DATE: December 6, 2007  
TO: Vice Provost Randy Smith  
FROM: Subcommittee B (Barringer, Caron, Robinson, Winer)  
RE: Bachelor of Science in Biomedical Engineering

**Recommendation**
Subcommittee B recommends approving this proposal.

**Comments on this proposal**
The college of Engineering would like to create a new degree program leading to the Bachelor of Science in Biomedical Engineering. We requested and received letters of concurrence from Biological Sciences, Biochemistry, Chemistry, and Anatomy. Below are additional questions raised by the committee and the answers we received. Below that are additional comments received from Chemistry. Chemistry mentions already supplying a letter of concurrence, but they actually sent a letter of concurrence for the BS in Environmental Engineering.

1. How do you plan to change the requirements to meet the new GEC requirements of your college?

The overall GEC hours will be reduced from 40 to 35, and the overall hours from 198 to 193. The new College of Engineering guidelines will be used for the GECs: 10 hours in English and Communication Skills: (English 110 and a 2nd writing course); 25 hours across Social Sciences, Historical Study, and Arts & Humanities with a minimum of 5 hours and maximum of 10 hours per category.

2. The proposal (p4) mentions that most of the pre-med requirements will be met automatically and that the 3 professional electives can be taken in pre-med. If the student takes those 3 professional electives in pre-med, will they have met all of the pre-med requirements or will additional courses be required?

This is described in more detail in response to question 26, p. 17 of the proposal. In brief, because the language that most medical schools use for their requirements are general, e.g., "a year of biology/life sciences" the specific courses that could be used to satisfy the requirements could vary (e.g., use of physiology or not?) However, with the most conservative reading of requirements, students would need the 3 professional elective courses plus another 4 to 9 credit hours. As mentioned on p. 17, before the pre-med template is generated, we will check carefully with the OSU Medical School admissions office to see what they require and what they recommend.

3. Please describe what area of specialization your department plans to focus on and whether this
is expected to compete or complement the other programs in Ohio listed on p8.

To be viable as a biomedical engineering major, at least some of the multi-disciplinary aspects of the field must be included. The domains of expertise that we’ve chosen, based on current interests and areas we plan to grow, are described at the bottom of page 7: bioimaging; biomaterials; biomechanics; biotransport; Biomedical Device Design and Instrumentation (focused on Biomedical Micro- and Nano-technology); and Molecular, Cellular, and Tissue Engineering. This choice will complement other programs in Ohio, but enable us to develop and enhance distinctive advantages for study at OSU.

4. How much does the success of this program depend on the 4 new faculty positions listed on p19, and 2 staff positions on p20? If the funding is not available for this positions, can the program go forward as planned?

The program is dependent on additional personnel to add an undergraduate major to a department that has previously focused on research and graduate education. The 2 staff are critical at the start of the program, as well as the 2 faculty that we are currently seeking to hire. The additional 4 listed in the proposal would enable us to handle the anticipated enrollment of 75 students per/year, while building our graduate programs and research portfolio. If they are not available, the program would need to remain small, but could still be initiated. We also will need equipment for teaching laboratories in space that is currently being renovated.

I’ve attached a letter of endorsement from Dean Baeslack that went with the original version of the proposal that was submitted to the College of Engineering’s CCAA last year. In the letter, he commit support for additional faculty and resources to the department. We both want to make sure, however, that the timing of the additional faculty is such that they can be added in a fiscally sound fashion -- dependent on enrollments and upon research successes.

Date: Tue, 27 Nov 2007 13:30:18 -0500
From: Ed McCaul <Ed_McCaul@engadmin.ohio-state.edu>
Subject: FW: Concurrence request for Biomedical Engineering
To: barringer.11@osu.edu
Cc: hart.322@osu.edu, smith.70@osu.edu, halasek.1@osu.edu, dutta.2@osu.edu

Professor Barringer, Shown below are some additional comments from Chemistry along with a reply from Rich Hart. Please let me know if you have any questions about this message.

Ed McCaul

-----Original Message-----
From: Rich Hart [mailto:hart.322@osu.edu]
Hi Christopher:

Thanks for your concurrence and comments. As a followup, please see below:

On Nov 21, 2007, at 8:29 AM, Christopher M. Hadad wrote:

> 
> > Dear Rich and Ed,
> >
> > I have already provided my concurrence on this request.
> >
> > However, in parallel, I sent the information to one of my staff, and
> > they offered some additional comments which I did not note earlier.
> >
> > (1) You have used the old GEC model - seems like now that the new
> > model is in place and the program would be for new students, you
> > should be using the new GEC model.

You are right. We prepared this in October 2006, and I didn't want to change the proposal mid-stream after approved by the College. However, we will switch to the current reduced engineering GEC model, which I believe reduces the hours to 35 (from 40), before all is said and done.

> (2) You have Chem 245 being taken concurrently with Chem 231, but
> Chem 245 specifically requires COMPLETION of Chem 231 or 251 prior
> to taking Chem 245. That was not a change from the past -- however,
> it is a scheduling issue, especially for competency in the laboratory.

OK, if I understand correctly, students are not permitted to take 245 concurrently with 231? My experience has been that students take the intro course with an intro lab to complement each other. But if that's not an option for these 2 courses, then we'll have to shift 245 to their 3rd year. I'll assume that's the case, unless you tell me there is a possibility to make an exception.

> (3) You are requiring only Chem 231 rather than Chem 251-252. We do
> not know if faculty teaching Biochem 511 have considered that the
> students are poorly prepared for Biochem 511 based on the limited
> exposure in Chem 231.

We’re still waiting to hear from Biochemistry, but the on-line
bulletin states that a grade of "C" or higher in 231 is sufficient for
the organic pre-requisite.

Thanks for your comments, and for your help in getting this another
step in the vetting and approval process.

--Rich

PS: I expect that up to 20% or so of the students will be pre-med, and
will want to take more or different levels of organic chemistry, as
noted on p. 17 of the proposal (response to question 26). We will
check with the medical school to see what they suggest and what they
require (if different), before preparing the template for the pre-meds.

> Please use this information as you see fit.
>
> Best regards,
>
> Christopher
>
> Acting Chair
> and
>
> Vice Chair for Undergraduate Studies/Chemistry
>
> (614) 292-6723 (Chair’s office)
> (614) 292-1204 (Vice Chair’s office)
>
> Christopher M. Hadad   E-mail: hadad@chemistry.ohio-state.edu
> Professor               Phone: (614) 292-1204 (office)
> Department of Chemistry  Ohio State University  FAX:
> (614) 292-1685
> 100 West 18th Avenue     Office: 100C Celeste Laboratory
> Columbus, OH  43210-1185 http://www.chemistry.ohio-state.edu/~hadad
Professor Barringer, Shown below is a statement of concurrence from the Department of Biochemistry for Biomedical Engineering to use Biochemistry 511 as part of the Biomedical BS degree program. This is the last concurrence that you requested. Please let me know if anything else is needed. Thanks.

Ed McCaul

On Jan 3, 2008, at 4:30 PM, Richard P. Swenson wrote:

Hello Dr. Hart,

First I apologize for the delay in our response. Your concurrence request needed to be evaluated by the Department’s Curriculum Committee and with the end of quarter and holidays, that process was delayed.

The Department of Biochemistry concurs with your request to incorporate Biochemistry 511 into the required curriculum for your proposed B.S. degree program in Biomedical Engineering. We think that this course should provide your students with a solid background in the basic concepts in biochemistry.

We should note that this course is heavily subscribed to but we try to accommodate all of the students that wish to enroll. We have a particularly heavy demand in the Autumn Quarter. We offer the course all four quarters.

The Curriculum Committee asked for you to keep in mind the prerequisites for Biochemistry 511. These are Chemistry 123 and 242 or 252, and 2 qtrs of biological sciences. The organic chemistry requirement may also be satisfied by Chemistry 231 with a C grade or better. We have found that students who have a weak background and preparation in organic chemistry (thus the stipulation within the prerequisites) typically struggle in this course.

This course is rather intensive in that it covers much of the conceptual base of biochemistry in a single quarter. The class meets five days a week and the material is presented at a rapid pace. It is essential that students study the material after each lecture. We would ideally like to offer this as a two-quarter series, however most programs that require this course wish to have the biochemistry requirement fulfilled in one quarter to fit their curriculum.

Thank you for considering Biochemistry 511 in your curriculum.

Best regards,

-Richard P. Swenson, Chair
Dept. of Biochemistry
November 28, 2007

Edgar C. Hendrickson Professor and Department Chair
Department of Biomedical Engineering
The Ohio State University
270 Bevis Hall
1080 Carmack Rd.
CAMPUS

Dear Professor Hart:

I am writing to provide a letter of concurrence with the Department of Biomedical Engineering’s plan for its undergraduate curriculum in so far as Anatomy is concerned. The plan calls for a 2 credit hour course in anatomy for biomedical engineering students in their sophomore year.

Anatomy will offer a lecture with lab experience course for the biomedical engineering students. We will use prosections in the lab to provide a systems approach to anatomy. We plan to offer the course to your first sophomore class (about 25 students), which would appear to be in the spring of 2009. I understand that the projected enrollment is 75 students within four years.

We are planning the course now and will soon submit a New Course Request. The course will be listed as an Anatomy 2XX course, probably Anatomy 210.

I wish you good luck in the new biomedical engineering undergraduate program at OSU.

With best wishes,

Kenneth H. Jones, Ph.D.
Director
Dear Dr. Hart:

I am pleased to offer my strong support of the proposed Biomedical Engineering major. We have often fielded queries from prospective students about the availability of an undergraduate major in this area, so I am certain that you will see considerable student demand for this major. I hope that we can continue discussions between our units about how to make the BME major and minor visible and attractive to students with majors in the College of Biological Sciences.

As Director of the (proposed) Center for Life Sciences Education, the unit which delivers all of the Biology courses, I understand that our courses Biology 113 and H115 are part of the proposed BS in BME curriculum and I agree that we will be able to handle the associated student load. As you may know, Dave Stetson in our college is spearheading the development of a one-quarter introductory biology course that is targeted to Engineering students generally, and we will make sure you have an early opportunity to consider whether this course is appropriate for the BME major.

Regards,

[Signature]

Caroline Breitenberger, Ph.D.
Associate Dean, College of Biological Sciences
Date: 12 April 2007

To: Randy Smith

From: Ed McCaul
Secretary College Committee on Academic Affairs

Subject: Biomedical Engineering Bachelor of Science Degree

Attached is a proposal from the Department of Biomedical Engineering requesting the creation of a Bachelor of Science Degree in Biomedical Engineering. This proposal has been unanimously approved by the College of Engineering's Committee on Academic Affairs. Biomedical Engineering has requested that the courses that are part of the proposal be processed immediately and not wait for the proposal's final approval. Consequently, I will be bringing the course requests to your office for processing at this time.
I. This proposal for a new undergraduate major is transmitted by the college to the Office of Academic Affairs. The proposal must be accompanied by a letter from the dean(s) that describes college resources committed to the program and the relationship of the new major to other priorities of the college.

II. GENERAL INFORMATION

1. Give the name of proposed major:
   Biomedical Engineering

2. State what degree students completing the major will receive:
   Bachelor of Science in Biomedical Engineering

3. State the proposed implementation date:
   Autumn 2007

4. Identify the academic units (e.g., department, college, etc.) responsible for administrating the major program.
   Department of Biomedical Engineering, College of Engineering

III. RATIONALE/GOALS/OBJECTIVES

5. Describe the rationale/purpose of the major.
   First, what is biomedical engineering? (Note that bioengineering and biomedical engineering are terms that have been used almost interchangeably, although biomedical engineering implies a stronger focus on human health applications and is the name of OSU’s new Department):

   During the past 25 years, biomedical engineering has become accepted as an important field of interdisciplinary study and research. The growth of the field was especially rapid in the late 1980’s and early 1990’s, and in July 1997 the National Institutes of Health issued a working definition of Biomedical Engineering:

   “The discipline of biomedical engineering lies at the forefront of the medical revolution. Advances in biomedical engineering are accomplished through interdisciplinary activities that integrate the physical, chemical, mathematical, and computational sciences with engineering principles in order to study biology, medicine, and behavior.”

   Following the consensus workshop, the newest NIH institute, NIBIB (National Institute of Biomedical Imaging and Bioengineering) was established in December 2000. More recently, in January 2006, the Board of Directors of BMES (Biomedical Engineering Society) made further progress in defining the field in response to a request from the National Research Council for a draft taxonomy for biomedical engineering. The suggestion is that the following seven domains become recognized as representative of this intrinsically interdisciplinary field:
1. Bioelectrical and neural engineering
2. Bioimaging and biomedical optics
3. Biomaterials
4. Biomechanics and biotransport
5. Biomedical devices and instrumentation
6. Molecular, cellular, and tissue engineering
7. Systems and integrative engineering

Second, the rationale for the major:
Although it is conceivable that any one of these domains could be developed as part of existing traditional engineering departments, in order to capture the interdisciplinary nature of the field and integrate engineering and life sciences, distinct educational programs are needed. These programs are increasingly attractive to excellent students: the number of currently enrolled undergraduate biomedical engineering students in the US quadrupled between 1979 and 2003 as new departments have been started across the nation.

Third, is there a need to increase the number of biomedical engineering graduates?
Although it is important to recognize the uncertainty inherent in making predictions, it is of interest to note the recent US Department of Labor Statistics Report (February 2004) (http://www.bls.gov/opub/mlr/2004/02/art5full.pdf). The report projects a growth of biomedical engineering jobs between 2002-2012 as 26.1%, almost double the overall job growth prediction (14.8%). This compares to more modest projected growth in “the big-4” traditional engineering disciplines: 0.4% for Chemical Engineers, 8% for Civil Engineers, 2.5% for Electrical Engineers, and 4.8% for Mechanical Engineers.

Finally, Biomedical Engineering at the Ohio State University:
Although graduate degrees in biomedical engineering have been offered through the Graduate School since the Biomedical Engineering Center was formed in 1971, the Ohio State University does not offer an undergraduate degree in biomedical engineering.

In November 2005, the Biomedical Engineering Center became the Department of Biomedical Engineering, the ninth engineering Department in the College of Engineering. By investing in the potential and existing strength of its health sciences and engineering, the Ohio State University is now poised to join other top-ranked Colleges of Engineering by offering a high quality undergraduate program in biomedical engineering.

6. State the general and specific educational goals and objectives of the major.
Beginning in July 2006, the BME faculty embarked on a process of strategic planning for the new department and the undergraduate major. We started with a candid SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis with full faculty involvement. We have objectively identified our current domains of research activity by doing a word frequency analysis of the most recent 10 journal article titles and keywords from each faculty member. The faculty examined trends in curricular development and mission statements from other biomedical engineering departments, and brainstormed to develop a consensus for the mission statement (over 25 potential mission statements were suggested). We have developed a vision statement and curricular philosophy statements, in addition to statements of undergraduate program objectives and program outcomes.

We have used the extensive planning process to develop and articulate a clear strategy and vision for the department and for the undergraduate major. While acknowledging previous curricular planning efforts, by approaching the program from a strategic view, we have essentially developed a new curriculum from a “blank page.”
The following statements regarding the Department’s Vision, Mission, Curriculum Philosophy, Program Objectives, and Program Outcomes provide the framework not only for this proposal, but are important steps toward eventual accreditation by ABET (American Board for Engineering and Technology). These statements are being vetted with stakeholders (participating faculty, students, alumni, External Advisory Committee, etc.) prior to their formal adoption.

**Mission:**

*To promote learning and discovery that integrates engineering and life sciences for the advancement of human health*

**Vision:**

The Department of Biomedical Engineering at the Ohio State University will be nationally ranked and internationally recognized for:

- The distinctive educational opportunities for its students and the outstanding achievements of its alumni
- Faculty and staff excellence and opportunities for continuing professional development
- Collaborative research with global impact on improving human health
- Service to the field of biomedical engineering and the community

**Undergraduate Program Objectives:**

The objective of our biomedical engineering undergraduate program is to provide educational opportunities for students to creatively integrate engineering and life sciences so that graduates can successfully pursue:

- Advanced study leading to research or professional practice in biomedical engineering
- Advanced study leading to research or professional practice in health care
- Careers in biomedical engineering industries or related technical and professional fields.

**Undergraduate Program Outcomes:**

Graduates from the biomedical engineering program will have demonstrated that they possess the ability to:

- Apply knowledge of mathematics, science, and engineering
- Design and conduct experiments, as well as to analyze and interpret data
- Design a system, component, or process to meet desired needs
- Function on multi-disciplinary teams
- Identify, formulate, and solve engineering problems
- Understand professional and ethical responsibility
- Communicate effectively
- Understand the impact of engineering solutions in a global and societal context
- Recognize the need to engage in life-long learning
- Demonstrate knowledge of contemporary issues
- Use the techniques, skills, and modern engineering tools necessary for engineering practice
- Solve problems at the interface of engineering and biology
- Measure and interpret data from living systems.
Undergraduate Program Guiding Philosophies and Features:

Guiding Philosophies and Features:

- Embrace the multidisciplinary nature of biomedical engineering. Take full advantage of existing strong science, math, and engineering science courses at OSU.
- Develop new BME “domain courses” that integrate engineering and life sciences (5 or 6 to be developed initially, undergraduates choose minimum of 3, insuring breadth in biomedical engineering content):
  - Each course to feature domain content with common threads: Creativity, Writing, Labs, Modeling/Simulation.
- Find and exploit distinctive curriculum features:
  - Quantitative Physiology, Domain courses, Team Design (Spring team design show).
- Satisfy most pre-med requirements automatically; make room in the curriculum to accommodate any added pre-med courses.
- Require a minimum of 2 BME advanced-level (6/7XX) follow-up courses (enabling focus) that have a domain course as the pre-requisite
- Require 3 “Professional Electives” (ProfE), an approved sequence of technical electives that allow students to achieve professional goals (e.g., pre-med, independent research, honors thesis, minors, domain depth or breadth, etc.)

7. Identify any unique characteristics or resources that make it particularly appropriate for Ohio State to offer the proposed major.

Background and History:
The Ohio State University was the first public university in Ohio and among the first public universities in the nation to offer distinct programs in biomedical engineering. Under the leadership of its first director, Professor Herman Weed, the Biomedical Engineering Center was established in 1971 as part of the Department of Electrical Engineering. The first M.S. and Ph.D. degrees were granted in 1975 and 1977, respectively. Since that time, BME has awarded 281 M.S. degrees and 96 Ph.D. degrees (through Summer 2006).

In 1988, the Biomedical Engineering Center was restructured as a fully independent academic unit within the College of Engineering. This reorganization included the appointment of a new director, J. Fredrick Cornhill, the establishment of new faculty lines, and the assignment and renovation of space in Bevis Hall on the West Campus.

The BME Center received an Academic Enrichment Award in 1999, and a Selective Investment Award in collaboration with the College of Medicine and Public Health in 2000 under the direction of Professor Mauro Ferrari. Funding from these awards included faculty lines in the areas of biomedical nanotechnology, tissue engineering, bioMEMS, biomaterials, robotic surgery, and biomedical imaging. The Center also secured a $1.5 million endowment from the Kettering Fund, specifically earmarked for undergraduate education.

Professor Andreas von Recum, appointed director of the Biomedical Engineering Center in August 2003, led the transformation of the Center into a Department of Biomedical Engineering in the College of Engineering. The process culminated in the approval by the Board of Trustees in November 2005, and Professor von Recum became the first Chair in January 2006. Professor von Recum was appointed Professor Emeritus in July 2006.
Current Status and Potential:

With the recent hiring of Richard T. Hart as the new Chair in July 2006, the Department currently has 15 core BME faculty members (9.5 FTE’s). The Dean of the College of Engineering has committed to hiring an additional BME faculty member in 2006-07 and a second faculty member in 2007-08. Pending the acceptance of a departmental business plan that outlines fiscally responsible growth opportunities, additional faculty lines are expected for the department (4 additional FTEs and 2 additional staff members are proposed in the initial budget that accompaniies this proposal). There are also approximately 60 BME “participating faculty” members from colleges across campus (participating faculty members support, advise, and examine graduate students and collaborate in research programs through the BME Department). Current BME enrollment is 41 graduate students (10 M.S. and 31 Ph.D.).

The combined technical and clinical research facilities of the College of Engineering, the College of Medicine and Public Health, and the College of Veterinary Medicine, in proximity to the medical center of the Ohio State University Hospitals, provide unique and extensive resources for biomedical education and research.

Building on these collaborative ties and the strength of the existing BME Department and Graduate Degree Programs, the proposed undergraduate degree program is poised to become a leading program in the field of Biomedical Engineering.

8. Cite the benefits for students, the institution, and the region or state.

The proposed undergraduate program in Biomedical Engineering is an important outcome of the university’s Academic Plan. Each of the 6 strategies will be addressed by the implementation of a “full-service” department of biomedical engineering that includes an undergraduate educational program in addition to the existing graduate program.

In particular, the new program will help allow us to:

1. Develop academic programs that define Ohio State as the Nation’s leading public land grant university. Over the past 25 years, Biomedical engineering has emerged as a legitimate – if multidisciplinary – branch of engineering. Ohio State is well positioned to progress toward its goal of being the leading public land-grant university by building upon two of its acknowledged areas of greatest strength: medicine and engineering. The potential to fully develop and exploit biomedical engineering will be realized only after our Department’s offerings include the full range of degree programs traditionally offered in engineering departments and are positioned to strategically integrate engineering and medicine.

2. Build a world-class faculty. We will seek faculty who have fundamental interests in research and teaching and who have the potential to attract students, collaborators, and research funding to advance the growing field of biomedical engineering. We plan to selectively grow the size of the faculty and develop distinctive domains within biomedical engineering that are of world-class caliber.

3. Enhance the quality of the teaching and learning environment. The new undergraduate major in biomedical engineering offers the potential to provide exceptional opportunities for students and faculty to generate and apply knowledge in an exciting and growing field. The undergraduate curriculum will build on the existing strengths of sciences and engineering sciences at Ohio State. In addition, distinctive “domain courses” will be developed that truly integrate engineering and medicine. These will include experience with hands-on labs, in silico simulation and modeling, and sharpening technical communication skills. The rigor and quality of these distinctive “domain courses” will provide a particularly rich addition to the teaching and learning environment at OSU.
4. **Enhance and better serve the student body.** The popularity of combining engineering and life sciences as the technical underpinnings for a career is clearly evident. At several private universities (with substantially smaller schools of engineering than at OSU), biomedical engineering has become the largest engineering major (e.g., Johns Hopkins, Duke, Tulane). Just as evident at these universities is the high quality of the motivated students that seek to tackle a broad and challenging multidisciplinary field. No doubt, an undergraduate program will attract many outstanding students to engineering and to OSU.

5. **Create a diverse university community.** Although it continues to be a challenge to attract women and minority students to engineering, biomedical engineering programs at other institutions generally lead other engineering fields in percentage of women. Unfortunately, similar comparisons are not available for minority students because the data are not known. The aggressive outreach programs in the OSU College of Engineering coupled with a new undergraduate program in biomedical engineering will lead to enhancing the diversity of the university’s engineering community.

6. **Help build Ohio’s future.** The Academic Plan specifically calls for efforts to become the catalyst for the development of Ohio’s technology-based economy. The potential for spin-off companies, enhanced medical care via biomedical engineering discovery, and the education of outstanding students can serve as ingredients for realizing the goal of strengthening and diversifying the future of the state.

9. **List similar majors offered in both public and private institutions in Ohio and the U. S. Explain how these majors compare to the one proposed.**

Below is the list of the 42 undergraduate Bioengineering/Biomedical Engineering programs that are ABET accredited as of October 2006, along with the year the program was first accredited. (From http://www.abet.org)

<table>
<thead>
<tr>
<th>University</th>
<th>Location</th>
<th>Year accredited</th>
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<tbody>
<tr>
<td>Duke University</td>
<td>Durham, NC</td>
<td>1972</td>
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<tr>
<td>Rensselaer Polytechnic Institute</td>
<td>Troy, NY</td>
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<td>University of Illinois at Chicago</td>
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<td>1976</td>
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<td>Case Western Reserve University</td>
<td>Cleveland, OH</td>
<td>1977</td>
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<tr>
<td>Texas A &amp; M University</td>
<td>College Station, TX</td>
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<td>Louisiana Tech University</td>
<td>Ruston, LA</td>
<td>1978</td>
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<td>Tulane University</td>
<td>New Orleans, LA</td>
<td>1981</td>
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<td>Marquette University</td>
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<td>Arizona State University</td>
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<td>University of Iowa</td>
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<td>Wright State University</td>
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<td>Syracuse University</td>
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<td>University of Miami</td>
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<td>University of Wisconsin-Madison</td>
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<td>University of Michigan</td>
<td>Ann Arbor, MI</td>
<td>2006</td>
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<tr>
<td>State University of New York at Stony Brook</td>
<td>Stony Brook, NY</td>
<td>2006</td>
</tr>
<tr>
<td>Oregon State University</td>
<td>Corvallis, OR</td>
<td>2006</td>
</tr>
<tr>
<td>Western New England College</td>
<td>Springfield, MA</td>
<td>2006</td>
</tr>
</tbody>
</table>

Note that of the 42 programs listed, half (21) became accredited since 2000.

