USF Board of Trustees
February 26, 2004

Issue: Proposed PhD in Biomedical Engineering

Proposed action: Approve submission to the Florida Board of Governors a proposal to implement a new PhD program in Biomedical Engineering (BME)

Background information: The proposed program is a joint effort of the Colleges of Engineering and Medicine and will build on the University’s existing academic and research strengths, its relationships with affiliated institutions such as the Moffitt Cancer Center, the Shriner’s Hospital, and the VA Medical Center, and the University’s location in an area with the second-largest concentration of biomedical-related industry in Florida. USF already has a well-established research program in biomedical engineering. Much of the University’s more than $250 million in external funding is in bioengineering and the life sciences. The proposed program will enhance USF’s role as a significant contributor to the realization of Florida’s vision of itself as a national center for biomedical research and technology transfer. The impact of the proposed program on economic development in the area is expected to be significant, as it will stimulate the growth of bioengineering and life sciences-related companies in the region.

The PhD/BME will include four areas of emphasis: Medical Imaging, Rehabilitation Engineering, Biomechanics and Biomaterials, and Cardiovascular Engineering. The program is designed to produce graduates who will be leaders in both industry and academia.

As USF’s commitment to biomedical engineering began several years ago, there are existing faculty in Engineering and the Health Sciences who will staff the program. All of the required courses are already in place. Thus, only minimal amounts of new resources will be needed for program implementation. The proposed program has been approved by the University Graduate Council and has the full support of the Deans of Engineering and Medicine and their respective faculties.

Workgroup Review: Academics and Campus Environment, February 5, 2004
Supporting documentation: Proposal for PhD in Biomedical Engineering
Prepared by: Kathleen Moore
974-5565
Note: This outline and the questions pertaining to each section must be reproduced within the body of the proposal in order to ensure that all sections have been satisfactorily addressed.

INTRODUCTION

I. Program Description

Describe the degree program under consideration, including its level, emphases (including tracks or specializations), and the total number of credit hours.

This document proposes the creation of a Ph.D. program in Biomedical Engineering (BME) at the University of South Florida, Tampa Campus, jointly supported by the College of Engineering and the College of Medicine. USF has been offering an M.S. degree in BME since 1998; as such, the Ph.D. would continue USF’s significant growth in the BME area, reflecting significant and unique opportunities described below.

Why here?: The University of South Florida presents a unique setting for this new doctoral program, certainly within the State of Florida and probably in the country. For a successful BME program, it is critical that the institution house strong established programs in engineering AND medicine; USF has demonstrated strengths in both areas. Biomedical engineering students absolutely should benefit from training within a biomedical science topic by immersion in an actual medical school, hospital, or other health care environment. Failure to provide such an experience puts biomedical engineering students at a significant disadvantage.

The University: The two sponsoring Colleges of Engineering and Medicine are located in convenient proximity on the same campus. Also, USF has the state’s only College of Public Health and complementary programs within the Health Science Center, including nursing and physical therapy. As such, USF is positioned to develop a meaningful M.D./Ph.D. program, a combination increasingly in demand throughout the nation as the significance of this combination to advancing medical and BME research is clearly recognized.

Supporting Institutions: The H. Lee Moffitt Cancer Center and Research Institute, the Shriners Orthopedic Hospital for Children (both located on the USF campus) and the James Haley Veterans Administration Hospital (located adjacent to USF) provide an outstanding training environment for BME students. Collaborative research involving USF continues to thrive and expand.

The Region: This very special academic setting, is in turn, ideally located in an area where biomedical related industries are rapidly becoming established. Currently, the Tampa Bay area is the 2nd highest concentration area in the State of Florida (yet still one of the highest concentrations nationally), reflecting the Tampa Bay region’s own technology environment as well as the area anchoring the western end of the High Technology Corridor. BME companies in the Tampa Bay region conduct both product development and manufacturing, establishing an increasingly thriving local professional population while simultaneously creating a demand for new BME-savvy professionals. The proposed Biomedical Engineering Ph.D. program, by its very nature, will benefit greatly from this environment. Of even greater importance, and as has been demonstrated in so many other states, the future growth and vitality of the region’s biomedical related industries will critically depend on related graduate programs such as this proposed BME Ph.D. Research programs in which the students train, will result in technology transfer direct to related industries but, most importantly, outstanding young bioengineers will be attracted to the program, remain in the state, and contribute to the local and state economy in ways that are hard to overestimate.
**Why now?:** USF already has a proven track record in BME-related research. Also, students have been pursuing the BME area through the existing M.S. in BME and at the doctoral level through either the existing departments or the Engineering Science track. Thus, this Ph.D. proposal seeks to formalize activities that have already been occurring.

**Locally:** USF already ranks in the top national classification of the Carnegie Foundation rankings with over $250 million in external funding, much of which is in bioengineering and the life sciences. USF is also listed in the top 100 nationally in terms of number of Ph.D. degrees granted (150 in 2002). Along with the University of Florida and Florida State University, USF serves as a State-designated Level I research institution. USF will continue to grow rapidly as a nationally recognized research university. Within the colleges of Engineering and Medicine, several areas of BME strength at USF have already grown to national prominence. These include Medical Imaging, Rehabilitation Engineering, Biomechanics and Biomaterials, Cardiovascular Engineering, cell-level drug delivery, biosensors, and the engineering and medical science aspects of neurology, including brain trauma treatment. In recognition of the outstanding graduate training opportunities available at USF, a very successful Biomedical Engineering Master's degree program was established in 1998. Graduates from this program are already contributing to local industrial growth; indeed, several local companies actively seek USF's BME graduates. In 1999, a Bioengineering Institute was formed in order to encourage and make visible this growing Biomedical Engineering strength. The Institute has already established important USF-local industry connections while launching several broad-based collaborations between Engineering and Health Sciences Center groups.

**State:** The State of Florida has appropriately launched initiatives reflecting the vision of Florida becoming a national center for biomedical research, technology transfer, and an associated thriving private sector. An important part of this initiative is the development of Florida-based academic and research programs of excellence, specifically programs in the biomedical sciences and engineering areas. The proposed Ph.D. program is exactly consistent with this vision, further advancing the infrastructure of Florida as a state to participate in the exploding biomedical technology field. Indeed, this would be an important addition to the High Technology Corridor's attractiveness both within and beyond the state, significantly expanding the biotechnology dimension.

**Nationally:** During this same period at the national level, Biomedical Engineering has grown dramatically both in the recognition of the importance of the field and in the need for graduate training programs in the discipline. The growing importance of Biomedical Engineering is no more vividly demonstrated than by the recent creation (December, 2000) of the National Institute of Biomedical Imaging and Bioengineering, an entire new division of the National Institutes of Health. This new division funds both research grants and pre and post-doctoral training grants and has FY 03 budget of $280M. It should be mentioned that USF engineering faculty have recently been awarded NIH grants in this area (the Medical School has traditionally been successful in securing NIH funding), reflecting USF's increasing competitiveness and recognition as a serious research institution. Also, the National Science Foundation has significantly increased funding in the bioengineering area. The College of Engineering has recently enjoyed a significant increase in NSF funding, again reflecting increased recognition as a national-class research institution.

**The USF Response:** Benefiting from this combination of unique features and accomplishments and in response to the growing state and national need for trained leaders in the field, the University of South Florida proposes the establishment of a Doctoral Degree Program in Biomedical Engineering designed to prepare outstanding individuals for leadership positions in industry and academia. This program should also further stimulate the development of BME-related companies in this region of Florida (already an important national presence), with positive
economic and cultural impacts, continuing on the foundations already established between USF and regional companies.

**Emphases:** The degree program will initially offer four areas of concentration based on existing areas of BME strength and national reputation at the University of South Florida. They are:

**Medical Imaging** Featuring significant interactions with the Moffitt Cancer Center as well as radiology and medical physics within USF, a strong academic and well-funded research presence is uniquely combined with a national-class clinical program. USF’s strong computer science program plays a significant role in this area.

**Rehabilitation Engineering** One of the first such programs in the U.S., engineering faculty collaborate with the unique VA Hospital Patient Safety Center, a national VA-designated center. Research is also well-funded by a number of companies that provide products to improve life quality in the aged and handicapped as well as new products to assist in high-tech health care of injured patients. Excellent research and clinical facilities support these efforts.

**Biomechanics and Biomaterials** Collaborating with biomedical companies and orthopedic groups, significant advances are being made mainly in the area of prosthetic devices and orthopedic surgical procedures. Proprietary biomaterial development is a related important activity.

**Cardiovascular Engineering** Multidisciplinary efforts involving engineering, cardiology, and surgery are developing novel diagnostic procedures, prosthetic devices, and generally advancing cardiovascular science. Again, program advances reflect the important presence of both an academic/research AND a clinical environment.

**Note:** All four areas identified above have established multidisciplinary research groups that meet on a regular basis, involving faculty members, graduate students, and other researchers. All four areas have also graduated M.S. BME students, with many students expressing a desire to continue their education at the Ph.D. level. Also, USF routinely receives inquiries from outside prospective Ph.D. students, with interest specifically expressed in one of these areas.

These will be the four areas of initial emphasis regarding the proposed Ph.D. degree. However, we fully anticipate continued academic and research development of other BME areas, including biosensors, bioinformatics, health care systems management, and "neuroengineering". As these areas grow, we anticipate creating defined academic tracks for the Ph.D. degree in the coming years.

**Credit Hours Required:** The proposed degree program will require 90 credit hours past the bachelor's degree and consist of 40 credit hours of coursework and 50 hours of dissertation research.
II. Institutional Mission and Strength

A. Is the proposed program listed in the current State University System Strategic Plan? How do the goals of proposed program relate to the institutional mission statement as contained in the SUS Strategic Plan and the University Strategic Plan?

While the PhD in Biomedical Engineering is not listed in the SUS Strategic Plan (the plan lists only the MS in Biomedical Engineering which was authorized for implementation in January 1999 and has been very successful), the proposed program is consistent with USF's mission as defined in the Plan. USF is one of three "major research universities" classified by the SUS as "Research I". The Plan states that the Research I universities will be characterized by "increased emphasis on research and graduate education" and "may expand doctoral offerings as appropriate to meet demonstrated need and as adequate funding is available." This proposal clearly demonstrates that these latter criteria are met in the case of the proposed PhD in Biomedical Engineering.

The USF Strategic Plan 2002-2007, consistent with its mission as described in the SUS Strategic Plan, commits the University of South Florida to excellence in research and graduate programs and through these programs, to the support of the economic vitality of the region and the state. In particular, "Strategy One" of the USF Strategic Plan is stated to be: "Promote nationally and internationally distinctive research and graduate programs. In pursuit of this strategy, "Action 1", under Graduate Program Development of the USF Strategic Plan specifically calls for establishment of new doctoral programs in interdisciplinary areas that have the greatest potential for achieving national distinction. The Ph.D. in Biomedical Engineering is listed as the first example of such doctoral programs to be established. The importance of such a program has been cited in recent speeches by the University President (Judy Genshaft) and the Deans of both Engineering and Medicine.

Also, the College of Medicine's Mission Statement (2003) states: The Mission ... is to provide for the education of students and professionals of the health and biomedical sciences through the creation of a scholarly environment that fosters excellence in the lifelong goals of education, research activity and compassionate patient care. The ability to offer the M.D./Ph.D. combination would be an important outcome of the proposed BME Ph.D. degree and is very consistent with the College's current mission.

B. How does the proposed program specifically relate to existing institutional strengths such as programs of emphasis, other academic programs and or / institutes and centers?

a) The sponsoring Colleges:

The College of Engineering. With an enrollment of 3,500 students, the USF College of Engineering (CoE) is the 27th largest in the country. The CoE currently houses six academic departments: Chemical Engineering, Industrial and Management Systems Engineering, Civil and Environmental Engineering, Electrical Engineering, Mechanical Engineering, and Computer Science & Engineering. Over 20% of the undergraduate engineering enrollment consists of women students. The CoE also ranks among the top 50 engineering colleges nationwide in graduates of either Hispanic or African-American origin.
Through a combination of existing faculty and recent hires, the CoE has assembled a very strong group of BME-oriented faculty, particularly in the areas of biomedical imaging, rehabilitation engineering, and biomaterials and biomechanics. Recent examples of the national recognition of these strengths include the federally funded, Rehabilitation Engineering and Technology Program and the NSF funded Integrative Graduate Education and Research (IGERT) program. The VA Hospital was also able to secure significant funding (over $12 million) for their Patient Safety Center as a result of the demonstration of significant engineering collaboration. Also, two new engineering faculty members have been successful at attracting significant NIH funding, normally a difficult challenge for engineering investigators.

BME courses have been offered since the early 1990s. This proposal does not require the creation of any new BME courses, reflecting USF’s demonstrated commitment to support this field academically. USF was one of the first institutions in this country to offer a course in product development and pharmaceutical engineering, considered at the time as models for similar development at other institutions. With recent building renovations and construction now completed, the CoE has dedicated over 10,000 square feet to bio-related research.

The College of Medicine  USF’s College of Medicine (CoM) is a principal part of the Health Sciences Center, also incorporating the colleges of Nursing, and Public Health in addition to the School of Physical Therapy. These work in conjunction with a network of major Tampa Bay area health care institutions, including the James Haley Veterans Administration Hospital, Tampa General Hospital, and All Childrens Hospital in St. Petersburg. As physicians, nurses, educators, public health professionals and researchers, faculty members provide health care, train future providers and create new knowledge related to current health issues. The CoM is currently organized into 20 departments, with about 450 full time faculty, 400 medical students, and 100 Ph.D. students. The HSC collectively is currently ranked 34th nationally in terms of research expenditures. A new program in Physical Medicine and Rehabilitation has just been approved. A new Medical Education and Clinical building is in the final planning stages, along with a new Alzheimer’s Clinical and Research building.

b) The Supporting Institutions:

The H. Lee Moffitt Cancer Center and Research Institute at USF Established in 1976, the H. Lee Moffitt Cancer Center & Research Institute (Moffitt), Florida’s only National Cancer Institute Comprehensive Cancer Center, is a recognized research center and an important resource for training future scientific and clinical leaders in oncology; Moffitt is currently ranked in the top 10 of such centers. With more than 280 physicians and 600 researchers, Moffitt has more than 6,000 inpatient admissions and 171,000 outpatient visits a year. The Center receives more than $40 million in research grants annually. After completion of a major expansion project (April 2003), Moffit Center will have over 700,000 square feet of research space spread out through three main buildings. In partnership with USF, Moffitt has recently initiated a Ph.D. program in Cancer Biology. The Ph.D. in Cancer Biology is a unique program and the only one of its kind in Florida. BME students would have a unique environment within which cancer-related research could be conducted.

The James Haley Veteran's Administration Hospital (Tampa VA Hospital) is a 431 bed Level III tertiary care teaching hospital, serving 350,000 veterans in central Florida. The hospital consists of 150 medicine, 96 surgery, 75 psychiatry, 60 spinal cord injury, 42 rehabilitation medicine and 8 neurology beds. A 180-bed Nursing Home Care Unit is attached to the hospital. A complete range of inpatient and outpatient services are provided in all specialties and subspecialties of medicine, surgery, psychiatry, radiology and pathology. This active hospital
treats over 12,000 inpatients annually, with outpatient care approaching 400,000 annually. These numbers make the hospital the busiest VA facility in the country. Approximately 2,500 employees, including 128 staff physicians, 130 resident physicians, and approximately 300 consultants and attending physicians, staff the clinical and educational programs. The VA center, collaborating with USF’s HSC and College of Engineering, has established one of the premier programs in patient safety in the nation, having attracted over $12 million in funding since its founding in 1999.

