DEPARTMENT OF BIOMEDICAL ENGINEERING

The Department of Biomedical Engineering offers the Master of Science degree in Biomedical Engineering and the Doctor of Philosophy degree in Biomedical Engineering.

- M.S. in Biomedical Technology Commercialization (p. 1)
- M.S. in Biomedical Engineering (p. 1)
- Ph.D. in Biomedical Engineering (p. 4)

Master of Science Degree in Biomedical Technology Commercialization

A Master of Science (M.S.) degree in Biomedical Technology Commercialization (BTC) at The University of Texas at San Antonio (UTSA) is a joint graduate program between the Department of Biomedical Engineering and Chemical Engineering in the College of Engineering and the Department of Information Systems and Cyber Security in the College of Business. This is a non-thesis degree program and the M.S. degree will be awarded to candidates who have satisfactorily completed all degree requirements for the program.

The regulations for this degree comply with the general University regulations (refer to Student Policies, General Academic Regulations, and the Graduate Catalog, Master's Degree Regulations).

Admission Requirements

Students who hold an undergraduate degree in engineering, sciences, or business administration may apply to the program. The minimum requirements for admission to the Master of Science degree in Biomedical Technology Commercialization program are described below. Note that satisfying these requirements does not guarantee admission.

- Applicants must have a grade point average of 3.0 or better in the last 60 semester credit hours of coursework with a major in a recognized science, engineering or business discipline. Students with borderline grade point average (that is between 2.9 and 3.0) will be required to satisfactorily complete selected courses as a condition of acceptance.
- The Graduate Record Examination (GRE) or Graduate Management Admission Test (GMAT) scores is not required for admission consideration.
- A minimum of one letter of recommendation attesting to the applicant's readiness for graduate study.
- Students whose native language is not English must achieve a university-wide minimum score on either the Test of English as a Foreign Language (TOEFL) paper or internet version or the International English Language Testing System (IELTS). The current university-wide minimum score for TOELF paper version is 60, TOEFL internet version is 79 and IELTS is 6.5. Students are also encouraged to visit the Graduate Catalog on any changes in the university-wide minimum scores for TOEFL/IELTS. Note that TOEFL/IELTS scores older than two years are not valid or accepted. This test score is waived for international students from countries where English is the official language, or for students who have earned a regionally accredited bachelor's degree or higher in the United States or in countries where English is the official language as indicated in the Graduate Catalog.

A complete application includes the application form, official transcripts, letter(s) of recommendation, and English Proficiency test (TOEFL or IELTS) scores if applicable.

Degree Requirements and Program of Study

The Master of Science (M.S.) degree in Biomedical Technology Commercialization (BTC) will consist of at least 30 semester credit hours beyond the bachelor's degree. Undergraduate courses, general education courses, and prerequisites for graduate courses cannot be counted toward this total. For transferring students, course credit allowed for transfer will be decided on a case-by-case basis by the program director and the admissions committee for Biomedical Technology Commercialization. If recommended by the program director and admissions committee, the request will then be submitted to the Dean of the Graduate School for approval. The required curriculum for all students is as follows:

A. Core courses		**18**
Required Core Courses offered in the College of Engineering:		
BME 6123	Medical Device Design	
BME 6403	Biomedical Terminologies for Entrepreneurs	
BME 6413	Working Knowledge in the Biomedical Industries	
Required Core Courses offered in the College of Business:		
MOT 5053	Technology Commercialization	
MOT 5243	Essentials of Project and Program Management	
MOT 5343	Financial Aspects of Management of Technology	
B. Electives		**9**
A minimum of 9 semester credit hours of prescribed courses selected from approved courses below or substitution of appropriate courses by the program director:		
BME 6303	Introduction to Python with Applications to Biomedical	
BME 6723	Bioinstrumentations	
BME 6913	Biomaterials II	
BME 6943	Biomaterials and Cell Signaling	
BME 6953	Biomaterials for Drug Delivery/Pharmacology	
MOT 5213	Organizational Systems for Management of Technology	
MOT 5253	Starting the High-Tech Firm	
C. Final Project		**3**
The final project, in the area of Biomedical Technology Commercialization, is a one semester project and will be conducted under the guidance of an instructor and approved by the program. Students may opt for a comprehensive exam in lieu of a final project. Students opting for comprehensive exam will need prior approval from the program director. Project/exam will be documented and filed with the student's dossier, indicating successful completion of the project/exam.		
BME 6133	Biomedical Project II	
Total Credit Hours		30

Master of Science Degree in Biomedical Engineering

A Master of Science (M.S.) degree in Biomedical Engineering (BME) at The University of Texas at San Antonio (UTSA) is offered through a joint graduate program with The University of Texas Health Science Center at San Antonio (UT Health San Antonio). A matrix of academic

tracks is offered based on segments of biomedical engineering and/or areas of clinical emphasis. Specifically, the program has emphases in the following areas: biomaterials, biomechanics, and bioimaging. The biological areas covered are orthopedics/dental tissues, cardiovascular systems, and neural systems. The M.S. degree in Biomedical Engineering (Thesis Option or Non-Thesis Option) will be awarded to candidates who have displayed an in-depth understanding of the concepts that are necessary for critically judging the scientific literature, for formulating novel hypotheses, designing experimental protocols to test the hypotheses, interpreting their results, and demonstrating their ability to make an original contribution to knowledge in the biomedical field.

The regulations for this degree comply with the general University regulations (refer to Student Policies, General Academic Regulations, and the Graduate Catalog, Master's Degree Regulations).

Admission Requirements

Students who hold an undergraduate degree may apply to the program. The minimum requirements for admission to the Master of Science degree in Biomedical Engineering program are described below. Note that admission is competitive and satisfying these requirements does not guarantee admission.

- Applicants must have a grade point average of 3.0 or better in the last 60 semester credit hours of coursework with a major in a recognized science or engineering discipline. All students should have had sufficient background in engineering, chemistry, biology, and physics prior to being admitted to the program. It is expected that these students will have B.S. degrees with an emphasis in either engineering, physical science, or biological science disciplines. All students are required to have completed at least one year of engineering physics, chemistry, biology, and mathematics (up to Differential Equations I or Applied Engineering Analysis I). Students with deficiencies in the above courses will be required to satisfactorily complete selected courses as a condition of acceptance.
- A satisfactory score, as evaluated by the Admissions Committee for Biomedical Engineering, is required on the Graduate Record Examination (GRE). Students whose native language is not English must achieve a minimum score of 60 on the Test of English as a Foreign Language (TOEFL) paper version or 79 on the Internet version. The applicant's performance on a standardized test will be considered in addition to other criteria for admission or competitive scholarship awards and will not be used as the sole criterion for consideration of an applicant.
- Three letters of recommendation attesting to the applicant's readiness for graduate study.
- A complete application includes the application form, official transcripts, letters of recommendation, GRE scores, a résumé, and a statement of the applicant's research experience, interests, and goals. TOEFL scores are required for those applicants whose native language is not English.

