

DEPARTMENT OF APPLIED PHYSICAL SCIENCES

The Department of Applied Physical Sciences expands interdisciplinary research and teaching by strengthening an intellectual climate in which science is collaborative and focused on applications. The department has connections among disciplinary departments across the natural sciences. The doctoral graduate program in materials science is housed in the department. The department offers undergraduate courses and a minor in applied sciences and engineering. APS is also home to BeAM (<https://beam.unc.edu>) (Be A Maker), the UNC network of makerspaces.

Minor

- Applied Sciences and Engineering Minor (<http://catalog.unc.edu/undergraduate/programs-study/applied-sciences-engineering-minor/>)

Graduate Programs

- Ph.D. in Materials Science (<https://aps.unc.edu/graduate-program-overview/>)

Professors

Theo J. Dingemans (APS), High-Performance Polymers and (Nano)composites.

Greg Forest (Mathematics), Flow and Structure of Complex Polymeric Fluids.

Jinsong Huang (APS), Perovskite Solar Cells, Photodetectors, X-ray Imaging, Radiation Detectors, Electronic Devices.

Rene Lopez (Physics and Astronomy – APS), Optical Materials, Photonic Structures, Photovoltaics.

Peter Mucha (Mathematics), Complex Systems, Networks, Complex Fluids.

Richard Superfine (APS), Biological Physics, Soft Matter, Biomedical Device Technologies.

Sean Washburn (Physics and Astronomy – APS), Quantum Transport, Mechanical and Electrical Response of Nanostructures.

Associate Professor

Ronit Freeman (APS), Development of Novel Designer Materials Using Self-Assembling Biological Components.

Daphne Klotsa (APS), Computational Soft and Active Matter.

Teaching Associate Professors

Richard Goldberg (APS), Assistive Technology, Rehabilitation Engineering, Engineering Education.

Glenn Walters (APS), Instrumentation for Innovation, BeAM Design Center, Engineering Education.

Assistant Professors

Wubin Bai (APS), Bioelectronics, Soft Materials, Advanced Manufacturing, Microsystems, Electronic Materials, Photonic Materials, and Biomaterials

Ehssan Nazockdast (APS), Modeling/Simulation of Biophysical Phenomena.

Nico Pegard (APS), Computational Optics, Imaging Systems, Optical Instrumentation and Digital Interfaces for Systems Biology and Neuroscience.

Scott Warren (Chemistry – APS), Supramolecular and Solid-State Chemistry for Materials Design.

Zijie Yan (APS), Optical Trapping and Manipulation, Holography, Microfluidics, Electronic and Photonics Nanomaterials.

Affiliated Faculty

James Cahoon (Chemistry), Nanoparticle Synthesis and Characterization.
Orlando Coronell (Environmental Sciences and Engineering), Wet Chemistry, Polymer Synthesis, Membrane Systems.

Joseph M. DeSimone (Chemistry), Polymeric Materials Synthesis.


J. Michael Ramsey (Chemistry), Analytical Chemistry, Microfabricated Chemical Instrumentation, Microfluidics, Nanofluidics.

Edward T. Samulski (Chemistry – APS), Liquid Crystals and Liquid Crystal Polymers.

Wei You (Chemistry), Organic and Polymer Synthesis, Organic Solar Cells, Molecular Electronics, Organic Spintronics.



Advanced Undergraduate and Graduate-level Courses

 **APPL 89. First-Year Seminar: Special Topics. 3 Credits.**
Special topics course. Content will vary each semester.

Rules & Requirements

 **IDEAs in Action Gen Ed: FY-SEMINAR.**

Grading Status: Letter grade.

APPL 101. Exploring Engineering. 3 Credits.

This course will explore fundamental engineering skills and the implications of engineering solutions. You will "learn how to learn" because technology changes rapidly and today's tools may soon be obsolete. The course will help you develop an entrepreneurial mindset to understand the larger context of solutions. A lot of class time is working time. For example, we will write computer programs to simulate real world systems. We will debate ethical issues associated with engineering innovations.

