7 new courses and 2 labs plus an additional “Systems Biology” course not included in the original curriculum) from various faculty. The following table gives a summary of BioE course(s) distribution and the departments/faculty participating in the course development.

Semester/Year	Courses – Department - Faculty
Fall 2008	BioE 201 – ABE and CBE- Peter Reilly and Raj Raman BioE 402 – ABE and CCEE – Hans van Leeuwen and Tae Hyun Kim
Spring 2009	BioE 202 – ABE, CBE and ECpE – Peter Reilly, Raj Raman and Santosh Pandey BioE 352 - AE – Ashraf and Hala Bastawros BioE 325– ECpE – Nicola Elia and Julie Dickerson BioE 428/528 – ECpE – Namrata Vaswani
Fall 2009	BioE 341 and 341L – ECpE – Liang Dong, Jaeyoun Kim and Santosh Pandey
Spring 2010	BioE 450 and 450L – ECpE – Liang Dong, Jaeyoun Kim and

	Santosh Pandey

The College of Engineering Dean is committed to using differential tuition funds and for providing funding/incentives (5K to faculty and 20K to Department) for the development of the new BioE courses.

e. thesis and non-thesis options in master's programs;

f. implications for related areas within the university;

The proposed minor has the potential to increase the workload of one or more of the departments that offer courses designated for credit in the Bioengineering Minor. These include: AE 216, AE 473, AE 480, CE 421, ChE 415, Biol 173, Micro 302, Gen 308, FSHN 351, Biol 155, Biol 313, Biol 314, BBMB 301, ChE 440, ChE 427 and ExSp 355. If enrollment in some or all of those courses increases to the point that additional sections must be offered, then additional resources may be needed to support those courses. However, for the planned steady-state enrollment in the minor (90 students), the anticipated increase in student enrollment in these courses is expected to be modest and is likely to increase class sizes somewhat, but will probably not necessitate adding new sections. The non-engineering courses are generally available to students from many departments. Many of them have large enrollments and given that these courses will be taken only by students in specific tracks, it is expected that the additional enrollment will not be a significant factor.

g. admissions standards for graduate programs

14. Attach to the program proposal memos from the department chair(s), the college dean(s), and other appropriate persons, agreeing to the allocation of new resources and/or the reallocation of resources as described in the Regents questions

15. Attach to the program proposal, letters of support, recommendations, and statements when appropriate:
a. from programs at the other Regents universities
b. from programs and departments at ISU which are associated with the proposed program or have an interest in the proposed program

Table 1. Requirements to complete a Bioengineering Minor Program at Iowa State University.

Bioengineering Minor Program (total of 15 credits)

1. Required Courses (6 credits)

No.	*Name*	*Description*	*Credit*	*Prerequisites*
1	BioE 201	Introduction to Bioengineering I	3	Chem 167
2	BioE 202	Introduction to Bioengineering II	3	BioE 201

2. Optional Courses (9 credits)

Track 1. Bioinformatics and Systems Biology

No.	*Name*	*Description*	*Credit*	*Prerequisites*
1	BCB211	Introduction to Bioinformatics and Computational Biology	3	None
2	BCB401	Fundamentals of Bioinformatics and Computational Biology I	3	BCB 211, Com S 228
3	BCB402	Fundamentals of Bioinformatics and Computational Biology II	3	BCB 401
4	BCB442	Bioinformatics Tools and Techniques	1	BCB 211
5	BioE 325	Systems Biology for Engineers	3	Math 267, BioE 201, 202

Track 2. Biomaterials and Biomechanics

No.	*Name*	*Description*	*Credit*	*Prerequisites*
1	BioE 352	Biomechanics	3	EM 324, MatE 272, BioE 201
2	MatE 456X	Biomaterials	3	Mat E 211 or Mat E 272
3	Ch E 427	Biological Engineering Laboratory	0-4	Ch E 325, 358, 382 and BBMB 301
4	Ch E 440	Biomedical applications of Chemical Engineering	3	Ch E 210, Math 266, Phys 222
5	ExSp 355	Biomechanics	3	Phys 106 or 111

Track 3: Bio Micro Systems

No.	*Name*	*Description*	*Credit*	*Prerequisites*
1	BioE 341	BioMEMs and Nanotechnology	3	BioE 201, 202
2	BioE 341L	BioMEMs and Nanotechnology Laboratory	1	BioE 201, 202
3	BioE 450	Biosensing	3	BioE 201, 202
4	BioE 450L	Biosensing Laboratory	1	BioE 201, 202

5	BioE 428	Biomedical Image Processing	3	EE 324

Track 4: Biosystems and Environmental Engineering

No.	*Name*	*Description*	*Credit*	*Prerequisites*
1	BioE 402	Bioprocessing and Bioproducts	3	AE 216, Math 160 or 165, Chem 167 and Biol 101
2	Ch E 415	Biochemical Engineering	3	Ch E 357, 382 recommended, Chem 331
3	AE 216	Fundamentals of Agricultural and Biosystems Engineering	3	AE 110, Engr 160, credit or enrollment in Math 166
4	AE 480	Engineering Quantification of Biological Processes	3	CE 216, Math 266; Biol 101 or 211 or 212; M E 330
5	CE 421	Environmental Biotechnology	3	CE 326

