List of Approved Discipline-Bridging Courses

This document provides a list of pre-approved discipline-bridging courses, organized by the domain requirement which they fulfill. Note that some courses are listed as fulfilling the requirement of more than one domain.

COMBINE Domains. COMBINE fellows are drawn from three broad scientific domains

- **Life Sciences (L),** including programs in Biological Sciences, Neuroscience and Cognitive science, and Public Health
- **Physical and Mathematical Sciences (P/M),** including programs in Physics, Biophysics, Chemistry and Biochemistry, Applied Mathematics & Statistics and Scientific Computing, and Mathematics
- **Computational and Engineering Sciences (C/E),** including programs in Computer Science, Electrical and Computer Engineering, Bioengineering, and Information Studies

Description of COMBINE's discipline-bridging course requirement:

In addition to completing PhD program requirements in one of three domains (Life Sciences; Physical/Mathematical Sciences; Computational/Engineering Science, COMBINE fellows must complete: (1) A 3+ credit course at the graduate or advanced undergraduate level from one of the other two domains (chosen from a list of appropriate courses) and (2) A 1+ credit out-of-field graduate seminar or course from the third domain. This document provides a list of approved courses. <u>Additional courses will be considered for approval upon request</u>. Note that some courses fulfilling these "out-of-discipline" requirements may actually be taught from within another domain. For example, the course BSCI474: Mathematical Biology may be used by a life science graduate student to fulfill the discipline-bridging requirement for the physical/mathematical science domain, since it contains a strong mathematical component. For students in programs outside the computational sciences who have no prior computational training, the 3+ credit course should be a computation/programming-intensive course.

Table of Contents

Computational and Engineering Sciences Domain

List of approved courses fulfilling the COMBINE discipline-bridging requirement from the Computational and Engineering Sciences domain

AMSC660: **Scientific Computing (3 credits) C/E**

Prerequisite: Must have knowledge of C or Fortran. And AMSC460 or CMSC460; or (CMSC466 or AMSC466); or (must have knowledge of basic numerical analysis (linear equations, nonlinear integration, interpolation); and permission of instructor).

Monte Carlo simulation, numerical linear algebra, nonlinear systems and continuation method, optimization, ordinary differential equations. Fundamental techniques in scientific computation with an introduction to the theory and software of each topic.

AMSC808N/CMSC 828V: **Advanced Topics in Information Processing; Numerical Methods for Data Science and Machine Learning (3 credits) C/E**

The course will go over a number of modern optimization and numerical linear algebra techniques used in data science and machine learning. These include: large-scale optimization methods, matrix data and latent factor models, kernel interpolation and Gaussian processes, and numerical methods for graph data analysis.

BIOL608J: **Biology Seminar; Statistical Learning in Ecology and Evolution (1 credit) C/E**

This course is structured as a reading group covers statistical learning with an eye toward applications in ecology & evolution. Topics include: methods for model selection & regularization; LASSO; ridge regression; generalized additive models (GAM); regression & classification trees; random forests; boosting; support vector machines (SVM); connection between & relative merits of PCA (principal components analysis), SVD (singular value decomposition), and MDS (multi-dimensional scaling); neural networks & deep learning.

The class meets once a week for 1hr (or longer if people would like), and one participant is for leading discussion each week (each person expected to lead once or twice over the semester). The weekly consists of three parts:

1. Textbook reading (Chapter/sections from ISL, optionally supplemented with ESL if enthusiastic)
2. Paper with application of topic to biological problem (chosen by discussion leader - should come up with a set of interesting/useful papers/reviews that are sent out to everyone as supplemental and one focal paper that everyone reads)
3. R code/tutorial (list of good tutorials on the topic found online, annotated code from the textbook, or custom-written code from the discussion leader) - also a list of useful packages

BIOL709D: **Selected Advanced Topics in Biology; Data Analysis & Modeling in Ecology and Environmental Life Sciences (3 credits) C/E**

Specifying and estimating models is, arguably, the essential task of life science researchers attempting to understand complex processes. In this course, we will provide an overview of contemporary statistical and computational modeling tools for performing inference, testing hypotheses, and fitting complex processes. This course will be highly applied-i.e., rather than dwell rigorously ontheory, We will use the R programming language to learn how to visualize data, estimate models, and report results.

