DEPARTMENT OF
BIOMEDICAL ENGINEERING

Technical Elective Requirements

November 26, 2013
# Table of Contents

<table>
<thead>
<tr>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMEN Technical Electives Policies</td>
<td>3</td>
</tr>
<tr>
<td>Bioinstrumentation &amp; Bioimaging</td>
<td>4</td>
</tr>
<tr>
<td>Biomaterials &amp; Tissue Engineering</td>
<td>5</td>
</tr>
<tr>
<td>Biomechanics</td>
<td>6</td>
</tr>
<tr>
<td>BMEN Inventory of Track Courses</td>
<td>7</td>
</tr>
<tr>
<td>Technical Electives Analysis Form</td>
<td>12</td>
</tr>
</tbody>
</table>
BMEN Technical Electives Policies

This document describes the requirements for the minimum 19 hours* of Technical Electives in the Biomedical Engineering curriculum. Electives must be selected, and approved, in advance, consistent with requirements in this document.

General Requirements:

1. All BMEN students must select a specific Technical Elective Track from those listed below. The tracks are as follows:
   - Bioinstrumentation
   - Biomaterials and Tissue Engineering
   - Biomechanics

2. Each Track typically has three categories of track courses including Required, Track and Other. The Required category contains 0-15 hours of restricted and prescribed coursework. The Track category contains 0-15 hours of coursework related to the specific Track field. The Other category contains 0-6 hours of course work and must generally be 300 – 400 level courses in a relevant discipline and consistent with the student’s professional goals.

3. Proposed deviations from the required and suggested courses in a Track must be approved in advance by the academic advisor, and one of the track faculty.

4. Track faculty are available to discuss the contents of a Track and reasons to pursue it, and must sign to indicate that a professional interview has occurred with the student.

5. Exceptions to track courses must be approved prior to taking courses by the Director of Undergraduate Programs. It is possible that courses taken prior to the approval of the Technical Electives Analysis form may not meet Technical Electives requirements if inconsistent with current Tracks or Track policies.

6. If a course has pre-requisites, the pre-requisites generally count toward completion of the selected Track, if completed.

7. If pre-requisites for a Track course are not met before taking the course, approval from the instructor offering the specific Track course is required.

8. Students may take up to 3 hours of 285, 485, and 491 which can be used in the Other category with prior approval from the academic advisor and track faculty.

9. Track courses are usually three (3) credit hours unless indicated in parenthesis next to course number.

* Students may need 18 hours depending on their catalog and degree plan requirements.
SCOPE: The Bioinstrumentation Track is designed to equip BMEN students for the medical device and imaging instrumentation field, which covers clinical and lab instrumentation from the nanoscale to the whole body. This track equips students with focus in either imaging or instrumentation, and provides guidance to select coursework in several application areas for each of the focus topics. Students will gain an understanding of medical device design, underlying physics and instrumentation for measuring physiological parameters and forming medical images, signal/image processing and control systems.

Required Courses (9 credits)
BMEN 322 (3) Bioskial Analysis
BMEN 401 (3) Principles and Analysis of Biological Control Systems
BMEN 4xx (3) Advanced Bioinstrumentation Course

Course Material: Digital circuits, microcontroller programming/interfaces, project with hardware

Track Courses (6 credits)
BMEN 402 (3) Biomedical Optics Laboratory
BMEN 405 (3) Virtual Instrumentation Design for Medical Systems
BMEN 427 (3) MR Engineering Lab
BMEN 440 (3) Design of Medical Devices
BMEN 469 (3) Entrepreneurial Issues in Biomedical Engineering
BMEN 470 (3) Introduction to Biomedical Optics
BMEN 489 (3) Healthcare Technology in the Developing World
BMEN 489 (3) Biomedical Electromagnetics
BMEN 2/491* Research with Instrumentation Focus (subject to prior approval by a member of the track committee)

Other Courses (4 credits)
These must generally be 300 or 400 level courses chosen from Track Courses listed above or from the following:
BMEN XXX BMEN Elective (subject to prior approval by a member of the track committee)
ENGR 181 (1) ESP Seminar I
ENGR 281 (1) ESP Seminar II
ENGR 381 (1) ESP Seminar III
ENGR 385 (1) Co-Op

* No more than 3 hours of BMEN 291/485/491 will count towards technical elective requirements.

