Office of the Registrar
FORM 40G REV. 1/17

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

PRINT

DEPARTMENT: Civil Engineering EFFECTIVE SESSION: Spring 2018

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	CE	Subject Abbreviation	
Course Number	59800	Course Number	
Long Title	Entrepreneurship and Business Strategy in Engineering		
Short Title			

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

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

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

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): (Note: If description will not fit in space provided, please create a separate document and attach to this form.)

see attached

*COURSE LEARNING OUTCOMES: (Note: If course learning outcomes will not fit in space provided, please create a separate document and attach it to this form.)

see attached

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	11/10/17 Date	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

Grad Form 40G must include the Graduate Council's supporting document, which is available at http://www.purdue.edu.registrar/forms/form_40_Intro.html

To: The Faculty of the College of Engineering

From: Lyles School of Civil Engineering of the College of Engineering

RE: New Graduate Course, CE 59800 Breakthrough Thinking for Complex Challenges

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

CE 59800 Breakthrough Thinking for Complex Challenges
Sem. 1, Lecture 3, Cr. 3
Prerequisites: Graduate standing is recommended. Exceptions may be granted by permission of the instructor.

Description: This course helps students learn and effectively employ high-impact design principles and structured problem solving methods to address complex multi-stakeholder socio-technical challenges. Case discussions of historical and contemporary high impact solutions to complex challenges are used to introduce techniques to frame problems, structure ambiguity, intentionally design non-incremental solutions, and communicate, trial, and iterate solutions to drive adoption and multifaceted sustainability. Techniques are drawn from multiple schools of thought such as business, design, engineering, and the social sciences. Over the course of the term, multi-disciplinary student teams directly apply cumulative learning to address a real-world complex societal challenge in close collaboration with a partner organization, in an experiential learning format.

This course can be counted toward the College of Engineering Minor in Innovation and Transformational Change and the Burton D. Morgan Center for Entrepreneurship (BDMCE) Certificate in Entrepreneurship and Innovation.

Reason: Engineers are increasingly engaged in developing solutions to major challenges which are referred to under varying names such as complex problems, grand challenges, or wicked problems. These categories of problems require solutions that span technical, economic, social, and cultural domains and thus impede approaches derived from only one perspective. Major challenges share the characteristics of being ambiguously bounded, involving multiple stakeholders and interdependencies, and displaying non-linear emergent behavior, network effects, and hysteresis. This course introduces and allows students to apply methods from varying fields that enable them to integrate differing ways of thinking to frame major challenges and design and advance holistic solutions, helping to build critical awareness and skills consistent with the College's vision to prepare Purdue engineers for leadership roles in the 21st century.

This course has been offered 3 times as a CE597 course, with the following

enrollments: S15 (21), S16 (14), S17 (8).

Rao S. Govindaraju, Bowen Engineering Head of Civil Engineering
Lyles School of Civil Engineering

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

To: Purdue University Graduate Council

From: Faculty Member: Joseph Sinfield
Department: Lyles School of Civil Engineering
Campus: West Lafayette

Date:

Subject: Proposal for New Graduate Course-Documentation Required by the Graduate Council to Accompany Registrar's Form 40G

Contact for information if questions arise:
Name: Teresa L. Cadwallader
Phone: 765-494-0987
E-mail: tlc3764@purdue.edu
Address: ARMS 3000

Course Subject Abbreviation and Number: CE 59800

Course Title: Breakthrough Thinking for Complex Challenges

A. Justification for the Course

Engineers are increasingly engaged in developing solutions to major challenges which are referred to under varying names such as complex problems, grand challenges, or wicked problems. These categories of problems require solutions that span technical, economic, social, and cultural domains and thus impede approaches derived from only one perspective. Major challenges share the characteristics of being ambiguously bounded, involving multiple stakeholders and interdependencies, and displaying non-linear emergent behavior, network effects, and hysteresis. This course introduces and allows students to apply methods from varying fields that enable them to integrate differing ways of thinking to frame major challenges and design and advance holistic solutions. In the course, students engage in problem exploration and participatory design in close partnership with an external organization. Conceived solutions must incorporate not only means to address technical challenges, but also aspects of stakeholder education and awareness, cultural adoption, resource availability and access, economic and operational sustainability, and governance. Collectively, co-designing holistic solutions inclusive of all of the aforementioned components, in collaboration with involved stakeholders, helps build critical awareness and skills consistent with the College's vision to prepare Purdue engineers for leadership roles in the 21st century.

This course has been offered 3 times as a CE597 course, with the following enrollments: S15 (21), S16 (14), S17 (8).