BIOL709F: **Selected Advanced Topics in Biology; Statistics & Modeling for Biologists (3 Credits) C/E**

This course will provide an overview of essential probability and statistics for biology graduate students using R. Topics include: parameter estimation (moment, likelihood, Bayesian), confidence intervals and hypothesis testing, multiple testing, experimental design and power analysis, and resampling-based measures of uncertainty. Practical use of computers will be emphasized, although previous experience with R is not necessary.

BSCI339P: **Selected Topics in Biology; Data Analysis & Modeling in Ecology & Environmental Life Sciences (3 credits) C/E**

Acceptable toward Biological Sciences specialization areas: ECEV, GENB (Quantitative Course). Specifying and estimating models is, arguably, the essential task of life science researchers attempting to understand complex processes. In this course, we will provide an overview of contemporary statistical and computational modeling tools for performing inference, testing hypotheses, and fitting complex processes. This course will be highly applied-i.e., rather than dwell rigorously on theory, we will use the R programming language to learn how to visualize data, estimate models, and report results.

CBMG688P: **Special Topics in Cell Biology and Molecular Genetics; Programming for Biology (2 Credits) C/E**

Students should gain an ability to implement standard bioinformatics tools and manipulate large data files in a unix environment. Although true programming is beyond the scope of this course, students should achieve an ability to understand, use and edit programs in awk, Python and R.

CBMG688Y: **Special Topics in Cell Biology and Molecular Genetics; Bioinformatics and Genomics (2 Credits) C/E**

provides an overview of some major topics and research areas bioinformatics and genomics, and includes material from basic foundations through advanced concepts. The course consists of readings, lectures, discussions, collaborative learning activities, writing assignments, and exams.

CBMG699D: **Special Problems in Cell Biology and Molecular Genetics; Molecular Genetics: Bioinformatics and Computation Biology (1 credit) C/E**

***CMSC422*: Introduction to Machine Learning (3 credits) C/E**

Prerequisite: Minimum grade of C- in CMSC320, CMSC330, and CMSC351; and 1 course with a minimum grade of C- from (MATH240, MATH461); and permission of CMNS-Computer Science department.

Machine Learning studies representations and algorithms that allow machines to improve their performance on a task from experience. This is a broad overview of existing methods for machine learning and an introduction to adaptive systems in general. Emphasis is given to practical aspects of machine learning and data mining.

***CMSC498Y:* Selected Topics in Computer Science; Statistical Inference and Machine Learning Methods for Genomics Data (3 credits) C/E**

Prerequisite: Minimum grade of C- in CMSC330 and CMSC351.

Covers statistical inference and machine learning methods for analyzing genomic data. Examples of topics covered will include maximum likelihood (including composite and pseudo-likelihood functions), expectation-maximization, clustering algorithms, hidden markov models, statistical testing, MCMC and variational inference. Our focus will be on how these techniques are utilized to solve biological problems and the practical challenges that arise when analyzing large genomic data sets.

***CMSC660:* Scientific Computing I (3 credits) C/E**

Prerequisite: Must have knowledge of C or Fortran. And CMSC466, AMSC466, AMSC460, or CMSC460; or (must have knowledge of basic numerical analysis (linear equations, nonlinear equations, integration, interpolation); and permission of instructor).

Also offered as: AMSC660.

Credit only granted for: AMSC660 or CMSC660.

Monte Carlo simulation, numerical linear algebra, nonlinear systems and continuation method, optimization, ordinary differential equations. Fundamental techniques in scientific computation with an introduction to the theory and software for each topic.

***CMSC661:*Scientific Computing II (3 credits) C/E**

Prerequisite: Must have knowledge of C or Fortran. And CMSC466, AMSC466, AMSC460, or CMSC460; or (must have knowledge of basic numerical analysis (linear equations, nonlinear equations, integration, interpolation); and permission of instructor).

Also offered as: AMSC661.

Fourier and wavelet transform methods, numerical methods for elliptic partial differential equations, numerical linear algebra for sparse matrices, Finite element methods, numerical methods for time dependent partial differential equations. Techniques for scientific computation with an introduction to the theory and software for each topic. Course is part of a two course sequence (660 and 661), but can be taken independently.