Rules & Requirements

Requisites: Prerequisites, COMP 110, 116, or other programming experience.

Grading Status: Letter grade.

 **APPL 110. Introduction to Design and Making: Developing Your Personal Design Potential. 3 Credits.**

Students work in flexible, interdisciplinary teams to assess opportunities, brainstorm, and prototype solutions. Design thinking and physical prototyping skills are developed through fast-paced, iterative exercises in a variety of contexts and environments.

Rules & Requirements

 **IDEAs in Action Gen Ed: FY-LAUNCH (only designated sections), FC-CREATE.**

Making Connections Gen Ed: VP.

Grading Status: Letter grade.

APPL 112. Practical Electronics for Everyone. 1 Credits.

Design and fabrication for practical electronics circuits, including interfacing with sensors and actuators. Previously offered as APPL 411.

Rules & Requirements

Grading Status: Pass/Fail.

APPL 113. LabView for Data Acquisition. 1 Credits.

The basics of data acquisition and hardware interfacing using LabVIEW graphical programming. Previously offered as APPL 413.

Rules & Requirements

Grading Status: Pass/Fail.

APPL 114. Arduino Bootcamp: A deep introduction for beginners. 0.5 Credits.

This course is for anyone - student, researcher, hobbyist, etc. - who has an interest in getting into the world of electronics and micro-controllers. No prior experience is required. By the end of this class, you will be able to create and program simple systems that allow coordination of real-world inputs (lights, sound, motion, etc.). You will also be able to demonstrate how these systems can be used to implement complex behavior in custom-designed systems.

Rules & Requirements

Grading Status: Pass/Fail.

APPL 115. Raspberry Pi Bootcamp. 1 Credits.

Learn how to use the premier microcontroller platform known as the Raspberry Pi (RPi)! This course is for anyone with an interest in programming, microcontrollers, and basic electronics. Prior experience with simple analog electronics (circuit-building) and the Arduino platform is recommended.

Rules & Requirements

Requisites: Prerequisite, APPL 114 or permission of instructor; APPL 112 is not a required prerequisite but is strongly encouraged.

Grading Status: Pass/Fail.

APPL 116. Electronics for Measurement, Control, and the Internet of Things. 1 Credits.

This course builds on APPL 112. Students will acquire signals from sensors and send them to an Arduino or other microcontroller. Students will also learn how to develop circuits that are part of the "Internet of Things" so that they can transmit sensor readings on the Internet. Most of the class time will be hands-on activities. Previously offered as APPL 414.

Rules & Requirements

Requisites: Prerequisite, APPL 112; permission from the instructor for students lacking the prerequisite.

Grading Status: Pass/Fail.

APPL 121. 3D Printing Technology and Practice. 1 Credits.

3D Printing, or additive manufacturing (AM), is used broadly from manufacturing to medical research. AM will play an increasingly large role in virtually all areas of research, industry, and commerce with new technologies and significant improvements occurring continually. The course will delve into major existing and developing technologies. We will explore design elements for AM, motion control and imaging technologies, materials performance and selection, and the physics of parts production. Previously offered as APPL 418.

Rules & Requirements

Grading Status: Pass/Fail.

APPL 190. Special Topics in Applied Physical Sciences. 3 Credits.

Specialty topics in applied physical sciences for undergraduates.

Rules & Requirements

Repeat Rules: May be repeated for credit. 12 total credits. 1 total completions.

Grading Status: Letter grade.

APPL 215. Design and Fabrication of Fluids Monitoring Devices. 1 Credits.

Review of fluid mechanics including the fundamentals of pressure/flow relationships, fluid properties, and flow regimes. Students will design and create physical prototypes that demonstrate specific concepts and measure defined parameters. Students will use the BeAM makerspace network to make things that illustrate fluid device design. Class time includes exercises to reinforce concepts and a guided design activity to create a physical device. Required preparation: BeAM orientation, laser training, 3D-printer training. Previously offered as APPL 475.