B. Learning Outcomes and Method of Assessment

Learning Outcomes – Upon successful completion of this course, students will be able to:

1. Employ rigorous issue analysis methods to develop mutually-exclusive collectively-exhaustive structured inventories of the issues involved in a major challenge
2. Understand stakeholder motivation and interpret the funds, services, and influence exchanged in stakeholder ecosystems
3. Understand the benefits and limitations of qualitative and quantitative methods to identify and interpret stakeholder needs
4. Gain familiarity with habit conversion methodologies and the role they can play in design activities
5. Recognize the importance of empathy in solution design and apply structured ideation methods to engender empathy in designers
6. Understand patterns of innovation success and the contextual circumstances in which they apply
7. Employ combinatorial business design methods to explore and prioritize alternative paths to achieve financial sustainability for an idea
8. Discern the broader societal impacts of design activities
9. Develop robust assessments of the assumptions underlying new ideas and means to test those assumptions rapidly and at low cost
10. Recognize and define influence paths and communication methods to drive awareness, consideration, conversion, and retention of new solutions

Relation to ABET Standards

Standard	***Corresponding Course Content***
A. Ability to apply mathematics, science and engineering principles	Team project involving designing and iteratively testing holistic solutions for complex challenges
C. Ability to design a system, component, or process to meet desired needs	Team work sessions and lecture content on issue and ecosystem analysis and stakeholder definition; lectures on systems thinking and solution right-sizing; team work session on systems-level solution prioritization
D. Ability to function on multidisciplinary teams	Team project involving multidisciplinary student teams; team work session and lecture on ideation best practices
E. Ability to identify, formulate, and solve engineering problems	Lectures on problem framing, hypothesis-driven problem solving, and leveraging structure and analogies to generate solutions;

	term project and collaborative co-design requiring development of holistic solutions to a major challenge
G. Ability to communicate effectively	Lecture on persuasive communications, ghosting, storylines, and storytelling; team oral presentations
H. The broad education necessary to understand the impact of engineering solutions in a global and societal context	Team project and course content centered around designing for major challenges
J. Knowledge of contemporary issues	Lecture and case discussions focused on addressing major societal challenges
K. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Lectures and multiple problem solving sessions on design, linking quality to context, and identifying barriers to uncover paths to breakthrough opportunity

Relation to Engineer of 2020 Target Attributes

Target Attribute	***Corresponding Course Content***
Decision-making ability	Team working sessions on systems-level solution prioritization; lecture on the many forms of risk
Ability to synthesize engineering, business, and societal perspectives	Team working sessions and lecture on multifaceted sustainability (operational, economic, environmental and cultural)
Open-ended design and problem solving skills	Term project aimed at framing and addressing major challenge that has no discreet solution path or solution; See also ABET standards A, C, E, and K; lecture on developing an outside-in perspective on solutions
Analytical skills	Lectures and iterative team working sessions to gather, analyze, and interpret multiple forms of technical, economic and social data; See also ABET standard C
Innovative mindset	Lecture on forms of innovation and impact; case studies illustrating achievement of high-impact innovation and innovator attributes

Adaptability in a changing environment	Team work sessions and lectures on ecosystem analysis, habit conversion, stakeholder influence and communication strategies

Method of Assessment – These learning outcomes are assessed as follows

Weight	Activity
65%	Term project team assignments: The term project for the class centers on a multifaceted problem representative of a major societal challenge that is provided by an external organization (e.g., Spring 2017 - Common Wealth Kitchen, a non-profit business incubator and scaling organization in Boston, sought support to optimize facility utilization and equipment investments in a shared food manufacturing facility used to help launch food industry start-ups while achieving its broader mission of creating gainful employment for underrepresented societal stakeholders and fostering economic development in lower-income regions of the city). Students in the class divide into teams of 3 to 5 and engage with the external organization and key stakeholders in problem framing and co-design activities leading to the development of holistic solutions to address the organization's challenge. Team assignments consist of 8 to 12 interim deliverables (e.g., issue analysis, stakeholder maps, context characterization, holistic solution requirements, solution design space definition, solution trees, prioritization criteria development, system-level solution selection, multifaceted sustainability evaluation, and assumption analysis) that are developed by the teams over the course of the semester and shared with the external organization as they work their way through framing and developing solutions to address the provided challenge.
35%	Homework and cases: Brief individual written assignments (< 3 pages) are employed to guide students through exploration of course concepts and cases illustrating discussed design principles and behaviors (typically 3-5 assignments)

Method of Instruction – Lecture, Case Discussion, and Joint Problem Solving
Course content is presented through lectures and case discussions, and reinforced through individual and team assignments as well as in-class joint problem solving sessions focused on addressing specific aspects of the overall process introduced in the course to tackle major challenges. Each concept in the process is explored by students as individuals through case analysis and/or homework assignment and/or examined in class in case discussions, and then employed by student teams in the context of focal major challenge for the course. Periodic report-outs of interim project analyses by the project teams and engagement in joint problem solving and co-design with the external organization then foster deeper discussion of the core concepts and engage students in participatory design and peer-to-peer feedback

C. Prerequisite(s)
There are no field-specific prerequisites. Graduate or senior level undergraduate standing is recommended. Exceptions may be granted by permission of the instructor.