***CMSC702*: Computational Systems Biology (3 credits) C/E**

***CMSC703*: Network Analysis and modeling of Biological Systems (3 credits) C/E**

Prerequisites: Computer Science or Applied Mathematics student or permission of instructor. No knowledge of biology required.

The course will focus on the computational network analysis and modeling of biological systems focusing on transcriptional, protein, signaling and metabolic networks (with primary emphasis on integrating the former within the latter). Computational methods studied for this type of analysis include: network and graph algorithms, network-based machine learning approaches, modeling dynamical systems, numerical optimization (linear, integer and quadratic programming) and a variety of other methods used to solve constraint based problems (primarily in the context of studying metabolic networks). These methods are complementary to those studied in CMSC701 and CMSC702.

***CMSC727:* Neural Modeling (3 credits) C/E**

Prerequisite: CMSC421; or students who have taken courses with comparable content may contact the department; or permission of instructor.

Fundamental methods of neural modeling. Surveys historical development and recent research results from both the computational and dynamical systems perspective. Logical neurons, perceptrons, linear adaptive networks, attractor neural networks, competitive activation methods, error back-propagation, self-organizing maps, and related topics. Applications in artificial intelligence, cognitive science, and neuroscience.

***CMSC828J:* Advanced Topics in Information Processing; Deep Learning Models for Video Analysis (3 credits) C/E**

***CMSC828P:* Advanced Topics in Information Processing; Algorithms and Machine Learning for Analyzing Mutations in Cancer (3 credits) C/E**

***CMSC828V:* Advanced Topics in Information Processing; Numerical Methods for Data Science and Machine Learning (3 credits) C/E**

***CMSC858D*: Advanced Topics in Theory of Computing; Algorithms, Data Structures and Inference fo High-Throughput Genomics (3 credits) C/E**

***CMCS882T:* Advanced Topics in Information Processing; Vision, Planning and Control in Aerial Robotics (3 credits) C/E**

This is a comprehensive course on aerial robotics, with a focus on quadcopters and their related hardware and software implementations. The course will cover both the theoretical and practical aspects of quadcopters, with special focus on perception, planning and control algorithms involved in the same.

***ENEE698Q:* Graduate Seminar; Colloquium Series (1 credit) C/E**

***NACS643*: Computational Neuroscience (4 credits) C/E**

Prerequisite: NACS641; and must have completed a course in calculus; and permission of instructor.

Provides a mathematical foundation in computational neuroscience.

***PHYS798D:* Special Problems in Advanced Physics; Applied Dynamics Seminar (1 Credits) C/E**

Also offered as ENEE698D. Credit granted ENEE698D or PHYS798D.

***NOTE:** do not to sign up before confirming with Michelle or Daniel that the course is being offered*

***STAT705*: Computational Statistics (3 credits) C/E**

Prerequisite: STAT700 or STAT420. Recommended: Have some programming experience (any language).

Modern methods of computational statistics and their application to bot practical problems and research. S-Plus and SAS programming with emphasis on S-Plus. S-Plus objects and functions, and SAS procedures. Topics include data management and graphics, Monte Carlo and simulation, bootstrapping, numerical optimization in statistics, linear and generalized linear models, nonparametric regression, time series analysis.

Life Sciences Domain

List of approved courses fulfilling the COMBINE discipline-bridging requirement from the Life Sciences (L) domain

***BCHM461:* Biochemistry I (3 credits) LS**

Prerequisite: Minimum grade of C- in CHEM271 and CHEM272; or minimum grade of C- in CHEM276 and CHEM277.

Credit only granted for: BCHM461 or BCHM463.

First semester of a comprehensive introduction to modern biochemistry. Structure, chemical properties, and function of proteins and enzymes, carbohydrates, lipids, and nucleic acids. Basic enzyme kinetics and catalytic mechanisms.

