Applied Science

PROFESSORS **Bradley** (Chair), **Hinders, Kelley, Manos,** and **Vold.** ASSOCIATE PROFESSORS, **Luepke, Lukaszew,** and **Smith.** ASSISTANT PROFESSORS **Del Negro, Shaw.** COURTESY PROFESSORS **Johnson, Kincaid, Kossler, Krakauer, Kranbuehl, Leemis, Li, Orwoll, Saha, Tracy,** and COURTESY ASSOCIATE PROFESSORS **Poutsma, Swaddle, Tian** and **Zhang.** ADJUNCT PROFESSORS **Dylla, Madaras, Mattauch, Tait,** and **Winfree.** ADJUNCT ASSISTANT PROFESSORS **Silva,** and **Weisenberger.**

Applied Science is an interdisciplinary graduate department that offers M.S. and Ph.D. degrees in the physical and biological sciences. Courses are offered cooperatively by the core faculty of Applied Science along with affiliated faculty from the Departments of Biology, Chemistry, Computer Science, Mathematics, Physics, and the Virginia Institute of Marine Sciences (VIMS), as well as from the NASA Langley Research Center (LaRC) and the Thomas Jefferson National Accelerator Facility (Jefferson Lab). In Applied Science we use the tools, the techniques, and the understanding involved in a wide range of sciences in order to solve complex scientific and technical problems. The Department has state-of-the-art facilities in: (1) experimental and computational analysis of physical and biological systems including neuroscience; (2) materials synthesis and characterization of small molecules, polymers, inorganics, and composites; (3) modification and evaluation of interfaces; (4) processing of materials and surface; and (5) imaging technology and theory from nano to planetary scales.

The Applied Science department does not offer an undergraduate major. A Minor in Applied Science is offered with a track in either Computational Biology or Materials Science.

Requirements for Minor

Required Credits: 18 hours

Core requirements: Six designated courses (see below), including independent research (at least 2 credits) Required Research Experience: APSC 402 or 404 or 495-496 (2 up to 4 credits), or pre-approved Senior Research projects from other departments. Two tracks are available:

TRACK ONE: COMPUTATIONAL AND MATHEMATICAL BIOLOGY. Take 2 of 3 required courses: APSC 451 Cellular Biophysics and Modeling; APSC 452 Self-organization in Life and Chemical Sciences; APSC 454 Bioinformatics and Molecular Evolution. Additional courses may be selected from the following: APSC 312 Medical Imaging; MATH 302 Ordinary Differential Equations; MATH 345 Mathematical Biology; MATH 351 Applied Statistics; CHEM 341 Principles of Biophysical Chemistry; BIOL 404 Topics in Biotechnology; BIOL 406 Molecular Cell Biology; BIOL 442 Molecular Genetics; MATH 441/442 Introduction to Applied Mathematics, BIOL401 Evolutionary Genetics, BIOL 425 Biostatistics, BIOL 448 Evolutionary Biology; and topics courses in mathematical biology (with permission). Additional APSC Graduate courses that may be taken and counted with instructor permission: APSC 631 Applied Cellular Neuroscience; APSC 632 Applied Systems Neuroscience; APSC751 Mathematical Physiology I; APSC 752 Mathematical Physiology II.

TRACK TWO: MATERIALS SCIENCE. Take 3 required courses: APSC 201 Materials Science; APSC 301 Mechanics of Materials; APSC 302 Applied Quantum Mechanics. Additional courses may be selected from the following: APSC 327 Lasers in Biomedicine; APSC 437 Intro to Medical Imaging; APSC or CHEM 411 Polymer Chemistry I; APSC or CHEM 412 & 416 Polymer Chemistry II; APSC 422 Intro Materials Characterization; APSC 474 Continuum Mechanics; CSCI 426 Simulation; MATH 441 or 442 Applied Mathematics I & II; PHYS 475 Mathematical Physics. Additional APSC Graduate courses that may be taken and counted with instructor permission: APSC 623 Intro. to Solid Surfaces and Interfaces; APSC 607 Mathematical and Computational Methods; APSC 621 Principles of Materials Science; APSC 627 Lasers in Medicine, Science, and Technology; APSC 637 Intro. to Optoelectronics. APSC 671 Solid State Nuclear Magnetic Resonance.

Description of Courses

150,150W. Freshman Seminar.
Fall and Spring (3-4) Hinders.

