FORM B

UNIVERSITY OF MASSACHUSETTS AMHERST
OFFICE OF THE SECRETARY
THE FACULTY SENATE

UNDERGRADUATE COURSE APPROVAL FORM
(Courses Numbered 001-599)

15 Copies Required for Courses Numbered 001-499
20 Copies Required for Courses Numbered 500-599

1. **DEPARTMENT, COURSE NUMBER AND TITLE: NatSci 189—Global Challenges, Scientific Solutions [iCons 1]**

2. **SCHOOL OR COLLEGE: College of Natural Sciences**

3. **Proposer's Name, Telephone and Email: Justin Fermann, 545-2054, fermann@chem.umass.edu**

4. **Proposed Instructors: Justin Fermann, Susan Leschine, Steven Petsch**

5. **Course Credits: 4**

6. **Are there Prerequisites? No If yes, please specify There are no prerequisites, but admission to the iCons Program is required, by application in the semester prior to enrolling in iCons 1**

7. **What is the intended clientele? X Lower Division Science, Engineering & Related Majors**
   Upper Division_____

   Department majors only_____ Departmental/related majors_____ Non-Majors _____

   If course is intended for majors, what role will it play in the curriculum? Required_____ Elective_____

8. **Complete Course Catalog Description (30 Words):**
   This course brings together topics from Life Sciences, Physical Sciences, Natural Systems, and Social Systems in the context of real world scientific issues. Students will be expected to grapple with the scientific underpinnings of complex problems, including issues surrounding Clean Water, Climate Change, Energy Demands, and Disease and Biomedicine. Case studies will serve as the format/foundation in which students will learn and use fundamental scientific principles to investigate these challenges and quantify the scientific contributions to solutions. The case studies pursued will have political, social, and economic relevance, allowing for the study of scientific concepts and methods as they impact our society. (Gen.Ed. I)

9. **Please attach the following materials:**

   _____ Week-by-week outline of topics covered in course (or syllabus)
   _____ List of Required readings
   _____ Description of required assignments (papers, exams, projects, reports, presentations, etc.)
   _____ Summary of course grade criteria
   _____ Selected bibliography of works used by instructor in developing course, especially recent works (as appropriate)

10. **If course has been offered as an experimental or special topics course, please comment (on an attached page) on its evolution.**

Upon approval of the course by the department head, one copy of this form shall be sent from the departmental office to the Faculty Senate Office to allow for the course to be published on the University's Web Site for comment.

For courses numbered 500-599, the "Guidelines for Course Approval Form" from the Graduate Council must accompany the new course proposal.

UNDERGRADUATE COURSE APPROVAL FORM ATTACHMENTS

FORM B

9. Please attach the following materials:

Week-by-week outline of topics covered in course (see also attached syllabus)
Global Challenges, Scientific Solutions, (NatSci 190I) explores case study topics in multi-period, multi-week segments, selected from current events. During Spring 2011, the iCons I class addressed case studies on Cholera in Haiti, Alzheimer's Disease, the BP Oil Spill, and Biofuels.

The specific week-by-week flow of this course will depend on the instructors and their choices of case studies to pursue. Below we offer the week-by-week flow that occurred in Spring 2011 as a sample. Future offerings of "Global Challenges, Scientific Solutions" will follow the same pedagogy and broad flow as that shown below:

Week 1: Introduction to the iCons Method
Weeks 2-3: Cholera in Haiti – Cycle 1: Science to Help Solve Cholera
Weeks 4-5: Cholera in Haiti – Cycle 2: Modeling to Track the Outbreak
Weeks 5-6: Alzheimer's and Aluminum: Cause or Coincidence?
Week 7: Retrospective: Structure of a Case Study
Weeks 8-9: Gulf Oil Spill: What Should We Have Known?
Weeks 10-11: Biofuel Utilization: National Energy Flows?
Weeks 12-13: Final Case Study Construction

List of Required Readings
The iCons 1 course does not use a textbook. Instead, readings, images and videos drawn from popular literature and website resources are used. These materials are made available to enrolled students through SPARK or MOODLE.

Description of Required Assignments
Required assignments include reports, experiment design, critiques, data analysis, proposal design, model design and class presentations. For the final course project, student teams research, develop and deliver a complete set of materials for a novel case study that may be used in the next offering of iCons 1.