D. Course Instructors

Name	Rank	School	Graduate Faculty
Joe Sinfield	Associate Professor	Civil Engineering	Yes

E. Course Outline

Week	*Topic*		*Reading/References*
1	I.	Addressing grand challenges	Sinfield and Solis, 2016b
2	II.	Forms of innovation / defining impact	Dewar and Dutton, 1986; Ettlie et. al., 1984; Anderson and Tushman, 1990; Henderson and Clark, 1990; Tushman and Murmann, 1998; Baldwin and Clark, 2000; Schilling 2000; Solis and Sinfield, 2014
3	III.	Design thinking and achieving breakthrough	Breakthrough Case #1; Sinfield and Solis, 2016b; Crismond and Adams, 2012; Brown and Wyatt, 2010
4,5,6	IV.	Issue analysis; hypothesis-driven problem solving	Minto, 1996
7,8	V.	Framing a problem; ecosystem analysis; stakeholder engagement	Belone et al., 2016
9	VI.	Making a problem personal; jobs-to-be-done and ethnography	Anthony et al., 2007; Beebe, 2014
10	VII.	Developing an outside-in perspective on solutions	Solis and Sinfield, 2016a
11	VIII.	Systems thinking; patterns of innovation success	Breakthrough Case #2 Goldenfeld, 1999; Bonabeau, 2002; DeLaurentis and Callaway, 2004; Gorod, et al., 2008; Mostafavi et al., 2011
11	IX.	Focusing on context to "right size" solutions	Sinfield, 2007

12	X.	Ideation best practices and stimuli development	Sinfield and Anthony, 2006; Sinfield et al., 2014; Girotra et al., 2010
13,14	XI.	Business model innovation to facilitate economic sustainability	Weill et al. 2004; Johnson et al. 2008; Sinfield et al. 2012
14	XII.	The many forms of risk	Damanpour, 1996; Sinfield and Solis, 2016a
15	XIII.	Persuasive communications; ghosting, storylines, and storytelling	Breakthrough Case #3
16	XIV.	Planning to learn	Mintzberg and Waters 1985; McGrath and MacMillan 1995

F. Reading List

1. Anderson, P. and Tushman, M. L., (1990) Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change, *Administrative Science Quarterly*, Vol. 35, No. 4, pp. 604-633
2. Anthony, S. D., and Sinfield, J.V. (2007) "Product for Hire: Master the Innovation Lifecycle with a Jobs-to-be-Done Perspective of Markets,"*Marketing Management*, March/April, 19-24.
3. Baldwin, C., & Clark, K. (2000). **Design rules: the power of modularity**. Cambridge, MA: The MIT Press.
4. Beebe, J. (2014). **Rapid Qualitative Inquiry: A Field Guide to Team-Based Assessment**, Second Edition. Lanham MD: Rowman & Littefield. 258 pp.
5. Belone, L., Lucero, J.E., Duran, B., Tafoya, G., Baker, E.A., Chan, D., Chang, C. Greene-Moton, E., Kelley, M. A., and Wallerstein, N., (2016). "Community-Based Participatory Research Conceptual Model: Community Partner Consultation and Face Validity," *Qualitative Health Research*, 26(1): 117-135.
6. Bonabeau, E. (2002). Agent-Based Modeling: Methods and Techniques for Simulating Human Systems. Proceedings of the National Academy of Sciences, 99(10), 7280-7287.
7. Brown, T., and Wyatt, J. (2010), "Design Thinking for Social Innovation," *Development Outreach,* (12)1, 29-43.
8. Crismond, D. P., and Adams, R. S. (2012). "The Informed Design Teaching and Learning Matrix." *Journal of Engineering Education*, 101(4), 738-797.
9. Damanpour, F. (1996). "Organizational Complexity and Innovation: Developing and Testing Multiple Contingency Models." *Management Science*, 42(5), 693 - 716.
10. DeLaurentis, D., & Callaway, R. (2004). "A systems-of-systems perspective for public policy decisions." *Review of Policy Research*, 21(6), 9.
11. Dewar, R., and Dutton, J. (1986). "The Adoption of Radical and Incremental Innovations: An Empirical Analysis." *Management Science*, 32(11), 1422 - 1433.
12. Ettlie, J.E. Bridges, W.P. and O'Keefe, R.D. (1984) "Organization Strategy and Structural Differences for Radical Versus Incremental Innovation," *Management Science* 30, (6): 682-695

