The University of Michigan
College of Engineering
Curriculum Committee

Agenda
March 6, 2007
1:30-3:00 p.m.
GM Room
Lurie Engineering Center

1. Approval of Minutes from January 23, 2007 Meeting
2. Change in BiomedE Curriculum
3. Proposed Natural Resources/Engineering MS/MSE Dual Program – Greg Keoleian
4. Course Approval Forms

COURSE APPROVAL FORMS

For March 06, 2007 CoE CC Meeting

BME 520(X-Listed with BA 518, HMP 630, PHRM 620) New Course
IOE 422 Modification – Changing Description
IOE 433 (X-Listed with MFG 433) Deletion
IOE 440 (X-Listed with MFG 440) New Course
IOE 905 Deletion
MSE 593 New Course
ME 350 Modification – Changing Description
ME 360 Modification – Changing Description
ME 487(X-Listed with MFG 488) Modification – Changing Prerequisite from: ME 481 ***to: ME 382***
ME 631 Modification – Changing Prerequisites from: ME 230 or MFG 336 ***to: ME 235 or MFG 336***

THESE COURSES ARE BEING RE-SUBMITTED WITH CORRECTIONS

ME 320 Modification – Changing Prerequisites from: ME 235 and ME 240 ***to: Math 215, ME 235, and ME 240***

ME 450 Modification – Changing Prerequisites from: ME 350, ME 360 and ME 395 (advised) ***to: ME 350, ME 360 and ME 395 (enforced);*** **Changing Credit Restrictions from: Recommend ME 495 not be elected concurrently. Not open to graduate students.** ***to: May not be taken concurrently with ME495. Not open to graduate students.***

ME 495 Modification – Changing Prerequisites from: ME360, ME395; preceded or accompanied by ME350 ***to: ME360, ME395, P/A ME335 and ME350*****; Changing Credit Restrictions from: Recommend ME450 not be elected concurrently. Not open to graduate students.** ***to: May not elect ME450 concurrently. Not open to graduate students.***

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number 1813

Action Requested

- (●) New Course
- ( ) Modification of Existing Course
- ( ) Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/26/2007
Effective Fall 2007

A. CURRENT LISTING

Home Department | Div # | Course Number

Cross Listed Course Information

Course Title: The Business of Biology

TITLE ABBREVIATION		
	Time Sched Max = 19 Spaces	
	Transcript Max = 20 Spaces	

Course Description

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites ○ Enforced ○ Advised

Credit Restrictions

Level of Credit
☐ Undergrad only ☐ All Credit types
☐ Rackham Grad ☐ Rckhm Grad w/add'l Worl
☐ Non-Rckhm Grad
☐ Ugrad or Rckhm Grad
☐ Ugrad or Non-Rckhm Grad

Credit Hours Min ___ Max ___
Contact Hrs/Wk ___
Number of Wks ___

B. REQUESTED LISTING

Home Department	Div #	Course Number
Biomedical Engineering	BME	520

Cross Listed Course Information

Ross School of Business	BA	518
School of Public Health	HMP	630
Medical School	PHRM	620

Course Title: The Business of Biology

TITLE ABBREVIATION		
	Time Sched Max = 19 Spaces	Business of Biology
	Transcript Max = 20 Spaces	Business of Biology

Course Description for Official Publication (Max = 50 words)
This multi-disciplinary course will explore the consequences of transformative change on the future of business and industry, medicine and health, and the complex ethical and legal issues that face individuals and society.

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites ○ Enforced ○ Advised

Credit Restrictions

Level of Credit
☐ Undergrad only ☐ All Credit types
☒ Rackham Grad ☐ Rckhm Grad w/add'l Work
☒ Non-Rckhm Grad
☐ Ugrad or Rckhm Grad
☐ Ugrad or Non-Rckhm Grad

Credit Hours Min 2.25 Max 2.25
Contact Hrs/Wk 4
Number of Wks 7

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ○ No
Maximum Hours? ___ Maximum Times? ___
Can it be repeated in the same term? ○ Yes ○ No

Class Type(s) ☐ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ___

Graded Section ○ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading ☐ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location ☐ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Printing Information (Optional) ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule

Terms & Freq. of Offering ☒ I ☐ II ☐ IIIa ☐ IIIb ☐ III
☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years
Half term ☒ 1st ☐ 2nd

Cognizant Faculty Member: Douglas C Noll
Title: Interim Chair, Biomedical Engineering

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
☐ Curriculum Comm. ___
☐ Faculty ___
☐ Rackham
☐ Cross listed Unit 1 ___
☐ Cross listed Unit 2 ___

Submitted By: ☒ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. ___
Cross-listed Dept(s). ___

Form Number

1813

SUPPORTING STATEMENT

The Life Sciences Institute recommended that the course currently offered by the Ross School of Business as BA 518 should be cross-listed with a course (required a new course number) in the CoE. BA 518 is already cross-listed in the School of Public Health and the Medical School.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

The University of Michigan

BA 518/HMP 630

The Business of Biology

Fall A 2006
Ross School of Business

Liz Barry, JD
Managing Director, Life Sciences Institute

Bill Hall, MBA, MS, PhD
Adjunct Professor of Corporate Strategy, Ross School of Business
Research Investigator, Life Sciences Institute

Course Description

The health care and life sciences industry is undergoing profound and transformative change in the U.S. and around the globe. The interactive effects of discoveries in the life sciences, advances in medical and information technology, and the emerging new consumerism is revolutionizing the industry creating new business opportunities and a new age of medicine. This multidisciplinary course will explore the consequences of transformative change on the future of business and industry, medicine and health, and the complex ethical and legal issues that face individuals and society.

The course will provide an overview of the collaborative research enterprise; the promise of personalized medicine and the challenge for the biopharmaceutical industry; the economic realities of the health care industry; the latest trends in venture investing; and the effort to finally bring health care into the digital age.

The purpose of this course is to provide you with a "helicopter view" of the dynamic developments in the life sciences and health care. Although the course will not make you an expert, it will provide you with a conceptual framework to help you identify the key trends, issues, challenges and opportunities in the burgeoning "Business of Biology."

Students will have the opportunity to work together on a group research project plus explore a topic in depth in an individual paper.

Course Materials

CoursePack (cases and readings). (A copy is available at the Business School library.)

Textbook:

Richards, Julia E., and Hawley, R. Scott, *The Human Genome,* Second Edition, Elsevier Academic Press, 2005.(Note that there is an errata sheet for this edition in the front of the coursepack.)

Note: Co-Author Julia E. Richards, PhD, is a University of Michigan Associate Professor in the Department of Ophthalmology and Visual Sciences at the Medical School and in the Department of Epidemiology at the School of Public Health.

Optional Web Resource:

UM Center for Genomics and Public Health presentation series and panel discussion: "Six Weeks to Genomic Awareness" at http://www.genomicawareness.org/

Additional optional web resources are posted on C-Tools.

C-Tools

C-Tools includes announcements, the syllabus, assignments, readings, summaries of the lectures, and the presentations. Further, optional articles, an optional bibliography, and optional web resources will also be posted.

C-Tools will also include short biographies of the instructors and guest lecturers plus students' own short biographies or resumes as well.

Times and Locations

Regular class sessions are held Monday and Wednesday from 8:30 am to 10:00 am at the Undergraduate Research Building in room 1230.

Required special evening sessions:

- Thursday, September 7th from 4:00 pm to 7:00 pm Life Sciences Institute 1250 Undergraduate Science Building
  - Topic: **Life Sciences and Genomics**

- Wednesday, September 20th from 4:00 pm to 6:30 p.m. 1250 Undergraduate Science Building
  - Topic: **Life Science Industry Perspectives**

- Tuesday, October 10th from 4:00 pm to 8:00 pm 1230 Undergraduate Science Building
  - Topic: **Colloquium for Student Research Project Presentations**
    …to be followed by a reception

Communication

Following is our contact information. Feel free to communicate with us as needed.

Liz Barry
Life Sciences Institute
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734-936-1525
Hours 7:00 a.m. – 4:00 p.m.
Barbara Reed
W7710 Ross School of Business
barbreed@umich.edu
734-615-4267
Hours 8:00 a.m. – 5:00 p.m.

E-mail is the best way to communicate with us for quick exchanges. If you want to talk by telephone, feel free to call us. If you want to get together for an in-person discussion, please make an appointment in advance by contacting our assistants, Sandra Moing 734-774-4502 and Paula Kopka 734-936-1525.

BA 518/HMP 630
The Business of Biology

September 6th – October 16th 2006

Course Schedule

Session 1 Wednesday, September 6 – Undergraduate Science Building 1230

Topic **Overview: Towards a Positive Health Care Future**

Leaders Liz Barry and Bill Hall

Reading Richards and Hawley, *The Human Genome,* Chapters 1 – 2. Required pre-reading only for students who do not have a strong biology background.

Evening 1 Thursday, September 7- Life Sciences Institute and Undergraduate Science Building 1250 4:00 p.m. – 7:00 p.m.

Topic **Life Sciences and Genomics**

Leaders Liz Barry and Julia Richards, PhD, Associate Professor of Ophthalmology

Reading Richards and Hawley, *The Human Genome,* Chapters 3 – 9, 14 – 16, 18 - 19.

After class: Richards and Hawley, *The Human Genome,* Chapters 10 – 13.

Session 2 Monday, September 11 - Undergraduate Science Building 1230

Topic **Drug Discovery and the Biopharmaceutical Industry**

Leader Bill Hall

Reading Richards and Hawley, *The Human Genome,* Chapters 25 - 28.

"Technical Note on the Evolving Economics of Drug Discovery, Development and Commercialization." The University of Michigan, 2005.

"The Biopharmaceutical Industry in the 21st Century." The University of Michigan, 2004.

Session 3 Wednesday, September 13 - Undergraduate Science Building 1230

Topic **Venture Investing: Biotechnology and Medical Devices**

Leaders Jan Garfinkle - Founding Principal, Arboretum Ventures
President, Michigan Venture Capital Association

Timothy Petersen
Principal, Arboretum Ventures

Reading Dotzler, Fred, "What Do Venture Capitalists Really Do, and Where Do They Learn to Do It?" *The Journal of Private Equity,* Winter 2001.

