To: The Faculty of the College of Engineering

From: The Curriculum Committee of the Innovation and Leadership Studies Program

RE: New Undergraduate Course, ENGR 49000 Breakthrough Thinking for Complex Challenges

The Curriculum Committee of the Innovation and Leadership Studies Program has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ENGR 49000 Breakthrough Thinking for Complex Challenges
Sem. 1, Lecture 3, Cr. 3
Prerequisites: None.

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 selected parts of 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 aspects of 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).

[Signature]

Director of the Innovation and Leadership Studies
ENGR490 Syllabus
Page 1 of 7

ENGR490
Breakthrough Thinking for Complex Challenges

Course: ENGR-49000 “Breakthrough Thinking for Complex Challenges”

Description: In this course, students engage in problem exploration and participatory
design in close partnership with an external organization to frame, design,
and advance holistic solutions to major challenges varyingly categorized
as complex problems, grand challenges, or wicked problems. These
categories of problems share the characteristics of being ambiguously
bounded, involving multiple stakeholders and inter-dependencies, and
displaying non-linear emergent behavior, network effects, and hysteresis,
and require solutions that span technical, economic, social, and cultural
domains. Conceived solutions focus on two or more aspects of the major
challenge, and may include means to address technical challenges, aspects
of stakeholder education and awareness, cultural adoption, resource
availability and access, economic and operational sustainability, or
governance. Collectively, co-designing solutions with a holistic
perspective 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.

Pre-requisites: None

Instructor: Professor Joe Sinfield Office: HAMP G231 Phone: x6-2742

Class hours: Two meetings per week: (1) 50 min + (1) 110 min

Classroom: TBD

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
7. Understand 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

<table>
<thead>
<tr>
<th>Alignment with standards:</th>
<th>ABET Standard</th>
<th>Corresponding Course Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Ability to apply mathematics, science and engineering principles</td>
<td>Team project involving designing and iteratively testing aspects of holistic solutions for complex challenges</td>
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<tr>
<td>C. Ability to design a system, component, or process to meet desired needs</td>
<td>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</td>
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<tr>
<td>D. Ability to function on multidisciplinary teams</td>
<td>Team project involving multidisciplinary student teams; team work session and lecture on ideation best practices</td>
<td></td>
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<tr>
<td>E. Ability to identify, formulate, and solve engineering problems</td>
<td>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 aspects of holistic solutions to a major challenge</td>
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<tr>
<td>G. Ability to communicate effectively</td>
<td>Lecture on persuasive communications, ghosting, storylines, and storytelling; team oral presentations in class and to engaged partner organization</td>
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<tr>
<td>H. The broad education necessary to understand the impact of engineering solutions in a global and societal context</td>
<td>Team project and course content centered around designing for major challenges</td>
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<tr>
<td>J. Knowledge of contemporary issues</td>
<td>Lecture and case discussions focused on addressing major issues</td>
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</table>
**K. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice**

| Societal challenges | 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**

<table>
<thead>
<tr>
<th>Target Attribute</th>
<th>Corresponding Course Content</th>
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</thead>
<tbody>
<tr>
<td>Decision-making ability</td>
<td>Team working sessions on systems-level solution prioritization; lecture on the many forms of risk</td>
</tr>
<tr>
<td>Ability to synthesize engineering, business, and societal perspectives</td>
<td>Team working sessions and lecture on multifaceted sustainability (operational, economic, environmental and cultural)</td>
</tr>
<tr>
<td>Open-ended design and problem solving skills</td>
<td>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</td>
</tr>
<tr>
<td>Analytical skills</td>
<td>Lectures and iterative team working sessions to gather, analyze, and interpret multiple forms of technical, economic and social data; See also ABET standard C</td>
</tr>
<tr>
<td>Innovative mindset</td>
<td>Lecture on forms of innovation and impact; case studies illustrating achievement of high-impact innovation and innovator attributes</td>
</tr>
<tr>
<td>Adaptability in a changing environment</td>
<td>Team work sessions and lectures on ecosystem analysis, habit conversion, stakeholder influence and communication strategies</td>
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**Grading:**

<table>
<thead>
<tr>
<th>Weight</th>
<th>Activity</th>
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<tbody>
<tr>
<td>65%</td>
<td>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. 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</td>
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</table>
key aspects of holistic solutions to help address the organization’s challenge. Team assignments consist of 6 to 8 interim deliverables (e.g., issue analysis, stakeholder maps, context characterization, holistic solution requirements, solution design space definition, prioritization criteria development, system-level solution selection, 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 aspects of solutions to address the provided challenge.