***BCHM669A:* Special Topics in Biochemistry; Methods for Structural Determination in Solution (1 - 3 credits) LS**

***BIPH698L*: Biophysics Seminar; Biophysics (1 credit) LS**

***BSCI474:* Mathematical Biology LS**

Prerequisite: MATH 130/MATH 131

Students develop quantitative reasoning skills through the understanding of mathematically based biological models. Models are chosen from a variety of biological disciplines, including biological population dynamics, infectious disease propagation, molecular evolution, and phylogenetic trees. Mathematical skills developed include: solving non-linear difference equations, eigenvector analysis, multi-dimensional stability analysis, and the use of Excel and Matlab to implement these algorithms as computer models.

BIOL608J: **Biology Seminar; Statistical Learning in Ecology and Evolution (1 credit) LS**

This course is structured as a reading group covers statistical learning with an eye toward applications in ecology & evolution. Topics include: methods for model selection & regularization; LASSO; ridge regression; generalized additive models (GAM); regression & classification trees; random forests; boosting; support vector machines (SVM); connection between & relative merits of PCA (principal components analysis), SVD (singular value decomposition), and MDS (multi-dimensional scaling); neural networks & deep learning.

The class meets once a week for 1hr (or longer if people would like), and one participant is for leading discussion each week (each person expected to lead once or twice over the semester). The weekly consists of three parts:

1. Textbook reading (Chapter/sections from ISL, optionally supplemented with ESL if enthusiastic)
2. Paper with application of topic to biological problem (chosen by discussion leader - should come up with a set of interesting/useful papers/reviews that are sent out to everyone as supplemental and one focal paper that everyone reads)
3. R code/tutorial (list of good tutorials on the topic found online, annotated code from the textbook, or custom-written code from the discussion leader) - also a list of useful packages

BIOL704: **Cell Biology from a Biophysical Perspective (3 credits) LS**

Also offered as: BSCI404. Formerly: BIOL708O

An approach to cell biology by focusing on mechanisms and unifying paradigms. It will not assume a great deal of factual biological knowledge, but will expect a background that prepares students to think quantitatively and mechanistically.

BIOL620: **Cell Biology (3 Credits) LS**

Offered with laboratory as BSCI 421. Molecular basis of cell structure and function in eukaryotes.

BIPH704: **Cell Biology from a Biophysical Perspective (3 credits) LS**

An approach to cell biology by focusing on mechanisms and unifying paradigms. It will not assume a great deal of factual biological knowledge, but will expect a background that prepares students to think quantitatively and mechanistically.

***BSCI404:* Cell Biology from a Biophysical Perspective (3 credits) LS**

Formerly: BSCI338O

An approach to cell biology by focusing on mechanisms and unifying physical paradigms. It will not assume a great deal of factual biological knowledge, but will expect a background that prepares students to think mechanistically and quantitatively.

***BSCI 441*: Plant Physiology (4 credits) LS**

This course will provide an introduction to the basic physical and physiological principles necessary for understanding the interactions between plants and their environment. The overall objective is to understand plant responses and adaptations to the environment and the ecological relevance of these responses.

***BSCI453*: Cellular Neurophysiology (3 credits) LS**

The cellular and molecular basis of nervous system function.

***CBMG688F:* Special Topics in Cell Biology and Molecular Genetics; Gene Expression (2 Credits) LS**

***CBMG688Y:* Special Topics in Cell Biology and Molecular Genetics; Bioinformatics and Genomics (2 Credits) LS**

provides an overview of some major topics and research areas bioinformatics and genomics, and includes material from basic foundations through advanced concepts. The course consists of readings, lectures, discussions, collaborative learning activities, writing assignments, and exams.

***CBMG699D:* Special Problems in Cell Biology and Molecular Genetics; Molecular Genetics: Bioinformatics and Computation Biology (1 credit) LS**

***NACS608:* Neuroscience & Cognitive Science (1 credit) LS**

***NACS641*: Introduction to Neurosciences (4 credits) LS**

Detailed examination of neurophysiology and sensorimotor systems.

***NACS643*: Computational Neuroscience (4 credits) LS**

Prerequisite: NACS641; and must have completed a course in calculus; and permission of instructor.

Provides a mathematical foundation in computational neuroscience.

***NACS644*: Cellular and Molecular Neuroscience (4 credits) LS**

Prerequisite: NACS641; or permission of instructor.

Overview of insights into the molecular mechanisms underlying the structure and function of the nervous system.