Track Faculty: Dr. Coté, Dr. Yeh, Dr. Meissner, Dr. McDougall, Dr. Applegate, Dr. Jo, Dr. K. Maitland, Dr. Yakovlev
SCOPE: The Biomaterials and Tissue Engineering Track is designed to equip BMEN students for the rapidly developing field at the multi-disciplinary interface of engineering, material science, biology, chemistry, and medicine. This track will provide students with a broad educational foundation with an emphasis on the principles and applications of biomaterials, particularly tissue engineering. Students will gain an understanding of biomaterial preparation and characterization, structure/property relationships, as well as cellular, blood, and tissue interactions with biomaterials. Selection and design of biomaterials for tissue engineering, artificial organs, drug delivery, and implanted devices is presented.

Required Courses (6 to 18 credits)

BMEN 451 (3)  Cell Mechanobiology
BMEN 480 (3)  Biomedical Engineering of Tissues
BMEN 482 (3)  Polymeric Biomaterials
BMEN 483 (3)  Polymeric Biomaterial Synthesis
BMEN 486 (3)  Biomedical Nanotechnology
BMEN 489 (3)  Drug Delivery

These are contained within the general core curriculum required courses during years 3 and 4.

Track Courses (0 to 12 credits)

BMEN 431 (3)  Thermodynamics of Biomolecular Systems
BMEN 432 (3)  Molecular and Cellular Biomechanics
BMEN 452 (3)  Mass and Energy Transfer in Biosystems
CHEM 466 (3)  Polymer Chemistry
CHEN 451 (3)  Introduction to Polymer Engineering
MEEN 458 (3)  Processing and Characterization of Polymers
MEEN 489 (3)  Tribology
BMEN 2/491*  Research w/ Biomaterials Focus (subject to prior approval by a member of the track committee)

Other Courses (0 to 6 credits)

These must generally be 300 or 400 level courses chosen from Track Courses listed above or from the following:

BMEN XXX  BMEN Elective (subject to prior approval by a member of the track committee)
ENGR 181 (1)  ESP Seminar I
ENGR 281 (1)  ESP Seminar II
ENGR 381 (1)  ESP Seminar III
ENGR 385 (1)  Co-Op

* No more than 3 hours of BMEN 291/485/491 will count towards technical elective requirements.

Track Faculty: Dr. Grunlan, Dr. McShane, Dr. Cosgriff-Hernandez, Dr. D. Maitland, Dr. Pishko, Dr. Gaharwar
Biomechanics Track Courses (19 credits total)

**SCOPE:** Mechanics is the study of responses of materials and structures to applied loads; biomechanics is the development, extension, and application of mechanics for purposes of understanding better the influence of applied loads on the structure, properties, and function of living things and the diverse systems that they interact with. Hence, among many other applications, biomechanics is fundamental to the design of wheelchairs, implantable medical devices, and instruments for quantifying properties of biomaterials and native tissues as well as understanding many disease processes and designing new approaches for their treatment. Recent findings show that many cell types are very sensitive to changes in their mechanical environment, hence biomechanics is also fundamental to understanding gene expression and associated basic changes in cell activity. The Track in Biomechanics enables students to develop breadth and depth in this essential field within Biomedical Engineering.

**Required Courses (9 credits: Select 3 credits in each of the 3 areas below):**

*Cell and Molecular Level (3 credits):*
- BMEN 451 (3) Cell Mechanobiology
- BMEN 432 (3) Molecular and Cellular Biomechanics

*Tissue Level (3 credits):*
- BMEN 460 (3) Vascular Mechanics
- BMEN 461 (3) Cardiac Mechanics
- BMEN 462 (3) Vascular Fluid Mechanics
- BMEN 457 (3) Orthopedic Biomechanics

*Quantitative Analysis / Modeling (3 credits):*
- BMEN 431 (3) Thermodynamics of Biomolecular Systems
- BMEN 452 (3) Mass and Energy Transfer in Biomedical Systems
- BMEN 463 (3) Soft Tissue Mechanics
- BMEN 489 (3) Numerical Methods for Biomedical Engineers