Degree Requirements and Program of Study – Thesis Option

The Master of Science (M.S.) degree in Biomedical Engineering (BME) will consist of at least 32 semester credit hours beyond the bachelor's degree. Undergraduate courses, general education courses, and prerequisites for graduate courses cannot be counted toward this total. For transferring students, course credit allowed for transfer will be decided on a case-by-case basis by the Biomedical Engineering Committee on Graduate Studies (COGS). If recommended by the COGS, the request will then be submitted to the Dean of the Graduate School for approval. Since this is a joint graduate program, some courses are offered at The University of Texas Health Science Center at San Antonio (UT Health). To enroll in UT Health courses (UT Health Catalog (http://catalog.uthscsa.edu/)), students must register through the UT Health website (http://www.uthscsa.edu). Any questions concerning registration at UT Health should be directed to the BME Program Office at UT Health. The required curriculum for all students in the Thesis Option is as follows:

A. Core courses		**17**
Required Core Courses offered at UTSA:		
BME 6033	BME Engineering Analysis	
BME 6303	Introduction to Python with Applications to Biomedical	
BME 6703	Biomedical Imaging	
BME 6803	Experimental Biomechanics	
BME 6903	Biomaterials	
Required Core Courses offered at UT Health :		
BIME 6004	Biology for Bioengineers [1]	
BIME 6006	Physiology for BME [1]	
TSCI 5070	Responsible Conduct of Patient-Oriented Clinical Research	
[1] Select one of these two courses to satisfy core requirements.		
B. Research seminar		**3**
BME 6011 (or BIME 6090 at UT Health) is required for three semesters, in order to satisfy the requirements for the Master's degree program in Biomedical Engineering.		
C. Elective courses		**6**
A minimum of 6 semester credit hours of elective courses selected from the list below. Courses not on this list may be taken with the approval of the BME Program.		
UTSA Prescribed Elective Courses:		
BME 6053	Independent Study in Biomedical Engineering (or BME 6052, BME 6051)	
BME 6093	Topics in Biomedical Engineering	
BME 6123	Medical Device Design	
BME 6143	Biomedical Device Development	
BME 6203	Physiology for Engineers	
BME 6213	Cellular Engineering	
BME 6233	Cardiovascular Bioengineering	
BME 6723	Bioinstrumentations	
BME 6733	Microfabrication and Application	
BME 6743	Biophotonics	
BME 6753	Biosensors: Fundamentals and Applications	
BME 6793	Topics in Image and Signal Processing	
BME 6823	Advanced Biomechanics	
BME 6843	Tissue Mechanics	
BME 6893	Topics in Biomechanics	
BME 6913	Biomaterials II	
BME 6923	Tissue Engineering	
BME 6933	Tissue-Biomaterials Interactions	
BME 6943	Biomaterials and Cell Signaling	
BME 6963	Fundamentals to Polymer Science with Select Biomedical Applications	

ME 5713	Mechanical Behavior of Materials	
MOT 5163	Management of Technology	
MOT 5243	Essentials of Project and Program Management	
UT Health Prescribed Elective Courses:		
BIME 5091	Independent Study	
CSAT 5022	Interprofessional Human Gross Anatomy	
CSAT 5095	Experimental Design and Data Analysis	
INTD 5007	Advanced Cell and Molecular Biology	
INTD 6033	Cell Signaling Mechanisms	
MICR 5051	Introduction to Immunology	
PHAR 5013	Principles of Pharmacology	
RADI 6016	Physics of Diagnostic Imaging II	
RADI 6051	Statistical Parametric Imaging	
D. A minimum of 6 semester credit hours of biomedical engineering Master's Thesis Research is required.		**6**
BIME 6098	Thesis	
BME 6981	Master's Thesis Research	
BME 6982	Master's Thesis Research	
BME 6983	Master's Thesis Research	
BME 6986	Master's Thesis Research	
Total Credit Hours		32

[1] Only one course is needed to satisfy the core requirement.

The entire program of study must be recommended by the student's Master's Thesis Advisor, Master's Thesis Committee, and the COGS and must be submitted to the Dean of the Graduate School for approval. The courses taken by students are intended to focus and support the individual's mastery of his or her particular area of specialization.

Advancement to Candidacy

The student should seek recommendations from the COGS for advancement to candidacy. The COGS reserves the right to deny recommendation of the student's admission to Master's candidacy based on the student's academics and proposed research. Upon recommendation from the COGS, all students are admitted to candidacy after successfully defending their proposed research, recommended by his/her Master's Thesis Committee, and approved by the Dean of the Graduate School. Students should also consult the University Master's Degree Regulations in this catalog for the other pertinent requirements.

Thesis Defense

A thesis, which is an original contribution to scholarship, based on independent investigation (graduate research) in the major area, is required of every candidate. The Master's thesis research will be conducted by the student under the guidance of the Supervising Professor and the advice of the Master's Thesis Committee. Prior to starting the thesis research, each student will submit a research proposal to the COGS for approval. The thesis will be the responsibility of the student and the Supervising Professor. Registration for thesis credit hours must be for a period of more than one semester. During each semester that a student receives advice and/or assistance from a faculty member or supervision by the Master's Thesis Committee or uses UTSA or UT Health resources, he or she will be required to enroll for credit in the appropriate Master's degree course. The form and format of the thesis should follow the guidelines and rules already in effect at UTSA or UT Health.

Composition of the Master's Thesis Committee

The Master's Thesis Committee is made up of at least four members. The committee should consist of the Supervising Professor, one BME Graduate Faculty member from UTSA, one BME Graduate Faculty member from UT Health, and one external member. The student's thesis proposal and the proposed composition of the Master's Thesis Committee will be evaluated and approved by the COGS.

Final Oral Examination (Defense of Thesis)

A satisfactory final oral examination is required for the approval of a thesis. Acceptance of the thesis will be contingent upon approval of the respective Master's Thesis Committee. The thesis defense consists of a seminar presentation by the candidate to the general public. A closed door examination by the Master's Thesis Committee follows and covers the general field of the thesis, and other parts of the student's program as determined by the respective committee. Members of the Master's Thesis Committee must be satisfied that the student has:

1. Completed the research approved by the Master's Thesis Committee
2. Passed all examinations required by the COGS, including the successful defense of the thesis
3. Completed the required coursework
4. Completed a thesis that is an independent investigation in the biomedical engineering field and constitutes a contribution to the respective discipline

Upon successful completion of the aforementioned requirements, the Master's Thesis Committee members will sign the approval forms for the Master's Thesis and make an official recommendation to the Graduate School of Biomedical Sciences at the UT Health or to the Graduate School at UTSA that the Master's degree be awarded.