Ferrari, Richard, "Keys to Creating Value for Early-Stage Medical Device Companies" *In Vivo: The Business & Medicine Report,* vol. 22, no 10 (January 2005)

May, David, "By The Numbers" *Modern Healthcare*, December 20, 2004 pp 1-58

Case Study

Session 4 Monday, September 18 - Undergraduate Science Building 1230

Topic **The Esperion Story: An Example of a Biotech Success in the Midwest**

Leader Roger Newton
President and CEO of Esperion Theraputics

Reading Herper, Matthew, "The Cleaner," Forbes Magazine, November 24, 2003, pp. 273-274.

Newton, R.S., Krause, B.R. HDL therapy for the acute treatment of atherosclerosis. *Atherosclerosis Supplement* 2002; 3:31-38

Nicholls, SJ, Tuzcu, EM, Sipahi, IS, et al., Relationship Between Atheroma Regression and Change in Lumen Size After the Infusion of Apolipoprotein A-I Milano. Journal of The American Medical Association. 2006; 47:992-997.

Nissen, SE, Tsunoda, T., Tuzcu, EM, et al., Effect of Recombinant Apo A-I Milano on Coronary Atherosclerosis in Patients with Acute Coronary Syndromes: A Randomized Controlled Trial. JAMA. 2003; 290:2292-2300.

Session 5 Wednesday, September 20 - Undergraduate Science Building 1230

Topic **In-Progress Group Research Project Presentations**

Leader Liz Barry and Bill Hall

Evening 2 Wednesday, September 20 - Undergraduate Science Building 1250
4:00 p.m. – 6:30 p.m.

Topic **Perspectives on Life Sciences Capital & Financing**

Leaders Craig Parker, Managing Director, Lehman Brothers
John Osborn, Executive Vice President and General Counsel, Cephalon, Inc.
Tom Porter, General Partner, Trillium Ventures

Session 6 Monday, September 25 - Undergraduate Science Building 1230

Topic	**Ethical Issues: Genetic Privacy and Discrimination**
Leader	Liz Barry
Reading	Greely, Henry T., *Banning Genetic Discrimination,* N Engl J Med 353:9, September 1, 2005 Richards and Hawley, *The Human Genome,* Chapter 37. On-line *(optional)* National Human Genome Research Institute *Policy and Ethics: Critical Issues and Legislation Surrounding Genetic Research* http://www.nhgri.nih/gov/PolicyEthics

Session 7 Wednesday, September 27 - Undergraduate Science Building 1230

Topic **From Genomics to Targeted Medicines**

Leader Gilbert S. Omenn, MD, PhD
Professor of Human Genetics
Professor of Internal Medicine
Professor of Public Health
President, American Association of the Advancement of Science

Reading Hanahan and Weinberg, "The Hallmarks of Cancer." *Cell,* Vol. 100, 57-70, January 7, 2000.

Omenn, Gilbert S., "Genetic Advances Will Influence the Practice of Medicine: Examples from Cancer Research and Care of Cancer Patients." *Genetics in Medicine,* November/December 2002, Vol. 4, No. 6, Supplement.

Omenn, Gilbert S., "The Crucial Role of the Public Health Sciences in the Postgenomic Era." *Genetics in Medicine,* November/December 2002, Vol. 4, No. 6, Supplement.

Richards and Hawley, *The Human Genome,* Chapter 33.

Session 8 Monday, October 2 - Undergraduate Science Building 1230

Topic **Placebo Economics: The Financing of Health Care in the U.S.**

Leader Kyle L. Grazier, MS, MPH, Dr. PH
Professor of Health Care Finance, Dept. of Health Management and Policy
Editor, Journal of Healthcare Management
Chair, UM Committee on Health Insurance Premium Design

Reading Anderson, Gerard F. et. al. "Health Spending in the United States and the Rest of the Industrialized World." *Health Affairs*, Vol. 24, No. 4, July/August 2005.

Chun, S. and Matisson, S., "Discovery Health (A)." Harvard Business School, Case 9-599-046, Rev. June 30, 1999.

Fuchs, Victor R., "What's Ahead for Health Insurance in the United States?" *New England Journal of Medicine*, Vol. 346, No. 23, June 6, 2002.

Ginsburg, Paul B., and Grossman, Joy M., "When the Price Isn't Right: How Inadvertent Payment Incentives Drive Medical Care." *Health Affairs* Web Exclusive, August 9, 2005.

Rosenbaum, Sara, "Medicaid." *New England Journal of Medicine*, Vol. 346, No. 8, February 21, 2002.

Stone, Deborah A., "The Struggle for the Soul of Health Insurance." *Journal of Health Politics*, Policy and Law. Vol. 18, No. 2, Summer 1993.

Winakur, Jerald, "What Are We Going To Do with Dad?" *Health Affairs*, Vol. 24, No. 4, July/August 2005.

Woolhandler, S. et. al., "Physicians' Working Group for Single-Payer National Health Insurance. Proposal of the Physicians' Working Group for Single-Payer National Health Insurance." *Journal of the American Medical Association*, Vol. 290, No. 6, August 13, 2005

Session 9 Wednesday, October 4 - Undergraduate Science Building 1230

Topic **Intellectual Property**

Leader Rebecca S. Eisenberg
Robert and Barbara Luciano Professor of Law

Reading Eisenberg, Rebecca S., "How Can You Patent Genes?" *In Genetics: Science, Ethics and Public Policy: A Reader*, Edited by T.A. Shannon, 131-45. Readings in Bioethics. Lanham, MD: Rowman & Littlefield Publishers, 2005. (originally published under the same title in Who Owns Life?, edited by D. Magnus et al., 117-34. Amherst, N.Y.: Prometheus Books, 2002)

Eisenberg, Rebecca S., "The Problem of New Uses." *Yale Journal of Health Policy L. & Ethics V*, No. 2 (205): 717-39

Eisenberg, Rebecca S. "Biotech Patents: Looking Backward While Moving Forward" *Nature Biotech, 24, no. 3 (* 2006): 317-9

Laboratory Corp. of America v. Metabolite Laboratories, Inc., US S Ct Slip Op. No. 04-607, 548 U.S.__(2006).

Eisenberg, Rebecca S., "Reexamining Drug Regulation from the Perspective of Innovation Policy." *Journal Institutional & Theoretical Economics* 160, no. 1 (2004): 126-35.

Session 10 Monday, October 9 - Undergraduate Science Building 1230

Topic **Molecular Diagnostics and Predictive Medicine**

Leader Bill Hall

Reading Case Study: Genomic Health, Inc. (Posted on C-Tools.)

Richards and Hawley, *The Human Genome,* Chapter 34.

Evening 3 Tuesday, October 10 - Undergraduate Science Building 1230
4:00 p.m. – 8:00 p.m.

Topic **Colloquium for Student Research Project Presentations**

Leaders Liz Barry, Bill Hall, Students

Session 11 Wednesday, October 11 - Undergraduate Science Building 1230

Topic **Ethical Issues: Genetic Enhancement**

Leader Liz Barry

Reading · Chapman, Audrey R. and Frankel, Mark S., Eds *Designing Our Descendants: The Promises and Perils of Genetic Modifications,* Chapter 1 and 9, The Johns Hopkins University Press, 2003

On-line *(optional)* The President's Council on Bioethics http://www.bioethics.gov

DVD (*optional*) Film: *Gattica*

Session 12 Monday, October 16 - Undergraduate Science Building 1230

Topic **Summary**

Leaders Liz Barry and Bill Hall

Reading To be assigned.

Course Assignments and Grading

30% Individual Paper (due Monday, October 16th choice of topic)

40% Group Project: Two-page Executive Summary and PowerPoint presentation. (due on Tuesday, October 10th)

30% Class preparation including the assigned readings and active class participation. Name tags are required to be displayed in class.

Individual Paper

You have a choice of two topics for the individual paper. Either assignment consists of an exercise in analysis rather than a traditional research paper. The paper should be no more than 5 to 7 pages in length, double-spaced, 12-pt type. The papers are due **October 16, 2006.**

1. Pfizer Case

Reading:

"Pfizer Inc.: Responding to Challenges in the 21st Century", Ross School of Business, The University of Michigan, 2005.

"The Lawyer is in at Pfizer", Business Week, August 14, 2006.

Assignment:

On July 28, 2006 the Pfizer Board of Directors named Mr. Jeffrey B. Kindler as Chief Executive Officer, replacing Mr. Hank McKinnell. In accepting the position, Mr. Kindler commented:

"Science is creating wholly new ways to treat disease; regulators and payers are more demanding, and patients are using newly available information to take control of their healthcare decisions. As a result, Pfizer must become more agile and entrepreneurial, embracing the spirit of a small company, while exploiting the advantages of our unmatched scale and reach."

Using concepts developed in this course and your own (documented, independent) research, prepare a "position paper" for Mr. Kindler with your recommendations as to how Pfizer should approach life science research and drug development in the 21st century.

2. Ethical/Legal/Social Issues

As an alternative to (1) above, you may choose to write your paper on an ethical, legal or social issue raised by the developments discussed in the course. The paper should be based on required readings, class sessions, outside readings and reflection.

You should analyze and synthesize some observations on your topic, including unresolved and/or important questions remaining. You may write on any topic that meets these general requirements but you must submit your paper topic to Liz Barry no later than **Wednesday, September 27th** for approval. Some example topics are listed below.

Examples. (1) What are the ethical questions raised by genetic enhancement? Does it turn on whether the changes affect the germ line? This paper might catalog the questions raised by different types of potential enhancements and explore the implications of humans "engineered" for a better result. (2) In the movie *Gattica*, the human engineered to be "better" is outfoxed by his "natural" brother? What moral thesis is the movie projecting? Do you agree or disagree? (3) What are the ethical and social issues raised by the Discovery Health case discussed by Professor Grazier? Analyze. (4) Do you see a rationale basis for the difference in the regulatory approval scheme for pharmaceuticals v. medical devices. How will this scheme be challenged by discoveries that blur the line between the two categories?

