GEORGE MASON UNIVERSITY

Course Approval Form

For instructions see: *http://registrar.gmu.edu/facultystaff/catalog-revisions/course/*

Action Requested:

- [x] Create new course
- [ ] Inactivate existing course
- [ ] Reinstate inactive course
- [ ] Modify existing course (check all that apply)
  - [ ] Title
  - [ ] Credits
  - [ ] Repeat Status
  - [ ] Grade Type
  - [ ] Prereq/coreq
  - [ ] Schedule Type
  - [ ] Restrictions
  - [ ] Other:

Course Level:

- [ ] Undergraduate
- [x] Graduate

College/School: College of Science
Department: Physics and Astronomy
Submitted by: Predrag Nikolic
Ext: 3-5068
Email: pnikolic@gmu.edu

Subject Code: PHYS **Number:** 786
(Do not list multiple codes or numbers. Each course proposal must have a separate form.)

Effective Term:
- [x] Fall
- [ ] Spring
- [ ] Summer

Year 2016

Title:
Current:
Banner (30 characters max w/ spaces): Quantum Field Theory
New: Quantum Field Theory of Particles and Condensed Matter

Fulfills Mason Core Req? (undergrad only)
- [ ] Currently fulfills requirement
- [ ] Submission in progress

Credits: (check one)
- [x] 3 Fixed
- [ ] Variable ___ or ___ to ___

Repeat Status: (check one)
- [ ] Not Repeatable (NR)
- [x] Repeatable within degree (RD)
- [ ] Repeatable within term (RT)

Maximum credits allowed: 6

Grade Mode: (check one)
- [x] Regular (A, B, C, etc.)
- [ ] Satisfactory/No Credit
- [ ] Special (A, B C, etc. +IP)

Schedule Type: (check one) LEC can include LAB or RCT
- [x] Lecture (LEC)
- [ ] Lab (LAB)
- [ ] Recitation (RCT)
- [ ] Internship (INT)
- [ ] Independent Study (IND)
- [ ] Seminar (SEM)
- [ ] Studio (STU)

Prerequisite(s):
PHYS 684: Quantum Mechanics I
PHYS 784: Quantum Mechanics II

Corequisite(s):

Instructional Mode:
- [x] 100% face-to-face
- [ ] Hybrid: ≤ 50% electronically delivered
- [ ] 100% electronically delivered

Restrictions Enforced by System: Major, College, Degree, Program, etc. Include Code.
Prerequisite: PHYS 784

Are there equivalent course(s)?
- [ ] Yes
- [x] No

If yes, please list

Catalog Copy for NEW Courses Only (Consult University Catalog for models)

Description (No more than 60 words, use verb phrases and present tense)	**Notes** (List additional information for the course)
Introduction to quantum field theory and its applications in particle and condensed matter physics. Topics: second quantization, scalar bosonic and fermionic fields, symmetries and conserved currents, Dirac equation, gauge theory, quantum electrodynamics, Feynman diagrams, renormalization, Fermi liquid, symmetry breaking, superconductivity, magnetism, path integral, quantum phase transitions, topological order, etc.	Concrete selection of topics and technical depth may vary depending on the student interest. By default, the course would alternate between the particle physics and condensed matter focus in a two-semester period. The course may be offered once every year or two years when there is sufficient student interest, but not in the same semester when PHYS 784 (Quantum Mechanics II) is scheduled.

Indicate number of contact hours: Hours of Lecture or Seminar per week: 3 Hours of Lab or Studio:

When Offered: (check all that apply)
- [x] Fall
- [ ] Summer
- [ ] Spring

Approval Signatures

Department Approval ____ Date ____ College/School Approval ____ Date ____

If this course includes subject matter currently dealt with by any other units, the originating department must circulate this proposal for review by those units and obtain the necessary signatures prior to submission. Failure to do so will delay action on this proposal.

Unit Name	Unit Approval Name	Unit Approver's Signature	Date

For Graduate Courses Only

Graduate Council Member ____ Provost Office ____ Graduate Council Approval Date ____

Course Proposal Submitted to the College of Science Curriculum Committee (COSCC)

The form above is processed by the Office of the University Registrar. This second page is for the COSCC's reference. Please complete the applicable portions of this page to clearly communicate what the form above is requesting.

FOR ALL COURSES (required)

Course Number and Title: PHYS 786, Quantum Field Theory of Particles and Condensed Matter

Date of Departmental Approval: March 4, 2016

FOR INACTIVATED/REINSTATED COURSES (required if inactivating/reinstating a course)

- Reason for Inactivating/Reinstating:

FOR MODIFIED COURSES (required if modifying a course)

- Summary of the Modification:
- Text before Modification (title, repeat status, catalog description, etc.):
- Text after Modification (title, repeat status, catalog description, etc.):
- Reason for the Modification:

FOR NEW COURSES (required if creating a new course)

- Reason for the New Course:

  1) A demonstrated high level of interest among the graduate students in the physics program.