Degree Requirements and Program of Study – Non-Thesis Option

The Non-Thesis Option is not offered to new incoming students. All students enrolled in the Non-Thesis Option will require approval from the Program Director and the Graduate Advisor of Record. The Master of Science (M.S.) degree in Biomedical Engineering (BME) (Non-Thesis Option) will consist of at least 36-semester-credit-hours beyond the bachelor's degree. Undergraduate courses, general education courses, and prerequisites for graduate courses cannot be counted toward this total. For transferring students, course credit allowed for transfer will be decided on a case-by-case basis by the Biomedical Engineering Committee on Graduate Studies (COGS). If recommended by the COGS, the request will then be submitted to the Dean of the Graduate School for approval. Since this is a joint graduate program, some courses are offered at The University of Texas Health Science Center at San Antonio (UT Health). To enroll in UT Health courses (UT Health Catalog (http://catalog.uthscsa.edu/)), students must register through the UT Health website (http://www.uthscsa.edu). Any questions concerning registration at UT Health should be directed to the BME Program Office at UT Health. The required curriculum for all BME students in the Non-Thesis Option is as follows:

A. Core Courses:		**18**
Required Core Courses offered at UTSA: (All courses listed below.)		
BME 6033	BME Engineering Analysis	
BME 6703	Biomedical Imaging	
BME 6803	Experimental Biomechanics	
BME 6903	Biomaterials	
BME 6961	Comprehensive Examination	

Required Core Courses offered at UT Health:		
BIME 6004	Biology for Bioengineers [1]	
BIME 6006	Physiology for BME [1]	
TSCI 5070	Responsible Conduct of Patient-Oriented Clinical Research	
[1] Select one of these two courses to satisfy core requirements.		
B. Research seminar		**3**
BME 6011 (or BIME 6090 at UT Health) is required for three semesters, in order to satisfy the requirements for the Master's degree program in Biomedical Engineering.		
C. Electives		**15**
A minimum of 15 semester credit hours of prescribed elective courses selected from the Thesis option above. Courses not on this list may be taken with the approval of the BME Program.		
Total Credit Hours		36

Doctor of Philosophy Degree in Biomedical Engineering

A Doctor of Philosophy degree in Biomedical Engineering (BME) at The University of Texas at San Antonio (UTSA) is offered through a joint graduate program with The University of Texas Health Science Center at San Antonio (UT Health San Antonio). A matrix of academic tracks is offered based on segments of biomedical engineering and/or areas of clinical emphasis. Specifically, the program has emphases in the following areas: biomaterials, biomechanics, and bioimaging. The biological areas covered are orthopedics/dental tissues, cardiovascular systems, and neural systems. The Ph.D. in Biomedical Engineering will be awarded to candidates who have displayed an in-depth understanding of the concepts that are necessary for critically judging the scientific literature, for formulating novel hypotheses, designing experimental protocols to test the hypotheses, interpreting their results and demonstrating their ability to make an original contribution to knowledge in the biomedical field.

The regulations for this degree comply with the general University regulations (refer to Student Policies, General Academic Regulations, and the Graduate Catalog, Doctoral Degree Regulations).

Admission Requirements

Students who hold an undergraduate or master's degree may apply to the program. The minimum requirements for admission to the Doctor of Philosophy in Biomedical Engineering degree program are described below. Note that admission is competitive and satisfying these requirements does not guarantee admission.

- Applicants must have a grade point average of 3.0 or better in the last 60 semester credit hours of coursework with a major in a recognized science or engineering discipline. All students should have had sufficient background in engineering, chemistry, biology, and physics prior to being admitted to the program. It is expected that these students will have B.S. degrees with emphasis in either engineering, physical science, or biological science disciplines. All students are required to have completed at least one year of engineering physics, chemistry, biology, and mathematics (up to Differential Equations I or Applied Engineering Analysis I). Students with deficiencies in the above courses will be required to satisfactorily complete selected courses as a condition of acceptance.
- Applicants with a master's degree must have a grade point average of 3.0 or better in their master's degree program. Applicants with a Master's degree in Biomedical Engineering or in a related field may apply a maximum of 30 semester credit hours of previously earned graduate credit (except research and thesis hours) toward their doctoral degree. The Committee on Graduate Studies (COGS) will evaluate each student's transcript and credit will be recommended for transfer on a course-by-course basis to satisfy the formal coursework requirements of the doctoral degree.
- A satisfactory score, as evaluated by the Admissions Committee for Biomedical Engineering, is required on the Graduate Record Examination (GRE). Students whose native language is not English must achieve a minimum score of 60 on the Test of English as a Foreign Language (TOEFL) paper version or 79 on the Internet version. The applicant's performance on a standardized test will be considered in addition to other criteria, for admission or competitive scholarship awards and will not be used as the sole criterion for consideration of an applicant.
- Three letters of recommendation attesting to the applicant's readiness for doctoral study.
- A complete application includes the application form, official transcripts, letters of recommendation, GRE scores, a résumé, and a statement of the applicant's research experience, interests, and goals. TOEFL scores are required for those applicants whose native language is not English.

Degree Requirements and Program of Study

The Doctor of Philosophy degree in Biomedical Engineering (BME) will consist of at least 82-semester-credit-hours for students with a bachelor's degree. Undergraduate courses, general education courses, and prerequisites for graduate courses cannot be counted toward this total. For students with a master's degree, course credit allowed for transfer will be decided on a case-by-case basis by the Biomedical Engineering COGS. If recommended by the COGS, the request will then be submitted to the Dean of the Graduate School for approval. Since this is a joint graduate program, some courses are offered at The University of Texas Health Science Center at San Antonio (UT Health). To enroll in UT Health courses (UT Health Catalog (http://catalog.uthscsa.edu/)), students must register through the UT Health website (http://www.uthscsa.edu). Any questions concerning registration at UT Health should be directed to the BME Program Office at UT Health.

Students with a M.S. degree in Biomedical Engineering will be reviewed on a case-by-case basis. All other students who have obtained a Master of Science degree in Biomedical Engineering from UTSA are required to complete the following courses:

CSAT 5095	Experimental Design and Data Analysis (at UT Health)
One prescribed BME elective	
Course requirements in Sections B, D (5 credits), E, and F of doctoral program	

Students will be required to complete a minimum of 82 hours for students matriculating into the doctoral program with a B.S. degree. The minimum required curriculum for all students is as follows:

A. Core Courses:		**17**
Required Core Courses offered at UTSA:		
BME 6033	BME Engineering Analysis [1]	
BME 6303	Introduction to Python with Applications to Biomedical	
BME 6703	Biomedical Imaging [1,3]	

