**GRADUATE ELECTIVES 2017-2018**

**COURSES IN *ITALICS*ARE REQUIRED (“CORE”) COURSES FOR THE DOCTORAL WRITTEN EXAM I.**

**FALL 2017**

**PHYS 405 Biophysics (R. Superfine)**

Biology succeeds in defining architecture, motion, response and replication through the generation of order and force from biochemistry. We will explore the fundamental thermodynamic and physical processes that underlie biological phenomena such as diffusion, entropy at the molecular and system level, electrostatics and hydrophobicity. These will form the basis for an understanding of self assembly and force generation that are responsible for molecular and cellular processes such as DNA replication and repair, intracellular transport and cell division. At the higher level of macromolecular assemblies, molecular machines are responsible for the construction of flagella and cilia, and for the manner in which these structures generate torque and force to propel organisms and fluid flow. We will explore the imaging technologies that have elucidated molecular and cellular structure such as electron, optical and atomic force microscopy. Measuring single molecule forces has been accomplished using atomic force microscopy, laser and magnetic tweezers and fluid flow. The overlying goal of the course is for us to understand the cell as a physical entity, and insist on understanding through principled mathematical models and precision measurements.

Pre-requisites: None

[Syllabus](https://physics.unc.edu/files/2017/04/PHYS405.pdf)

**PHYS 545 Particle Physics (J. Heckman)**

Textbook: Griffiths Particle Physics

Pre-requisites: undergraduate QM and EM

**ASTR 719 Astronomical Data (N. Law)**

The course is designed as an introduction to astronomical observing, with a focus on optical / infrared telescopes. The course is based on a practical approach to learning astronomical observing and data reduction, with hands-on experience. We will analyze existing astronomical datasets from large world-class observatories like UNC’s SOAR. Every student will use the PROMPT array to observe several objects (including attempting to detect an exoplanet transit).

Pre-requisites: an undergraduate course in general astronomy and some programming experience

[Syllabus](https://physics.unc.edu/files/2017/04/ASTR719.pdf)

**SPRING 2018**

**PHYS 415 Optics (A. Oldenburg)**

This is intended to be a first optics course for advanced undergraduates or beginning graduate students in STEM fields. It is designed as a survey course aiming to expose students to a broad array of topics in optics, with an emphasis on understanding over-arching concepts, general physical principles that dictate the behavior of light, as well as practical knowledge about common optical components and devices, and analytical tools for engineering simple optical systems. Because this is a mixed undergraduate-graduate course, I will attempt to present both basic concepts and advanced reasoning behind the principles in the same lecture; in many cases, the textbook reading jumps around in order to provide multiple levels of insight about the same topic. We will do a mixture of analytical and numerical problems, emphasizing topics of most interest to an experimentalist wishing to apply knowledge from this course to his/her laboratory.

Pre-requisites: Undergraduate EM I & II

[Syllabus](https://physics.unc.edu/files/2017/04/PHYS415.pdf)

**PHYS 594 Nonlinear Dynamics (J. Lu)**

This course will cover nonlinear differential equations and mappings, and their application to physics, chemistry, and biology. About the last third of the course will be on chaos. We’ll also do some computing, either online with codes that already exist, or in in a more extensive way.

The only real prerequisite for the course is a basic knowledge of differential equations. Knowledge of a programming language is useful, but not required.

[Syllabus](https://physics.unc.edu/files/2017/04/PHYS594.pdf) (from previous offering)

**PHYS 632 Advanced Research Techniques: Statistics, Data Analysis, Numerics (J. Wilkerson)**

Mo/We 9:05-10:20am

Methods required for the analysis, interpretation, and evaluation of physics measurements and theory. Error analysis, statistical tests, model fitting, parameter estimation, Monte Carlo methods, Bayesian inference, noise mitigation, experimental design, big data, selected numerical techniques including differential equations and Fourier techniques.

Pre-requisites: Students are expected to be able to program in a high-level computer language. Students lacking or uncertain about this prerequisite should contact the instructor for permission.

[Syllabus](https://physics.unc.edu/files/2017/11/syllabus_phys632.pdf)

***PHYS 712 Electromagnetic Theory (C. Evans)***

Mo/We 11:15am-12:30pm

**PHYS 722 Quantum Mechanics II (D. Khveshchenko)**

Tu/Th 11:00-12:15am

***PHYS 741 Statistical Mechanics (Y. Wu)***

Tu/Th 9:30-10:45am

**PHYS 822 Quantum Field Theory I (L. Dolan)**

We cover the scalar field, the Dirac fermion field, the abelian gauge field, with some mention of the non-abelian gauge field, and other p-form fields.  We study their Lagrangians, Hamiltonians, equations of motion, symmetries, conserved charges and currents, emphasizing Lorentz symmetry and its representation theory. We study their quantization, commutation relations, and normal mode expansions. We explain how a quantum field ties measurement by operators to a point in space-time, thus enabling quantum physics to be compatible with Einstein causality, by a suitable choice of commutation relations. We then study interacting fields via scattering perturbation theory, using Wick’s theorem and Feynman diagrams. We cover several scattering processes, including Coulomb and Compton scattering. Renormalization and counterterms are introduced. The path integral is introduced. Spontaneous symmetry breaking and the Higgs mechanism are introduced. We begin to relate these quantum fields to standard model physics.

Pre-requisites: PHYS 722

[Syllabus](https://physics.unc.edu/files/2017/04/PHYS822.pdf)

**PHYS 861 Nuclear Physics I (R. Henning)**

We/Fr 1:25-2:45pm

The intent of the course is to provide an overview of fundamental symmetries and neutrinos in nuclear physics. Many of the topics of interest are aimed at probing for physics beyond the standard model of fundamental interactions, often using the nucleus as a laboratory to make precision tests. The course will be enriched by selected readings from foundation papers in the published literature. These examples will prove interesting while motivating the underlying nuclear and particle physics. The plan is to on average cover a foundations related topic every week, either in class or as part of the homework.

Pre-requisites: PHYS 543 (or equivalent undergraduate nuclear physics course), PHYS 721

[Syllabus](https://physics.unc.edu/files/2017/04/PHYS861.pdf)

**ASTR 701 Stellar Interiors, Evolution, and Populations (G. Cecil)**

This lecture/seminar examines the structure and evolution of stars from Main Sequence youth to death, as individuals and as a population. Earlier events, including the collapse of constituent gas clouds into accretion disks, are covered in other courses, as are rare relativistic end-products such as neutron stars and black holes whose study benefits from a course on general relativity. Thermonuclear fusion and atmospheric energy transfer bound stellar volumes; information from these regions comes to us directly as neutrinos and photons, respectively. The course will genera- lize power input and gas opacity sources to treat current exoplanet atmospheres illuminated and viewed from above, but heated both above and below.

Pre-requisites: None

[Syllabus](https://physics.unc.edu/files/2017/04/ASTR701.pdf)

**MTSC 720 Fabrication of Materials (O. Zhu)**

Mo 4:40-7:10pm

**MTSC 735 Material Techniques (LC Quin)**

Tu/Th 2:00-3:15pm