Group Project

Overview

The group project is intended to develop research skills in analyzing how various public and private organizations are dealing with the scientific, behavioral, ethical and economic trends taking place in the life sciences in the early 21st century. Each student research group will be assigned to: (1) compare and contrast the objectives and approaches of their assigned organizations in dealing with these complex issues, (2) evaluate these policies from an economic, legal and ethical perspective; and (3) formulate predictions about likely potential outcomes if these organizations maintain their current policies as well as analyze alternative options that may be better than these current approaches.

Library, internet and direct field research is required for these research projects, and a bibliography of all source documentation should be submitted along with visual aids supporting the oral reports.

Process

Students will be assigned to a research group at the first or second course session. Each student research group should submit a written "bid" providing a list of group members and the first and second choice of preferred topics (listed below) no later than **Monday, September 11th**. The instructors will assign research topics to student teams using these "bids" as guidelines on **Wednesday, September 13th**. As part of an in class assignment on **Wednesday, September 20th**, groups will present preliminary outline to the class.

Each student research group should prepare a twenty minute oral presentation with visual aids (allowing five minutes for Q&A) to be delivered on the evening of **Tuesday, October 10th** 1230 Undergraduate Science Building from 4:00 to 8:00 pm. These presentations will summarize the group's research findings, with appropriate audiovisual support and supplemental handouts of source documentation.

These oral reports will be presented in a colloquium-like format at the with a reception to immediately follow for course participants and our guests. We expect that a significant subset of the guest lecturers in the class will attend the colloquium and the reception afterward. We also plan to invite other distinguished guests from the Business School, Life Sciences Institute, School of Public Health, Medical School and so on to join us for the evening.

Topics

Topic 1	Pharmaceutical Competitors	Roche and AstraZeneca
Topic 2	Biotechnology Competitors	Genentech and Amgen
Topic 3	Medical Diagnostic Equipment Competitors	General Electric & Seimens
Topic 4	Medical Information Technology Competitors	Cerner and Epic
Topic 5	Medical Device Competitors	Boston Scientific and Johnson & Johnson
Topic 6	Governmental Regulation	US: FDA Europe: European Agency for the Evaluation of Medicinal Products (EMEA) China: National Institute for the Control of Pharmaceutical and Biological Products
Topic 7	Governmental Policy on Stem Cell Research	US: California South Korea Singapore: Biopolis
Topic 8	University Approach to Interdisciplinary Research In the Life Sciences	Harvard University (Broad Institute, etc) University of Michigan Stanford University (BIOX)
Topic 9	Scientific Equipment Competitors	Thermo/Fisher Scientific, Inc. Applied Biosystems Affymetrix
Topic 10	Intellectual Property and Patent Regulation	US Patent Agency EU Patent Agency Chinese Patent Agency

Business of Biology
BA 518/HMP 630

Summary Report

Course Synopsis:

The health care and life sciences industry is undergoing profound and transformative change both here in the U.S. and around the globe. The interactive effects of discoveries in the life sciences, advances in medical and information technology, and the emerging new consumerism is revolutionizing the industry creating new business opportunities and a new age of medicine. This multi-disciplinary course explores the consequences of transformative change on the future of business and industry, medicine and health, and the complex ethical and legal issues that face individuals and society. The course provides an overview of the collaborative research enterprise in the Age of Biology; the promise of personalized medicine and the challenge for the biopharmaceutical industry; the economic realities of the industry and the latest trends in venture investing; and the effort to finally bring health care into the digital age. Students have the opportunity to work together on a group research project plus explore a topic of choice in depth in an individual paper.

Course Credits: 2.25

Course Schedule: Fall "A" Term

Enrollment by School /College:

School	*2004*	*2005*	*2006*
Engineering	3	1	7
Business	42	15	14
Medicine		4	10
Public Health	5		8
Pharmacy		3	2
School of Info			1
Law	1		
Other Science (Rackham)		4	7
Total Students	*51*	*27*	*49*

Student Evaluations (3 year average 2004 – 2006; on a scale of 1-5)

4.82 Upon entering, I had a strong interest in taking this class.
4.50 The instructor expected a high level of academic excellence on the part of the Students
4.68 Overall, this is an excellent course
4.81 Overall quality of the instructor's job in teaching this course

Sample Student Comments:

"As a scientist, this course opened my eyes to how our economy is dealing with medical needs & advancing technology. It was invaluable to work with business students in the group project & to get a feel for how collaborations between business & science work."

"Covered many topics and interesting dilemmas facing the healthcare industry. The mix of student backgrounds gave a richer experience."

"This was one of the best courses I have taken here so far. It was especially great having other students from different backgrounds in the class."

"What went well in the course for me was the interaction between business & science students, class discussions on topics presented and the amount learned from case studies."

"Exceeded my expectations in terms of quality of course materials, lectures and in particular, guest lectures and multidisciplinary approach. It should be a semester long course! Loved this course and wished that there were more multi-disciplinary courses like it."

"I appreciated the interaction with other students and the instructors, both in and outside of class. I thought the lecturers were thoughtfully chosen. I like the structure of doing group projects and I was happy with the environment that the instructors fostered to encourage group discussion. I also appreciated the accessibility of the instructors. Often I left class feeling invigorated by the discussion and frustrated to have to go back to the lab. You may have converted a scientist into a future MBA."

"This course was quite useful either for beginner without science background or professional to know more about commercialization practice of discovery."

"It would be great to have a life sciences PhD/MBA program. The need is there and Michigan B-School is revolutionary enough to stat the trend."

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number 1799

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/7/2007
Effective Fall 2007

A. CURRENT LISTING

Home Department | Div # | Course Number

Cross Listed Course Information

Course Title

TITLE ABBREVIATION: Time Sched (Max = 19 Spaces) / Transcript (Max = 20 Spaces)

X Course Description
Engineering students will learn the dynamics of turning an innovative idea into a successful commercial venture, including the role of e-commerce. By creating an actual business plan they will learn about innovation and creativity, risk management, stress and failure, ethics and other necessary business skills.

PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ l

Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ◉ Tech Elective ○ Other

Prerequisites: ○ Enforced ○ Advised

Credit Restrictions

Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Worl

Credit Hours Min Max

Contact Hrs/Wk

Number of Wks

B. REQUESTED LISTING

Home Department: IOE | Div #: 272 | Course Number: 422

Cross Listed Course Information

Course Title: Entrepreneurship

TITLE ABBREVIATION: Time Sched (Max = 19 Spaces): Entrepreneurship / Transcript (Max = 20 Spaces): Entrepreneurship

Course Description for Official Publication (Max = 50 words)
Engineering students will explore the dynamics of turning an innovative idea into a commercial venture in an increasingly global economy. Creating a business plan originating in an international setting will: challenge students to innovate; manage risk, stress and failure; confront ethical problems; question cultural assumptions; and closely simulate the realities of life as an entrepreneur.

PROGRAM OUTCOMES: ☐ a ☐ b ☒ c ☐ d ☐ e ☒ f ☒ g ☒ h ☐ i ☐ j ☒ k

Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ◉ Tech Elective ○ Other

Prerequisites: Senior Standing ⊙ Enforced ○ Advised

Credit Restrictions: Not for Graduate Credit

Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours Min 3 Max 3

Contact Hrs/Wk 3

Number of Wks 14

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ○ No
Maximum Hours? ____ Maximum Times? ____
Can it be repeated in the same term? ○ Yes ○ No

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ____

Graded Section: ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Printing Information (Optional): ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule

Terms & Freq. of Offering: ■ I ■ II ☐ IIIa ☐ IIIb ☐ III ■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Half term: ☐ 1st ☐ 2nd

Cognizant Faculty Member: Lawrence Seiford Title: Professor and Chair

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
- ☐ Curriculum Comm.
- ☐ Faculty
- ☐ Rackham
- ☐ Cross listed Unit 1
- ☐ Cross listed Unit 2

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept.
Cross-listed Dept(s).

Form Number

1799

SUPPORTING STATEMENT

This change will more accurately reflect the current content of the course and supports the new initiatives in entrepreneurship in the College of Engineering.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

IOE 422 -- Entrepreneurship

Time & Place:
Tuesday, Thursday, 2:30 to 4:00
White Auditorium Cooley Building

Instructor:
Ken Ludwig
2769 IOE Building,
Office hours Tue and Thursday 1:30-2:30 @ IOE 2769 or by appointment
E-mail; <mailto:kludwig@umich.edu>kludwig@umich.edu

Teaching Assistant:
Cassandra Green
E-mail: <mailto:clsimpsz@umich.edu>clsimpsz@umich.edu
Office hours by appointment

Course Description:
Engineering students will explore the dynamics of turning an innovative idea into a commercial venture in an increasingly global economy. Creating a business plan originating in an international setting will challenge students to innovate; manage risk, stress and failure; confront ethical problems; question cultural assumptions; and closely simulate the realities of life as an entrepreneur.

IOE 422 is an unusually demanding course designed for seniors who may be interested in one day owning their own business or have ideas for starting their own business after graduating. Students will be exposed to the skills and traits entrepreneurs must have and what the "entrepreneurial lifestyle" is all about. Students will work in teams on their own business plan which will focus on opportunities in developing countries and on other assigned projects, and in the process learn what it takes to grow an innovative idea into a successful business. IOE 422 will mesh the tools of business with community development including: cultural sensitivity and privilege, need assessment, appropriate technology, sustainable green engineering, and the role of engineering in society. Upon completion of business plans students will have an opportunity to present them to local investors and receive feedback.

This class exists to help students determine whether the entrepreneurial path is right for them and give them the confidence to proceed with a real business venture. It is not "How to start a business in X easy steps". The course includes guest lectures by local entrepreneurs and an entrepreneur interview assignment. In addition, the class will address E-commerce, and how it is changing the way business is done. Students will be encouraged to develop a business plan that incorporates E-commerce. Other topics addressed include innovation and creativity, risk management, stress and failure, and necessary business skills. Throughout the course students will assess their goals and personal values. The class is designed to be interactive and student centered. This course is designed to be unstructured and will not adhere rigidly to the syllabus. Changes will be made as opportunities present themselves much like the way that "real world" businesses react to changes in their environment.