<table>
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<tr>
<th>35%</th>
<th>Homework and cases: Brief individual written assignments (&lt; 3 pages) are employed to guide students through exploration of course concepts and cases illustrating discussed design principles and behaviors (typically 3-5 assignments)</th>
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</thead>
</table>


Attendance: Due to the nature of this class, class participation is a must. In order to receive course credit and a full grade, a student must:

1. Have no more than two unexcused absences.
2. Satisfactorily complete ALL assignments.

Three unexcused absences will result in a grade reduction of one letter grade. Four unexcused absences will result in a grade of ‘I’ or ‘F’, depending on whether or not the student is considered to be passing in all other aspects at the time of the fourth absence. Failure to complete ALL assignments will result in a grade of ‘I’ or ‘F’, depending on whether or not the student is considered to be passing in all other aspects.

Homework/cases/project deliverables: No assignments can be missed without penalty, unless the missed assignment is authorized by the instructor.

Ethics: Students are expected to uphold all university policies and regulations on academic integrity and conduct. Academic dishonesty will not be tolerated, and any acts of academic dishonesty will be dealt with on a case by case basis. Penalties for violations will be levied at the discretion of the instructor and may include but are not limited to reduction in the grade received for an assignment or exam, loss of credit for an assignment or exam, reduction in the FINAL grade for the course, and/or failure of the course.
<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Reading/References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I. Addressing grand challenges</td>
<td>Sinfield and Solis, 2016b</td>
</tr>
<tr>
<td>2</td>
<td>II. Forms of innovation / defining impact</td>
<td>Solis and Sinfield, 2014</td>
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<tr>
<td>3</td>
<td>III. Design thinking and achieving breakthrough</td>
<td>Breakthrough Case #1; Sinfield and Solis, 2016b; Crismond and Adams, 2012</td>
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<tr>
<td>4,5,6</td>
<td>IV. Issue analysis; hypothesis-driven problem solving</td>
<td>Minto, 1996</td>
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<td>7,8</td>
<td>V. Framing a problem; ecosystem analysis; stakeholder engagement</td>
<td>Belone et al., 2016</td>
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<td>9</td>
<td>VI. Making a problem personal; jobs-to-be-done and ethnography</td>
<td>Anthony et al., 2007; Beebe, 2014</td>
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<tr>
<td>10</td>
<td>VII. Developing an outside-in perspective on solutions</td>
<td>Solis and Sinfield, 2016a</td>
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<tr>
<td>11</td>
<td>VIII. Systems thinking; patterns of innovation success</td>
<td>Breakthrough Case #2 DeLaurentis and Callaway, 2004; Mostafavi et al., 2011</td>
</tr>
<tr>
<td>11</td>
<td>IX. Focusing on context to “right size” solutions</td>
<td>Sinfield, 2007</td>
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<tr>
<td>12</td>
<td>X. Ideation best practices and stimuli development</td>
<td>Sinfield and Anthony, 2006; Sinfield et al., 2014; Girotra et al., 2010</td>
</tr>
<tr>
<td>13,14</td>
<td>XI. Business model innovation to facilitate economic sustainability</td>
<td>Weill et al. 2004; Johnson et al. 2008; Sinfield et al. 2012</td>
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<tr>
<td>14</td>
<td>XII. The many forms of risk</td>
<td>Damanpour, 1996; Sinfield and Solis, 2016a</td>
</tr>
<tr>
<td>15</td>
<td>XIII. Persuasive communications; ghosting, storylines, and storytelling</td>
<td>Breakthrough Case #3</td>
</tr>
<tr>
<td>16</td>
<td>XIV. Planning to learn</td>
<td>Mintzberg and Waters 1985; McGrath and MacMillan 1995</td>
</tr>
</tbody>
</table>
Reading list: Readings will be drawn from the following references


ENGR - 49000 - Breakthrough Thinking for Complex Challenges
2017-2018 Course Create New Undergraduate

General Course Information

- **Originating Campus**: West Lafayette
- **Non-Originating Campus(es)**: No other campus involved
  - West Lafayette
  - Northwest
  - Fort Wayne
  - IUPUI
  - Northwest & Fort Wayne
  - Northwest & IUPUI
  - West Lafayette & Northwest
  - West Lafayette & Fort Wayne
  - West Lafayette & IUPUI
  - Fort Wayne & IUPUI
  - Northwest, Fort Wayne, & IUPUI
  - West Lafayette, Fort Wayne, & IUPUI
  - West Lafayette, Northwest, & IUPUI
  - West Lafayette, Fort Wayne, & Northwest

**Multiple Campuses**: There is only one version of a course in the Banner catalog. All campus locations offering this course must agree. Choosing the locations above allows all involved campuses to approve the proposal.