***NACS728A:* Selected Topics in Neuroscience and Cognitive Science; Hearing (Credits: 3) LS**

***PLSC 411*: Plant Sciences((4 credits) LS**

Prerequisite: BSCI170; and BSCI171. Or PLSC201; or permission of AGNR-Plant Science & Landscape Architecture department.

An introduction to genetic principles and technologies in plants, centered on linking phenotype to genotype. Topics include Mendelian inheritance of single and complex traits, epigenetics, population genetics and plant breeding. Examples on creating and mapping genetic mutations in both model plants and non-model crops are discussed. Current genetic and genomic approaches are highlighted, such as genome engineering and reprogramming, TILLING, and genome-wide association mapping.

Physical and Mathematical Sciences Domain

List of approved courses fulfilling the COMBINE discipline-bridging requirement from the Physical and Mathematical Sciences (P/M) domain

AMSC466:**Introduction to Numerical Analysis I (3 credits) P/M**

Prerequisite: 1 course with a minimum grade of C- from (MATH240, MATH461, MATH341); and 1 course with a minimum grade of C- from (MATH340, MATH241); and 1 course with a minimum grade of C- from (CMSC106, CMSC131); and minimum grade of C- in MATH410.

Also offered as: CMSC466.

Credit only granted for: AMSC460, CMSC460, AMSC466, or CMSC466.

Floating point computations, direct methods for linear systems, interpolation, solution of nonlinear equations.

AMSC660: **Scientific Computing (3 credits) P/M**

Prerequisite: Must have knowledge of C or Fortran. And AMSC460 or CMSC460; or (CMSC466 or AMSC466); or (must have knowledge of basic numerical analysis (linear equations, nonlinear integration, interpolation); and permission of instructor).

Monte Carlo simulation, numerical linear algebra, nonlinear systems and continuation method, optimization, ordinary differential equations. Fundamental techniques in scientific computation with an introduction to the theory and software of each topic.

BIOL705: **Statistics & Modeling for Biologists (3 credits) P/M**

Restriction: Must be in the Biological Sciences Graduate program; or permission of Biology Department.

Credit only granted for: BIOL705 or BIOL709F.

Formerly: BIOL709F.

An overview of essential probability and statistics using R with a focus on biological problems. Topics include: parameter estimation (likelihood, Bayesian), confidence intervals and hypothesis testing, multiple testing, experimental design and power analysis, and resampling-based measures of uncertainty. Practical use of computers will be emphasized.

BIOL704: **Cell Biology from a Biophysical Perspective (3 credits) P/M**

Also offered as: BSCI404. Formerly: BIOL708O

An approach to cell biology by focusing on mechanisms and unifying paradigms. It will not assume a great deal of factual biological knowledge, but will expect a background that prepares students to think quantitatively and mechanistically.

BIOL709F: **Selected Advanced Topics in Biology; Statistics & Modeling for Biologists (3 Credits) P/M**

This course will provide an overview of essential probability and statistics for biology graduate students using R. Topics include: parameter estimation (moment, likelihood, Bayesian), confidence intervals and hypothesis testing, multiple testing, experimental design and power analysis, and resampling-based measures of uncertainty. Practical use of computers will be emphasized, although previous experience with R is not necessary.

BIOM601: **Biostatistics I (4 credits) P/M**

Prerequisite: BIOM301 or STAT464; or students who have taken courses with comparable content may contact the department.

Estimation and hypothesis testing, t tests, one and two way analysis of variance, regression, analysis of frequency data. Lecture will emphasize uses and limitations of these methods in biology, while the laboratory will emphasize the use of statistical analysis software for the analysis of biological data.

BIPH698L**: Biophysics Seminar; Biophysics (1 credit) P/M**

BIPH704: **Cell Biology from a Biophysical Perspective (3 credits) P/M**

An approach to cell biology by focusing on mechanisms and unifying paradigms. It will not assume a great deal of factual biological knowledge, but will expect a background that prepares students to think quantitatively and mechanistically.

BSCI404: **Cell Biology from a Biophysical Perspective (3 credits) P/M**

Formerly: BSCI338O

An approach to cell biology by focusing on mechanisms and unifying physical paradigms. It will not assume a great deal of factual biological knowledge, but will expect a background that prepares students to think mechanistically and quantitatively.