The Shriner’s Orthopedic Hospital for Children (Shriners Hospital) is a 58-bed pediatric orthopedic hospital providing comprehensive orthopedic care to children at no charge. The hospital employs state-of-the-art equipment and advanced treatment programs, including complete facilities to fit and assemble a range of orthotic and prosthetic devices (largest such facility in the southeast and 2nd largest nationally). The Tampa Hospital has provided care to more than 21,000 children since its opening in October 1985. Current research is directed towards providing an understanding of the musculo-skeletal problems affecting children as well as developing new and better treatments for these problems. Several collaborations with engineering faculty have been underway during the last few years. The pediatric orthopedic problems treated are primarily congenital orthopedic deformities, diseases of the bones, joints and muscles and orthopedic conditions resulting from traumatic injuries. The research component has offices and laboratories housed in over 15,000 square feet of space.

C. Describe the planning process leading up to submission of this proposal. Include a chronology of activities, listing the university personnel directly involved and any external individuals who participated in planning. Provide a timetable of events for the implementation of the proposed program.

Dr. Lee (College of Engineering) has been leading the Ph.D. development effort since its inception, assisted by colleagues from Engineering, the Health Sciences Center, and the Moffitt Cancer Center. Other key faculty include: Dr. Don Hilbelink (Anatomy), Dr. Maria Kallergi (Radiology/Moffitt), Dr. Sanjay Agarwal (Moffitt), Dr. Paul Sanberg (neurosurgery), Dr. Dale Johnson (physics/engineering), Dr. Leo Ondrovic (Surgery), Dr. Francis Moussy (engineering) and Drs. Sudeep Sarkar and Dimitry Goldgof of Computer Science & Engineering. There has also been significant involvement from regional companies, from both a potential employer and research collaborator viewpoint. Planning for this degree actually began when the M.S. degree application was submitted (the M.S. degree in BME was approved in 1998). To all faculty involved, it was clear that the Ph.D. degree would be required in order to fully position USF as a major player in BME. More aggressive planning for the Ph.D. was initiated when Dr. Louis Martin-Vega assumed the position of Dean within the College of Engineering (Fall, 2001). Shortly after this time, the Deans (and Associates) of both the College of Engineering and College of Medicine began joint meetings, focusing on both the proposed Ph.D. program and a proposed new department in BME.

The currently proposed timetable for the remaining Ph.D.-related activities is as follows:

Fall 2003
Finalize Ph.D. program proposal
Approvals from both the College of Engineering and College of Medicine’s Deans
III. Program Quality - Reviews and Accreditation

If there have been program reviews, accreditation visits, or internal reviews in the discipline pertinent to the proposed program, or related disciplines, provide all the recommendations and summarize the institution's progress in implementing the recommendations.

An external assessment of BME capabilities at USF was conducted in February, 2001, by Dr. Eric Guilbeau, chair of the bioengineering department at Arizona State University. It should be noted that Dr. Guilbeau was intimately involved with the defining and establishing of ASU's department; he is also very active in the national Biomedical Engineering Society. This document addresses biomedical engineering infrastructure through its analysis of the USF Bioengineering Institute, an organization which existed until 2000 as a means of promoting BME-related research at USF. Dr. Guilbeau met with a number of faculty from several academic units during his visit. His report is included as Appendix A. The report speaks very favorably of existing USF strengths in the BME area. A summary of the main findings and observations is as follows:

- The unique combination of USF's College of Engineering, Health Sciences Center, Moffitt Cancer Center, and Shriner's Hospital was definitely recognized; Dr. Guilbeau reports that this has national significance.

- The present status and potential growth of biomedical companies in the immediate area was favorably recognized. It was clear that increased USF activities in the BME area would serve as a catalyst for further industrial development.

- USF's M.S. program as developed to date was comparable in depth and quality to other existing programs in this country. The program's vision of providing students significant learning and research experiences within a clinical environment was strongly supported. The foundations for a Ph.D. program were definitely in place; he strongly encouraged USF to continue this development.

- Current collaborative research between the College of Engineering and Health Science Center was appropriate, given USF's emerging national status. Increased BME infrastructure would definitely assist in such collaborations.

Dr. Guilbeau's 2001 review noted that there was a significant deficiency in terms of available dedicated office and research space. This has since been addressed by the allocation of dedicated space in the newly renovated Kopp Engineering Building, including a dedicated office suite, additional faculty offices, graduate student space, and several new laboratories, including new laboratories in biomechanics, biosensor development, rehabilitation engineering, cardiovascular engineering, and biomanufacturing.
IV. Curriculum

A. For all programs, provide, a sequenced course of study and list the expected specific learning outcomes and the total number of credit hours for the degree. Degree programs in the science and technology disciplines must discuss how industry-driven competencies were identified and incorporated into the curriculum, as required in FS 1001.02 (6). Also indicate the number of credit hours for the required core courses, other courses, dissertation hours and the total hours for the degree.

Learning Outcomes: Students that complete the Ph.D. program should be able to:

* Apply basic and advanced engineering principles to the solution of contemporary problems in the biomedical engineering field
* Conduct significant research, advancing the biomedical engineering discipline and contributing to improved health care and quality of life advances as possible
* Evaluate relevant medical and clinical literature as to its relationship to biomedical problems of interest (including appropriate statistical design and analysis)
* Function effectively as part of multidisciplinary teams
* Communicate effectively
* Have an appreciation for safety and relevant regulatory issues
* Become sound professionals and leaders/visionaries in industry, academia, and the health professions.

As required by Florida Statutes, Title 58 Chapter 1001.02(6), industry-driven competencies were identified and incorporated into the curriculum. Such industry-driven issues were very much considered when developing the outcomes statements just presented. Also, USF has developed courses that address legal issues, regulatory issues, and product development, all definitely "industrial environment" in intent. This was accomplished by involving professionals from regional biomedical companies (Linvatec, Bausch & Lomb, Smith & Nephew, Baxter Healthcare, and Cardinal Medical) in the program development. This Advisory Board will include frequent curriculum reviews in the style of ABET (American Board for Engineering and Technology) as part of their activities.

The basic curriculum would be as follows (this assumes the incoming student has a Bachelor's degree in an engineering discipline):

Core courses (22 credit hours minimum)
BME 6xxx\(^1\) Biomedical Engineering Fundamentals (3 cr)  
GMS 6xxx\(^1\) Anatomy & Physiology for Biomedical Engineering (3 cr)  
GMS 6001\(^2\) Foundations in Biomedical Sciences (4 cr)  
PHC 6051\(^2\) Biostatistics II (3 cr)

One additional approved course in biostatistics\(^2\) (3 cr)  
Approved courses in the medical sciences\(^5\) (6 credits min)  
Notes:  
1. 6xxx course that has been taught several times as a 6000 level course (special topics); it is being formalized as a permanent 6000 level BME course.  
2. Currently existing course

Specialization courses (18 credit hours minimum - see list below)

At least 9 of these hours must be at the 6000 level; 15 of these hours must be within engineering unless approved by the student's committee.

Dissertation hours (40 hrs minimum)

One of our design objectives was to maximize research-related experiences rather than commit a significant number of hours to classroom experiences. This reflects the seriousness of our approach to research.

Specialization areas

An underlying philosophy of the curriculum design is to maximize the hours that focus on the student's chosen area of specialization. While "biomedical engineering" is a recognized distinct engineering discipline, it is nonetheless a broadly-encompassing field, including relatively unrelated specialties such as medical imaging, biomechanics, biomaterials, biomedical instrumentation and sensors, health care systems, etc. Building on existing USF strengths, USF students can specialize in one of the following areas:

- biomechanics/biomaterials  
- medical imaging  
- biomedical instrumentation/sensors  
- cardiovascular engineering

(note: the area "rehabilitation engineering" would be included within biomechanics)

Specialization course selection would complete the University general Ph.D. requirements (with committee approval as required; the committee may require additional courses as appropriate).

Table 1 presents a list of existing courses that could be used to satisfy the
specialization. It is anticipated that the list of courses (and, longer term, the number of specialization areas) will expand as academic and research efforts in biomedical engineering continue to grow.

For reference, Appendix B includes the graduate biomedical engineering programs from the other two state institutions that currently offer the Ph.D. degree in biomedical engineering (FSU/FAMU and UF). It should be noted that UF’s BME Ph.D. program evolution involved the initial incorporation of a significant number of existing engineering courses; USF’s program will be launched in a very similar fashion.

B. Describe the admission standards and graduation requirements for the program.

Students admitted to the Ph.D. in BME must satisfy the general University admission requirements. Beyond these requirements, the BME Ph.D. program also requires: 1) a GRE score of 1200 or higher; 2) either an undergraduate GPA of 3.5 or higher, or a GPA of 3.5 or higher in a Master’s degree program; and 3) 3 letters of recommendation. Exceptions to these requirements must be approved by the program director AND the Engineering Associate Dean for Academic Affairs.

C. List the accreditation agencies and learned societies that would be concerned with corresponding bachelor’s or master’s programs associated with the proposed program. Are the programs accredited? If not, why?

Undergraduate programs in BME would be accredited by the Accrediting Board for Engineering and Technology (ABET). USF does not currently have (nor is one anticipated) a B.S.-level BME program. It should be noted that many BME programs offer graduate degrees only. At this time, there are no accreditation-granting entities that address graduate programs in BME. The single national professional society is the Biomedical Engineering Society (BMES), (USF has a student chapter) although many traditional engineering discipline professional societies may also have strong BME sections/divisions (for example, the Institute for Electrical and Electronic Engineers – IEEE - has historically had a very strong BME division).

D. Provide a one or two sentence description of each required or elective course.

**Required courses**

BME 6xxx Biomedical Engineering Fundamentals (3 credits)
The major biomedical engineering disciplines are discussed in some detail, including biomechanics, biomaterials (including biocompatibility), prosthetic devices, medical imaging, medical physics, cardiovascular engineering, clinical engineering, instrumentation, sensors, and medical ethics.

GMS 6xxx Anatomy & Physiology for Biomedical Engineers (3 credits)
Human anatomy and physiology for biomedical engineers, with a focus on major tissues (bone, vascular, nervous, etc.). This class should prepare students for other medical sciences courses in anatomy and physiology.
GMS 6001  Foundations in Biomedical Sciences (4 credits)
Fundamentals of the molecular, genetic, biochemical, and cellular level basics for
the medical sciences.

PHC 6051  Biostatistics II (3 credits)
A continuation of Biostatistics I (note: BME students would not receive credit for
PHC 6050 – Biostatistics I), with a detailed treatment of Analysis of Variance
(ANOVA), repeated measures, time series analysis, experimental design, and
related topics. Extensive use of statistical software.

Elective courses

Table 1 presents a list of elective courses. Most of these courses are existing
USF courses. A number of new courses have recently been offered in support of
the graduate BME program. These courses are described below (note: the xxx in
a course number designation indicates a course that has previously been offered
as a “special topics” and is in the process of being formalized as a permanent
course offering).

BME6335  Tissue Biomechanics (3 credits)
A detailed treatment of hard and soft tissue biomechanics, including mechanical
properties, aging effects, measurement techniques, and prosthetic devices.

BME 6xxx  Orthopedic Biomechanics (3 credits)
A detailed treatment of orthopedic biomechanics, including prosthetic device
design, evaluation procedures, fracture repair and bone healing, aging influences,
and trauma.

BME 6749, BME 6xxx  Biomaterials and Biocompatibility I, II (3 credits each)
Materials employed in biomedical applications, including prosthetic devices. Main
biocompatibility issues related to biomaterial selection and development.
Applications in clinical and prosthetics.

BME 5xxx  Legal Issues in Biomedical Engineering (2 credits)
(this course has been offered under BME 5748 Selected Topics in Biomedical
Engineering)
Legal issues in biomedical engineering, including product liability, intellectual
property issues, whistleblowing, and related regulatory issues.

BME 6xxx  Clinical Biomechanics Research Methods (2 credits)
Research methods used in clinical biomechanics, including gait analysis, motion
tracking, force plates, and ergonomics methods. Clinical applications.

BME 6xxx  Injury Biomechanics (3 credits)
Application of basic biomechanics to the understanding of injury situations
encountered in the workplace, accidents, and athletics. Aging effects, information
sources, and the physics of injury.

BME 6034  Biofluid Mechanics and Bioheat Transfer (3 credits)
Fundamentals of biomedical fluids, including nonNewtonian fluid behavior and
pulsatile flow. Also biomedical heat transfer, including energy balances,
metabolism, experimental methods, anesthesiology issues, aging issues, and
disease processes.

BME 6xxx  Biomedical Imaging I, II (3 credits each)
Taught by Moffitt Center DMIP (Digital Medical Imaging Program) staff, this course examines the basics of medical imaging, medical physics, and related subjects, drawing upon actual research examples and applications.

BME 6340 Biomedical Fluids and Cardiovascular Engineering (3 credits)
Blood flow, vascular flow, and cardiology fundamentals.; prosthetic devices Experimental methods, modeling, and clinical applications.

BME 6xxx Biomedical Sensors (3 credits)
Fundamentals of sensor design, including underlying chemistry and biochemistry, device design and fabrication, and biocompatibility issues.

BME 6xxx Tissue Engineering (3 credits)
Fundamentals of tissue engineering, including culture techniques, scaffold considerations, clinical applications, and future trends.

BME 6xxx Gait Analysis (2 credits)
Taught by staff at Shriners Orthopedic Hospital, this course introduces the BME student to gait analysis, including the underlying physical principals, instrumentation system, and clinical issues.

BME 6xxx Clinical Biomechanics Research Methods (2 credits)
Taught by staff at the VA Patient Safety Research Center, this course covers human factors testing, patient safety testing, and rehabilitation and occupational biomechanics testing of human subjects.

EML 6931 Rehabilitation Engineering (3 credits)
Fundamentals of rehabilitation engineering, including basic rehabilitation science, engineering design aspects of rehabilitation, assist devices, and product evaluation.

E. Describe briefly the anticipated delivery system for the proposed program as it may relate to resources e.g., traditional delivery on main campus; traditional delivery at branches or centers; or nontraditional instruction such as instructional technology (distance learning), self-paced instruction, and external degrees. Include an assessment of the potential for delivery of the proposed program through collaboration with other universities, both public and private. Cite specific queries made of other institutions with respect to the feasibility of shared courses utilizing distance learning technologies, and joint-use facilities for research or internships.

This program would largely be delivered through traditional delivery on the Tampa campus. Based on limited information, regional biomedical companies have been very supportive of their employees leaving work to take courses (although most students would do so on a part time basis). Many instructors are already making use of "blackboard" type educational software to further provide better "high tech" learning experiences for their students.

The efforts by Dr. Hilbelink and co-workers (also involving engineering faculty and students) to provide distance learning-friendly materials and CD/DVD-based materials in the area of anatomy and physiology education has attracted interest of institutions that do not have a medical school (UCF, for example). Otherwise, most other major Florida institutions either already have or are planning BME programs.
Exploratory discussions have been held with the University of Florida's BME program to consider the possibility of "off-campus" semesters, where the BME student would in effect spend one-two semesters at the other institution (USF students at UF, vice versa) to take advantage of selected courses or facilities that are not available at one of the institutions. At this time, it is unclear when this program might be implemented.

V. Assessment of Current and Anticipated Faculty

A. Use DCU Table One to provide information about each existing faculty member who is expected to participate in the proposed program by the fifth year. Append to the table the number of master's theses directed, number of doctoral dissertations directed, and the number and type of professional publications for each faculty member.