BME 6803	Experimental Biomechanics [1]	
BME 6903	Biomaterials [1]	
Required Core Courses offered at UT Health:		
BIME 6004	Biology for Bioengineers [1,2]	
BIME 6006	Physiology for BME [1,2]	
CSAT 5095	Experimental Design and Data Analysis	
TSCI 5070	Responsible Conduct of Patient-Oriented Clinical Research	
RADI 5015	Physics of Diagnostic Imaging I [1,3]	
[1] Select any four (4) courses to satisfy the core requirements.		
[2] Only one of these courses may be counted toward the core requirements.		
[3] Only one of these courses may be counted toward the core requirements.		
B. Research seminar		**8**
BME 6011 (at UTSA) or BIME 6090 (at UT Health) must be registered for during each Fall and Spring semester while in the BME Doctoral program. With the approval of the Program Director, Ph.D. students are not required to register for the seminar if they are in their fifth year of the program as a full-time student and have registered for the Fall and Spring semester seminars during the preceding four years.		
C. A minimum of 9 semester credit hours of elective courses selected from the list below. Courses not on this list may be taken with the approval of the BME Program.		**9**
UTSA Prescribed Elective Courses:		
BIO 5433	Systems Neuroscience	
BIO 5483	Computational Neuroscience	
BME 6043	Critical Thinking and Writing for BME	
BME 6053	Independent Study in Biomedical Engineering (or BME 6051, BME 6052)	
BME 6093	Topics in Biomedical Engineering	
BME 6123	Medical Device Design	
BME 6143	Biomedical Device Development	
BME 6213	Cellular Engineering	
BME 6233	Cardiovascular Bioengineering	
BME 6723	Bioinstrumentations	
BME 6733	Microfabrication and Application	
BME 6743	Biophotonics	
BME 6753	Biosensors: Fundamentals and Applications	
BME 6793	Topics in Image and Signal Processing	
BME 6823	Advanced Biomechanics	
BME 6843	Tissue Mechanics	
BME 6893	Topics in Biomechanics	
BME 6913	Biomaterials II	
BME 6923	Tissue Engineering	
BME 6933	Tissue-Biomaterials Interactions	
BME 6943	Biomaterials and Cell Signaling	
BME 6963	Fundamentals to Polymer Science with Select Biomedical Applications	
ME 5713	Mechanical Behavior of Materials	
UT Health Prescribed Elective Courses:		
BIME 5091	Independent Study	
CSAT 5022	Interprofessional Human Gross Anatomy	
IBMS 5000	Fundamentals of Biomedical Science	
INTD 5007	Advanced Cell and Molecular Biology	
INTD 6033	Cell Signaling Mechanisms	
MICR 5051	Introduction to Immunology	
PHAR 5013	Principles of Pharmacology	
PHAR 5014	Integrated Physiology and Therapeutics	
RADI 6016	Physics of Diagnostic Imaging II	
RADI 6051	Statistical Parametric Imaging	
D. Supervised Teaching		**1**
A minimum of 1 semester credit hour of Supervised Teaching is required to satisfy the degree's requirement. Students may take up to 3 semester credit hours. (1-3 semester credit hours)		
BIME 6071	Supervised Teaching	
E. Doctoral Research and Dissertation		**12**
1. Doctoral Research requires a minimum of 6 semester credit hours.		
BME 7951	Doctoral Research	
BME 7952	Doctoral Research	
BME 7953	Doctoral Research	
BME 7956	Doctoral Research	
BIME 6097	Research	
2. Doctoral Dissertation requires a minimum of 6 semester credit hours.		
BME 7991	Doctoral Dissertation	
BME 7992	Doctoral Dissertation	
BME 7993	Doctoral Dissertation	
BME 7996	Doctoral Dissertation	
BIME 7099	Dissertation	
F. Electives		**35**
The remainder of the hours can be BME approved graduate level courses or research credits.		
Students in the program must complete at least 82 semester credit hours for graduation. The entire program of study must be recommended by the student's Dissertation Advisor, Dissertation Committee, and COGS and must be submitted to the Dean of the Graduate School for final approval. The courses taken by students are intended to focus and support the individual's mastery of his or her particular area of specialization.		
Total Credit Hours		82

Advancement to Candidacy

All students seeking a doctoral degree must be admitted to candidacy after passing a doctoral qualifying examination. Students should consult Doctoral Degree Regulations in this catalog for the other pertinent requirements.

Satisfactory Performance on the Doctoral Qualifying Examination for Admission to Candidacy

The qualifying examination will be administered before the student commences the chosen dissertation research. This examination will be comprehensive in nature and may be written, oral, or both. Topics covered will include not only information provided in courses taken by the student but also basic knowledge necessary for research in the student's chosen area of study. The Committee on Graduate Studies (COGS) will determine the format of the examination and the composition of the Qualifying Examination Committee (QEC), with the provision that BME faculty from

both UTSA and UT Health will be included. The QEC will administer the examination, evaluate the student's performance, and report its judgment to the Committee on Graduate Studies. A student is allowed to take the qualifying examination twice. Admission to candidacy will be contingent on passing the qualifying examination. Students who do not pass the qualifying examination may be accommodated with a terminal Master's degree after completing additional prescribed courses and/or research approved by the Supervising Professor, Program Director and the COGS.

Doctoral Dissertation

A dissertation, which is an original contribution to scholarship, based on independent investigation (doctoral research) in the major area, is required of every candidate. The doctoral research will be conducted by the student under the guidance of the Supervising Professor and the advice of the Dissertation Committee. Prior to starting the doctoral research, each student will submit a dissertation proposal to the COGS for approval. The doctoral dissertation will be the responsibility of the student and the Supervising Professor. Registration for dissertation credit hours must be for a period of more than one semester. During each semester that a student receives advice and/or assistance from a faculty member or supervision by the Dissertation Committee or uses UTSA or UT Health resources, he or she will be required to enroll for credit in the appropriate dissertation course. The form and format of the dissertation should follow the guidelines and rules already in effect at UTSA or UT Health.

Composition of the Dissertation Committee

The Dissertation Committee is made up of at least five members. The committee should consist of the Supervising Professor, one BME Graduate Faculty member from UTSA, one BME Graduate Faculty member from UT Health, one member of the graduate faculty outside of the BME Graduate Faculty from either UTSA or UT Health, and one member from outside both institutions. In addition, there is a minimum of 50 percent dissertation committee membership from UTSA for students with a Supervising Professor from UTSA. The student's dissertation proposal and the proposed composition of the Dissertation Committee will be evaluated and approved by the COGS.

Final Oral Examination (Defense of Dissertation)

A satisfactory final oral examination is required for the approval of a dissertation. Acceptance of the dissertation will be contingent upon approval of the respective Dissertation Committee.

The dissertation defense will consist of a seminar presentation by the candidate to the general public. A closed door examination by the Dissertation Committee follows and covers the general field of the dissertation, and other parts of the student's program as determined by the respective committee. Members of the Dissertation Committee must be satisfied that the student has:

1. Completed the research approved by the Dissertation Committee
2. Passed all examinations required by the COGS, including the successful defense of the dissertation
3. Completed the required coursework
4. Completed a dissertation that is an independent investigation in the biomedical engineering field and constitutes a contribution to the respective discipline
5. Submitted an abstract for publication in Dissertation Abstracts International that meets with the approval of University requirements

Upon successful completion of the aforementioned requirements, the Dissertation Committee members will sign the approval forms for the doctoral dissertation and make an official recommendation to the Graduate School of Biomedical Sciences at the UT Health or to the Graduate School at UTSA that the Doctoral degree be awarded.

Students should note that the above is a summary of the requirements for the Doctoral degree and are advised to consult the University (UTSA) Doctoral Degree Regulations as well as the BME Student Handbook which contains details specific to the UTSA/UT Health Joint Graduate Program in Biomedical Engineering.

