

PHY 680
Mo-We-Fr 11-12

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INTRODUCTION TO MODERN THEORETICAL PHYSICS

General Relativity, Supersymmetric quantum mechanics and Supergravity, Path Integrals for quantum mechanics, basics of Quantum Field Theory, basics of Yang-Mills theory, and basics of Group Theory.

This is a new class which intends to provide an introduction (only an introduction!) to the many new concepts in modern theoretical physics. It is intended for graduate students who are unfamiliar with General Relativity, Quantum Field Theory and Supersymmetry and Supergravity. It offers an introduction to these fields but full-fledged courses are available in the spring. In General Relativity we not only introduce the Einstein field equations for the metric, but we also introduce the vielbein formalism with the spin connection because that is the formalism used in modern classical and quantum gauge field theories, and we solve the Einstein field equations using forms in n dimensions, obtaining black holes and black branes in 4 and higher dimensions. Supersymmetry and Supergravity are introduced in quantum mechanics. The path integrals are for bosonic but also fermionic point particles (using coherent states), and boundary conditions play an important part. The BRST symmetry (a residual rigid symmetry of classical gauge invariance that is left at the quantum level) is also introduced and worked out in quantum mechanics. Then an introduction to quantum field theory is given which is used to briefly introduce these concepts in 4 dimensions. Finally the basics of non-abelian gauge theories (Yang-Mills theory) and Lie algebras for $SU(N)$ and $SO(N)$ are discussed. (A full-fledged course in Group Theory will be given next fall).

The material of this class is assumed to be known in the string class, and topics are discussed in this class before they are used in the string class. However, this class is independent of the string class and string theory will not be discussed, so it is of interest for all students with interest in pure theory. No cosmology or details of 4-dimensional supersymmetry will be discussed.

PRE-REQUISITES: none, just an undergraduate education

EXAMS: there is a midterm exam, a final exam and weekly homeworks, each of which counts for 1/3 of the final grade.