All participating faculty are productive in teaching and research. Several of the "new" faculty members were recently hired as part of the College of Engineering's continuing commitment to support the biomedical engineering presence within the college; all such faculty should achieve tenure by year five. These "new" faculty join senior faculty who have already established track records in BME education and research.

B. Also, use DCU Table One to indicate whether additional faculty will be needed to initiate the program, their faculty code (i.e., A, B, C, D, or E as detailed in the lower portion of Table One), their areas of specialization, their proposed ranks, and when they would be hired. Provide in narrative the rationale for this plan; if there is no need for additional faculty, explain.

As stated previously, USF's commitment to biomedical engineering began several years ago. As a result, a number of established faculty with a strong BME component area already present, including faculty from engineering, the HSC, and Arts & Sciences. All of the courses that are required for the proposed Ph.D. are already offered, being taught by existing faculty. As a result, no new faculty are required to implement the proposed Ph.D. degree.

C. Use DCU Table One to estimate each existing and additional faculty member's workload (in percent person-years) that would be devoted to the proposed program by the fifth year of implementation, assuming that the program is approved. *(Note: this total will carry over to DCU Table Four's fifth year summary of faculty positions.)*

D. In the case of PhD programs, use DCU Table Two to compare the number of faculty, research productivity and projected number of students to at least three peer programs, two of which must be outside Florida. For those disciplines that are included in the National Research Council (NRC) Research-Doctorate Programs in the United States and the National Science Foundation (NSF), please utilize the data from these two sources. NRC data is available on CD ROM and the NSF data is available on-line at [www.nsf.gov/sbe/srs/profiles/](http://www.nsf.gov/sbe/srs/profiles/). For disciplines that are not included in these two sources, please utilize alternate sources to provide comparable
data. Universities may choose to provide additional peer data comparisons that are not available from NRC or NSF, such as percent of graduate students supported by contracts and grants, and total contracts and grants for the most recent year.

The three universities selected as "peers" are: 1) University of Iowa (Biomedical Engineering Dept.); 2) Florida International University (Biomedical Engineering Program); and 3) University of Pittsburgh (Bioengineering Dept.). FIU was the only Florida SUS school included in the NSF database that had expenditures under "bioengineering". University of Iowa is very comparable in size (14 versus 11 faculty) and overall research expenditures. University of Pittsburgh is a little larger and more established, but is still a good benchmark. Only faculty with clear biomedical engineering research interests were counted in the faculty headcount.

VI. Assessment of Current and Anticipated Resources

A. In narrative form, assess current facilities and resources available for the proposed program in the following categories:

1. Library volumes (Provide the total number of volumes available in this discipline and related fields.)

The USF main library and Health Sciences Center library have extensive collections of biomedical science, engineering, and BME-related texts, series, monographs, and other references. Library resources have been developed through the years to support academic and research efforts in the medical and clinical sciences, biology, chemistry, engineering, etc. No specific new requests of the library are anticipated as a result of the implementation of this program. Current USF holdings are as follows:

<table>
<thead>
<tr>
<th>Discipline area</th>
<th>Volumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomechanics</td>
<td>148</td>
</tr>
<tr>
<td>Biomaterials</td>
<td>46</td>
</tr>
<tr>
<td>Biomedical engineering</td>
<td>203</td>
</tr>
<tr>
<td>Medical imaging</td>
<td>214</td>
</tr>
<tr>
<td>Cardiology/biomechanology</td>
<td>96</td>
</tr>
</tbody>
</table>

There are additional holdings in related areas, such as ergonomics, biostatistics, health care systems, clinical engineering, and regulatory issues. In addition, basic science holdings in areas such as biochemistry, materials science, medical microbiology, imaging, biomathematics, modeling, physiology, etc. are extensive.

2. Serials (Provide the total number available in this discipline and related fields, and list those major journals which are available at your institution.)

In addition, journal offerings are adequate. It should be noted that many journals now offer on-line versions, accessible through LUIS, USF's computer-based information system. Library resources have been developed through the years to support academic and research efforts in the medical and clinical sciences, biology, chemistry, engineering, etc. No specific new requests of the library are anticipated as a result of the implementation of this program. Examples of current periodical holdings are as follows (total number of journals are indicated in parentheses):

Biomechanics (12 journals)
Basic Biomechanics
Clinical Biomechanics
Journal of Applied Biomechanics
Journal of Biomechanical Engineering
Journal of Biomechanics

(note: there are also journals in Ergonomics available at USF)

Biomaterials (6 journals)

Biomaterials
Biomaterials Science and Engineering
Biomedical Microdevices
Journal of Biomaterials Research
Journal of Materials Science. Materials in Medicine
Polymers in Medicine

Biomedical Engineering (44 journals)

Advances in Biomedical Engineering
Advances in Biotechnological Processes
Annals of Biomedical Engineering
Annual Review of Biomedical Engineering
Annual Review of Biophysics and Bioengineering
CRC Critical Reviews in Bioengineering
Critical Reviews in Biomedical Engineering
IEEE Engineering in Medicine and Biology
IEEE Transactions in Biomedical Engineering
Journal of Medical Engineering
Medical Engineering and Physics

Biomedical Imaging (18 journals)

Bioimaging
Computerized Medical Imaging and Graphics
Critical Reviews in Diagnostic Imaging
Journal of Neuroimaging

Cardiology/biorheology (54 journals)

American Journal of Cardiology
Basic Research in Cardiology
Biorheology
Cardiology
International Journal of Cardiology
Journal of Electrocardiology

3. Describe classroom, teaching laboratory, research laboratory, office, and any other type of space, which is necessary and currently available for the proposed program.
Medical Sciences  Existing teaching and research laboratories throughout the Health Sciences Center are already adequate. These accredited facilities provide for both medical sciences graduate students and medical students. BME students would take anatomy, physiology, and related medical sciences in the HSC. Also, BME students would take biostatistics, epidemiology, and related subjects within the College of Public Health, facilities that house state-of-the-art biostatistics computational facilities.

General Engineering  Similarly, existing facilities within the College of Engineering are sufficient to support the proposed Ph.D. program. The College of Engineering currently consists of three main buildings with over 182,000 square feet of space. This space was sufficient to allow ABET (Accreditation Board for Engineering and Technology) to grant six year accreditations for all six existing engineering departments.

BME specifically  Most of the existing participating faculty already have research laboratory space. With the completion of the Kopp Building renovation (Fall 2003), one whole wing (corridor) has been dedicated to bioengineering-related research exclusively (all of this new space).

4. Equipment, focusing primarily on instructional and research requirements.

Since no undergraduate degree program exists (nor is one anticipated), formal instructional equipment/laboratory experiences are minimal (other than core Anatomy & Physiology) and easily handled through existing facilities.

5. Fellowships, scholarships, and graduate assistantships (List the number and amount allocated to the academic unit in question for the past year.)

No fellowships or scholarships have been provided specifically for BME students to date; all graduate students have (to date) been supported by research funds. The University will provide funds for five new Ph.D. students per year, including a stipend and tuition waiver.

6. Internship sites if appropriate

A number of local biomedical companies already accept BME student interns: Baxter Healthcare, Linvatec, Bausch & Lomb, and Smith & Nephew. Also, Florida Orthopedics Institute and the VA Hospital actively involve on-site graduate student research. The Moffitt Cancer Center, Shriners Orthopedic Hospital, and the VA Hospital have always actively involved BME graduate students as interns. While only speculative at this time, it would also be our intention to explore internships with the proposed Scripps Research Institute's Florida complex.

B. Describe additional facilities and resources required for the initiation of the proposed program (e.g., library volumes, serials, space, assistantships, specialized equipment, other expenses, OPS time, etc.). If a new capital expenditure for instructional or research space is required, indicate where this item appears on the university's capital outlay priority list. The provision of new resources will need to be reflected in the
ACCOUNTABILITY

VII. Assessment of Need and Demand

A. What national, state, or local data support the need for more people to be prepared in this program at this level? (This may include national, state, or local plans or reports that support the need for this program; demand for the proposed program which has emanated from a perceived need by agencies or industries in your service area; and summaries of prospective student inquiries.) Indicate potential employment options for graduates for the program. If similar programs (either private or public) exist in the state, provide data that support the need for an additional program. Summarize the outcome of communication with such programs.

As general background, the document Report on the Medical Products and Biomedical Industry: Florida High Tech Corridor (Florida High Tech Corridor Council, Inc., 1999) identified 190 bioproduct companies along the I-4 "High Tech Corridor" (see Appendix C), of which most of these were focused on biomedical products. The highest concentration of such companies was within Pinellas County. Significant companies currently located in the Tampa Bay area include Baxter Healthcare (2 separate facilities), Linvatec, Smith & Nephew, Bausch and Lomb, Critikon, and Cardinal Health. The 1999 study asked industrial representative about how universities might help them. Responses indicated that "workforce and training", "employee training" and concerns related to the supply of qualified engineers were important issues that, if not corrected, could slow the growth of bioproduct companies within this region of Florida.

Since 2000, the Pinellas County Economic Development group, Enterprise Florida, and the Tampa Bay Partnership have collaboratively been developing infrastructure to continue the growth of biomedical companies in the area. In 2002, the Tampa Bay Business Journal identified 176 biomedical companies in the Tampa Bay area, with this growth projected to continue in the next decade.

The attractiveness of the Tampa Bay area to industrial growth and business investment follows from information such as:

- Population: 1,016,500 (14th among US metropolitan areas, 2002)
  (U.S. Bureau of Labor Statistics)
- Business growth: 7th metropolitan area in terms of companies with annual
sales growth of 20% or more (Progressive Policy Institute's Metropolitan New Economy Index, 2001)

#1 in relative high-tech GDP growth (Forbes/Milken Institute, 5/02)

Other:

- One of the best biotech locations in the south: 165 companies take in over $1.3 billion annually (Southern Business & Development, 7/02)

- One of the world's top 7 "intelligent" communities (referring to the High Tech Corridor) (Intelligent Community Forum, 6/02)

Appendix D presents governmental job projections for the biomedical engineering field. The Whitaker Foundation, summarizing US Department of Labor data, has projected biomedical engineering jobs to climb 31.4% through 2010, a rate that is double that of all other jobs combined (www.whitaker.org). This reflects the increasing demand for improved medical devices and systems. As noted above, the Tampa Bay area should be a significant recipient of such growth.

Reflecting this recognition of the importance of biomedical engineering, there are now four graduate programs in biomedical engineering within the SUS:

- University of Florida (M.S. and Ph.D.)
- Florida State University/FAMU (Master's and Ph.D.)
- University of South Florida (Master's only)
- Florida International University (M.S. and Ph.D.)

A program is also under development at the University of Central Florida. It should be noted that none of these programs existed before 1998. On the national level, there are now just over 100 programs in biomedical engineering.

Dr. Lee (an Engineering professor at USF) convened a meeting of the Florida-based programs (not including University of Miami) during Fall 2000. All institutions participated with the exception of FAU. It was unanimously decided at that meeting to encourage all institutions to work together for the collective benefit of all. The collective feeling was that Florida could indeed support biomedical graduate programs at all of the participating institutions. No one institution expressed concern regarding the ability of the job market to handle the rising number of graduate students, or related issues.

It should be noted that USF received approximately 60 applications for the graduate biomedical engineering program during calendar year 2002. Phone/email inquiries were around 200. Many of these inquiries specifically asked about the availability of a Ph.D. program. The Medical School independently reports a rise in interest in the availability of an M.D./Ph.D. BME program from their applicants. This interest was accomplished with a minimum of advertising.

B. Use DCU Table Three-B to indicate the number of students (headcount and FTE) you expect to major in the proposed program during each of the first five years of
implementation, categorizing them according to their primary sources. In the narrative following Table Three, the rationale for enrollment projections should be provided and the estimated headcount to FTE ratio explained. If, initially, students within the institution are expected to change majors to enroll in the proposed program, describe the shifts from disciplines, which will likely occur.

It is anticipated that 5 students presently enrolled as graduate students in either Engineering Science or traditional departments (for example, chemical engineering or mechanical engineering) would switch over to the Ph.D. in biomedical engineering during the first year. Since this situation is known to the current associated departments, no disruption to any existing engineering departments is anticipated.

During the last 2-3 years, a number of students have been inquiring from the outside regarding opportunities for Ph.D.-level biomedical engineering research. With continued success of the biotechnology/biomedical engineering research initiatives, it seems plausible that graduate students will naturally seek out this program from the outside.

Assuming the present number of participating faculty, it is estimated that the program will achieve steady-state by year four. At that time, the incoming students (estimated at 5) will match the graduating students (estimated at 5). We anticipate that 15-20 students would be in residence at any point in time.

C. For all programs, indicate what steps will be taken to achieve a diverse student body in this program. Please create a place for signature at the end of section (VII) (C) and have your university’s Equal Opportunity officer read, sign, and date this section of the proposal.

An Equal Opportunity Statement is included in this proposal that outlines the steps to be taken to achieve a diverse student body.

The faculty and staff involved in the Biomedical Engineering Program are committed to the principles of equal education and employment opportunities without regard to race, color, marital status, sex, religion, national origin, disability, age, sexual preference, Vietnam or disabled veterans status as provided by law and in accordance with the University’s respect for personal dignity. Valuing diverse viewpoint, beliefs, opinions and actions is inherent in the study of bioengineering, and this respect for diversity will be reflected in the recruitment of students and staff. We will use our resources to recruit and retain a diverse staff and student body. Biomedical engineering is a field that encourages diversity and employs high numbers of women and minorities.

VIII. Budget

A. Assuming no special appropriation for initiation of the program, how would resources within the institution be shift to support the new program?

This has largely already occurred. Several engineering departments (chemical, mechanical, computer science & engineering, industrial engineering, electrical engineering) have developed and offered on a frequent basis courses in the BME area. This is a direct reflection of Dean Martin-Vega’s college-wide support of bio-related thrusts (educational and research). Research funding from BME-related investigators already funds graduate students in this
B. Use DCU Table Four to display dollar estimates of both current and new resources for the proposed program for the first and the fifth years of the program. In narrative form, identify the source of both current and any new resources to be devoted to the proposed program. If other programs will be negatively impacted by a reallocation of resources for the proposed program, identify the program and provide a justification.

All the courses are currently being offered by the existing engineering departments and all necessary faculty are already in place, so no new budgetary allocations are requested or required to initiate the Ph.D. program. Therefore, there would be no significant negative impacts to any existing programs as a result of program implementation. The Dean of the College of Engineering has encouraged the existing departments to continue to develop new courses in the BME area; this growth is expected to continue for the next few years.

It is anticipated that the program cost will ramp up quickly from the estimated first year estimates, achieving the "year 5" estimates by the second year of implementation.

C. Describe what steps have been taken to obtain information regarding resources available outside the institution (businesses, industrial organizations, governmental entities, etc.). Delineate the external resources that appear to be available to support the proposed program.

In addition to the extensive resources that will be available to the program through its collaborative program partners, i.e., the Moffitt Cancer Center, Shriners Orthopedic Hospital, and the Tampa VA Hospital, several visits have been made to regional biomedical companies to explore potential resources, company-sponsored projects and internships, and also to recruit students. Several companies have expressed a definite willingness to make available high-end analytical equipment to assist in USF research projects. As noted elsewhere, several companies have already sponsored graduate student internships. The Dean of Engineering (Dr. Martin-Vega) currently sits on the Board of the Florida Medical Manufacturing Consortium (FMAC), another potential source of internships and related resources for the program.