Rules & Requirements

Grading Status: Pass/Fail.

APPL 240. Developing Your Sixth Sense: Designing Sensors and Electrical Circuits to Make Measurements. 3 Credits.

Learn how to analyze, design, and build systems. Model and understand how physical and environmental parameters of sensors work and interact with electrical circuits. Learn the basics of circuit design and analysis to amplify and "clean up" the signals with filters. Learn how to acquire these signals to a computer through data acquisition hardware and LabView software. Develop an entrepreneurial mindset to understand the economic, environmental, and ethical issues that affect your system design.

Rules & Requirements

Requisites: Prerequisite, PHYS 105, 115, 117, or 119.

Grading Status: Letter grade.

APPL 260. Materials Science and Engineering: Living in a Material World. 3 Credits.

This course will be an introduction to topics in materials science and with a strong focus on materials, processing and engineering and how design plays a pivotal role in materials selection. A central theme will be in-class demonstrations and hands-on experiments so you will experience first-hand why materials do what they do and how to select the appropriate material for the right application. It's a materials world after all!

Rules & Requirements

Requisites: Prerequisites, CHEM 102, and PHYS 116 or PHYS 118; permission of the instructor for students lacking the prerequisites.

Grading Status: Letter grade.

APPL 285. Fluid Relationships: An Intuition Building Approach to Fluid Mechanics. 3 Credits.

Immersive treatment of concepts and methods of fluid mechanics - the study of fluids at rest and in motion. This course provides a solid grounding in the fundamentals and applications of fluid mechanics through extensive hands-on exercises. Topics include pressure, pressurized flow, gravity flow, viscous flow, boundary layers, system losses, microfluidics, and measurement techniques. Includes exposure to standard fluid appurtenances such as pumps, blowers, gauges, valves, ducts, pipes, and fittings. Previously offered as APPL 280.

Rules & Requirements

Requisites: Prerequisites, APPL 110, and PHYS 114 or 118; permission of the instructor for students lacking the prerequisites.

Grading Status: Letter grade.

APPL 290. Special Topics in Applied Physical Sciences. 3 Credits.
Specialty topics in applied physical sciences for undergraduates.

Rules & Requirements

Repeat Rules: May be repeated for credit. 12 total credits. 4 total completions.

Grading Status: Letter grade.

APPL 295. Research in Applied Physical Sciences. 1-3 Credits.

A research experience provides students with practical experience in a research lab, performing work that is relevant to their UNC education. The research internship will develop and enhance the students' professional skill set and involve experiences that allow students to have responsibility for results that are of value to the research laboratory.

Rules & Requirements

Repeat Rules: May be repeated for credit. 6 total credits. 6 total completions.

Grading Status: Letter grade.

APPL 296. Independent Study in Applied Sciences and Engineering. 1-3 Credits.

Through independent study, students gain practical experience in an independent project either on campus or off campus, performing work that is relevant to their studies in Applied Physical Sciences. The independent study will develop and enhance the students' professional skill set and involve experiences that enhance their entrepreneurial mindset. Students are mentored by a faculty member and others at UNC who have relevant expertise.

Rules & Requirements

Repeat Rules: May be repeated for credit. 6 total credits. 6 total completions.

Grading Status: Letter grade.

APPL 350. Data Science for Applied Science and Engineering. 3 Credits.

This course brings together mathematical, statistical, and computational methods for representing data and machine learning that are of particular interest for studying different systems across applied science and engineering. Topics will include dimensionality reduction, transforms, clustering, classification, and neural networks. Course activities will emphasize both the underlying mathematical framework and the ability to perform these data analyses in different computational environments. This class will require you to participate actively in class computations and discussion.

Rules & Requirements

Grading Status: Letter grade.

