

## MATH 7590 SYLLABUS FOR SPRING 2022

**Course Title, Time, Location.** Geometry and Physics: Introduction to Quantum Field Theory for Mathematicians; Tuesdays and Thursdays, 3:00-4:20 PM, 138 Lockett Hall. Course information will be available on the LSU Moodle system.

**Office Hours.** By appointment via Zoom.

**Objective, Texts, and Prerequisite.** This course will help you obtain basic knowledge of notions of Quantum Field Theory from a path integral perspective.

The prerequisite is MATH 7550.

The approximate plan is as follows:

### Part I

- Atiyah-Segal approach to quantum field theory and path integrals
- Some extra geometric background: connections on vector bundles.
- Classical mechanics and symplectic geometry
- Classical field theory
- Introduction to quantum mechanics
- Path integral formulation of quantum mechanics
- Free quantum fields and axioms of quantum field theory

### Part II

- Finite-dimensional integrals: stationary phase method
- Fermions: Berezin integral
- Feynman diagrams and their combinatorics
- Introduction to renormalization

### Part III

- Gauge theories via path integrals: DeWitt-Faddeev-Popov method
- Elements of supergeometry
- BRST formalism
- Batalin-Vilkovisky (BV) formalism
- Alexandrov-Kontsevich-Schwarz-Zaboronsky (AKSZ) construction
- Localization techniques
- Index theorems and enumerative problems via path integrals

Useful texts:

- L. Takhtajan, “Quantum Mechanics for Mathematicians”, Graduate Studies in Mathematics Volume 95, AMS, 2008
- C. Nash, “Differential topology and quantum field theory”, Academic Press, 1991.
- M. Nakahara, “Geometry, Topology and Physics”, Graduate Student Series in Physics, IOP, 2003
- A. Schwartz, “Quantum field theory and topology”, Grundlehren der Math. Wissen. 307, Springer 1993

- P. Mnev, “Quantum Field Theory: Batalin-Vilkovisky Formalism and its Applications”, University Lecture Series, AMS, Volume 72, 2019
- R. Dijkgraaf, “Les Houches Lectures on Fields, Strings and Duality”, hep-th/9703136

**Evaluation.** There will be 3 homeworks, each devoted to the relevant part of the course.

**Safety.**

- LSU strongly encourages all students, faculty and staff to get vaccinated for COVID-19. Visit <http://www.lsu.edu/roadmap/vaccines/> to learn how to get vaccinated on campus. Vaccination helps keep our campus community safe, helps protect those among us who are most vulnerable to COVID-19, and is our path back to more normal operations and the full college experience that our students deserve.
- Please, consult [Presidential Directive on COVID Safety](#).