D. Specifically address the potential negative impacts that implementation of the proposed program will have on related undergraduate programs (i.e., shift in faculty effort, reallocation of instructional resources, reduced enrollment rates, greater use of adjunct faculty and teaching assistants) and explain what steps will be taken to mitigate any such impacts. Also discuss the potential positive impacts that the proposed program might have on related undergraduate programs (i.e., increased undergraduate research opportunities, improved quality of instruction associated with cutting edge research, improved labs and library resources).

USF's BME efforts to date have been largely graduate level-focused. With the overall growth of the total number of engineering faculty, there have been no reported negative impacts on the undergraduate program. However, there have been definite undergraduate benefits; such
benefits are expected to continue and grow, including: increased undergraduate research experiences (for example: there have been several NSF-funded "Research Experience for Undergraduates" BME students in the last 2-3 years) and the increased availability of electives at the 5000 level. Also, a number of Honors College students have conducted their required Senior Thesis research projects within BME-related laboratories.

E. Describe any other projected impacts on related programs, such as required courses in other departments.

No additional impacts are anticipated.

IX. Productivity

Provide evidence that the academic unit(s) associated with this new degree have been productive in teaching, research, and service. Such evidence may include trends over time for average course load, FTE productivity, student headcounts in major or service courses, degrees granted, external funding attracted; as well as qualitative indicators of excellence.

Appendix E presents information on M.S. theses and Ph.D. dissertations related to biomedical engineering for the time period 1995-2001. M.S. students before 1998 and all Ph.D. students pursued their degrees either through the Engineering Science track or a traditional engineering department track (chemical, mechanical, electrical, etc.). Appendix F presents information on funded research related to biomedical engineering for the same time period.

The M.S. degree in Biomedical Engineering was initiated in 1998. Enrollment and graduation information since this time are summarized as follows:

<table>
<thead>
<tr>
<th>Academic year</th>
<th>In residence</th>
<th>Completed degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998 - 1999</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>1999 - 2000</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>2000 - 2001</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>2001 - 2002</td>
<td>24</td>
<td>5</td>
</tr>
</tbody>
</table>

In addition, there are 7 students presently enrolled as Ph.D. Engineering Science students who would immediately switch over to the Ph.D. in Biomedical Engineering once the degree is formalized. Two of these students are Moffitt-based, and the other five are within existing engineering departments.
Equal Opportunity Statement

Proposed Ph.D. degree in BioMedical Engineering

The faculty and staff involved in the Biomedical Engineering Program are committed to the principles of equal education and employment opportunities without regard to race, color, marital status, sex, religion, national origin, disability, age, sexual preference, Vietnam or disabled veterans status as provided by law and in accordance with the University’s respect for personal dignity. Valuing diverse viewpoint, beliefs, opinions and actions is inherent in the study of bioengineering, and this respect for diversity will be reflected in the recruitment of students and staff.

We will use our resources to recruit and retain a diverse staff and student body. It is anticipated that students in the Ph.D. degree program will be full or part time engineering students and part-time professionals. Biomedical engineering is a field that encourages diversity and employs high numbers of women and minorities. Representative numbers within chemical engineering (from Inomart) are as follows (it is likely that the chemical engineering composition would be similar to that for the biomedical engineering graduate student composition):

Total degrees granted by chemical engineering:

<table>
<thead>
<tr>
<th></th>
<th>98-99</th>
<th>99-00</th>
<th>00-01</th>
<th>01-02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
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</tr>
<tr>
<td>male</td>
<td>8</td>
<td>8</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>female</td>
<td>4</td>
<td>8</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Asian</td>
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<tr>
<td>male</td>
<td>8</td>
<td>7</td>
<td>5</td>
<td>5</td>
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<tr>
<td>female</td>
<td>8</td>
<td>9</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Hispanic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>11</td>
<td>8</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>female</td>
<td>11</td>
<td>10</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Total (all groups)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>101</td>
<td>98</td>
<td>122</td>
<td>120</td>
</tr>
<tr>
<td>female</td>
<td>61</td>
<td>69</td>
<td>72</td>
<td>78</td>
</tr>
</tbody>
</table>

Deborah Love, Associate Vice President
Diversity and Equal Opportunity

Date
<table>
<thead>
<tr>
<th>Faculty Code</th>
<th>Faculty Name or New Hire</th>
<th>Academic Discipline/Specialty</th>
<th>Rank</th>
<th>Contract Status/Status in Proposed Program</th>
<th>Highest Degree Held</th>
<th>Interim Date for Certification in Proposed Program</th>
<th>Source of Funding for Faculty</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>William E Lee III</td>
<td>Chemical/biomedical</td>
<td>Assoc</td>
<td>Tenured</td>
<td>Ph.D.</td>
<td>August 04</td>
<td>Current General Revenue</td>
</tr>
<tr>
<td>A</td>
<td>Mark Jaroszeski</td>
<td>Chemical/biomedical</td>
<td>Assoc</td>
<td>Untenured</td>
<td>Ph.D.</td>
<td>August 04</td>
<td>New Faculty – To be Hired on Existing Vacant Line</td>
</tr>
<tr>
<td>A</td>
<td>Michael Van Auker</td>
<td>Chemical/biomedical</td>
<td>Assist</td>
<td>Untenured</td>
<td>Ph.D.</td>
<td>August 04</td>
<td>New Faculty – To be Hired on a New Line</td>
</tr>
<tr>
<td>A</td>
<td>Rajiv Dubey</td>
<td>Mechanical</td>
<td>Prof</td>
<td>Tenured</td>
<td>Ph.D.</td>
<td>August 04</td>
<td>New Faculty – To be Hired on Contracts and Grants</td>
</tr>
<tr>
<td>A</td>
<td>Francis Moussy</td>
<td>Mechanical/biomedical</td>
<td>Assoc</td>
<td>Untenured</td>
<td>Ph.D.</td>
<td>August 04</td>
<td>New Faculty – To be Hired on Contracts and Grants</td>
</tr>
<tr>
<td>A</td>
<td>Karl Muffy</td>
<td>Anatomy</td>
<td>Assoc</td>
<td>Tenured</td>
<td>Ph.D.</td>
<td>August 04</td>
<td>New Faculty – To be Hired on Contracts and Grants</td>
</tr>
<tr>
<td>A</td>
<td>Don Hibelink</td>
<td>Anatomy</td>
<td>Prof</td>
<td>Tenured</td>
<td>Ph.D.</td>
<td>August 04</td>
<td>New Faculty – To be Hired on Contracts and Grants</td>
</tr>
<tr>
<td>A</td>
<td>Dale Johnson</td>
<td>Engineering/physics</td>
<td>Prof</td>
<td>Tenured</td>
<td>Ph.D.</td>
<td>August 04</td>
<td>New Faculty – To be Hired on Contracts and Grants</td>
</tr>
<tr>
<td>A</td>
<td>Leo Ondrovic</td>
<td>Surgery</td>
<td>Assist</td>
<td>Untenured</td>
<td>Ph.D.</td>
<td>August 04</td>
<td>New Faculty – To be Hired on Contracts and Grants</td>
</tr>
<tr>
<td>A</td>
<td>Maria Kallergi</td>
<td>Radiology</td>
<td>Prof</td>
<td>Tenured</td>
<td>Ph.D.</td>
<td>August 04</td>
<td>New Faculty – To be Hired on Contracts and Grants</td>
</tr>
<tr>
<td>A</td>
<td>Dimitry Golgof</td>
<td>Computer Science</td>
<td>Assoc</td>
<td>Tenured</td>
<td>Ph.D.</td>
<td>August 04</td>
<td>New Faculty – To be Hired on Contracts and Grants</td>
</tr>
<tr>
<td>A</td>
<td>Joel Strom</td>
<td>Cardiology</td>
<td>Prof</td>
<td>Tenured</td>
<td>M.D.</td>
<td>August 04</td>
<td>New Faculty – To be Hired on Contracts and Grants</td>
</tr>
<tr>
<td>A</td>
<td>Wes Johnson</td>
<td>Surgery</td>
<td>Assist</td>
<td>Untenured</td>
<td>Ph.D.</td>
<td>August 04</td>
<td>New Faculty – To be Hired on Contracts and Grants</td>
</tr>
<tr>
<td>A</td>
<td>Variable</td>
<td>Biostatistics</td>
<td>Var</td>
<td>Var</td>
<td>Ph.D.</td>
<td>August 04</td>
<td>New Faculty – To be Hired on Contracts and Grants</td>
</tr>
</tbody>
</table>

Revised 5/6/03
SUPPORTING INFORMATION FOR DCU TABLE ONE

1. Masters/PhD students directed and refereed publications for the participating faculty members.

<table>
<thead>
<tr>
<th>Participating faculty member</th>
<th>Master's thesis directed (last 5 yrs)</th>
<th>Ph.D. directed (last 5 yrs)</th>
<th>Refereed publications (last 5 yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>William E Lee III</td>
<td>9</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Mark Jaroszeski</td>
<td>2</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Michael VanAuker</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Rajiv Dubey</td>
<td>4</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Francis Moussy</td>
<td>3</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Karl Muffly</td>
<td>0</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Don Hilbelink</td>
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<td>10</td>
</tr>
<tr>
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<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Dimitry Golgof</td>
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<td>2</td>
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</tr>
<tr>
<td>Maria Kallergi</td>
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</tr>
</tbody>
</table>

Note: “Directed” means thesis/dissertation directed or co-directed.
DCU TABLE TWO
PEER COMPARISON DATA

Select at least three peer programs, two of which must be outside Florida, offering the proposed Ph.D. In identifying peers select programs in the same or similar field which are comparable to yours, perhaps located in institutions with missions analogous to yours, except that they already offer a Ph.D. Specify your criteria for selecting the peers. Utilizing data from the National Research Council (NRC) and National Science Foundation (NSF), provide comparative data for the department that will house the new program or core faculty who will participate in the new program, and comparative data for the projected student headcount. If the discipline proposed is not included in these sources, obtain comparable data from other sources. Universities may choose to provide additional data comparisons that are not available from NRC or NSF, such as percent of graduate students supported by contracts and grants, and total contracts and grants for the most recent year.

<table>
<thead>
<tr>
<th>MRQ DATA</th>
<th>Your University &amp; Program</th>
<th>Peer University 1 &amp; Program</th>
<th>Peer University 2 &amp; Program</th>
<th>Peer University 3 &amp; Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Program Faculty</td>
<td>11</td>
<td>14</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>% Supported</td>
<td>64</td>
<td>75</td>
<td>30</td>
<td>65</td>
</tr>
<tr>
<td>% with Publications</td>
<td>91</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Publications/Faculty</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Total Graduate Students</td>
<td>45</td>
<td>50</td>
<td>28</td>
<td>55</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NASA/NIH</th>
<th>Your University &amp; Program</th>
<th>Peer University 1 &amp; Program</th>
<th>Peer University 2 &amp; Program</th>
<th>Peer University 3 &amp; Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D Expenditures (most recent three years in NSF data)</td>
<td>907,965</td>
<td>1,370,000</td>
<td>426,000</td>
<td>1,147,000</td>
</tr>
<tr>
<td>Year 1 Total</td>
<td>255,000</td>
<td>430,000</td>
<td>312,000</td>
<td>712,000</td>
</tr>
<tr>
<td>Year 2 Total</td>
<td>653,784</td>
<td>182,000</td>
<td>0</td>
<td>323,000</td>
</tr>
<tr>
<td>Year 3 Total</td>
<td>253,926</td>
<td>759,000</td>
<td>114,000</td>
<td>112,000</td>
</tr>
</tbody>
</table>

**DEFINITIONS**

Total Faculty: Total headcount of ranked faculty (professor, associate or assistant professor) participating in the program; full-time or part-time.

% Supported: Percentage of Total Program Faculty with external research support. If not using NRC data, specify time period and sources. For visual and performing arts faculty, include any external grants, commissions, and performance fees.

% with Publications: Percentage of Total Program Faculty publishing refereed journal articles. If not using NRC data specify time period. If this is a discipline in which books, music or other creative activity are a more important indicator of scholarly activity, you may include them, but justify doing so.

Publications/Faculty: The ratio of the total number of program publications to the number of Total Program Faculty. If not using NRC data, specify time period.

Total Students: The number of full and part-time graduate students enrolled. For the proposed program list projected headcount in the fifth year. Specify the year for peer data.

R&D Expenditures: Separately budgeted R&D current fund expenditures designed to produce specific research outcomes and either funded by an agency external to an academic institution or separately budgeted by an internal unit of the institution.

Revised 7/28/03
NARRATIVE FOR DCU TABLE TWO

Peer selection

The three universities selected as "peers" are: 1) University of Iowa (Biomedical Engineering Dept.); 2) Florida International University (Biomedical Engineering Program); and 3) University of Pittsburg (Bioengineering Dept.). FIU was the only Florida SUS school included in the NSF database that had expenditures under "bioengineering". University of Iowa is very comparable in size (14 versus 11 faculty) and overall research expenditures. University of Pittsburg is a little larger and more established, but is still a good benchmark. Only faculty with clear biomedical engineering research interests were counted in the faculty headcount.

The USF Program is chemical engineering, the host department for the proposed Ph.D. program.
### DCU TABLE THREE-B

**NUMBER OF ANTICIPATED MAJORS FROM POTENTIAL SOURCES**

<table>
<thead>
<tr>
<th>Source of Students</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individuals drawn from agencies/industries in your service area (e.g., older returning students)</td>
<td>7</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students who transfer from other graduate programs within the university</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Individuals who have recently graduated from preceding degree programs at this university**</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Individuals who graduated from preceding degree programs at other Florida public universities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individuals who graduated from preceding degree programs at non-public Florida institutions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional in-state residents**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional out-of-state residents**</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Additional foreign residents**</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Other (Explain)**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

* List projected yearly cumulative ENROLLMENTS instead of admissions.

Revised 8/6/03

** Do not include individuals counted in any PRIOR category in a given COLUMN.

*** If numbers appear in this category, they should go DOWN in later years.
1. It is anticipated that 7 students presently enrolled as graduate students in either Engineering Science or traditional departments (for example, chemical engineering or mechanical engineering) would switch over to the Ph.D. in biomedical engineering during the first year. Since this situation is known to the current associated departments, no disruption to any existing engineering departments is anticipated.

2. During the last 2-3 years, a number of students have been inquiring from the outside regarding opportunities for Ph.D.-level biomedical engineering research. With continued success of the bioengineering/biomedical engineering research initiatives, it seems plausible that graduate students will naturally seek out this program from the outside.