Graduate Certificate in Medical Device Commercialization and Entrepreneurship

The Graduate Certificate program in Medical Device Commercialization and Entrepreneurship (MDCE) is administered by the Department of Biomedical Engineering and Chemical Engineering in the College of Engineering. This certificate is for students who are interested in gaining entry into the biomedical industry workforce. The MDCE graduate certificate will be awarded to candidates who have satisfactorily completed all the requirements for the program and are in good academic standing.

The regulations for this certificate comply with the general University regulations (refer to Student Policies, General Academic Regulations, and the Graduate Catalog, Master's Degree Regulations).

Admission Requirements

Undergraduate and graduate students who are currently in engineering, sciences, or business discipline may apply to the certificate program. The minimum requirements for admission to the Graduate Certificate program in Medical Device Commercialization and Entrepreneurship are described below. Note that satisfying these requirements does not guarantee admission.

- All applicants (graduate and undergraduate students) must have a grade point average of 3.0 or better in the last 60 semester credit hours of coursework with a major in a recognized science, engineering or business discipline. Students with deficiencies in the above courses will be required to satisfactorily complete selected courses as a condition of acceptance.
- Current undergraduate students must be in the final three semester of their program and must have a grade point average of 3.0 or better in their discipline. Students are limited to only registering for 6 semester credit hours of the certificate courses, and these courses should not be counted towards their undergraduate degree of study. The final 6 semester credit hours required for the award of the certificate should be taken after completing their undergraduate program.
- Current graduate students or students must be in good academic standing, that is, having a grade point average of 3.0 or better.
- Applicants who have already completed their undergraduate degree program of study, are currently not in a graduate program, and are not working in a medical device industry must have a grade point average of 3.0 or better in the last 60 semester credit hours of coursework with a major in a recognized science, engineering or business discipline. Students with borderline grade point average (that is between 2.9 and 3.0) will be required to satisfactorily complete selected courses as a condition of acceptance.
- Applicants who are currently employed in a medical device industry and does not meet the 3.0 grade point average needed for admission, work experience will be taken into account. A 0.5 grade point average credit will also be applied for students given for every full-time year of

experience in the medical device industry. For example, if a candidate had a 2.0 grade point average with two years of industry experience, the grade point average will be calculated to be 3.0 (given the two years work experience) at that time of application.

- Graduate Record Examination (GRE) or Graduate Management Admission Test (GMAT) scores is not required for admission consideration.
- A minimum of one letter of recommendation attesting to the applicant's readiness for this certificate program.
- Students whose native language is not English must achieve a university-wide minimum score on either the Test of English as a Foreign Language (TOEFL) paper or internet version or the International English Language Testing System (IELTS). The current university-wide minimum score for TOELF paper version is 60, TOEFL internet version is 79 and IELTS is 6.5. Students are also encouraged to visit the Graduate Catalog on any changes in the university-wide minimum scores for TOEFL/IELTS. Note that TOEFL/IELTS scores older than two years are not valid or accepted. This test score is waived for international students from countries where English is the official language, or for students who have earned a regionally accredited bachelor's degree or higher in the United States or in countries where English is the official language as indicated in the Graduate Catalog.

A complete application includes the application form, official transcripts, letter(s) of recommendation, and English Proficiency test (TOEFL or IELTS) scores if applicable

Certificate Requirements and Program of Study

The Graduate Certificate in Medical Device Commercialization and Entrepreneurship will consist of at least 12 semester credit hours beyond the bachelor's degree. Undergraduate courses, general education courses, and prerequisites for graduate courses cannot be counted toward this total. For transferring students, course credit allowed for transfer will be decided on a case-by-case basis by the program director and the admissions committee for this certificate program. If recommended by the program director and admissions committee, the request will then be submitted to the Dean of the Graduate School for approval. The required curriculum for all students is as follows:

12 hours of coursework chosen from the following, in consultation with your graduate advisor:		12
BME 6213	Cellular Engineering	
BME 6143	Biomedical Device Development	
BME 6153	Medical Device Project Management	
BME 6073	Professional Science Master's Practicum [1]	
BME 6133	Biomedical Project II	
BME 6163	Medical Technology Regulatory	
BME 6173	Biomedical Commercialization and Entrepreneurship	
BME 6303	Introduction to Python with Applications to Biomedical	
BME 6723	Bioinstrumentations [2]	
BME 6953	Biomaterials for Drug Delivery/Pharmacology	
Total Credit Hours		12

1 Students currently working in the biomedical industry or undertaking biomedical industry experiences have the option to request experiential credits using a competency-based exam. Students will have to register for BME 6073 and must submit a written request to take the competency-based exam. Three (3) semester credit hours will be award for the course upon passing the competency-based exam. The administration of the exam and the period of experiences needed to qualify for the exam will be the responsibility of the program director.

2 One of BME 6203, BME 6723 or BME 6953 can be taken as a specialization elective if desired to fit industry specific technical competency. Students can only count one of these courses towards the certificate program.

Biomedical Engineering (BME) Courses

BME 6011. Research Seminar. (1-0) 1 Credit Hour.
Prerequisites: Graduate student standing; consent of the instructor and the Graduate Advisor of Record. The seminar coordinator may require students to present their research. May be repeated for credit. The grade report for the course is either "CR" (satisfactory performance) or "NC" (unsatisfactory performance). (Formerly BME 5011 and BME 6991. Same as BIME 6090 at UT Health San Antonio.) Differential Tuition: $55.

BME 6021. Supervised Teaching. (0-0) 1 Credit Hour.
Prerequisites: Doctoral student standing; consent of the instructor and the Graduate Advisor of Record. Supervised teaching of undergraduate or graduate students will be required for at least one semester. Students may be required to lecture at undergraduate courses or graduate courses in the field of their expertise. Students will work with the instructor of the course or with their research supervisor on the number of classes to be taught. (Same as BIME 6071 at UT Health San Antonio.) Differential Tuition: $55.

BME 6033. BME Engineering Analysis. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in engineering or consent of the instructor. This course is designed to introduce students to advanced mathematical and numerical methods necessary to solve problems frequently encountered in biomedical engineering. Topics covered include vector differential and integral calculus, linear algebraic equations, and ordinary and partial differential equations. (Same as EGR 6013 and ME 6013. Same as BME 6093 offered in Fall 2007. Credit can be earned for only one of the following: BME 6033, BME 6093 taken Fall 2007, EGR 6013, or ME 6013.) Differential Tuition: $165.

BME 6043. Critical Thinking and Writing for BME. (3-0) 3 Credit Hours.
Prerequisites: Doctoral students who are either taking their qualifying examinations or have been admitted to candidacy; consent of the instructor and of the Graduate Advisor of Record. This course introduces students to grant applications and manuscript writing, and provides the opportunity to learn through writing and critiquing research proposals, manuscripts, abstracts, and scientific presentations. Differential Tuition: $165.

