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 61014 Electromagnetic and Electromechanical Component Design

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 61014 Electromagnetic and Electromechanical Component Design

Sem. 1, Lecture 3, Cr. 3.

Prerequisite:

Prerequisite by Topic: Knowledge of the use of field and co-energy techniques to calculate force/torque, Understanding of theory of operation of permanent magnet ac machines (brushless dc machines), basic knowledge of electromagnetic fields.

Description: This course focuses on the design of electromagnetic and electromechanical systems, with power applications. The course includes optimization methods, modeling techniques for design (as opposed to for simulation), and the formulation of design problems as optimization problems.

Reason: Power magnetic devices include components such as inductors, electromagnets, transformers, and rotary and linear motors and generators. Purdue University's Electrical and Computer Engineering's Power Area has a long history in the design techniques for power magnet components as well as in inventing new components. Indeed, approximately one-half the graduate students in the area are involved in either design techniques or the invention of novel devices. This course is the final level of preparation needed to be able to work in this area. The course utilizes the advanced graduate level text book, *Power Magnetic Devices: A Multiobjective Design Approach,* by S.D. Sudhoff, which was published in 2014, is highly rigorous, and is the result of a number of recent papers in the area. The book, and the course, scorn the traditional design approach for power magnet devices based on practice and rules-of-thumb, and instead focuses on casting design problems as rigorously posed multiple objective optimization problems. Students cast and solve several design problems using this approach. All students also are required to work an independent project as part of the course. Note that the course is not suitable for undergraduates.

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

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 2016

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:	EXISTING:
Subject Abbreviation	ECE	
Course Number	61014	
Long Title	Electromagnetic and Electromechanical Component Design	
Short Title	Electromag & Electromech Comp Des	

Abbreviated title will be entered by the Office of the Registrar if omitted. (30 CHARACTERS ONLY)

TERMS OFFERED
Check All That Apply:
- [x] Fall
- [ ] 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
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	3	50	16	100
Recitation				
Presentation				
Laboratory				
Lab Prep				
Studio				
Distance				
Clinic				
Experiential				
Research				
Ind. Study				
Pract/Observ				

Cross-Listed Courses

COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS):

This course focuses on the design of electromagnetic and electromechanical systems, with power applications. The course includes optimization methods, modeling techniques for design (as opposed to for simulation), and the formulation of design problems as optimization problems.

*COURSE LEARNING OUTCOMES:

a. a. Understanding of multi-objective design techniques as they relate to the design of power magnetic devices (a,b,c)
b. Understanding of the use of computationally efficient methods of solving field problems including analytical methods and magnetic equivalent circuits (a,c)

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
Michael R Melloch (signature) West Lafayette Department Head	10/28/15 Date	(signature) West Lafayette College/School Dean	12/2/15 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: Scott Sudhoff

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 61014

Course Title: Electromagnetic and Electromechanical Component Design

Course Description:

This course focuses on the design of electromagnetic and electromechanical systems, with power applications. The course includes optimization methods, modeling techniques for design (as opposed to for simulation), and the formulation of design problems as optimization problems.

Semesters Offered:

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

Power magnetic devices include components such as inductors, electromagnets, transformers, and rotary and linear motors and generators. Purdue University's Electrical and Computer Engineering's Power Area has a long history in the design techniques for power magnet components as well as in inventing new components. Indeed, approximately one-half the graduate students in the area are involved in either design techniques or the invention of novel devices. This course is the final level of preparation needed to be able to work in this area. The course utilizes the advanced graduate level text book, *Power Magnetic Devices: A Multiobjective Design Approach,* by S.D. Sudhoff, which was published in 2014, is highly rigorous, and is the result of a number of recent papers in the area. The book, and the course, scorn the traditional design approach for power magnet devices based on practice and rules-of-thumb, and instead focuses on casting design problems as rigorously posed multiple objective optimization problems. Students cast and solve several design problems using this approach. All students also are required to work an independent project as part of the course. Note that the course is not suitable for undergraduates.

Use the following criteria:
Graduate Council policy requires that courses at the 50000 level in the Purdue system should be taught at the graduate level and meet four criteria: a) the use of primary literature in conjunction with advanced secondary sources (i.e., advanced textbooks); b) assessments that demonstrate synthesis of concepts and ideas by students; c) demonstrations that topics are current, and; d) components that emphasize research approaches/methods or discovery efforts in the course content area (reading the research, critiquing articles, proposing research, performing research). Such courses should be taught so that undergraduate students are expected to rise to the level of graduate work and be assessed in the same manner as the graduate students.

- Anticipated enrollment
    - Undergraduate 0
    - Graduate 20-30

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):

  a. Understanding of multi-objective design techniques as they relate to the design of power magnetic devices (a,b,c)
  b. Understanding of the use of computationally efficient methods of solving field problems including analytical methods and magnetic equivalent circuits (a,c)
  c. Understanding of loss mechanisms in power magnet devices including hysteresis, eddy current, and resistive losses (a,c)
  d. Understanding of design of distributed conductors systems such as rotating electric machinery (a,c)
  e. Understanding working practices on homework, exams, and projects (d)
  f. Understanding how to compete component architectures in a rigorous and meaningful way (a,b,c)

- Methods of Instruction

  - Lecture

- Will/can this course be offered via Distance Learning?

  Yes, this course is offered vis Distance Learning

- 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.

  - exams
  - projects (common and individual research)
  - homework

  ▶ Describe the criteria that will be used to assess students and how the final grade will be determined:

Approximately 70% of the course grade is determined by the projects/homework. These represent a very substantial effort. The remaining 30% of the course grade is determined by the midterm and final exam.

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
- Prerequisite by Topic: Knowledge of the use of field and co-energy techniques to calculate force/torque, Understanding of theory of operation of permanent magnet ac machines (brushless dc machines), basic knowledge of electromagnetic fields.

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
Scott Sudhoff	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	Single Objective Optimization
1	Multi Objective Optimization
4	Applied Magnetics
	Review of Fundamental Field Laws

Representation of Magnetic Materials
High Fidelity Magnetic Equivalent Circuits

1 Power Inductor Design
MEC Modeling
Design Formulation

0.5 Calculating Force Using Magnetic Equivalent Circuits

0.5 Electromagnet Design
MEC Modeling Design
Design Formulation

1 Losses in Magnetic Materials
Eddy Current Loss
Hysteresis Loss
Empirical Loss Models

4 Permanent Magnet Synchronous Machine Design
Review
Distributed Winding Systems
Analytical Field Solutions
Design Formulation

2 Advanced Topics
High-Frequency Conductor Losses
Skin Effect
Proximity Effect
Thermal Analysis
Thermal Equivalent Circuit

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
  - S.D. Sudhoff, *Power Magnetic Devices, A Multi-Objective Design Approach*, IEEE Press/Wiley.
- Secondary Reading List

- Papers available through IEEE Explore (available to all Purdue students at no cost)

- **G. Library Resources**

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

H. Course Syllabus

(While not a necessary component of this supporting document, an example of a course syllabus is available, for information, by clicking on the link below, which goes to the *Graduate School's Policies and Procedures Manual for Administering Graduate Student Program.*
See Appendix K.
http://www.purdue.edu/gradschool/faculty/documents/Graduate_School_Policies_and_Procedures_Manual.pdf