3. Assuming the present number of participating faculty, it is estimated that the program will achieve steady-state by year three. At that time, the incoming students (estimated at 5) will match the graduating students (estimated at 5).
## DCU TABLE FOUR
### COSTS FOR PROPOSED PROGRAM

<table>
<thead>
<tr>
<th></th>
<th>Instruction &amp; Research</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>General Revenue</td>
<td>Current</td>
<td>New</td>
<td>Summary</td>
</tr>
<tr>
<td>Faculty</td>
<td>3.4</td>
<td></td>
<td></td>
<td>3.4</td>
</tr>
<tr>
<td>A &amp; P</td>
<td>0</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>USPS</td>
<td>0.5</td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>3.9</strong></td>
<td>0</td>
<td>0</td>
<td><strong>3.9</strong></td>
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<table>
<thead>
<tr>
<th></th>
<th>Contracts &amp; Grants</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A &amp; P</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USPS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>0</strong></td>
<td></td>
<td></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>General Revenue</th>
<th>Current</th>
<th>New</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty</td>
<td>4.2</td>
<td></td>
<td></td>
<td>4.2</td>
</tr>
<tr>
<td>A &amp; P</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USPS</td>
<td>0.5</td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>4.7</strong></td>
<td>0</td>
<td>0</td>
<td><strong>4.7</strong></td>
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</table>

*Cells should relate directly to faculty*

### 2014 FIRST YEAR

<table>
<thead>
<tr>
<th></th>
<th>Salary</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Faculty</td>
<td>272,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A &amp; P</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USPS</td>
<td>12,500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>284,500</strong></td>
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</table>

### 2014 FUTURE YEAR

<table>
<thead>
<tr>
<th></th>
<th>Salary</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty</td>
<td>272,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A &amp; P</td>
<td>378,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USPS</td>
<td>12,500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>392,670</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2015

<table>
<thead>
<tr>
<th></th>
<th>Expenses</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Salaries and Benefits</td>
<td>361,315</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Personnel Services</td>
<td>85,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Capital Outlay</td>
<td>5,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Library Resources</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Categories</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>366,315</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Revised 5/6/03

30
NARRATIVE FOR DCU TABLE 4

All the courses are currently being offered by the existing engineering departments, so no new budgetary allocations are requested or required to initiate the Ph.D. program. Therefore, there would be no negative impacts to any existing programs as a result of program implementation.

The Dean of the College of Engineering has encouraged the existing departments to continue to develop new courses in the BME area; this growth is expected to continue for the next few years. These new courses would be included in the home departments budgets, so again no additional funding is required to implement the new Ph.D. program.

It is anticipated that the program cost will ramp up quickly from the estimated first year estimates, achieving the "year 5" estimates by the second year of implementation.
APPENDICES

A. External review report (April 24, 2001)

B. Program information from other Florida biomedical engineering Ph.D. programs

C. List of selected biomedical product companies along I-4 “High Tech Corridor”

D. Biomedical Engineering job market growth projection information

E. Engineering M.S. theses and Ph.D. dissertations in the biomedical engineering area (1995-2001)

F. Engineering funded research in the biomedical engineering area (1995-2001)
A. External review report (April 24, 2001)
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<td>BRIEF SUMMARY OF THE INSTITUTE'S HISTORY</td>
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<tr>
<td>ACCOMPLISHMENTS TO DATE</td>
<td>3</td>
</tr>
<tr>
<td>EXISTING STRENGTHS THAT SUPPORT BIOENGINEERING</td>
<td>4</td>
</tr>
<tr>
<td>CHALLENGES</td>
<td>5</td>
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<tr>
<td>RECOMMENDATIONS</td>
<td>7</td>
</tr>
<tr>
<td>APPENDIX: SUMMARY OF SCHEDULED MEETINGS</td>
<td>9</td>
</tr>
</tbody>
</table>
Bioengineering Institute External Visit Report

Purpose of Visit

I was invited to meet with various faculty members and administrators to review ongoing Bioengineering Institute activities. I was also asked to provide informal advice on future directions that the University of South Florida might consider or not consider as it further develops the scope of its Bioengineering Program.

Brief Summary of the Institute’s History

The Bioengineering Institute at the University of South Florida (USF) was established approximately two years ago. The mission of the Institute is to promote bioengineering research and education at USF. This is accomplished by fostering educational collaborations, joint research and the shared use of facilities among the various academic and research units at USF including hospitals, clinics and biomedical/biotechnology companies.

Accomplishments to Date

During the first two years of operation of the Bioengineering Institute, the Institute’s Director has been successful in accomplishing the following:

1) A functional advisory committee has been formed.

2) Individuals from various departments with an interest in Bioengineering educational and research activities have been identified and recruited to join the Institute.

3) A Bioengineering Seminar series has been initiated and a number of guests have been invited to the USF campus to give seminars and to interact with the Institute’s membership.

4) A number of new research projects have been “seed” funded using institute funds.

5) An Internet home page has been developed for the Institute that includes information about the institute’s membership and the participating departments and the research activities of the members.

6) A new anatomy course for Bioengineers has been developed by one of the Institute’s members, Dr. Karl Muffly, Associate Professor of Anatomy. The course is attracting a growing number of students from the MS degree program in Bioengineering.

7) A new MS degree program in Bioengineering was developed with the leadership of Dr. William Lee, Associate Professor of Chemical Engineering and a member of the Bioengineering Institute. The degree program has been institutionalized within the Department of Chemical Engineering. A governance committee has been appointed. The committee members include:
William Lee, Ph.D., Associate Professor of Chemical Engineering
Roger Crane, Ph.D., Professor of Mechanical Engineering
Sudeep Sarkar, Ph.D., Professor of Computer Science
Ravi Sankar, Ph.D., Professor of Electrical Engineering
Don Hilbelink, Ph.D., Professor of Anatomy

8) A joint meeting with Bioengineering faculty members from the University of Florida and Florida State University is planned for the near future. The purpose of the joint meeting is to identify potential areas of cooperation among the three universities and to discuss whether or not a state-wide initiative in Bioengineering might be formed to request funding from the Florida Legislature for the future development of Bioengineering.

9) Considerable enthusiasm has been generated for continuing to develop Bioengineering Programs at USF.

These are significant accomplishments considering the short period of time that the Institute has been functioning, the modest initial budget allocated to the Institute, and the lack of space for the institute's activities. Professor Deans has done an excellent job and should be commended for his leadership.

Existing Strengths that Support Bioengineering

The Bioengineering Institute at the USF exists in a local environment that I believe justifies the continuing future development of Bioengineering by the university's administration. This environment includes the following institutions:

1) The University of South Florida Health Sciences Center and Medical School.

2) The H. Lee Moffett Cancer Center and Research Institute.

3) The highest concentration of Bioindustry in the State of Florida, located a short distance across the bay from Tampa and the University.

The potential for interdisciplinary research between Bioengineering faculty members and students within the college of engineering and the staffs of the medical school and the Moffett Cancer Center is large and to date essentially untapped.

Other opportunities that exist within the local USF environment include:

1) Existing high quality Bioengineering research activities within the department of Physics in collaboration with researchers at the Moffett Cancer Center and some past collaboration between faculty members in computer science and the Moffett Cancer Center.

2) An existing MS degree program in Bioengineering with a growing enrollment of approximately 20 – 25 students of which about 30% eventually desire a career in medicine.

3) A group of existing Bioengineering courses (mostly developed by Dr. William Lee and taught by faculty from engineering and the medical school).
4) Research strengths in Biomedical Imaging, Biosensors and Bioinstrumentation, and Biomechanics and Biomaterials.

5) The Visible Human project.

6) Active recruitment within the department of Physics of new faculty with interests in medical imaging and collaborations with ongoing bioengineering research.

7) High interest within the Department of Physiology and Biophysics for engineering students to be involved in various research projects.

8) A new engineering building that is under construction that provides the opportunity to allocate space for new initiatives.

These factors coupled with the following facts lead me to believe that the administration at the USF should consider taking the Bioengineering Program to the next level:

- Funding for Bioengineering from national funding agencies is at an all time high and is likely to increase in the future. Congress recently approved a new Institute for Bioimaging and Bioengineering that is now being instituted at NIH. Funding for Bioengineering at NSF continues to increase and agencies that historically have not funded Bioengineering research have recently instituted new programs, including the defense agencies.

- The USF is a Research I University with a large enrollment and the presence of a viable Bioengineering Program will help it continue to maintain its Research I status and attract high quality students.

- No dominant Bioengineering program currently exists in the State of Florida.

- The current Dean of the Graduate College was at the University of Washington during the development of that University's Bioengineering Program and has experience in what is needed to develop a high quality Bioengineering program. His advice should be sought and carefully considered as the USF moves its Bioengineering program to the next level.

Challenges

A number of situations exist that might hamper the future development of Bioengineering unless corrected or changed. These include:

1) The upper administration is undergoing change at many levels including the appointment of a new President and Provost. The USF is searching for a new VP for Research, and The College of Engineering is searching for a new Dean.

2) Barriers to interdisciplinary and cross-college and cross-institutional research projects may still exist at USF. Some faculty members are concerned that they might not receive credit for interdisciplinary activities in the faculty performance evaluation process used to determine merit raises. I was not able to identify special USF programs that encourage interdisciplinary research or that reduce the teaching loads of faculty who are attempting to build bridges among diverse disciplines in either research or educational endeavors. Some faculty with whom I met indicated that because of this they do not have time to pursue collaborative opportunities without negative impact on their disciplinary responsibilities. The administration should recognize that interdisciplinary activities are more time consuming than activities
focused within a single discipline. The fact that there is not a long history of collaboration between the college of engineering and the medical school and medical science departments is evidence that this may be a problem.

3) Numerous faculty members and administrators were frustrated that the quality of the student body was low and decreasing in quality rather than increasing in quality. Bioengineering programs usually attract a high quality student body that in many cases would otherwise not be members of the college of engineering. Typically, about 30% of Bioengineering students seek a medical career and plan to attend a medical school following graduation. These students elevate the quality of the Bioengineering degree program and also the other courses in which they participate.

4) Medical science courses like human physiology, cell biology, etc. taught in the medical school are currently not available to Bioengineering students because medical school enrollment fills the classes. Unless larger classrooms can correct this situation, new sections of some medical science courses designed specially for Bioengineers will have to be developed. If existing laboratory space is not available, new laboratories will have to be built and equipped.

5) The resources directed toward Bioengineering in the past are very modest. When the MS degree program was approved, no new money was provided for graduate student recruiting, administration, equipment for new laboratories, or faculty lines. No new space was allocated for either research or instructional laboratories. The Institute budget of $40,000 has been sufficient for its limited mission of the past; however, a larger budget will be needed if USF is to become the dominant Bioengineering program in the State of Florida and the Southeast.

6) The number of Bioengineering courses available to students in the MS degree program in Bioengineering is low and have been developed by a limited number of faculty members with expertise in how engineering can be applied to solve problems in medicine and biology. More Bioengineering faculty members are needed if USF wishes to take it Bioengineering program to the next level especially if a Ph.D. program in Bioengineering is desired.

7) A clear vision for the future of the Bioengineering Institute and the Bioengineering Educational Program has not been developed. This may in part be because the immediate past dean of the college of engineering placed emphasis on programs within Electrical Engineering. New program growth is almost always centered on educational objectives and strategic research opportunities. Although semiconductor processing has been and will continue to be an important strategic area for engineering, Universities that do not recognize the revolution that is occurring in the Biological Sciences will lose their competitive edge in the future. Bioengineering is engineering's ticket to the Biological "event" that will provide the enabling technologies for a new generation of technology for health care in the future. It is for this reason that most major research universities are currently making major investments in the development of comprehensive Bioengineering programs including full-time faculty devoted 100% to Bioengineering. To date, the MS degree program in Bioengineering has been administered within the Chemical Engineering department. Although this is a typical scenario for new program development, it is clear that the program is not central to the Chemical Engineering mission. The regular CHE faculty may naturally have little interest in the future development of the MS degree program and other Bioengineering educational developments and even if they do, have little or no expertise to help in this development. So it is natural to assume there will be little support for expansion of the program within CHE especially if doing so drains resources from the CHE programs.

8) The balance between industrial consulting and federal funded research may be shifted too much toward consulting. Future college administrations may want to institute policies that
reward federally funded research and discourage excessive industrial consulting if indeed this is a problem.

9) Professor Stanley Deans is the first to recognize his own limited knowledge of Bioengineering. As a distinguished professor in the department of Physics, Dr. Deans has accomplished much more than the average individual would have been able to accomplish in starting the Bioengineering Institute at USF, and he should be recognized and rewarded for his efforts. Professor Deans expertise is in medical physics and he has also built strong collaborative ties to the Moffett Cancer Center and Research Institute in the area of medical imaging. Professor Deans recognizes, however, that to take the Bioengineering program to the next level will require someone with primary expertise in Bioengineering and the time to devote 100% of their efforts to building the program. Professor Deans explained during the visit that he has committed to significant new professional Physics responsibilities at the national level that will limit the time he can devote to the Institute’s future development.

10) Finally, the competition for high quality Bioengineering faculty members and graduate students among universities is intense because of the number of new programs currently under development. To attract high quality faculty members, the USF will have to provide competitive startup resources.

Recommendations

USF faculty members have made excellent progress toward achieving the Institute’s mission. To move the Bioengineering Institute to the next level, however, will require the investment of resources. With proper planning, the Whitaker Foundation might share in the investment needed if the USF’s commitment is significant and a long-term vision for future development and enhancement of the Bioengineering program is developed. To this end, the University might consider the following:

1) Re-evaluate the Institute’s leadership. Professor Deans has done an excellent job of starting the Institute and should be rewarded for this; however, his expertise in the area of Bioengineering is limited. He recognizes these limitations and suggested during my visit that it is probably time for someone with more formal training in Bioengineering to assume the leadership role. He will be assuming new responsibilities in the leadership of national Physics Professional activities that will decrease the time he can devote to the Institute. A leadership role in the Institute may help in the recruitment of a full-time Bioengineering faculty member.

2) Develop a long-term vision for the Institute. This will almost certainly have to wait for the new college dean to be appointed and for stability to return to the upper administration.

3) If the college develops a vision that includes enhancement of the program, serious consideration should be given to re-submitting the Whitaker Foundation Special Opportunity Award Proposal that was unsuccessful several years ago. The proposal might include a request for Whitaker funds to help USF do the following:

   - Move the administrative responsibility for MS degree in Bioengineering from the Department of Chemical Engineering to the Bioengineering Institute.

   - Hire additional full-time Bioengineering faculty members and provide tenure homes for these individuals in the Bioengineering Institute. Whitaker funds could be requested for research equipment for new faculty startup with USF providing a commitment to provide the salary via tenured positions.
• Encourage faculty members who are currently active in Bioengineering education and research within Chemical Engineering, Physics and other departments to consider joint appointments or affiliated appointments in the Bioengineering institute.

• Develop new courses that support the existing MS degree program and that would be needed for a new Ph.D. degree in Bioengineering at sometime in the future. Whitaker funds could be requested to pay partial summer salary for faculty members who commit to develop the new courses.

• Provide reasonable space for administrative office for the Institute. Whitaker funding could be requested for partial support of the institute's administrative staff.

• Add new shared-use laboratories for Bioengineering research and instruction that are under the administrative responsibility of the Institute director. Laboratories might include space and equipment for the teaching of physiology and courses involving measurements on living systems. Research facilities might supplement those that already exist in areas of Bioengineering research strengths. Whitaker might provide funds for equipment with USF providing the space for the laboratories.

• Allocate funds for a number of graduate student assistantships to help recruit high quality students to the MS degree program. Whitaker funds could be used to provide the assistantships with USF providing tuition waivers to students who receive the fellowships.

Success in seeking funds from the Whitaker Foundation is highly dependent upon strong leadership for the Institute and a strong commitment from the university toward the development of the program and a substantial cost share in the form of faculty lines, space, and/or other resources provided by USF to the program. Absent this commitment, it is unlikely a grant will be provided. Professor Lee in the Chemical Engineering Program is highly qualified to write this proposal but only if the university is willing to provide a significant cost share on the proposal. Otherwise, it is a waste of Dr. Lee’s time.

4) Institute a seed-funding program that distributes small amounts of funds to faculty members interested in establishing new collaborative research projects. Require that one of the participating faculty members are from engineering or the physical sciences with a primary interest in Bioengineering and that the other be from a program within the Health Sciences Center or the Moffett Cancer Research Center. Encourage recipients to use results as preliminary data for proposals to federal agencies.