BME 6051. Independent Study in Biomedical Engineering. (0-0) 1 Credit Hour.
Prerequisites: Graduate standing; consent of the instructor and of the Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of regular course offerings. May be repeated for credit on a different topic of study, but no more than 6 credit hours, regardless of discipline, will apply toward the degree. Differential Tuition: $55.

BME 6052. Independent Study in Biomedical Engineering. (0-0) 2 Credit Hours.
Prerequisites: Graduate standing; consent of the instructor and of the Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of regular course offerings. May be repeated for credit on a different topic of study, but no more than 6 credit hours, regardless of discipline, will apply toward the degree. Differential Tuition: $110.

BME 6053. Independent Study in Biomedical Engineering. (0-0) 3 Credit Hours.
Prerequisites: Graduate standing; consent of the instructor and of the Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of regular course offerings. May be repeated for credit on a different topic of study, but no more than 6 credit hours, regardless of discipline, will apply toward the degree. Differential Tuition: $165.

BME 6063. Introduction to Scientific Computing and Visualization. (3-0) 3 Credit Hours.
Prerequisites: Graduate standing; consent of the instructor. This is an introductory course covering the basic concepts and tools of scientific computing and visualization. It will cover basic UNIX operations (shell scripts and editors), UNIX tools (grep, awk, sed), basic visualization concepts and software tools (ParaView and VisIt). It will also cover parallel programming using Fortran/C/C++ with Message Passing Interface (MPI) and public domain libraries. (Credit can be earned for only one of the following: BME 6063, ME 4953 or ME 5013.) Differential Tuition: $165.

BME 6073. Professional Science Master's Practicum. (0-0) 3 Credit Hours.
Prerequisites: Graduate standing and consent of the Program Director. An internship in a Biomedical Engineering company. Students must have completed all required core courses and electives, and be in the writing phase of their thesis. May not be repeated for credit. Differential Tuition: $165.

BME 6093. Topics in Biomedical Engineering. (3-0) 3 Credit Hours.
Prerequisites: Graduate standing; consent of the instructor and of the Graduate Advisor of Record. May be repeated for credit on a different topic of study. Differential Tuition: $165.

BME 6103. Biology for Bioengineers. (3-0) 3 Credit Hours.
Prerequisites: Graduate standing; consent of the instructor and of the Graduate Advisor of Record. This course provides a broad background in biological concepts with specific attention given to biological processes important to bioengineering. Topics may include biochemistry, genetics, molecular biology, cell biology, and physiology. (Same as BIME 6004 at UT Health San Antonio. Credit cannot be earned for both BME 6103 and BIME 6004.) Differential Tuition: $165.

BME 6123. Medical Device Design. (3-0) 3 Credit Hours.
Prerequisites: Graduate standing; consent of the instructor and of the Graduate Advisor of Record. This course will educate students about current biomedical technologies and product development. Topics covered will include ideation, concept development, design methodologies, business plan basics, regulatory concepts for medical devices and intellectual property management. Differential Tuition: $165.

BME 6131. Biomedical Project. (0-0) 1 Credit Hour.
Prerequisites: Graduate standing; consent of the instructor and of the Graduate Advisor of Record and concurrent enrollment in BME 6143. This project course will be offered to nonthesis students as an alternative to the comprehensive examination and will involve the design and development of a biomedical device or instrument. This course requires the final presentation of a prototype at the end of the semester and cannot be repeated for credit. The grade report for the course is either "CR" (satisfactory performance in Biomedical Project) or "NC" (unsatisfactory performance in Biomedical Project). (Credit cannot be earned for both BME 6131 and BME 6961.) Differential Tuition: $55.

BME 6133. Biomedical Project II. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing, consent of the instructor and of the Graduate Advisor of Record and concurrent enrollment in BME 6143. This project course will be offered to non-thesis students as an alternative to the comprehensive examination and will involve the design and development of a biomedical device or instrument. This course requires the final presentation of a prototype at the end of the semester and cannot be repeated for credit. The grade report for the course is either "CR" (satisfactory performance in Biomedical Project) or "NC" (unsatisfactory performance in Biomedical Project). Differential Tuition: $165.

BME 6143. Biomedical Device Development. (3-0) 3 Credit Hours.
Prerequisites: Graduate standing; consent of the instructor and of the Graduate Advisor of Record and BME 6123. This course involves the development of project proposals, testing of the design project and presentation of conceptual designs and a final prototype. Industrial collaboration and/or faculty sponsorship of these projects is encouraged. Differential Tuition: $165.

BME 6153. Medical Device Project Management. (3-0) 3 Credit Hours.
Prerequisite: Consent of the instructor. This course addresses concepts and techniques for the management of business and technology projects. Includes topics such as the project life cycle, project planning, project scheduling, project cost estimating, project risk analysis, project control techniques, earned value management, project organizations and functions, project manager responsibilities, and team building. Differential Tuition: $165.

BME 6163. Medical Technology Regulatory. (3-0) 3 Credit Hours.
Prerequisites: Graduate standing, consent of the instructor and of the Graduate Advisor of Record and BME 6123. This course provides an overview of product quality and safety responsibilities during device development, the regulatory framework, both nationally as well as internationally, and product monitoring standards. An understanding of the approval submission process and the nature of benchmarking and testing products as well as product classifications will be covered. Differential Tuition: $165.

BME 6173. Biomedical Commercialization and Entrepreneurship. (3-0) 3 Credit Hours.
Prerequisites: Graduate standing, consent of the instructor and of the Graduate Advisor of Record and BME 6123. A review of the steps and processes involved in starting a biomedical technology-based commercial endeavor. The focus is built around the steps of identifying a problem area, identifying potential technological solutions to the identified need, and developing a proposed business entity to commercialize the technology solution. Differential Tuition: $165.

BME 6203. Physiology for Engineers. (3-0) 3 Credit Hours.
Prerequisite: Consent of the instructor or completion of BIME 6004 (UT Health San Antonio). Designed to provide students with the essential graduate-level background for applications and practices of biomedical engineering. Integration of the nervous, skeletal, muscle, cardiovascular, and other systems from the sub-cellular to the whole-organism level will be emphasized. Differential Tuition: $165.

BME 6213. Cellular Engineering. (3-0) 3 Credit Hours.
Prerequisites: Consent of the instructor and completion of BIME 6004 (UT Health San Antonio) or BME 6203. This course will focus on the use of engineering skills and principles in the analysis and design of cellular function including protein engineering, enzyme kinetics, drug design, receptor-ligand interactions, cell signaling, metabolism, growth, adhesion and migration. Differential Tuition: $165.

BME 6233. Cardiovascular Bioengineering. (3-0) 3 Credit Hours.
Prerequisites: BME 2103, BME 6203, and BME 6033 or consent of the instructor. This course introduces the bioengineering principles applied to the understanding and modeling of the cardiovascular system. Topics covered include anatomy of the human cardiovascular system; comparative anatomy; allometric scaling principles; cardiovascular molecular and cell biology; overview of continuum mechanics; form and function of blood, blood vessels, and the heart from an engineering perspective; normal, diseased and engineered replacement tissues and medical devices. Differential Tuition: $165.