**Track Courses (7 credits):**
Select any of the above courses that are not used for the 9 credits of required courses or courses from the following list:

- BMEN 480 (3) Biomedical Engineering of Tissues
- BMEN 405 (3) Virtual Instrumentation Design for Medical Systems
- BMEN 482 (3) Polymeric Biomaterials
- BMEN 440 (3) Design of Medical Devices
- BMEN 469 (3) Entrepreneurial Issues in Biomedical Engineering
- BMEN 489 (3) Special Topics (subject to prior approval by a member of the track committee)
- BMEN 2/491* Research w/ mechanics focus (subject to prior approval by a member of the track committee)

**Other Courses (3 credits)**
*These must generally be 300 or 400 level courses chosen from Track Courses listed above or from the following:*

- BMEN XXX BMEN Elective (subject to prior approval by a member of the track faculty)
- ENGR 181 (1) ESP Seminar I
- ENGR 281 (1) ESP Seminar II
- ENGR 381 (1) ESP Seminar III
- ENGR 385 (1) Co-Op (one semester credit hour per term up to three credit hours)

* No more than 3 hours of BMEN 291/485/491 will count towards technical elective requirements.

**Track Faculty:** Dr. Criscione, Dr. Hwang, Dr. Kaunas, Dr. Moreno
BMEN INVENTORY of TRACK COURSES

In addition to the required courses, the Texas A&M Department of Biomedical Engineering offers a wide range of elective courses to give undergraduates the opportunity to study further what most interests them. Roman numerals to the right of the credit indicate the semester in which it is usually offered – “I” for fall and “II” for spring; few elective courses are offered in the summer, but are denoted by “S”. Here is a brief description of current Biomedical Engineering courses suitable for use in the Other Courses section of each track:


Permits students to undertake special projects in biomedical engineering at an earlier point in their studies than required for BMEN 485.
Prerequisite: Approval of program chair.

289. Special Topics in... Credit 1 to 4.

Selected topics in an identified area of biomedical engineering. May be repeated for credit.
Prerequisite: Approval of instructor.

322. Biosignal Analysis (3-0) Credit 3. II

Design and application of analog and digital signal analysis in biomedical engineering; characteristics of biomedical signals; design considerations for analog-to-digital circuitry; biosignal transformation methods; analog and digital filter design for biomedical signals.
Prerequisite: BMEN 321, VTPP 434 and VTPP 435; junior or senior classification.

341. Biofluid Mechanics (3-0) Credit 3. I

Introduction into the mechanics of fluids in biomechanics, including blood, synovial fluid and physiological solutions, with an emphasis on the importance of mechanobiology and the formation of biological problems within the context of 1) kinematics, 2) the concept of stress, 3) linear momentum balance, 4) constitutive relations, and 5) boundary conditions.
Prerequisite: BMEN 240; junior or senior classification.

361. Biosolid Mechanics (3-0) Credit 3. II

Introduction to the mechanics of deformable media in biomedical engineering, including medical devices, biomaterials, and soft and hard biological tissues: emphasis on biomechanics and mechanobiology and formulation of problems within the context of basic continuum biomechanics; problems include analytical solutions for stress-strain analysis of extension, distension, bending, buckling, and torsion of biosolids.
Prerequisite: BMEN 341.

401. Principles and Analysis of Biological Control Systems (3-0) Credit 3. I

Techniques for generating quantitative mathematical models of physiological control systems and devices; the behavior of physiological control systems using both time and frequency domain methods.
Prerequisites: BMEN 321; MATH 308; VTPP 334 and 335.
402. Biomedical Optics Laboratory. (2-3) Credit 3. I

Biomedical optics technology; basic engineering principles used in developing therapeutic and diagnostic devices; hands-on labs will be performed including optical monitoring, diagnostic and therapeutic experiments.
Prerequisite: PHYS 208 or approval of instructor.

405. Virtual Instrumentation Design for Medical Systems. (2-3) Credit 3. I

Design of medical systems using graphics programming language of LabVIEW including the designing and programming of three virtual systems as follows: cardiac monitor, electromyogram system for biomechanics, and sleep stage analyses from electroencephalograms.


