Biomedical Engineering Graduate Concentration – Fall 2016

Biomechanics
Advisor: David Kohn, Ph.D.

BIOMECHANICS (select one course):
- BIOMED 456 Tissue Mechanics (3) (I)
- BIOMED 476 Biofluid Mechanics (4) (II)

GENERAL (both courses are required):
- BIOMED 500 Biomedical Engineering Seminar (1) (I,II)
- BIOMED 550 Ethics and Enterprise (1) (I)

BIOMEDICAL RESEARCH AND DESIGN (select one – BIOMED 590 or BIOMED 599.002 and BIOMED 599.004):
- BIOMED 590 Directed Research (2 - 3) (I,II,III)
- BIOMED 599.002 Graduate BME Innovative Design Team (3) (I)
- BIOMED 599.004 Graduate BME Innovative Design Team (4) (II)

NOTE: In order for BIOMED 599.002 and BIOMED 599.004 to count toward their degree in BME, students must register for these courses in both the fall and winter terms, and they must adhere to the following rules:

  a) this course can be counted as a SUGS, terminal MS, or MS/PhD student's 2 credit hour technical elective (fall term) and Biomedical Research and Design requirement (winter term),
  b) this course, taken in both terms, can be counted as a technical elective for a student that has already taken BIOMED 590,
  c) this course can be counted as PhD coursework providing that it has not already been counted as the student's Biomedical Research and Design requirement or technical elective in their MS program, and the student's advisor approves.

MATHEMATICS (select one course):
- MATH 450 Advanced Mathematics for Engineers I (4) (I,II,IIIb)
- MATH 454 Boundary Value Problems for Partial Differential Equations (3) (I,II,IIIa)
- MATH 462 Mathematical Models (3) (II)
- MATH 463 Mathematical Modeling in Biology (3) (I)
- MATH 471 Introduction to Numerical Methods (3) (I,II,IIIb)
- MATH 540 Mathematics of Biological Networks (3) (I)
- MATH 550 Introduction to Adaptive Systems (3) (I)
- MATH 555 Introduction to Functions of a Complex Variable with Applications (3) (I,II)
- MATH 556 Applied Functional Analysis (3) (I)
- MATH 557 Applied Asymptotic Analysis (3) (II)
- MATH 558 Applied Nonlinear Dynamics (3) (I)
- MATH 559 Topics in Applied Mathematics (3)
- MATH 561 Linear Programming I (3) (I,II)
- MATH 562 Continuous Optimization Methods (3) (II)
- MATH 563 Advanced Mathematical Methods in Biology (3) (II)
- MATH 564 Topics Math Biology (3)
- MATH 571 Numerical Linear Algebra (3) (I,II)
- MATH 572 Numerical Methods for Differential Equations (3) (II)
- MATH 651 Topics in Applied Mathematics I (3)
- MATH 656 Introduction to Partial and Differential Equations (3) (I)
- MATH 657 Nonlinear Partial Differential Equations (3)
- MATH 756 Advanced Topics in Partial Differential Equations (3)
- MECHENG 501 Math Methods in Mechanics (3) (II)
- MECHENG 564 Linear Systems Theory (4) (I)
BIOINSTRUMENTATION (select one course):
BIOLCHEM 516  Intro Biochemistry Lab (3) (I)
BIOMEDE 458  Biomedical Instrumentation and Design (4) (I, II)
BIOMEDE 510  Medical Imaging Laboratory (3) (II)
IOE 432  Industrial Engineering Instrumentation Methods (3) (I)
MCDB 429  Cellular & Molecular Biology Lab (3) (II)

STATISTICS (select one course):
BIOMEDE 503  Statistical Methods for Biomedical Engineering (3) (II)
BIOSTAT 602  Biostatistical Inference (4) (II)
BIOSTAT 650  Applied Statistics I: Linear Regression (4) (I)
BIOSTAT 651  Applied Statistics II: Extensions for Linear Regression (3) (II)
EECS 501  Probability and Random Processes (4) (I,II)
IOE 461  Quality Engineering Principles and Analysis (3) (I)
STATS 470  Introduction to the Design of Experiments (4) (I)
STATS 500  Applied Statistics I (3) (I)
STATS 525  Probability Theory (3) (I)

NOTE: BME graduate students can only take EECS 501 in the winter term.

LIFE SCIENCE (two courses are required – at least one course must be outside of the College of Engineering):

Required:
BIOMEDE 519  Quantitative Physiology (4) (I)

Select one course:
ANAT 403  Human Anatomy (5) (I,II)
ANAT 541  Mammalian Reproductive Physiology (4) (II)
BIOLCHEM 451  Advanced Biochemistry I (4) (I)
BIOLCHEM 515  Introductory Biochemistry (3) (I, II)
BIOLCHEM 550  Macromolecular Structure and Function (3) (I)
BIOPHYS 520  Methods of Biophysical Chemistry (3) (I)
CANCIBIO 553  Molecular Biology of Cancer (3) (I)
CANCIBIO 554  Cancer Pathogenesis and Treatment (3) (II)
CDB 530  Cell Biology (3) (I)
CDB 550  Histology (4) (II)
CDB 581  Development Genetics (3) (I)
CDB 583  Organogenesis: Stem Cells to Regenerative Biology (3) (II)
KINESLGY 522  Clinical Neurophysiology and Neuroimaging (3)
KINESLGY 545  Metabolic Responses to Exercise (3)
MCDB 422  Brain Development, Plasticity, and Circuits (3) (I)
MCDB 423  Introduction to Research in Cellular and Molecular Neurobiology (3) (I) (II)
MCDB 427  Molecular Biology (4) (I) (II)
MCDB 428  Cell Biology (4) (I) (II)
MCDB 429  Cellular and Molecular Biology Laboratory (3) (II)
MCDB 435  Intracellular Trafficking (3) (II)
MICRBIOL 540  Human Immunology (3) (II)
NEUROSCI 570  Human Neuroanatomy I (3) (I)
NEUROSCI 601  Principles Neuro I (3) (I)
NEUROSCI 602  Princ Neurosc II (3) (II)
PATH 581  Tissue, Cellular and Molecular Disease (4) (II)
PHYSIOL 592  Integrated Neuroscience (2-4) (II)
**TECHNICAL ELECTIVES:**
5 hours of graduate level engineering courses (technical electives). No more than 2 credit hours of seminar courses may be applied to the 30 credit hours needed to fulfill the MS degree requirement.

