

**DEGREE/PROGRAM CHANGE
FORM C
Form Number: C1402**

Fields marked with * are required

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Associated Forms exist? Initiator's Title
Faculty Contact Administrative Contact
Department Admin Email
Branch Admin Phone

Proposed effective term

Semester Year

Course Information

Select Appropriate Program
Name of New or Existing Program
Select Category Degree Type
Select Action

Exact Title and Requirements as they should appear in the catalog. If there is a change, upload current and proposed requirements.

See current catalog for format within the respective college (upload a doc/pdf file)

[2014 Form C Class Materials UPDATED FINAL.docx](#)

Does this change affect other departmental program/branch campuses? If yes, indicate below.

Reason(s) for Request (enter text below or upload a doc/pdf file)

This change does not affect other departmental program/branch campuses. The new concentration will utilize current faculty and courses in the supporting departments of Physics and Electrical Computer Engineering. The Optical Science and Engineering interdisciplinary program has full support of the Physics and Electrical and Computer Engineering departments as well as the School of Engineering and College of Arts and Sciences.

[Peceny Quantum Optics Letter.pdf](#)
[SOE letter suspporting OO concentration in OSE.pdf](#)
[OSE_ECESppport.pdf](#)
[OSA-QuOpt-support-letter-P&A.pdf](#)

Upload a document that inlcudes justification for the program, impact on long-range planning, detailed budget analysis and faculty workload implications.(upload a doc/pdf file)

[OSE PhD Quantum Optics LongRangeGoals-3.pdf](#)

Are you proposing a new undergraduate degree or new undergraduate certificate? If yes, upload the following documents.

Upload a two-page Executive Summary authorized by Associate Provost. (upload a doc/pdf file)

Upload memo from Associate Provost authorizing go-ahead to full proposal. (upload a doc/pdf file)

Ph.D. in Optical Science and Engineering

Concentration: Quantum Optics (NEW)

Courses requirements for the Quantum Optics Concentration:

30 credit hours of core classes consisting of a mixture of mandatory and option-based electives as described below:

A. Mandatory courses (18 Credit Hours)

- Laser Physics I - PHYC *464 / ECE *464
- Graduate Quantum Mechanics I – PHYC 521
- Graduate Quantum Mechanics II – PHYC 522
- Electrodynamics – PHYC 511 or ECE 561
- Quantum Optics – PHYC 566
- 3 credit hours of seminar, including OSE Graduate Seminar

B. Concentration-specific mandatory courses (9 Credit Hours)

Choice of **three** courses from the following list:

- Nonlinear Optics – PHYC 568
- Advanced Optics I - PHYC 463 / ECE 463
- Advanced Optics II - PHYC 554 / ECE 554
- Experimental Techniques of Optics – PHYC 476L or PHYC 477L
- Advanced Topics: Quantum Optics II - PHYC 581
- Quantum Information Theory – PHYC 572
- Quantum Computation – PHYC 571
- Optoelectronic Semiconductor Materials and Devices - ECE 570
- Semiconductor Physics - ECE 572
- Digital Image Processing - ECE 533
- Probability and Stochastic Processes - ECE 541

- Materials and Devices II – ECE *471

C. Option-based elective (3 Credit Hours):

- 3 credit hours from the list of OSE approved courses as shown below:

Microelectronics Processing Lab (ECE 574L)
 Nonlinear Optics (PHYC 568)
 Advanced Optics I (PHYC/ECE 463)
 Advanced Optics II (PHYC 554 or ECE 554)
 Condensed Matter I (PHYC 529) or Physics of Semiconductors (ECE 572)
 Advanced Topics in Modern Optics (PHYC 569) or Special Topics (ECE 595)
 Laser Physics I (PHYC 464)
 Experimental Techniques of Optics (PHYC *476L or *477L)
 Pattern Recognition (ECE 517)
 Probability Theory and Stochastic Processes (ECE 541)
 Digital Image Processing (ECE 533)
 ECE 539 - Digital Signal Processing
 ECE 549 - Information Theory and Coding
 ECE 500 - Theory of Linear Systems
 ECE 475 - Introduction to Electro-Optics and Opto-Electronics
 ECE 516 - Computer Vision
 ECE 595 –ST: Microwave Photonics
 ECE 570 – Optoelectronic Semiconductor Materials and Devices
 ECE 547 - Neural Networks
 ECE 581 – Colloidal Nanocrystals for Biomedical Applications
 ECE 510 - Medical Imaging
 ECE 512 - Advanced Image Synthesis
 ECE 506 - Optimization Theory
 ECE 563 – Computational Methods for Electromagnetics
 ECE 595 – ST: Detectors and Hardware
 ECE 642 – Detection and Estimation Theory
 Fundamentals of Semiconductor LEDs and Lasers (ECE 577)
 Advanced Topics: Quantum Optics II (PHYC 581)
 Atomic and Molecular Structure (PHYC 531)
 Methods of Theoretical Physics I (PHYC *466) or Mathematical Methods
 for Science and Engineering (MATH *466)
 Foundations of Engineering Electromagnetics (ECE 555)
 Advanced Techniques in Optical Imaging- (BIO 547)
 Guided Wave Optics (ECE 564)
 Optical Communication Components and Subsystems (ECE 565)
 Synthesis of Nanostructures (ECE 518 or NSMS 518)

