Fall 2023 Core Courses

Classical Physics, PHYS 776-001
Dates: September 5 – October 6, 2023
Instructor: Aldo Riello
Description: TBD
Details: 0.5 Weight, CR/NCR Evaluation

Quantum Theory, PHYS 605
Dates: September 5 – October 6, 2023
Instructors: Dan Wohns/Bindiya Arora
Description: The first part of the course reviews the foundations of quantum mechanics: an overview of the density matrix approach, path integrals, and time evolution of quantum systems utilising various approaches are all presented. The second part of the course derives the Feynman rules for scalar quantum field theory and introduces renormalization.
Details: 0.5 Weight, CR/NCR Evaluation

Relativity, PHYS 604
Dates: October 10 – November 7, 2023
Instructors: David Kubiznak/Ghazal Geshnizjani
Description: This is an introductory course on general relativity (GR). We shall cover the basics of differential geometry and its applications to Einstein's theory of gravity. The plan is to discuss black holes, gravitational waves, and observational evidence for GR, as well as to cover some advanced topics.
Details: 0.5 Weight, CR/NCR Evaluation

Quantum Field Theory I, PHYS 601
Dates: October 10 – November 7, 2023
Instructor: Gang Xu
Description: The first half of the course explains why fields are necessary when quantum mechanics meets special relativity. The second half introduces different kinds of spinor fields and their interactions.
Details: 0.5 Weight, CR/NCR Evaluation

Statistical Physics, PHYS 602
Dates: November 14 – December 12, 2023
Instructor: Emilie Huffman (Giuseppe Sellaroli)
Description: TBD
Details: 0.5 Weight, CR/NCR Evaluation

Quantum Field Theory II, PHYS 603
Dates: November 14 – December 12, 2023
Instructor: François David (Dan Wohns)
Description: This course introduces the functional integral formalism, the renormalization group, and non-abelian gauge theory. Additional topics may be covered as time allows.
Details: 0.5 Weight, CR/NCR Evaluation

Winter / Spring 2024 Core Courses*

**All courses are officially listed as Spring 2024*

Mathematical Physics (Core), PHYS 776
Dates: January 8 – February 8, 2024
Instructor: Giuseppe Sellaroli
Description: This course will introduce you to some of the geometrical structures underlying theoretical physics. Previous knowledge of differential geometry is not required. Topics covered in the course include: Introduction to manifolds, differential forms, symplectic manifolds, symplectic version of Noether's theorem, integration on manifolds, fiber bundles, principal bundles and applications to gauge theory.
Details: 0.5 Weight, CR/NCR Evaluation

Numerical Methods (Core), PHYS 776
Dates: January 8 – February 8, 2024
Instructor: Erik Schnetter/Dustin Lang (Mohamed Hibat Allah)
Description: TBD
Details: 0.5 Weight, CR/NCR Evaluation

Winter / Spring 2024 Elective Courses*

**All courses are officially listed as Spring 2024*

Standard Model, PHYS 622
Dates: January 8 – February 8, 2024
Instructor: Michael Trott (Gang Xu)
Description: The Standard Model of particle physics is introduced, and reviewed, from a modern effective field theory perspective.
Details: 0.25 Weight, CR/NCR Evaluation

2023-24 PSI Course Descriptions

Gravitational Physics, PHYS 636
Dates: January 8 – February 8, 2024
Instructor: Ruth Gregory (Ghazal Geshnizjani)
Description: The Gravitational Physics course takes your knowledge and practice of gravity to the next level. We start by recapping the essential elements of differential geometry, adding some new techniques to the toolbox, then apply some of these methods to learning about submanifolds, extra dimensions, and black hole thermodynamics. Towards the end of the course, we delve into the frontiers, with a sample of recent research topics.
Details: 0.25 Weight, CR/NCR Evaluation, first lecture on Zoom only.