Grades are based on: Individual and team assignments, class projects, class participation and the instructor's assessment.

Intended Outcomes:
1) Provide information that allows the student to make an informed decision prior to embarking on an entrepreneurial career.

2) Demonstrate the skills that are required of entrepreneurs and people who practice innovation. This will allow students to build the requisite skills prior to starting a business.

3) Teach the basic skills of working as part of a group, group development, sales, negotiation, and dealing with risk and uncertainty.

4) Introduce the basic concepts of e-commerce and the way business is done on the WEB.

5) Give the student experience in writing a business plan and presenting it to a bank or venture capitalist.

Teaching Approach:
This class will consist of about thirty percent lectures. Several of the classes will have entrepreneurs relating their experiences and points of view. The balance of the classes will consist of case studies, role-playing, workshops and other interactive learning techniques including class time devoted to developing your business plan.

Assignments & Exams:
Grades are based on individual assignments (Entrepreneur Interview, Book Reviews, and Life Plan Paper), team assignments (Business Plan, Business Plan Presentation, and Team Member Assessments), class projects, class participation and the instructors' assessment.

Course Materials (Agreed Upon Reading):
Banker To The Poor: Muhammad Yunus
Natural Capitalism: Paul Hawken, Amory Lovins, L. Hunter Lovins

Website:
<http://coursetools.ummu.umich.edu>http://coursetools.ummu.umich.edu

Homework & Participation

Attendance at class is very important for your own learning but also for your teammates. The work within assigned groups will be an important part of the learning experience and the grading process. The teams will evaluate individual team member performance, and these evaluations will be used to modify the individual's grade.

COURSE PROFILE

Degree Program: Industrial and Operations Engineering **Date : February 7, 2007**

COURSE #: IOE 422	**COURSE TITLE:** Entrepreneurship
TERMS OFFERED: Fall, Winter	**For each prerequisite below, "E" denotes Enforced and "A" denotes Advised.**
TEXTBOOKS/REQUIRED MATERIAL:	**PREREQUISITES:** Senior Standing (E)
INSTRUCTOR(S): Ludwig	**COGNIZANT FACULTY:** Seiford
CoE BULLETIN DESCRIPTION: Engineering students will explore the dynamics of turning an innovative idea into a commercial venture in an increasingly global economy. Creating a business plan originating in an international setting will challenge students to innovate; manage risk, stress and failure; confront ethical problems; question cultural assumptions; and closely simulate the realities of life as an entrepreneur.	**COURSE TOPICS:** E-commerce, public presentations, marketing, market research, cost vs. value pricing, spontaneous engineering, business design, product design, construction and cost risk taxonomy, values, written and oral communications, personnel evaluations, international business
COURSE STRUCTURE/SCHEDULE: Lecture: 2 per week @ 90 minutes	

COURSE OBJECTIVES	Links shown in brackets are to departmental educational outcomes: 1 To expose students to the skills and traits entrepreneurs must have as well as the realities of life as an entrepreneur 2 To give students the opportunity to work in a dynamic team setting and interactive class setting 3 To expose students to the successes and failures of local and global entrepreneurs 4 To teach students what it takes to grow an innovative idea into a successful business. 5 To identify and define problems that are initially ill-defined and outside the student's common experience
COURSE OUTCOMES For each course outcome, links to the Program Outcomes are identified.	Links shown in brackets are to course objectives: 1 Help students make an informed decision prior to embarking on an entrepreneurial career and provide them the confidence and tools to continue with a real business venture. [1,3,4] 2 Demonstrate the skills that are required of entrepreneurs and people who practice innovation. This will allow students to build the requisite skills prior to starting a business. [1,3,4] 3 Teach the basic skills of working as part of a group, group development, sales, negotiation, and dealing with risk and uncertainty. [2,5] 4 Students able to adapt to changes made as opportunities present themselves much like the way that "real world" businesses react to changes in their environment. [1,5] 5 Give the student experience in writing a business plan and presenting it to a bank or venture capitalist. [1,2,4]
ASSESSMENT TOOLS For each assessment tool, links to the course outcomes are identified.	1 Presentation to a local investor, banker, or venture capitalist measures outcomes 3-5 2 Team Projects & team member's evaluation as well as self evaluation measures outcomes 2-5 3 Individual writing assignments: Entrepreneur Interview, Book Critiques, Life Plan measure outcomes 1-5 4 Course evaluation by each student at the end of the course assesses outcomes 1-5

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Form Number **1798**

Action Requested

- ○ New Course
- ○ Modification of Existing Course
- ◉ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/1/2007
Effective Fall 2007

A. CURRENT LISTING

Home Department	Div #	Course Number
IOE	272	433
Cross Listed Course Information		
Mfg	275	433

Course Title: Occupational Ergonomcis

TITLE ABBREVIATION		
Time Sched Max = 19 Spaces	Occupational Ergonomics	
Transcript Max = 20 Spaces	Occupational Ergo	

Course Description:
Principles, concepts and procedures concerned with worker performance, health, and safety. Topics include biomechanics, work physiology, psychophysics, work stations, tools, work procedures, work standards, musculoskeletal disorders, noise, vibration, heat stress, and the analysis and design of work.

PROGRAM OUTCOMES:
☒ a ☒ b ☒ c ☐ d ☒ e ☐ f ☐ g ☐ h ☐ i ☒ j ☐ l

Degree Requirements ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites ○ Enforced ○ Advised

Credit Restrictions: No credit for those who have credit for IOE 333.

Level of Credit
☒ Undergrad only ☒ Rackham Grad ☒ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad
☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min 3 Max 3
Contact Hrs/Wk 14
Number of Wks 14

C. Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ○ No
Maximum Hours? ____ Maximum Times? ____
Can it be repeated in the same term? ○ Yes ○ No

Class Type(s) ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ____

Graded Section ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

B. REQUESTED LISTING

Home Department	Div #	Course Number

Cross Listed Course Information

Course Title

TITLE ABBREVIATION	
Time Sched Max = 19 Spaces	
Transcript Max = 20 Spaces	

Course Description for Official Publication (Max = 50 words)

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites ○ Enforced ○ Advised

Credit Restrictions

Level of Credit
☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad
☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min ____ Max ____
Contact Hrs/Wk ____
Number of Wks ____

Printing Information (Optional) ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule

Terms & Freq. of Offering ☐ I ☐ II ☐ IIIa ☐ IIIb ☐ III ☐ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years
Half term ☐ 1st ☐ 2nd

Cognizant Faculty Member: ____ Title ____

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
☐ Curriculum Comm. ____
☐ Faculty ____
☐ Rackham ____
☐ Cross listed Unit 1 ____
☐ Cross listed Unit 2 ____

Submitted By: ☐ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. ____ [IOE]
Cross-listed Dept(s). ____ [Mfg]

Form Number

1798

SUPPORTING STATEMENT

IOE 433 has not been taught since Fall of 2001. There are no plans to offer this course in the future.

Are any special resources or facilities required for this course? ☐ Yes ☐ No

Detail the Special requirements

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Form Number **1794**

Action Requested

- (●) New Course
- ( ) Modification of Existing Course
- ( ) Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 1/25/2007
Effective Fall 2007

A. CURRENT LISTING	B. REQUESTED LISTING
Home Department / Div # / Course Number	Home Department: IOE / Div #: 272 / Course Number: 440
Cross Listed Course Information	Cross Listed Course Information: Mfg / 275 / 440
Course Title	Course Title: Operations Analysis and Management
TITLE ABBREVIATION — Time Sched (Max = 19 Spaces):	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): OPERATIONS ANAL & MGT
TITLE ABBREVIATION — Transcript (Max = 20 Spaces):	TITLE ABBREVIATION — Transcript (Max = 20 Spaces): OPERATIONS ANAL & MGT
Course Description	Course Description for Official Publication (Max = 50 words): Principles and models for analyzing, engineering, and managing manufacturing and service operations as well as supply chains. Emphasis on capacity management; queueing models of operational dynamics (including cycle time, work-in-process, inventory, throughput, and variability); operational flexibility; the math and physics of lean enterprises.
PROGRAM OUTCOMES: ☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐l	PROGRAM OUTCOMES: ☒a ☐b ☒c ☐d ☒e ☐f ☐g ☒h ☐i ☒j ☒k
Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ● Tech Elective ○ Other	Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ● Tech Elective ○ Other
Prerequisites: ○ Enforced ○ Advised	Prerequisites: IOE 310 and 316 or Grd Standing ⊙ Enforced ○ Advised
Credit Restrictions:	Credit Restrictions: No credit granted for students who have credit for OMS 605.
Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Worl	Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☒ All Credit types ☐ Rckhm Grad w/add'l Work
Credit Hours Min ___ Max ___ / Contact Hrs/Wk ___ / Number of Wks ___	Credit Hours Min 3 Max 3 / Contact Hrs/Wk 3 / Number of Wks 14
C. Repeatability (Indi Research, Dir. Study, Dissertation): Is this course repeatable? ○ Yes ○ No; Maximum Hours? ___ Maximum Times? ___; Can it be repeated in the same term? ○ Yes ○ No	Printing Information (Optional): ☒ Print the course in the Bulletin ☐ Print the course in the Time Schedule
Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ___ Graded Section: ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other. Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension	Terms & Freq. of Offering: ■ I ☐ II ☐ IIIa ☐ IIIb ☐ III; ■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years; Half term ☐ 1st ☐ 2nd
	Cognizant Faculty Member: Mark Van Oyen; Title: Assoc. Professor
	Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
- ☐ Curriculum Comm. ___
- ☐ Faculty ___
- ☐ Rackham ___
- ☐ Cross listed Unit 1 ___
- ☐ Cross listed Unit 2 ___

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. Larry Seiford [IOE]
Cross-listed Dept(s). [signature] (Mfg)

Form Number

1794

SUPPORTING STATEMENT

The IOE curriculum needs additional courses to support the Production, Distribution, and Logistics area, which is one of 4 core areas of study in the IOE curriculum. Every IOE must take at least one Technical Elective in 3 of 4 core areas, so PDL courses in "Group A" (i.e. IOE 441, 447, and 449) are a critical part of the department and IOE 441 in particular is offered twice a year with enrollments well over 100 in some cases when Goker Aydin teaches the section. Under the proposed plan, IOE 440 would supplement this group. Note that IOE 440 would be offered in the Fall while IOE 441 would be offered Winter Term, so the curricular change will increase the range of courses offered, but not increase the total sections taught.

