## Frontier Courses

**Note re frontier courses:** Courses covering areas currently considered in the frontiers of Medical Physics including (but are not limited to) genetics, bio-informatics, molecular biology, nano-technology, photonics, and biochemistry. To qualify as a frontier course, the course should be prospectively approved as such by the curriculum committee. The following courses are currently approved.

**BME 240 Env Mol Biotechnology**

**BME 265 Modern Microscopy**

**BGT 200 / STA 270 stat methods / computational biolg**

**BGT 201 Statistical genetics**

**BGT 203 Genome informatics seq. analys**

**BGT 204 Algorithms in compu biology**

**BGT 206 Genome technologies**

**BIOCHEM 227 Intro Biochemistry I (3 c.h.).** Chemistry of the constituents of proteins, lipids, carbohydrates, and nucleic acids and their metabolic interrelationships. Structure, function, and biosynthesis of biological macromolecules. Prerequisite: two semesters of organic chemistry.

**BIOLOGY 271 Genomics (3 c.h.).** Introduction to the field of genomics. Genomic techniques including genome sequencing, microarray analysis, proteomics, and bioinformatics; applications of genomics to understanding biological problems including biological networks, human origins, evolution; applications to medicine and agriculture. Lecture and discussion. Prerequisites: Biology 118 or consent of instructor.

**MEDINFO 333B Intro Medical Informatics (3 c.h.).** An in-depth study of the use of computers in biomedical applications. Important concepts related to hardware, software, and applications development are studied through analysis of state-of-the-art systems involving clinical decision support, computer-based interviewing, computer-based medical records, departmental/ancillary systems, instructional information systems, management systems, national data bases, physiological monitoring, and research systems. Approval of the instructor required. C-L: BME-243 (Graduate School).

**MGM 300 Gene Regulation.** Principles of prokaryotic and eukaryotic gene regulation at transcriptional and post-transcriptional levels. Topics include promoter structure and transcription factor function; processing, transport, and degradation of mRNA' translation. Gene regulatory pathways.

## Other suggested courses

**Note re electives:** Any 3 credit-hr equivalent graduate course(s) (200 level and up) offered by Duke University is qualified as elective provided that it would fit in the student's plan of study as judged by the student's advisor.

**BAA 133L. The Human Body (1 c.h.).** Human gross anatomy seen from a functional and evolutionary perspective. Laboratory involving study of prosected cadavers and other anatomical preparations.

**BAA 200B. Gross Human Anatomy (4 c.h.).** First-year medical students are required to take gross anatomy. The course includes the complete dissection of a cadaver; laboratory work is supplemented by conferences which place emphasis upon biological and evolutionary aspects.

**BAA 239L Radiology Sports-rel injury**

**BAA 305 Gross Anatomy (3 c.h.).** Includes complete dissection of a cadaver; laboratory work is supplemented by conferences which emphasize biological and evolutionary aspects. Required of entering graduate students in anatomy; by arrangement, may extend into second semester. Prerequisites: adequate background in biology, including comparative anatomy and embryology and written consent of instructor.

**BME 171. Signals and Systems.** Convolution, deconvolution, Fourier series, Fourier transform, sampling, and the Laplace transform. Continuous and discrete formulations with emphasis on computational and simulation aspects and selected biomedical examples. Prerequisites: Electrical Engineering 61L and Mathematics 111 or equivalents.

**BME 222. Principles of Ultrasound Imaging**. Propagation, reflection, refraction, and diffraction of acoustic waves in biologic media. Topics include geometric optics, physical optics, attenuation, and image quality parameters such as signal-to-noise ratio, dynamic range, and resolution. Emphasis is placed on the design and analysis of medical ultrasound imaging systems. Prerequisites: Mathematics 111 and Physics 52L.

**BME 233. Modern Diagnostic Imaging Systems**. The underlying concepts and instrumentation of several modern medical imaging modalities. Review of applicable linear systems theory and relevant principles of physics. Modalities studied include X-ray radiography (conventional film-screen imaging and modern electronic imaging), computerized tomography (including the theory of reconstruction), and nuclear magnetic resonance imaging. Prerequisites: junior or senior standing.

**BME 334. Radiology in Practice (3.c.h.).** Designed to complement BME 233 Modern Diagnostic Imaging Systems. Review and real-life exercises on principles of modern medical imaging systems with emphasis on the engineering aspects of image acquisition, reconstruction and visualization, observations of imaging procedures in near clinical settings, and hands-on experience with the instruments. Modalities covered include ultrasound, CT, MRI, nuclear medicine and optical imaging.

