TO: The Faculty of the College of Engineering

FROM: School of Electrical and Computer Engineering of the College of Engineering

RE: New Graduate Course, ECE 60419 Numerical Simulations of Electro-optic Energy Systems

The faculty of the School of Electrical and Computer Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ECE 60419 Numerical Simulations of Electro-optic Energy Systems

Sem. 2, Lecture 3, Cr. 3.
Prerequisite by Topic: A broad and strong foundation in undergraduate computer engineering courses, and good programming skills. A prior course in operating systems or networking will be useful but not essential.

Description: Introduction to computational techniques employed in research on energy systems involving quantum electronics and electromagnetics. You will learn the strengths and weaknesses of each approach; what types of problems call for which one; and how your simulation will perform. Techniques include eigenvalue problems, fast Fourier transforms, band structure calculations, rigorous-coupled wave analysis, beam-propagation methods, finite-difference time-domain, and finite element methods. Applications include nanophotonics, photovoltaics, thermal management, radiative control, and nonlinear optics.

Reason: The goal of this course is to provide graduate students with basic capabilities to judge the appropriateness of various numerical techniques applied to electro-optic systems. These lessons can benefit a broad range of students performing research in micro and nanosystems (MN), as well as fields and optics (FO). For experimentalists, this provides a way to design and validate the results of their experiments to save time and effort in the long run. For simulation-based researchers, this provides a more in-depth understanding of the tools they use on a daily basis, broadening their horizons to other capabilities and judging when to use each one. This course fills a gap in the curriculum by treating multiple physical phenomena (optical, electrical, thermal, and quantum) on an equal basis, and focusing more on approaches most commonly used in the current research literature, compared to more mathematical courses such as ECE 61800, CS 51400, and CS 61500. In terms of content, there is only a slight 7% overlap with quantum electronics courses, specifically as ECE 65000, ECE 65600, and ECE 65900. This course will provide a greater depth of understanding than afforded by ECE 60400 or ECE 60600 by connecting more closely with the research literature, and as such, will serve as an upper-level elective for MN and FO graduate students.

Michael R. Melloch

Michael R. Melloch, Associate Head
School of Electrical and Computer Engineering

Approved for the faculty of the Schools
of Engineering by the Engineering
Curriculum Committee

ECC Minutes #6 Date 11-15-16
Chairman ECC [signature]

Office of the Registrar
FORM 40G REV. 4/13

PURDUE UNIVERSITY
REQUEST FOR ADDITION, EXPIRATION, OR REVISION OF A GRADUATE COURSE (50000-60000 LEVEL)

DEPARTMENT: Electrical and Computer Engineering   EFFECTIVE SESSION: Spring 2017

INSTRUCTIONS: Please check the items below which describe the purpose of this request.

- [x] 1. New course with supporting documents (complete proposal form)
- [ ] 2. Add existing course offered at another campus
- [ ] 3. Expiration of a course
- [ ] 4. Change in course number
- [ ] 5. Change in course title
- [ ] 6. Change in course credit/type
- [ ] 7. Change in course attributes
- [ ] 8. Change in instructional hours
- [ ] 9. Change in course description
- [ ] 10. Change in course requisites
- [ ] 11. Change in semesters offered
- [ ] 12. Transfer from one department to another

PROPOSED:
Subject Abbreviation: ECE
Course Number: 60419
Long Title: Numerical Simulations of Electro-optic Energy Systems
Short Title: Num Simul Elctro-opt Energy Sy
Abbreviated title will be entered by the Office of the Registrar if omitted. (30 CHARACTERS ONLY)

EXISTING:
Subject Abbreviation:
Course Number:

TERMS OFFERED
Check All That Apply:
- [ ] Fall
- [x] Spring
- [ ] Summer

CAMPUS(ES) INVOLVED
- [ ] Calumet
- [ ] Cont Ed
- [ ] Ft. Wayne
- [ ] Indianapolis
- [ ] N. Central
- [ ] Tech Statewide
- [x] W. Lafayette

CREDIT TYPE
1. Fixed Credit: Cr. Hrs. 3.0
2. Variable Credit Range:
   Minimum Cr. Hrs
   (Check One) To [ ] Or [ ]
   Maximum Cr. Hrs
3. Equivalent Credit: Yes [ ] No [x]
4. Thesis Credit: Yes [ ] No [x]