BME 6303. Introduction to Python with Applications to Biomedical. (3-0) 3 Credit Hours.
Students will be exposed to coding for applications using Python in the biomedical industries. The course aims to provide students with the ability to apply Python to analyze biological data and solve contemporary problems in the biosciences, bioengineering and biomedicine. Differential Tuition: $165.

BME 6313. Computational Bioengineering and Biomedicine. (3-0) 3 Credit Hours.
Prerequisite: BME 6033 or consent of the instructor. The objective of this course is to provide both engineering and medical students an introductory knowledge and skills of mathematical modeling and computer simulation, particularly in bioengineering. The course will consist of three parts: theoretical background, computational methods, and practical applications. (Same as ME 6873. Credit cannot be earned for both BME 6313 and ME 6873.) Differential Tuition: $165.

BME 6403. Biomedical Terminologies for Entrepreneurs. (3-0) 3 Credit Hours.
Prerequisite: Completion of or concurrent enrollment in BME 6123. Designed to provide students with an introduction to concepts and terminologies that span across the fields of biomedical engineering, technologies, medical devices and healthcare. Differential Tuition: $165.

BME 6413. Working Knowledge in the Biomedical Industries. (3-0) 3 Credit Hours.
Prerequisite: Completion of or concurrent enrollment in BME 6403. Designed to provide students with an introduction to biomedical industries and medical product categories. Examples will be provided for specific companies in regards to the technologies, intellectual property protection and business models that provide the foundation for their success. Differential Tuition: $165.

BME 6593. Biomaterials for Drug Delivery/Pharmacology. (3-0) 3 Credit Hours.
Provides a conceptual understanding of therapeutic agents used to regulate physiological function of cells comprising organ systems with relevance to biomaterials. Interpretation of drug mechanisms at a molecular, cellular and tissue level. Traditional reviews of pharmacodynamics and pharmacokinetics will be addressed with particular application to biomaterial interaction and drug-delivery systems. Differential Tuition $165.

BME 6703. Biomedical Imaging. (3-0) 3 Credit Hours.
Prerequisite: Consent of the BME Program Director. This course will examine, from a systems perspective, the techniques used in a variety of medical imaging modalities, which include X-ray imaging, computed tomography (CT), magnetic resonance imaging (MRI), nuclear medicine (PET), ultrasound imaging, optical imaging and photoacoustic imaging. The fundamental principles and engineering underlying each imaging modality will be discussed and a performance analysis of each system will be examined. With approval from the BME Program Director, credit for this course can be counted towards satisfying the imaging core course for Ph.D. students. (Credit can be earned for only one of the following: BME 6703 or RADI 5015 at UT Health San Antonio.) Differential Tuition: $165.

BME 6723. Bioinstrumentations. (3-0) 3 Credit Hours.
Prerequisite: Consent of the instructor. This course will cover fundamental principles of bioinstrumentation used in clinical and research measurements. Topics include: principles of transducer operation, amplifiers and signal processing, recording and display. Overview of specific examples in optical sensors, biological sensors, MRI, ultrasound, pacemakers and defibrillators. Differential Tuition: $165.

BME 6733. Microfabrication and Application. (3-0) 3 Credit Hours.
Prerequisite: Consent of the instructor. This course describes the science of miniaturization which is essential for nanotechnology development. Microfabrication techniques for micro-electro-mechanical systems (MEMS), bioMEMS, microfluidics, and nanomaterials and their applications in biomedical research will be covered. Differential Tuition: $165.

BME 6743. Biophotonics. (3-0) 3 Credit Hours.
Prerequisite: Consent of the instructor. This course describes the fundamental principles of biophotonics and their wide range of applications in biomedical research. Topics will include fundamentals of light interactions with molecules, cells, and tissues, optical biosensing (fiber-optic biosensors, evanescent wave biosensors, surface plasmon resonance biosensors), optical imaging (transmission microscopy, fluorescence microscopy, confocal scanning microscopy, multiphoton microscopy, fluorescence lifetime imaging microscopy), flow cytometry, photodynamic therapy, laser tweezers and laser scissors, and nanotechnology for biophotonics. Differential Tuition: $165.

BME 6753. Biosensors: Fundamentals and Applications. (3-0) 3 Credit Hours.
Prerequisite: Consent of the instructor. This course will cover biosensing basics and in-depth view of device design and performance analysis. Topics include optical, electrochemical, acoustic, piezoelectric, and nano-biosensors. Emphasized applications in biomedical, environmental, and homeland security areas are discussed. Differential Tuition: $165.

BME 6793. Topics in Image and Signal Processing. (3-0) 3 Credit Hours.
Prerequisite: Consent of the instructor. May be repeated for credit on a different topic of study. Differential Tuition: $165.

BME 6803. Experimental Biomechanics. (3-0) 3 Credit Hours.
Prerequisites: BME 6033 and graduate standing. Fundamental applications of engineering mechanics in studying and modeling fluid flow, tissues, organs, and the whole human body will be discussed. This course includes a laboratory. (Formerly BME 6833. Same as ME 6833. Credit can be earned for only one of the following: BME 6803, BME 6833, ME 5833, or ME 6833. Formerly titled "Biomechanics I.") Differential Tuition: $165.

BME 6823. Advanced Biomechanics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing. This course covers biomechanics of biological tissue deformation and their constitutive equations. Topics may include elasticity, viscoelasticity, deformation, stress analysis, strain measurement, stress and strain in organs. Tissues covered may include heart, blood vessels, cartilage, and bone. (Formerly titled "Biomechanics II.") Differential Tuition: $165.

BME 6843. Tissue Mechanics. (3-0) 3 Credit Hours.
Prerequisite: BME 6803 or ME 3663 or consent of the instructor. Topics may include biomechanics characterization, modeling, and properties of regenerating tissues ranging from bone, cartilage, tendons, ligaments, skin, adipose tissue, nerves, bladder, eye, and pulmonary and cardiovascular tissues. Differential Tuition: $165.

BME 6893. Topics in Biomechanics. (3-0) 3 Credit Hours.
Prerequisite: Consent of the instructor. May be repeated for credit on a different topic of study. (Same as ME 6893. Credit cannot be earned for both BME 6893 and ME 6893 when the topic is the same.) Differential Tuition: $165.

BME 6903. Biomaterials. (3-0) 3 Credit Hours.
Prerequisite: Consent of the instructor. Fundamentals of biomaterials science and engineering principles and concepts in repairing, replacing, and protecting human tissues and organs will be discussed. (Formerly BME 5903 and BME 6813. Same as ME 6813. Credit can be earned for only one of the following: BME 5903, BME 6903, BME 6813, ME 5813 or ME 6813.) Differential Tuition: $165.

BME 6913. Biomaterials II. (3-0) 3 Credit Hours.
Prerequisites: BME 6903 and consent of the instructor. Application of biomaterials in medicine and dentistry will be emphasized. Differential Tuition: $165.