BSCI474: **Mathematical Biology P/M**

Prerequisite: MATH 130/MATH 131

Students develop quantitative reasoning skills through the understanding of mathematically based biological models. Models are chosen from a variety of biological disciplines, including biological population dynamics, infectious disease propagation, molecular evolution, and phylogenetic trees. Mathematical skills developed include: solving non-linear difference equations, eigenvector analysis, multi-dimensional stability analysis, and the use of Excel and Matlab to implement these algorithms as computer models.

CHEM687: **Statistical Mechanics and Chemistry (3 credits) P/M**

***CMSC660:* Scientific Computing I (3 credits) P/M**

Prerequisite: Must have knowledge of C or Fortran. And CMSC466, AMSC466, AMSC460, or CMSC460; or (must have knowledge of basic numerical analysis (linear equations, nonlinear equations, integration, interpolation); and permission of instructor).

Also offered as: AMSC660.

Credit only granted for: AMSC660 or CMSC660.

Monte Carlo simulation, numerical linear algebra, nonlinear systems and continuation method, optimization, ordinary differential equations. Fundamental techniques in scientific computation with an introduction to the theory and software for each topic.

***CMSC661:*Scientific Computing II (3 credits) P/M**

Prerequisite: Must have knowledge of C or Fortran. And CMSC466, AMSC466, AMSC460, or CMSC460; or (must have knowledge of basic numerical analysis (linear equations, nonlinear equations, integration, interpolation); and permission of instructor).

Also offered as: AMSC661.

Fourier and wavelet transform methods, numerical methods for elliptic partial differential equations, numerical linear algebra for sparse matrices, Finite element methods, numerical methods for time dependent partial differential equations. Techniques for scientific computation with an introduction to the theory and software for each topic. Course is part of a two course sequence (660 and 661), but can be taken independently.

***CMSC703*: Network Analysis and modeling of Biological Systems (3 credits) P/M**

Prerequisites: Computer Science or Applied Mathematics student or permission of instructor. No knowledge of biology required.

The course will focus on the computational network analysis and modeling of biological systems focusing on transcriptional, protein, signaling and metabolic networks (with primary emphasis on integrating the former within the latter). Computational methods studied for this type of analysis include: network and graph algorithms, network-based machine learning approaches, modeling dynamical systems, numerical optimization (linear, integer and quadratic programming) and a variety of other methods used to solve constraint based problems (primarily in the context of studying metabolic networks). These methods are complementary to those studied in CMSC701 and CMSC702.

***CMSC727:* Neural Modeling (3 credits) P/M**

Prerequisite: CMSC421; or students who have taken courses with comparable content may contact the department; or permission of instructor.

Fundamental methods of neural modeling. Surveys historical development and recent research results from both the computational and dynamical systems perspective.

Logical neurons, perceptrons, linear adaptive networks, attractor neural networks, competitive activation methods, error back-propagation, self-organizing maps, and related topics. Applications in artificial intelligence, cognitive science, and neuroscience.

CMSC828D: **Advanced Topics in Information Processing; Introduction to Data Visualization**
(3 Credits) P/M

EDMS646: **General Linear Models I (3 Credits) P/M**

Prerequisite: EDMS645; or an equivalent introductory statistics course.

A first post-introductory inferential statistics course, with emphasis on analysis of variance procedures and designs from within the general linear modeling framework. Assignments include student analysis of education and related data; application of statistical software packages is emphasized.

ENEE620**: Random Processes in Communications and Control (3 credits) P/M**

Prerequisite: ENEE 324 or equivalent.

Introduction to random processes: characterization, classification, representation; Gaussian and other examples. Linear operations on random processes, stationary processes: covariance function and spectral density. Linear least square waveform estimating Wiener-Kolmogroff filtering, Kalman-Bucy recursive filtering: function space characterization, non-linear operations on random processes.

ENEE660: **System Theory (3 credits) P/M**

Prerequisite: ENEE460 and MATH463; or students who have taken courses with comparable content may contact the department.