Summary of Course Grade Criteria
Students will be evaluated based on:
1. Effective teamwork, leadership, and innovation in problem solving.
2. Faculty critique of team projects centered on each case study, which may include written reports, oral presentations, group decision-making, and other forms of scientific communication.
3. Peer review of these projects.
4. In-class discussion and participation.
5. Symposium presentation of novel case study materials.

Selected bibliography of works used by instructor in developing course, especially recent works
Because of the novelty of this teaching approach, there is no book on integrative science, or narrative on the current events that serves as bibliographic material to aid in the development of this course. Instead, the instructors amassed a significant amount of primary literature, popular literature, and online sources that serve as the "inception materials" (see below for definition) to aid in the development and delivery of this course. Examples include:

- CDC Reports on Cholera in Haiti
- New York Times Op-Ed Pieces on Aluminum and Alzheimer's
- "Chemical and Engineering News" story on the Gulf Oil Spill and Chemical Dispersants used
- US Dept of Energy's "National Energy Flow Diagram" showing sources and uses of energy in the USA.

These were all made available to iCons students via the Spark page for the course. In future offerings of the course, these and updated inception materials will be used.

10. If course has been offered as an experimental or special topics course, please comment (on an attached page) on its evolution.

Global Challenges, Scientific Solutions, (NatSci 190I) was offered for the first time in Spring 2011 as a 4 credit Experimental Course, fulfilling the GenEd Interdisciplinary requirement and carrying Honors Credit. It launched the iCons, (Interdisciplinary Concentration in Sciences) Program, a concentration providing enhancement for students enrolled in traditional science and engineering majors. (Link to the iCons website: http://www.cns.umass.edu/icons-program/about/what-is-icons)

iCons 1 (NatSci 190I) is the first in a 4-course sequence that allows students to develop the attitudes, knowledge, and skills needed to become leaders in the development of scientific solutions to our inherently multidisciplinary challenges. In iCons 1: Global Challenges, Scientific Solutions, students work in multidisciplinary teams to discover the roles that scientific investigation and advance can play in solving challenges pulled from real world case studies such as the cholera outbreak in Haiti following the 2010 earthquake and the Deep Water Horizon oil spill.

The course structure revolves around a novel pedagogical loop designed to maximize both the student-driven aspects of learning and the creation of new understanding through teamwork. Each case study works through several iterations of a loop consisting of the following stages:

- **Inception.** Introduce topic, issues. Generate questions requiring scientific inquiry.
- **Engagement**. Explore boundaries of personal understanding. Identify growth opportunities.
- **Research**. Grow skills and knowledge based on opportunities and necessity.
- **Create**. Use new skills and knowledge to build a scientifically meaningful and useful product.
- **Reflect**. Analyze, critique, and evaluate the product. Recognize growth of transferable skills.

A multidisciplinary team of three instructors establishes a classroom environment that allows this pedagogical loop to progress in a smooth and very student-driven manner. Virtually all work—both in class and out—is performed in small (4-5 member) teams of students, with the full team of instructors participating in every class session. The enhanced pedagogy developed for the delivery of iCons 1 entirely shifts the focus of learning from lecture-style (or even instructor-led discussion) to active learning driven by students in small teams.

When the course was first offered in Spring 2011, the primary course objectives, to have students:

Grow appreciation of the multidisciplinary nature of societal challenges,
Discover the boundaries of their own understanding and expand them,
Apply scientific principles correctly in the context of real world problems,
Communicate effectively about scientific contributions to solutions, and
Recognize their own scientific growth through reflection on progress

clarified as the semester progressed. In fact, it was the student's participation in setting learning objectives for themselves that resulted in the incredible buy-in from this initial cohort of iCons students. All of these course objectives were met, and quantified through the generic SRTI responses, the open-ended SRTI questions, and our own programmatic assessment tools (in collaboration with Joe Berger in the School of Education). Some sample student responses are:

"This course is great because it forces students to initiate their own learning and the free form of these case studies give a lot of room for us to develop our own research techniques."

(What I liked most about this class was) "The top-down approach to problem solving. Also the large degree of freedom involved in many facets of the course."

"I loved the teaching of this class! The classroom environment was great for discussions and I was thrilled with the amount of hands-on activities and group work. The idea of this course is genius! "

"One of the best classes I've ever taken. I love how it's a different type of learning. Not to mention, the discussions were very stimulating. I really like working with diverse groups; it's opened my eyes and expanded my perspective on how to approach various societal and scientific problems."