In Ohio, there are five accredited undergraduate programs:
- Case Western Reserve University, Cleveland 1st accredited in 1977
- Wright State University, Dayton 1st accredited in 1988
- The University of Toledo, Toledo 1st accredited in 2000
- The University of Akron, Akron 1st accredited in 2003
- The University of Cincinnati, Cincinnati 1st accredited in 2006

The interdisciplinary breadth of the field – coupled with the relatively recent formation of departments – leads to more curricular variety in BME compared to traditional engineering departments. Educational programs in BME are generally based on the local research interests, collaborations, and facilities. Further, the seven representative “domains” listed above (in item 5) have only recently been articulated, and the list does not include a host of other “niche domains” that are nonetheless distinct and valid biomedical engineering activities.

Given the variety of the programs, it’s difficult to make detailed comparisons, but the following describes our plans and then lists emphasis topics at other Ohio institutions.

**OSU Planned Emphasis**

The specific choices made in the proposed curriculum for OSU are shaped by the guiding philosophies for the program (see response to item 6, above). The initial “domain courses” reflect the expertise and interest of current faculty members, and will be distinct courses in the proposed curriculum. Each undergraduate domain course will be designed to fully integrate topics in engineering and medicine, and will be the pathway to follow-up advanced-level courses, allowing substantial focus in the domain for undergraduates. We plan to offer domain courses in:

- Bioimaging
- Biomaterials
- Biomechanics
- Biotransport
- Biomedical Device Design and Instrumentation: Biomedical Micro- and Nano-technology
- Molecular, Cellular, and Tissue Engineering

(Note these choices reflect a subset of the domains recently articulated by BMES and listed in response to part 5, above).
The domains chosen for OSU’s curriculum were identified during the word frequency analysis of the core faculty’s 10 most recent publications. These areas are where faculty expertise will enable development of innovative course sequences starting from 3rd year undergraduate offerings and stretching to intermediate and advanced level graduate courses. This sequence is thus well suited to build on strengths unique to The Ohio State University.

**Other Programs in Ohio**
A very brief description of other programs in Ohio follows for comparison:

**Case Western Reserve University:**
BME “Specialty Sequences:”
- Orthopaedic and polymeric biomaterials
- Biomechanics
- Devices & sensors for biomedical instrumentation
- Biomedical imaging and computing
- Biomedical systems & control

**Wright State University:**
“Curriculum A prepares the graduate for the engineering industry employment. Graduates are also prepared for graduate training in biomedical engineering or in a traditional engineering area.”
“Curriculum B (pre-med track) also satisfies the admission requirements for medical, osteopathic, dental, or veterinary schools. Graduates are also well prepared to pursue graduate training in engineering or the life sciences.”

**University of Toledo:**
Suggested technical course sequences:
- Biochemical Engineering
- Biomechanics
- Neuroengineering & Nanotechnology
- Optics & Imaging
- Pre-Medicine
- Tissue Engineering

**University of Akron:**
Two tracks:
- Biomechanics
- Instrumentation, Signals, and Imaging

**University of Cincinnati:** (5-year BS program with required CO-OP)
Two curricular options:
- Biomechanics
- Medical Device Innovation

10. **Cite the enrollment patterns of similar majors in Ohio or in the United States.**
Data from the Engineering Workforce Commission of the American Association of Engineering Societies and published on-line (http://bluestream.wustl.edu/WhitakerArchives/glance/enrollments.html) shows that the enrollment in undergraduate bioengineering/ biomedical engineering programs in the United States quadrupled between 1979 and 2003.
During this same period, the enrollment in all undergraduate engineering programs fluctuated, with 2003 enrollment approximately the same as in 1981.

11. Describe career opportunities and/or opportunities for graduate or professional study available to persons who complete the major.

Each year, a survey is conducted by the Academic Council of AIMBE (American Institute for Medical and Biological Engineering) to determine the placement of undergraduate biomedical engineering students. Portions of the results are published on the web (http://aimbe.org/content/index.php?pid=201). The most recent data continue to show the trend of continued education as the top choice for BS graduates in biomedical engineering -- over half to graduate school (generally in engineering) or to medical school. Students also pursue MBA degrees, LLD degrees, or other health care delivery careers (e.g., dentistry). Approximately one-third of the BS graduates go directly to the job market, securing positions in government (e.g., FDA, NASA), the medical device industry (e.g., Zimmer, Johnson & Johnson), or other related technical fields.

These national trends are reflected in the three objectives we propose for the OSU program, (listed in response to part 6, repeated here):

The objective of our biomedical engineering undergraduate program is to provide educational opportunities for students to creatively integrate engineering and life sciences so that graduates can successfully pursue:
Advanced study leading to research or professional practice in biomedical engineering
Advanced study leading to research or professional practice in health care
Careers in biomedical engineering industries or related technical and professional fields.

At OSU, we will help students prepare for these career paths by making clear what steps are needed prior to graduation to enable later successes.

- Students planning to go to graduate school will be advised to pursue opportunities for independent research projects (e.g., honors thesis), advised about planning the sequence of Professional Elective courses based on anticipated future studies, and kept informed about the GRE process.

- Students planning to attend medical school will need to take a specific organic chemistry sequence for their Professional Electives, and will be kept informed about the MCAT process.

- Students planning to go directly to the job market will be advised to work closely with Engineering Career Services and aggressively seek summer internship opportunities. They will receive advice about focusing Professional Electives to develop areas of concentration attractive to potential employers, and will be strongly encouraged to take the FE (Fundamentals of Engineering) licensing exam.

12. Describe any licensure or certification for which this major will prepare students.
   The focus of the FE (Fundamentals of Engineering) exam, the first step toward professional licensing, is to test breadth in science and engineering science courses. Seniors in BME will be very well prepared for the exam, based on the breadth of the science and engineering science courses in the curriculum.

   There is currently no PE (Professional Engineering) exam for biomedical engineering.

IV. RELATIONSHIP TO OTHER PROGRAMS

13. Describe current major and minor programs in the department(s) and how they relate to the proposed major.
   There is no current undergraduate major in biomedical engineering. There is a minor program that includes a subset of courses offered in the current graduate program. The minor program will be revised following the approval of the major program.

14. Identify any overlaps with other programs or departments within the University. Append letters of concurrence or objection from related units.
   Not applicable.

15. Indicate any cooperative arrangements with other institutions and organizations that will be used to offer this major.
   Not applicable.

16. Specify any articulation arrangements (direct transfer opportunities) with other institutions that will be in effect for the major.
   As described in response to 19, below, during the initial years of the major when enrollments will be limited, transfer students will generally not be accepted unless they can join a suitable cohort of students entering the program in the sophomore year. Once the facilities are
appropriate to handle additional students, agreements with other institutions will be based on finding equivalences between courses and providing this information to both Ohio State Admissions, and to potential students and their advisors at the institutions with agreements. Transfer students will have to meet all the criteria for entry into the program as an Ohio State student, but transfer credits for each course will be publicly known, so that students can plan their programs through more than one institution.

17. Provide information on the use of consultants or advisory committees in the development of the major. Describe any continuing consultation.

The current version of the curriculum has had a long gestation period. While still a Center, the core faculty discussed curricular options in 2001 and again during the 2004-05 and 2005-06 academic years, when a BME curriculum committee with college-wide membership was established. The College of Engineering Associate Dean for Academic Affairs and Student Services was consulted for formative feedback, and an earlier version was vetted for comment to current students and the External Advisory Committee.

As we move from planning the ideal academic program toward its implementation, meetings are planned with a host of staff and faculty at OSU in order to: build on best practices for labs; find suitable temporary facilities while renovations for teaching labs are completed and equipment obtained; and to seek help with finding internship and career opportunities for students. Initial meetings have included Professor Bruce Biagi (Associate Director for the School of Biomedical Science) Professor Allan Yates (Director of the Integrated Biomedical Science Program), Rosemary Hill (Director of Engineering Career Services), and Rich Rosen (VP External Business Relations, Battelle). Additional meetings with a variety of Engineering and Medical School colleagues will help insure a smooth realization of the proposed plans.

Current graduate students were given the opportunity to comment on the proposed sequence of courses for the undergraduate major. Their responses were generally favorable but they did raise several concerns that we will examine as we fine-tune advising practices and course sequencing. A summary of critical comments includes:

- Freshman year looks to be quite challenging, and the FEH sequence may not fit
- Spring quarter of sophomore year will be intense for BME majors
- Look to include biology in Year 1 if possible (will also help with research early in program)
- Design course and undergraduate research are of particular interest to students
- May need to look more closely at pre-med biology requirements

18. Indicate whether this major or a similar major was submitted for approval previously. Explain at what stage and why that proposal was not approved or was withdrawn.

A proposal was submitted April 30, 2001, and tabled by the College of Engineering Committee on Academic Affairs. The 2001 submission consisted of individual “tracks.” In addition, the BME Center at the time had only 7 faculty members with a total of 5 FTE’s.

Following the transition from a Center to a Department and the appointment of the new Department Chair in July 2006, planning began anew. The prior mission statement and objectives, suitable for a Center, were updated with Mission, Vision, Objective and Outcome statements suitable for the new Department. The high-level, strategic discussions drove the formulation of the educational program, resulting in the current version of the curriculum. The two biggest changes in the new version are from:
Embracing the multi-disciplinary nature of the field
  • Which led to requiring broad science and engineering science courses for all
    students, and elimination of “tracks” in favor of more flexible sequences of
    Professional Electives
Identifying the core BME educational goal of integrating engineering and life sciences
  • Which led to the formation of “domain courses”

The current proposal is from the new Department of Biomedical Engineering that has 15 faculty
members (9.5 FTEs) and commitments from the College to add at least 2 additional FTEs in
BME by the end of the 2007-08 academic year. Pending the formulation and acceptance of a
departmental business plan that outlines fiscally responsible growth opportunities, additional
faculty lines are expected for the department (4 additional FTEs are proposed in this proposal).

19. Indicate where students will be drawn from, e.g., existing academic programs, outside of
   the University, etc. Estimate the mix of students entering the major internally and
   externally.

   The new program in biomedical engineering is expected to attract new students to the College of
   Engineering. Initially, some of the students joining this program will likely come from within
   Ohio State; however, new CoE undergraduates will be attracted to Ohio State once the proposed
   program is established, as predicted by the increasing enrollment in biomedical engineering
   nationwide.

   In particular, the BME program is expected to attract a significant number of women to the
   College of Engineering. Nationally, the percentage of women engineering students is only about
   20%. Recent data presented during the March 2007 meeting of the American Institute of Medical
   and Biological Engineering in Washington DC indicated that 46% of the BS degrees in BME
   went to women in 2005; 42% of the MS degrees, and 30% of the Ph.D. degrees. Recognizing
   that the statistics of small numbers can be misleading, we nonetheless expect that the BME
   program at OSU will be similar to these national averages, and we will actively encourage a
   diverse student population.

   Students will be able to enter the proposed BS BME program by several routes. Most common
   will be by direct enrollment in the College of Engineering as a pre-BME major when they enter
   the University. Other students will enter the proposed BME program from the engineering
   undecided ranks in the College of Engineering. A third source is students transferring from other
   OSU engineering programs. Occasionally, students may enter the program from a non-
   engineering program within OSU or as a transfer from another university. It is expected that a
   few students will choose to double-major in BME and another OSU program.

   **Enrollment Management:**
   **General:**
   Students must first be accepted into the College of Engineering. Incoming students will be
classified as pre-majors until they have completed Math 153, Physics 132, Chemistry 123,
and Engineering 183 at which time they can apply to enter the (proposed) Biomedical
Engineering program as a major (see below).

   **Honors:**
   We plan to use the same language noted on the Fundamentals of Engineering for Honors
Program web page for the Pre-Chemical Engineering students. “Pre-Biomedical
Engineering majors will be faced with the challenge of completing the required three
quarters of chemistry in the freshman year in addition to the FEH courses. Some advanced
placement or post-secondary credit in chemistry is advantageous, and pre-Biomedical
Engineering majors who choose to accept the challenge of the FEH program may substitute Chem 123 for ME H210 in Spring Quarter.”

**Enrollment Limits: Numerical caps**

Because of the need to develop new BME courses, with attendant lab spaces and facilities, enrollment will be limited to 25 new students initially, with an expected increase to 75 students per year in year 4 (see response to item 20, following). Once that level of enrollment has been reached, and depending upon student interest and appropriate facilities and sufficient faculty, enrollment limits would be re-examined.

During the first years while the number of majors is ramping from 0 to 75, enrollment in most BME courses will be restricted to majors only so that we can plan for needed renovations and lab facilities. In addition, courses will be taught just once per year, so opportunities for Co-op students will also be limited, at least initially.

**Application Procedure:**

A formal application process is needed to limit enrollment as the BME program is “rolled out” with courses and labs taught for the first time just ahead of the cohort of students moving through the sequence. A two-part application procedure is proposed to produce a well-prepared, motivated, diverse cohort of students that is willing to take the role of pioneer as we smooth the rough edges that will invariably be part of the new major.

Initial applications will be invited at the end of the Spring quarter for 1st year students, and based on the quality of the applications, interviews will be scheduled during the Autumn quarter prior to admission decisions prior to the start of the following Winter quarter.

**Part 1:** Initial applications are encouraged from 1st year students by June 1, but no later than August 1. A form will be developed for students to complete with self-reported grades in the pre-major courses (listed above). Grades for courses in progress will be included by the Department during the summer. Students will be asked to include an essay that asks about the student’s interest and career goals, and how a BS on biomedical engineering will enable them to study topics of most interest and to succeed in achieving career goals.

**Part 2:** During the initial weeks of the Autumn quarter, students may be invited to interview with BME faculty members based on the cumulative point-hour ratio (CPHR) and the secondary point-hour ratio (SPHR*) and the student essay. Following the interviews, admission decisions will be made prior to the start of pre-registration for the Winter quarter.

*SPHR is based on the technical courses in the curriculum (all courses except the GEC courses not specified by the major).

Following the start-up phase admission to the major will be made consistent with college procedures. Prior to admission of students into the major, a policy will be prepared regarding the required standards of academic achievement for continuing students, as well as processes for cases of probation, academic dismissal, reinstatement, and appeals.

V. **STUDENT ENROLLMENT**

20. Indicate the number of students you anticipate will be admitted to the major each year.

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time</td>
<td>25</td>
<td>25</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>Part-time</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
Estimated Summer enrollments:

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Part-time</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

VI. REQUIREMENTS

21. List the courses (department, title, credit hours, description) that constitute the requirements and other components of the major. Indicate which courses are currently offered and which will be new. Append a quarter-by-quarter sample program and all New Course, Course Change, and Course Withdrawal forms necessitated by the implementation of the proposed major.

<table>
<thead>
<tr>
<th>Department</th>
<th>Title</th>
<th>Credit Hours</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH</td>
<td>Math 151 (Calc and Analytic Geom)</td>
<td>5</td>
<td>Limits, continuity, derivatives, Mean Value Theorem, extrema, curve sketching, related rates, differentiation of the trig, log, and exp functions</td>
</tr>
<tr>
<td></td>
<td>Math 152 (Calc and Analytic Geom)</td>
<td>5</td>
<td>Integrals, area, fundamental theorems of calculus, logarithmic and exponential functions, trigonometric and inverse trigonometric functions, methods of integration, applications of integration, polar coordinates.</td>
</tr>
<tr>
<td></td>
<td>Math 153 (Calc and Analytic Geom)</td>
<td>5</td>
<td>Indeterminate forms, Taylor's formula, improper integrals, infinite series, parametric curves, and vectors in the plane; vectors, curves, and surfaces in space.</td>
</tr>
<tr>
<td></td>
<td>Math 254 (Calc and Analytic Geom)</td>
<td>5</td>
<td>Partial differentiation, Lagrange multipliers, multiple integrals, line integrals, and Green's theorem.</td>
</tr>
<tr>
<td></td>
<td>Math 415 ( Ordinary and Partial DEQ)</td>
<td>4</td>
<td>Ordinary, partial, linear, and nonlinear differential equations; Fourier series; boundary value problems; and Bessel functions.</td>
</tr>
<tr>
<td></td>
<td>STAT 427 (Prob and Stat I)</td>
<td>3</td>
<td>Introduction to probability, discrete and continuous random variables, expected value, and sampling distributions.</td>
</tr>
<tr>
<td>CHEMICAL SCIENCES</td>
<td>Chem 121 (General Chemistry)</td>
<td>5</td>
<td>First course for science majors and engineering students, covering dimensional analysis, atomic structure, the mole, stoichiometry, chemical reactions, thermo chemistry, electron configuration, periodicity, bonding, and molecular structure.</td>
</tr>
<tr>
<td></td>
<td>Chem 122 (General Chemistry)</td>
<td>5</td>
<td>Continuation of 121 for science majors, covering acids and bases, redox reactions, gases, liquids, solids, solutions, colligative properties, kinetics, and chemical equilibrium.</td>
</tr>
<tr>
<td></td>
<td>Chem 123 (General Chemistry)</td>
<td>5</td>
<td>Continuation of 122 for science majors, covering solubility and ionic equilibrium, qualitative analysis, thermodynamics, electrochemistry, descriptive chemistry, coordination compounds, and nuclear chemistry.</td>
</tr>
<tr>
<td></td>
<td>Chem 231 (Intro Organic Chem)</td>
<td>3</td>
<td>A condensed presentation of organic chemistry organized by functional groups with an emphasis on practical application.</td>
</tr>
<tr>
<td></td>
<td>Chem 245 (Organic Chem Lab 1)</td>
<td>2</td>
<td>Introduction to the scientific writing, computational chemistry and laboratory techniques of organic chemistry, including synthesis, isolation, purification, and identification of organic compounds.</td>
</tr>
<tr>
<td></td>
<td>BioChem 511 (BioChemistry)</td>
<td>5</td>
<td>An introductory course in biochemistry dealing with the molecular basis of structure and metabolism of plants, animals, and microorganisms. (Pre-reqs: ... organic chemistry requirement may also be satisfied by Chem 231 with a C grade or better)</td>
</tr>
<tr>
<td>PHYSICAL SCIENCES</td>
<td>Physics 131 (Particles and Motion)</td>
<td>5</td>
<td>Major concepts of physics from a contemporary point of view; for students in physical sciences, mathematics, or engineering.</td>
</tr>
<tr>
<td></td>
<td>Physics 132 (Electricity and Mag)</td>
<td>5</td>
<td>Continuation of 131.</td>
</tr>
<tr>
<td></td>
<td>Physics 133 (Electrodyn and Quant)</td>
<td>5</td>
<td>Continuation of 132.</td>
</tr>
<tr>
<td>LIFE SCIENCES</td>
<td>Biol 113/115 (General Biology I)</td>
<td>5</td>
<td>Exploration of biology and biological principles; topics include cell structure and function, reproduction and development of plants and animals, bioenergetics, genetics, and evolution.</td>
</tr>
<tr>
<td></td>
<td>EEOB 232 (Intro Physiology )</td>
<td>5</td>
<td>A survey of the human nervous system, sense organs, muscle function, circulation, respiration, digestion, metabolism, kidney function, and reproduction.</td>
</tr>
<tr>
<td></td>
<td>EEOB 415 (Animal Cell and Develop)</td>
<td>4</td>
<td>Introduction to the structure and function of animal cells, and to patterns of early development in vertebrates and invertebrates.</td>
</tr>
<tr>
<td>COURSE CODE</td>
<td>COURSE TITLE</td>
<td>CREDIT HOURS</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
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<td>-------------</td>
</tr>
<tr>
<td>Engr 100 (Engr Survey)</td>
<td>1</td>
<td>Academic requirements; University procedures, grading system, and resources; overview of engineering academic areas of study and series</td>
<td></td>
</tr>
<tr>
<td>Engr 181 (Intro to Engr I)</td>
<td>3</td>
<td>Visualization and sketches, introduction to spreadsheets and CAD, working drawings, experimental design and data analysis, problem solving approaches, hands-on lab, reporting, and production dissection</td>
<td></td>
</tr>
<tr>
<td>Engr 183 (Intro to Engr II)</td>
<td>3</td>
<td>Team building, design/build project; project management, introduction to MATLAB, written and oral reports, preparation of visual aids, hands-on lab and reporting</td>
<td></td>
</tr>
<tr>
<td>MSE 205 (Intro Mat Sci)</td>
<td>3</td>
<td>Structure, processing, properties, and applications of metals, ceramics, polymers, and composite materials</td>
<td></td>
</tr>
<tr>
<td>ME 410 (Statics)</td>
<td>4</td>
<td>Vector concepts of static equilibrium for isolated and connected bodies, centroids, inertia, truss, frame and machine analysis, shear force and bending moment diagrams, and friction</td>
<td></td>
</tr>
<tr>
<td>ME 420 (Intro Strength Mat)</td>
<td>4</td>
<td>Stress and strain analysis of structural components subjected to unidirectional and combined loads; pressure vessels; beam deflections, Mohr's Circle, and columns</td>
<td></td>
</tr>
<tr>
<td>ME 500 (Fluid, Thermo, Heat)</td>
<td>4</td>
<td>Introduction to thermodynamics, fluid mechanics and heat transfer with engineering applications</td>
<td></td>
</tr>
<tr>
<td>ECE 300 (Circuits)</td>
<td>3</td>
<td>Introduction to circuit analysis; circuit analysis concepts and their extension to mechanical and thermal systems by analogy; electrical instruments and measurements</td>
<td></td>
</tr>
<tr>
<td>ECE 309 (Circuits Lab)</td>
<td>1</td>
<td>Accompanys and complements 300 by demonstrating the physical principles discussed there; use of electrical instruments such as oscilloscopes, voltmeters, ammeters, etc., are also emphasized</td>
<td></td>
</tr>
</tbody>
</table>

### GENERAL EDUCATION

<table>
<thead>
<tr>
<th>COURSE CODE</th>
<th>COURSE TITLE</th>
<th>CREDIT HOURS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEC 1-8</td>
<td>40</td>
<td>The 8 general education courses will collectively be structured to meet College of Engineering GEC requirements: English &amp; Communication Skills (10) English 110 (5) 2nd Writing Course (5) Social Diversity in US (0) Ethics (5) Ethics Group 1 (Social Sci) Or Ethics Group 2 (Analysis of Texts) Social Sciences (5-10, 5 if Ethics G1 is taken) A. Individuals and Groups B. Organization and Policies C. Human, Natural &amp; Economic Resources Arts and Humanities (15-20) A. Historical Survey (10) B. Analysis of Texts (10, 5 if Ethics G2 is taken) 1. Literature (no more than one from a group) 2. Visual/Performing Arts 3. Culture and Ideas</td>
<td></td>
</tr>
</tbody>
</table>

### BIOMEDICAL ENGINEERING

<table>
<thead>
<tr>
<th>COURSE CODE</th>
<th>COURSE TITLE</th>
<th>CREDIT HOURS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 202</td>
<td>Intro BME</td>
<td>3</td>
<td>Introduction to the engineering aspects of life science, utilizing lectures from medicine, engineering, and life science</td>
</tr>
<tr>
<td>BME 205</td>
<td>Numerical Simulations in BME</td>
<td>2</td>
<td>Introduction to numerical simulations for biomedical engineering applications. Graphics, visualization and image display, solution of hemoglobin saturation using differential equations; numerical solution of Hodgkin-Huxley equation, finite difference simulations of blood flow, etc</td>
</tr>
<tr>
<td>ANAT XXX</td>
<td>Human Anatomy Lab</td>
<td>2</td>
<td>Introduction to human anatomy via a systems approach that includes lecture and dissection. (Note: Following discussion with the Anatomy Department, this is a new course that will be developed specifically for engineering students</td>
</tr>
<tr>
<td>BME 402</td>
<td>Biomedical Engineering Lab</td>
<td>2</td>
<td>Measurement and interpretation of data from living systems; Measurement and analysis of signals generated by biomedical transducers and bioelectric potentials, and their relationship to human physiology and bodily function; techniques of molecular and cellular engineering</td>
</tr>
<tr>
<td>BME 403</td>
<td>Quantitative Physiology</td>
<td>4</td>
<td>Introducing and building on fundamentals of control system theory, quantitative models of physiological systems will be developed and studied</td>
</tr>
<tr>
<td>BME 411</td>
<td>Domain Course: Bioimaging</td>
<td>4</td>
<td>Introduction to medical imaging techniques, including data collection and image processing for projection x-ray, computed tomography, ultrasonic, and magnetic resonance</td>
</tr>
<tr>
<td>BME 421</td>
<td>Domain Course: Biotransport</td>
<td>4</td>
<td>Theoretical and phenomenological derivation of transport mechanisms important for biological systems. Includes passive, active and extracellular transport</td>
</tr>
<tr>
<td>BME 431</td>
<td>Domain Course: Biomaterials</td>
<td>4</td>
<td>Review of basic concepts of materials science; biocompatibility and biological reactions to implanted materials; natural biomaterials and synthetic materials used in biological applications</td>
</tr>
</tbody>
</table>
### BME 441 Domain Course: Biomechanics 4
- Mechanical characterization of biological tissues at the organ and system level; exploration of interactions with physiological and pathological conditions.