5) Re-evaluate the college and university policies for returning indirect costs to faculty members who generate research funding that pays indirect cost. If indirect costs are returned to faculty and departments, require that faculty contribute funds toward cost sharing on grants that is matched by higher levels within the administrative chain.

6) Insure that the university has a system in place that insures all participants in collaborative research projects share the credit for the research expenditures within the context of the merit evaluation process.

My visit to the University of South Florida was a pleasure. I would like to take this opportunity to thank Professor Dean's for his hospitality. I hope that these comments are helpful and congratulate those who have helped the University with the initial development of the Bioengineering Institute and I hope that future efforts to move the program to the next level are highly successful.
Appendix: Summary of Scheduled Meetings

During the visit, I had the pleasure of meeting with the following individuals during a number of individual and group meetings. A number of other USF faculty participated in a luncheon discussion.

- Stanley R. Deans, Ph.D., Interim Director: USF Bioengineering Institute and Professor of Physics
- William E. Lee III, Ph.D., Associate Professor of Chemical Engineering
- Valerie J. Harwood, Ph.D., Assistant Professor of Biology
- Luis Humberto Garcia-Rubio, Ph.D., Professor of Chemical Engineering
- Karl E. Muffly, Ph.D., Associate Professor of Anatomy
- Bruce G. Lindsey, Ph.D., Interim VP for Research and Professor of Physiology and Biophysics
- Daniel K. P. Yip, Ph.D., Assistant Professor of Physiology and Biophysics
- Joel M. Price, Ph.D., Professor of Physiology and Biophysics
- Roger Shannon, Ph.D., Professor of Physiology and Biophysics
- Kendall Morris, Ph.D., Assistant Professor of Physiology and Biophysics
- Robert S.F. Chang, Ph.D., Professor and Chair of Physics and Director of the Applied Physics Ph.D. Program
- Dale Johnson, Ph.D., Dean of the Graduate School and Professor of Physics
- Maria Kallergi, Ph.D., Director of Digital Medical Imaging, H. Lee Moffett Cancer Center and Research Institute
- Daniel Lim, Ph.D., Professor of Biology
B. Program information from other Florida biomedical engineering Ph.D. programs
Biomedical Engineering

College of Engineering

Graduate Faculty 2000-2001


The Biomedical Engineering (BME) program is interdisciplinary, focusing on four principal areas: biomaterials; biomechanics; molecular, cellular, and tissue engineering; and biomedical imaging and signal processing. Partnering with engineering in the BME program are several clinical departments in the College of Medicine.

The mission of the BME program is to educate students with strong engineering and science backgrounds for master's and/or Ph.D. degrees so that they can provide solutions to engineering problems in the fields of medicine, biology, and related fields. The BME program collaborates with departments in the College of Engineering (COE) and College of Medicine (COM). The program currently focuses on four principal areas: biomaterials, biomechanics, cellular and tissue engineering, and biomedical imaging and signal processing. COE participating departments include Aerospace Engineering, Mechanics, and Engineering Science; Chemical Engineering; Computer and Information Science and Engineering; Electrical and Computer Engineering; Materials Science and Engineering; Mechanical Engineering; and Nuclear and Radiological Engineering. The participating departments within COM are Anesthesiology, Cardiology, Pathology, Radiology, and Surgery. The COE administers the program with the assistance of an executive committee consisting of the Deans of the Colleges of Engineering and Medicine and the Graduate School who provide program guidance and oversight.

Biomedical engineering students are admitted to the Graduate School through the BME program. The BME Graduate Committee accepts them for admission. Each student's research adviser must be a member of the BME Graduate Faculty. The Ph.D. supervisory committee must consist of five members, including at least three BME Graduate Faculty members whose research interests are within the selected
area of specialization. Supervisory committees normally include one faculty member from the COM or from another health-related profession outside the COE. Students are expected to select an area of study by the end of their first semester.

M.S. students take a total of 30 credit hours in the thesis option and 32 credit hours in the nonthesis option, which includes 11 (nonthesis) or 9 (thesis) credits of BME courses, 12 credits of BME courses from their area of specialization, and 9 biomedical engineering elective credits, that can include up to 6 research credits. Ph.D. students are required to fulfill the M.S. course work requirements plus an additional 18 BME elective credits for a total of 90 hours, which may include up to 50 research credits. The core courses required of all BME students include Introduction to Biomedical Engineering and Physiology I and II, Clinical Shadowing, and Seminar. The program has major ongoing research in areas such as biomaterials, medical imaging, orthopedics, anesthesiology, neuroscience, transplantation, and cardiology. These programs provide strong support for the academic dimensions. A web page, that is maintained at http://www.bme.ufl.edu, contains additional information on admissions requirements, faculty and research projects.

Joint Program—Biomedical Engineering also offers a combined bachelor's/master's degree program in collaboration with the Departments of Aerospace Engineering, Mechanics, and Engineering Science and the Materials Science and Engineering. This program allows qualified students to earn both a bachelor's degree and a master's degree with a savings of one year.

Biomedical Engineering Certificate—The Biomedical Engineering program offers a BME certificate. Please contact the program office for additional information.

Biomedical Engineering

BME 5001—Biomedical Engineering and Physiology I (3) Physiology of cells, bones, and circulator system from a biomaterials, biomechanics, cellular, and tissue engineering perspective. Intellectual property and technology transfer included.

BME 5002—Biomedical Engineering and Physiology II (3) Physiology of human body, imaging techniques and subsequent processing. Various imaging modalities discussed along with appropriate processing methods to reveal details of physiology and diagnosis.

BME 5085—Patents, Product Development, and Technology Transfer (2) For engineers and scientists. Product discovery and development; patents and trade secrets; copyright and trademark law; international intellectual property considerations; regulatory issues; business planning and market research; and licensing, marketing, negotiation, and technology transfer.

BME 5937—Special Topics (1-4; max: 6)
BME 6010—Clinical Shadowing for Engineers (2; max: 6) Students observe clinical faculty and work with engineering faculty to examine current clinical practice and restraints with goal to propose jointly possible improvements.

BME 6330—Cell and Tissue Engineering (3) Prereq: GMS 6421, BME 5001, or permission of instructor. Application of engineering principles, combined with molecular cell biology, to develop fundamental understanding of property-function relationships in cells and tissues. Exploitation of this understanding to manipulate cell and tissue properties rationally to alter, restore, maintain, or improve cell and tissue functions as well as to design bioartificial tissue substitutes.

BME 6400—Theory and Instrumentation for Medical Image Acquisition (3) Physics of ionizing and non-ionizing radiation interactions with biological systems; radiation detection systems utilized in medical image acquisition; radiation sources for image generation; features of image quality; applications of these concepts to project radiography, fluoroscopy, nuclear medicine, computer tomography, magnetic resonance imaging, and ultrasound.

BME 6905—Individual Work in Biomedical Engineering (1-4; max: 8)

BME 6910—Supervised Research (1-5; max: 5) S/U.

BME 6936—Biomedical Engineering Seminar (1; max: 4)

BME 6938—Special Topics in Biomedical Engineering (1-4; max: 6)

BME 6940—Supervised Teaching (1-5; max: 5) S/U.


BME 7979—Advanced Research (1-12) Research for doctoral students before admission to candidacy. Designed for students with master's degree in the field of study or for students who have been accepted for a doctoral program. Not open to students who have been admitted to candidacy. S/U.


Biomaterials

EMA 6001—Properties of Materials—A Survey (3) Prereq: bachelor's degree in physics, chemistry or engineering. Review of physical properties of materials such as mechanical, electrical, optical, magnetic, and thermal properties.

EMA 6165—Polymer Physical Science (3) Prereq: EMA 3066. Solid state properties of amorphous and semi-crystalline polymers.

EMA 6166—Polymer Composites (3) Physical and mechanical properties of polymers and polymer composites as related to preparation and microstructure.

EMA 6316—Materials Thermodynamics (3) Prereq: EMA 4314. Thermodynamics of
materials systems, surfaces in solids, irreversible processes.

EMA 6461 — Polymer Characterization (3) Prereq: EMA 3066. Use of broad variety of spectroscopic and other scattering phenomena in polymer research.

EMA 6580 — Science of Biomaterials I (3) Prereq: undergraduate chemistry. Introduction to variables that control compatibility and performance of biomaterials, including physical and chemical properties, corrosion, fatigue, and interfacial histochemical changes.

EMA 6581C — Polymeric Biomaterials (4) Prereq: undergraduate chemistry and EMA 3066. Biomedical implant and device applications of synthetic and natural polymers. Biocompatibility and interfacial properties of polymers in physiological environment, especially concerning short-term devices (catheters) and long-term implants (intraocular lenses, vascular and mammary prostheses, etc.).

Biomechanics

EGM 5111L — Experimental Stress Analysis (3) Prereq: EGM 3520. Introduction to techniques of experimental stress analysis in static systems. Lecture and laboratory include applications of electrical resistance strain gauges, photoelasticity, brittle coatings, moire fringe analysis, and X-ray stress analysis.


EGM 5533 — Advanced Mechanics of Solids and Structures (3) Prereq: EGM 3520. Bars, beams, thin-walled structures, and simple continua in the elastic and inelastic range. Virtual work approaches, elastic energy principles, plastic limit theorems, creep deformation procedures, introduction to instability and fracture mechanics. Design applications.


EGM 6322 — Principles of Engineering Analysis II (3) Prereq: EGM 4313 or MAP

EGM 6570—Principles of Fracture Mechanics (3) Prereq: EGM 6611. Introduction to the mechanics of fracture of brittle and ductile materials. Linear elastic fracture mechanics; elastic-plastic fracture; fracture testing; numerical methods; composite materials; creep and fatigue fracture.

EGM 6595—Bone Mechanics (3) Biology, composition, and mechanical properties of cortical bone tissue, cancellous bone tissue, and cartilage. Bone as it can be modeled as an anisotropic elastic material, as a bioviscoelastic material, and as a composite material.


EMA 6580—Science of Biomaterials I (3) Prereq: undergraduate chemistry. Introduction to variables that control compatibility and performance of biomaterials, including physical and chemical properties, corrosion, fatigue, and interfacial histochemical changes.


EML 5504—Mechanical Design I (3) Prereq: EML 4500. Problem formulation for design, design criteria, and structuring of appropriate methodologies for developing and comparing problem solutions. Applications covering a broad
spectrum of mechanical systems.

EML 5591—Biometrics (3) Prereq: EGM 2511, EMA 3010, EEL 3003 or EEL 3111 EML 3023. Basic human anatomy introduced. Physical capabilities and limitations explored in context of practical design problems. Injury prevention, both acute and cumulative, investigated.


EML 6716—Advanced Fluid Dynamics (3) Prereq: EML 4702. Extends the previous fluid flow courses to include a wider range of subject material and provide a background for convection heat transfer courses.

Biomedical Imaging and Signal Processing

CAP 5416—Computer Vision (3) Prereq: MAC 2312, CGN 3421 or C-language. Introduction to image formation and analysis. Monocular imaging system projections, camera model calibration, and binocular imaging. Low-level vision techniques, segmentation and representation techniques, and high-level vision.

CAP 5515—Computational Molecular Biology (3) Algorithms related to molecular biology. Sequence comparisons, pattern matching, pattern extraction, graph techniques in phylogeny construction, secondary structure prediction, multiple sequence alignment, contig search, DNA computing, computational learning theory, and genetic algorithms.

CAP 6737—Visual Modeling (3) Prereq: graduate standing and proficiency in high-level programming language; coreq: CAP 5416, CAP 5705, or EEL 6562. Study of object shape modeling from point of view of geometry, topology, physics, and computational algorithms.


EEL 5830—Human-Computer Interaction (3) Designing human-computer interfacing; cognition, perception, sensing, displays, speech, dialogs, and graphics.

EEL 6562—Image Processing and Computer Vision (3) Pictorial data representation, feature encoding, spatial filtering; image enhancement; image segmentation; cluster seeking; two-dimensional z-transforms; scene analysis; picture description language; object recognition; pictorial database; interactive graphics; picture understanding machine.

EEL 6585—Computer Speech Systems (3) Prereq: EEL 5701. Design and analysis of speech synthesizers; speech recognizers; speaker recognition, verification, and identification; intelligent interface systems; speech understanding.


EEL 6825—Pattern Recognition and Intelligent Systems (3) Decision functions; optimum decision criteria; training algorithms; unsupervised learning; feature extraction, data reduction; potential functions; syntactic pattern description; recognition grammars; machine intelligence.

ENU 5615—Nuclear Radiation Detection and Instrumentation (3) Interaction of radiation with matter, radiation detector systems, pulse shaping, amplification, amplitude and time-analyzing circuitry; counting and measuring devices, and control systems for nuclear reactors.

ENU 5615L—Nuclear Radiation Detection and Instrumentation Lab (1) Laboratory associated with ENU 5615.

ENU 5626—Radiation Biology (3) Prereq: one year each of college biology, chemistry, and physics; permission of instructor. Effects of radiation on biological molecules, cells, and man including cancer and mutagenesis; use of radiation in treatment of disease.

ENU 6051—Radiation Interaction Basics and Applications I (3) Interaction of X-rays, gamma rays, neutrons, and charged particles with matter; radioactive decay, nuclear moments, and nuclear transitions. Application to basic problems in nuclear engineering sciences.


Radiation measurement and dosimetry clinical applications. Radiation protection and quality assurance.


Molecular, Cellular, and Tissue Engineering

ECH 6126 — Thermodynamics of Reaction and Phase Equilibria (3) Methods of treating chemical and phase equilibria in multi-component systems through application of thermodynamics and molecular theory.

ECH 6261 — Introduction to Transport Phenomena (3) Basic equations for change of heat, mass, and momentum. Applications of conservation and flux equations for laminar and turbulent flow. Transfer coefficients, macroscopic balances.

ECH 6726 — Interfacial Phenomena I (2) Air-liquid and liquid-liquid interfaces; surface-active molecules, adsorption at interfaces, foams, micro- and macro-emulsions, retardation of evaporation and damping of waves by films, surface chemistry of biological systems.

ECH 6727 — Interfacial Phenomena II (2) Prereq: CHM 2046 and CHM 2046L. Solid-gas, solid-liquid, solid-solid interfaces. Adsorption of gases and surface-active molecules on metal surfaces, contact angle and spreading of liquids, wetting and dewetting, lubrication, biolubrication, flotation, adhesion, biological applications of surfaces.

EMA 6105 — Fundamentals and Applications of Surface Science (3) Prereq: CHM 2045, MAP 2302, or consent of instructor. Fundamental and experimental description of phenomena occurring at surface of solids, including structure, composition, atomic and molecular processes, and electronic properties. Experimental approaches and data used to support theoretical models.


EMA 6461 — Polymer Characterization (3) Prereq: EMA 3066. Use of broad variety of spectroscopic and other scattering phenomena in polymer research.

GMS 6421 — Cell and Tissue Biology (4) Prereq: undergraduate biochemistry or cell biology or consent of instructor. Cell specializations and interactions that account for the organization and functions of the basic tissues (epithelium, connective tissue, muscle, and nerve).
General Information

Faculty

Ph.D. Program

Curriculum

Admission requirements

M.Sc. Program

Curriculum

Admission requirements

Undergraduate Program

General Description

Curriculum

Undergraduate Research Program

Required Courses (18 hours)

1. BMS 5109C, Human Anatomy (5)
2. BMS 5510, Mammalian Physiology I (4)
3. BME 5005, Engineering and Applied Science Aspects of Biology and Medicine (3)
4. BME 5030, Biochemical Transport Phenomena (3)
or ECH 5261, Advanced Transport Phenomena (3)
5. ECH 5842 Advanced Chemical Engineering Mathematics (3)

Doctoral Biomedical Engineering Electives, choose four of nine, at least 6 hours of which must be at the 6000 level (12 hours).