On the other hand, the less structured classroom environment was not amenable to some:

"I wasn't a big fan of the general looseness of the program. It allows for growth, but one can get lost."

"Sometimes discussions get way too long. A little more structure is needed by giving out more lecture/group work."

"At times ambiguity seemed frustrating—but I understand that that was basically the point of the class."

The most critical thing that this first iteration of iCons I was missing was a more targeted and specific grading rubric. Although all of the students in the class performed at an extremely high level, there was uncertainty among them as to how their work was being evaluated:

"It seems there's much less emphasis on grades and more on participation. I like this, but I'm unsure how all this will factor into the final grade. It would be nice in the course syllabus if there was more clarity on how grades will be calculated. Sorry, but I'm a student—I have to worry about grades."

This wasn't unexpected, because the nature of the work that students execute does not lend itself at all to traditional evaluation tools (such as exams). We (the team of course instructors and program developers) are working with Martha Stassen and her assessment team to implement an explicit evaluation scheme that honors the spirit of iCons and provides feedback to students based on the specific learning objectives. This evaluation scheme will involve significant amounts of peer-review and feedback - as suggested by this first cohort of students - as well as instructor evaluation of student project outcomes communicated through meetings, written feedback, etc.

One other feature that will be added to the second and future offerings of iCons I will be the inclusion of a strong mentoring component. Students enrolled in iCons I will be paired with experienced students in the second year of the program to offer guidance and feedback on their challenges, growth, and objectives. This mentoring aspect is being designed by a team of instructors overseen by Susan Bronstein, Director of the Learning Resources Center.

NatSci 190 – Global Challenges, Scientific Solutions [iCons I]

Syllabus

Instructors: Justin Ferman (fermann@chem.umass.edu); Physical Sciences
Susan Leschine (suel@microbio.umass.edu); Life Sciences
Steven Petsch (spetsch@geo.umass.edu); Natural Sciences

Class Meetings, ISB 221: Tuesday 12:00PM – 12:50PM
Thursday 11:15AM – 12:55PM

Course Description:

iCons I: "Global Challenges, Scientific Solutions" is a 4-credit course that brings together topics from Life Sciences, Physical Sciences, Natural Systems, and Social Systems in the context of real world scientific issues. Students are expected to grapple with the scientific underpinnings of complex problems, including issues surrounding Clean Water, Climate Change, Energy Demands, and Disease & Biomedicine. Case studies serve as the format and foundation in which students learn and use fundamental scientific principles to investigate these challenges and quantify the scientific contributions to solutions. Each course activity explicitly marbles content with context; as the case studies reveal a need for students to use a particular concept or skill, those fundamentals are discussed and developed. The specific content that students master is described in the Student Learning Goals, and the context through which those concepts and skills are motivated is described in the Case Study Outlines. This is the first course in the iCons program, and is the prerequisite for the three subsequent iCons courses. There are no prerequisites, but admission to the iCons program is by application in the semester prior to enrolling in iCons I.

Attendance:

Attendance is required for every course period. This is not a course in which you could "get the notes" from someone else. Each day you will be expected to work in and on behalf of your team, and to engage in group- or whole-class discussion and presentation. If you are absent, your grade and your team's grade will suffer.

Learning Goals:

By participating in this course, you will:

- Critically evaluate the nature of certain societal challenges (access to clean water, energy demands, climate change, and disease and biomedicine), and explore scientific contributions to solutions to those problems.
- Discover scientific principles and concepts in the context of real world problems facing society.
- Work in diverse teams to collaboratively solve problems and develop leadership qualities.
- Develop appreciation of the interdisciplinary nature of the scientific process and scientific solutions to problems.
- Master the quantitative basis for evaluating the magnitudes and rates pertinent to societal challenges, and the quantitative assessment of cause-and-effect relationships in potential scientific investigations of these challenges.
- Quantitatively express magnitudes and rates associated with these challenges and solutions.
- Use and interpret primary data in formulating a scientific argument.
- Gain confidence in your ability to seek answers through direct observation and analytical reasoning.
- Use computer programming as a tool to analyze data sets.
- Understand the differences in experimental design, depending on the scientific question to be answered.
- Determine the validity and reliability of experimental data, and critically assess scientific statements based on that data.
- Learn about technology and tools used to perform scientific investigations.