A course designed to introduce freshmen to specific topics in the study of applied science. 150W satisfies the lower-level writing requirement.

Astrophotography. *Vold.*
This course will focus on identifying suitable night sky objects for amateur astronomers to photography through small telescopes, and on the type of scientific information obtainable by such methods using professional equipment.

The Shape of Things. *Manos.*
This course is an introduction to material science that will appeal to science majors and to students who do not plan to become scientists or engineers. Students will read extensively about forms and structures which occur most frequently in natural and man-made objects seeking the reasons for common patterns that occur. Topics from outside the usual materials science and engineering mainstream, including materials used in art, architecture or biological systems will be encouraged.

Recycling Technology. *Kelley.*
While most agree that recycling is desirable, implementation continues to face growing issues. Using a nearby city as a case study, this course investigates technology, economics, and policy issues and the students work as a team with city staff to develop and present an improved recycling plan, each class member being responsible for specific areas.

Applied Pseudoscience. *Hinders.*
This course offers a brief introduction to the scientific method, and then explores systematically a variety of paranormal phenomena (UFOs, ESP, Bermuda Triangle, etc.). It will help students to distinguish between legitimate scientific discoveries and the bogus claims of tricksters and fools.

201. Introduction to Materials Science.
Spring (3) Hinders.

An introduction to the chemical and physical aspects of materials. Topics include structural, mechanical, electrical, and thermal properties of materials. Applications are stressed.

275W. University Seminar.
Fall and Spring (4) Staff.

A reading-, writing-, and discussion-intensive seminar. Topics vary by semester and by instructor. Restricted to transfer students and co-enrolled students Students receiving a grade of "C-" or better in the seminar will have satisfied the lower-division writing requirement. This course does not fulfill the Freshman Seminar requirement.

301. Mechanics of Materials.
Fall (3) Hinders.

Introduction to the concepts of stress and strain applied to analysis of structures. Development of problem solving ability for modeling and analysis of simple structures subject to axial, torsional, and bending loads, and physical intuition of realistic outcomes.

302. Applied Quantum Mechanics.
Spring (3) Staff.

The applications of quantum mechanics to problems in materials science, with particular reference to quantum descriptions of solid state phenomena and the use of spectroscopy as a tool for materials characterization.

312. Medical Imaging.

Spring (3) Hinders. Prerequisites: PHYS 101/102 or PHYS 107/108.

Introduction to the modern clinical non-invasive diagnostic imaging techniques. The course will cover the physical, mathematical and computational principles of x-ray, ultrasound, radionuclide and magnetic resonance imaging techniques.

327. Introduction to Laser Biomedicine.

Spring (3) Luepke. Prerequisites: Junior standing or consent of instructor.

The course will build a foundation for understanding the use of lasers in biology and medicine. There will be particular emphasis on laser beam interactions with human tissue for diagnosis, therapy, and surgery, with additional attention to optical coherence tomography, two-photon microscopy, fluorescent imaging, optical tweezers, and refractive surgery.

401,402. Research in Applied Science.

Fall or Spring (1-3,1-3) Staff. Prerequisites: consent of the instructor.

Independent experimental or computational research under supervision of a faculty member. Hours to be arranged.

403,404. Independent Study in Applied Science.

Fall or Spring (1-3,1-3) Staff. Prerequisites: consent of the instructor.

Independent study under supervision of a faculty member. Hours to be arranged.

411. Polymer Science I.

Fall (3) Staff. Prerequisites: CHEM 209, CHEM 301.

An introduction to the chemical aspects of polymer science at the molecular level. Topics include the preparation, modification, degradation and stabilization of polymers. Reaction mechanisms are stressed.

412. Polymer Science II.

Spring (3) Kranbuehl. Prerequisite: CHEM 301.

An introduction to the physical aspects of polymer science at the molecular level. Topics include the properties of polymers in building and in solution, conformational analysis, viscoelasticity and rubber elasticity.

416. Polymer Laboratory.

Spring (1) Staff. Prerequisite or Corequisite: APSC 411 or APSC 412.

A series of experiments in polymer synthesis, solution characterization, and mechanical and thermal properties of polymers.

422. Introduction to Materials Characterization.

Spring (3) Kelley. Prerequisite: Background in physical sciences.