### BME 451 Domain Course: Molecular, Cellular, Tissue Engineering 4
- Introduction to the incorporation of living components and compatible biomaterials to repair or replace biological functions.

### BME 461 Domain Course: Biomedical Micro/Nano Technology 4
- Survey of biomedical technology with particular emphasis on nanoscale mass transport, nanomechanics, nanofluidics and medical therapeutics.

### BME 501 Design 1 4
- Aid to the disabled: Projects with 4-6 students working with a disabled client to identify the client’s needs and to plan, design, and build a device or process to meet those needs.

### BME 502 Design 2 5
- Continuation of BME 401 culminating in a public show.

### BME 503 Professional Development 1
- Development of professional skills; engineering economy; project planning; ethics, best business practices

### BME 581.1,2,..,3 (Seminar) 1
- Topics of current interest in the field are presented by local and outside speakers

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22. State the minimum number of credits required for completion of the major.

198

23. State the average number of credits expected for a student at completion of the major.

198 for most, 202-207 for pre-meds (see response to 26, below)

24. Give the average number of credits taken per quarter by a typical student. Estimate the average for each year.

<table>
<thead>
<tr>
<th>Department</th>
<th>Credits</th>
<th>Level*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 151 (Calc and Analytic Geom)</td>
<td>5</td>
<td>Undergraduate</td>
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<td>STAT 427 (Prob and Stat I)</td>
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<tr>
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</tr>
<tr>
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<td>3</td>
<td>Undergraduate</td>
</tr>
<tr>
<td>Chem 245 (Organic Chem Lab 1)</td>
<td>2</td>
<td>Undergraduate</td>
</tr>
<tr>
<td>BioChem 511 (BioChemistry)</td>
<td>5</td>
<td>Undergraduate</td>
</tr>
<tr>
<td>Undergraduate Physics 131 (Particles and Motion)</td>
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<td>Biol 113/115 (General Biology I)</td>
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</tr>
<tr>
<td>EEOB 232 (Intro Physiology)</td>
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</tr>
<tr>
<td>EEOB 415 (Animal Cell and Develop)</td>
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<tr>
<td>Engr 100 (Engr Survey)</td>
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<tr>
<td>Engr 181 (Intro to Engr I)</td>
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<tr>
<td>Engr 183 (Intro to Engr II)</td>
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25. Give the number of credits a students is required to take in other departments.

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<tr>
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<td>Department, course</td>
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<td>Level*</td>
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<td>ME 410 (Statics)</td>
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<td>ME 420 (Intro Strength Mat)</td>
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<td>ME 500 (Fluid, Thermo, Heat)</td>
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<td>GEC 1-8</td>
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</table>

*Level: lower-division or upper-division undergraduate, masters, doctoral, or graduate/professional.

26. Give number of credits a typical student might take as electives in other departments.

Pre-Med:
Most medical schools require a year of organic chemistry, with lab, but don’t specify a specific course sequence. Likewise, most require a year of biology/life sciences (e.g., BIOL 113/115, EEOB 232, EEOB 415, BME 303), rather than specific courses. If the most conservative reading of the requirements holds true, then the additional requirements for pre-med students are:

Chem 254 (Organic Lab, 3 credits) would be taken in place of the usually required Chem 245 (Organic Lab, 2 credits), so this sequence of professional electives is 18 credits. Pre-med students would thus need 9 additional credit hours beyond the planned 3-course professional elective sequence. (Note: If the 4-course sequence in life sciences (Biol 113/115, EEOB 232, EEOB 415, and BME 303) were regarded as meeting the life science requirement, then Biol 114, 5 credits, would be dropped from this list. We will check carefully into these points prior to preparing a suggested course template for OSU pre-medical students.)

Other:
It is not possible to provide meaningful projections about other elective sequences until we have some experience with student interests. However, sequences of Professional Electives will likely include courses in other engineering departments (e.g., Chemical and Biomolecular Engineering; Mechanical Engineering; Materials Science and Engineering, etc.), in other medical school or science departments, or in business.

27. Describe other major requirements in addition to course requirements, e.g., examinations, internships, final projects.
The 2-quarter design sequence will have an associated design show where student teams have the opportunity to show and describe the projects they have planned and built.
Plans call for this program to be geared toward having student engineering teams with 4-5 members work with a specific disabled client from the local community. For these real-world, open-ended experiences, students will determine what is needed and will work to design and construct a device to meet their client’s needs.

There are funding programs available for Aid-To-The-Disabled courses from the NSF (National Science Foundation), see [http://www.nsf.gov/pubs/2006/nsf06566/nsf06566.htm](http://www.nsf.gov/pubs/2006/nsf06566/nsf06566.htm)

28. Identify from which specialized professional association(s) accreditation will be sought. List any additional resources that will be necessary to gain such accreditation.

We will seek accreditation from ABET (American Board for Engineering and Technology).

The program objectives and outcomes have been formulated with a view to satisfying ABET requirements. Prior to applying to ABET, a graduating class will have to complete the curriculum, and the earliest that can occur is 2011.

29. Describe the number and qualifications of full-time and part-time faculty. List current faculty and areas of expertise. Describe the number and type of additional faculty needed.

**CURRENT**

<table>
<thead>
<tr>
<th>Name</th>
<th>Area of Expertise</th>
<th>Full or Part Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gunjan Agarwal, Ph.D.</td>
<td>Biomedical Imaging AFM (Biophysics)</td>
<td>Assistant Professor 50%</td>
</tr>
<tr>
<td>Rita Alevriadou, Ph.D.</td>
<td>Cellular Engineering (Chemical Engineering)</td>
<td>Associate Professor 50%</td>
</tr>
<tr>
<td>William Brantley, Ph.D.</td>
<td>Tissue Engineering (Metallurgical and Materials Science Engineering)</td>
<td>Full Professor 0%</td>
</tr>
<tr>
<td>Bradley Clymer, Ph.D.</td>
<td>Biomedical Imaging, MRI (Electrical Engineering)</td>
<td>Associate Professor 25%</td>
</tr>
<tr>
<td>Keith Gooch, Ph.D.</td>
<td>Tissue Engineering (Chemical Engineering)</td>
<td>Associate Professor 100%</td>
</tr>
<tr>
<td>Derek Hansford, Ph.D.</td>
<td>Micro-Technology (Materials Engineering)</td>
<td>Assistant Professor 100%</td>
</tr>
<tr>
<td>Richard T. Hart, Ph.D.</td>
<td>Tissue Mechanics (Bone and Eye) (Mechanical Engineering)</td>
<td>Professor and Chair 100%</td>
</tr>
<tr>
<td>Doug Kniss, Ph.D.</td>
<td>Tissue Engineering (Biology)</td>
<td>Full Professor 0%</td>
</tr>
<tr>
<td>Stephen Lee, Ph.D.</td>
<td>Nano-Technology (Biochemistry)</td>
<td>Associate Professor 90%</td>
</tr>
<tr>
<td>Jun Liu, Ph.D.</td>
<td>Biomedical Imaging (Bioacoustics) (Biomedical Engineering)</td>
<td>Assistant Professor 100%</td>
</tr>
<tr>
<td>Alan Litsky, M.D., Sc.D.</td>
<td>Biomaterials (Chemistry, Bioengineering &amp; Medicine)</td>
<td>Associate Professor 50%</td>
</tr>
<tr>
<td>Cynthia Roberts, Ph.D.</td>
<td>Ophthalmic Engineering (Electrical Engineering &amp; Nursing)</td>
<td>Associate Professor 20%</td>
</tr>
</tbody>
</table>
PROPOSED ADDITIONAL FACULTY

Additional faculty are needed in the new Department of Biomedical Engineering in order to have sufficient breadth and depth to teach the undergraduate program, but also to have “critical mass” in areas of research and graduate education to be competitive for funding and to garner the reputation for excellence and impact that we seek.

This proposal balances the immediate needs for faculty with modest near-term growth of faculty size. We expect that the new undergraduate program will generate substantial additional interest in the graduate program and the research potential at OSU, and lead to continued growth that is sustainable and fiscally sound.

Below, six additional faculty lines are proposed for Biomedical Engineering. Two have already been committed by the Dean of the College of Engineering, so this represents four additional lines, hired over a 4-year period. During this same period, the number of students per undergraduate graduating class is planned to ramp up from 0 to 75.

If approved and implemented, after the startup phase, the department would have 15.5 FTE’s with 75 x 4 = 300 undergraduates. The result is an undergraduate BME student-faculty ratio of 19:1 (a bit higher than the current College of Engineering student-faculty ratio of 18:1).

<table>
<thead>
<tr>
<th>Name</th>
<th>Area of Expertise</th>
<th>Full or Part Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBD</td>
<td>Quantitative Systems Physiology: Multiscale modeling</td>
<td>Professor</td>
</tr>
<tr>
<td>TBD</td>
<td>Micro/Nano Technology</td>
<td>Associate Professor</td>
</tr>
<tr>
<td>TBD</td>
<td>Design, specific expertise with Device construction, aid to the disabled</td>
<td>Clinical Professor</td>
</tr>
<tr>
<td>TBD</td>
<td>Biomaterials</td>
<td>Assistant Professor</td>
</tr>
<tr>
<td>TBD</td>
<td>Tissue Mechanics: experimental</td>
<td>Associate Professor</td>
</tr>
<tr>
<td>TBD</td>
<td>Biomechanics; whole body</td>
<td>Assistant Professor</td>
</tr>
</tbody>
</table>

1 FTE position, previously approved for hiring in 2006-07.
2 FTE position, previously approved for hiring in 2007-08. The domain of expertise is a placeholder here -- it has not yet been decided by the faculty.
3 Newly proposed FTE position. The domain of expertise is a placeholder here -- it has not yet been decided by the faculty. However, a clinical faculty member, preferably with design experience, is envisioned.
4 Newly proposed FTE position. The domain of expertise is a placeholder here -- it has not yet been decided by the faculty.
**Additional Staff**
In addition to the proposed new faculty members, two new BME staff members are proposed for the new undergraduate major. One staff member is needed to provide support for a broad range of administrative duties associated with the undergraduate program including recruitment, advising, retention, and placement of undergraduate students. The second, a technical staff member, would provide support for the teaching laboratories, including the domain course labs and the team design projects.

**Diversity**
We recognize that the opportunity to hire additional personnel provides us with an unusual opportunity to add to the diversity of biomedical engineering faculty and staff. We will aggressively seek to increase the pool of applicants for all positions prior to selecting the strongest candidates.

30. Describe existing facilities, equipment, and off-campus field experience and clinical sites to be used. Indicate how the use of these facilities, equipment, etc. will impact other existing programs.

The Department of Biomedical Engineering has 16,700 square feet of office and laboratory space in Bevis Hall on West Campus. Adequate office space is available for current faculty, and minor renovations would allow for consolidation of small postdoc offices to make them suitable for future faculty hires.

The Department has two classrooms and a small computer laboratory. There is a large lecture hall in Bevis that requires renovation, but will then be ideal for large classes (over 40 students) and departmental seminars. Space is available for an undergraduate teaching lab to accommodate the hands-on portions of the domain classes, and for the team design lab, but renovation will be required, as well as equipment dedicated to undergraduate teaching.

Several key core research and individual laboratory facilities are located in Bevis Hall, and renovation is underway to make these useful to satisfy needs for imaging and computing, cell culture, and tissue engineering facilities. Additional renovated laboratory space will be required for new faculty hires.

In addition, the Nanotech West Laboratory (formerly called MicroMD) will be available on a fee-for-service basis. This a world-leading Biomedical Nanotechnology and Biological Micro Electromechanical Systems (BioMEMS) Laboratory. Facilities will include a microfabrication facility dedicated to biomedical microdevices (class 100 clean room) coupled with a complete biochemistry, cell culture, tissue culture, and biohybrid device laboratory. Both academic and industrial researchers will be able to perform research and development ranging from basic science to fabrication of prototype medical devices usable in early stage clinical trials.

Laboratories in the Davis Heart and Lung Research Institute are currently assigned to BME core faculty.

Concurrently with the deliberations of this proposal, we will be seeking to reach agreements for temporarily sharing space for teaching labs – a need anticipated due to the time required for renovating labs. Details are emerging as the specifics for the proposed courses are being developed, but undergraduates will need access to cell culturing facilities, digital imaging, strain gauging, and materials testing equipment, etc. The temporary needs may be satisfied if teaching activities are allowed in research labs – a plan that may be feasible during the initial growth phase of the program, with relatively small numbers of students.
31. Describe additional University resources, including libraries, that will be required for the new major.

Because the proposed curriculum draws upon the existing strengths in OSU’s engineering, math, and sciences, BME undergraduates will take an extensive list of these courses offered by other departments. As the BME enrollment grows, additional resources will be required for teaching these courses in the other departments.

No other specific new university resources are envisioned, beyond what is needed for other engineering students. It is hoped that the library collections and journals will continue to serve a broad range of research and teaching topics in biomedical engineering.

32. Describe the major as it would appear in the appropriate college bulletin.

The following is a description of the program, as it would appear in The Ohio State University Bulletin, College of Engineering Book 9:

### Biomedical Engineering

270 Bevis Hall, 1080 Carmack Road, Columbus, Ohio 43210-1002; 614-292-7152

Biomedical engineering is a relatively new, rapidly growing discipline that requires in-depth and systematically organized instruction in both engineering and life sciences. Biomedical engineers pursue professional careers in research and development of new medical products and systems, design of prosthetics, medical devices and diagnostic instrumentation, technical sales and customer service, market research and analysis, or management functions in these areas. They are employed in health services, pharmaceutical industries, rehabilitation engineering, biomedical product industries, consulting companies, government laboratories and agencies, and many relatively new companies involved with emerging technologies such as tissue engineering, micro-fluidics, and bio-microelectromechanical systems (bioMEMS).

**Definition:**

“The discipline of biomedical engineering lies at the forefront of the medical revolution. Advances in biomedical engineering are accomplished through interdisciplinary activities that integrate the physical, chemical, mathematical, and computational sciences with engineering principles in order to study biology, medicine, and behavior.” National Institutes of Health, working definition of Biomedical Engineering, 1997.

**Mission:**

To promote learning and discovery that integrates engineering and life sciences for the advancement of human health

---

**Undergraduate Program Objectives:**

The objective of our biomedical engineering undergraduate program is to provide educational opportunities for students to creatively integrate engineering and life sciences so that graduates can successfully pursue:

- Advanced study leading to research or professional practice in biomedical engineering
- Advanced study leading to research or professional practice in health care
- Careers in biomedical engineering industries or related technical and professional fields

**Undergraduate Program Outcomes:**

Graduates from the biomedical engineering program will have demonstrated that they possess the ability to:
(a) Apply knowledge of mathematics, science, and engineering
(b) Design and conduct experiments, as well as to analyze and interpret data
(c) Design a system, component, or process to meet desired needs
(d) Function on multi-disciplinary teams
(e) Identify, formulate, and solve engineering problems
(f) Understand professional and ethical responsibility
(g) Communicate effectively
(h) Understand the impact of engineering solutions in a global and societal context
(i) Recognize the need to engage in life-long learning
(j) Demonstrate knowledge of contemporary issues
(k) Use the techniques, skills, and modern engineering tools necessary for engineering practice
(l) Solve problems at the interface of engineering and biology
(m) Measure and interpret data from living systems

**Degrees offered:** Bachelor of Science in Biomedical Engineering, Master of Science, Doctor of Philosophy

The philosophical choices made in designing the undergraduate program at the Ohio State University are to:

- Embrace the multidisciplinary nature of biomedical engineering
  - Take full advantage of existing strong science, math, and engineering science courses at OSU
- Feature BME “domain courses” that *integrate engineering and life sciences*
  - (undergraduates choose minimum of 3, insuring breadth in biomedical engineering content)
  - Each course features domain content with common threads: Creativity, Writing, Labs, Modeling/Simulation.
- Exploit distinctive curriculum features:
  - Quantitative Physiology, Domain courses, Team Design (Spring team design show)
- Satisfy *most* pre-med requirements automatically
- Require a minimum of 2 BME advanced-level (6/7XX) follow-up courses (enabling focus) that have a domain course as the pre-requisite
- Require 3 “Professional Electives” (*ProfE*), an approved sequence of technical electives that allow students to achieve professional goals (e.g., pre-med, independent research, honors thesis, minors, domain depth or breadth, etc.)

The curriculum follows a standard first-year engineering sequence of mathematics, sciences (including chemistry, physics), English, and introductory engineering courses. These topics have follow-up courses during the second year, and expand to include life sciences (biology, organic chemistry) as well as engineering sciences and initial biomedical engineering courses. Life sciences and engineering sciences continue in the 3rd year, but the focus is upon biomedical engineering with biomedical measurement and techniques labs, and the “domain” courses. Each of the six domain courses (students are required to take at least 3) are intended to build on previous engineering and life sciences courses to truly integrate engineering and medicine content. Pedagogically similar (each domain course includes a portion and projects with technical communication, *in silico* modeling and simulation, hands-on experiments) the domain courses are pathways to advanced biomedical engineering courses and research. The 4th year has three distinctive features: a requirement for students to take two advanced-level BME courses as follow-ups to 1 or 2 of the domain classes; an individually designed and approved 3-course sequence of professional electives (allowing for students to pursue independent research projects,
honors theses, minors, technical or business courses); and the two-quarter team design project. These design projects will be based on student engineering teams with 4-5 members who will work with a specific disabled client from the local community. For these real-world, open-ended experiences, students will determine what is needed and will work to design and construct a device to meet their client’s needs, with a public show of the designs in the Spring of the Senior year.

Candidates for the degree Bachelor of Science in Biomedical Engineering can also pursue the pre-professional option to satisfy the requirements for pre-medical, pre-dental, pre-veterinary, or pre-optometry programs by taking the appropriate electives.

The following curriculum and list of minimum requirements for the degree Bachelor of Science in Biomedical Engineering are effective for all students entering the University without prior college credit. The sequence or Professional Electives in the fourth year must be chosen with the advice and approval of a department faculty advisor.

<table>
<thead>
<tr>
<th><strong>First Year:</strong></th>
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<tbody>
<tr>
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<td>GEC 1: (English 110)</td>
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<tr>
<th><strong>Second Year:</strong></th>
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<td>ME 410 (Statics)</td>
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<tr>
<td>Winter</td>
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<td>Math 415 (Ordinary and Partial DEQ)</td>
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<td>BME 402 (Biomed Engineering Lab)</td>
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**Fourth Year**

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<td>BME 581.3 (Seminar)</td>
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BME Domain Courses:
- BME 411 Bioimaging
- BME 421 Biotransport
- BME 431 Biomaterials
- BME 441 Biomechanics
- BME 451 Molecular, Cellular and Tissue Engineering
- BME 461 Biomedical micro/nano tech

*Form approved 3/2/88, Council on Academic Affairs*

Attached:

Quarter by Quarter sequence for undergraduate degree in Biomedical Engineering
Appendices
- Appendix 1. Text of the current Engineering Core Curriculum requirements, highlighted to demonstrate how the proposed major satisfies the requirements.
- Appendix 2. Transition plan for enrollment of undergraduates in biomedical engineering
- Appendix 3. ABET planning:
  - Proposed syllabus addendum for Biomedical Engineering Courses
  - Template of worksheet for planning curricular content to document coverage of ABET criteria
- Appendix 4. BME syllabi
### Proposed Biomedical Engineering Curriculum

**2/8/2007**

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<thead>
<tr>
<th>Autumn</th>
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<td>Physics 132 (Electricity and Mag) 5</td>
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<td>STAT 427 (Prob and Stat I) 3</td>
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</tr>
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**General Education (40)**

- English & Communication Skills (10)
  - English 110 (5)
  - 2nd Writing Course (5)
  - Social Diversity in US (0)
  - Ethics (5)
  - Ethics Group 1 (Social Sci)
- Or Ethics Group 2 (Analysis of Texts)
- Social Sciences (5-10, 5 if Ethics G1 is taken)
  - A. Individuals and Groups
  - B. Organization and Policies
  - C. Human, Natural & Economic Resources
  - Arts and Humanities (15-20)
    - A. Historical Survey (10)
    - B. Analysis of Texts (10, 5 if Ethics G2 is taken)
  - 1. Literature (no more than one from a group)
  - 2. Visual/Performing Arts
  - 3. Culture and Idea

**“Domain Courses”**

- 6 courses to be offered, students are required to take at least 3, each has:
  - **Integration theme:** each has life science and engineering science pre-reqs
  - Each has technical writing/communications component
  - Each has lab experience
  - Each has simulation/modeling project
  - Each has at least 1 followup 6/7XX course

| BME 411 Bioimaging                        | BME 412 Biotransport                       | BME 431 Biomaterials                      |
| BME 441 Biomechanics                     | BME 451 Molecular, Cellular and Tissue Engineering | BME 461 Biomedical micro/nano tech |

**“Professional Electives”**

- A sequence of approved technical electives that allow students to achieve professional goals (e.g., pre-med choices, independent research, honors thesis, minors, domain depth or breadth)

**2 “Advanced-Level Courses”**

- 2 advanced-level (6/7XX) follow-up courses (enabling focus) that have a domain course as the pre-requisite sequence.
The attached appendices may be useful in evaluating the merits of the proposed plan.

**Appendix 1.** Text of the current Engineering Core Curriculum requirements, highlighted to demonstrate how the proposed major satisfies the requirements.

**Appendix 2.** Transition plan for enrollment of undergraduates in biomedical engineering

**Appendix 3.** ABET planning:
- Proposed syllabus addendum for Biomedical Engineering Courses
- Template of worksheet for planning curricular content to document coverage of ABET criteria

**Appendix 4.** BME syllabi
- BME 202
- BME 205
- BME 402
- BME 403
- BME 411
- BME 421
- BME 431
- BME 441
- BME 451
- BME 461
- BME 501
- BME 502
- BME 503
- BME 581

**Note** that in both Appendix 3 and 4, we have adopted a method for measuring the degree of coverage aimed at ABET criteria, described as follows:

- **ABET criteria a-k** (common to all engineering programs): For each 1 hour of course credit, 3 “chits” are allocated for assignment (e.g., a 4 hour course has 12 a-k chits)
- **ABET criteria l, m** (distinct for biomedical engineering programs): For each 1 hour of course credit, 1 “chits” are allocated for assignment (e.g., a 4 hour course has 4 l,m chits)

**Chit:** *n a note, bill, or any small slip of paper with writing on it, especially a statement of money owed for food and drink (dated)*

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Appendix 1: Highlighted copy of Engineering Core showing how proposed BME major satisfies requirements

COLLEGE OF ENGINEERING CORE CURRICULUM
24 July 2001
Administratively Revised 31 March 2005

<table>
<thead>
<tr>
<th>Required Central Core *</th>
<th>(Satisfied by BME proposal)</th>
</tr>
</thead>
</table>

All engineering students must take the following courses:

- Engineering 181, 183 (6)
- Physics 131, 132 (10)
- Chemistry 121 (5)
- Math 151, 152, 153, 254 (or equivalent) (20)

The total hours of the above courses, including English 110, is 46

**Selected Core**

All engineering programs must include at least 9 topics intended to provide breadth for all engineering students from within the following three subsections (*Additional Science; Mathematics and Statistics; General Engineering*). The topics are listed below along with courses. These courses include the original sample courses referred to below in (2) and denoted in italics, as well as courses which have since been approved by College Committee on Academic Affairs (CCAA) as appropriate for the topic. This list of approved courses may be amended or changed at any time through CCAA’s approval. Programs may satisfy a topic requirement by requiring single courses, or by material distributed through several courses. The onus is on the program to demonstrate:

1. That the number of hours devoted to the topic meets the credit requirements (at least three credit hours).
2. That the level of the material is at least equivalent to that of the sample courses cited.
3. That the courses selected are appropriate for accreditation requirements of the program.

This must be done by submission of appropriate syllabi and other materials to CCAA.

The topics listed in the General Engineering subsection are selected as being those that a significant number of programs will choose to require at a level appropriate for a breadth requirement. That is, those programs will not require those topics at a depth requiring a multi-course sequence. Courses may be either within or outside the College of Engineering.

It is recognized that engineering is a continually changing discipline and that changes in the core structure may be appropriate from time to time. First, the proposed core provides great flexibility for departments to adjust the core components of its programs. Second, a department
may bring a proposal to CCAA if they believe a change in the core structure is necessary. The onus will be on the department to convince CCAA that the proposed change is consistent with the criteria cited herein for the subsections of the engineering core. CCAA may drop topics from any subsection of the selected core. A topic may be dropped if it is not being used or is no longer needed by any program to satisfy the core requirements.