3. Related Courses

No.	*Name*	*Description*	*Credit*	*Prerequisites*
1	Biol 155	Introduction to the Human Body	3	None
2	Biol 173	Environmental Biology	3	None
3	Biol 313	Principles of Genetics	3	Biol 211 and 212
4	Biol 314	Principles of Molecular Cell Biology and Biochemistry	3	Biol 313
5	BBMB 301	Survey of Biochemistry	3	Chem 231 or 331
6	FSHN 351	Unit Operations in Food Processing	3	Calculus and Phys 106
7	Gen 308	Biotechnology in Agriculture, Food and Human Health	3	Biol 211 and 212
8	Micro 302	Biology of Microorganisms	3	Biol 211, credit or enrollment in 212

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

College of Engineering
Office of the Dean
104 Marston Hall
Ames, Iowa 50011-2151 USA
515 294-9988
FAX 515-294-9273
mjk@iastate.edu
College: http://www.eng.iastate.edu

21 December 2007

Dr. Maneesha Aluru
Iowa State University
Ames, IA 50011

Dear Dr. Aluru,

This letter confirms the strong support of the office of the dean for establishing the Bioengineering Minor (BEM) in the College of Engineering. I strongly endorse the program as described in your proposal to the Board of Regents. The BEM is a critical offering for the future of the College as biological topics become more integrated and ingrained into virtually all engineering disciplines. In order for the College to remain nationally competitive for undergraduate students, particularly so those in underrepresented groups, the BEM is essential.

The College commits to supporting the course development and delivery of instruction for the BEM. The department chairs also strongly support the BEM. This support is recorded by their signatures on the attached memoranda of agreement outlining the commitments the College is making and administrative structure of the BEM.

Sincerely,

Mark J. Kushner
Dean, College of Engineering
James and Katherine Melsa Professor of Engineering

Memorandum of Understanding
College of Engineering and Engineering Departments

Establishing the Bioengineering Minor

Introduction:
The College of Engineering will offer an interdisciplinary undergraduate minor in bioengineering. The goal of the minor is to provide educational experiences on applying engineering skills to solving problems and creating new products and devices in biology, biotechnology, medicine and agriculture. To achieve this goal, the expertise of all engineering departments is required. This collaboration will ensure that the quality of the minor is commensurate with current and future research activities in bioengineering in the College.

Statement of Collaboration:
This memorandum of understanding (MOU) describes a governing structure for the interdisciplinary Bioengineering Minor. The College of Engineering and the undersigned department agree to work in collaboration to enhance education and research training activities in the field of bioengineering at Iowa State University.

With this goal, the MOU identifies the following long-term joint objectives:

Curriculum Development: Engineering departments participating in the Bioengineering Minor will collaborate in the development and/or enhancement of curriculum and courses.

Administrative Structure: To facilitate a college-wide partnership in the Bioengineering Minor, the following administrative structure will be adopted:

1. Administration at the College level.
2. Program Director (25 – 50% effort).
3. Bioengineering Minor Committee with representation from all engineering departments.
4. Funding or incentives for developing courses in the program
5. Funding or incentives for teaching courses in the program.
6. Funding or incentives for hiring new faculty working in the area.
7. Advising provided by students' home department advising staff.

The initial term of this MOU shall be for 3 years from August 1, 2008 – July 31, 2011. The MOU will remain in effect unless terminated or amended by the agreement of all parties involved.

College of Engineering	**Department:** Aerospace Engineering
Accepted By: MARK J. KUSHNER	**Accepted By:** Tom I-P. Shih
Signature: Mark J. Kushner	**Signature:**
Date: 12-21-2007	**Date:** Dec. 13, 2007

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College of Engineering
Accepted By: Ramesh Kawwal
Signature: Ramesh Kawwal
Date: 12/22/07

Department: ABE
Accepted By: MARK J. KUSTHAN
Signature: Mark J. Kusthan
Date: 1/8/08

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College of Engineering
Accepted By: MARK J. KUSHNER
Signature: Mark J. Kushner
Date: 1/3/08

Department: Civil, Construction, and Environmental Engineering
Accepted By: James E. Alleman
Signature: JE Alleman
Date: 12/31/2007

Memorandum of Understanding
College of Engineering and Engineering Departments

Establishing the Bioengineering Minor

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College of Engineering
Accepted By: MARK J. KUSHNER
Signature: Mark J. Kushner
Date: 1/3/08

Department: Chemical&Biolog. Engineering
Accepted By: James C. Hill
Signature: James C Hill
Date: 12/31/07

Memorandum of Understanding
College of Engineering and Engineering Departments

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College of Engineering
Accepted By: Mark J. KUSHNER
Signature: Mark J. Kushner
Date: 12-21-2007

Department: Electrical & Computer Eng.
Accepted By: Arun K. Somani
Signature:
Date: 12/13/07

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College of Engineering and Engineering Departments

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College of Engineering
Accepted By: MARK J. KUSHNER
Signature: Mark J. Kushner
Date: 1/3/08

Department: Ind & Manuf Sys Eng
Accepted By: Sarah Mirka
Signature:
Date: 12/21/2007

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College of Engineering
Accepted By: MARK J. KUSTHNER
Signature: Mark J. Kushner
Date: 1/3/08

Department: MATERIALS SCIENCE AND ENGINEERING
Accepted By: RICHARD LEGAR
Signature: Richard Legar
Date: 31 Dec 2007

Memorandum of Understanding
College of Engineering and Engineering Departments

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College of Engineering
Accepted By: MARK J. KUSHNER
Signature: Mark J. Kushner
Date: 12-21-2007

Department: Mechanical Engineering
Accepted By: Jonathan Wickert
Signature: Jon Wickert
Date: 12-12-2007