- **College/School**: College of Engineering - WL
- **Department**: College of Engineering Administration (Graduate) - WL

**Course Numbers**: All course numbers may only be used once for a course in order to allow our repeat course audit to work properly. Before submitting a form for a new course or renumber, please make sure the course number is available. Please remember Purdue
now uses 5-digit course numbers to allow more options for the departments. This may be verified through the following:

Legacy Course Catalog: [https://www.purdue.edu/registrar/legacy/catalog.cfm](https://www.purdue.edu/registrar/legacy/catalog.cfm)

Banner Course Catalog: [https://selfservice.mypurdue.edu/prod/bwckctlg.p_disp_dyn_ctlg](https://selfservice.mypurdue.edu/prod/bwckctlg.p_disp_dyn_ctlg)

<table>
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<tr>
<th>Proposed Effective Term</th>
<th>Spring 2018</th>
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<tbody>
<tr>
<td>Proposed Subject Code*</td>
<td>ENGR</td>
</tr>
<tr>
<td>Proposed 5 digit course #*</td>
<td>49000</td>
</tr>
<tr>
<td>Long Title*</td>
<td>Breakthrough Thinking for Complex Challenges</td>
</tr>
</tbody>
</table>

| Short Title (max 30 characters) |  |

<table>
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<tr>
<th>Terms offered (Select all that apply)</th>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
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</table>

**Credit Hour Guidelines:** Purdue’s credit hour guidelines are provided below.


Please use the following two options to specify if the course credit is fixed or variable:

**Option #1: Fixed Credit Hours**

| Proposed Credit Hours | 3 |

**Option #2: Variable Credit Range**

| Minimum |  |
| Variable Credit | To | OR |  |
| Maximum |  |

<table>
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<tr>
<th>Course Repeat Status</th>
<th>Course may be repeated</th>
<th>Course may not be repeated</th>
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</table>

| If repeatable: | Unlimited Amount of times |
If this course is crosslisted, navigate to the crosslisting icon 🔄 in the Proposal Toolbox.

**Click on 'Add Crosslisting'**
- Select the proposal that has (crosslisting) after the course title
- Update any fields that pertain to the crosslisted course
- Save your changes
- Navigate back to the Primary proposal by clicking on the 'View Primary' icon in the top left corner of the proposal

**Course Fees:** The following fees are provided on the form: Coop, Lab, and Rate Request. In order to ensure the accurate fee is assessed on a course, the Bursar's Office would like to have an explanation included with the form along with the business manager's contact information if additional information is needed.

**Registration Approvals**
- Department
- Instructor
**Attributes:**

(Select all that apply)

- Variable Title
- Honors
- Full-Time Privileges
- Half-Time Privileges
- Internship
- Coop
- Parallel Coop
- Credit by Exam

**Schedule Types/Credit Hours:** The following links will provide explanations of the schedule types and credit hours to assist in assigning accurate types to a course.

- **Schedule Type Classifications**
- **Credit Hour Guidelines**

Use the following instructions to add each schedule type for the course in the text box. Examples are listed below.

**Schedule Types:** Lecture (LEC), Recitation (REC), Presentation (PRS), Laboratory (LAB), Lab Prep (LBP), Studio (SD), Distance Learning (DIS), Clinic (CLN), Experiential (EX), Research (RES), Individual Study (IND), Practice Study Observation (PSO)

- Minutes per Meeting
- Number of Meetings per week
- Weeks per term

Examples: (3 credit course) LEC/50min per mtg/3mtgs per wk/16 wks per term OR (3 credit course with Lecture and Lab) LEC/50/2/16 and LAB/100/1/16

**Proposed Schedule Type:**

- LEC/50min per mtg/3mtgs per wk/16 wks per term

**Restrictions:**

If restrictions are being requested, please provide the proper Banner codes (major, program etc.) to ensure all are accurately reflected on the course. All codes may be found on our
Restriction Types: major, program or school codes; never use more than one
Use the words "and" or "or" when filling out form instead of commas

Restrictions List: Department, Field of Study, Class, Level, Degree, Program, Campus, College

<table>
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<tr>
<th>Proposed Restrictions:</th>
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</table>

**Requisites:**

Requisite information can only be selected from active offerings.

- Co-requisite courses are always required to be taken at the same time
- Concurrent prerequisite courses may be taken during the same semester or in a previous term
- 600-level prerequisites are not enforced, they are added to description as informational text

If there is an equivalent course the department would like listed with the prerequisites, that specific course will need to be specified on the form in order to have it enforced through the system.

<table>
<thead>
<tr>
<th>Pre-Requisites:</th>
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<tbody>
<tr>
<td>D- equals the lowest passing grade, unless otherwise noted</td>
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<table>
<thead>
<tr>
<th>Co-Requisites</th>
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</table>

**Course Information:**
Course 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 selected parts of a real-world complex societal challenge in close collaboration with a partner organization, in an experiential learning format.

Learning Outcomes

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

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

Additional Course Information (if needed)
**Syllabus** - Attach using the directions below:

Navigate to the Proposal Toolbox at the top of the right side.
Select the "Add Files" button
Upload file to be attached.

**Validate and Launch Proposal**

Once you have completed all fields:

Click “Save All Changes”
Click on the arrow at the top of the page to launch the proposal. (Only launch the proposal after completing all necessary fields.) The proposal will now be sent on for approvals.

**WL Catalog Use Only**

<table>
<thead>
<tr>
<th>Catalog Ownership</th>
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<tr>
<th>Course Type</th>
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