Science and technology of determining surface and bulk structure and composition of organic and inorganic materials under instrument and 'in-situ' conditions. Examples chosen appropriate to class interests.

431. Applied Cellular Neuroscience.

Fall (3) Del Negro. Prerequisite BIOL 345.

We examine cellular neurophysiology including membrane potentials, ion channels and membrane permeability, electrical signaling and cable properties, synaptic transmission, neuromodulation, and second messenger systems. We apply these concepts to motor control, homeostatic regulation, special senses.

432. Applied Systems Neuroscience.

Spring (3) Del Negro. Prerequisites: BIOL 345, BIOL 447, PSYC 313.

We explore how behaviors arise due to multiple levels of organization in the nervous system. Topics include: reflexes, central pattern generator networks, neural control of breathing, the neural control of appetite, body weight and obesity, and the neuropharmacology of nicotine addiction.

446. Introduction to Mathematical Physics.

Spring (3) Staff.

Vector analysis, complex variables, matrices, and series solutions of differential equations, orthogonal functions and partial differential equations. (Cross listed with PHYS 475)

451. Cellular Biophysics and Modeling.

Fall (3) Smith. Prerequisite: MATH 112 or 113, BIOL 203, or consent of instructor.

An introduction to simulation and modeling of dynamic phenomena in cell biology and neuroscience. Topics covered will include the biophysics of excitable membranes, the gating of voltage- and ligand-gated ion channels, intracellular calcium signaling, and electrical bursting in neurons. (Cross listed with BIOL 451)

452. Self-Organization in Life and Chemical Sciences

Spring (3) Del Negro and Bagdassarian.

Here we investigate self-organization and complex collective behaviors that emerge from simple dynamical principles in a variety of living and chemical systems. We consider, for example, oscillatory chemical reactions, single-celled organisms and their communal behaviors, as well as the spread of HIV in human populations using agent-based computer simulation to model and analyze these systems. The course culminates in a final research project wherein students, in consultation with the instructors, develop and analyze their own original model. (Cross listed with BIOL 452)

453. Cellular Signaling in MATLAB.

Spring (3) Smith. Prerequisite: MATH 112 OR 113, BIOL 203, or consent of instructor.

An introduction to computer modeling of cell signal transduction, that is, how cells convert external stimuli such as hormones and neurotransmitters into an integrated and coordinated intracellular response. Topics covered include: binding of ligand to receptors, ion channels and electrical signals, metabotropic signaling (G protein coupled receptors, effector molecules, second messengers), intracellular calcium dynamics, and sensory transduction in the visual and auditory systems. Each topic will be introduced from the biological perspective and studied by simulation using MATLAB. Prior experience with mathematical and computer modeling is not required.

454. Bioinformatics and Molecular Evolution.

Spring (3) Smith. Prerequisite: MATH 112 or 113, BIOL 203, or consent of instructor.

An introduction to computational molecular biology and molecular evolution including nucleotide and amino acid sequence comparison, DNA fragment assembly, phylogenetic tree construction and inference, RNA and protein secondary structure prediction and substitution models of sequence evolution. (Cross listed with BIOL 454)

474. Continuum Mechanics.

Spring (3) Hinders.

This course covers the basic concepts of mechanics and thermodynamics of continua, including conservation of mass, momentum and energy; stresses and strains; viscous fluids, elasticity and thermal stresses; viscoelasticity and creep; ultimate failure; introduction to plasticity; elastic waves and elastodynamics.

490. Studies in Applied Science.

Fall and Spring (1-5) Staff.

Advanced or specialized topics in Applied Science. Subjects, prerequisites, credits and instructors may vary from year to year. Course may be repeated for credit if the instructor determines that there will not be a duplication of material.

†495-496. Honors.

Fall, Spring (3) Staff. Prerequisite: Senior standing, an overall GPA of 3.0, and consent of the instructor.

Independent laboratory or computational research in applied science under the supervision of a faculty member. Students are required to write an Honors thesis based on a review of the literature and their research. For College provisions governing the Admission to Honors, see catalog section titled Honors and Special Programs.

†498. Internship.

Fall, Spring, and Summer (1-5) Bradley.

Research in accelerator science, atmospheric science, polymer science or quantitative materials characterization at the NASA-Langley Research Center in Hampton or the Thomas Jefferson National Accelerator Facility (TJNAF) in Newport News. Approval of the Chair of Applied Science is required prior to enrollment.