**Additional Science:** All programs must include **at least one** of the following topics. Some programs may specify what is required for students in their program. Others may leave some choice to their students. **No more than three** topics from this list may be counted toward the selected core requirement.

<table>
<thead>
<tr>
<th>TOPIC</th>
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<tbody>
<tr>
<td>Biological Science</td>
<td>Biology 113</td>
</tr>
<tr>
<td>Chemistry</td>
<td>Chemistry 122</td>
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<tr>
<td>Earth and Geological Sciences</td>
<td>Geological Science 121</td>
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<tr>
<td>Physics</td>
<td>Physics 133</td>
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<td>Advanced Chemistry</td>
<td>Chemistry 231</td>
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<td>Chemistry 251</td>
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</table>

The criteria for a topic to considered part of the additional science subsection of the proposal are (1) Ensure reasonable breadth in natural science (physical or biological) appropriate for individual programs. (2) Provide programs the flexibility to specify appropriate additional science for their students. (3) Have a course available college wide. Its longest prerequisite chain should be no more than **one** beyond the required central core.

**Mathematics and Statistics:** All programs must include **at least two** of the following topics. Some programs may specify what is required for students in their program. Others may leave some choice to their students. **No more than four** of the following topics from this list may be counted toward the selected core requirement.

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<thead>
<tr>
<th>TOPIC</th>
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<td>Linear Algebra</td>
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<td>Math 571</td>
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<tr>
<td><strong>Ordinary Differential Equations</strong></td>
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<td><strong>Math 415</strong></td>
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<td>APPROVED COURSES</td>
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<td>CSE 541</td>
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<td>Partial Differential Equations</td>
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<td><strong>Probability and/or Statistics</strong></td>
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<td>FABE 225</td>
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<td>Math 551</td>
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The criteria for a topic to be considered part of the mathematics and statistics subsection of the proposal are (1) Ensure depth in mathematics and statistics appropriate for individual programs, (2) Provide programs the flexibility to specify appropriate mathematics and statistics for their students. (3) Have a course available college wide. Its longest prerequisite chain should be no more than one beyond the required central core.

**General Engineering:** All programs must include at least four of the following topics. Some programs may specify what is required for students in their program. Others may leave some choice to their students.

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<tr>
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<td>Geod 573</td>
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<td>Geod 574</td>
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<td>Geod 575</td>
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<td>CIS 222</td>
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<td>Geod 563</td>
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<td>CSE 221</td>
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<td>EG 167</td>
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<td><strong>ME 410</strong></td>
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<td>Dynamics</td>
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<td>Phy 262</td>
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<td><strong>Strength of Materials</strong></td>
<td><strong>ME 420</strong></td>
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<td>Materials</td>
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<td><strong>MSE 205</strong></td>
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<tr>
<td>Engineering Economics</td>
<td>ChE 760 – both courses must be taken</td>
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The criteria for a topic to be considered part of the general engineering subsection of the proposal are: (1) ensure breadth in general engineering topics, (2) have a course available college wide with its longest prerequisite chain no more than **two courses** beyond the required central core, and (3) be such that at least two programs utilize the topic.

* Students successfully completing the full Freshman Engineering Honors Program will be considered to have satisfied the following core course requirements:

  From the Central Core:
  Engineering 181, 183  
  Physics 131, 132  
  Math 151, 152, 153, 254  

  From the General Engineering Topics:
  Programming
  Statics
Appendix 2: Transition Plan

In order to have time to implement the proposed major, student enrollment will be limited as the curriculum is sequentially developed.

The sequential implementation of the curriculum will allow us time to hire faculty, develop labs and course resources and content. For that reason, we will not allow currently enrolled students to transfer into the program – upper level courses will simply not yet be available. In addition, the plan calls for a second year of very limited student enrollment to allow for us to address startup issues that are not known in advance, prior to working with large numbers of students. The number of incoming students is increased in the third year, and again in the fourth.

If our proposal is approved in time to admit pre-BME students from next academic year’s incoming students (1st year students in Autumn 2007), then the first BME sophomore-level courses could be ready for those students in 2008-09. As seen below, the first class could then graduate in 2011 – good timing for the current CoE schedule for ABET accreditation.

Table 1. Planned limits on student enrollment.

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<td>25</td>
<td>25</td>
<td>50</td>
<td>75</td>
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</table>

Note, however, even with an optimistic timetable for approval and implementation of the major, enrollment is not projected to reach a steady state of 75 students per class until 2013-14. That would be the time to re-evaluate student interest and capacity to consider adjusting enrollment.
1. Attached is a DRAFT proposed 2-page syllabus addendum for Biomedical Engineering Courses
2. Also attached is a DRAFT template for a worksheet for planning curricular content to document coverage of ABET criteria with the proposed BME major (based on current practice at Tulane University)
Department of Biomedical Engineering  
Syllabus Addendum

Our mission is to promote learning and discovery that integrates engineering and life sciences for the advancement of human health

Vision:
The Department of Biomedical Engineering at the Ohio State University will be nationally ranked and internationally recognized for:
  o The distinctive educational opportunities for its students and the outstanding achievements of its alumni
  o Faculty and staff excellence and opportunities for continuing professional development
  o Collaborative research with global impact on improving human health
  o Service to the field of biomedical engineering and the community

Undergraduate Program Objectives:
  o The objective of our biomedical engineering undergraduate program is to provide educational opportunities for students to creatively integrate engineering and life sciences so that graduates can successfully pursue:
    o Advanced study leading to research or professional practice in biomedical engineering
    o Advanced study leading to research or professional practice in health care
    o Careers in biomedical engineering industries or related technical and professional fields

Undergraduate Program Outcomes:
  Graduates from the biomedical engineering program will have demonstrated that they possess the ability to:
  (a) Apply knowledge of mathematics, science, and engineering
  (b) Design and conduct experiments, as well as to analyze and interpret data
  (c) Design a system, component, or process to meet desired needs
  (d) Function on multi-disciplinary teams
  (e) Identify, formulate, and solve engineering problems
  (f) Understand professional and ethical responsibility
  (g) Communicate effectively
  (h) Understand the impact of engineering solutions in a global and societal context
  (i) Recognize the need to engage in life-long learning
  (j) Demonstrate knowledge of contemporary issues
  (k) Use the techniques, skills, and modern engineering tools necessary for engineering practice
  (l) Solve problems at the interface of engineering and biology
  (m) Measure and interpret data from living systems

(over)
The College of Engineering at the Ohio State University plans to request a visit to determine the BME program’s suitability for accreditation by the Accreditation Board for Engineering and Technology, Inc. (ABET) as soon as it meets eligibility requirements (following the graduation of the first class). Among the criteria for accreditation adopted by ABET for programs that are accredited after 2000 is ‘Criterion 3. Program Outcomes and Assessment’ which states that:

Accredited Biomedical Engineering programs must demonstrate that their graduates have:
(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) 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
(d) an ability to identify, formulate, and solve engineering problems
(e) an ability to function on multi-disciplinary teams
(f) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
(l) an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology
(m) the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems.

In addition, ‘Criterion 4. Professional Component’ states that:

The professional component requirements specify subject areas appropriate to engineering but do not prescribe specific courses. The engineering faculty must assure that the program curriculum devotes adequate attention and time to each component, consistent with the objectives of the program and institution. Students must be prepared for engineering practice through the curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating engineering standards and realistic constraints that include most of the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political. The professional component must include
   a) one year of a combination of college level mathematics and basic sciences (some with experimental experience) appropriate to the discipline
   b) one and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study
   c) a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives

Students participate in our assessment and continuous improvement of courses by completing end-of-semester course evaluations.

For more information about accreditation, see the official ABET webpage at: http://www.abet.org/
### OUTCOMES

... apply knowledge of math, science, and engineering
... design and/or conduct experiments
... analyze and interpret data
... design a system, process, or component
... function within a team
... identify, formulate, and solve engineering problems
... understanding of professional and/or ethical responsibility
... ability to communicate effectively
... the broad education necessary to understand the impact of engineering
... a recognition of the need for and an understanding of contemporary issues
... use the techniques, skills, and modern tools necessary for practice
... understanding of biology and physiology to solve problems
... make measurements and/or interpret data from interactions between phenomena

### Course and Credit Information

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<tr>
<td>Math 151</td>
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### Domain

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<td>BME 451</td>
<td>4</td>
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<tr>
<td>BME 461</td>
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### Subtotal

| Autumn | 198 |
| Winter | 125 |
| Senior | 144 |

### Percentage

| Autumn | 100% |
| Winter | 10%  |
| Senior | 6%   |

### Average from Domain Courses

| BME 411 | 2.5 |
| BME 421 | 2.5 |
| BME 431 | 2.5 |
| BME 441 | 2.5 |
| BME 451 | 2.5 |
| BME 461 | 2.5 |

Updated 12/20/2006
Appendix 4. BME syllabi

BME 202
BME 205
BME 402
BME 403
BME 411
BME 421
BME 431
BME 441
BME 451
BME 461
BME 501
BME 502
BME 503
BME 581

Note that in both Appendix 3 and 4, we have adopted a method for measuring the degree of coverage aimed at ABET criteria, described as follows:

**ABET criteria a-k** (common to all engineering programs): For each 1 hour of course credit, 3 “chits” are allocated for assignment (e.g., a 4 hour course has 12 a-k chits)

**ABET criteria l, m** (distinct for biomedical engineering programs): For each 1 hour of course credit, 1 “chits” are allocated for assignment (e.g., a 4 hour course has 4 l,m chits)

**Chit:** n a note, bill, or any small slip of paper with writing on it, especially a statement of money owed for food and drink (dated)

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Is this a course with decimal subdivisions? If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

18-Character Transcript Abbreviation: Intro to Biomed E

Level: U ☑ G ☐ P ☐ Credit Hours: 3

Description (not to exceed 25 words):
Introduction to the engineering aspects of life science, utilizing lectures from engineering, medicine, and life science

Quarter offered (check): SU ☐ AU ☐ WI ☑ SP ☐ *Distribution of class time/contact hours: 2x1.5 hr_cl.

Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) ☐

Prerequisite (s): ME 410 or equiv; BIOL 113 or equiv; pre-req or concurrent Math 415; or permission of instructor

Exclusion or limiting clause: open to BME undergraduate students only

Repeatable to a maximum of _0__ credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter ☑ S/U ☐ Progress ☐

If this course is Progress graded, what course is the last one in the series?

Honors Statement: Yes ☑ No ☐ GEC: Yes ☑ No ☐ Admission Condition: Course: Yes ☑ No ☐

Off-Campus: Yes ☑ No ☐ EM: Yes ☑ No ☐

Embedded Honors Statement: Yes ☑ No ☐

Other General Course Information:
(e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

Subject Code 140501 Subsidy Level (V, G, T, B, M, D, or P) B

(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes ☑ No ☐

B. General Information:

1. Provide the rationale for proposing this course: New Biomed E major

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.
   This course is (check one) Required ☑ Elective ☐ Other (Explain) ☐
4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?

Yes □ No ☑ List:

5. If this course is part of a sequence, list the number of the other course(s) in the sequence: __________________________

6. Expected section size: 25 Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes ☑

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☑

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

******************************************************************************

APPROVAL SIGNATURES (As needed. All signatures on lines in ALL CAPS (e.g. ACADEMIC UNIT) must be completed)

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<th>Academic Unit Undergraduate Studies Committee Chair (Undergraduate course)</th>
<th>Printed Name</th>
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ACADEMIC UNIT CHAIR/SCHOOL DIRECTOR

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<tr>
<td>Office of International Education (study tour only)</td>
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<tr>
<th>ACADEMIC AFFAIRS</th>
<th>Printed Name</th>
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</table>
1. **Department**: Biomedical Engineering

2. **Number**: 202

3. **Title of course**: Introduction to Biomedical Engineering

4. **Description** (*from Course Description Bulletin*)
   Introduction to the engineering aspects of life science, utilizing lectures from engineering, medicine, and life science.

5. **Level**: U = Undergraduate

6. **Credits**: 3

7. **Class Time Distribution**: 2 cl.

8. **Prerequisites**: Statics (OSU ME 410 or equivalent), Biology (OSU BIOL 113 or equivalent), Differential Equations (OSU Math 254 or equivalent and OSU Math 415 as co-requisite), or permission of instructor

9. **Quarters Offered**: Winter

10. **General Information**: This course introduces the students to the use of engineering approaches to life science problems. The students will learn many aspects of biomedical engineering, including physiological modeling, biomechanics, biomaterials, biosensors and biosignal processing, biomedical imaging, and diagnostic devices. Throughout the course, students will be exposed to the complexities of living systems and how we can use engineering processes to model and interact with living systems.

11. **Exclusions**: 

12. **Cross-Listings**: 

13. **Other Information**: 

14. **Course Objectives**
   1. Students will be able to apply free body diagrams to rehabilitative device design for simplified human structures. \((a,c,e,f,h,k)\)
   2. Students will be able to perform transfer function derivations for simple circuits. \((a,e,k,l,m)\)
   3. Students will be able to derive the Nernst potential from equilibrium conditions and apply it to the measurement of molecular concentrations using an enzyme-based biosensor. \((a,e,l,m)\)
   4. Students will be able to derive a single compartment model of drug clearance. \((a,c,e, l)\)
   5. Students will be able to explain the “toe”, “linear”, and “failure” regions of ligament mechanical tests based on the molecular structure of the tissue. \((a,g,l,m)\)
6. Students will be able to explain the foreign body response to implant materials. (a,c,g,k,m)
7. Students will be able to explain the degradation mechanisms of degradable polymers and hydroxyapatite for tissue engineering applications. (a,c,f,g,j,k)
7. Students will understand signal attenuation in tissue and be able to model an idealized CAT scan signal through heterogeneous material. (a,e,k,l,m)
8. Students will understand biomolecular separations for clinical diagnostics and be able to model electrophoresis and isoelectric focusing in gels. (a,e,f,k,m)

15. Textbooks and Other Required Material

16. Topics (including approximate duration)
- Introduction, overview of physiology (2 classes)
- Clinical and rehabilitation engineering (1 class)
- Bioinstrumentation/ signal processing (2 classes)
- Biomedical sensors (2 classes)
- Physiological modeling (2 classes)
- Biomechanics (2 classes)
- Biomaterials (2 classes)
- Tissue engineering (2 classes)
- Biomedical imaging (2 classes)
- Biomedical diagnostics (2 classes)

Note 2 classes per week = 20 classes, 1 in-class midterm

17. Representative Lab Assignments (if applicable)
N/A

18. Grading Plan
40%: Weekly homework assignments
25%: Midterm exam
35%: Final exam

19. Contribution to Meeting ABET "Professional Component" (i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (if applicable)
(a) an ability to apply knowledge of mathematics, science, and engineering (2 chits)
   All of the specific aims, homeworks, and tests involve the application of math, biology and physical sciences towards engineering applications.
(c) 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 (1 chit)
   Several components of this course emphasize the analysis of systems and its use for the design of more advanced systems.
(e) an ability to identify, formulate, and solve engineering problems (1 chit)
   The course focuses on training the students to formulate biological systems into
engineering problems for solving and optimizing.

(f) an understanding of professional and ethical responsibility (1 chit)
Students will learn about the ethics involved in dealing with patients as well as bioethics debates on the use of stem cells.

(g) an ability to communicate effectively (1 chit)
Students will learn to communicate complex ideas about biological systems in simple explanations and in more specific engineering terms.

(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context (1 chit)
The impact of biomedical devices on patients’ lives and the quality of life in an array of societies will be taught in this course.

(j) a knowledge of contemporary issues (1 chit)
Examples of current biomedical devices and treatments will expose the students to the contemporary field. As a more specific example, the discussion of stem cells for tissue engineering will introduce the students both to the ethical considerations as well as their impact on healthcare and politics.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (1 chit)
The students’ abilities to use modern engineering computer programs, such as Matlab, will be important to their successful completion of the course. The course will also teach the students about using other tools such as cell culture for quantifying biocompatibility.

20. Relationship to ABET-Accredited Program Objectives (if applicable)
(l) an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology (2 chits)
Many of the specific aims of this course require the use of differential equations related to biological systems for modeling and extracting data from biosignals.

(m) the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems (1 chit)
While no direct measurements from living systems will be performed in this course, the mathematical tools used to analyze data from living systems will be taught in several sections of the course.

21. Preparation Date: December 11, 2006

22. Preparer Name: Derek J. Hansford
OHIO STATE NEW COURSE REQUEST

College: Engineering

Academic unit: Biomedical Engineering

Proposed Course No: 205

Full Title of Course: Numerical Simulations in BME

Numerical Simulations in BME

Proposed Effective Qtr/Yr: SU □ AU □ WI ☑ SP □ YEAR: 2008

(See OAA Academic Organization and Curriculum Handbook for Deadlines)


Is this a course with decimal subdivisions? If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

18-Character Transcript Abbreviation: Numer Simul in BME

Level U ☑ G □ P □ Credit Hours: 2

Description (not to exceed 25 words): Computer based simulations for problems in biomedical engineering

Quarter offered (check): SU □ AU □ WI ☑ SP □

*Distribution of class time/contact hours: 2x1hr

Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) ☐

Prerequisite(s): prereq or concur: Introductory MATLAB experience (OSU ENG 183 or equivalent), BME 202 concurrently; or permission of instructor

Exclusion or limiting clause:

Repeateable to a maximum of __0__ credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter ☑ S/U □ Progress □

If this course is Progress graded, what course is the last one in the series?

Honors Statement: Yes □ No ☑ GEC: Yes □ No ☑ Admission Condition

Off-Campus: Yes □ No ☑ EM: Yes □ No ☑ Course: Yes □ No ☑

Embedded Honors Statement: Yes □ No ☑

Other General Course Information:

(e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

Subject Code 140501

Subsidy Level (V, G, T, B, M, D, or P) ☑ B

(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes □ No ☑

B. General Information:

1. Provide the rationale for proposing this course:

New Biomed E major

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.

This course is (check one) Required ☑ Elective □ Other (Explain) □
* If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Off
Campus/Workshop Request form.

3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this
new course.
   New departmental status for Biomed E

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes ☐ No ☒ List:

5. If this course is part of a sequence, list the number of the other course(s) in the sequence:

6. Expected section size: 25 Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes ☒

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with
academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☒

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-
campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

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<td>Printed Name</td>
<td>Date</td>
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<tr>
<td>ACADEMIC AFFAIRS</td>
<td>Printed Name</td>
<td>Date</td>
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</tbody>
</table>
1. **Department**: Biomedical Engineering

2. **Number**: 205

3. **Title of course**: Numerical Simulations in BME

4. **Description** *(from Course Description Bulletin)*
   Introduction to numerical simulations for biomedical engineering applications. Graphics, visualization and image display, solution of hemoglobin saturation using differential equations; numerical solution of Hodgkin-Huxley equation; finite difference methods for blood flow, etc.

5. **Level**: U = Undergraduate

6. **Credits**: 2

7. **Class Time Distribution**: 2 cl.

8. **Prerequisites**: Introductory MATLAB experience (OSU ENG 183 or equivalent), Differential Equations (OSU Math 415 or equivalent or as a co-req), Introduction to BME (OSU BME 202 or equivalent or as a co-req), Biology (OSU BIOL 113/115 or equivalent), Statics (OSU ME 410 or equivalent), or permission of instructor

9. **Quarters Offered**: Winter

10. **General Information**:
    This course focuses on the application of computer-based numerical and graphical display skills for solving problems relevant to biomedical engineering. Areas of application are based upon prior knowledge of biology, mechanics, and mathematics, and will help students develop skills for finding *in silico* solutions for *in vivo* problems. This skill set will form the basis for later “domain” courses in BME.

11. **Exclusions**:

12. **Cross-Listings**:

13. **Other Information**:

14. **Course Objectives**
   1. Students will be able to develop MATLAB scripts for graphical display of analytical solutions, input data and models, and output solutions. \((k)\)
   2. Students will be able to find numerical solutions for sets of differential equations describing biological-based phenomena (e.g., current flow in cardiac tissue; soft tissue mechanics) using MATLAB-based functions. \((a, e, k, l)\)
   3. Students will be able to model feedback control systems for biological-based phenomena (e.g., bone adaptation, cardiac output). \((a, e, k, l)\)
   4. Students will be able to solve finite difference problems in biofluid mechanics (e.g., flow in an aneurism). \((a, e, k, l)\)
15. **Textbooks and Other Required Material**

16. **Topics (including approximate duration)**
   Review of the MATLAB environment 3 classes
   - As a calculator
   - Debugger
   - Graphics
   - On-Line Help
   - Toolboxes
   Graphics 5 classes
   - Plots of analytical solutions
   - Hemoglobin saturation
   - Figures: imaging data display
     - Stack of MRI images
   - Fringe plots of results
     - Finite element result output
   Systems of Equations 2 classes
   - Direct methods
   - Iterative methods
   Finite differences 4 classes
   - Solution of blood flow in aneurism
   Differential Equations 4 classes
   - Hodgkin-Huxley equation
   - Constitutive equations of viscoelastic tissues
   - Cell differentiation
   Sets of Differential Equations 2 classes
   - Equation of motion

Note 2 classes per week = 20 classes

17. **Representative Lab Assignments (if applicable)**
   NA

18. **Grading Plan**
   70%: Weekly project assignments
   30%: Final project

19. **Contribution to Meeting ABET "Professional Component" (i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (if applicable)**
   (a) an ability to apply knowledge of mathematics, science, and engineering (1 chit)
   The students' ability to develop engineering approaches by application of mathematics and biology is a major outcome of the course. The demonstration of increasing proficiency begins with Assignment 1 through the final project.

   (e) an ability to identify, formulate, and solve engineering problems (1 chit)
   The course focuses on using knowledge from biology, engineering mechanics...
and mathematics to formulate and solve biomedical engineering problems.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (2 chits)

This ability is developed during the quarter, exemplified by the use of the MATLAB (Mathworks, Natick, MA) program.

20. Relationship to ABET-Accredited Program Objectives (if applicable)

(l) an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology (2 chits)

This capability is the focus for the course, with essentially all examples and assignments based on solving biomedical engineering problems at the interface of engineering and biology.

21. Preparation Date: February 8, 2007

22. Preparer Name: Richard T. Hart

Is this a course with decimal subdivisions? If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

18-Character Transcript Abbreviation: Biomed E Lab Level U ☒ G ☐ P ☐ Credit Hours: 2

Description (not to exceed 25 words): Measurement and interpretation of data from living systems; Measurement and analysis of signals generated by bioelectrical potentials, and their relationship to human physiology and function.

Quarter offered (check): SU ☐ AU ☐ WI ☒ SP ☐ ☐ Distribution of class time/contact hours: 1h lecture + 3h lab per week
Quarter and contact class time hours information should be omitted from Book 3 publication: (check here) ☐

Prerequisite(s): BME 202; EEOB 232 or equiv; prereq or concur: EEOB 415; or permission of instructor

Exclusion or limiting clause:

Repeatable to a maximum of ___0___ credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter ☒ S/U ☐ Progress ☐

If this course is Progress graded, what course is the last one in the series?

Honors Statement: Yes ☒ No ☐ GEC: Yes ☒ No ☐ Admission Condition: Course: Yes ☐ No ☒
Off-Campus: Yes ☒ No ☐ EM: Yes ☒ No ☐
Embedded Honors Statement: Yes ☒ No ☐

Other General Course Information:
(e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

Subject Code ___ 140501 ___________ Subsidy Level (V, G, T, B, M, D, or P) ___ B ___________
(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes ☐ No ☒

B. General Information:
1. Provide the rationale for proposing this course:
New Biomed E major

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.
   This course is (check one) Required ☒ Elective ☐ Other (Explain) ☐:
* If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Off-Campus/Workshop Request form.

3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course.
   New departmental status for Biomed E

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes ☐ No ☒ List:

5. If this course is part of a sequence, list the number of the other course(s) in the sequence:

6. Expected section size: 25 Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes ☒

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☒

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

-----------------------------------------------------------------------------------
**APPROVAL SIGNATURES**  (As needed. All signatures on lines in ALL CAPS (e.g. ACADEMIC UNIT) must be completed

| Academic Unit Undergraduate Studies Committee Chair (Undergraduate course) | Printed Name | Date |
| Academic Unit Graduate Studies Committee Chair(Undergraduate/Graduate course) | Printed Name | Date |
| School /College Undergrad Curriculum Committee (Undergraduate/Graduate course) | Printed Name | Date |
| School /College Graduate Curriculum Committee (Undergraduate/Graduate course) | Printed Name | Date |
| ACADEMIC UNIT CHAIR /SCHOOL DIRECTOR | Printed Name | Date |
| COLLEGE DEAN | Printed Name | Date |
| Graduate School (If Appropriate) | Printed Name | Date |
| ASC Curriculum Committee Chair (If Appropriate)) | Printed Name | Date |
| University Honors Center (If Appropriate) | Printed Name | Date |
| Office of International Education (study tour only) | Printed Name | Date |
| ACADEMIC AFFAIRS | Printed Name | Date |
1. **Department:** Biomedical Engineering

2. **Number:** 402

3. **Title of course:** Biomedical Engineering Lab

4. **Description (from Course Description Bulletin)**
   Measurement and interpretation of data from living systems; Measurement and analysis of signals generated by bioelectrical potentials, and their relationship to human physiology and bodily function.