An important new role for IOE 440 is to provide an introduction to supply chain management. In addition, it teaches operational modeling based on probability, queueing models, and approximations. IOE 440 contains some of the material (the core Factory Physics models in particular) which used to be taught in IOE 441 back when it was a 4 credit course (it's now at 3 credits). Another goal is to teach a course that bridges from the core methodologies of operations research to the business and managerial issues/perspective of the business side.

IOE 440 was initially offered F06 as IOE 491-21 by Prof. Van Oyen. (Q1 = 3.36 for course, Q2 = 4.00 for instructor)

*No credit should be offered for IOE 440 and OMS 605, due to too much overlap between these courses. This should be reevaluated in a year or two.

ENFORCED PREREQUISITE: IOE 310 and 316 or Grd Standing

ENFORCED PREREQUISITE LONG DESCRIPTION:

IOE 310 and 316

or

Graduate Standing

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

IOE 440 Operations Analysis & Management
First offered Fall 2006; to be offered annually in the Fall semester

Revised 2-1-07

Instructor: Mark P. Van Oyen, Assoc. Prof. of IOE, Room 2853 IOE, Phone: 763-1454
vanoyen@umich.edu

Course Description:
Principles and models for analyzing, engineering, and managing manufacturing and service operations as well as supply chains. Emphasis on capacity management; queueing models of operational dynamics (including cycle time, work-in-process, inventory, throughput, and variability); operational flexibility; the math and physics of lean enterprises.

Core Content: • Production capacity management (Bottleneck Analysis, Product Mix and LP models, Cross-training and flexibility) • Operations models and performance measures • Queueing models and management of congestion and • Intro to supply chain management

Optional or Secondary Content: • Operational issues in labor management: Cross-training strategy and tactics • Flexibility, agility, and emerging paradigms for high performance • Linkages between production and inventory • Introduction to manufacturing strategy

Course Outcomes: We expect that the students who take this course will have an understanding of some of the fundamental issues of operations management and engineering-oriented analytical tools to address them. Core issues involve effective management of production capacity via a systems approach that identifies critical capacity constraints, deterministic and stochastic modeling of capacity and both principles and methods for designing and improving operation. Specific attention is given to production flexibility as a mechanism for improving performance. Fundamental analytical models describing the relationships between work-in-process, cycle (waiting) time, and system throughput will be learned to provide quantitative approximations of system performance for purposes of benchmarking and improvement. Models of inventory and production that incorporate economic optimization as well as quality of service will be learned. Some specific examples of the above include:
(a) gain knowledge of a modeling hierarchy beginning with deterministic models of capacity, system capacity, line balancing, and the role of variability as captured in queueing models
(b) understand the how the concepts of push and pull relate to work release policies and flow control
(c) master analytical models of the throughput, cycle time, and WIP of operations under varying levels of variability
(d) articulate fundamental challenges and solutions of supply chain management (e.g., bullwhip effect, decentralized decision-making under local information, use of modularity and risk pooling, risk-sharing via contracts, vendor-managed inventory)
(e) gain experience with the interplay between theory/modeling and the dynamics and management of business (e.g., case studies, readings on management of operations, experience gained via business simulation)

Prerequisites: IOE 310 and 316 or equivalent. IOE 440 is open to advanced undergraduates, Master's, and Ph.D. students. Credit may not be earned for both IOE 440 and OMS 605.

Texts:

1. *Factory Physics: The Foundations of Manufacturing Management*, W.J. Hopp and M.L. Spearman, McGraw-Hill/Irwin, 2nd edition, 2000. ISBN: 0256247951

Please note the Errata for Second Edition, First Printing: Errata_for_Second_Edition.pdf

2. *The Goal*, Goldratt, E., and Cox, North River Press; 3rd edition, 2004. ISBN: 0884271781

3. Selected Case Studies The XanEdu coursepacket, only at the N. Campus B&N Bookstore.

4. Course materials available online (mostly from this site, but announcements and some material could appear on CTools).

Factory Physics will be the primary text. *The Goal* will be used to illustrate principles, explore managerial issues, and motivate the course. Supplementary course materials will be introduced to broaden the course as needed.

Grading and Course Structure: Lectures, homework exercises, limited use of case studies, Midterm and a final.

- Class participation: 6.25%
- Homework & case assignments:50%
- Midterm Test 1: 18.75%
- Final: 25%

The "homework type projects" which will include case studies (plan 3 Harvard cases and 3 or 4 other small projects) must be done in teams of 3-4 students and the *group writeup must be submitted as a single copy bearing the names of all group members.* All other homework is to be done individually. The final examination will be given on the date scheduled by the university.

Interpretation of the Honor Code for this class:
You may obtain help from others in doing the homework and projects (with the exception that some assignments may explicitly disallow teamwork), but the purpose of teamwork is to help *you* to fully comprehend the material. While you may discuss assignments with multiple people, actual completion of an assignment must be *limited to a team of at most four (4) members*. A homework assignment or project that is prepared as a team should be submitted as a single copy containing the names of all group members (and all members will share the grade given).

COURSE PROFILE

Degree Program: IOE Undergraduate **Date:** 2-1-07

Prepared by: Mark P. Van Oyen, Assoc. Prof. of IOE

COURSE #: IOE 440	**COURSE TITLE: Operations Analysis & Management**
TERMS OFFERED: Fall	**For each prerequisite below, "E" denotes Enforced and "A" denotes Advised.**
TEXTBOOKS/REQUIRED MATERIAL: Factory Physics + Harvard Cases	**PREREQUISITES:**
INSTRUCTOR(S): M. Van Oyen	**COGNIZANT FACULTY: M. Van Oyen, G. Aydin**
CoE BULLETIN DESCRIPTION: Principles and models for analyzing, engineering, and managing manufacturing and service operations as well as supply chains. Emphasis on capacity management; queueing models of operational dynamics (including cycle time, work-in-process, inventory, throughput, and variability); operational flexibility; the math and physics of lean enterprises. Prerequisites: IOE 310 and 316 or equivalent. IOE 440 is open to undergraduates, Master's, and Ph.D. students. Credit may not be earned for both IOE 440 and OMS 605.	**COURSE TOPICS:** Core Content: • Production capacity management (Bottleneck Analysis, Product Mix and LP models, Cross-training and flexibility) • Operations models and performance measures • Queueing models and management of congestion • Intro to supply chain management Optional or Secondary Content: • Operational issues in labor management: Cross-training strategy and tactics • Flexibility, agility, and emerging paradigms for high performance • Linkages between production and inventory • Introduction to manufacturing strategy.
COURSE STRUCTURE/SCHEDULE Lecture: 3 per week @ 50 minutes	

COURSE OBJECTIVES	Links shown in brackets refer to IOE program outcomes (see Appendix) 1.Understand capacity management in production (manufacturing and services) including variability effects. [1, 3, 5, 10-12] 2.Gain a fundamental set of operational principles for effective design, management, and operation. [1, 3, 5, 10-12] 3.Understand key issues of supply chain management and effectively matching supply with demand. [1, 3, 5, 8, 10-12] 4.Gain stochastic modeling skills for solving operational performance analysis and optimization problems. [1, 3, 5, 10-12]
COURSE OUTCOMES For each course outcome, links to the Program Outcomes are identified.	1. Gain knowledge of a modeling hierarchy beginning with deterministic models of capacity, system capacity, capacity/line balancing, and the rol variability as captured in queueing models. [1, 3, 5, 11, 12] 2. Understand the how the concepts of push and pull relate to work release policies and flow control. [3, 5, 11, 12] 3. Master analytical models of the throughput, cycle time, and WIP of operations under varying levels of variability. [1, 3, 5, 11, 12] 4. Articulate fundamental challenges and solutions of supply chain management (e.g., bullwhip effect, decentralized decision-making under local information, use of modularity and risk pooling, risk-sharing via contracts, vendor-managed inventory). [1, 3, 5, 10, 11, 12] 5. Gain experience with the interplay between theory/modeling and the dynamics and management of business (e.g., case studies, readings on mar of operations, experience gained via business simulation). [1, 3, 5, 10, 11, 12]
ASSESSMENT TOOLS For each assessment tool, links to the course outcomes	1. Midterm and final examinations measure all outcomes for individual students under a time constraint. 2. Homeworks measure all outcomes for individual students without a time constraint. 3. Written reports on case studies evaluate outcomes [1, 5, 7, 10-12, and provide team experience, part of 4] 4. End of term student evaluations provide for feedback relevant to all outcomes.

are identified.	

Revised 11 11 04

APPENDIX: IOE program outcomes: All Industrial and Operations Engineering graduates should have

1. An ability to apply knowledge of mathematics, science, and engineering;
2. An ability to design and conduct experiments, as well as analyze and interpret data;
3. An ability to design and improve integrated systems of people, materials, information, facilities, and technology;
4. An ability to function as a member of a multidisciplinary team;
5. An ability to identify, formulate, and solve industrial and operations engineering problems;
6. An understanding of professional and ethical responsibility;
7. An ability to communicate effectively;
8. The broad education necessary to understand the impact of engineering solutions in a global and societal context;
9. A recognition of the need for, and an ability to engage in life-long learning;
10. A knowledge of contemporary issues;
11. An ability to use updated techniques, skills and tools of industrial and operations engineering throughout their professional careers; and
12. A base set of skills and knowledge, regardless of specific professional goals, in human resource management, personal management, macro analysis, critical thinking, operations management, operations research, and information systems (see IOE Core skills list).