**BME 243. Introduction to Medical Informatics.** An introduction to medical informatics: an in-depth study of the use of computers in biomedical applications. Hardware, software, and applications programming. Data collection, analysis, and presentation studied within application areas such as patient monitoring, computer-based medical records, computer-aided decision making, computer-aided instruction, quality assurance laboratory systems, wave form analysis, hospital information systems, and medical information systems.

**BME 246. Computational Methods in Biomedical Engineering.** Introduction to practical computational methods for data analysis and simulation with a major emphasis on implementation. Methods include numerical integration and differentiation, extrapolation, interpolation, splining FFTs, convolution, ODEs, and simple one and two-dimensional PDEs using finite differencing. Introduction to concepts for optimizing codes on a CRAY-YMP. Examples from biomechanics, electrophysiology, and imaging. Project work included and students must have good working knowledge of Unix, Fortran, or C. Intended for graduate students and seniors who plan on attending graduate school. Prerequisite: Engineering 53L or equivalent, Mathematics 111 or equivalent, or consent of instructor.

**BME (265). Medical Image Processing**

**BME (265). Principles and applications of magnetic resonance imaging (3 c.h.)** Tentative course.

**BME 320. Medical Ultrasound Transducers**. A study of the design, fabrication, and evaluation of medical ultrasound transducers. Topics include wave propagation in piezoelectric crystals, Mason and KLM circuit models, linear arrays and two-dimensional arrays, piezoelectric ceramic/epoxy composite materials, piezoelectric polymers, and photo-acoustic materials. Consent of instructor required.

**BME 333. Biomedical Imaging (3 c.h.)**. A study of the fundamentals of information detection, processing, and presentation associated with imaging in biology and medicine. Analysis of coherent and incoherent radiation and various image generation techniques. Design and analysis of modern array imaging systems as well as systems.

**BME 350. Principles of Research Management (1 c.h.).** A survey of topics in modern research management techniques that will cover proven successful principles and their application in the areas of research lab organization, resource management, organization of technical projects, team leadership, financial accountability, and professional ethics.

**BME 360. Leading Medical Devices: Innovation to Market (3 c.h.).** Interdisciplinary examination of the medical device landscape for business, engineering, and medicine. Provides core tools for individuals interested in product design and development. Includes market definition and modeling, financing, reimbursement, business plan modeling, and the global marketplace. Case-based and team-based learning including developing a business plan and 510K approval will augment core instruction and guest lecturers.

**CELLBIO 203. Introduction to Physiology (2 c.h.).** Modern organ physiology; cellular physiology, the heart and cardiovascular system, the kidney, the gastrointestinal, endocrine, and nervous systems. Minicourse. Prerequisite: elementary biology.

**COMPSCI 150. Introduction to Numerical Methods and Analysis (1 c.h.).** Theory, algorithms, and software that concern numerical solution of linear equations, approximation and interpolation of functions, numerical solution of nonlinear equations, and numerical solution of ordinary differential equations.

**ECE 243 Pattern classification & recognition (3 c.h.).** Theory and practice of recognition technology: pattern classification, pattern recognition, automatic computer decision-making algorithms. Applications covered include medical diseases, severe weather, industrial parts, biometrics, bioinformation, animal behavior patterns, image processing, and human visual systems. Perception as an integral component of intelligent systems. This course prepares students for advanced study of data fusion, data mining, knowledge base construction, problem-solving methodologies of "intelligent agents" and the design of intelligent control systems. Prerequisites: Mathematics 104, Statistics 113 or Mathematics 135, Computer Science 6, or consent of instructor.

**ECE 281. Random Signals & Noise (3 c.h.).** Introduction to mathematical methods of describing and analyzing random signals and noise. Review of basic probability theory; joint, conditional, and marginal distributions; random processes. Time and ensemble averages, correlation, and power spectra. Optimum linear smoothing and predicting filters. Introduction to optimum signal detection, parameter estimation, and statistical signal processing.

**ECE 282. Digital Signal Processing (3 c.h.).** Introduction to the fundamentals of processing signals by digital techniques with applications to practical problems. Discrete time signals and systems, elements of the Z-transform, discrete Fourier transforms, digital filter design techniques, fast Fourier transforms, and discrete random signals.