  2) The need to provide basic conceptual knowledge and training for graduate students who pursue experimental or theoretical research in the mainstream high energy or condensed matter physics.

- Relationship to Existing Programs:

  Quantum field theory (QFT) is taught at all major universities that offer a Ph.D. in physics. It has been taught at Mason only a very few times as a special topics course. Several Mason faculty (Rubin, Satija, Zhao, Nikolic) conduct research that is directly based on QFT. The work of some other faculty (e.g. Mishin, Tian, Sauer) has inter-disciplinary connections to QFT subjects or methods.

- Relationship to Existing Courses:

  A natural sequel to the graduate-level quantum mechanics courses.

- Semester of Initial Offering:

  Fall 2016

- Proposed Instructors:

  Predrag Nikolic, Erhai Zhao, Indu Satija

- Insert Tentative Syllabus Below

  Attached.

Also see the web-site http://physics.gmu.edu/~pnikolic/PHYS780/index.html of the QFT course taught by Nikolic in Spring 2011 as a special topics course (PHYS 780).

PHYS 786: Quantum Field Theory

Science and Technology I Room 310, Thu 4:30-7:10 pm

Brief Course Description (tentative, time permitting)

Second quantization: from classical to quantum coupled oscillators. Real and complex scalar fields. Propagators and wave functionals. Relativistic quantum fields. Scalar, vector and spinor fields. Canonical formalism, Lagrangian and action. Conservation laws and symmetries (Lorentz, translational, rotational, gauge). Second quantization of electromagnetic fields, photons, the gauge principle. Quantum mechanics of relativistic fermions: Dirac equation. Quantum field theory of relativistic fermions. Dynamics of interacting fields. Perturbation theory with Feynman diagrams. Quantum electrodynamics. Renormalization.

Prerequisite

PHYS 684: Quantum Mechanics I
PHYS 784: Quantum Mechanics II

Course Textbook

Kerson Huang, *Quantum Field Theory: From Operators to Path Integrals* (Wiley-VCH, second edition, 2010) see the course website below for additional literature suggestions

Instructor

Predrag Nikolic
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Email: pnikolic@gmu.edu
Web: http://physics.gmu.edu/~pnikolic/PHYS780/

Office Hours

Thu 11:00 am - noon (tentative), or by appointment

Grading

- Homework 100%, no exams.
- Credit will be a strong function of demonstrated effort (independent creative thinking, persistent approach to all problem sets and individual problems, class activity, etc), and a weaker function of solution correctness.
- Collaboration with peers, use of any literature, questions and discussions inside and outside of class are all strongly encouraged (and probably necessary to learn this subject).

Homework

- Assigned once a week on Thursdays (tentative, there may be exceptions).
- Due at the beginning of the following week's class.
- While collaboration is encouraged, grades will be based on the evidence of original thinking. All steps leading to the results must be shown and explained for full credit.

Important dates
Feb 08: Last day to drop classes with no tuition penalty, last day to add classes
Feb 25: Last day to drop with tuition penalty, last day to drop classes

Tentative Class Schedule
Jan 27 #1 Second quantization: from classical to quantum coupled oscillators.
Feb 03 #2 Bose and Fermi statistics. Klein-Gordon equation.
Feb 10 #3 Real and complex scalar fields. Propagators and wave functionals.
Feb 17 #4 Relativistic quantum scalar, vector and spinor fields. Lorentz transformations. Poincare group.
Feb 24 #5 Lagrangian and the principle of stationary action. Conservation laws and symmetries.
Mar 03 #6 Quantum field theory of electromagnetic radiation (gauge theory). Photons. Casimir effect.
Mar 10 #7 Quantum mechanics of relativistic fermions: Dirac equation.
Mar 17 … *spring break*
Mar 24 #8 Quantum field theory of relativistic fermions.
Mar 31 #9 Dirac fields and propagators.
Apr 07 #10 Dynamics of interacting fields. Time evolution. Interaction picture. Correlations. Scattering.
Apr 14 #11 Perturbation theory and Feynman diagrams.
Apr 21 #12 Lehmann representation. Dyson-Schwinger equation. Bound states. Bethe-Salpeter equation.
Apr 28 #13 Quantum electrodynamics (QED). Feynman rules.
May 05#14 Processes in QED.
May 10#15 Renormalization. Primitive divergences. Running coupling constant.