High-resolution, high-throughput, and dynamic imaging and sequencing data is the substrate of modern biology. In this course we learn how to perform experiments, and computational work with, analyze, and make sense of experimental dataset using fundamental principles of mathematics, statistics, and physics. No formal course prerequisites. Programming in python.

ES_APPM 395-0 Special Topics (1 Unit)

ES_APPM 398-0 Introduction to Applied Math Research (0 Unit)
This is a seminar course where ESAM faculty present their current and planned research topics in applied mathematics.

ES_APPM 401-0 Options Pricing: Theory and Applications (1 Unit)
Consideration of ordinary and elementary partial differential equations models of problems in science and engineering, arising in various areas of application.
Prerequisites: Permission of instructor and department.

ES_APPM 411-1 Differential Equations of Mathematical Physics (1 Unit)

ES_APPM 411-2 Differential Equations of Mathematical Physics (1 Unit)

ES_APPM 411-3 Differential Equations of Mathematical Physics (1 Unit)

ES_APPM 412-0 Methods of Nonlinear Analysis (1 Unit)

ES_APPM 420-1 Asymptotic and Perturbation Methods in Applied Mathematics (1 Unit)

ES_APPM 420-2 Asymptotic and Perturbation Methods in Applied Mathematics (1 Unit)

ES_APPM 420-3 Asymptotic and Perturbation Methods in Applied Mathematics (1 Unit)

ES_APPM 421-1 Models in Applied Mathematics (1 Unit)
Applications to illustrate typical problems and methods of applied mathematics. Mathematical formulation of models for phenomena in science and engineering, problem solution, and interpretation of results. Examples from solid and fluid mechanics, combustion, diffusion phenomena, chemical and nuclear reactors, and biological processes.

**ES_APPM 425-0 Theory of Flows With Small Inertia (1 Unit)**
Asymptotic methods for flows with small inertia: flows past bodies and matching procedures. Slowly varying flows: lubrication theory and Hele-Shaw flow; swimming of microorganisms and suspension of particles.

**ES_APPM 429-0 Hydrodynamic Stability Theory (1 Unit)**
Mathematical theory of hydrodynamic states; energy methods, linear theories, and nonlinear bifurcation theories. Convective, centrifugal, and shear flow instabilities. Instability of unsteady flows and systems having interfaces. Physical mechanisms and results of experiments.

**ES_APPM 430-0 Wave Propagation (1 Unit)**

**ES_APPM 440-0 Integral Equations & Applications (1 Unit)**

**ES_APPM 442-0 Stochastic Differential Equations (1 Unit)**
Brownian motion and Langevin’s equation. Ito and Stratonovich stochastic integrals. Stochastic calculus and Ito’s formula. SDEs and PDEs of Kolmogorov, Fokker-Planck, and Dynkin. Boundary conditions, exit times, exit distributions, stability. Asymptotic analysis of SDE, the Smoluchowski-Kramers approximation, and diffusion approximation to Markov chains. Applications.

**ES_APPM 444-0 High Performance Scientific Computing (1 Unit)**
Solving partial differential equations using high performance computing platforms. Basic C programming. Distributed computing using MPI. GPU programming using CUDA. Adaptation of algorithms for solving PDE’s to different architectures.

**ES_APPM 445-0 Iterative Methods for Elliptic Equations (1 Unit)**
Analysis and application of numerical methods for solving elliptic equations. Stationary iterative, multigrid, conjugate gradient, GMRES methods and preconditioners.

**ES_APPM 446-1 Numerical Solution of Partial Differential Equations (1 Unit)**

**ES_APPM 446-2 Numerical Solution of Partial Differential Equations (1 Unit)**

**ES_APPM 447-0 Boundary Integral Method (1 Unit)**

**ES_APPM 448-0 Numerical Methods for Random Processes (1 Unit)**
Analysis and implementation of numerical methods for random processes: random number generators, Monte Carlo methods, Markov chains, stochastic differential equations, and applications.

**ES_APPM 449-0 Numerical Methods for Moving Interfaces (1 Unit)**
Methods for simulating sharp interfaces. Marker particle, level set, fast marching, volume of fluid, and phase fields methods.

**ES_APPM 451-0 Mathematical Models in Biology (0.5 Unit)**
This half-credit course discusses classical mathematical models of biological systems, with emphasis on the modeling process. Modeling tools used include ordinary and partial differential equations as well as agent-based frameworks. Topics may include chemotaxis, cellular aggregation, morphogenesis, and other classical systems that lend themselves to mathematical modeling. No biological background is required.

**ES_APPM 470-0 Introduction to the Analysis of RNA Sequencing Data (1 Unit)**
This course is an introduction to the theory and practice of analyzing high-throughput RNA sequencing data. This includes working with data up to and including a differential expression analysis, and troubleshooting issues. The course will also cover some of the theory, i.e., we will discuss the mathematical and statistical assumptions made in order to perform the various steps described above.

**ES_APPM 475-0 What Do Your Data Say? A course to help you better understand your data. (1 Unit)**
Modern data streams, whether from biomedical research labs, environmental research teams, or social-media survey projects, are increasingly quantitative and noisy. In this class, we will teach you to think quantitatively and statistically about your data, so that you can confidently answer the question "What do my data (actually) say?"

**ES_APPM 479-0 Data Driven Methods for Dynamical Systems (1 Unit)**
The course will survey methods for characterizing time-series data by reading and discussing primary literature and implementing and testing methods. Students will simulate time-series from deterministic, chaotic, and stochastic systems and apply a range of data-driven methods. The goal is to understand the suitability of different methods for characterizing dynamical systems with noise, nonlinearities, and other characteristics.

**ES_APPM 495-0 Selected Topics in Applied Mathematics (0.5-1 Unit)**
Topics selected from research of current interest in applied mathematics.

**ES_APPM 499-0 Projects (1 Unit)**
Special projects to be carried out under faculty direction. Permission of instructor and department required.

**ES_APPM 519-0 Responsible Conduct of Research Training (0 Unit)**

**ES_APPM 550-0 Research (1-4 Units)**
Independent investigation of selected problems pertaining to thesis or dissertation. May be repeated for credit.