APPL 385. Transport: Flow of Force, Matter and Energy through the Biosphere. 3 Credits.

Flow and movement of matter, force and energy are ubiquitous in every aspect of life on our biosphere, from our motile cells that transfer chemical energy to motion to the flow and mixing of air and water in the atmosphere and the oceans. By studying different examples, we will see throughout the course that the flow of mass, momentum and energy can be analyzed in a single framework known as Transport Phenomena in science.

Rules & Requirements

Requisites: Prerequisite, MATH 233.

Grading Status: Letter grade.

APPL 390. Special Topics in Applied Physical Sciences. 3 Credits.

Permission of the instructor. Advanced specialty topics in applied physical sciences for undergraduates.

Rules & Requirements

Repeat Rules: May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 4 total completions.

Grading Status: Letter grade.

APPL 405. Convergent Engineering: Team-Science Approaches to Discovery and Innovation. 3 Credits.

Students will participate in activities, group discussion, and problem-solving coaching to understand how chemistry, physics, materials science, and biology are applied to engineering. Topics are introduced through discussing relevant scientific literature, and guest lecturers and faculty discuss expertise in fields like mathematical modeling, mechanical engineering, or circuit design. Guest lecturers can provide new perspective on the problems so students gain an interdisciplinary view of the subject.

Rules & Requirements

Grading Status: Letter grade.

 **APPL 412. Turning Your Entrepreneurial Ideas Into Reality. 3 Credits.**

Students will work in groups on a semester project to turn their entrepreneurial ideas into reality.

Rules & Requirements

 **IDEAs in Action Gen Ed:** FC-CREATE.

Making Connections Gen Ed: EE- Field Work.

Requisites: Prerequisite, APPL 110; permission of the instructor for students lacking the prerequisite.

Grading Status: Letter grade.

APPL 420. Introduction to Polymers. 3 Credits.

Chemical structure and nomenclature of macromolecules, synthesis of polymers, characteristic polymer properties.

Rules & Requirements

Requisites: Prerequisite, CHEM 261 or 261H; pre- or corequisites, CHEM 262 or 262H, and 262L or 263L.

Grading Status: Letter grade.

Same as: CHEM 420.

APPL 421. Synthesis of Polymers. 3 Credits.

Synthesis and reactions of polymers; various polymerization techniques.

Rules & Requirements

Requisites: Prerequisites, CHEM 251 and 262 or 262H.

Grading Status: Letter grade.

Same as: CHEM 421.

APPL 422. Physical Chemistry of Polymers. 3 Credits.

Polymerization and characterization of macromolecules in solution.

Rules & Requirements

Requisites: Prerequisites, CHEM 420 and 481.

Grading Status: Letter grade.

Same as: CHEM 422.

APPL 423. Intermediate Polymer Chemistry. 3 Credits.

Polymer dynamics, networks and gels.

Rules & Requirements

Requisites: Prerequisite, CHEM 422.

Grading Status: Letter grade.

Same as: CHEM 423.

APPL 430. Optical Instrumentation for Scientists and Engineers. 3 Credits.

This is an introduction to methods of automatic computation of specific relevance to biomedical problems. Sampling theory, analog-to-digital conversion, and digital filtering will be explored in depth. Previously offered as APPL 460.

Rules & Requirements

Requisites: Prerequisite, MATH 383.

Grading Status: Letter grade.

APPL 435. Nanophotonics. 3 Credits.

This course introduces the principles of nanophotonics - an emerging frontier at the nexus of nanotechnology and photonics that deals with light-matter interactions at the nanometer scale. The course will cover the theoretical foundations of nanoscale materials and optics, fabrication and characterization of optical nanostructures, plasmonics, nanomanipulation by optical tweezers, electrodynamic simulations, nanoscale light emitters, and applications of nanophotonics.

Rules & Requirements

Requisites: Prerequisite, PHYS 117 or 119.

Grading Status: Letter grade.

APPL 462. Engineering Materials: Properties, Selection and Design. 3 Credits.