5. **Level:** U = Undergraduate

6. **Credits:** 2

7. **Class Time Distribution:** 1h lecture + 3h lab per week

8. **Prerequisites:** BME 202; Physiology (OSU EEOB 232 or equivalent plus EEOB 415 or as a co-req), or permission of instructor

9. **Quarters Offered:** Winter

10. **General Information:**
    This course focuses on the measurement and interpretation of data from living systems, specifically, the measurement and analysis of bioelectrical potentials. The relationship between biopotentials and human physiology and bodily function will be studied, and the students will gain hands on experience by measuring and analyzing biopotentials in a laboratory setting. The students will also learn experimental design by completing the term project.
    The course contains one lecture and one lab period per week.

11. **Exclusions:**

12. **Cross-Listings:**

13. **Other Information:**

14. **Course Objectives**

   1. Students will be able to correctly measure the essential bioelectrical potentials of the human body, namely, EMG, EEG, ECG and EOG, under different physiological conditions. \((b, d, l)\)
   2. Students will be able to analyze the measurement results from living systems, and apply engineering and mathematical models to interpret the data. \((a, k, l)\)
   3. Students will be able to design experiments for measurements of living systems by
applying basic principles of scientific investigation and experimentation. Students will pose questions, generate hypotheses, design experiments, collect data, analyze data, and interpret experimental results in completing the term project. (b, d, g, m)

15. Textbooks and Other Required Material
Biopac Student Lab – Laboratory Manual.

16. Topics (including approximate duration)
   Week 1: Introduction
   Week 2: Biopotentials: volume conductor model and electrodes
       Lab: Biopac tutorial
   Week 3: EMG: physiology, measurement methods/issues, biomedical applications
       Lab: Standard and Integrated EMG (Biopac Lesson 1)
   Week 4: EMG: Motor unit
       Lab: Motor Unit and Fatigue (Biopac Lesson 2)
   Week 5: Data analysis and Biostatistics
       Lab: Term Project Design
   Week 6: EEG: physiology, measurement methods/issues, biomedical applications
       Lab: Relaxation and Brain Rhythms (Biopac Lesson 3)
   Week 7: EEG: Alpha rhythms
       Lab: Alpha rhythms in the occipital lobe (Biopac Lesson 4)
   Week 8: ECG: physiology, measurement methods/issues, biomedical applications
       Lab: Components of ECG (Biopac Lesson 5)
   Week 9: ECG: Einthoven’s law
       Lab: Bipolar leads, Einthoven’s law, and Mean Electrical Axis (Biopac Lesson 6)
   Week 10: EOG: physiology, measurement methods/issues, biomedical applications
       Lab: EOG (Biopac Lesson 10)

17. Representative Lab Assignments (if applicable)
The students will form 2-person teams and learn to use the Biopac system at the beginning of the quarter. For each lab, the students will follow the protocol described in the Biopac manual to set up the electrodes, calibrate the system, and collect data. Students will perform calculations, statistical analysis, and interpretation of the measurement results as they complete the lab reports, which contain tables, parameter calculations, and short-assay questions.

18. Grading Plan
   60%: Lab reports
   20%: Quizzes and tests
   20%: Term project presentation and report

19. Contribution to Meeting ABET "Professional Component" (i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (if applicable)

   (b) an ability to design and conduct experiments, as well as to analyze and interpret data (2 chits)
   Students will design an experiment to measure one or multiple biopotential
signals using the Biopac system. The experiments will aim to solve a meaningful physiological question (for example, the effect of caffeine on heart rate). The students will design the experimental protocol, analyze the measured data, and interpret the results with reference to existing literature.

(d) **an ability to function on multi-disciplinary teams (1 chit)**
Students will be asked to form teams for their weekly lab assignments and the term projects. They will play different roles, such as the observer, data recorder, experimental subject or report preparer.

(g) **an ability to communicate effectively (1 chit)**
The students will practice both written and oral communication skills as they complete their term project. The student teams will conduct a 20-minutes PowerPoint presentation to the entire class on their experimental design, outcome and analysis with regard to their term project. The students will also complete a report on their project in manuscript format.

20. **Relationship to ABET-Accredited Program Objectives (if applicable)**

(m) **the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems (2 chits)**
The weekly laboratory exercises to measure and analyze bioelectrical potentials will provide students ample practices of making measurements on living systems. The lab reports contain data analysis and short-assay questions that examine how the students interpret the measurements. The interpretation will address not only physiological phenomena and principles, but also the interaction between the living system and the measurement system.

21. **Preparation Date:** November 15, 2006

22. **Preparer Name:** Jun Liu

Is this a course with decimal subdivisions? If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

18-Character Transcript Abbreviation: Quant Physiol          Level U ☒ G ☐ P ☐ Credit Hours: 4

Description (not to exceed 25 words): Introducing and building on fundamentals of control system theory. Quantitative models of physiological systems will be developed and studied.

Quarter offered (check): SU ☐ AU ☐ WI ☐ SP ☒ *Distribution of class time/contact hours: 4 x 1 hr
di__
Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) ☐

Prerequisite(s): BME 205; EEOB 232 and 415; Math 415

Exclusion or limiting clause:

Repeatable to a maximum of _0__ credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter ☒ S/U ☐ Progress ☐

If this course is Progress graded, what course is the last one in the series?

Honors Statement: Yes ☐ No ☒ GEC: Yes ☐ No ☒ Admission Condition

Off-Campus: Yes ☐ No ☒ EM: Yes ☐ No ☒ Course: Yes ☐ No ☒

Embedded Honors Statement: Yes ☐ No ☒

Other General Course Information:
(e.g. "Taught in English." "Credit does not count toward BSBA degree.")

Subject Code 140501 Subsidy Level (V, G, T, B, M, D, or P) B

(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes ☐ No ☒

B. General Information:
1. Provide the rationale for proposing this course:
   New Biomed E major

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.
   This course is (check one) Required ☒ Elective ☐ Other (Explain) ☐
If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Off Campus/Workshop Request form.

3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course. Will require new faculty.

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes ☐ No ☒ List:

5. If this course is part of a sequence, list the number of the other course(s) in the sequence:

6. Expected section size: 25  Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.)  Yes ☒

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☒

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

*****************************************************************************
**APPROVAL SIGNATURES** (As needed. All signatures on lines in ALL CAPS (e.g. ACADEMIC UNIT) must be completed)

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<tr>
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ACADEMIC AFFAIRS

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<th>Printed Name</th>
<th>Date</th>
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</table>
1. **Department**: Biomedical Engineering

2. **Number**: 403

3. **Title of course**: Quantitative Physiology

4. **Description** (*from Course Description Bulletin*)
   Building upon the fundamentals of control systems theory, quantitative models of physiological systems will be developed and studied.

5. **Level**: U = Undergraduate

6. **Credits**: 4

7. **Class Time Distribution**: 4 cl per week

8. **Prerequisites**: Physiology (OSU EEOB 232 and EEOB 415), Differential Equations (OSU Math 415), Computer Applications (OSU BME 205)

9. **Quarters Offered**: Spring

10. **General Information**:
    This course focuses on the development of quantitative understanding of a selected set of physiological systems. Methods of control systems will be introduced as motivated by physiological homeostatic systems, and physiological systems of current interest will be explored, including cellular, cardiovascular, musculoskeletal, and visual systems.

11. **Exclusions**:

12. **Cross-Listings**:

13. **Other Information**:

14. **Course Objectives**
    1. Students will be able to develop negative feedback diagrams from governing equations, and solve analytically or numerically. *(a,e,k,l)*
    2. Students will be able to develop multiple levels of complexity to quantitatively describe physiological systems, including cellular and system functions (e.g., calcium dynamics; cardiac regulation; muscle force-velocity relationships; retinal intensity-response relations). Quantitative description of physiological systems will be used to derive constraints of prosthetic biomedical devices *(a,c,e,k,l)*
    3. Students will be able to identify experiments needed to obtain physiological measures for quantitative modeling of physiological systems. *(a,e,l,m)*

15. **Textbooks and Other Required Material**

16. **Topics (including approximate duration)**

Introduction to Control Systems Analysis 2.5 weeks
- Linear systems
- Distributed-parameter, lumped parameter models
- Nonlinear systems; space-state analysis
- Open-loop, closed loop dynamics
- Numerical solutions: SIMULINK

Quantitative Cellular Physiology 2.5 weeks
- Cellular homeostasis
  - Diffusion, active transport, membrane potential, control of cell volume
- Membrane Ion Channels
- Excitability
  - Hodgkin-Huxley model
- Calcium dynamics
- Intercellular dynamics

Quantitative Systems Physiology: Cardiac and Circulatory 2 weeks
- Cardiac Systems
  - Pacemakers, arrhythmias, defibrillation
- Circulatory system
  - Simple linear system, multicompartement system, baroreceptor loop

Quantitative Systems Physiology: Musculoskeletal 2 weeks
- Muscle Crossbridge theory
  - Hill model; Huxley model; Rate equations
- Bone Adaptation
  - Wolff's Law; Adaptive elasticity; hormonal and mechanical stimuli

Quantitative Systems Physiology: Visual 1 week
- Photoreceptor physiology
- Light adaptation, lateral inhibition

17. **Representative Lab Assignments (if applicable)**
N/A (Students will all have had BME 302 measurement lab course prior to this course.)

18. **Grading Plan**
- 40%: Weekly Homework
- 20%: Computer project
- 20%: Tests
- 20%: Final exam
19. **Contribution to Meeting ABET "Professional Component"** *(i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (If applicable)*

(a) **an ability to apply knowledge of mathematics, science, and engineering** *(4 chits)*

Students will develop skills in analytical and computational methods for solving problems related to physiological systems.

(c) **an ability to design a system, component or process to meet desired needs** *(2 chits)*

Students will develop understanding of the physiological parameters that drive design of pacemakers and defibrillation devices based on cardiac electrophysiology models.

(e) **an ability to identify, formulate, and solve engineering problems** *(3 chits)*

Students will develop skills in formulating governing equations and critical parameters related to physiological system behaviors.

(k) **an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice** *(3 chits)*

Students will develop the ability to use MATLAB and SIMULINK to find numerical solutions for physiological system behaviors.

20. **Relationship to ABET-Accredited Program Objectives** *(if applicable)*

(l) **an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology** *(3 chits)*

Students will develop skills in formulating quantitative descriptions of physiological systems from experimental observations and measures.

(m) **the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems** *(1 chit)*

Although there is not an experimental component for this course, students will develop the ability to define needed parameters and measures for quantitative models of physiological systems.

21. **Preparation Date:** December 20, 2006

22. **Preparer Name:** Richard T. Hart and Stephen Lee
**OHIO STATE NEW COURSE REQUEST**

College: Engineering

<table>
<thead>
<tr>
<th>Academic unit:</th>
<th>Biomedical Engineering</th>
<th>Book 3 Listing:</th>
<th>Biomedical Engineering</th>
</tr>
</thead>
</table>

Proposed Course No: 411  
Full Title of Course: Bioimaging

Proposed Effective Qtr/Yr:  
- SU  
- AU  
- WI  
- SP  
- YEAR: 2008  
(See OAA Academic Organization and Curriculum Handbook for Deadlines)

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### A. Course Offerings Bulletin Information

**Follow instructions in the OAA Academic Organization and Curriculum Handbook.**

**Is this a course with decimal subdivisions?** If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

<table>
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<tr>
<th>18-Character Transcript Abbreviation: Bioimaging</th>
<th>Level</th>
<th>U</th>
<th>G</th>
<th>P</th>
<th>Credit Hours: 4</th>
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**Description (not to exceed 25 words):**  
Introduction to medical imaging techniques, including data collection and image processing for projection x-ray, computed tomography, ultrasonic, and magnetic resonance.

**Quarter offered (check):**  
- SU  
- AU  
- WI  
- SP  

*Distribution of class time/contact hours: 2 x 2 hr.

Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) ☐

**Prerequisite(s):** BME 205; Physics 133; EEOB 232 or equiv; or permission of instructor

**Exclusion or limiting clause:**

Repeatable to a maximum of ___ credit hours.

**Cross-listed with:** n/a

**Grade Option (Please check):**  
- Letter ☒  
- S/U ☐  
- Progress ☐

**If this course is Progress graded, what course is the last one in the series?**

**Honors Statement:**  
- Yes ☐  
- No ☒  

**Off-Campus:**
- Yes ☐  
- No ☒  

**Embedded Honors Statement:**  
- Yes ☐  
- No ☒  

**GEC:**
- Yes ☐  
- No ☒

**Admission Condition:**
- Course: Yes ☐  
- No ☒

**Other General Course Information:** BME Bioimaging "domain class"

(e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

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**Subject Code** 140501  
**Subsidy Level (V, G, T, B, M, D, or P)** ☒  
(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

**Will course be taught in distance learning format:**  
- Yes ☐  
- No ☒

---

### B. General Information

1. Provide the rationale for proposing this course:  
   - New Biomed E major
2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.
   This course is (check one) Required ☐ Elective ☐ Other (Explain) ☐:
   Students to choose 3 courses from 411, 421, 431, 441, 451, or 461

* If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Off
  Campus/Workshop Request form.

3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this
   new course.
   New departmental status for Biomed E

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes ☐ No ☐ List:

5. If this course is part of a sequence, list the number of the other course(s) in the sequence:

6. Expected section size: 25 Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes ☐

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with
   academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☐

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-
   campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

*****************************************************************************
** APPROVAL SIGNATURES ** (As needed. All signatures on lines in ALL CAPS (e.g. ACADEMIC UNIT) must be completed

| Academic Unit Undergraduate Studies Committee Chair (Undergraduate course) | Printed Name | Date |
| Academic Unit Graduate Studies Committee Chair(Undergraduate/Graduate course) | Printed Name | Date |
| School /College Undergrad Curriculum Committee (Undergraduate/Graduate course) | Printed Name | Date |
| School /College Graduate Curriculum Committee (Undergraduate/Graduate course) | Printed Name | Date |

ACADEMIC UNIT CHAIR /SCHOOL DIRECTOR

| COLLEGE DEAN | Printed Name | Date |
| Graduate School (If Appropriate) | Printed Name | Date |
| ASC Curriculum Committee Chair (If Appropriate)) | Printed Name | Date |
| University Honors Center (If Appropriate) | Printed Name | Date |
| Office of International Education (study tour only) | Printed Name | Date |

ACADEMIC AFFAIRS

| Printed Name | Date |
BME 411: Bioimaging

1. **Department:** Biomedical Engineering

2. **Number:** 411

3. **Title of course:** Bioimaging

4. **Description (from Course Description Bulletin)**
   Introduction to medical imaging techniques, including data collection and image processing for projection x-ray, computed tomography, ultrasonic, electron paramagnetic resonance and magnetic resonance imaging and microscopy.

5. **Level:** U = Undergraduate

6. **Credits:** 4

7. **Class Time Distribution:** 2 cl. @ 2 hours each

8. **Prerequisites:** Physics (133), Physiology (OSU EEOB 232 or equivalent), BME 205, or permission of instructor

9. **Quarters Offered:** Winter or Spring

10. **General Information:**
    This course focuses on the integration of physics, instrumentation and life sciences for the study of bioimaging at the molecular, cellular and tissue level. An understanding and introduction to various imaging modalities (infrared, ultrasound, microscopy, NMR, MRI, CT, PET, EPR) will be covered with their applications in biomedicine. The course is primarily a lecture course and includes a site-visit to bioimaging instrumentation(s). It will satisfy the BME “domain class” requirements for:

    1. Hands-on experience: students will witness acquisition of data in real-time for at least two bioimaging techniques (listed above) and perform image analysis and interpretation of the acquired data for the medical imaging instrumentation.

    2. Technical communication: Each student will write a term paper and give a short presentation on a bioimaging topic. In addition students will be divided into teams and asked to present the solution to a hypothetical bioimaging problem. These activities will encourage written and verbal technical communication skills.

    3. Modeling/Simulation: students will be assigned homework assignments involving scripting calls to MATLAB for mathematical modeling, computer simulation and global optimization techniques to simulate, predict or verify image reconstruction or perform contrast enhancement. For instance load an image file (DICOM or other) into MATLAB workspace, extract values for specified pixels as a MAT file and write scripts to perform specified manipulations.

    4. Creativity: The class will include opportunities for students to brainstorm technical challenges and limitations in bioimaging techniques and in their
adaptation for biomedicine, through interactive lectures, laboratory visit(s) and term paper/oral presentation.

11. Exclusions:

12. Cross-Listings:

13. Other Information:

14. Course Objectives
The goals of this course are to provide the student with the following:

1. Students will learn the fundamentals of mathematical techniques such as linear algebra, Fourier theory and multiresolution/wavelet techniques and apply them in signal processing settings \((a, e, l)\).

2. Develop an understanding of signals and fundamentals of bioimaging modalities and how to interpret them quantitatively for biomedicine \((a, b, d, i, l)\).

3. Develop knowledge of instrumentation and image processing techniques in biomedicine and ability to communicate at an interface between biology and medicine \((b, d, g, i, m)\).

15. Textbooks and Other Required Material
Biomedical Imaging (Principles and Applications in Engineering, 10) by Karen M. Mudry, Robert Plonsey, and Joseph D. Bronzino (Hardcover - Mar 26, 2003)

Introduction to Biomedical Imaging (IEEE Press Series on Biomedical Engineering) by Andrew G. Webb (Hardcover - Dec 26, 2002)

16. Topics (including approximate duration)
1. Electromagnetic spectrum and bio-interactions (2 lectures)
   (interactions between tissue and visible light, infrared, X-ray, ultrasound, radiowaves).

2. Wave theory and fourier transforms (1D and 2D) (3 lectures)
   (also include fundamentals of projection x-rays)

3. Introduction to molecular, cellular and in-vivo imaging (1 lecture)
   (resolution required, signals that can be detected)

4. Introduction of various imaging modalities (8 lectures)
   (infrared, ultrasound, microscopy, NMR, MRI, CT, PET, EPR)

5. Introduction to image processing (3 lectures)
   (image reconstruction, visual improvement and preparation for quantitative analysis)

6. Applications (2 lectures)
   (bioimaging in biomedical research and clinical applications)
Note 2 classes per week = 19 classes

17. Representative Lab Assignments *(if applicable)*
Visit to labs to see instrumentation for various imaging modalities.

18. Grading Plan
30%: Weekly project assignments
10% Term paper
20%: Midterm
40%: Final exam

19. Contribution to Meeting ABET "Professional Component" *(i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (if applicable)*
   *(a) an ability to apply knowledge of mathematics, science, and engineering (3 chits)*
   The students will develop engineering approaches by application of mathematics and physics to bioimaging and instrumentation. The demonstration of increasing proficiency will be evaluated through assignments and tests.
   *(b) an ability to design and conduct experiments, as well as to analyze and interpret data (3 chits)*
   The students will develop an understanding of a broad range of imaging modalities, their strengths and limitations and will be asked to select and describe how and which bioimaging technique(s) could be applied for an assigned biomedical application. These aspects will be discussed both through didactic training in class-lectures and through assignments and tests.
   *(d) an ability to function on multi-disciplinary teams (2 chits)*
   A term-paper or project report on a bioimaging problem will be assigned to a team of students. The students will develop a solution for the problem through an understanding of the biological problem, spatial and temporal resolution desired, signals to be collected and selection of bioimaging technique and image analysis. Each member of the team will (anonymously) evaluate all other members on the team on the key contributions to the project. These peer evaluations then become the assessment for each team member.
   *(e) an ability to identify, formulate, and solve engineering problems (2 chits)*
   The bioimaging course focuses on using knowledge from physics, engineering, biology and physiology that students integrate to identify, formulate and solve biomedical problems involving bioimaging. Assessments will be made based on home work assignments and tests on the course objectives.
   *(g) an ability to communicate effectively (1 chits)*
   The students will be asked to orally present their term paper in class in an interactive session and answer questions on it. This will help develop communication skills for scientific writing and technical presentations.
   *(i) a recognition of the need for, and an ability to engage in life-long learning (1 chit)*
   A periodic review of the current scientific literature will be used to motivate the progress in bioimaging research and applications and underscore the need for,
BME 411: Bioimaging

and the students’ ability to learn from current literature.

20. **Relationship to ABET-Accredited Program Objectives (if applicable)**

   (I) an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology (2 chits)

   This capability is well integrated in the bioimaging course, with essentially all examples and assignments based on solving biomedical engineering problems at the interface of engineering and biology.

   (m) the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems (2 chit)

   The bioimaging course will focus on interpreting quantitative data from biomolecules, cells and tissues both in-vitro and in-vivo obtained from journal articles or research labs. Secondly the course will develop an understanding for the right selection of a bioimaging technique for a given biomedical problem and the challenges associated with it for making measurements on living systems.

21. **Preparation Date:** March 2, 2007

22. **Preparer Name:** Gunjan Agarwal
### A. Course Offerings Bulletin Information

Follow instructions in the *OAA Academic Organization and Curriculum Handbook*.

**Is this a course with decimal subdivisions?** If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

<table>
<thead>
<tr>
<th>Quarter offered (check):</th>
<th>SU</th>
<th>AU</th>
<th>WI</th>
<th>SP</th>
<th>*Distribution of class time/contact hours: 2x2 hr.</th>
<th>Level</th>
<th>U</th>
<th>G</th>
<th>P</th>
<th>Credit Hours: 4</th>
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</thead>
</table>

Description *(not to exceed 25 words):* Integrating fundamental engineering and life science principles to cover key mass plus momentum transport concepts, and contemporary applications in biomedical engineering.

Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) ☐

Prerequisite(s): BME 205; ME 420 or equiv and ME 500 or equiv; EEOB 232 or equiv; prereq or concur: EEOB 415; or permission of instructor.

Exclusion or limiting clause:

Repeateable to a maximum of _0_ credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter ☒ S/U ☐ Progress ☐

If this course is Progress graded, what course is the last one in the series?

| Honors Statement: | Yes ☐ No ☒ | GEC: Yes ☐ No ☒ | Admission Condition: Course: Yes ☐ No ☒ |
| Off-Campus: | Yes ☐ No ☒ | EM: Yes ☐ No ☒ |
| Embedded Honors Statement: | Yes ☐ No ☒ |

Other General Course Information: BME Biotransport “domain course”

(e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

Subject Code 140501 Subsidy Level (V, G, T, B, M, D, or P) B

(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes ☐ No ☒

### B. General Information

1. Provide the rationale for proposing this course:
   New Biomed E major

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.
This course is (check one) Required ☐ Elective ☐ Other (Explain) ☒
Students choose 3 courses from 411, 421, 431, 441, 451, or 461

* If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Off Campus/Workshop Request form.

3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course. New departmental status for Biomed E

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes ☐ No ☒ List:

5. If this course is part of a sequence, list the number of the other course(s) in the sequence:

6. Expected section size: 25 Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes ☒

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☒

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

________________________________________________________________________

APPROVAL SIGNATURES (As needed. All signatures on lines in ALL CAPS (e.g. ACADEMIC UNIT) must be completed

Academic Unit Undergraduate Studies Committee Chair (Undergraduate course) Printed Name Date

Academic Unit Graduate Studies Committee Chair(Undergraduate/Graduate course) Printed Name Date

School /College Undergrad Curriculum Committee (Undergraduate/Graduate course) Printed Name Date

School /College Graduate Curriculum Committee (Undergraduate/Graduate course) Printed Name Date


ACADEMIC UNIT CHAIR /SCHOOL DIRECTOR

COLLEGE DEAN

Graduate School (If Appropriate) Printed Name Date

ASC Curriculum Committee Chair (If Appropriate)) Printed Name Date

University Honors Center (If Appropriate) Printed Name Date

Office of International Education (study tour only) Printed Name Date

ACADEMIC AFFAIRS Printed Name Date
1. **Department**: Biomedical Engineering

2. **Number**: 421

3. **Title of course**: Biotransport

4. **Description** *(from Course Description Bulletin)*
   
   This course brings together fundamental engineering and life science principles to cover key transport concepts in biomedical engineering. Emphasis is put on mass and momentum transport with applications related to contemporary biology, medical science and biotechnology.

5. **Level**: U = Undergraduate

6. **Credits**: 4

7. **Class Time Distribution**: 4 cl.

8. **Prerequisites**: BME 205, Differential Equations (OSU Math 415 or equivalent), Fluid Mechanics (OSU ME 500 or equivalent), Physiology (OSU EEOB 232 or equivalent plus EEOB 415 or as a co-req), or permission of instructor.