Quantum Foundations, PHYS 639
Dates: January 8 – February 8, 2024
Instructor: Lucien Hardy (Bindiya Arora)
Description: TBD
Details: 0.25 Weight, CR/NCR Evaluation

Particle Physics, PHYS 646
Dates: February 26 – March 28, 2024
Instructor: Asimina Arvanitaki / Junwu Huang (Gang Xu)
Description: This course will cover phenomenological studies and experimental searches for new physics beyond the Standard Model, including: natruralness, extra dimension, supersymmetry, grand unification, dark matter candidates (WIMPs and axions) and their detection.
Details: 0.25 Weight, CR/NCR Evaluation

Quantum Fields and Strings, PHYS 777
Dates: February 26 – March 28, 2024
Instructor: Jaume Gomis / Davide Gaiotto / Dan Wohns
Description: This survey course introduces some advanced topics in quantum field theory and string theory. Topics may include anomalies, conformal field theory, and bosonic string theory and are subject to change depending on the topics covered in the TBD elective course.
Details: 0.25 Weight, CR/NCR Evaluation

Quantum Matter, PHYS 777
Dates: February 26 – March 28, 2024
Instructor: Tim Hsieh / Yin-Chen He (Mohamed Hibat Allah)
Description: This course will cover quantum phases of matter, with a focus on long-range entangled states, topological states, and quantum criticality.
Details: 0.25 Weight, CR/NCR Evaluation

2023-24 PSI Course Descriptions

Quantum Information, PHYS 635
Dates: February 26 – March 28, 2024
Instructor: TBD (Bindiya Arora)
Description: TBD
Details: 0.25 Weight, CR/NCR Evaluation

Cosmology, PHYS 621
Dates: February 26 – March 28, 2024
Instructor: TBD (Ghazal Geshnizjani)
Description: TBD
Details: 0.25 Weight, CR/NCR Evaluation

Strong Gravity, PHYS 777
Dates: April 2 – May 2, 2024
Instructor: William East (Ghazal Geshnizjani)
Description: This course will introduce some advanced topics in general relativity related to describing gravity in the strong field and dynamical regime. Topics covered include properties of spinning black holes, black hole thermodynamics and energy extraction, how to define horizons in a dynamical setting, formulations of the Einstein equations as constraint and evolution equations, and gravitational waves and how they are sourced.
Details: 0.25 Weight, CR/NCR Evaluation

Quantum Gravity, PHYS 650
Dates: April 2 – May 2, 2024
Instructor: Aldo Riello
Description: The course centers on an in-depth study of the symmetry structure of General Relativity and how this is intimately related to its dynamics and to the challenges posed to its quantization. To achieve this understanding, we will introduce a host of concepts and techniques, broadly (and loosely) known under the name of “Covariant Phase Space Method”. This provides a different perspective on GR’s physics, a perspective in which phase space, rather than spacetime, is front and center. We will apply these ideas and techniques to discuss the so-called Problem of Time, Wald's approach to black hole entropy as a Noether charge, and the relationship between Dirac's Hypersurface Deformation Algebra and GR's symmetries and dynamics. We will also discuss the problem of detecting single gravitons as well as crucial analogies and differences between a quantum electromagnetic and gravitational field. Lecture notes specific for the course will be provided.
Details: 0.25 Weight, CR/NCR Evaluation

2023-24 PSI Course Descriptions

Mathematical Physics, PHYS 777
Dates: April 2 – May 2, 2024
Instructor: Kevin Costello (Giuseppe Sellaroli)
Description: We will discuss mathematical aspects of classical and quantum field theory, including topics such as: symplectic manifolds and the phase space, symplectic reduction, geometric quantization, Chern-Simons theory, and others.
Details: 0.25 Weight, CR/NCR Evaluation

Machine Learning, PHYS 777
Dates: April 2 – May 2, 2024
Instructor: Mohamed Hibat Allah
Description: Machine learning has become a very valuable toolbox for scientists including physicists. In this course, we will learn the basics of machine learning with an emphasis on applications for many-body physics. At the end of this course, you will be equipped with the necessary and preliminary tools for starting your own machine learning projects.
Details: 0.25 Weight, CR/NCR Evaluation

Additional Elective
Dates: April 2 – May 2, 2024
Details TBD