5000 Level Courses

1. BME 5020, Biophysical Chemistry and Biothermodynamics (3)
2. BME 5105, Biomaterials (3)
3. BME 5330, Tissue Engineering (3)
4. BME 5385, Animal Surgical Techniques (3)
5. BME 5500, Biomedical Instrumentation (3)

6000 Level Courses (at least 6 hours)

1. BME 6210, Biomechanics of Human Structure and Motion (3)
2. BME 6510, Biomechanics of Human Structure and Motion (3)
3. BME 6530, NMR and MRI Methods in Biology and Medicine (3)
4. BME 6550, Computer Aided Design and Control in Medicine and Surgery (3)
5. BME 6720, Biostatistical Mechanics (3)

Dissertation Hours (36 hours)

BME 6980r, Dissertation (36)

The following requirements for the PhD degree in Biomedical Engineering must be met:

1. Passage of the BME PhD Qualifying Examination within two consecutive exam attempts; this will result in formal admission to candidacy for the PhD degree.

http://www.eng.fsu.edu/cheme/biomed/phd/curriculum.html

3/20/2003
2. Selection of a research topic and major professor.
3. Formation of a supervisory committee with at least two designated Biomedical Engineering faculty members.
4. Submission and defense of a prospectus on the dissertation topic to the supervisory committee.
5. Completion of a minimum of 36 hours of advanced course work in biomedical engineering and related disciplines. This course work includes the 21 hours of required courses under the MS Thesis Option Program (see above). In addition, the 36 hours of course work must include at least 6 course work hours at the 6000 level (see above).
6. Satisfaction of University residency requirements.
7. Completion of at least thirty-eight (38) credit hours of dissertation research.
8. Presentation and defense of an original dissertation.
9. Assist in the teaching of at least one laboratory course.
10. Presentation of one paper at a local, regional, national, or international professional meeting.

All biomedical engineering graduate students are required to attend the Program for Instructional Excellence (PIE) Workshop to prepare for teaching assistant (TA) duties. This requirement is mandatory regardless of the assistant (TA) duties. This requirement is mandatory regardless of the student's classification as a Teaching Assistant or Research Assistant. In addition, all students are required to take the Safety Training course.
C. List of selected biomedical product companies along the I-4 "High Tech Corridor"
Biomedical companies located along the Florida High Tech Corridor

Note: The University of South Florida main campus is located in Tampa (Hillsborough County).

Total biomedical-related companies located within the Florida High Tech Corridor: 190

Selected companies:

<table>
<thead>
<tr>
<th>Company name</th>
<th>Products manufactured or services performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-Ability Medical Equipment</td>
<td>Designs environments for the disabled</td>
</tr>
<tr>
<td>ASO Corp.</td>
<td>Mfg adhesive bandages and related products</td>
</tr>
<tr>
<td>Aaron Medical Industries</td>
<td>Mfg surgical and medical instruments &amp; apparatus</td>
</tr>
<tr>
<td>Advanced Plasma Systems</td>
<td>Mfg gas plasma machines &amp; vacuum chambers</td>
</tr>
<tr>
<td>Advanced Sensor Technologies</td>
<td>Mfg surgical &amp; medical instruments</td>
</tr>
<tr>
<td>Alpha Industries</td>
<td>Mfg surgical &amp; medical instruments</td>
</tr>
<tr>
<td>An-Con Genetics</td>
<td>Mfg surgical &amp; medical instruments</td>
</tr>
<tr>
<td>Ashwin Systems</td>
<td>Mfg infrared diagnostic equipment</td>
</tr>
<tr>
<td>Atlantic Coastal Electronics</td>
<td>Mfg of medical robotic equipment</td>
</tr>
<tr>
<td>Autonomous Technologies</td>
<td>Mfg Electromedical devices</td>
</tr>
<tr>
<td>B &amp; M Precision</td>
<td>Mfg surgical instruments</td>
</tr>
<tr>
<td>Bauer Medical</td>
<td>Mfg biopsy devices</td>
</tr>
<tr>
<td>Bausch &amp; Lomb</td>
<td>Mfg ophthalmic products</td>
</tr>
<tr>
<td>Bausch &amp; Lomb Pharmaceuticals</td>
<td>Mfg pharmaceutical &amp; ophthalmic products</td>
</tr>
<tr>
<td>Baxter Healthcare</td>
<td>Mfg medical equipment &amp; hospital supplies</td>
</tr>
<tr>
<td>Bay Brace &amp; Limb</td>
<td>Mfg orthopedic braces &amp; artificial limbs</td>
</tr>
<tr>
<td>Beach Pharmaceuticals</td>
<td>Mfg pharmaceutical preparations</td>
</tr>
<tr>
<td>Beckton Dickinson/Visitec</td>
<td>Mfg ophthalmic products</td>
</tr>
<tr>
<td>Benz Research</td>
<td>Mfg optical lenses</td>
</tr>
<tr>
<td>Bioderm</td>
<td>Mfg surgical devices</td>
</tr>
<tr>
<td>Cardiovascular Research</td>
<td>Mfg cardiovascular surgery equipment</td>
</tr>
<tr>
<td>Conax</td>
<td>Mfg surgical &amp; medical instruments</td>
</tr>
<tr>
<td>Consolidated Polymer Technologies</td>
<td>Mfg surgical devices</td>
</tr>
<tr>
<td>Company</td>
<td>Product Description</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Contour Medical</td>
<td>Mfg disposable medical products</td>
</tr>
<tr>
<td>Critikon/Johnson &amp; Johnson Medical</td>
<td>Mfg medical diagnostic equipment and catheters</td>
</tr>
<tr>
<td>Dobi Symplex</td>
<td>Mfg orthopedic appliances</td>
</tr>
<tr>
<td>Endo-therapeutics</td>
<td>Mfg surgical &amp; medical products</td>
</tr>
<tr>
<td>Hoveround</td>
<td>Mfg motorized wheelchairs</td>
</tr>
<tr>
<td>Human Technologies</td>
<td>Mfg medical electronics</td>
</tr>
<tr>
<td>Icare Industries</td>
<td>Mfg ophthalmic products</td>
</tr>
<tr>
<td>Ideas for Medicine</td>
<td>Mfg surgical and medical instruments</td>
</tr>
<tr>
<td>Immunomed</td>
<td>Mfg therapeutic products</td>
</tr>
<tr>
<td>Invivo Research</td>
<td>Mfg medical diagnostic equipment</td>
</tr>
<tr>
<td>Invacare</td>
<td>Mfg implantable materials</td>
</tr>
<tr>
<td>Life Sciences</td>
<td>Mfg diagnostic substances</td>
</tr>
<tr>
<td>Lintronics</td>
<td>Mfg medical diagnostic equipment</td>
</tr>
<tr>
<td>Linvatec</td>
<td>Mfg surgical instruments</td>
</tr>
<tr>
<td>Maxim Medical</td>
<td>Mfg disposable medical products</td>
</tr>
<tr>
<td>McNeil Health Equipment</td>
<td>Mfg electromechanical medical equipment</td>
</tr>
<tr>
<td>Medical Device Systems</td>
<td>Mfg surgical &amp; medical instruments</td>
</tr>
<tr>
<td>Medcomp</td>
<td>Mfg cardiac monitoring equipment</td>
</tr>
<tr>
<td>Medrx</td>
<td>Mfg surgical and medical products</td>
</tr>
<tr>
<td>Medtronic</td>
<td>Mfg cardiovascular products</td>
</tr>
<tr>
<td>Mercury Enterprises</td>
<td>Mfg life support medical equipment</td>
</tr>
<tr>
<td>Molecular Genetic Resources</td>
<td>Mfg biotechnology equipment</td>
</tr>
<tr>
<td>Orthokraft Laboratories</td>
<td>Mfg surgical supplies</td>
</tr>
<tr>
<td>Orthosis Corrective Systems</td>
<td>Mfg orthotic splints</td>
</tr>
<tr>
<td>Oscor Medical</td>
<td>Mfg surgical products</td>
</tr>
<tr>
<td>Pace Technology</td>
<td>Mfg medical monitoring equipment</td>
</tr>
<tr>
<td>Peterson Orthotics and Prosthetics</td>
<td>Mfg orthopedic braces &amp; artificial limbs</td>
</tr>
<tr>
<td>PhysioMetrics</td>
<td>Mfg medical devices and monitors</td>
</tr>
<tr>
<td>Premier Orthodontics</td>
<td>Mfg orthodontic supplies</td>
</tr>
<tr>
<td>Promedica</td>
<td>Mfg surgical products</td>
</tr>
<tr>
<td>Restorative Care of America</td>
<td>Mfg orthopedic appliances and orthotic devices</td>
</tr>
<tr>
<td>Scott Robert Ocularists</td>
<td>Mfg artificial eyes</td>
</tr>
<tr>
<td>Second Step USA</td>
<td>Mfg orthopedic devices</td>
</tr>
<tr>
<td>Separation Technology</td>
<td>Mfg medical devices</td>
</tr>
<tr>
<td>R P Shearer</td>
<td>Mfg pharmaceuticals</td>
</tr>
<tr>
<td>Sherwood Medical</td>
<td>Mfg hypodermic needles &amp; syringes</td>
</tr>
<tr>
<td>Smith &amp; Nephew</td>
<td>Mfg hospital care and skin care products</td>
</tr>
<tr>
<td>Sterile Design</td>
<td>Mfg surgical &amp; medical products</td>
</tr>
<tr>
<td>Surgical Safety Products</td>
<td>Mfg medical information systems</td>
</tr>
<tr>
<td>Syncor International</td>
<td>Mfg imaging products</td>
</tr>
<tr>
<td>Unimed Surgical Products</td>
<td>Mfg surgical products</td>
</tr>
<tr>
<td>Witt Biomedical</td>
<td>Mfg monitoring and diagnostic medical equipment</td>
</tr>
<tr>
<td>Vascular Products</td>
<td>Mfg medical devices</td>
</tr>
</tbody>
</table>

D. Biomedical Engineering job market growth projection information
Biomedical Engineers

Nature of the Work | Employment | Job Outlook | Earnings | Sources of Additional Information

NATURE OF THE WORK

By combining biology and medicine with engineering, biomedical engineers develop devices and procedures that solve medical and health-related problems. Many do research, along with life scientists, chemists, and medical scientists, on the engineering aspects of the biological systems of humans and animals. Biomedical engineers also design devices used in various medical procedures, such as the computers used to analyze blood or the laser systems used in corrective eye surgery. They develop artificial organs, imaging systems such as ultrasound, and devices for automating insulin injections or controlling body functions. Most engineers in this specialty require a sound background in one of the more basic engineering specialties, such as mechanical or electronics engineering, in addition to specialized biomedical training. Some specialties within biomedical engineering include biomaterials, biomechanics, medical imaging, rehabilitation, and orthopedic engineering.

EMPLOYMENT

Biomedical engineers held about 7,200 jobs in 2000. Manufacturing industries employed 30 percent of all biomedical engineers, primarily in the medical instruments and supplies industries. Many others worked for health services. Some also worked on a contract basis for government agencies or as independent consultants.

http://www.bls.gov/oco/ocos262.htm

3/23/2003
JOB OUTLOOK

Employment of biomedical engineers is expected to increase faster than the average for all occupations through 2010. The aging population and the focus on health issues will increase the demand for better medical devices and systems designed by biomedical engineers. For example, computer-assisted surgery and cellular and tissue engineering are being more heavily researched and are developing rapidly. In addition, the rehabilitation and orthopedic engineering specialties are growing quickly, increasing the need for more biomedical engineers. Along with the demand for more sophisticated medical equipment and procedures is an increased concern for cost efficiency and effectiveness that also will increase the need for biomedical engineers.

EARNINGS

Median annual earnings of biomedical engineers were $57,480 in 2000. The middle 50 percent earned between $45,760 and $74,120. The lowest 10 percent earned less than $36,860 and the highest 10 percent earned more than $90,530.

According to a 2001 salary survey by the National Association of Colleges and Employers, bachelor's degree candidates in biomedical engineering received starting offers averaging $47,850 a year and master's degree candidates, on average, were offered $62,600.

SOURCES OF ADDITIONAL INFORMATION

For further information about biomedical engineers, contact:

- Biomedical Engineering Society, 8401 Corporate Dr., Suite 110, Landover, MD 20785-2224. Internet:
  http://www.bmes.org

http://www.bls.gov/oco/ocos262.htm
Selected industries employing biomedical engineers that appear in the 2002-03 \textit{Career Guide to Industries}:

- Drug manufacturing
- Health services
- Wholesale trade

17-2031.00
### Total employment by occupation and industry, 2000 and projected 2010

**Biomedical engineers**

[Industries with fewer than 50 workers in 2000 are not displayed]

<table>
<thead>
<tr>
<th>Industry</th>
<th>2000</th>
<th>2010</th>
<th>Employment change, 2000-10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent of occupation</td>
<td>Number</td>
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<tr>
<td>Total employment, all industries</td>
<td>7,221</td>
<td>100.00</td>
<td>9,487</td>
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<tr>
<td>Self-employed workers, all jobs</td>
<td>1,441</td>
<td>20.00</td>
<td>1,774</td>
</tr>
<tr>
<td>Self-employed workers, primary job</td>
<td>1,249</td>
<td>17.30</td>
<td>1,662</td>
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<tr>
<td>Self-employed workers, secondary job</td>
<td>195</td>
<td>2.70</td>
<td>162</td>
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<tr>
<td>Wage and salary employment, all industries</td>
<td>5,777</td>
<td>80.00</td>
<td>7,714</td>
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<tr>
<td>Manufacturing</td>
<td>2,162</td>
<td>29.94</td>
<td>2,801</td>
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<td>Durable goods manufacturing</td>
<td>1,371</td>
<td>18.98</td>
<td>1,858</td>
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<td>Instruments and related products</td>
<td>1,344</td>
<td>18.61</td>
<td>1,826</td>
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<tr>
<td>Measuring and controlling devices</td>
<td>77</td>
<td>1.06</td>
<td>88</td>
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<tr>
<td>Medical instruments and supplies</td>
<td>1,266</td>
<td>17.30</td>
<td>1,725</td>
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<tr>
<td>Nondurable goods manufacturing</td>
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<td></td>
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<tr>
<td>Chemicals and allied products</td>
<td>791</td>
<td>10.96</td>
<td>943</td>
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<tr>
<td>Plastics materials and synthetics</td>
<td>772</td>
<td>10.88</td>
<td>924</td>
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<tr>
<td>Drugs</td>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
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<tr>
<td>Wholesale trade</td>
<td>318</td>
<td>4.41</td>
<td>411</td>
</tr>
<tr>
<td>Wholesale trade, other</td>
<td>318</td>
<td>4.41</td>
<td>411</td>
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<tr>
<td>Services</td>
<td>2,855</td>
<td>39.33</td>
<td>4,011</td>
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<tr>
<td>Business services</td>
<td>157</td>
<td>2.18</td>
<td>209</td>
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<tr>
<td>Computer and data processing services</td>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
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<tr>
<td>Health services</td>
<td>1,704</td>
<td>24.86</td>
<td>2,337</td>
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<tr>
<td>Offices of physicians including osteopaths</td>
<td>263</td>
<td>3.85</td>
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<tr>
<td>Hospitals, public and private</td>
<td>1,370</td>
<td>18.97</td>
<td>1,848</td>
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<tr>
<td>Medical and dental laboratories</td>
<td>143</td>
<td>1.98</td>
<td>212</td>
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<tr>
<td>Engineering and management services</td>
<td>699</td>
<td>12.45</td>
<td>1,371</td>
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<tr>
<td>Engineering and architectural services</td>
<td>111</td>
<td>1.53</td>
<td>162</td>
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<tr>
<td>Research and testing services</td>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Government, except State and Local education and hospitals</td>
<td>378</td>
<td>5.23</td>
<td>411</td>
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<tr>
<td>Federal government, except Postal Service</td>
<td>256</td>
<td>3.54</td>
<td>263</td>
</tr>
<tr>
<td>State government, except education and hospitals</td>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
</tr>
</tbody>
</table>

1. Data are suppressed to protect confidentiality.
2. Except secondary jobs in agricultural production, forestry, fishing, or private households.
The Future of Your Discipline

Prognosis Positive for Biomedical Engineering Grads

by Shayna Sobol

The employment outlook for biomedical engineering graduates is, in a word, good. So say three professors who are tops in the field, from Northwestern University in Evanston, Ill., to Clemson University in South Carolina.