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number **1800**

Action Requested

- ○ New Course
- ○ Modification of Existing Course
- ◉ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/7/2007
Effective Fall 2007

A. CURRENT LISTING

Home Department	Div #	Course Number
IOE	272	906

Cross Listed Course Information:

Course Title: Master's Thesis Project

TITLE ABBREVIATION		
Time Sched Max = 19 Spaces	Master's Thesis Project	
Transcript Max = 20 Spaces	Master's Thesis Project	

Course Description: none

PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ l

Degree Requirements ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other

Prerequisites: Permission of Department ○ Enforced ○ Advised

Credit Restrictions:

Level of Credit
☐ Undergrad only
☒ Rackham Grad
☐ Non-Rckhm Grad
☐ Ugrad or Rckhm Grad
☐ Ugrad or Non-Rckhm Grad
☐ All Credit types
☐ Rckhm Grad w/add'l Worl

Credit Hours: Min 1, Max 6

Contact Hrs/Wk ____ Number of Wks ____

B. REQUESTED LISTING

Home Department	Div #	Course Number

Cross Listed Course Information:

Course Title:

TITLE ABBREVIATION		
Time Sched Max = 19 Spaces		
Transcript Max = 20 Spaces		

Course Description for Official Publication (Max = 50 words):

PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other

Prerequisites: ○ Enforced ○ Advised

Credit Restrictions:

Level of Credit
☐ Undergrad only
☐ Rackham Grad
☐ Non-Rckhm Grad
☐ Ugrad or Rckhm Grad
☐ Ugrad or Non-Rckhm Grad
☐ All Credit types
☐ Rckhm Grad w/add'l Work

Credit Hours: Min ____ Max ____

Contact Hrs/Wk ____ Number of Wks ____

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ⊙ No
Maximum Hours? ____ Maximum Times? ____
Can it be repeated in the same term? ○ Yes ○ No

Class Type(s) ☐ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☒ Ind ☐ Other ____

Graded Section ○ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ⊙ Other

Grading ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Printing Information (Optional) ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule

Terms & Freq. of Offering: ■ I ■ II ■ IIIa ■ IIIb ■ III ☐ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Half term ☐ 1st ☐ 2nd

Cognizant Faculty Member: ____ Title ____

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
- ☐ Curriculum Comm. ____
- ☐ Faculty ____
- ☐ Rackham ____
- ☐ Cross listed Unit 1 ____
- ☐ Cross listed Unit 2 ____

Submitted By: ☐ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. ____
Cross-listed Dept(s). ____

Form Number

1800

SUPPORTING STATEMENT

This course has been on the books since 1968 with a very few students over the years having elected the course.

Students doing research generally elect IOE 590 or IOE 801.

Are any special resources or facilities required for this course? ☐ Yes ☐ No

Detail the Special requirements

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number **1810**

Action Requested

- (•) New Course
- ( ) Modification of Existing Course
- ( ) Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/20/2007
Effective Fall 2007

A. CURRENT LISTING

Home Department | Div # | Course Number

Cross Listed Course Information

Course Title

TITLE ABBRE-VIATION	Time Sched Max = 19 Spaces	
	Transcript Max = 20 Spaces	

Course Description

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites ○ Enforced ○ Advised

Credit Restrictions

Level of Credit
☐ Undergrad only ☐ All Credit types
☐ Rackham Grad ☐ Rckhm Grad w/add'l Worl
☐ Non-Rckhm Grad
☐ Ugrad or Rckhm Grad
☐ Ugrad or Non-Rckhm Grad

Credit Hours Min ___ Max ___ | Contact Hrs/Wk ___ | Number of Wks ___

C. Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ○ No
Maximum Hours? ___ Maximum Times? ___
Can it be repeated in the same term? ○ Yes ○ No

Class Type(s) ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ___

Graded Section (•) Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

B. REQUESTED LISTING

Home Department: MATSCIE | Div #: 281 | Course Number: 593

Cross Listed Course Information

Course Title: Special Topics in Materials Science & Engineering

TITLE ABBRE-VIATION	Time Sched Max = 19 Spaces	MSE SPECIAL TOPICS
	Transcript Max = 20 Spaces	MSE SPECIAL TOPICS

Course Description for Official Publication (Max = 50 words)

Special topics of interest to graduate students; and, possibly, undergraduate students.

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites Permission of instructor. ○ Enforced (•) Advised

Credit Restrictions

Level of Credit
☐ Undergrad only ☒ All Credit types
☐ Rackham Grad ☐ Rckhm Grad w/add'l Work
☐ Non-Rckhm Grad
☐ Ugrad or Rckhm Grad
☐ Ugrad or Non-Rckhm Grad

Credit Hours Min 1 Max 4 | Contact Hrs/Wk ARR | Number of Wks 14

Printing Information (Optional) ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule

Terms & Freq. of Offering ■ I ■ II ☐ IIIa ☐ IIIb ☐ III ■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Half term ☐ 1st ☐ 2nd

Cognizant Faculty Member: John Kieffer **Title** Assoc. Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
☐ Curriculum Comm.
☐ Faculty
☐ Rackham
☐ Cross listed Unit 1
☐ Cross listed Unit 2

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.

Name, Signature & Department
Home Dept. Peter Green, Dept. Chair

Cross-listed Dept(s).

Form Number

1810

SUPPORTING STATEMENT

This course will allow new and special topics courses to be taught primarily for graduate students, but also open to undergraduates. This course will supplement MSE 493 (primarily for undergraduates), and MSE 693 (for graduate students only).

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number 1574

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/28/2007
Effective Fall 2007

A. CURRENT LISTING	B. REQUESTED LISTING
Home Department / Div # / Course Number	Home Department: Mechanical Engineering / Div # / Course Number: 350
Cross Listed Course Information	Cross Listed Course Information
Course Title	Course Title: Design and Manufacturing II
TITLE ABBREVIATION — Time Sched Max = 19 Spaces:	TITLE ABBREVIATION — Time Sched Max = 19 Spaces: Des & Mfg II
TITLE ABBREVIATION — Transcript Max = 20 Spaces:	TITLE ABBREVIATION — Transcript Max = 20 Spaces: Des & Mfg II
[X] Course Description: Principles of mechanical design; synthesis and selection of machine components. Design project. Three hours of lecture and one lab.	Course Description for Official Publication (Max = 50 words): Principles of mechanical design and manufacturing. Analysis, synthesis and selection of mechanisms, machine components and associated manufacturing processes. Design projects. Three hour lecture and one two-hour lab.
PROGRAM OUTCOMES: ☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐k	**PROGRAM OUTCOMES:** ☐a ☒b ☒c ☐d ☒e ☐f ☐g ☐h ☐i ☐j ☒k
Degree Requirements: ○ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective	Degree Requirements: ○ Degree Requirement ○ Free Elective ○ Other ◉ Core Course ○ Tech Elective
Prerequisites: ○ Enforced ○ Advised	Prerequisites: ME211, ME240, ME250:P/A ME382 ○ Enforced ◉ Advised
Credit Restrictions	Credit Restrictions
Level of Credit: ☐ Undergrad only ☐ Ugrad or Non-Rckhm Grad ☐ Rackham Grad ☐ All Credit types ☐ Non-Rckhm Grad ☐ Rckhm Grad w/add'l Work ☐ Ugrad or Rckhm Grad; Credit Hours Min ___ Max ___; Contact Hrs/Wk ___; Number of Wks ___	Level of Credit: ☒ Undergrad only ☐ Ugrad or Non-Rckhm Grad ☐ Rackham Grad ☐ All Credit types ☐ Non-Rckhm Grad ☐ Rckhm Grad w/add'l Work ☐ Ugrad or Rckhm Grad; Credit Hours Min 4 Max 4; Contact Hrs/Wk 4; Number of Wks 14
C. Repeatability (Indi Research, Dir. Study, Dissertation: Is this course repeatable? ○ Yes ◉ No; Maximum Hours? ___ Maximum Times? ___; Can it be repeated in the same term? ○ Yes ○ No	Printing Information (Optional): ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule
Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☒ Lab ☐ Dis ☐ Ind ☐ Other ___; Graded Section: ◉ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other; Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y; Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension	Terms & Freq. of Offering: ☒ I ☒ II ☐ IIIa ☐ IIIb ☐ III; ☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years; Half term ☐ 1st ☐ 2nd
	Cognizant Faculty Member: D. Brei; Title: Assoc. Prof.
	Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm.
- ☐ Faculty
- ☐ Rackham
- ☐ Cross listed Unit 1
- ☐ Cross listed Unit 2

Submitted By: ☒ Home Dept. ☐ Cross-listed Dept.

Name, Signature & Department

Home Dept. Mechanical Engineering

Cross-listed Dept(s).

Form Number

1574

SUPPORTING STATEMENT

The course topics/objectives are being updated to reflect the new course structure.

Are any special resources or facilities required for this course? ☒ Yes ☐ No

Detail the Special requirements

machine shop

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number 1575

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/28/2007
Effective Fall 2007

A. CURRENT LISTING

Home Department | Div # | Course Number

Cross Listed Course Information

Course Title

TITLE ABBRE-VIATION	Time Sched Max = 19 Spaces	
	Transcript Max = 20 Spaces	

X Course Description
Unified approach to abstracting real mechanical, fluid, and electrical systems into proper models in graphical and state equation form to meet engineering design and control system objectives. Introduction to system analysis (eigenvalues, time and frequency response) and linear feeback control. Synthesis and analysis by analytical and computer methods. Four lectures per week.

PROGRAM OUTCOMES:
☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐k

Degree Requirements ○ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective

Prerequisites ○ Enforced ○ Advised

Credit Restrictions

Level of Credit
☐ Undergrad only ☐ Ugrad or Non-Rckhm Grad
☐ Rackham Grad ☐ All Credit types
☐ Non-Rckhm Grad ☐ Rckhm Grad w/add'l Work
☐ Ugrad or Rckhm Grad

Credit Hours Min ___ Max ___
Contact Hrs/Wk ___
Number of Wks ___

C. Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ○ No
Maximum Hours? ___ Maximum Times? ___
Can it be repeated in the same term? ○ Yes ○ No

Class Type(s) ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ___

Graded Section ○ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

B. REQUESTED LISTING

Home Department: Mechanical Engineering | Div # | Course Number: 360

Cross Listed Course Information

Course Title: Modeling, Analysis and Control of Dynamic Systems

TITLE ABBRE-VIATION	Time Sched Max = 19 Spaces	
	Transcript Max = 20 Spaces	

Course Description for Official Publication (Max = 50 words)
Developing mathematical models of dynamic systems, including mechanical, electrical, electromechanical, and fluid/thermal systems, and representing these models in transfer function and state space form. Analysis of dynamic system models, including time and frequency responses. Introduction to linear feedback control techniques. Synthesis and analysis by analytical and computer methods. Four hours of lecture per week.