9. **Quarters Offered**: Winter or Spring

10. **General Information**:
    
    This course focuses on the integration of transport phenomena and life sciences for the junior biomedical engineering student. It covers such topics as physical and flow properties of blood, receptor-ligand binding, hemodialysis, tissue oxygen transport and pharmacokinetic models.
    
    The course is primarily a lecture course, but will satisfy the BME “domain class” requirements for:

    1. Hands-on experience: Nitric oxide (NO) gas is a potent vasodilator that is generated and released to the bloodstream by the endothelial cells on the vessel wall. Students will perform a laboratory experiment where they will record NO consumption kinetics in solution in the presence of either cell-free oxyhemoglobin (oxyHb) or oxyHb encapsulated in red blood cells (RBCs; blood will be drawn earlier from a rat) using a UV-VIS spectrophotometer.
    
    2. Technical communication: Each student will write a term paper and give a short presentation on a biotransport topic. Each group will turn in a laboratory report following the laboratory exercise.
    
    3. Modeling/Simulation: Following the laboratory experiment, each group will have to analytically solve the mass transfer problem (diffusion with reaction at the cell boundary) that describes the experimental setup, and use MATLAB to plot fit of the collected data to the analytical result (concentration of NO in the bulk as a function of time) to estimate the kinetic rate of NO consumption by RBC-encapsulated oxyHb.
    
    4. Creativity: The class will include opportunities for students to generate creative hypotheses for biotransport applications both through the laboratory experience.

and the term paper/oral presentation.

11. Exclusions:

12. Cross-Listings:

13. Other Information:

14. Course Objectives
   1. Students will be able to learn human physiology as it relates to specific applications to biomedical engineering, eg. physiology of the cardiovascular system as it relates to biological mass transport \((a, i, l, m)\).
   2. The students will be able to derive and solve differential equations of models of fluid and mass transport both analytically and through computer simulations \((a, e, k, l)\).
   3. The students will demonstrate that they can effectively communicate ideas by describing, both orally and in writing, biotransport problems \((b, g, m)\).

15. Textbooks and Other Required Material

16. Topics (*including approximate duration*)
    Lecture 1: The role of transport processes in biological systems. Definition of transport processes. Transport at the cellular level. Physiological transport systems (eg. cardiovascular system). Applications in disease pathology, treatment and device development. (Chapter 1)

    Lecture 2: Physiological fluid mechanics (Fluid kinematics; constitutive relations). (Chapters 2.1-2.6)

    Lecture 3: Physiological fluid mechanics (Momentum balances and applications; rheology and flow of blood). (Chapters 2.7-2.8)

    Lecture 4: Conservation relations for fluid transport (Equation of conservation of mass; equation of conservation of linear momentum). (Chapters 3.1-3.3)

    Lecture 5: Continue on conservation relations for fluid transport (Navier-Stokes equations for an incompressible Newtonian fluid; dimensionless form and groups). (Chapters 3.4-3.5)

    Lectures 6-7: Mass transport in biological systems (constitutive relations; steady-state diffusion in one dimension; radial diffusion in cylindrical or spherical coordinates). (Chapters 6.1-6.7)

    Lecture 8: Continue on mass transport in biological systems (unsteady diffusion in one
dimension; protein adsorption to biomaterials). (Chapter 6.8)

Lecture 9: Diffusion-limited reactions (diffusion-limited binding between a cell surface protein and a solute; diffusion-limited binding on a cell surface). (Chapter 6.9)

Lecture 10: Diffusion with convection (conservation of mass for dilute solutions; mass transfer coefficient). (Chapters 7.1-7.7)

Lecture 11: Continue on diffusion with convection (mass transfer across membranes: hemodialysis). (Chapter 7.8)

Lecture 12: Laboratory exercise (hands on experience for half of the class). Lecture 13: Laboratory exercise (hands on experience for the rest of the class).

Lecture 14: Mass transport and biochemical interactions (chemical kinetics and reaction mechanisms; effect of diffusion and convection on chemical reactions). (Chapters 10.1-10.6)

Lecture 15: Mass transport at the cellular level (receptor-ligand binding kinetics on the cell surface and molecular transport within cells). (Chapters 11.1-11.5)

Lecture 16: Tranport of gases between blood and tissues (oxygen-hemoglobin equilibria; oxygen delivery to tissues). (Chapters 13.1-13.5)

Lecture 17: Transport in organs and organisms (pharmacokinetic models). (Chapters 16.1-16.4)

Lecture 18: Term papers due. Student oral presentations for half of the class. Lecture 19: Term papers due. Student oral presentations for the rest of the class.

Lecture 20: Final exam (in class).

17. **Representative Lab Assignments (if applicable)**
A protocol is being developed. However, the plan is to have 2-student teams record NO concentration vs. time following the addition of NO in solution containing either cell-free oxyHb or RBC-encapsulated oxyHb (blood will be drawn earlier from a rat) using a UV-VIS spectrophotometer.

18. **Grading Plan**

25%: Homework assignments (at least 3 of them)
25%: Term paper on a transport topic of the student’s choice (Instructor will provide a list of topics; followed by a short Powerpoint oral presentation to the class by each student)
25%: Lab assignment (execution of experiment by 2-student teams, data collection and report writeup)
25%: Final exam
19. Contribution to Meeting ABET "Professional Component" (i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (if applicable)
   (a) an ability to apply knowledge of mathematics, science, and engineering (3 chits)
       The students’ ability to apply the knowledge of mathematics, science and engineering is expected to be a major outcome of the course.
   (b) an ability to design and conduct experiments, as well as to analyze and interpret data (2 chits)
       The course through the laboratory experience will allow the students to design and conduct an experiment, and to analyze and interpret experimental data.
   (e) an ability to identify, formulate, and solve engineering problems (3 chits)
       The biotransport course focuses on using knowledge from transport phenomena, fluid mechanics and physiology that students integrate to identify, formulate and solve biotransport problems.
   (g) an ability to communicate effectively (2 chits)
       This will be cultivated via the term paper (oral presentation based on Powerpoint) and the lab report (following the laboratory experiment).
   (i) a recognition of the need for, and an ability to engage in life-long learning (1 chit)
       The whole course material and, in particular, the term paper will be used to motivate the students to learn more on biotransport research and applications and will underscore the need for learning from current literature.
   (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (1 chit)
       This ability is exemplified by the use of the MATLAB (Mathworks, Natick, MA) programming environment.

20. Relationship to ABET-Accredited Program Objectives (if applicable)
   (l) an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science and engineering to solve the problems at the interface of engineering and biology (2 chits)
       The course will cover certain topics of physiology and biology and will instruct the students, through examples, assignments and the laboratory experience, how to apply mathematics, science and engineering to solve problems at the interface of engineering and biology/medicine.
   (m) the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems (2 chits)
       The laboratory exercise that will measure kinetics of NO uptake from RBC-encapsulated oxyHb is not an in vivo test, but the consumption of gas NO in solution by RBCs from fresh rat blood is a central focus of the lab.

21. Preparation Date: March 2, 2007

22. Preparer Name: B. Rita Alevriadou
### A. Course Offerings Bulletin Information

Follow instructions in the OAA Academic Organization and Curriculum Handbook.

**Is this a course with decimal subdivisions?** If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

| 18-Character Transcript Abbreviation: | Biomaterials | Level | U | G | P | Credit Hours: | 4 |
|------------------------------------|--------------|------|---|---|---|----------------|

Description *(not to exceed 25 words)*: Review of basic concepts of materials science; biocompatibility and biological reactions to implanted materials; natural biomaterials and synthetic materials used in biological applications.

**Quarter offered (check):** SU ☑ AU ☐ WI ☑ SP ☑ *Distribution of class time/contact hours: 2 x 2 hr cls*

Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) ☐

**Prerequisite(s):** BME 205; MSE 205; ME 420; ME 500; EEOB 232; prreq or concur: EEOB 415; or permission of instructor

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<th>Exclusion or limiting clause:</th>
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<tr>
<td>Repeatable to a maximum of <em>0</em>_ credit hours.</td>
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**Cross-listed with:** n/a

**Grade Option (Please check):** Letter ☑ S/U ☐ Progress ☐

If this course is Progress graded, what course is the last one in the series?

<table>
<thead>
<tr>
<th>Honors Statement:</th>
<th>Yes ☑ No ☐</th>
<th>GEC:</th>
<th>Yes ☑ No ☐</th>
<th>Admission Condition</th>
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<tbody>
<tr>
<td>Off-Campus:</td>
<td>Yes ☑ No ☐</td>
<td>EM:</td>
<td>Yes ☑ No ☐</td>
<td>Course: Yes ☑ No ☐</td>
</tr>
<tr>
<td>Embedded Honors Statement:</td>
<td>Yes ☑ No ☐</td>
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</table>

**Other General Course Information:** BME Biomaterials "domain class"

(e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

Subject Code 140501

Subsidy Level (V, G, T, B, M, D, or P) B

(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

**Will course be taught in distance learning format:** Yes ☑ No ☐

### B. General Information:

1. Provide the rationale for proposing this course:
   - New Biomed E major

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.
   - This course is (check one) Required ☐ Elective ☐ Other (Explain) ☑
   - Students to choose 3 courses from 411, 421, 431, 441, 451, or 461
3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course.
   New departmental status for Biomed E

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes [ ] No [X] List:

5. If this course is part of a sequence, list the number of the other course(s) in the sequence:

6. Expected section size: 25   Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes [X]

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable [ ]

   This course has been discussed with Materials Science and Engineering. They are satisfied with the content, but would like to have this cross-listed with MSE. We are discussing logistics if that should happen.

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

*****************************************************************************

APPROVAL SIGNATURES (As needed. All signatures on lines in ALL CAPS (e.g. ACADEMIC UNIT) must be completed)

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<thead>
<tr>
<th>Academic Unit Undergraduate Studies Committee Chair (Undergraduate course)</th>
<th>Printed Name</th>
<th>Date</th>
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<tbody>
<tr>
<td>Academic Unit Graduate Studies Committee Chair(Undergraduate/Graduate course)</td>
<td>Printed Name</td>
<td>Date</td>
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<tr>
<td>School /College Undergrad Curriculum Committee (Undergraduate/Graduate course)</td>
<td>Printed Name</td>
<td>Date</td>
</tr>
<tr>
<td>School /College Graduate Curriculum Committee (Undergraduate/Graduate course)</td>
<td>Printed Name</td>
<td>Date</td>
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ACADEMIC UNIT CHAIR /SCHOOL DIRECTOR

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<th>Printed Name</th>
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COLLEGE DEAN

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Graduate School (If Appropriate)

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ASC Curriculum Committee Chair (If Appropriate)

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University Honors Center (If Appropriate)

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Office of International Education (study tour only)

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ACADEMIC AFFAIRS

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<th>Date</th>
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* If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Off Campus/Workshop Request form.
1. **Department**: Biomedical Engineering

2. **Number**: 431

3. **Title of course**: Biomaterials

4. **Description** (*from Course Description Bulletin*)
   Integrate life and materials science topics focused upon biocompatibility and biological reactions to implanted materials and to characterize natural biomaterials and synthetic materials used in biological applications.

5. **Level**: U = Undergraduate

6. **Credits**: 4

7. **Class Time Distribution**: 2 – 2 hour classes

8. **Prerequisites**: BME 205, Materials Science (MSE 205 or equivalent), Differential Equations (OSU Math 415 or equivalent), Solid Mechanics (OSU ME420 or equivalent), Fluid Mechanics (OSU ME 500 or equivalent), Physiology (OSU EEOB 232 or equivalent plus EEOB 415 or as a co-req), or permission of instructor

9. **Quarters Offered**: Winter or Spring

10. **General Information**:
   This course focuses on the properties of synthetic and natural biomaterials commonly used for implantation, and the biological response to the implanted materials. Areas of application include hard material and soft material properties, biomaterial-tissue interfacial phenomena, and biomaterial selection.
   The course is primarily a lecture course, but will satisfy the BME “domain class” requirements for:
   1. Hands-on experience: Students will measure biomaterial (metal, polymer, natural) strength, elongation and load to failure by mechanical loading to failure using an Instron machine.
   2. Technical communication: Students will prepare a technical note (in journal format) from the stress-strain curves obtained from the mechanical loading of biomaterials (biomedical polymer, tendon/ligament, bone) and present the analysis of the data to the class; a term paper will be prepared on a relevant biomaterial topic.
   3. Modeling/Simulation: Modeling/Simulation: Students will develop a MATLAB/SIMULINK program to solve for and predict the viscoelastic responses of homogeneous and polymer-layered metal beams. Students will use the standard Voigt-Kelvin equation to develop the viscoelastic modeling program. The MATLAB scripts would generate small equation sets (Voigt-Kelvin equations) to be solved by calling routines for solving differential equations to that would simulate the viscoelastic response of
metal beams or multi-layer, polymer-coated beams. Damping parameters and Young's modulus would be identified for accurate material representation.

4. Creativity: The class will include opportunities for students to participate in the process of selecting biomaterials and/or creating novel biomaterials for different biomedical applications.

11. Exclusions:

12. Cross-Listings:

13. Other Information:

14. Course Objectives
   1. Students will be able to interpret and analyze stress-strain curves for the major classes of biomaterials. \((a, b, e, k)\)
   2. Students will be able to describe the sequence of events involved in the biological response to biomaterials. \((e, l)\)
   3. Students will be able to generate selection criteria for a biomaterial for a given implant application site. \((a, c, i, l)\)
   4. Students will be able to experimentally determine the elongation and Young’s modulus of common biomaterials. \((a, e, k)\)

15. Textbooks and Other Required Material

16. Topics (including approximate duration)
   Properties of Materials \((2\text{ class})\)
   Hard Biomaterials \((6\text{ classes})\)
      Metals (Synthetic)
      Ceramics (Synthetic)
      Bone (Natural)
   Soft Biomaterials \((6\text{ classes})\)
      Polymers (Synthetic)
      Hydrogels (Synthetic)
      Protein-based (Natural)
   Tissue response \((2\text{ classes})\)
   Biomaterial selection \((4\text{ class})\)
      Surface consideration
      Selection criteria
   Note 2 classes per week = 20 classes
17. **Representative Lab Assignments (if applicable)**
A protocol is being developed. However, the plan is to have 2-student teams generate stress-strain curves for a variety of common biomaterials. The ends would be fixed and tested using an MTS or Instron machine to simultaneously measure elongation, force, and strain to failure. Students can then calculate displacements, strains and ultimate stress.

18. **Grading Plan**
- 25%: Weekly project assignments
- 10%: Term paper
- 15%: Lab assignment
- 30%: Quizzes and tests
- 20%: Final exam

19. **Contribution to Meeting ABET "Professional Component" (i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (if applicable)**

(a) **an ability to apply knowledge of mathematics, science, and engineering (4)**
The students' ability to develop engineering approaches by application of mathematics and physics is a major outcome of the course. The demonstration of increasing proficiency begins with Assignment 1 through the final exam.

(b) **an ability to design and to design and conduct experiments, as well as to analyze and interpret data (2)**
The inclusion of the laboratory component will allow the student to calculate the material properties from an experiment each student (in teams) will conduct.

(c) **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 (2)**
The course emphasizes analysis as an important component of the design process. Students will be asked to generate selection criteria using mechanical and physiological considerations for biomaterial usage in a given application.

(e) **an ability to identify, formulate, and solve engineering problems (2)**
The biomechanics course focuses on using knowledge from engineering mechanics and physiology that students integrate to identify, formulate and solve biomaterial problems.

(i) **a recognition of the need for, and an ability to engage in life-long learning (1)**
Current literature and lecture will be used to motivate the progress in biomaterials research and applications and underscore the need for, and the students’ ability to learn from current literature.

(k) **an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (1)**
This ability is developed during the quarter, exemplified by the use of the MATLAB (Mathworks, Natick, MA) programming environment, and an Instron machine.

20. **Relationship to ABET-Accredited Program Objectives (if applicable)**
(l) an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology (2)

This capability is the focus for the biomaterials course, with essentially all examples and assignments based on solving biomedical engineering problems at the interface of engineering and biology.

21. **Preparation Date:** March 2, 2007

22. **Preparer Name:** Mark A. Ruegsegger

Is this a course with decimal subdivisions? If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

18 Character Transcript Abbreviation: Biomechanics

Description (not to exceed 25 words): Mechanical characterization of biological tissues at the organ and system level; exploration of biomechanical factors on physiological and pathological conditions.

Quarter offered (check): 

Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here)  

Prerequisite (s): BME 205; ME 420 or equiv and ME 500 or equiv; EEOB 232 or equiv; prereq or concur: EEOB 415; or permission of instructor

Exclusion or limiting clause:

Repeatable to a maximum of __0__ credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter  S/U  Progress

If this course is Progress graded, what course is the last one in the series?

Honors Statement: Yes  No  GEC: Yes  No  Admission Condition Course: Yes  No  Embedded Honors Statement: Yes  No

Other General Course Information: BME Biomechanics “domain course” (e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

Subject Code  140501  Subsidy Level (V, G, T, B, M, D, or P)  B

(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes  No  

B. General Information:
1. Provide the rationale for proposing this course:

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.

This course is (check one) Required  Elective  Other (Explain) 

Students to choose 3 courses from 411, 421, 431, 441, 451, or 461

* If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Off Campus/Workshop Request form.

3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course.
   New departmental status for Biomed E

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes [ ] No [x] List:

5. If this course is part of a sequence, list the number of the other course(s) in the sequence:

6. Expected section size: 25 Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes [x]

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable [x]

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

*******************************************************************************

APPROVAL SIGNATURES (As needed. All signatures on lines in ALL CAPS (e.g. ACADEMIC UNIT) must be completed

Academic Unit Undergraduate Studies Committee Chair (Undergraduate course)          Printed Name Date

Academic Unit Graduate Studies Committee Chair (Undergraduate/Graduate course)      Printed Name Date

School/College Undergrad Curriculum Committee (Undergraduate/Graduate course)       Printed Name Date

School/College Graduate Curriculum Committee (Undergraduate/Graduate course)        Printed Name Date

[Signature]

ACADEMIC UNIT CHAIR /SCHOOL DIRECTOR

Printed Name Date

COLLEGE DEAN

Printed Name Date

Graduate School (If Appropriate)

Printed Name Date

ASC Curriculum Committee Chair (If Appropriate)

Printed Name Date

University Honors Center (If Appropriate)

Printed Name Date

Office of International Education (study tour only)

Printed Name Date

ACADEMIC AFFAIRS

Printed Name Date
1. **Department**: Biomedical Engineering

2. **Number**: 441

3. **Title of course**: Biomechanics

4. **Description (from Course Description Bulletin)**
   Mechanical characterization of biological tissues at the organ and system level; exploration of biomechanical factors on physiological and pathological conditions.

5. **Level**: U = Undergraduate

6. **Credits**: 4

7. **Class Time Distribution**: 4 cl.

8. **Prerequisites**: Differential Equations (OSU Math 415 or equivalent), Solid Mechanics (OSU ME420 or equivalent), Fluid Mechanics (OSU ME 500 or equivalent), Physiology (OSU EEOB 232 or equivalent plus EEOB 415 or as a co-req), BME 205, or permission of instructor

9. **Quarters Offered**: Winter or Spring

10. **General Information**:  
    This course focuses on the integration of mechanics and life sciences for the study of theory and applications in biomechanics. Areas of application include hard tissue mechanics, soft tissue mechanics, and biofluid mechanics.  
    The course is primarily a lecture course, but will satisfy the BME “domain class” requirements for:  
    1. **Hands-on experience**: Students will measure bone stiffness and strength by application of strain gages to chicken bone that is loaded until failure. 
    2. **Technical communication**: A presentation of experimental results will be prepared; a manuscript on a biomechanics topic will be prepared in the format of the *Journal of Biomechanics*.  
    3. **Modeling/Simulation**: Students will write a MATLAB script to solve for and display the response of solid viscoelastic materials to the standard 2-stage test. Students will write a MATLAB script to generate the finite difference approximation for steady flow in an aneurysm.  
    4. **Creativity**: The class will include opportunities for students to generate creative hypotheses for biomechanics applications (e.g., response of bone to implants; optic nerve head response to elevated intraocular pressure).

11. **Exclusions**:  

12. **Cross-Listings**:  

13. **Other Information**:  

14. **Course Objectives**
   1. Students will be able to derive the governing equations for the 3-parameter viscoelastic solid, and write a computer program to display the response of viscoelastic materials to testing protocols. \((a, e, k,f)\)
   2. Students will be able to apply the Navier-Stokes equations to approximate blood flow in an aneurysm. \((a, e, k, l)\)
   3. Students will be able to experimentally determine the Young’s modulus and strength of excised bone.\((m)\)
   4. Students will be able to generate lists of mechanical and physiological considerations important for prosthesis design and analysis for cardiovascular, musculoskeletal, and visual systems. \((c, i, j)\)

15. **Textbooks and Other Required Material**

16. **Topics (including approximate duration)**
   Constitutive Equations \(\text{5 classes}\)  
   Elasticity  
   Viscoelasticity  
   Viscous Fluids  
   Experimental Methods \(\text{2 classes}\)  
   Hard Tissues \(\text{5 classes}\)  
   Bone  
   Cartilage  
   Soft Tissues \(\text{4 classes}\)  
   Passive Tissues  
   Muscle Tissues  
   Fluids \(\text{4 classes}\)  
   Blood  
   Finite Difference Application \(\text{1 class}\)  
   (Note 2 classes per week = 20 classes)

17. **Representative Lab Assignments (if applicable)**
   A protocol has not been developed. However, the plan is to have 2-student teams apply strain rosettes to chicken bone (purchased from grocery store). The ends would be fixed, and tested using an MTS or Instron machine to simultaneously measure stroke, force, and strain to failure. Students can then calculate displacements, strains, ultimate stress. Pooled data will allow for statistical analysis. Reports, from each team but using the pooled data, will be written following the format of a Technical Note for the *Journal of Biomechanics*.

18. **Grading Plan**
   25%: Weekly project assignments  
   10%: Term paper  
   15%: Lab assignment  
   30%: Quizzes and tests  
   20%: Final exam
19. Contribution to Meeting ABET "Professional Component" (i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (if applicable)

(a) an ability to apply knowledge of mathematics, science, and engineering (4 chits)

The students’ ability to develop engineering approaches by application of mathematics and physics is a major outcome of the course. The demonstration of increasing proficiency begins with Assignment 1 through the final exam.

(c) 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 (2 chits)

The course emphasizes analysis as an important component of the design process. Students will be asked to prepare lists of mechanical and physiological considerations in device analysis and design.

(e) an ability to identify, formulate, and solve engineering problems (3 chits)

The biomechanics course focuses on using knowledge from engineering mechanics and physiology that students integrate to identify, formulate and solve biomechanics problems.

(i) a recognition of the need for, and an ability to engage in life-long learning (1 chit)

The current literature from the Biomedical Engineering Society will be used to motivate the progress in biomechanics research and applications and underscore the need for, and the students’ ability to learn from current literature.

(j) a knowledge of contemporary issues (1 chit)

In addition to the use of biomedical engineering literature (see above), the legal, ethical and financial considerations for device design will be introduced via study of the Björk-Shiley heart valve case study.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (1 chit)

This ability is developed during the quarter, exemplified by the use of the MATLAB (Mathworks, Natick, MA) programming environment.

20. Relationship to ABET-Accredited Program Objectives (if applicable)

(l) an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology (3 chits)

This capability is the focus for the biomechanics course, with essentially all examples and assignments based on solving biomedical engineering problems at the interface of engineering and biology.

(m) the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems (1 chit)

The laboratory exercise that tests excised bone to determine stiffness and strength is not an in vivo test, but the interaction of moist bone with strain gages and testing instrumentation is a central focus of the lab.

21. Preparation Date: March 2, 2007

22. Preparer Name: Richard T. Hart
OHIO STATE NEW COURSE REQUEST

College: Engineering

Academic unit: Biomedical Engineering

Book 3 Listing: Biomedical Engineering

(e.g., Portuguese)

Proposed Course No: 451

Full Title of Course: Molecular, Cell, and Tissue Engineering

Proposed Effective Qtr/Yr: SU □ AU □ WI ☑ SP □ YEAR: 2008

(See OAA Academic Organization and Curriculum Handbook for Deadlines)


Is this a course with decimal subdivisions? If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

18-Character Transcript Abbreviation: Mol Cell Tiss Eng Level U ☑ G □ P □ Credit Hours: 4

Description (not to exceed 25 words): Introduction to the incorporation of living components and compatible biomaterials to repair or replace biological functions.

Quarter offered (check): SU □ AU □ WI ☑ SP ☑

*Distribution of class time/contact hours: 2x2 hr.

Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) □

Prerequisite (s): BME 205; ME 500 or equiv; EEOB 232 or equiv; prereq or concur: EEOB 415; BioCHEM 511; or permission of instructor

Exclusion or limiting clause:

Repeatable to a maximum of 0 credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter ☑ S/U □ Progress □

If this course is Progress graded, what course is the last one in the series?