Nonlinear Dynamics and Chaos (MATH **412)
Quantum Computation (PHYC 571)
Quantum Information Theory (PHYC 572)

D. Free elective (22 Credit Hours):

- 22 credit hours of free electives (500-level courses and above, including problems courses)

E. Dissertation hours (18 Credit hours): ECE 699 or PHYC 699

Optical Science and Engineering Program

Center for High Technology Materials

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**Proposal for a New PhD Concentration in the Optical Science and Engineering PhD
Degree
Concentration Title: Quantum Optics**

Background:

The purpose here is to expand the scope of OSE's PhD degrees to include a fourth concentration beyond the existing concentrations (Optical Sciences, Photonics, and Imaging). This expansion is expected to increase enrollment, degrees awarded, publications and potentially introduce synergistic activities (e.g., new opportunities for research collaborations) with the Physics and Astronomy Department at UNM in general and with the Center for Quantum Information Science in particular.

In this direction and in the past year and a half there have been numerous discussions, first initiated by Professors Ivan Deutsch, Carl Caves, and Sudhakar Prasad among the OSE faculty to introduce a new track in OSE under the title of Quantum Optics (QO). OSE currently has three tracks: Optical Sciences, Imaging, and Photonics. Since the creation of the Photonics track in 2006, it has been attracting a substantial number of students, and the graduation rates have been healthy and steady within this track. A key factor in the success of the Photonics track in OSE has been the existing strength and vast reputation of UNM in this area, with faculty in CHTM, ECE, Physics and Chemical and Nuclear Engineering supporting the track.

Clearly, UNM has left its mark nationally and internationally in the area of theoretical quantum optics due to its strong overlap with quantum information science. UNM's excellence in this area has led to attracting top-notch graduate students from all over the world, who have been primarily enrolled in the Physics and Astronomy (P&A) department, particularly through the Center for Quantum Information Science. With the recent strategic decision to expand the existing capabilities in quantum optics at UNM to include experimental research, with the hire of Elohim Becerra, we envision a great opportunity for OSE to attract students in a new track that can fit the needs of both theoretically inclined and experimentally inclined students seeking a doctoral degree in quantum optics. A quantum optics track in OSE can be an excellent way to seize such an opportunity.

After many discussions with the quantum-optics faculty in P&A, the OSE Graduate committee examined a proposal regarding introducing a QO track in OSE. Overall, the OSE Graduate Committee felt that this is a very exciting initiative that will benefit OSE, Physics, ECE and CHTM considerably in the future by attracting students to the OSE program while creating new opportunities for collaborations between OSE faculty and the Quantum-Information Group at UNM.

Justification for the program:

- Quantum optics is an area of excellence at UNM that has been attracting students from around the world.
- Graduate degrees offered in this area are primarily in the Physics and Astronomy (P&A) department, with support from the Center for Quantum Information Science.
- Optical Science and Engineering (OSE) Program envisions a great opportunity for attracting additional students in a new PhD track in OSE in the area quantum optics that can fit the needs of both theoretically inclined as well as experimentally inclined students seeking a doctoral degree in quantum optics.
- A quantum optics concentration in OSE can further attract students to the OSE program
- It will create new opportunities for collaborations between the faculty and students in OSE, Electrical & Computer Engineering (ECE), P&A, Chemistry, Chem-Nuc, and the Quantum-Information Group at UNM.
- This proposal for creating a new OSE track in quantum optics has been supported by the Quantum-Information Group, Quantum Optics faculty in P&A, the OSE Graduate Committee, and the OSE General Faculty.

Impact on long-range planning:

In terms of resources, the proposed QO track will tap into the existing courses from P&A for its core, with possible OSE electives that come from other departments such as ECE, Chemistry, Chemical Engineering, Mathematics, etc. As such, no new courses need to be created for the QO track; however, new courses that are expected to arise in experimental quantum optics within P&A can and will be used to further support and enrich the list of elective courses for the new QO track.

Also, the qualifying exam will tap into existing exams, so no new exams will be required to be created. The exam structure for the QO track will remain the same as that for other OSE tracks. Namely, the qualifying exam will consist of:

- (a) Common Exams: (i) General Optics exam, covering general-optics knowledge, and (ii) the Electromagnetics exam. These two exams are common to all OSE tracks.
- (b) Track-specific Exams: (i) Lasers (also required by the Optical Sciences track), and (ii) Quantum Mechanics (with questions shared from the P&A prelims).

The General Optics exam will be expanded upon to accommodate students who may not have taken classes such as Optics Lab and Advanced Optics I. To grade out of the qualifying exam, students in the QO track must have an average GPA of 4.0 in the QO core courses consisting of Phys 464, Phys 521, Phys 522 and Phys 511. This rule is consistent with the existing rule for grading out of the OSE qualifying exam in other OSE tracks.

Budget analysis:

There is no significant impact on the OSE budget as we are using existing faculty, staff and resources within the OSE program. We will monitor the enrollment, and if a 20% or more increase is observed then OSE may expand its budget to support additional staff service in accommodating student needs.

Faculty workload implications:

No new courses are to be created for the proposed new quantum-optics OSE concentration. All the courses that are required by the proposed quantum-optics concentration are either existing, routinely-offered courses in P&A and ECE, or they are courses that are required by existing OSE concentrations, which are too routinely offered. Thus, the faculty teaching load is unaffected by the introduction of the new quantum-optics concentration in OSE.