### Course Approval Form

**Action Requested:**  
- [ ] Create new course  
- [ ] Inactivate existing course  
- [ ] Reinstatement of inactive course  

**Modify existing course (check all that apply):**  
- [ ] Title  
- [ ] Prereq/coreq  
- [ ] Schedule Type  
- [ ] Repeat Status  
- [ ] Grade Type  

**Course Level:**  
- [ ] Undergraduate  
- [ ] 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  
**Effective Term:**  
- [ ] Fall  
- [ ] Spring  
- [ ] Summer  
**Year:** 2016

**Title:** Quantum Field Theory of Particles and Condensed Matter

**Credits:**  
- [ ] Fixed  
- [ ] Variable  
- [ ] Other

**Grade Mode:**  
- [ ] Regular  
- [ ] Satisfactory/No Credit  
- [ ] Special

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

**Maximum credits allowed:** 6

**Schedule Type:**  
- [ ] Lecture (LEC)  
- [ ] Lab (LAB)  
- [ ] Recitation (RCT)  
- [ ] Internship (INT)

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

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

**Corequisite(s):**

**Restrictions Enforced by System:** Major, College, Degree, Program, etc. Include Code.

**Prerequisite:** PHYS 784

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

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

**Description (No more than 60 words, use verb phrases and present tense):**  
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.

**Notes (List additional information for the course):**  
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: 3
- Hours of Lab or Studio: 0

**When Offered:**  
- [ ] Fall  
- [ ] Spring  
- [ ] Summer

**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 interdisciplinary 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
Brief Course Description (tentative, time permitting)

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
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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. Poincaré group.
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 14 #11 Perturbation theory and Feynman diagrams.
Apr 28 #13 Quantum electrodynamics (QED). Feynman rules.
May 05#14 Processes in QED.
May 10#15 Renormalization. Primitive divergences. Running coupling constant.