PROGRAM OUTCOMES:
☒a ☐b ☐c ☐d ☒e ☐f ☐g ☐h ☐i ☐j ☒k

Degree Requirements ○ Degree Requirement ○ Free Elective ○ Other ◉ Core Course ○ Tech Elective

Prerequisites ME240 ○ Enforced ◉ Advised

Credit Restrictions

Level of Credit
☒ Undergrad only ☐ Ugrad or Non-Rckhm Grad
☐ Rackham Grad ☐ All Credit types
☐ Non-Rckhm Grad ☐ Rckhm Grad w/add'l Work
☐ Ugrad or Rckhm Grad

Credit Hours Min 4 Max 4
Contact Hrs/Wk 4
Number of Wks 14

Printing Information (Optional) ☒ Print the course in the Bulletin ☐ Print the course in the Time Schedule

Terms & Freq. of Offering ■ I ■ II ☐ IIIa ☐ IIIb ☐ III ■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years
Half term ☐ 1st ☐ 2nd

Cognizant Faculty Member: D.Tilbury **Title** Assoc Prof

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
☐ Curriculum Comm.
☐ Faculty
☐ Rackham
☐ Cross listed Unit 1
☐ Cross listed Unit 2

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. Mechanical Engineering
Cross-listed Dept(s).

Form Number

1575

SUPPORTING STATEMENT

Modification made to more accurately reflect the material taught in the course.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number 1005

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 3/22/2006
Effective ~~Winter~~ 2007 Fall

A. CURRENT LISTING	B. REQUESTED LISTING
Home Department / Div # / Course Number	Home Department: MECHENG / Div # / Course Number: 487
Cross Listed Course Information	Cross Listed Course Information: MANUFACTURING 488
Course Title	Course Title: WELDING
TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): / Transcript (Max = 20 Spaces):	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): WELDING / Transcript (Max = 20 Spaces): WELDING
Course Description	Course Description for Official Publication (Max = 50 words): Study of the mechanism of surface bonding, welding metallurgy, effect of rate of heat input on resulting microstructures, residual stresses and distortion, economics and capabilites of the various processes.
PROGRAM OUTCOMES: ☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐k	**PROGRAM OUTCOMES:** ☒a ☐b ☒c ☐d ☒e ☐f ☐g ☐h ☐i ☐j ☐k
Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other	Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ◉ Tech Elective ○ Other
X Prerequisites ME481 ○ Enforced ○ Advised	Prerequisites ME382 ○ Enforced ◉ Advised
Credit Restrictions	Credit Restrictions
Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work; Credit Hours Min ___ Max ___; Contact Hrs/Wk ___; Number of Wks ___	Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☒ All Credit types ☐ Rckhm Grad w/add'l Work; Credit Hours Min 3 Max 3; Contact Hrs/Wk 3; Number of Wks 14
C. Repeatability (Indi Research, Dir. Study, Dissertation): Is this course repeatable? ○ Yes ○ No; Maximum Hours? ___ Maximum Times? ___; Can it be repeated in the same term? ○ Yes ○ No	Printing Information (Optional): ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule
Class Type(s): ☑ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ___; Graded Section: ☑ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other; Grading: ☑ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y; Location: ☑ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension	Terms & Freq. of Offering: ☐ I ☒ II ☐ IIIa ☐ IIIb ☐ III; ☐ Yearly ☒ Alter Years ☐ Even Years ☐ Odd Years; Half term ☐ 1st ☐ 2nd
	Cognizant Faculty Member: E. Kannatey-Asibu; Title: Professor
	Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm. ___
- ☐ Faculty ___
- ☐ Rackham ___
- ☐ Cross listed Unit 1 ___
- ☐ Cross listed Unit 2 ___

Submitted By: ☒ Home Dept. ☐ Cross-listed Dept.

Name, Signature & Department

Home Dept. MechEngin

Cross-listed Dept(s). Mfg

Form Number

1005

SUPPORTING STATEMENT

ME281 was deleted in January 1999. ME382 was created in 1999. The pre-requisite for ME487 was not updated at that time so it is being done now.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number 1192

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 02/06/2007
Effective Fall 2007

A. CURRENT LISTING	B. REQUESTED LISTING
Home Department / Div # / Course Number	Home Department: Mechanical Engineering / Div # / Course Number: 631
Cross Listed Course Information	Cross Listed Course Information
Course Title	Course Title: Statistical Thermodynamics
TITLE ABBREVIATION — Time Sched Max = 19 Spaces:	TITLE ABBREVIATION — Time Sched Max = 19 Spaces: Stat Thermo
TITLE ABBREVIATION — Transcript Max = 20 Spaces:	TITLE ABBREVIATION — Transcript Max = 20 Spaces: Stat Thermo
Course Description	Course Description for Official Publication (Max = 50 words): Introduction to statistical methods for evaluating thermodynamics and transport properties. Elements of quantum mechanics, statistical mechanics, and kinetic theory, as applied to engineering thermodynamics.
PROGRAM OUTCOMES: ☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐k	**PROGRAM OUTCOMES:** ☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐k
Degree Requirements ○ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective	**Degree Requirements** ○ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective
X Prerequisites: ME230 or ME336 ○ Enforced ◉ Advised	Prerequisites: ME235 or ME336 ○ Enforced ◉ Advised
Credit Restrictions	Credit Restrictions
Level of Credit ☐ Undergrad only ☐ Ugrad or Non-Rckhm Grad ☐ Rackham Grad ☐ All Credit types ☐ Non-Rckhm Grad ☐ Rckhm Grad w/add'l Work ☐ Ugrad or Rckhm Grad; Credit Hours Min Max; Contact Hrs/Wk; Number of Wks	**Level of Credit** ☐ Undergrad only ☐ Ugrad or Non-Rckhm Grad ☐ Rackham Grad ☒ All Credit types ☐ Non-Rckhm Grad ☐ Rckhm Grad w/add'l Work ☐ Ugrad or Rckhm Grad; Credit Hours Min 3 Max 3; Contact Hrs/Wk 3; Number of Wks 14
C. Repeatability (Indi Research, Dir. Study, Dissertation): Is this course repeatable? ○ Yes ◉ No; Maximum Hours? ; Maximum Times? ; Can it be repeated in the same term? ○ Yes ○ No	**Printing Information (Optional)** ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule
Class Type(s) ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other; **Graded Section** ◉ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other; **Grading** ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y; **Location** ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension	Terms & Freq. of Offering ■ I ☐ II ☐ IIIa ☐ IIIb ☐ III; Half term ☐ 1st ☐ 2nd; ☐ Yearly ■ Alter Years ☐ Even Years ☐ Odd Years
	Cognizant Faculty Member: K. Pipe; Title: Asst. Prof
	Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
- ☐ Curriculum Comm.
- ☐ Faculty
- ☐ Rackham
- ☐ Cross listed Unit 1
- ☐ Cross listed Unit 2

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. Mechanical Engineering
Cross-listed Dept(s).

Form Number

1192

SUPPORTING STATEMENT

Modification solely to update pre-requisite

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number 1786

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 11/9/2006
Effective Winter 2007

A. CURRENT LISTING

Home Department | Div # | Course Number

Cross Listed Course Information

Course Title

TITLE ABBREVIATION: Time Sched Max = 19 Spaces; Transcript Max = 20 Spaces

Course Description

PROGRAM OUTCOMES:
☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐k

Degree Requirements ○ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective

X Prerequisites ME235 and ME240
○ Enforced ⊙ Advised

Credit Restrictions

Level of Credit
☐ Undergrad only ☐ Ugrad or Non-Rckhm Grad
☐ Rackham Grad ☐ All Credit types
☐ Non-Rckhm Grad ☐ Rckhm Grad w/add'l Work
☐ Ugrad or Rckhm Grad

Credit Hours Min Max
Contact Hrs/Wk
Number of Wks

C. Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ○ No
Maximum Hours? Maximum Times?
Can it be repeated in the same term? ○ Yes ○ No

Class Type(s) ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other
Graded Section ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other
Grading ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y
Location ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

B. REQUESTED LISTING

Home Department: Mechanical Engineering | Div #: 280 | Course Number: 320

Cross Listed Course Information

Course Title: Fluid Mechanics I

TITLE ABBREVIATION: Time Sched Max = 19 Spaces: Fluid Mechanics I; Transcript Max = 20 Spaces: Fluid Mechanics I

Course Description for Official Publication (Max = 50 words)
Fluid statics; conservation of mass, momentum, and energy in fixed and moving control volumes; steady and unsteady Bernoulli's equation; differential analysis of flluid flow; dimensional analysis and similitude; laminar and turbulent flow; boundary layers; lift and drag; introduction to commercial CFD packages; applications to mechanical, biological, environmental, and micro-fluidic systems.

PROGRAM OUTCOMES:
☒a ☐b ☒c ☐d ☒e ☒f ☐g ☒h ☒i ☒j ☒k

Degree Requirements ○ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective

Prerequisites MATH215, ME235, and ME240
○ Enforced ⊙ Advised

Credit Restrictions

Level of Credit
☒ Undergrad only ☐ Ugrad or Non-Rckhm Grad
☐ Rackham Grad ☐ All Credit types
☐ Non-Rckhm Grad ☐ Rckhm Grad w/add'l Work
☐ Ugrad or Rckhm Grad

Credit Hours Min 3 Max 3
Contact Hrs/Wk 3
Number of Wks 14

Printing Information (Optional) ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule

Terms & Freq. of Offering ■ I ■ II ☐ IIIa ☐ IIIb ☐ III ■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years
Half term ☐ 1st ☐ 2nd

Cognizant Faculty Member: R. Akhavan **Title** Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
☐ Curriculum Comm.
☐ Faculty
☐ Rackham
☐ Cross listed Unit 1
☐ Cross listed Unit 2

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. Mechanical Engineering
Cross-listed Dept(s).