*Sample Course Sequences*

**Biofluids concentration:**
Fall  
BIOMEDE 500, BIOMEDE 550, BIOMEDE 519, MECHENG 520  
Winter  
BIOMEDE 458, BIOMEDE 476, MATH 454, MECHENG 521  
Fall  
STATS 500, BIOMEDE 479, BIOMEDE 590

**Tissue Mechanics concentration:**
Fall  
MCDB 428 or BIOLCHEM 451, BIOMEDE 458, BIOMEDE 500, BIOMEDE 519, BIOMEDE 550  
Winter  
BIOMEDE 418, BIOMEDE 590, MECHENG 501, MECHENG 505  
Fall  
ANAT 403, STATS 500, technical elective

**Whole Body Dynamics concentration:**
Fall  
BIOMEDE 456, BIOMEDE 500, BIOMEDE 519, BIOMEDE 550, BIOMEDE 590  
Winter  
BIOMEDE 458, MECHENG 501, BIOMEDE 534 or MECHENG 560, BIOMEDE 646  
Fall  
ANAT 403, MECHENG 543, STATS 500

**Technical Electives with BioFluids Content:**
CEE 528  
Flow & Transport in Porous Media (3) (II)  
CHE 527  
Fluid Flow (3) (I)  
CHE 542  
Intermediate Transport Phenomena (3) (I)  
MECHENG 520  
Advanced Fluid Mechanics I (3) (I)  
MECHENG 521  
Advanced Fluid Mechanics II (3) (II)  
MECHENG 523/AERO 523  
Computational Fluid Dynamics I (3) (I)  
MECHENG 524  
Advanced Engineering Acoustics (3) (II)  
MECHENG 527  
Multiphase Flow (3) (II)  
MECHENG 562  
Dynamic Behavior of Thermo-Fluid Processes (3) (II-alternate years)  
MECHENG 622  
Inviscid Fluids (3) (II)  
MECHENG 623  
Hydrodynamic Stability (3) (I)  
MECHENG 625  
Nonhomogeneous Fluids (3) (I,II)  
MECHENG 627  
Wave Motion in Fluids (3) (I)

*Other courses of interest to Fluid Mechanics students:*
AEROSP 521  
Experimental Methods in Fluid Mechanics (3) (II)  
BIOMEDE 479  
Biotransport (4) (II)  
MECHENG 530  
Advanced Heat Transfer (3) (I)  
MECHENG 617  
Mechanics of Polymers II (3) (II-alternate years)

**Technical Electives with Biomechanics Content:**
BIOMEDE 534/IOE 534  
Occupational Biomechanics (3) (II)  
BIOMEDE 556  
Molecular & Cellular Biomechanics I (3)  
BIOMEDE 599  
Special Topics I,II (1-6) (I,II)  
BIOMEDE 646  
Human Movement (3) (II-alternate years)  
MECHENG 599.002  
Cellular Engineering (3) (I)
Technical Electives with Connective Tissue Content:
- **BIOMEDE 410** Design and Applications of Biomaterials (3) (I)
- **MECHENG 505** Finite Elem Meth in Mech Engineering (3) (I,II)
- **MECHENG 511** Theory of Solid Cont (3) (I)
- **MECHENG 512/CEE 509** Theory of Elasticity (3) (II)
- **MECHENG 517** Mech of Polymers I (3) (II)

Technical Electives with Dynamics/Control Content:
- **EECS 562/AEROSP 551** Nonlinear Systems & Control (3) (II)
- **MECHENG 440** Intermediate Dynamics & Vibrations (4) (II)
- **MECHENG 540/AEROSP 540** Intermed Dynamics (4) (I or II)
- **MECHENG 543** Analytical & Computational Dynamics I (3) (I)
- **MECHENG 560/MFG 562** Modeling Dynamic Systems (3) (II)
- **MECHENG 561/EECS 561** Design of Digital Control Systems (3) (I,II)

Technical Electives with Rehabilitation Engineering:
- **IOE 463** Measurement and Design of Work (3) (I,II)

Dual Degree (Second Masters, in MECHENG for example) (20 additional credits):

MECHENG requirements: 30 credits total (10 of BIOMEDE MS credits can double-count towards 30 required for MECHENG MS) including:
- 12 credits in MECHENG at 500 level or above.
- 6 credits maximum of MECHENG 590.
- 6 credits advanced math courses (any engineering related course for which MATH 215 and/or MATH 216 is prerequisite).
- 6 credits elected cognate courses outside your program (flexible, MATH, BIOMEDE count, but not MECHENG).

**KEY AND ADDITIONAL NOTES:**
Course Department and Number Course Name (# of credits) (term offered)

Terms: 1 - fall, II - winter, III - spring-summer, IIIa - spring half, IIIb - summer half

If a term is not listed after the course, please contact the department for course offering information.

Every effort is made to make sure that the course offering information listed on the concentration is correct. Students can also refer to the Schedule of Classes or the department for the current offering.