13. Girotra, K., Terwiesch, C., and Ulrich, K. T., (2010) "Idea Generation and the Quality of the Best Idea", *Management Science*, Vol. 56, No. 4 (April 2010), pp. 591-605.
14. Goldenfeld, N. (1999). "Simple Lessons from Complexity." *Science*, 284(5411), 8789. doi: 10.1126/science.284.5411.87
15. Gorod, A., Sauser, B., and Boardman, J. (2008) "System-of-Systems Engineering Management: A Review of Modern History and a Path Forward," *IEEE Systems Journal*, (2) 4, 484-499.
16. Henderson, R., and Clark, K. (1990). "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms." *Administrative Science Quarterly*, 35(1), 9- 30.
17. Johnson, M., Christensen, C., and Kagermann, H. (2008). "Reinventing your business model." *Harvard Business Review*, December, 51-59.
18. McGrath, R., and MacMillan, I. (1995). "Discovery-driven planning." *Harvard Business Review*, 73(4), 44-54.
19. Minto, B. (1996) **The Minto Pyramid Principle: Logic in Writing, Thinking, and Problem Solving**, Minto International, Inc., London.
20. Mintzberg, H., and Waters, J. (1985). "Of strategies, deliberate and emergent." *Strategic Management Journal*, 6(3), 257-272.
21. Mostafavi, M., Abraham, D., DeLaurentis, D., and Sinfield, J. (2011). "Exploring the Dimensions of Systems of Innovation Analysis: A System of Systems Framework." *IEEE Systems Journal,* 5(2), 256 - 265.
22. Schilling, M. (2000). "Toward a General Modular Systems Theory and its Application to Interfirm Product Modularity." *Academy of Management Review*, 25(2), 312 - 334.
23. Sinfield, J. and Anthony, S. (2006) "Constraining Innovation: How Developing and Continually Refining Your Organization's Goals and Bounds Can Help Guide Growth", *Strategy & Innovation*, November – December, v. 4, n. 6, 1, 6-9.
24. Sinfield, J.V., (2007) "Gives, Gets, and the Good Enough: A methodical, consumer driven approach to cutting features, benefits—and costs", *Strategy & Innovation*, November – December, v. 5, n. 6, 1, 6-10.
25. Sinfield, J.V., and Solis, F., (2016a) "Finding a Lower-risk Path to High-impact Innovations," **Sloan Management Review**, 79-89, Summer.
26. Sinfield, J.V., and Solis, F., (2016b) "Thinking Big to Address Major Challenges: Design and Problem-Solving Patterns for High-Impact Innovation, National Academy of Engineering, *The Bridge*, 11-18, Summer.
27. Sinfield, J.V., Calder, E.S., Colson, S., McConnell, B., (2012) "How to Identify New Business Models," *Sloan Management Review*, v. 53, n. 2, Winter.
28. Sinfield, J.V., Gustafson, T., and Hindo, B. (2014) "The Discipline of Creativity," *Sloan Management Review*, 55(2), 24-26, Winter.
29. Solis, F. and Sinfield, J.V. (2014) "Rethinking Innovation: Characterizing Dimensions of Impact," ASEE Annual Conference, 360 Degrees of Engineering Education, June 15 - 18, 2014 Indianapolis, Indiana, Paper ID #9284.
30. Solis, F., and Sinfield, J.V., (2016) "From Entrepreneur to Designer: The Transferable Design Principles of the Entrepreneur," (2016) ASEE Annual Conference & Exposition, Jazzed about Engineering Education, June 26-29, 2016, New Orleans, LA, Paper ID#15965.
31. Tushman, M., and Murmann, J. (1998). "Dominant Designs, Technology Cycles, and

Organizational Outcomes." *Research in Organizational Behavior*, 20, 231 - 266.
32. Weill, P., Malone, T. W., D'Urso V.T., Herman, G. and Woerner S. (2004) "Do Some Business Models Perform Better Than Others?" MIT Sloan School of Management Working Paper/ MIT Center for Coordination Science Working Paper No. 226, 6 May.

G. Library Resources

Readings and resources for this course are readily accessed by students through the Purdue University Libraries.