General systems models. State variables and state space. Linearity and its implications. Controllability and observability. State space structure and representation. Realization theory and algorithmic solutions. Parameterizations of linear systems; canonical forms. Basic results from stability theory. Stabilizability. Fine structure of linear multivariable systems; minimal indices and polynomial matrices. Interplay between frequency domain and state space.

ENEE690**: Quantum and Wave Phenomena with Electrical Application (3 credits) P/M**

Prerequisite: ENEE381; or students who have taken courses with comparable content may contact the department.

Introduction of quantum and wave phenomena from electrical engineering point of view. Topics included: general principles of quantum mechanics, operator algebra, the microwave resonant cavity and the analagous potential well problem, harmonic oscillator, hydrogenic atom. Perturbation method applied to the transmission line and potential well problems. Periodically loaded transmission line and Kronig-Penny model of band theory.

***ENPM600:* Probability and Stochastic Processes for Engineers (3 credits) P/M**

Prerequisite: Undergraduate introduction to discrete and continuous probability.

Axioms of probability; conditional probability and Bayes' rule; random variables, probability distributions and densities; functions of random variables; definition of stochastic process; stationary processes, correlation functions, and power spectral densities; stochastic processes and linear systems; estimation and optimum filtering. Applications in communication and control systems, signal processing, and detection and estimation.

***EPIB655*: Longitudinal Data Analysis (3 credits) P/M**

Prerequisite: EPIB651

Statistical models for drawing scientific inferences from longitudinal data, longitudinal study design, repeated measures and random effects to account for experimental designs that involve correlated responses, handling of missing data.

***MATH420*: Mathematical Modeling (3 credits) P/M**

Also offered as: AMSC420

Prerequisite: MATH240 or MATH461 or MATH341 and MATH241 or MATH340 and MATH246, or MATH341 and STAT400 And CMSC106 or CMSC131 or students who have taken courses with comparable content may contact the department.

The course will develop skills in data-driven mathematical modeling through individual and group projects. Emphasis will be placed on both analytical and computational methods, and on effective oral and written presentation of results.

***MATH461*:Linear Algebra for Scientists and Engineers (3 credits) P/M**

Prerequisite: Minimum grade of C- in MATH141; and must have completed any MATH or STAT course with a prerequisite of MATH141.

Credit only granted for: MATH240, MATH341, or MATH461

Additional information: This course may not be used towards the upper level math requirements for MATH/STAT majors.

Basic concepts of linear algebra. This course is similar to MATH 240, but with more extensive coverage of the topics needed in applied linear algebra: change of basis, complex eigenvalues, diagonalization, the Jordan canonical form.

***Math689, STAT689, AMSC689:* Research Interactions in Mathematics (1credit) P/M**

***PHYS615*: Nonlinear Dynamics of Extended Systems (3 credits) P/M**

Prerequisite: PHYS601.

Theory and applications of nonlinear dynamics of extended systems including nonlinear waves, pattern formation, turbulence, self-organized criticality and networks. Additional topics to be selected by instructor from areas of current research.

***PSYC602:*Quantitative Methods (4 credits) P/M**

Prerequisite: PSYC601

A continuation of PSYC 601. Topics include experimental design, analysis of variance, analysis of covariance, multiple regression, and general linear models.

***PHYS798D:* Special Problems in Advanced Physics; Applied Dynamics Seminar (1 Credits) P/M**

Also offered as ENEE698D. Credit granted ENEE698D or PHYS798D.

***STAT650:* Applied Stochastic Processes (3 credits) P/M**

Prerequisite: STAT410; or students who have taken courses with comparable content may contact the department.

Basic concepts of stochastic processes. Markov processes (discrete and continuous parameters), Random walks, Poisson processes, Birth and death processes. Renewal processes and basic limit theorems. Discrete time martingales, stopping times, optional sampling theorem. Applications from theories of stochastic epidemics, survival analysis and others.

***STAT741:* Linear Statistical Models II (3 credits) P/M**

Prerequisite: STAT740

Continuation of STAT 740. Multiway layouts, incomplete designs, Latin squares, complete and fractional factorial designs, crossed and nested models. Balanced random effects models, mixed models, repeated measures.General mixed model, computational algorithms, ML and REML estimates. Generalized linear models, logistic and loglinear regression.*Offered Spring only.*