This course will cover both fundamental and applied aspects of modern materials science. We will discuss how to select materials based on their properties and how they can be processed into products that you encounter in everyday life. A strong focus will be on the relationship between processing, structure (development), and properties of solid materials, such as metals, ceramics, and polymers.

Rules & Requirements

Requisites: Prerequisite, CHEM 102; or PHYS 116 or PHYS 118.

Grading Status: Letter grade.

APPL 463. Bioelectronic Materials. 3 Credits.

Developing electronic systems that can seamlessly integrate with biological systems represents a pivotal foundation for building a smart healthcare platform, advanced clinical technology, and beyond. Through multiple hands-on projects, this course will explore and discuss: 1) electronic materials, mechanisms, and designs at the biotic-abiotic interface, 2) their impacts for a wide range of applications ranging from medicine, robotics, to human augmentation, and 3) the associated ethics that aim to harmonize the development pathways.

Rules & Requirements

Requisites: Prerequisites, BMME 209 or APPL 260 or CHEM 102 and PHYS 115 or PHYS 119 and permission of the instructor.

Grading Status: Letter grade.

APPL 465. Sponge Bob Square Pants and Other Soft Materials. 3 Credits.

What kind of material is Sponge Bob made of? What about the slime of his pet snail, Gary? We are taught that there are three states of matter: solid, gas, and liquid. However, in our daily lives we encounter materials that challenge this simple description such as foams, pastes, gels, soap, and rubber. These are Soft Materials and in this course we will learn about their special properties.

Rules & Requirements

Grading Status: Letter grade.

APPL 470. Fundamentals of Materials Science. 3 Credits.

Crystal geometry, diffusion in solids, mechanical properties of solids, electrical conduction in solids, thermal properties of materials, phase equilibria.

Rules & Requirements

Requisites: Prerequisite, CHEM 482 or PHYS 128; Pre- or corequisite, PHYS 441.

Grading Status: Letter grade.

Same as: CHEM 470.

APPL 472. Chemistry and Physics of Electronic Materials Processing. 3 Credits.

Permission of the instructor. A survey of materials processing and characterization used in fabricating microelectronic devices. Crystal growth, thin film deposition and etching, and microlithography.

Rules & Requirements

Requisites: Prerequisite, CHEM 482 or PHYS 117 or 119.

Grading Status: Letter grade.

Same as: PHYS 472, CHEM 472.

APPL 473. Chemistry and Physics of Surfaces. 3 Credits.

The structural and energetic nature of surface states and sites, experimental surface measurements, reactions on surfaces including bonding to surfaces and adsorption, interfaces.

Rules & Requirements

Requisites: Prerequisite, CHEM 470.

Grading Status: Letter grade.

Same as: CHEM 473.

APPL 490. Special Topics. 1-3 Credits.

Topics vary from semester to semester.

Rules & Requirements

Repeat Rules: May be repeated for credit; may be repeated in the same term for different topics; 9 total credits. 9 total completions.

Grading Status: Letter grade.

APPL 491L. Materials Laboratory I. 2 Credits.

Structure determination and measurement of the optical, electrical, and magnetic properties of solids.

Rules & Requirements

Requisites: Prerequisites, APPL 470 and PHYS 351.

Grading Status: Letter grade.

Same as: PHYS 491L.

APPL 492L. Materials Laboratory II. 2 Credits.

Continuation of PHYS 491L with emphasis on low- and high-temperature behavior, the physical and chemical behavior of lattice imperfections and amorphous materials, and the nature of radiation damage.

Rules & Requirements

Requisites: Prerequisite, APPL 491L or PHYS 491L.

Grading Status: Letter grade.

Same as: PHYS 492L.

APPL 493. Internship in Applied Physical Sciences. 3 Credits.

An ideal internship provides students with practical experience in an organization outside of UNC, doing work that is relevant to their UNC education. The internship should develop and enhance the students' professional skill sets and involve experiences that allow students to have responsibility for results that are of value to the organization.