Honors Statement: Yes □ No ☑ GEC: Yes □ No ☑ Admission Condition

Off-Campus: Yes □ No ☑ EM: Yes □ No ☑ Course: Yes □ No ☑

Embedded Honors Statement: Yes □ No ☑

Other General Course Information: BME Molecular, Cell, Tissue Engineering “domain course:

(e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

Subject Code ____________ 14051 ____________ Subsidy Level (V, G, T, B, M, D, or P) ____________ B

(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes □ No ☑

B. General Information:

1. Provide the rationale for proposing this course:

New Biomed E major

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.

This course is (check one) Required □ Elective □ Other (Explain) ☑
Students to choose 3 courses from 411, 421, 431, 441, 451, and 461

* If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Off Campus/Workshop Request form.

3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course.
   New departmental status for Biomed E

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes □ No ☒ List:

5. If this course is part of a sequence, list the number of the other course(s) in the sequence:

6. Expected section size: 25 Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes ☒

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☒

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

APPROVAL SIGNATURES (As needed. All signatures on lines in ALL CAPS (e.g. ACADEMIC UNIT) must be completed)

| Academic Unit Undergraduate Studies Committee Chair (Undergraduate course) | Printed Name | Date |
| Academic Unit Graduate Studies Committee Chair(Undergraduate/Graduate course) | Printed Name | Date |
| School /College Undergrad Curriculum Committee (Undergraduate/Graduate course) | Printed Name | Date |
| School /College Graduate Curriculum Committee (Undergraduate/Graduate course) | Printed Name | Date |

ACADEMIC UNIT CHAIR /SCHOOL DIRECTOR

| Printed Name | Date |

| COLLEGE DEAN | Printed Name | Date |
| Graduate School (If Appropriate) | Printed Name | Date |
| ASC Curriculum Committee Chair (If Appropriate)) | Printed Name | Date |
| University Honors Center (If Appropriate) | Printed Name | Date |
| Office of International Education (study tour only) | Printed Name | Date |

ACADEMIC AFFAIRS

| Printed Name | Date |
1. **Department**: Biomedical Engineering

2. **Number**: 451

3. **Title of course**: Molecular, Cell, and Tissue Engineering

4. **Description (from Course Description Bulletin)**
   Introduction to the design and manipulation of biological structures on the molecular, cellular, and tissue level to achieve a desired purpose.

5. **Level**: U = Undergraduate

6. **Credits**: 4

7. **Class Time Distribution**: 4 cl.

8. **Prerequisites**: BME 205, Differential Equations (OSU Math 415 or equivalent), Physiology (OSU EEOB 232 or equivalent plus EEOB 415 or as a co-req), BioCHEM 511, ME 500, or permission of instructor

9. **Quarters Offered**: Winter or Spring

10. **General Information**: 
    This course focuses on the integration of engineering modeling, material fabrication, and life sciences to understand and manipulate biological processes at the molecular, cellular and tissue level.

    The course is primarily a lecture course, but will satisfy the BME “domain class” requirements for:
    1. Modeling/Simulation: Students will…
       - postulate a kinetic model governing cellular chemotaxis in response to a chemoattractant gradient and derive the ordinary differential equations corresponding to the kinetic model.
       - use MATLAB routines to numerically solve these differential equation and to perform a sensitivity analysis on relevant parameters.
       - will develop specific experimentally testable predictions that their model makes regarding chemotaxis as a function of chemoattractant gradients.
    2. Hands-on experience: Students will measure cell chemotaxis in response to chemoattractant gradients.
    3. Technical communication:
       - Students will attend two research seminars presentation (e.g., departmental seminars) and for each write a 3/4-page technical summary of the seminar content and a 1/4-page critique/commentary of the effectiveness of the communication.
       - Laboratory report.
4. Creativity: The class will include opportunities for students to generate creative hypotheses for cell, molecular and tissue engineering applications (e.g., new applications; product improvements).

11. Exclusions:

12. Cross-Listings:

13. Other Information:

14. Course Objectives
   1. Students will be able to will apply knowledge of mathematics, science, and engineering to propose novel and evaluate pending / existing Molecular, Cell and Tissue Engineering applications. (a, e, k, l)
   2. Students will be able to develop kinetic models of receptor-ligand interactions and to solve these models analytically and numerically. (a, k)
   3. Students will be able to experimentally determine cell migration rates in response to chemoattractant gradients. (m)

15. Textbooks and Other Required Material

16. Topics (including approximate duration)

MCT = molecular, cellular, and tissue

**Introduction**

Overview and history (2 hours)

Current and pending applications of MCT engineering

**Reverse Engineering of Natural Processes in the following systems**

We will explore how specific design challenges are accomplished on the molecular, cellular, and tissue level.

- Developmental biology (3 hours)
- Tissue Maintenance (3 hours)
- Regeneration (2 hours)
- Wound Healing (2 hours)
- Immunology (2 hours)

**Principles of MCT engineering**

- Proliferation (1 hour)
- Differentiation (1 hour)
- Migration (1 hour)
- Molecular Signaling Transduction (2 hours)
- Nutrient transport (1 hour)

**Methods of MCT engineering**
Cell culture (1 hour)
Biomaterials (1 hour)
Gene transfer (1 hour)
Characterization of biological materials (1 hour)
Modeling (3 hours)

**Applications of MCT engineering**

Diabetes (cell engineering) (4 hours)
Small diameter vascular grafts (tissue engineering) (4 hours)
Select molecular engineering applications (4 hours)
  - Molecular imaging of specific nucleic acids sequences
  - Biomimetic synthetic materials
  - Directed evolution of signal transduction molecules
  - Ration design of proteins to reduce immunogenecity

In class "post mortem" of lab experience and write up. (1 hour)

17. **Representative Lab Assignments (if applicable)**

2-student teams will use their mathematical model of cell migration in response to a chemoattractant gradient to develop specific testable predictions. An experiment will be designed to test on such experiment and conducted. The results will be written up in a short (2-page) laboratory report.

18. **Grading Plan**

25%: Weekly project assignments
5% Writing assignments (seminar write ups)
15%: Lab assignment
35%: Quizzes and tests
20%: Final exam

19. **Contribution to Meeting ABET "Professional Component" (i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (If applicable)**

(a) an ability to apply knowledge of mathematics, science, and engineering (2 chits)

Students will apply knowledge of mathematics, science, and engineering to propose novel and evaluate pending / existing CMT applications.

(b) an ability to design and conduct experiments, as well as to analyze and interpret data (3 chits)

Students will a) use mathematical models of their own construction to aid in the design of a cell migration experiment, (b) conduct the experiment and analyze their group’ results, and (c) analyze and interpret the class’s collective results.

(c) 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 (2 chits)

Students will prepare lists of biological, physiological, economic, and
legal/regulatory considerations relevant to CMT applications.

(d) an ability to function on multi-disciplinary teams (2 chits)
   Students’ laboratory experiment and write up will be conducted in 2-member teams. The students will also organize and interact on the class-level to coordinate experimental design and exchange/analyze resulting data.

(g) an ability to communicate effectively (2 chits)
   Students will generate written summaries of research seminars and their own laboratory results.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (1 Chit)
   Students will use of the MATLAB programming environment to implement the kinetic models of cell migration.

20. Relationship to ABET-Accredited Program Objectives (if applicable)

(l) an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology (2 chits)
   Students will use mathematical models of their own construction coupled with implementation of these models in a MATLAB environment to explore the relationship between cell migration and chemoattractant gradients.

(m) the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems (2 chit)
   Students will experimentally determine cell migration rates in response to chemoattractant gradients and analyze and interpret the resulting data.

21. Preparation Date: March 2, 2007

22. Preparer Name: Keith Gooch

Is this a course with decimal subdivisions? If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

18-Character Transcript Abbreviation: Bio Micro Nano Level U ☒ G ☐ P ☐ Credit Hours: 4

Description (not to exceed 25 words): Micro/nanotechnology focusing on integrating basic physics, chemistry, biochemistry and physiology of micro- and nanoscale devices in biomedical applications.

Quarter offered (check): SU ☐ AU ☐ WI ☒ SP ☒ Distribution of class time/contact hours: __2x2 hr. cl. __
Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) ☐

Prerequisite(s): BME 202, 205; MSE 205; Biochem 511; EEOB 232; or permission of instructor

Exclusion or limiting clause:

Repeatable to a maximum of ___0___ credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter ☒ S/U ☐ Progress ☐

If this course is Progress graded, what course is the last one in the series?

Honors Statement: Yes ☐ No ☒ GEC: Yes ☐ No ☒ Admission Condition
Off-Campus: Yes ☐ No ☒ EM: Yes ☐ No ☒ Course: Yes ☐ No ☒
Embedded Honors Statement: Yes ☐ No ☒

Other General Course Information: BME Micro/Nano tech “domain course”
(e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

Subject Code 140501 Subsidy Level (V, G, T, B, M, D, or P) B
(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes ☐ No ☒

B. General Information:
1. Provide the rationale for proposing this course:
   New Biomed E major

   2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.
   This course is (check one) Required ☐ Elective ☐ Other (Explain) ☒
   Students to choose 3 courses from 411, 421, 431, 441, 451, and 461
* If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Off
Campus/Workshop Request form.

3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this
new course.
   New departmental status for Biomed E

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes ☐ No ☒ List:

5. If this course is part of a sequence, list the number of the other course(s) in the sequence:

6. Expected section size: 25 Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes ☒

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with
academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☒

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-
campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

*****************************************************************************

APPROVAL SIGNATURES (As needed. All signatures on lines in ALL CAPS (e.g. ACADEMIC UNIT) must be completed

Academic Unit Undergraduate Studies Committee Chair (Undergraduate course) Printed Name Date

Academic Unit Graduate Studies Committee Chair(Undergraduate/Graduate course) Printed Name Date

School /College Undergrad Curriculum Committee (Undergraduate/Graduate course) Printed Name Date

School /College Graduate Curriculum Committee (Undergraduate/Graduate course) Printed Name Date


ACADEMIC UNIT CHAIR /SCHOOL DIRECTOR Printed Name Date

COLLEGE DEAN Printed Name Date

Graduate School (If Appropriate) Printed Name Date

ASC Curriculum Committee Chair (If Appropriate)) Printed Name Date

University Honors Center (If Appropriate) Printed Name Date

Office of International Education (study tour only) Printed Name Date

ACADEMIC AFFAIRS Printed Name Date
1. Department: Biomedical Engineering

2. Number: 461

3. Title of course: Biomedical Micro/nanotechnology

4. Description *from Course Description Bulletin*  
   Micro/nanotechnology focusing on integrating basic physics, chemistry, biochemistry  
   and physiology of micro- and nanoscale devices in biomedical applications.

5. Level: U = Undergraduate

6. Credits: 4

7. Class Time Distribution: 4

8. Prerequisites:  
   BME 202, 205, MSE 205, Biochem 511, EEOB 232 or permission of instructor

9. Quarters Offered: Winter or Spring

10. General Information:  
    The course focuses on functional nano- and microarchitectures in diagnostic and  
    therapeutic applications. Areas of application include in vitro immunoassay,  
    microfluidics, controlled drug delivery and molecular imaging.

    The course is primarily a lecture course, but will satisfy the BME “domain class”  
    requirements for:  
    1. Hands-on experience: Teams of four students will conduct an immunoassay in a  
       microfluidic device using quantum dot fluorescence for detection of  
       immunocomplexes.  
    2. Technical communication: A term paper on a biomedical nano/microtechnology  
       topic and a related presentation will be prepared by teams of four students.  
       Furthermore, a laboratory report will prepared by each team of four students.  
    3. Modeling/Simulation: Students will use finite element models to describe the  
       behavior of the microfluidic immunoassay system to determine the concentration  
       of an unknown antibody. Specifically, students will develop a CFD model of  
       pressure-driven fluid flow within a microfluidic device that related pressure  
       field, geometry of channel, and concentration of constituent molecules to  
       determine the reaction of antibodies in one fluid stream with quantum dots  
       in a second fluid stream. The concentration of the unknown feed stock of  
       antibody will then be determined using this concentration and  
       association/dissociation constants to analyze the fluorescent signal at the  
       detection site (with bound antigen on the surface). The modeling will
include:
  Scripting the finite element equations into MATLAB or COMSOL
  Generating 3D plots of concentration
  Extracting of parameter values at specific geometrical locations
4. Creativity: The term paper will contain a proposal for a micro/nanodevice in a biomedical application.

11. Exclusions:

12. Cross-Listings:

13. Other Information:

14. Course Objectives
Students will learn to:
1. Describe synthetic and biologic nanoscale materials and their production (a, h, i, j)
2. Understand sample fabrication protocols for top-down and bottom-up micro- and nanodevices (a, b, e, f, h, i, j)
3. Operate simple immunoassay and fluidic systems (b, g, k)
4. Understand the basics of targeted delivery in vivo (a, b, e, f, h, i, j)
5. Delineate common physiological responses to indwelling micro/nanodevices
6. Model fluid flow in microfluidic devices using commercial finite element modeling packages (b, g, k)
7. Calculate unknown chemical concentrations based on fluorescent detection compared to a known control concentration (b, g, k)

15. Textbooks and Other Required Material
A course packet will be derived from textbooks selected by instructors.

16. Topics (including approximate duration)
  Intro (why micro- and nano-technologies are important for BME) (1 week)
  Top-down, bottom-up, and hybrid forms of fabrication/assembly (5 weeks)
  Modeling of microfluidic devices and biochemical reaction kinetics (2 weeks)
  Specific application examples (2 weeks)

17. Representative Lab Assignments (if applicable)
A protocol is being developed. However, the plan is for 4-student teams will deploy commercially obtained antibodies (abs) onto the surface of commercially obtained protein-G coupled quantum dots (QD) in a microfluidics system. Complex formation occurs at the interface between microfluidic streams. The students will detect the formation of ab-QD complexes by the development of fluorescence on a downstream surface of the device that has been patterned with the cognate antigen. Based on concentration of protein G QDs, kinetics of fluorescent complex deposition, Kd of antibody for protein G, Kd of antigen for ab and microfluidic parameters, students will derive the concentration of the antibody in their feed stocks.

18. Grading Plan
30%: Homework and quizzes
20% Term paper & presentation
20%: Team lab assignment
30%: Final exam

19. **Contribution to Meeting ABET "Professional Component"** (i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (if applicable)
   
   (a) **an ability to apply knowledge of mathematics, science, and engineering (2 chits)**
   
   The students’ ability to develop applications of engineering and biological knowledge to clinical problems in drug delivery or diagnosis is a major outcome of the course. The demonstration of increasing proficiency begins with Assignment 1 through the final exam.

   (c) **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 (2 chits)**
   
   The course emphasizes analysis as an important component of the design process and is exemplified by modeling of fluid dynamics and binding parameters in the immunoassay.

   (e) **an ability to identify, formulate, and solve engineering problems (1 chit)**
   
   The course focuses on integration of knowledge of micro/nanofabrication with knowledge of bioconjugate chemistry and pharmacology to identify, formulate and address clinically relevant problems.

   (g) **an ability to communicate effectively (1 chit)**
   
   Exemplified in both written communication (written term paper) and public Presentation (presentation of same).

   (i) **a recognition of the need for, and an ability to engage in life-long learning (1 chit)**
   
   The current literature from the Biomedical Engineering Society and other scientific sources will be used to motivate the progress in nano/microtechnology applications and underscore the need for, and the students’ ability to learn from current literature.

   (j) **a knowledge of contemporary issues (1 chit)**
   
   In addition to the use of biomedical engineering literature (see above), the legal, ethical and financial considerations for nanomaterials and devices

   (k) **an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (1 chit)**
   
   This ability is developed during the quarter, exemplified by the use of microfluidic immunoassay systems to label nanoparticles, and use of labeled conjugates to detect antigen.

20. **Relationship to ABET-Accredited Program Objectives (if applicable)**

   (l) **an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology (2 chits)**
   
   This capability is the focus for the course, with essentially all examples and assignments based on solving clinical problems at the interface of engineering
and biology. (m) the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems (1 chit)

This demonstrated, for example, by the ability of students to detect specific antigens by immunoassay using a nanoparticulate detection reagent (quantum dot).

21. **Preparation Date:** March 2, 2007

22. **Preparer Name:** Stephen C. Lee
### A. Course Offerings Bulletin Information.

Follow instructions in the OAA Academic Organization and Curriculum Handbook.

**Is this a course with decimal subdivisions?** If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

- 18-Character Transcript Abbreviation: Biomed E Design 1
- Level: U ☒ G ☐ P ☐
- Credit Hours: 4

**Description (not to exceed 25 words):** Biomedical device design, prototyping, testing, material considerations, regulatory requirements, product documentation, ethics. Application of design principles via student team projects to aid the disabled.

- Quarter offered (check): SU ☐ AU ☒ WI ☐ SP ☐
- *Distribution of class time/contact hours: 2 x2 hr cl, and 1 3hr lab*

Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) ☐

**Prerequisite(s):** Senior standing in BME and completion of at least 2 BME domain classes (BME 4X1), Co-requisite: BME 503

**Exclusion or limiting clause:**

- Repeatable to a maximum of _0_ credit hours.

**Cross-listed with:** n/a

**Grade Option (Please check):** Letter ☒ S/U ☐ Progress ☒

If this course is Progress graded, what course is the last one in the series?

**Honors Statement:**
- Yes ☐ No ☒

**GEC:**
- Yes ☐ No ☒

**Admission Condition:**
- Yes ☐ No ☒

**Off-Campus:**
- Yes ☐ No ☒

**Course:**
- Yes ☐ No ☒

**Embedded Honors Statement:**
- Yes ☐ No ☒

**Other General Course Information:** First BME capstone course.
- (e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

**Subject Code:** 140501

**Subsidy Level (V, G, T, B, M, D, or P):** B

(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

**Will course be taught in distance learning format:** Yes ☐ No ☒

### B. General Information:

1. Provide the rationale for proposing this course:
   - New departmental status for Biomed E

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.
   - This course is (check one) Required ☒ Elective ☐ Other (Explain) ☐:
If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Global Campus/Workshop Request form.

3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course. Will require new faculty

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes ☐ No ☒ List:

5. If this course is part of a sequence, list the number of the other course(s) in the sequence: 402

6. Expected section size: 25 Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes ☒

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☒

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

APPROVAL SIGNATURES (As needed. All signatures on lines in ALL CAPS (e.g. ACADEMIC UNIT) must be completed)

<table>
<thead>
<tr>
<th>Academic Unit Undergraduate Studies Committee Chair (Undergraduate course)</th>
<th>Printed Name</th>
<th>Date</th>
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<tbody>
<tr>
<td>Academic Unit Graduate Studies Committee Chair(Undergraduate/Graduate course)</td>
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<tr>
<td>School /College Undergrad Curriculum Committee (Undergraduate/Graduate course)</td>
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<tr>
<td>School /College Graduate Curriculum Committee (Undergraduate/Graduate course)</td>
<td>Printed Name</td>
<td>Date</td>
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<tr>
<td>Richard T. Hart, Ph.D.</td>
<td>Date</td>
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<tr>
<td>ACADEMIC UNIT CHAIR /SCHOOL DIRECTOR</td>
<td>Printed Name</td>
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<td>Date</td>
</tr>
<tr>
<td>ACADEMIC AFFAIRS</td>
<td>Printed Name</td>
<td>Date</td>
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</tbody>
</table>
1. Department: Biomedical Engineering

2. Number: 501

3. Title of course: Biomedical Engineering Design I

4. Description (from Course Description Bulletin)  
   First course in a two-course BME capstone sequence. Introduction to design principles;  
   Challenges of biomedical device design, prototyping and testing, material  
   considerations, regulatory requirements, product documentation, and ethics. Application  
   of design principles via student team projects to aid the disabled.

5. Level: U = Undergraduate

6. Credits: 4

7. Class Time Distribution: 2 cl. @ 1 hr each, 1 lab @ 3hrs each

8. Prerequisites: Senior Standing in BME and completion of at least 2 BME “domain  
   classes” (BME 4X1). Co-requisite is BME 503, Professional Development.

9. Quarters Offered: Autumn

10. General Information:  
    This course focuses on application of engineering principles to benefit life science  
    through designing, prototyping and developing biomedical systems to address open- 
    ended problems, specifically targeted to aid the disabled.

    The course sequence provides a capstone for undergraduates in BME and is focused on:  
    1. Hands-on experiences: Students will be given the opportunity to design and  
       prototype the biomedical systems by applying the engineering principles they  
       have been taught in the classroom.
    2. Technical communication: 4-5 students will form a team to work on a specific  
       project. They will practice project management and documentation skills. The  
       team will present their design to peer students in forms of either oral presentation  
       or engineering mock-up. A final report will be prepared to summarize their work,  
       and the designs will be displayed during a BME team design show in the Spring.
    3. Modeling/Simulation: Students will use engineering analysis software to initiate  
       and optimize their design.
    4. Creativity: The class will encourage students to bring up with innovative solutions  
       to clinical problems by following systematic invention processes and by  
       stimulating brain storming discussions.

    Design Capability: Students will practice the entire design cycle for typical biomedical  
    products and will master state-of-the-art tools for engineering design and optimization.

11. Exclusions:
12. Cross-Listings:

13. Other Information:

14. Course Objectives:
   o Students will gain hands-on experience in biomedical engineering design by working in a team of 5-8 members on a design project to aid the disabled; (c,d,f,h,l)
   o Students will be able to abstract engineering specifications from clinical needs by applying various design analysis methods such as QFD and axiomatic design; (c,j)
   o Students will be able to use design tools facilitate engineering design and optimization; (a,e)
   o Students will be able to use state-of-the-art tools (e.g., MATLAB, LabVIEW) for system simulation and control; (a,k,m)
   o Students will be able to gain professional presentation skills and team working capability. (g,i)

15. Textbooks and Other Required Material
   King, P.H. and R.C. Fries, Design of Biomedical Devices and Systems, Marcel Dekker, 2003;
   Witkin, Karen B. Clinical Evaluation of Medical Devices: Principles and Case Studies, Humana Press, 1997;
   Geddes, Leslie, Medical Device Accidents With Illustrative Cases, New York, CRC Press, 1998;

16. Topics (including approximate duration)
   Lecture: Introduction to biomedical device design (1 class)
   Lab: Tour to biomedical engineering labs and clinical sites (2 classes)
   Lecture: Engineering design tools, design analysis and production definition (2 classes)
   Lab: Focus group survey on clinical problems, site visit, form the team (2 classes)
   Lecture: Project management and documentation (2 classes)
   Lab: Customer requirements and design specifications (3 classes)
   Lab: Concept design and engineering mock-up (4 classes)
   Lecture: Design, prototyping and commercialization (2 classes)

   Initial Presentations: Problem definition, design analysis and concept (3 classes)

17. Representative Lab Assignments (if applicable)
   N/A

18. Grading Plan
   10%: Class attendance
   20%: Progress reports and performance
   20%: Midterm presentation
   30%: Final presentation
   20%: Project deliverables
19. Contribution to Meeting ABET "Professional Component" (i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (If applicable)

(a) an ability to apply knowledge of mathematics, science, and engineering (3 chits)

The fundamental design theory is one key component of the courses, which includes mathematic basic and engineering principle/practice. Students will be given the opportunity to synthetically combine and apply into the design and development of the biomedical systems in the subsequent course projects.

(b) an ability to design and conduct experiments, as well as to analyze and interpret data (3 chits)

The students will be exposed to experiments to develop systems to address real world problems, and gain hands-on experience for data analysis and interpretation.

(c) 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 (4 chits)

One of the major outcomes of this course is students’ ability to design a system, component, or process to meet desired needs within realistic constraints. The lecture component will focus on design of biomedical systems and devices within realistic constraints such as economic, social, ethical, ergonomic, regulatory, safety and manufacturability.

(d) an ability to function on multi-disciplinary teams (4 chits)

In the lab component of the course, students are asked to form a multi-disciplinary team working on the real clinical projects where they will play different functional rules such as marketing, project management, engineering, clinical affair, testing and QA.

(e) an ability to identify, formulate, and solve engineering problems (2 chits)

The courses focus on using knowledge from mathematics, engineering, biology and science to identify, formulate and solve practical clinical problems.

(f) an understanding of professional and ethical responsibility (3 chits)

The lecture component of the courses will address professional and ethical issues involved in the biomedical device and system design, test and fabrication.

(g) an ability to communicate effectively (2 chits)

The team project will require allow students to practice their communication skills within the team. Students are also encouraged to communicate with clients and physicians to understand their specific needs and critical clinical problems. The project presentations, contests and reports will offer additional opportunities for students to communicate in public.

(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context (1 chit)

The societal aspects are important contents of engineering design. The students will be taught in the courses to aware of the interaction of global and societal issues with the engineering design so as to bring up biomedical systems better fitting in these aspects.

(i) a recognition of the need for, and an ability to engage in life-long learning (2
chits)

The methodology and principles of engineering design will be conveyed in the courses, which will benefit the students in their later study and career development, and encourage them to form a good practice in engineering design.