COURSE ATTRIBUTES: Check All That Apply
1. Pass/Not Pass Only [ ]
2. Satisfactory/Unsatisfactory Only [ ]
3. Repeatable [ ]
   Maximum Repeatable Credit:
4. Credit by Examination [ ]
5. Fees [ ] Coop [ ] Lab [ ] Rate Request
   Include comment to explain fee
6. Registration Approval Type
   Department [ ] Instructor [ ]
7. Variable Title [ ]
8. Honors [ ]
9. Full Time Privilege [ ]
10. Off Campus Experience [ ]

Schedule Type	Minutes Per Mtg	Meetings Per Week	Weeks Offered	% of Credit Allocated
Lecture	75	2	16	100%
Recitation				
Presentation				
Laboratory				
Lab Prep				
Studio				
Distance				
Clinic				
Experiential				
Research				
Ind. Study				
Pract/Observ				

Cross-Listed Courses

COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS):
Introduction to computational techniques employed in research on energy systems involving quantum electronics and electromagnetics. You will learn the strengths and weaknesses of each approach; what types of problems call for which one; and how your simulation will perform. Techniques include eigenvalue problems, fast Fourier transforms, band structure calculations, rigorous-coupled wave analysis, beam-propagation methods, finite-difference time-domain, and finite element methods. Applications include nanophotonics, photovoltaics, thermal management, radiative control, and nonlinear optics.

*COURSE LEARNING OUTCOMES:
1. Explain strengths and weaknesses of computational techniques for electro-optic systems
2. Calculate computational complexity of a given algorithm
3. Perform conventional and Fast Fourier transforms, based on existing codes
4. Solve for eigenvalues and eigenvectors, for both standard and generalized eigenproblems

Calumet Department Head / Date	Calumet School Dean / Date	Calumet Director of Graduate Studies / Date
Fort Wayne Department Head / Date	Fort Wayne School Dean / Date	Fort Wayne Director of Graduate Studies / Date
Indianapolis Department Head / Date	Indianapolis School Dean / Date	IUPUI Associate Dean for Graduate Education / Date
North Central Department Head / Date	North Central School Dean / Date	North Central Director of Graduate Studies / Date
[signature] 10/6/16 West Lafayette Department Head / Date	[signature] 12/7/16 West Lafayette College/School Dean / Date	Date Approved by Graduate Council / Date
Graduate Area Committee Convener / Date	Graduate Dean / Date	Graduate Council Secretary / Date
		West Lafayette Registrar / Date

OFFICE OF THE REGISTRAR

Supporting Document to the Form 40G
for a New Graduate Course

To: Purdue University Graduate Council

From: Faculty Member: Peter Bermel

Department: Electrical and Computer Engineering

Campus: West Lafayette

Date:

Subject: Proposal for New Graduate Course

Contact for information if questions arise:
Name: Matt Golden
Phone: 494-3374
Email: goldenm@purdue.edu
Address: EE Building, Room 135

Course Subject Abbreviation and Number: ECE 60419

Course Title: Numerical Simulations of Electro-optic Energy Systems

Course Description:

Introduction to computational techniques employed in research on energy systems involving quantum electronics and electromagnetics. You will learn the strengths and weaknesses of each approach; what types of problems call for which one; and how your simulation will perform. Techniques include eigenvalue problems, fast Fourier transforms, band structure calculations, rigorous-coupled wave analysis, beam-propagation methods, finite-difference time-domain, and finite element methods. Applications include nanophotonics, photovoltaics, thermal management, radiative control, and nonlinear optics.

Semesters Offered:

For the benefit of graduate student plan of study development, how frequently will this prototype be offered? Which semesters?
Spring odd years

A. Justification for the Course:

Provide a complete and detailed explanation of the need for the course (e. g., in the preparation of students, in providing new knowledge/training in one or more topics, in meeting degree requirements, etc.), how the course contributes to existing majors and/or concentrations, and how the course relates to other graduate courses offered by the department, other departments, or interdisciplinary programs.

Justify the level of the proposed graduate course (500- or 600-level) including statements on, but not limited to: (1) the target audience, including the anticipated number of undergraduate and graduate students who will enroll in the course; and (2) the rigor of the course.

The goal of this course is to provide graduate students with basic capabilities to judge the appropriateness of various numerical techniques applied to electro-optic systems. These lessons can benefit a broad range of students performing research in micro and nanosystems (MN), as well as fields and optics (FO). For experimentalists, this provides a way to design and validate the results of their experiments to save time and effort in the long run. For simulation-based researchers, this provides a more in-depth understanding of the tools they use on a daily basis, broadening their horizons to other capabilities and judging when to use each one. This course fills a gap in the curriculum by treating multiple physical phenomena (optical, electrical, thermal, and quantum) on an equal basis, and focusing more on approaches most commonly used in the current research literature, compared to more mathematical courses such as ECE 61800, CS 51400, and CS 61500. In terms of content, there is only a slight 7% overlap with quantum electronics courses, specifically as ECE 65000, ECE 65600, and ECE 65900. This course will provide a greater depth of understanding than afforded by ECE 60400 or ECE 60600 by connecting more closely with the research literature, and as such, will serve as an upper-level elective for MN and FO graduate students.