Course Expectations

In this course, you should expect:

- Interdisciplinarity: Team taught by faculty from different fields confronting relevant, non-disciplinary specific, challenges.
- Integration: Every topic is examined with participation from all faculty.
- Discovery: You will be engaged in an active learning process, discovering scientific principles as they become required for mastery.
- Connections: Complete understanding is achieved only through agile use of ideas from all disciplinary fields.
- Collaboration: You will work in teams to solve problems and discover concepts. Teams are formed and re-formed as different challenges are presented and different skills are needed.
- Mastery: You will become experts in certain topical areas, so that a team of experts can approach a problem as more than a sum-of-parts.
- Content: Developed around timely, relevant, and weighty societal challenges.
- Analysis: You will use primary sources (literature and data) to develop understanding through data interpretation and analytical reasoning.
- Human Connections: Topics include not only scientific concepts, but their relevance to and impact on human life and society.

Course Calendar and Outline

NatSci 190 will meet Tuesday and Thursday for a total of 28 class meeting periods. Following a first week of introductory material, including team-building exercises and familiarization with the approach of the iCons course that expands the materials introduced in the iCons orientation (Cholera in Haiti), we will explore case study topics in multi-period, multi-week segments that will be selected from the following list based on time and student interest:

Alzheimer's Disease
The Bhopal Chemical Explosion Disaster
Biofuels and the proposed Greenfield Biomass power plant
Biomimetics
Use of Dispersants in the BP Oil Spill
Desertification
Endocrine Disruptors in the Environment
Genetically Modified Foods

Each case study will proceed through four stages:

1. **Inception:** This is the first stage in each case study. It involves introducing students to the topic, the issues, the problems, and the underlying science. *Inception* may involve any/all of: articles, videos, animations, demonstrations, data sets.
2. **Engagement:** This is the stage where students become personally invested in the case study. *Engagement* may involve a discussion, initial report, debate, design, list, vote, etc. In *Engagement*, students think about and begin to learn something about the topic, exploring the boundaries of their knowledge, and determine what further information or understanding is required to fully comprehend the topic(s).
3. **Research:** This is the stage where students answer what has not been fully or adequately explored and understood during preceding stages. In *Research* students may design an experiment, critically evaluate data, formulate and address hypotheses, compile information to fill in knowledge gaps.
4. **Creation:** This is the stage where students develop a new understanding based on what was learned through their research. In *Creation* a tangible product of the activity is created, such as a revised report, list, design, proposal, etc. Importantly, the knowledge gained during *Creation* involves communication to the rest of the group or class.

Assignments, readings, and course materials

The iCons I course will not use a textbook. Instead, readings, images and videos drawn from popular literature and website resources will be used. These materials will be made available to enrolled students through SPARK. You will be responsible for completing all assigned readings and web-viewings before class.
While many assignments (reports, experiment design, critiques) will be begun in class, you are responsible for continuing to work on these assignments with your team outside of class. Many assignments (data analysis, proposal design, model design) will only be completed outside of class time. This will require you to organize the most effective means to work with your team (evening face-to-face meetings, Skype, electronic postings, etc.).

Symposium Project

Student teams will, over the course of the semester, research, develop, and deliver a complete set of materials for a novel case study that may be used in the next offering of iCons I. This work will be done outside of class time, and the new case study materials will be presented at an end-of-semester iCons symposium. Details will be presented after completion of the first case study of the semester.

General Education

iCons I is a 4-credit Interdisciplinary General Education course (GenEd 'I' designation). This means that questions, methods and concepts from numerous disciplines will be used, often with no reference to the field from which they are drawn. Students will be expected to bring expertise from their own disciplines to bear on problems, but also integrate across disciplines by working closely with teammates and seeking information wherever necessary.

Experimental Course

iCons I is listed as NatSci190P because it is an experimental course. In this course, we will be approaching learning in ways that are new to us, and we expect new to you as well. Because of that, we together have a unique opportunity to not only participate in but also guide the development of an exciting new course that is part of an exciting new program. We encourage you to approach iCons I as both a learner and a builder, and focus not only on *what* we are doing, but also *how we are doing it*. In fact, we are counting on you - and all future iCons students - to play an integral role in the establishment and evolution of this program.

Grading criteria

Students will be evaluated based on:
1. Effective teamwork, leadership, and innovation in problem solving.
2. Faculty critique of team projects centered on each case study, which may include written reports, oral presentations, group decision-making, and other forms of scientific communication.
3. Peer review of these projects.
4. In-class discussion and participation.
5. Symposium presentation of novel case study materials.