Design, construction and application of instrumentation for MR imaging; fundamentals of the architecture of an MR spectrometer and the gradient subsystem used for image localization; emphasis on the radiofrequency sensors and systems used for signal generation and reception.
Prerequisites: BMEN 420, ECEN 410, ECEN 411, or approval of instructor; junior or senior classification.

431. Thermodynamics of Biomolecular Systems. (3-0) Credit 3. I

Introduces equilibrium and non-equilibrium statistical mechanics and applies them to understand various biomolecular systems; including ensemble theory, reaction kinetics, nonlinear dynamics, and stochastic processes; with applied examples such as enzyme-ligand binding kinetics, conformational dynamic of proteins and nucleic acids, population dynamics, and noise in biological signals.
Prerequisites: BMEN 240, PHYS 208, MATH 308.

432. Molecular and Cellular Biomechanics. (3-0) Credit 3. II

Introduces biomolecules and their assemblies that play structural and dynamical roles in sub-cellular to cellular level mechanics, with emphasis on quantitative/theoretical descriptions, and discussions of the relevant experiment approaches to probe these nano- to micro-scale phenomena; including topics in (1) self assembly of cytoskeleton and biomembranes, (2) molecular motors, (3) cell motility, and (4) mechanotransduction.
Prerequisites: BMEN 240, MATH 304; junior or senior classification.

440. Design of Medical Devices. (3-0) Credit 3. II

Overview of the multiple issues in designing a marketable medical device, including the design process from clinical problem definition through prototype and clinical testing to market readiness; includes FDA regulation, human factors and system safety considerations and medical product liability.
Prerequisites: BMEN 342; senior classification in engineering.

451. Cell Mechanobiology. (3-0) Credit 3. II

Focus on how mechanical forces influence cell behavior through physical and biochemical mechanisms; integrating engineering and cell biology to solve biomedical problems, which includes developing models for applying forces to cultured cells and tissues and measuring changes in cell biochemistry, structure, and function.
Prerequisite: BMEN 282 and admitted to major degree sequence in biomedical engineering.
452. Mass and Energy Transfer in Biosystems. (3-0) Credit 3. II

Transport phenomena associated with physiological systems and their interaction with medical devices; exchange processes in artificial life support systems and diagnostic equipment.
Prerequisites: BMEN 341; MATH 308; VTPP 334 and 335.

457. Orthopedic Biomechanics. (3-0) Credit 3. II

Development of competencies in biomechanical principles using practical examples and clinical case studies; application of biomechanical knowledge to the evaluation of musculoskeletal tissues and structures, and treatment options for musculoskeletal dysfunction.
Prerequisites: Admitted to major degree sequence in biomedical engineering; junior or senior classification.

460. Vascular Mechanics. (3-0) Credit 3.

Application of continuum mechanics to the study of the heart arteries; emphasis on the measurement and quantification of material properties, and the calculation of vascular stresses; analysis of several cardiovascular devices to reinforce the need for careful analysis in the device design.
Prerequisites: BMEN 240.

461. Cardiac Mechanics. (3-0) Credit 3.

Application of continuum mechanics and computational solid mechanics to the study of the mammalian heart; utilization of continuum mechanics and finite element analysis in solving non-linear boundary value problems in biomechanics.
Prerequisites: BMEN 240 and 463; approval of instructor.

462. Vascular Fluid Mechanics. (3-0) Credit 3.

Bio-fluid mechanics of the human circulatory system including examination of disease development and medical treatments.
Prerequisites: BMEN 341 or equivalent; junior or senior classification.


Application of continuum mechanics and finite element methods to the study of the mechanical behavior of soft tissues and associative applications in biomedicine.
Prerequisites: BMEN 240 or equivalent; junior or senior classification.


Practical applications in biomechanics (solid and fluid); includes experimental methods used to investigate biomechanical factors in the assessment of therapeutic interventions using state-of-the-art tools; mechanical testing load frames, motion capture systems, high speed imaging, and flow systems; hypothesis forming, experimental design, empirical observation, data collection and interpretation, and presentation of results.
Prerequisites: Admitted to major degree sequence in biomedical engineering; junior or senior classification.
468. Biothermomechanics. (3-0). Credit 3.

