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.

Preferred Frontier course

MP 370 Frontier of Biomedical Sciences (3c.h.) A course coverings the frontier topics of biomedical sciences that are currently not within the domain of medical physics, but a medical physicists, nonetheless, need to have knowledge of. Topics include genomics, bioinformatics, proteomics, and others.

Other possible Frontier courses

BME 220L Introduction to Biomolecular Engineering Structure of biological macromolecules, recombinant DNA techniques, principles of and techniques to study protein structure-function. Discussion of biomolecular design and engineering from the research literature. Linked laboratory assignments to alter protein structure at the genetic level. Expression, purification, and ligand-binding studies of protein function.

BME 236 Biophotonic Instrumentation* design and application of opticalinstruments for biomedical applications. Focus on optical theory,instrumentation, and engineering design with consideration to ethics and safety

BME 335 ADVANCES IN PHOTONICS* The main goal of this course is to provideand overview of various photonics techniques and their applications. Thepurpose is to enhance the students' breath of understanding and knowledgeof advanced techniques and introduce them to the wide variety ofapplications in photonics, the science and technology associated withinteractions of light with matter. Examples of topics include:High-resolution Luminescence Techniques, Raman Techniques, OpticalCoherence Techniques, Ultrafast Laser-base Techniques, Near-Filed andConfocal Optical Techniques, Remote Sensing Techniques, Advanced LightMeasurement Techniques, Optical Biosensors, Nano Micro ElectroopticsSystems, Highthroughput Assays using Optical Detection, Photonics MetaMaterials and Applications, Optics in Telecommunications, andNanophotonics. The lectures will be presented by faculty members who areleaders in their areas of research in photonics. Instructor: Vo-Dinh

CBB 200 / STA 270 stat methods / computational biology*

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.

BIOCHEM 417 CELLULAR SIGNALING* Mechanism of action of hormones at the cellular level including hormone-receptor interactions, secondary messenger systems for hormones, mechanisms of regulation of hormone responsiveness, regulation of growth, differentiation and proliferation, mechanisms of transport and ion channels, stimulus sensing and transduction. Some lectures stress the clinical correlation of the basic course concepts. rosslisted as: CELLBIO 417,PHARM 417,MOLCAN 417

BIOLOGY 117 STRUCTURE-FUNCTION IN BIOLOGY* Mechanisms and processes that organisms use to deal withthe challenges posed by their physical, chemical, and ecological contexts. Structure-functionrelationships explored from molecules and cells to tissues and organ systems. Topics include cellulararchitecture, energy metabolism, molecular motors, motility/locomotion, sensory mechanisms/signaltransduction, ionic/ osmotic balance, gas exchange, thermal physiology. Constraints and adaptations related the evolution of eukaryotes and the evolution of multicellularity. Prerequisite: Biology 25Lor equivalent.

BIOLOGY 118 GENETICS AND MOLECULAR BIOLOGY Explores flow of information from gene to phenotype.Social implications of modern genetic analysis and the genomic revolution. Topics include:organization and stability of genomes from bacteria to higher vertebrates (humans), conversion of thegenetic code into a functioning organism, classical transmission (Mendelian) genetics and itsrelevance to human hereditary disorders, content of the genome and social implications of geneticknowledge including issues of genetic privacy, eugenics, genetically modified organism, and cloning.Prerequisite: Biology 25L or equivalent; Chemistry 22L or equivalent.

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.

CBI 280S GENETIC ENGINEER/BIOTECH Applications of recombinant DNA in medicine and in agriculture. Topics include diagnosis of genetic diseases, gene therapy, drugs for AIDS and cancer, DNA fingerprinting, cloning of mammals, phytoremediation, crop improvement, and pharmaceutical protein production in transgenic plants and animals. Social and environmental impacts of biotechnology. Prerequisites: Biology 118 and 119 or consent of instructor.

CMB 297 Modern Techniques in Molecular Biology Discussions of nucleic acid sequencing and manipulation, cloning strategies, vectors, expression, hybridization and blotting methods, PCR, etc. Consent of instructor required for undergraduates. First half of fall semester.

ECE 285 Signal Detection and Extraction Theory* 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.

GLHLTH 251 Global Health Ethics Ethical issues of conducting research on or working with marginalized/stigmatized populations, using theoretical frameworks and case studies. Investigations of ethical choices made by multinational, national and local policymakers, clinicians, and researchers and their impact on individuals, families and communities. Emphasis on working with community partners in developing needs assessment programs. Topics include: differential standards of care; protection of human subjects; access to essential medicines; genetic information and confidentiality; pharmaceutical development; health information technology; placebo controlled trials; best outcomes vs. distributive justice. Written paper required.