"The outlook is good and getting better as employers recognize the value of the specialty of biomedical engineering," notes Dr. Scott Delp, associate professor of biomedical engineering and rehabilitation at Northwestern University, as well as a research scientist at the Rehabilitation Institute of Chicago. "The more biomedical engineers who go out into industry, the more I see that trend continuing."

Currently, Delp estimates that about half of Northwestern's biomedical engineering undergrads go on to medical school, while 25 percent head to grad school and the remaining 25 percent, roughly 20 students, go on to jobs in industry right out of college.

"Biomedical engineers have unique skills," Delp says. "Often they are needed to bridge traditional engineering skills with medical applications. For someone to have a formal education in both disciplines is very helpful."

Delp asserts that the U.S. dominates the world in the healthcare marketplace, which translates into an optimistic view of the future for his field.

"We have a strong export/import balance," he says. "The growth of the healthcare industry and the domination of the U.S. healthcare industry worldwide are strong indicators that biomedical engineers will be doing well in the coming years."

As vast as the field is, all areas of biomedical engineering represent good employment prospects for today's graduates, according to Dr. Larry Dooley, professor of bioengineering and director of the School of Chemical University. Dooley notes that both the medical device marketplace and the diagnostics marketplace are expanding in the U.S. in terms of new production capability. That translates into a wealth of opportunities for grads possessing bioengineering skills.

WORKERS NEEDED, STAT!
"Industry went through a downsizing period," Dooley relates.
"but now the economy is booming, healthcare is an important issue and industry is looking to expand. It's a good, dynamic time."

Dr. David Kelso, professor of biomedical engineering at Northwestern University, is an expert in the emerging area of biosensor technology. He says the employment outlook is upbeat, ranging from the hiring patterns of large diagnostic companies such as Abbott Laboratories and Hoffman-La Roche to a number of small start-ups pursuing technological development in the biosensor area. Among the exciting avenues available to graduates is exploring new ways of doing blood tests, from infectious diseases to genetic screening to hormones, says Kelso.

"There are opportunities at all levels," he adds. "With the population in this country aging and with people's growing concern for healthcare, there's very little on the downside these days. Issues of cost-containment and cost-control associated with the healthcare industry simply represent more engineering problems that need to be solved."

While the interest in and need for new, cost-effective technologies is high, Kelso says the demand is equally strong for biomedical engineers to work in large systems areas, such as designing and testing in large, centralized manufacturing environments.

"What makes a biomedical engineer so valuable," Kelso says, "is that they understand the medical problem, the chemistry, the biochemistry involved in doing the sensing, yet they also understand the engineering that goes into developing the devices. They have a great ability to interface with all of the specialties that come together in the field."

Dooly of Clemson University points out another area related to health biomedical engineering grads.

"Information technology application in healthcare is changing the way medical centers and hospitals are approaching the management of clinical information," Dooley explains. "That includes billing, radiographic information and clinical information. Merging all of this into a clinical database is changing the way information is used. Doctors are wanting the most up-to-date clinical information at the [hospital] bedside and in the operating room."

Device capability is another strong area, according to Dooley. "We know more now about the way materials behave inside the body and so we're changing the way we think about implantable devices," he says. "This represents new opportunities in design."

**DIVERSE DISCIPLINES DESIRED**

Delp highlights some burgeoning areas of opportunity in his field of expertise. "Biomaterials, rehab engineering, computer-assisted surgery and medical imaging are all areas that draw on engineering, science and medical applications," Delp says.

Other than the good news they have to offer, the common thread expressed by these professors is the list of traits employers appear to be demanding from today's graduates. Delp notes that for undergraduates, "employers are looking for people with native intelligence, drive and the capacity to learn. Quantitative skills and the ability to analyze a problem in detail are also valued."
Dooley adds that a solid foundation in engineering is essential, even for students looking to enter medically dominated areas. "Of course they should also have math skills and teamwork skills," he notes.

And though biomedical engineering programs are growing by leaps and bounds in this country, there doesn't seem to be any fear of oversaturating the industrial marketplace any time soon. The bottom line? A biomedical engineering graduate can look forward to a dynamic career ahead.
E. Engineering M.S. theses and Ph.D. dissertations in the biomedical engineering area (1995-2001)
Students' Research Projects

Summary: The theses and dissertations related to the Biomedical Engineering area are shown below, along with the year and major professor(s). The first M.S. Thesis was presented in 1987, and the first Ph.D. Dissertation in 1988.

Masters Theses

"A Generalized Mathematical Model for Hypertherm Treatment of Brain Tumors,” Hussain, M.S., 1987 (Dr. R. Crane)

"A Study of the Mechanical Properties of Composite Materials Used for Artificial Bones,” Bing-Chew, L., 1989 (Dr. S. Ying)

"An Instrument System for the Acquisition and Analysis of Arterial Pressure and Flow Waves,” Jaroszinski, M., 1990 (Dr. W. Lee)

"An Integrated Test/Expert System for a Medical Monitor,” Lysy, G., 1991 (Dr. L. Hall)

"A review of work completed on an air-flow, direct calorimeter to measure heat dissipation from small mammals,” Stevenson, E., 1991, (Dr. W. Lee)

"Segmentation of Magnetic Resonance Images of the Brain Using Neural Networks and Fuzzy Clustering Techniques," Bensaid, A. M., 1992 (Dr. L. Hall)

"Evaluation of six delipidating reagents for use in the production of reference sera in the clinical chemistry laboratory,” Houchin, C., 1992 (Dr. W. Lee)

"Rheological Effects of the Growth Medium on the Growth of Saccharomyces Cerevisiae," Arakali, N., 1994 (Dr. W. Lee)

"A Rheological Investigation of the Orientation Behavior of Erythrocytes Subjected to Alternating Mechanical Deformation and Relaxation in Whole Human Blood,” Gajiari, C., 1994 (Dr. W. Lee)

"Selection of Alternative Sterilization Method for a New Biomaterial,” Ondrovic, L. 1995 (Dr. W. Lee)

"Analysis of the Chemical Sepsis Syndrome Using the Most Typical Value and the Fuzzy Clinical Feature,” De Estrada, W. 1996 (Dr. A. Kandel)

"Slope Analysis of Mammographic Calcification Clusters,” Gavrieledis, M., 1996 (Dr. D. Snider)

"An Expert System for Assigning Patients Into Clinical Trials Based on Bayesian Methods,” Theocharus, G., 1996 (Dr. Mahadevan)

"A Region Based Enhancement Technique for Evaluation of Mammograms and its VLSI Implementation,” Henriques, W. G., 1996 (Dr. Ranganathan)

"In-Vitro Investigation of Blood-Material Interaction of Three Surfaces of a New Biomaterial,” Wong, A. M., 1996 (Dr. W. Lee)

"Feature Based Classification Techniques for Interpolation of Mammograms,” Iyer, N., 1996 (Dr. L. Hall)

"Investigation of the Mechanical Properties of Vivathane as a Function of Isocyanate Concentration and Diamine Monomer Molecular Weight,” McGill, B., 1996 (Dr. W. Lee)


"Using Neural Networks to Predict Blood Type From Spectrophotometer Readings,” Illindala, U. K., 1999 (Dr. R. Perez)
“Production and Purification of Chondromadilin, A Glycoprotein Unique to Cartilage,” Haladay, N., 1999 (Dr. R. Gilbert)
“Investigating Loosening of Orthopedic Screws Subject to Low Frequency Dynamic Loading,” Graham, A. K., 1999 (Dr. D. Hess)
“Feasibility Study of Immuno-Magnetic Separation of Tumor Cells From Normal Cells,” Bunch, S. E., 2000 (Dr. W. Lee)
“Perceptual Linearization of Digital Mammograms,” Komaravolu, P. 2000 (Dr. D. Rundus)
“Computer Aided Image Analysis of Spin Histology Images.” Zhon, L., 2000 (Dr. D. Goldgof)
“A Physical Model Based Motion Recovery Algorithm and Its Application in Computer Vision and Imaging,” Zhang, Y., 2000, (Dr. D. Goldgof)
“Analysis of a New Blood Oxygenation Device and Procedure,” Shah, B., 2000 (Dr. W. Lee)
“Software Development for the Data Acquisition of Airway and Physiological Variables During Respiratory Assistance,” Rogers, K., 2000 (Dr. R. Gilbert)
“A Comparison Study of Three Surface Models of the 4th Cervical Vertebrae Derived From the Visible Human Data for Finite Element Modeling,” Ross, T, 2001 (Drs. Lee and Besterfield)

Ph.D. Dissertations
“Measurement and Analysis of Temperature Rhythms in Normal and Tumor-Bearing Mice,” Griffith, D. J., 1988 (Dr. W. Lee)
“Mechanically Facilitated Cell-Cell Electrofusion,” Jaroszetski, M., 1993 (Dr. Gilbert)
“Monochrome and Multichrome Image Processing: Application to Communications and Biomedicine,” Li, H. D., 1995 (Dr. V. J. Jain)
“Automated Image Analysis Techniques for Digital Mammography,” Woods, K.S., 1994 (Dr. L. Hall)
“Multiresolution Statistical Analysis of High Resolution Digitized Mammograms and Other Gray Scaled Images,” Heine, J. J., 1996 (Dr. S. Deans)
“Image Unwarping and Difference Analysis: A Technique for Detecting Abnormalities in Mammograms,” Sallam, M. Y., 1997 (Dr. K. Bowyer)
“Knowledge-Guided Processing of Magnetic Resonance Images of the Brain,” Clark, M. C., 1998 (Dr. L. Hall)
“Physically-Based Modelling of Nonrigid Motion in Biomechanics Problems,” Tsap, L. V., 1999 (Dr. D. Goldgof)
“Dual Projection Computer Aided Detection for Mammography,” Heath, M. D., 2000 (Dr. L. Hall)
“Automatic Segmentation of Non-Enhanced Brain Tumors in Magnetic Resonance Images,” Fletcher-Heath, L. M., 2000 (Dr. L. Hall)
F. Engineering funded research in the biomedical engineering area (1995-2001)
**Funded Research Projects**
Summary: The research grants awarded to the faculty of Engineering from 1996-1997 to the present are presented below.

### Fiscal Year 2000 – 2001
1. Garcia-Rubio, L. H.  
Development of Instrumentation Based Technology for the Separation of Various Selected Bacteria  
$111,511
2. Lee, W. E.  
Evaluation of Post-Operative Pain Management System Associated with Orthopedic Implant Procedures  
$24,288
3. Bowyer, K. W.  
Data Sets, Base Line Performance Reference Points, and Evaluation Metrics for Human ID Volume 1 – Technical Proposal  
$91,125
4. Bowyer, K. W.  
Data Sets, Base Line Performance Reference Points, and Evaluation Metrics for Human ID Volume 1 – Technical Proposal  
$179,608
5. Dubey, R. V.  
Rehabilitation Engineering and Technology Services Program  
$599,413
6. Wilkinson, S.  
Creation of Virtual “Safe Patient Care Room of the Future”  
$15,258
Total  
$1,021,203

### Fiscal Year 1999 – 2000
1. Lee, III, W.  
Biomechanics and Characterization of Orthopedic Prosthetic Reconstruction  
$114,723
2. Bowyer, K.  
Human ID Experimental Methods and Baselining Effort  
$75,507
3. Bowyer, K.  
BCRP Grant for Computer Aided Diagnostics  
$12,000
4. Hall, L.  
Improved Breast Cancer Research Through Automated Matching of Patients to Clinical Trials  
$102,806
5. Crane, R.  
Cardiovascular Biomechanics  
$10,221
6. Dubey, R.  
Rehabilitation Technology Needs Assessment  
$60,000
7. Dubey, R.  
Human Machine Cooperative Telerobotics  
$50,000
8. Dubey, R.  
Technology Development (Phase I) for Patient Safety  
$55,125
Total  
$480,382

### Fiscal Year 1998 – 1999
1. Garcia-Rubio, L.H.  
Characterization of Pathogens
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Project Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rose, J.</td>
<td>Using a FFF/Uv-vsi System</td>
<td>$ 29,865</td>
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<tr>
<td>Lee, W.E.</td>
<td>In-situ Comparison of the Biomechanics of the Biomet and Zimmer Total Elbow Prosthesis</td>
<td>$ 18,060</td>
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<td>Ondrovic, L.O.</td>
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<td>Markee, B.</td>
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<td>Greenwald, D.P.</td>
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<tr>
<td>Goldgof, D.B.</td>
<td>A Qualitative Reasoning Expert System for Assigning Patients into Clinical Trials</td>
<td>$ 10,500</td>
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<td>Hall, L.O.</td>
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<tr>
<td>Carne, R.A.</td>
<td>Cardiovascular Biomechanics</td>
<td>$ 30,663</td>
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<td>Dubey, R.V.</td>
<td>Human-Machine Cooperative Telerobotics for Complex Task Execution</td>
<td>$ 12,900</td>
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<td><strong>Total</strong></td>
<td><strong>$101,988</strong></td>
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**Fiscal Year 1997 – 1998**

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<td>Sarkar, S.</td>
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<tr>
<td>Hall, L.O.</td>
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<tr>
<td>Goldgof, D.B.</td>
<td>A Qualitative Reasoning Expert System for Assigning Patients into Clinical Trials</td>
<td>$ 17,000</td>
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<td>Hall, L.O.</td>
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<td></td>
<td><strong>Total</strong></td>
<td><strong>$ 76,232</strong></td>
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**Fiscal Year 1996 – 1997**

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<tr>
<th>Author(s)</th>
<th>Project Description</th>
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<tr>
<td>Garcia-Rubio, L.H.</td>
<td>UV-VIS Characterization of Blood: Applications to the Blood Banking Industry</td>
<td>$100,946</td>
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<tr>
<td>Garcia-Rubio, L.H.</td>
<td>Measurement of Hematocrit Concentration: A Simulation Study</td>
<td>$123,600</td>
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<tr>
<td>Lee, W.E.</td>
<td>Measurement of Polymer Biomaterial Characteristics I: Permeability and Puncture Resistance</td>
<td>$ 2,904</td>
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<td>Greenwald, D.P.</td>
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<tr>
<td>Ondrovic, L.E.</td>
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<tr>
<td>Goldgof, D.B.</td>
<td>A Qualitative Reasoning Expert System for Assigning Patients into Clinical Trials</td>
<td>$ 10,900</td>
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<tr>
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<td><strong>$238,350</strong></td>
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