(j) a knowledge of contemporary issues (1 chit)

The courses will focus on the recently deployed projects from instructors and colleagues to give students a clear picture of the status and challenges in engineering system design.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (2 chits)

Students will be exposed to state-of-the-art technologies for engineering design and product development. The use prevailing engineering tools (MATLAB, LabVIEW, Solidworks) will also be included to facilitate the design process.

Total Chits = 27 (9 credit hours)

20. Relationship to ABET-Accredited Program Objectives (if applicable)

(l) an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology (4 chits)

This capability is the focus for the design course, with essentially all examples and assignments based on solving biomedical engineering problems at the interface of engineering and biology.

(m) the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems (4 chits)

The lecture component will introduce essentials in biomedical data acquisition and analysis. The lab component will allow student to practice what they learn by applying these measurement and data analysis principles to clinical problem solving practice.

21. Preparation Date: February 9, 2007

22. Preparer Name: Yi Zhao and Ron Xu
**A. Course Offerings Bulletin Information.** Follow instructions in the *OAA Academic Organization and Curriculum Handbook.*

*Is this a course with decimal subdivisions?* If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

18-Character Transcript Abbreviation: Biomed E Design II

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<th>Level</th>
<th>U</th>
<th>G</th>
<th>P</th>
<th>Credit Hours:</th>
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Description (*not to exceed 25 words*): Biomedical device design, prototyping, testing, material considerations, regulatory requirements, product documentation, ethics. Application of design principles via student team projects to aid the disabled.

Quarter offered (*check*): SU [ ] AU [ ] WI [x] SP [ ]

*Distribution of class time/contact hours: 2 x2 hr cl. and 2 x3 hr labs*

Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) [ ]

Prerequisite(s): BME 501

Exclusion or limiting clause:

Repeatable to a maximum of _0_ credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter [x] S/U [ ] Progress [ ]

If this course is Progress graded, what course is the last one in the series?

Honors Statement: Yes [ ] No [x] GEC: Yes [ ] No [x] Admission Condition: [ ]

Off-Campus: Yes [ ] No [x] EM: Yes [ ] No [x] Course: Yes [ ] No [x]

Embedded Honors Statement: Yes [ ] No [x]

Other General Course Information: Continuation of BME design capstone. (e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

Subject Code: 140501 Subsidy Level (V, G, T, B, M, D, or P) B

(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes [ ] No [x]

**B. General Information:**

1. Provide the rationale for proposing this course:
   New departmental status for Biomed E

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.
   This course is (check one) Required [x] Elective [ ] Other (Explain) [ ]
* If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Off-Campus/Workshop Request form.

3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course. Will require new faculty

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests? Yes ☐ No ☒ List:

5. If this course is part of a sequence, list the number of the other course(s) in the sequence: 501

6. Expected section size: 25 Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes ☒

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☒

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

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**APPROVAL SIGNATURES** (As needed. All signatures on lines in ALL CAPS (e.g. ACADEMIC UNIT) must be completed)

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<td><strong>ACADEMIC AFFAIRS</strong></td>
<td>Printed Name</td>
<td>Date</td>
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</table>
1. **Department:** Biomedical Engineering

2. **Number:** 502

3. **Title of course:** Biomedical Engineering Design II

4. **Description (from Course Description Bulletin)**
Second course in a two-course BME capstone sequence. Introduction to design principles; Challenges of biomedical device design, prototyping and testing, material considerations, regulatory requirements, product documentation, and ethics. Application of design principles via student team projects to aid the disabled.

5. **Level:** U = Undergraduate

6. **Credits:** 5

7. **Class Time Distribution:** 2 cl. @ 1 hr each, 2 labs @ 3hrs each

8. **Prerequisites:** BME 501

9. **Quarters Offered:** Winter

10. **General Information:**
This course focuses on application of engineering principles to benefit life science through designing, prototyping and developing biomedical systems to address open-ended problems, specifically targeted to aid the disabled.

The course sequence provides a capstone for undergraduates in BME and is focused on:

1. **Hands-on experiences:** Students will be given the opportunity to design and prototype the biomedical systems by applying the engineering principles they have been taught in the classroom.
2. **Technical communication:** 4-5 students will form a team to work on a specific project. They will practice project management and documentation skills. The team will present their design to peer students in forms of either oral presentation or engineering mock-up. A final report will be prepared to summarize their work, and the designs will be displayed during a BME team design show in the Spring.
3. **Modeling/Simulation:** Students will use engineering analysis software to initiate and optimize their design.
4. **Creativity:** The class will encourage students to bring up with innovative solutions to clinical problems by following systematic invention processes and by stimulating brain storming discussions.

**Design Capability:** Students will practice the entire design cycle for typical biomedical products and will master state-of-the-art tools for engineering design and optimization.

11. **Exclusions:**

12. **Cross-Listings:**
13. Other Information:

14. Course Objectives:
   o Students will gain hands-on experience in biomedical engineering design by working in a team of 5-8 members on a design project to aid the disabled; (c,d,f,h,l)
   o Students will be able to abstract engineering specifications from clinical needs by applying various design analysis methods such as QFD and axiomatic design; (c,j)
   o Students will be able to use design tools facilitate engineering design and optimization; (a,e)
   o Students will be able to use state-of-the-art tools (e.g., MATLAB, LabVIEW) for system simulation and control; (a,k,m)
   o Students will be able to gain professional presentation skills and team working capability. (g,i)

15. Textbooks and Other Required Material
King, P.H. and R.C. Fries, Design of Biomedical Devices and Systems, Marcel Dekker, 2003;
Witkin, Karen B. Clinical Evaluation of Medical Devices: Principles and Case Studies, Humana Press, 1997;
Geddes, Leslie, Medical Device Accidents With Illustrative Cases, New York, CRC Press, 1998;

16. Topics (including approximate duration)
   Lab: Engineering design using CAD/CAM tools (4 classes)
   Lab: Development of the engineering prototype (4 classes)
   Lecture: Design validation, testing and regulatory (2 classes)
   Lab: Validation and debugging of the engineering prototype (3 classes)
   Lab: Design documentation (2 classes)

   Final presentations: Project demonstration, contest and presentation (3 classes)

17. Representative Lab Assignments (if applicable)
N/A

18. Grading Plan
10%: Class attendance
20%: Progress reports and performance
20%: Midterm presentation
30%: Final presentation
20%: Project deliverables

19. Contribution to Meeting ABET "Professional Component" (i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (if applicable)
   (a) an ability to apply knowledge of mathematics, science, and engineering (3 chits)
The fundamental design theory is one key component of the courses, which includes mathematic basic and engineering principle/practice. Students will be given the opportunity to synthetically combine and apply into the design and development of the biomedical systems in the subsequent course projects.

(b) an ability to design and conduct experiments, as well as to analyze and interpret data (3 chits)

The students will be exposed to experiments to develop systems to address real world problems, and gain hands-on experience for data analysis and interpretation.

(c) 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 (4 chits)

One of the major outcomes of this course is students’ ability to design a system, component, or process to meet desired needs within realistic constraints. The lecture component will focus on design of biomedical systems and devices within realistic constraints such as economic, social, ethical, ergonomic, regulatory, safety and manufacturability.

(d) an ability to function on multi-disciplinary teams (4 chits)

In the lab component of the course, students are asked to form a multi-disciplinary team working on the real clinical projects where they will play different functional roles such as marketing, project management, engineering, clinical affair, testing and QA.

(e) an ability to identify, formulate, and solve engineering problems (2 chits)

The courses focus on using knowledge from mathematics, engineering, biology and science to identify, formulate and solve practical clinical problems.

(f) an understanding of professional and ethical responsibility (3 chits)

The lecture component of the courses will address professional and ethical issues involved in the biomedical device and system design, test and fabrication.

(g) an ability to communicate effectively (2 chits)

The team project will require allow students to practice their communication skills within the team. Students are also encouraged to communicate with clients and physicians to understand their specific needs and critical clinical problems. The project presentations, contests and reports will offer additional opportunities for students to communicate in public.

(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context (1 chit)

The societal aspects are important contents of engineering design. The students will be taught in the courses to aware of the interaction of global and societal issues with the engineering design so as to bring up biomedical systems better fitting in these aspects.

(i) a recognition of the need for, and an ability to engage in life-long learning (2 chits)

The methodology and principles of engineering design will be conveyed in the courses, which will benefit the students in their later study and career development, and encourage them to form a good practice in engineering.
(j) a knowledge of contemporary issues (1 chit)
The courses will focus on the recently deployed projects from instructors and colleagues to give students a clear picture of the status and challenges in engineering system design.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (2 chits)
Students will be exposed to state-of-the-art technologies for engineering design and product development. The use prevailing engineering tools (MATLAB, LabVIEW, Solidworks) will also be included to facilitate the design process.

Total Chits = 27 (9 credit hours)

20. Relationship to ABET-Accredited Program Objectives (if applicable)
(l) an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology (4 chits)
This capability is the focus for the design course, with essentially all examples and assignments based on solving biomedical engineering problems at the interface of engineering and biology.

(m) the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems (4 chits)
The lecture component will introduce essentials in biomedical data acquisition and analysis. The lab component will allow student to practice what they learn by applying these measurement and data analysis principles to clinical problem solving practice.

21. Preparation Date: December 12, 2006

22. Preparer Name: Yi Zhao and Ron Xu

Is this a course with decimal subdivisions? If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

18-Character Transcript Abbreviation: Prof Dev Biomed E

Level U ☒ G ☐ P ☐ Credit Hours: 1

Description (not to exceed 25 words): Development of professional skills; engineering economy; project planning; ethics, best business practices in biomedical engineering.

Quarter offered (check): SU ☐ AU ☒ WI ☐ SP ☐ *Distribution of class time/contact hours: __1 hr cl __

Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) ☒

Prerequisite(s): pre-req or concurrent BME 501

Exclusion or limiting clause:

Repeatable to a maximum of _0_ credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter ☒ S/U ☐ Progress ☐

If this course is Progress graded, what course is the last one in the series?

Honors Statement: Yes ☐ No ☒ GEC: Yes ☐ No ☒ Admission Condition

Off-Campus: Yes ☐ No ☒ EM: Yes ☐ No ☒ Course: Yes ☐ No ☒

Embedded Honors Statement: Yes ☐ No ☒

Other General Course Information:

(e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

Subject Code 140501 Subsidy Level (V, G, T, B, M, D, or P) B
(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes ☐ No ☒

B. General Information:

1. Provide the rationale for proposing this course:

   New Biomed E major

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.

   This course is (check one) Required ☒ Elective ☐ Other (Explain) ☐:
* If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Off Campus/Workshop Request form.

3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course.
   New departmental status for Biomed E

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes ☐ No ☒ List: 

5. If this course is part of a sequence, list the number of the other course(s) in the sequence: n/a

6. Expected section size: 25  Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.)  Yes ☒

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☒

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

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| ACADEMIC AFFAIRS | Printed Name | Date |
1. **Department:** Biomedical Engineering

2. **Number:** 503

3. **Title of course:** Professional Development

4. **Description (from Course Description Bulletin)**
   Development of professional skills; engineering economy; project planning; ethics, best business practices.

5. **Level:** U = Undergraduate

6. **Credits:** 1

7. **Class Time Distribution:** 1 cl.

8. **Prerequisites:** BME Senior Standing; pre-req or concurrent BME 501

9. **Quarters Offered:** Autumn

10. **General Information:**
    This course focuses on developing an understanding of the ethical issues facing biomedical engineers, as well as developing skills in project planning and engineering economics.

11. **Exclusions:**

12. **Cross-Listings:**

13. **Other Information:**

14. **Course Objectives**
   1. Students will be able to develop a project plan and determine the economic consequences of engineering decisions. \((f,g)\)
   2. Students will be able to discuss ethical considerations related to biomedical engineering research with human and animal subjects. \((f,g)\)

15. **Textbooks and Other Required Material**

16. **Topics (including approximate duration)**
   Engineering Economy \(\text{(4 classes)}\)
   - Engineering Economic Decisions
   - Cost Concepts and Behavior
   - Time Value of Money and Money Management
   - Project Sensitivity and Risk Analysis
   Project Planning \(\text{(1 class)}\)
Best Business Practices (1 class)
Human Subjects Research (1 class)
  - Confidentiality
  - Belmont Report
  - Nuremburg Code
  - Institutional Review Board
Animal Subjects Research (1 class)
Data Ownership and Management (1 class)
  - authorship
  - plagiarism
  - citation practices
(Note 1 class per week = 10 classes total)

17. Representative Lab Assignments (if applicable)
   Not applicable

18. Grading Plan
   25%: Project assignment
   10%: Attendance
   15%: Homework
   30%: Quizzes and tests
   20%: Final exam

19. Contribution to Meeting ABET "Professional Component" (i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (if applicable)
   (f) an understanding of professional and ethical responsibilities (2 chits)
   The Professional Development course focuses on developing an understanding of professional and ethical responsibilities.
   (g) an ability to communicate effectively (1 chit)
   Students will be expected to communicate their ideas and opinions through ethical discussions in class, as well as through written assignments.

20. Relationship to ABET-Accredited Program Objectives (if applicable)
   (l) an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology (1 chit)
   The BME Professional Development Course will involve understanding of biology and physiology in relation to discussions of the limitations of research with human and animal subjects.

21. Preparation Date: November 15, 2006

22. Preparer Name: Cynthia Roberts, Ph.D.
OHIO STATE NEW COURSE REQUEST

College: Engineering

Academic unit: Biomedical Engineering Book 3 Listing: Biomedical Engineering

(e.g., Portuguese)

Proposed Course No: 581 Full Title of Course: Biomedical Engineering Seminar

Proposed Effective Qtr/Yr: SU ☐ AU ☐ WI ☒ SP ☐ YEAR: 2008 (See OAA Academic Organization and Curriculum Handbook for Deadlines)


Is this a course with decimal subdivisions? If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

18-Character Transcript Abbreviation: Biomed E Seminar Level U ☐ G ☒ P ☐ Credit Hours: 0

Description (not to exceed 25 words): Weekly biomedical engineering seminars by students and faculty.

Quarter offered (check): SU ☐ AU ☐ WI ☒ SP ☒ *Distribution of class time/contact hours: Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) ☐

Prerequisite(s):

Exclusion or limiting clause:

Repeatable to a maximum of __ credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter ☐ S/U ☐ Progress ☐

If this course is Progress graded, what course is the last one in the series? 481.03

Honors Statement: Yes ☐ No ☐ GEC: Yes ☐ No ☐ Admission Condition Course: Yes ☐ No ☐

Off-Campus: Yes ☐ No ☐ EM: Yes ☐ No ☐

Embedded Honors Statement: Yes ☐ No ☐

Other General Course Information: 1 credit awarded upon completion of 3 quarters of 581 (581.01-581.03). (e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

Subject Code________________________ Subsidy Level (V, G, T, B, M, D, or P)________________________

(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes ☒ No ☐

B. General Information:

1. Provide the rationale for proposing this course:
   New Biomed E major

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.
   This course is (check one) Required ☐ Elective ☐ Other (Explain) ☐

* If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Off Campus/Workshop Request form.
3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course.
   Generic course

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes ☒ No ☐ List: BME 581.01; .02; .03

5. If this course is part of a sequence, list the number of the other course(s) in the sequence:

6. Expected section size: Proposed number of sections per year:

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes ☐

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☒

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

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Is this a course with decimal subdivisions? If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

18-Character Transcript Abbreviation: BME Seminar I Level U ☑ G ☑ P ☑ Credit Hours: 0

Description (not to exceed 25 words): Weekly biomedical engineering seminars by students and faculty.

Quarter offered (check): SU ☑ AU ☑ WI ☑ SP ☑ *Distribution of class time/contact hours: 1 hr per week
Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) ☑

Prerequisite(s): BME senior standing

Exclusion or limiting clause:

Repeatable to a maximum of 0 credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter ☑ S/U ☑ Progress ☑

If this course is Progress graded, what course is the last one in the series?

Honors Statement: Yes ☑ No ☑ GEC: Yes ☑ No ☑ Admission Condition Course: Yes ☑ No ☑
Off-Campus: Yes ☑ No ☑ EM: Yes ☑ No ☑
Embedded Honors Statement: Yes ☑ No ☑

Other General Course Information: 1 credit of BME 581 awarded upon completion of 3 quarters of 581 (581.01-581.03). (e.g. "Taught in English." "Credit does not count toward BSBA degree.")

Subject Code 140501 Subsidy Level (V, G, T, B, M, D, or P) B (If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes ☑ No ☑

B. General Information:
1. Provide the rationale for proposing this course:
   New Biomed E major

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.
   This course is (check one) Required ☑ Elective ☑ Other (Explain) ☑:
If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled Campus/Workshop Request form.

3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course.
   New departmental status for Biomed E

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes ☒ No ☐ List: BME 581.01 and BME 581.03

5. If this course is part of a sequence, list the number of the other course(s) in the sequence: 581.02, 581.03

6. Expected section size: 25 Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes ☒

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☒

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

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Is this a course with decimal subdivisions? If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

Quarter offered (check): SU ☐ AU ☒ WI ☒ SP ☒

*Distribution of class time/contact hours: 1 hr per week

Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) ☐

Prerequisite(s): BME 581.01

Exclusion or limiting clause:

Repeatable to a maximum of 0 credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter ☐ S/U ☒ Progress ☐

If this course is Progress graded, what course is the last one in the series? 481.03

Honors Statement: Yes ☐ No ☒ GEC: Yes ☐ No ☒ Admission Condition: Course: Yes ☐ No ☒

Off-Campus: Yes ☐ No ☐ EM: Yes ☐ No ☒

Embedded Honors Statement: Yes ☐ No ☒

Other General Course Information:
(e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

Subject Code: 140501 Subsidy Level: (V, G, T, B, M, D, or P) B

(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes ☐ No ☒

B. General Information:

1. Provide the rationale for proposing this course:
   New Biomed E major

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.
   This course is (check one) Required ☒ Elective ☐ Other (Explain) ☐:
3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course.
   New departmental status for Biomed E

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes ☒ No ☐ List: BME 581.01; BME 581.03

5. If this course is part of a sequence, list the number of the other course(s) in the sequence: 581.01, 581.03

6. Expected section size: 25 Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.) Yes ☒

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☒

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

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Is this a course with decimal subdivisions? If so, use one New Course Request form for the generic information that will apply to all subdivisions. Use separate forms for each new decimal subdivision, including on each form only the information that is unique to that subdivision.

18-character Transcript Abbreviation: BME Seminar III Level U ☐ G ☑ P ☐ Credit Hours: 1

Description (not to exceed 25 words): Weekly biomedical engineering seminars by students and faculty.

Quarter offered (check): SU ☐ AU ☑ WI ☑ SP ☑ *Distribution of class time/contact hours: 1 hr per week
Quarter and contact/class time hours information should be omitted from Book 3 publication: (check here) ☐

Prerequisite (s): BME 581.02

Exclusion or limiting clause:

Repeatable to a maximum of ___ credit hours.

Cross-listed with: n/a

Grade Option (Please check): Letter ☐ S/U ☑ Progress ☐

If this course is Progress graded, what course is the last one in the series? 481.03

Honors Statement: Yes ☐ No ☑ GEC: Yes ☐ No ☑ Admission Condition Course: Yes ☐ No ☑

Off-Campus: Yes ☐ No ☑ EM: Yes ☐ No ☑ Embedded Honors Statement: Yes ☐ No ☑

Other General Course Information:
(e.g. “Taught in English.” “Credit does not count toward BSBA degree.”)

Subject Code 140501 Subsidy Level (V, G, T, B, M, D, or P) B
(If you have questions please email Jed Dickhaut @ dickhaut.1@osu.edu)

Will course be taught in distance learning format: Yes ☐ No ☑

B. General Information:

1. Provide the rationale for proposing this course:
   New Biomed E major

2. List Major/Minor affected by the creation of this new course. Attach revisions of all affected programs.
   This course is (check one) Required ☑ Elective ☐ Other (Explain) ☐:
* If the course offered is less than quarter, term, or semester, please also complete the Flexibly Scheduled/Campus/Workshop Request form.

3. Indicate the nature of the program adjustments, new funding, and/or withdrawals that make possible the implementation of this new course.
   New departmental status for Biomed E

4. Is the approval of this request contingent upon the approval of other course requests or curricular requests?
   Yes ☒ No ☐ List: BME 581.01 and BME 581.02

5. If this course is part of a sequence, list the number of the other course(s) in the sequence: 581.01, 581.02

6. Expected section size: 25  Proposed number of sections per year: 1

7. Do you want prerequisites enforced electronically? (See OAA Curriculum Manual for what can be enforced.)  Yes ☒

8. This course has been discussed with and has the concurrence of the following academic units needing this course or with academic units having directly related interests (List units and attach letters and/or forms): Not Applicable ☒

9. Attach a course syllabus that includes a topical outline of the course, student learning outcomes and/or course objectives, off-campus field experience, methods of evaluation, and other items as stated in the OAA Curriculum Handbook.

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<td>ACADEMIC AFFAIRS</td>
<td>Printed Name</td>
<td>Date</td>
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BME 581 Biomedical Engineering Seminar

1. Department - Biomedical Engineering
2. Number - 581
3. Title of course – Biomedical Engineering Seminar
4. Description (from Course Description Bulletin)
   Weekly seminars by students and faculty. Au, Wi, Sp Qtrs. Required of all biomedical engineering seniors. Final grade awarded upon completion of 3 quarters. Seniors must complete the following series of 581 classes for 1 hr credit: 581.01 – 581.02 and 581.03.
5. Level – U
6. Credits – 1
7. Class Time Distribution – 1 hr per week; Thursdays, 4:00pm – 5:00pm in Bevis 245
8. Prerequisites – BME Senior standing
9. Quarters Offered – AU/WI/SP
10. General Information – 1 credits of BME 581 (3 quarters) are required for BS degrees in BME.
11. Exclusions – none
12. Cross-Listings – none
13. Other Information - Attendance is required. Students must sign an attendance sheet each week to receive credit for attending. In the event of a conflict, students may attend substitute biomedical-related seminars and submit summaries for them, listing seminar title; location; time; presenter; brief notes; one-sentence justification that the seminar is related to BME.
14. Course Objectives – To expose students to a broader view of biomedical engineering than is available while they are engaged in personal research, the seminar will feature speakers from different areas represented in biomedical engineering including those from industry and the research community.
15. Textbooks and Other Required Material – none
16. Topics (samples, including approximate duration) –
   Some topics from recent seminar series:

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<thead>
<tr>
<th>Date</th>
<th>Speakers</th>
<th>Notes</th>
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<tbody>
<tr>
<td>9/28/06</td>
<td>Prof. Michael Paulaitis,</td>
<td>Protein Microarrays for Characterizing Diverse T-cell Populations</td>
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<thead>
<tr>
<th>Date</th>
<th>Speaker/Title</th>
<th>Topic</th>
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<tr>
<td>10/5/06</td>
<td>Prof. Keith Gooch</td>
<td>Effects of Microstructure on Engineered Tissue</td>
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<tr>
<td>10/12/06</td>
<td>Prof. Yi Zhao</td>
<td>The use of Dielectric Stimulation for Cellular &amp; Tissue Engineering</td>
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<td>10/19/06</td>
<td>Prof. John Lannutti, MSE</td>
<td>Process-Property Interactions in Electrospun Nanofiber for Tissue Engineering Scaffolds</td>
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<td>10/26/06</td>
<td>Prof. Robert Lee, Pharmacy</td>
<td>Targeted Drug Delivery via Folate Receptor</td>
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<td>11/2/06</td>
<td>Dr. William Shiels, Dept. of Radiology, Children’s Hospital</td>
<td>Current Biomedical Engineering Applications in Pediatric Radiology</td>
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<td>11/9/06</td>
<td>Aravind Chakrapani, BME</td>
<td>TBA</td>
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<td>11/16/06</td>
<td>Dr. Russell Faust, Children’s Hospital</td>
<td>Evolution of the Stethoscope</td>
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17. **Representative Lab Assignments (if applicable)**

N/A

18. **Grading Plan** - This course is graded S/U based on attendance.

19. **Contribution to Meeting ABET "Professional Component" (i.e., to ABET "mathematics and basic sciences, engineering topics, and general education") (if applicable)**
   
   (i) a recognition of the need for, and an ability to engage in life-long learning (2 chits)

   The current topics being presented in a wide variety of biomedical engineering topics underscores the need for continuing to learn about the field.

   (j) a knowledge of contemporary issues (1 chit)

   By having presentations of current research, contemporary topics can be highlighted prior to their appearance in the literature.

20. **Relationship to ABET-Accredited Program Objectives (if applicable)**

   (I) an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology (1 chit)

   The majority of topics presented are expected to include a focus on applications of biomedical engineering techniques to study physiological systems.

21. **Preparation Date** – 12/20/06

22. **Preparer Name** – Richard T. Hart