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: Environmental and Ecological Engineering | EFFECTIVE SESSION: Fall 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	EEE	Subject Abbreviation	
Course Number	53000	Course Number	
Long Title	Life Cycle Assessment: Principles and Applications		
Short Title	LCA: Principles & Applications		

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 [ ]
4. Thesis Credit: Yes [ ] No [ ]

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	50	3	15	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 covers the basic concept of life cycle thinking, framework and computational structure of process and economic input-output based life cycle assessment (LCA), state-of-the-art LCA software tools, industrial case studies, and recent advances in LCA methodology. Students are required to complete a group project that could potentially facilitate the adaptation of LCA tools in engineering research, education, or practice.

***COURSE LEARNING OUTCOMES:**

Be able to conduct an LCA study using state-of-the-art software tools and databases according to ISO 14040 standards; Be able to identify the limitations and weakness of an existing LCA study; Be able to develop customized inventory dataset using information available in literature and current inventory databases; Be able to develop a simplified yet functional LCA software tool tailored for an enterprise or organization; Be able to combine LCA results with economic and social impact analysis to support decision making;

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
West Lafayette Department Head	2/22/16 Date	West Lafayette College/School Dean	4/5/16 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

TO: The Engineering Faculty

FROM: The Faculty of the Division of Ecological and Environmental Engineering

RE: New Dual Level Course **EEE 53000**

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

EEE 53000 Life Cycle Assessment: Principles and Applications

Sem. 1, Class 3, cr. 3.

Prerequisite: MA 26200 or equivalent, CHM 11500 or equivalent, PHYS 17200 or equivalent; or Graduate Standing.

Course description: This course covers the basic concept of life cycle thinking, framework and computational structure of process and economic input-output based life cycle assessment (LCA), state-of-the-art LCA software tools, industrial case studies, and recent advances in LCA methodology. Students are required to complete a group project that could potentially facilitate the adaptation of LCA tools in engineering research, education, or practice.

Learning objectives:

- Be able to conduct an LCA study using state-of-the-art software tools and databases according to ISO 14040 standards;
- Be able to identify the limitations and weakness of an existing LCA study;
- Be able to develop customized inventory dataset using information available in literature and current inventory databases;
- Be able to develop a simplified yet functional LCA software tool tailored for an enterprise or organization;
- Be able to combine LCA results with economic and social impact analysis to support decision making;

Reasons: Life Cycle assessment takes a holistic approach and provides a comprehensive view of the environmental impacts over entire life cycle of a product, and is one of the most powerful tools available to engineers working on the development and evaluation of environmental benign product, process, and technology. The principles behind Life Cycle Assessment are introduced in this course, followed by computational structure, demonstration of state-of-the-art software packages, and recent advancement. Through this course students are expected to develop a thorough understanding of the life cycle thinking concept, gain knowledge and hands-on experience on how to identify and evaluate potential environmental and ecological consequence associated with an engineering decision from a systematic, holistic view by using state-of-the-art software

tools. This course has been offered six times on an experimental basis as ME59700-031 "Sustainable Design and Manufacturing" with enrollment of 22-33 students per semester.

John W. Sutherland

John W. Sutherland, Fehsenfeld Family Head
Division of Environmental and Ecological Engineering

Approved for the faculty of the Schools
of Engineering by the Engineering
Curriculum Committee
ECC Minutes 16 Date 4-5-16
Chairman ECC

Supporting Documentation:

1. Level: Graduate and Undergraduate

2. Course Instructor: Fu Zhao

3. Sample Lecture Schedule

Lecture 1	History and Framework of LCA
Lecture 2	Goal and Scope Definition
Lecture 3	Basics of Inventory Analysis
Lecture 4	LCI Databases
Lecture 5	Process tree development
Lecture 6	Customized unit process
Lecture 7	Review on Matrix Algebra
Lecture 8	Computation structure of LCA: Basic Setup
Lecture 9	Computation structure of LCA: Allocation and Cutoff
Lecture 10	Computation structure of LCA: Aggregated Process and Multiple Suppliers
Lecture 11	Computation structure of LCA: Recycling
Lecture 12	Computation structure of LCA: Sensitivity Analysis
Lecture 13	Review on Probability, Statistics, and Random Variables
Lecture 14	Computation structure of LCA: Uncertainty Analysis
Lecture 15	Case Study: Fluorescent Lamp vs Incandescent Lamp -1
Lecture 16	Case Study: Fluorescent Lamp vs Incandescent Lamp -2
Lecture 17	LCA Software Demo: SimaPro
Lecture 18	LCA Software Demo: GaBi
Lecture 19	Term Project Topics/Proposal
Lecture 20	Midterm Exam
Lecture 21	Life Cycle Impact Assessment: Impact Categories
Lecture 22	Life Cycle Impact Assessment: Procedures and Methodologies
Lecture 23	Carbon Footprinting
Lecture 24	Interpretation
Lecture 25	Critiques of LCA Studies
Lecture 26	Economic Input Output Model
Lecture 27	EIO-LCA
Lecture 28	EIO-LCA Software Demo and Case Study
Lecture 29	Hybrid LCA
Lecture 30	Next Generation LCI Database: uplci
Lecture 31	Dynamic LCA
Lecture 32	Consequential LCA: Framework and Methodology
Lecture 33	Consequential LCA: Case Study
Lecture 34	LCA Project Management
Lecture 35	Review on Life Cycle Cost Analysis

Lecture 36	Social LCA-1: Introduction
Lecture 37	Social LCA-2: Methodology
Lecture 38	Social LCA-3: Database Demo
Lecture 39	Multi-criteria Decision Making and AHP
Lecture 40	Life Cycle Sustainability Analysis
Lecture 41	Review for Final Exam
Lecture 42	Final Project Presentation
Lecture 43	Final Project Presentation
Lecture 44	Final Project Presentation

4. Textbook/References:

Environmental Life Cycle Assessment, by Rita Schenck and Philip White (Editors), American Center for Life Cycle Assessment, 2014.

