

## **Biomedical Engineering Graduate Concentration – Fall 2016**

### **Biomechanics**

**Advisor: David Kohn, Ph.D.**

#### **BIOMECHANICS (select one course):**

BIOMEDE 456	Tissue Mechanics (3) (I)
BIOMEDE 476	Biofluid Mechanics (4) (II)

#### **GENERAL (both courses are required):**

BIOMEDE 500	Biomedical Engineering Seminar (1) (I,II)
BIOMEDE 550	Ethics and Enterprise (1) (I)

#### **BIOMEDICAL RESEARCH AND DESIGN (select one – BIOMEDE 590 or BIOMEDE 599.002 and BIOMEDE 599.004):**

BIOMEDE 590	Directed Research (2 - 3) (I,II,III)
BIOMEDE 599.002	Graduate BME Innovative Design Team (3) (I)
BIOMEDE 599.004	Graduate BME Innovative Design Team (4) (II)

NOTE: In order for BIOMEDE 599.002 and BIOMEDE 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 BIOMEDE 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)
CANCBIO 553	Molecular Biology of Cancer (3) (I)
CANCBIO 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) (1)
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: I - 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.