**ECE 285. Signal Detection & Extraction Theory (3 c.h.).** Introduction to signal detection and information extraction theory from a statistical decision theory viewpoint. Subject areas covered within the context of a digital environment are decision theory, detection and estimation of known and random signals in noise, estimation of parameters and adaptive recursive digital filtering, and decision processes with finite memory. Applications to problems in communication theory.

**ECE 288. Image/array signal processing (3 c.h.).** Multidimensional digital signal processing with applications to practical problems in image and sensor array processing. Two-dimensional discrete signals and systems, discrete random fields, 2-D sampling theory, 2-D transforms, image enhancement, image filtering and restoration, space-time signals, beamforming, and inverse problems.

**MATH 221. Numerical analysis (3 c.h.).**

**MATH 224. Scientific Computing I (3 c.h.).** Structured scientific programming in C/C++ and FORTRAN. Floating point arithmetic and interactive graphics for data visualization. Numerical linear algebra, direct and iterative methods for solving linear systems, matrix factorizations, least squares problems and eigenvalue problems. Interactive methods for nonlinear equations and nonlinear systems, Newton's method.

**MATH 225. Scientific Computing I (3 c.h.).** Compressible fluid flow. Shock-capturing methods for conservation laws. Incompressible fluid flow. Vortex and probabilistic methods for high Re flow. Viscous Navier-Stokes equations and projection methods.

**Phys 213. Introduction to Nonlinear Dynamics.** This course is a graduate-level introduction to nonlinear dynamics, the study of the stability and the properties of mathematical, physical, chemical and biological systems that evolve in time. It is also appropriate for upper division undergraduate physics majors.

**Phys 230. Math Methods for Physicists.** This course is designed to introduce first-year graduate student to mathematical concepts and tools needed for research, and more advanced math courses. The subject exposes the students to the level of mathematical rigor required for doctoral research. It helps students acquire the mathematical methods and tools for other graduate course (particularly E&M, QM and SM), necessary research while earning their Ph.D.'s, and understanding journals and papers (e.g. PRLs) necessary for their study. This course also introduces the students to the mathematical tool, *Mathematica*.

**STA 213. Introduction to Statistical Methods (3 c.h.).** Emphasis on classical techniques of hypothesis testing and point and interval estimation, using the binomial, normal, t, F, and chi square distributions.

**STA 214. Probability and Statistical Models (3 c.h.).** An introduction to applied probability and to the parametric probability models commonly used in statistical analysis. The generation of random variables with specified distributions, and their use in simulation. Mixture models; linear regression models; random walks, Markov chains, and stationary and ARMA process; networks and queuing models. Prerequisite: Statistics 213 and 244 or consent of instructor.

**STA 215. Statistical Inference (3 c.h.).** Classical, likelihood, and Bayesian approaches to statistical inference. Foundations of point and interval estimation, and properties of estimators (bias, consistency, efficiency, sufficiency, robustness). Testing: Type I and II errors, power, likelihood ratios; Bayes factors, posterior probabilities of hypotheses. The predictivist perspective. Applications include estimation and testing in normal models; model choice and criticism.

**STA 216. Generalized Linear Models (3 c.h.).** Likelihood-based and Bayesian inference of binomial, ordinal, and Poisson regression models, and the relation of these models to item response theory and other psychometric models. Focus on latent variable interpretations of categorical variables, computational techniques of estimating posterior distributions on model parameters, and Bayesian and likelihood approaches to case analyses and goodness-of-fit criterion. Theory and practice of modern regression modeling within the unifying context of generalized linear models. A brief review of hierarchical linear models. Students expected to use several software packages and to customize functions in these packages to perform applied analyses.

**STA 244. Linear Models (3 c.h.).** Multiple linear regression and model building. Exploratory data analysis techniques, variable transformations and selection, parameter estimation and interpretation, prediction, Bayesian hierarchical models, Bayes factors and intrinsic Bayes factors for linear models, and Bayesian model averaging. The concepts of linear models from Bayesian and classical viewpoints. Topics in Markov chain Monte Carlo simulation introduced as required.

**STA 290. Statistical Laboratory (3 c.h.).** Introduction to statistical thinking, data management and collection, sampling and design, exploratory data analysis, graphical and tabular displays, summarizing data. Introduction to applied work. Computer orientation, statistical packages and operating systems, especially unix on high-speed workstations, and the statistical package S-Plus. Graphics and numerical computing. Examples from various disciplines.