Introduction to a continuum thermomechanics approach to quantifying soft tissue behavior in response to combined thermal and mechanical loads including thermoelasticity and thermal damage. Prerequisites: BMEN 241 and 341; junior or senior classification.

469. Entrepreneurial Issues in Biomedical Engineering. (3-0) Credit 3. I

Description and analysis of issues associated with initiating business ventures to transfer biomedical technologies into the health care sector, including intellectual property protection, seed funding alternatives, and business strategies relevant to the biomedical engineering technology area; and utilizing recent case studies of previous ventures. Prerequisites: Admitted to major degree sequence (upper-level) in biomedical engineering.

470. Introduction to Biomedical Optics. (3-0) Credit 3.

Fundamentals of biomedical optics; basic engineering principles used in optical therapeutics, optical diagnostics and optical biosensing. Prerequisites: MATH 308; PHYS 208. Cross-listed with CHEN 470

480. Biomedical Engineering of Tissues. (3-0) Credit 3.

Introduction to aspects of tissue engineering with an emphasis placed on tissue level topics including tissue organization and biological processes, with insights from recent literature (state-of-the-art). Prerequisites: Admitted to major degree sequence (upper-level) in biomedical engineering.

482. Polymeric Biomaterials. (3-0). Credit 3.

Preparation, properties, and biomedical applications of polymers including: polymerization; structure-property relationships; molecular weight and measurement; morphology; thermal transitions; network formation; mechanical behavior; polymeric surface modification; polymer biocompatibility and bioadhesion; polymers in medicine, dentistry, and surgery; polymers for drug delivery; polymeric hydrogels; and biodegradable polymers. Prerequisites: BMEN 342 or approval of instructor; junior or senior classification.

483. Polymeric Biomaterial Synthesis. (3-0) Credit 3. I

Overview of polymer synthetic routes and key structure-property relationships with emphasis on the design of polymeric systems to achieve specific properties; tissue engineering and drug delivery applications will be used as model systems to explore the process of biomaterial design from synthesis to device evaluation. Prerequisite: BMEN 343 or approval of instructor.


Permits students to undertake special projects in biomedical engineering. Prerequisite: Approval of instructor.
486. Biomedical Nanotechnology. (3-0) Credit 3. I

Nanotechnology applications in biomedicine; concepts of scale; unique properties at the nanoscale; biological interaction, transport, and biocompatibility of nanomaterials; current research and development of nanotechnology for medical applications, including sensors, diagnostic tools, drug delivery systems, therapeutic devices, and interactions of cells and biomolecules with nanostructured surfaces.
Prerequisite: BMEN 343, senior classification, or approval of instructor.

489. Special Topics in... Credit 1 to 4. I, II, S

New or unique areas of biomedical engineering which are of interest to biomedical engineering and other undergraduate students.

491. Research. Credit 1 to 4. I, II, S

Research conducted under the direction of faculty member in biomedical engineering. May be repeated two times for credit. Registration in multiple sections of this course is possible within a given semester provided that the per semester credit hour limit is not exceeded.
Prerequisites: Junior or senior classification and approval of instructor.
TECHNICAL ELECTIVES ANALYSIS FORM
(to be filed in the student’s records)

Student Name:______________________________Date:___________________________
Track:_____________________________________UIN:____________________________
Student E-mail Address: ______________________Cell #:___________________________

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<tr>
<th>Required Course(s)</th>
<th>ENGR/CPSC Credits</th>
<th>Other Credits</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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Track Courses

|                    |                  |              |
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Other Courses

|                    |                  |              |
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Biological Science Course*

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TOTALS

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<table>
<thead>
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</tr>
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Grand Total*______________       Catalog __________

Student Signature: _____________________________ __________________________

Approval if Track is followed exactly:

_____________________________   ____________________
(Academic Advisor)    Date

Professional Review:

_____________________________         ____________________
(Track Coordinator)                    Date

Approval of deviations from Track:

_____________________   /   _____________________ ____________________
(Track Coordinator 1)     (Track Coordinator 2)  Date

* A minimum of 19 Technical Elective hours are required  for catalogs 2014 and later.