IMMUNOL 244 PRINCIPLES OF IMMUNOLOGY An introduction to the molecular and cellular basis of the immune response. Topics include anatomy of the lymphoid system, lymphocyte biology, antigen-antibody interactions, humoral and cellular effector mechanisms, and control of immune responses. Prerequisites: Biology 119 and Chemistry 151L or equivalents.

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).

MEDINFO 334B ARTIFICAL INTELL IN MED* An introduction to basic concepts of Artificial Intelligence (AI) and an in-depth examination of medical applications of AI. The course includes heuristic programming, a brief examination of the classic AI programming languages (LISP and PROLOG), and a study of rule-based systems and cognitive models. Specific applications examined in detail include MYCIN, ONCOCIN,

PIP, CASNET, ILIAD, QMR, and DXPLAIN and selected EXPERT systems. Approval of the instructor required. C-L: BME-241 (Graduate School). Credit: 3. Staff

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.

MOLCAN 300 Cancer as a Disease* This course looks at cancer from the point of view of the patient, the doctor and the scientist. Topics include diagnosis, detection and prediction of cancer, themolecular basis of the disease, and new approaches to therapy. Faculty (including guests from aroundthe medical center) will provide perspective on each topic. The object is to give students a deeperappreciation for the clinical aspects of cancer and how molecular biology can contribute to improvedunderstanding and treatment of the disease. This course is mandatory for all MCB students, and wouldbe suitable for second year students with a solid background in molecular biology.

MOLCAN 208 STEM CELL BIOLOGY MINICOURSE* The course is designed for first-year graduate students tolearn the fundamentals of stem cell biology and to gain familiarity with current research in thefield. The course will be presented in a lecture and discussion format based on the primaryliterature. Topics include: stem cell concepts, methodologies for stem cell research, embryonic stemcells, adult stem cells, cloning and stem cell reprogramming and clinical applications of stem cellresearch. Prerequisites: undergraduate level cell biology, molecular biology, and genetics.

MP 332 Molecular imaging (1 c.h.) The course covers topics related toimaging molecular processes in small animal and human applications.

NEUROBIO 381 FUNCTIONAL MAGNETIC RESONANCE The course covers all aspects of functional magnetic resonance imaging, from its basic principles in physics, engineering, biophysics, and physiology; through computational, analytic, and signal processing issues; to its applications in neurobiology and cognitive neuroscience. The course will consist of weekly lectures and integrated laboratory sessions. Lectures will be given by BIAC faculty, and will incorporate primary readings in the field to encourage discussion. The laboratory sessions will involve analysis of fMRI data sets that illustrate issues discussed in the lectures. Students will gain experience both in the theoretical principles of fMRI and in the practical aspects of experimental design and data analysis.

PATHOLOGY 385 Molecular Aspects of Disease* Background, investigative methods, and recent advances in understanding the molecular basis of selected diseases. In-depth focus on selected diseases whose defects are known at genetic or molecular levels.

PHARM 233 ESSENTIALS PHARM/TOXICOL Drug absorption, distribution, excretion, and metabolism. Structure and activity relationships; drug and hormone receptors and target cell responses. Consent of instructor required. Prerequisite: introductory biology; Chemistry 151L; Mathematics 31 and 32.

Pharm 234 Interdiciplinary Approach to Pharmacology* Use of pathologicalmodels for molecular, biochemical and physiological basis of chemical drugactions and results. Emphasis on cancerous tumors and immunologicaldisorders

Pharm 364 Neurotoxicology" Effects of toxins on CNS and PNS, includingneurotoxicity, screening and assessment, experimental methods fordetection

SBB 345 Molecular Biophysics Seminar"

SBB 346 Structural Biology and Biophysics

Elective courses (as electives not frontier)

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.

Any MP course

BAA 239L Radiology Sports-rel injury*

BAA 305 (3c.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 262 Design Developing World (3 c.h.) Design of custom devices to help the specific and unique needs of developing world hospitals. Formal engineering design principles will be emphasized; overview of developing world conditions, patent issues, engineering ethics. Oral and written reports will be required. Students may elect to personally deliver their projects to a developing world hospital, if selected, in the summer following the course. Prerequisite: Biomedical Engineering 154L or equivalent, or consent of instructor.

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

ECE 281 RandomSignals& 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* (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 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.

* Courses not offered in Fall 2009, but may be offered in Spring 2010 or next year