BME 6923. Tissue Engineering. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing. This course is an introduction to the principles and current practice of tissue engineering endeavors. Strategies for choosing and using mammalian cells and scaffold biomaterials as well as select chemical and biophysical stimuli in order to obtain neotissue formation are reviewed in detail. Case studies are discussed to illustrate successful tissue engineering solutions of clinical problems pertinent to tissue regeneration. (Formerly BME 5923 and BME 6853. Credit can be earned for only one of the following: BME 5923, BME 6853, or BME 6923.) Differential Tuition: $165.

BME 6933. Tissue-Biomaterials Interactions. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing. This course is an introduction to biocompatibility with special emphasis on the interaction of proteins, cells and tissues with biomaterials. Blood-material interactions are reviewed in detail. Case studies of implants are discussed to illustrate biomaterial selection as a key aspect to successful design of implant materials and prosthetic devices. Differential Tuition: $165.

BME 6943. Biomaterials and Cell Signaling. (2-3) 3 Credit Hours.
Prerequisite: Graduate standing. Develop current understanding of topics in cell receptors and signaling mechanisms with application for biomaterial design. Focus will emphasize receptor-ligand communication, methods of identification and quantification, and pathways involved for cell to material stress response. Differential Tuition: $165.

BME 6953. Biomaterials for Drug Delivery/Pharmacology. (3-0) 3 Credit Hours.
Prerequisite: Completion of or concurrent enrollment in BME 6403. Provides a conceptual understanding of therapeutic agents used to regulate physiological function of cells comprising organ systems with relevance to biomaterials. Interpretation of drug mechanisms at a molecular, cellular and tissue level. Traditional reviews of pharmacodynamics and pharmacokinetics will be addressed with particular application to biomaterial interaction and drug-delivery systems. Differential Tuition: $165.

BME 6961. Comprehensive Examination. (0-0) 1 Credit Hour.
Prerequisite: Approval of the Biomedical Engineering Committee on Graduate Studies to take the Comprehensive Examination. Independent study course for the purpose of taking the Comprehensive Examination for M.S. students in the nonthesis option. May be repeated once if approved by the Biomedical Engineering Committee on Graduate Studies and if the student received an "unsatisfactory performance" on his/her previous attempt on the Comprehensive Examination. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either "CR" (satisfactory performance on the Comprehensive Examination) or "NC" (unsatisfactory performance on the Comprehensive Examination). (Credit cannot be earned for both BME 6961 and BME 6131.) Differential Tuition: $55.

BME 6963. Fundamentals to Polymer Science with Select Biomedical Applications. (3-0) 3 Credit Hours.
Prerequisites: Graduate standing and BME 6903; or consent of the instructor. This course introduces the fundamentals of polymer chemistry, characterization of the chemical and material properties, and determination of the biocompatibility of polymer formulations. Current applications of polymeric biomaterials in diagnostic and therapeutic devices, implants, tissue engineering and regenerative medicine are highlighted and discussed in detail. Differential Tuition: $165.

BME 6981. Master's Thesis Research. (0-0) 1 Credit Hour.
Prerequisites: Master's student standing; consent of the instructor and of the Graduate Advisor of Record. May be repeated for a maximum of 9 credit hours. (Same as BIME 6098 at UT Health San Antonio.) Differential Tuition: $55.

BME 6982. Master's Thesis Research. (0-0) 2 Credit Hours.
Prerequisites: Master's student standing; consent of the instructor and of the Graduate Advisor of Record. May be repeated for a maximum of 9 credit hours. (Same as BIME 6098 at UT Health San Antonio.) Differential Tuition: $110.

BME 6983. Master's Thesis Research. (0-0) 3 Credit Hours.
Prerequisites: Master's student standing; consent of the instructor and of the Graduate Advisor of Record. May be repeated for a maximum of 9 credit hours. (Same as BIME 6098 at UT Health San Antonio.) Differential Tuition: $165.

BME 6986. Master's Thesis Research. (0-0) 6 Credit Hours.
Prerequisites: Master's student standing; consent of the instructor and of the Graduate Advisor of Record. May be repeated for a maximum of 9 credit hours. (Same as BIME 6098 at UT Health San Antonio.) Differential Tuition: $330.

BME 7951. Doctoral Research. (0-0) 1 Credit Hour.
Prerequisites: Doctoral student standing; consent of the instructor and of the Graduate Advisor of Record. This course consists of independent, original research under the direction of a faculty advisor. May be repeated for a maximum of 18 credit hours. (Same as BIME 6097 at UT Health San Antonio.) Differential Tuition: $55.

BME 7952. Doctoral Research. (0-0) 2 Credit Hours.
Prerequisites: Doctoral student standing; consent of the instructor and of the Graduate Advisor of Record. This course consists of independent, original research under the direction of a faculty advisor. May be repeated for a maximum of 18 credit hours. (Same as BIME 6097 at UT Health San Antonio.) Differential Tuition: $110.

BME 7953. Doctoral Research. (0-0) 3 Credit Hours.
Prerequisites: Doctoral student standing; consent of the instructor and of the Graduate Advisor of Record. This course consists of independent, original research under the direction of a faculty advisor. May be repeated for a maximum of 18 credit hours. (Same as BIME 6097 at UT Health San Antonio.) Differential Tuition: $165.

BME 7956. Doctoral Research. (0-0) 6 Credit Hours.
Prerequisites: Doctoral student standing; consent of the instructor and of the Graduate Advisor of Record. This course consists of independent, original research under the direction of a faculty advisor. May be repeated for a maximum of 18 credit hours. (Same as BIME 6097 at UT Health San Antonio.) Differential Tuition: $330.

BME 7991. Doctoral Dissertation. (0-0) 1 Credit Hour.
Prerequisites: Admission to Doctoral candidacy; consent of the Graduate Advisor of Record and Dissertation Advisor. May be repeated for a maximum of 18 credit hours. (Same at BIME 7099 at UT Health San Antonio.) Differential Tuition: $55.

BME 7992. Doctoral Dissertation. (0-0) 2 Credit Hours.
Prerequisites: Admission to Doctoral candidacy; consent of the Graduate Advisor of Record and Dissertation Advisor. May be repeated for a maximum of 18 credit hours. (Same at BIME 7099 at UT Health San Antonio.) Differential Tuition: $110.

BME 7993. Doctoral Dissertation. (0-0) 3 Credit Hours.
Prerequisites: Admission to Doctoral candidacy; consent of the Graduate Advisor of Record and Dissertation Advisor. May be repeated for a maximum of 18 credit hours. (Same at BIME 7099 at UT Health San Antonio.) Differential Tuition: $165.

BME 7996. Doctoral Dissertation. (0-0) 6 Credit Hours.
Prerequisites: Admission to Doctoral candidacy; consent of the Graduate Advisor of Record and Dissertation Advisor. May be repeated for a maximum of 18 credit hours. (Same at BIME 7099 at UT Health San Antonio.) Differential Tuition: $330.