The Computational Structure of Life Cycle Assessment, by Reinout Hejungs and Sangwon Suh, Kluwer Academic Publishers, 2002.

Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach, by Chris T. Hendrickson, Lester B. Lave, and H. Scott Matthews, Resources for the Future, Washington D.C., 2006.

5. Grading: (Plus/minus grading system)

Homework	20%
Midterm exam	15%
Term project	40%
Final exam	20%
Participation:	5%

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

To: Purdue University Graduate Council

From: Faculty Member: John W. Sutherland

Department: Environmental and Ecological Engineering

Campus: West Lafayette

Date:

Subject: Proposal for New Graduate Course

Contact for information if questions arise:
Name: Nina Robinson
Phone: 67578
Email: nlrobins@purdue.edu
Address: POTR 364D

Course Subject Abbreviation and Number: EEE 53000

Course Title: Life Cycle Assessment: Principles and Applications

Course Description:

This course covers the basic concept of life cycle thinking, framework and computational structure of process and economic input-output based life cycle assessment (LCA), state-of-the-art LCA software tools, industrial case studies, and recent advances in LCA methodology. Students are required to complete a group project that could potentially facilitate the adaptation of LCA tools in engineering research, education, or practice.

Semesters Offered:

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

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.

- Life Cycle assessment takes a holistic approach and provides a comprehensive view of the environmental impacts over entire life cycle of a product, and is one of the most powerful tools available to engineers working on the development and evaluation of environmental benign product, process, and technology. The principles behind Life Cycle Assessment are introduced in this course, followed by computational structure, demonstration of state-of-the-art software packages, and recent advancement. Through this course students are expected to develop a thorough understanding of the life cycle thinking concept, gain knowledge and hands-on experience on how to identify and evaluate potential environmental and ecological consequence associated with an engineering decision from a systematic, holistic view by using state-of-the-art software tools. This course has been offered six times on an experimental basis as ME59700-031 "Sustainable Design and Manufacturing" with enrollment of 22-33 students per semester.

- The target audience will be graduate students in engineering and senior undergraduates. We anticipate that the enrollment will vary from 10-20 depending on the subject matter. Depending on the subject matter the course may be delivered by lecture or laboratory or a combination. The courses will be taught at the graduate level so it is appropriate that it is a 50000 level course.
  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 5-10
  - Graduate 10-20

B. Learning Outcomes and Method of Evaluation or Assessment:

Describe the course objectives and student learning outcomes that address the objectives (i.e., knowledge, communication, critical thinking, ethical research, etc.). Expand lists and sub lists as needed.

- Objectives and Student Learning Outcomes

  - Able to identify environmental hotspots of a product life cycle or a manufacturing process based on information gathering and literature review.
  - Able to utilize state-of-the-art software tools to analyze environmental performance of a product or process.
  - Able to analyze the potential societal impacts of products, processes, or technologies.
  - Able to analyze and synthesize data to support decision making.
  - Able to communicate and present environmental performance assessment results to management and general public.

- Methods of Evaluation

Describe the methods of evaluation or assessment of student learning outcomes. (Include evidence for both direct and indirect methods.) Expand table rows as needed.

Learning Objective	Methods of Evaluation
o Able to identify environmental hotspots of a product life cycle or a manufacturing process based on information gathering and literature review.	Homework, exams, projects
o Able to utilize state-of-the-art software tools to analyze environmental performance of a product or process.	Homework, exams, projects
o Able to analyze the potential societal impacts of products, processes, or technologies.	Homework, exams, projects

o Able to analyze and synthesize data to support decision making.	Homework, exams, projects
o Able to communicate and present environmental performance assessment results to management and general public.	Homework, exams, projects

- 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.

Grading Criteria (replace with check for all that apply)	Weight Toward Final Grade
Exams and Quizzes	35%
Papers and Projects	40%
Homework	20%
Attendance and Class Participation	5%

- Methods of Instruction

Identify the method(s) of instruction and describe how the methods promote the likely success of the desired student learning outcomes. Add and delete rows as needed.

Hours per Week	Method of Instruction (replace with check for all that apply)	Contribution to Outcomes
3	Lecture	Contribute 100% to the outcomes

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.

- MA 26200 or equivalent, Linear Algebra And Differential Equations
- CHM 11500 or equivalent, General Chemistry
- PHYS 17200 or equivalent, Modern Mechanics

- Or Graduate Standing

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
Fu Zhao	Associate Professor	ME/EEE	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).**

Lecture 1	History and Framework of LCA
Lecture 2	Goal and Scope Definition
Lecture 3	Basics of Inventory Analysis
Lecture 4	LCI Databases
Lecture 5	Process tree development
Lecture 6	Customized unit process
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Lecture 40	Life Cycle Sustainability Analysis
Lecture 41	Review for Final Exam
Lecture 42	Final Project Presentation
Lecture 43	Final Project Presentation
Lecture 44	Final Project Presentation

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
    - Environmental Life Cycle Assessment, by Rita Schenck and Philip White (Editors), American Center for Life Cycle Assessment, 2014.
    - The Computational Structure of Life Cycle Assessment, by Reinout Hejungs and Sangwon Suh, Kluwer Academic Publishers, 2002.
    - Environmental Life Cycle Assessment of Goods and Services: An

Input-Output Approach, by Chris T. Hendrickson, Lester B. Lave, and H. Scott Matthews, Resources for the Future, Washington D.C., 2006.

- Secondary Reading List
  - none

G. Library Resources

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

- E-publications accessible via Purdue libraries will be used in this 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