Rules & Requirements

Making Connections Gen Ed: EE- Academic Internship.

Grading Status: Letter grade.

APPL 495. Mentored Research in Applied Physical Sciences. 3 Credits.

Students undertake independent research with a faculty mentor. In order to register for this class, students must submit a learning contract and research proposal for approval. At the end of the semester, students submit a final report that describes their research. Students are encouraged to present their work either internally at UNC or externally at a conference or symposium.

Rules & Requirements

Making Connections Gen Ed: EE- Mentored Research.

Grading Status: Letter grade.

APPL 496. Independent Study in Applied Physical Sciences. 1-3 Credits.

Permission of the director of undergraduate studies is required. Independent study under a member of the applied physical sciences faculty. Approved learning contract required.

Rules & Requirements

Repeat Rules: May be repeated for credit. 6 total credits. 6 total completions.

Grading Status: Letter grade.

 **APPL 520L. Polymer Chemistry Laboratory. 2 Credits.**

Various polymerization techniques and characterization methods. One four-hour laboratory each week.

Rules & Requirements

 **IDEAs in Action Gen Ed:** RESEARCH.

Making Connections Gen Ed: EE- Mentored Research.

Requisites: Pre- or corequisite, CHEM 420 or 421 or 425.

Grading Status: Letter grade.

Same as: CHEM 520L.

APPL 573. Introductory Solid State Physics. 3 Credits.

Crystal symmetry, types of crystalline solids; electron and mechanical waves in crystals, electrical and magnetic properties of solids, semiconductors; low temperature phenomena; imperfections in nearly perfect crystals.

Rules & Requirements

Requisites: Prerequisite, PHYS 421; permission of the instructor for students lacking the prerequisite.

Grading Status: Letter grade.

Same as: PHYS 573.

APPL 590. Special Topics in Applied Physical Sciences. 3 Credits.

Advanced specialty topics in applied physical sciences for undergraduates and graduates.

Rules & Requirements

Repeat Rules: May be repeated for credit. 12 total credits. 4 total completions.

Grading Status: Letter grade.

APPL 690. Special Topics in Applied Physical Sciences. 3 Credits.

Advanced specialty topics in applied physical sciences for undergraduate and graduates.

Rules & Requirements

Repeat Rules: May be repeated for credit. 12 total credits. 4 total completions.

Grading Status: Letter grade.

APPL 710. Design and Making for the Researcher. 3 Credits.

In this course intended for graduate student researchers, we will parallel the discovery process taught in APPL 110: human-centered design, needs identification, and the iterative design and prototyping process. You will learn technical areas common to research laboratories - hardware selection, gas and liquid management, material compatibilities, electronics and data acquisition. In addition to the BeAM makerspace focused skills development activities, students will work on a personal project related to their laboratory work or research topic.

Rules & Requirements

Grading Status: Letter grade.

APPL 760L. Nanofabrication/micro-electromechanical systems (MEMS) Laboratory. 2 Credits.

Permission of the instructor. A laboratory course covering fabrication technologies for building materials and structures in biomedical devices, electronics, MEMS, and nanomedicine. The course includes lectures on thin film deposition, etching, and photolithography and hands-on laboratories to apply knowledge and practice skills covered in the lectures.

Rules & Requirements

Grading Status: Letter grade.

Material Science (MTSC)

Advanced Undergraduate and Graduate-level Courses

MTSC 615. Structure of Solids. 3 Credits.

Crystallography, reciprocal lattices, Bloch waves, band structure, electronic wave functions, phonons, thermal expansion. Superlattice structures, including liquid crystals. Overview of properties of ceramic, amorphous, polymeric, and composite materials.

Rules & Requirements

Grading Status: Letter grade.

Contact Information

Department of Applied Physical Sciences

Visit Program Website (<https://aps.unc.edu/apse-minor/>)

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