- Anticipated enrollment
  - Graduate 17-25

B. Learning Outcomes and Method of Evaluation or Assessment:

ECE Graduate Learning Outcomes:

a. Knowledge and Scholarship (thesis/non-thesis)
b. Communication (thesis/non-thesis)
c. Critical Thinking (thesis/non-thesis)
d. Ethical and Responsible Research (thesis) or Professional and Ethical Responsibility (non-thesis)

- List Learning Objectives for this course and map each Learning Objective to one or more of the ECE Learning Outcomes (a-d, listed above):

1. Explain strengths and weaknesses of computational techniques for electro-optic systems [b]
2. Calculate computational complexity of a given algorithm [a,c]
3. Perform conventional and Fast Fourier transforms, based on existing codes [a]
4. Solve for eigenvalues and eigenvectors, for both standard and generalized eigenproblems [a]

- Methods of Instruction
  - Lecture
- Will/can this course be offered via Distance Learning?
  - It could be, although there are no immediate plans to do so.
- Grading Criteria

Grading criteria (select from checklist); include a statement describing the criteria that will be used to assess students and how the final grade will be determined. Add and delete rows as needed.

Quizzes	100 points
Class Participation	100 points
Homework	100 points
Final Project	200 points
Total	500 points

- Describe the criteria that will be used to assess students and how the final grade will be determined:
  The course will be graded primarily on a combination of quizzes and course projects. A smaller part of the grade will be based on homework assignments and class participation. The examination component will include a mid-term and final examination.

C. Prerequisite(s):

List prerequisites and/or experiences/background required. If no prerequisites are indicated, provide an explanation for their absence. Add bullets as needed.

- Graduate Standing or Consent of Instructor
- Prerequisite by Topic: Elect/Magn Interactions (ECE 604 or equivalent); Programming For Engineers (C, MATLAB, or similar); Linear Algebra; Ordinary Differ. Equatn; and Signals and Systems

D. Course Instructor(s):

Provide the name, rank, and department/program affiliation of the instructor(s). Is the instructor currently a member of the Graduate Faculty? (If the answer is no, indicate when it is expected that a request will be submitted.) Add rows as needed.

Name	Rank	Dept.	Graduate Faculty or expected date
Peter Bermel	Assistant Professor	ECEN	Yes

E. Course Outline:

Provide an outline of topics to be covered and indicate the relative amount of time or emphasis devoted to each topic. If laboratory of field experiences are used to supplement a lecture course, explain the value of the experience(s) to enhance the quality of the course and student learning. For special topics courses, include a sample outline of a course that would be offered under the proposed course. **(This information must be listed and may be copied from syllabus).**

Weeks	Principal Topics
1	Overview of numerical computing: basic techniques, quantifying performance
1.5	Eigensystem and generalized eigenproblem solution methods
1.5	Conventional and fast Fourier transforms
2	Overview of partial differential equation solution techniques
1	Beam-propagation methods for photonic crystal fibers
1	Bandstructure calculations for crystals
1	Transfer-matrix analysis for optical and electrical transport
1	Rigorous coupled-wave analysis for optical and electrical transport
2	Finite-difference time-domain calculations for coupled electro-optic transport problems
1	Finite-element method for electrical, optical, and thermal transport
2	Final Project Discussions + Presentations

F. Reading List (including course text):

A primary reading list or bibliography should be limited to material the students will be required to read in order to successfully complete the course. It should not be a compilation of general reference material.

A secondary reading list or bibliography should include material students may use as background information.

- Primary Reading List
  - Salah Obayya, Computational Photonics, John Wiley & Sons September 6, 2010, ISBN Number 9780470688939Secondary Reading List
- Secondary Reading List
  - J. D. Joannopoulos, S. G. Johnson, J. N. Winn, R. B. Meade, Photonic Crystals: Molding the Flow of Light, Princeton University Press, 2008, ISBN Number 9780691124568

G. Library Resources

Describe any library resources that are currently available or the resources needed to support this proposed course.

All library resources (textbooks and papers) are already provided to Purdue students and faculty, so no extra effort is required here.

H. Course Syllabus

The latest course syllabus is available online via this link:
http://web.ics.purdue.edu/~pbermel/ece695/ECE695CoursePolicy-Bermel.pdf