Form Number

1786

SUPPORTING STATEMENT

MATH 215 introduces vector algebra, vector functions, functions of several variables, partial differentiation; line, surface and volume integrals and their applications; Green's theorem and Stokes theorem. These are important concepts for students to have learned prior to taking ME320.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number 1736

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 4/21/2006
Effective Winter 2007

A. CURRENT LISTING	B. REQUESTED LISTING
Home Department / Div # / Course Number	Home Department: Mechanical Engineering / Div # / Course Number: 450
Cross Listed Course Information	Cross Listed Course Information
Course Title	Course Title: Design and Manufacturing III
TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): / Transcript (Max = 20 Spaces):	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): Des & Mfg III / Transcript (Max = 20 Spaces): Des/Mfg III
Course Description	Course Description for Official Publication (Max = 50 words): A mechanical engineering design project by which the student is exposed to the design process from concept through analysis to layout and report. Projects are proposed from the different areas of study within mechanical engineering and reflect the expertise of instructional faculty and industrial representatives. Three hours of lecture and two labs.
PROGRAM OUTCOMES: ☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐k	**PROGRAM OUTCOMES:** ☒a ☐b ☒c ☒d ☒e ☒f ☒g ☒h ☒i ☐j ☒k
Degree Requirements ◉ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective	**Degree Requirements** ◉ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective
X Prerequisites: ME350, ME360, and ME395 ○ Enforced ◉ Advised	Prerequisites: ME350, ME360, and ME395 ◉ Enforced ○ Advised
X Credit Restrictions: Recommend ME495 not be elected concurrently. Not open to graduate studentss.	Credit Restrictions: May not be taken concurrently with ME495. Not open to graduate students.
Level of Credit ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work	**Level of Credit** ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work
Credit Hours Min ___ Max ___ / Contact Hrs/Wk ___ / Number of Wks ___	Credit Hours Min 4 Max 4 / Contact Hrs/Wk 8 / Number of Wks 14
C. Repeatability (Indi Research, Dir. Study, Dissertation: Is this course repeatable? ○ Yes ◉ No; Maximum Hours? ___ Maximum Times? ___; Can it be repeated in the same term? ○ Yes ○ No	**Printing Information (Optional)** ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule
Class Type(s) ☒ Lec ☐ Rec ☐ Sem ☒ Lab ☐ Dis ☐ Ind ☐ Other ___ **Graded Section** ◉ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other **Grading** ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y **Location** ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension	Terms & Freq. of Offering: ☒ I ☒ II ☐ IIIa ☐ IIIb ☐ III; ☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years; Half term ☐ 1st ☐ 2nd
	Cognizant Faculty Member: S. Skerlos; Title: Assoc. Professor
	Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm.
- ☐ Faculty
- ☐ Rackham
- ☐ Cross listed Unit 1
- ☐ Cross listed Unit 2

Submitted By: ☒ Home Dept. ☐ Cross-listed Dept.

Name, Signature & Department

Home Dept. Mechanical Engineering

Cross-listed Dept(s).

Form Number

1736

SUPPORTING STATEMENT

The ME program does not recommend that students take ME450 and ME495 concurrently. For the past couple of years, this has been communicated to students on an individual basis when the come to the ASO to talk about their studies. For students who wish to take both at the same time, they are asked to see the UG Program Director to talk about their situation and why they need/desire to take this undesirable combination of courses. Typically, their course load is evaluated so that it, at most, includes 450, 495 and no more than one technical course.

At issue is that the 450/495 course combination not only adversely impacts the particular student taking these two courses, but even more importantly can adversely impact the group member of that student in both of the courses.

The proposed change would formalize the existing advising process and better help students develop their plan of study.

Are any special resources or facilities required for this course? ☒ Yes ☐ No

Detail the Special requirements

Unchanged since 1997-98

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number 1750

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 6/29/2006
Effective Fall 2006

A. CURRENT LISTING	B. REQUESTED LISTING
Home Department / Div # / Course Number	Home Department: Mechanical Engineering / Div # / Course Number: 495
Cross Listed Course Information	Cross Listed Course Information
Course Title	Course Title: LAB II
TITLE ABBREVIATION — Time Sched Max = 19 Spaces: / Transcript Max = 20 Spaces:	TITLE ABBREVIATION — Time Sched Max = 19 Spaces: LAB II / Transcript Max = 20 Spaces: LAB II
Course Description	Course Description for Official Publication (Max = 50 words): Weekly lectures and extended experimental projects designed to demonstrate experimental and analytical methods as applied to complex mechanical systems. Topics will include controls, heat transfer, fluid mechanics, thermodynamics, mechanics, materials, and dynamical systems. Emphasis on laboratory report writing, oral presentations, and team-building skills, and the design of experiments.
PROGRAM OUTCOMES: ☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐k	**PROGRAM OUTCOMES:** ☒a ☒b ☐c ☒d ☐e ☐f ☒g ☐h ☐i ☐j ☒k
Degree Requirements: ○ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective	Degree Requirements: ◉ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective
X Prerequisites: ME360, ME395; preceded or accompanied by ME350 ⊙ Enforced ○ Advised	Prerequisites: ME360, ME395, P/A ME335 and ME350 ⊙ Enforced ○ Advised
X Credit Restrictions: Recommend ME450 not be elected concurrently. Not open to graduate students.	Credit Restrictions: May not elect ME450 concurrently. Not open to graduate students.
Level of Credit: ☐ Undergrad only ☐ Ugrad or Non-Rckhm Grad ☐ Rackham Grad ☐ All Credit types ☐ Non-Rckhm Grad ☐ Rckhm Grad w/add'l Work ☐ Ugrad or Rckhm Grad; Credit Hours Min / Max; Contact Hrs/Wk; Number of Wks	Level of Credit: ☒ Undergrad only ☐ Ugrad or Non-Rckhm Grad ☐ Rackham Grad ☐ All Credit types ☐ Non-Rckhm Grad ☐ Rckhm Grad w/add'l Work ☐ Ugrad or Rckhm Grad; Credit Hours Min 4 / Max 4; Contact Hrs/Wk 5; Number of Wks 14
C. Repeatability (Indi Research, Dir. Study, Dissertation: Is this course repeatable? ○ Yes ⊙ No; Maximum Hours?; Maximum Times?; Can it be repeated in the same term? ○ Yes ⊙ No	Printing Information (Optional): ☒ Print the course in the Bulletin ☐ Print the course in the Time Schedule
Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☒ Lab ☐ Dis ☐ Ind ☐ Other; Graded Section: ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other; Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y; Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension	Terms & Freq. of Offering: ■ I ■ II ☐ IIIa ☐ IIIb ☐ III; ■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years; Half term ☐ 1st ☐ 2nd
	Cognizant Faculty Member: A.M. Sastry; Title: Professor
	Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☒ Curriculum Comm.
- ☐ Faculty
- ☐ Rackham
- ☐ Cross listed Unit 1
- ☐ Cross listed Unit 2

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.

Name, Signature & Department

Home Dept. Mechanical Engineering

Cross-listed Dept(s).

Form Number

1750

SUPPORTING STATEMENT

Adding preceded or accompanied by ME335 is necessary because ME495 includes one or more heat transfer based laboratories. Consequently, students need to have a working knowledge of heat transfer for these labs.

The ME program does not recommend that students take ME450 and ME495 concurrently. For the past couple of years, this has been communicated to students on an individual basis when they come to ASO to talk about their studies. For students who want to take both, they are asked to seek the approval of the UG Program Director by discussing their situation; why they want/need to do so. Typically, the course load is evaluated so that it, at most, includes ME450, ME495 and no more than one more technical course.

At issue is that the ME450/ME495 combination not only adversely impacts the particular student taking these courses, but even more importantly, can adversely impact the group members in each of these courses.

The proposed change would formalize the existing advising process and better help students develop their plan of study.

Are any special resources or facilities required for this course? ☒ Yes ☐ No

Detail the Special requirements

Unchanged since 1998-99

THE UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING
BIOMEDICAL ENGINEERING

1107 CARL A. GERSTACKER BUILDING
2200 BONISTEEL BLVD.
ANN ARBOR, MI 48109-2099
734 764-9588 FAX: 734 936-1905
http:www.bme.umich.edu

MEMORANDUM

TO: College of Engineering Curriculum Committee

FROM: Douglas C. Noll
Interim Department Chair

DATE: January 30, 2007

SUBJECT: Change in BiomedE Curriculum

As of Fall 2007, the Department of Biology will no longer be teaching Biology 162 and 163, Introductory Biology (5). The courses expected to replace Biology 162 are:
Biology 171, Introductory Biology-Ecology and Evolution (4);
Biology 172, Introductory Biology-Molecular, Cellular, and Developmental (4); and
Biology 173, Introductory Biology Laboratory (2).

To replace the Biology 162 (5) course in the Biomedical Engineering curriculum, Biology 172 (4) or, if approved by LS&A, 174 (4), will be required. The remaining one credit hour will be added to the Biomedical Engineering free elective total, bringing it to 10 credit hours.

Students who indicate interest in the Pre-Health program will need to take Biology 171, 172, and 173.

Attached are documents describing Biology 171, 172, 173 and the proposed course 174.

If you have any questions, please do not hesitate to contact me at dnoll@umich.edu.

Date: Tue, 19 Dec 2006 15:19:50 -0500
From: Bob Bender <rbender@umich.edu>
To: sbitzer@umich.edu
Subject: Intro Biol
X-Remote-Browser: Mozilla/5.0 (Macintosh; U; PPC Mac OS X; en)
AppleWebKit/416.11 (KHTML, like Gecko) Safari/416.12
X-IMP-Server: 141.211.144.230
X-Originating-IP: 141.211.153.36
X-Originating-User: rbender
X-Virus-Scan: : UVSCAN at UoM/EECS

Susan,
We just heard that LSA Executive Committee has approved the new intro courses. So as of Fall 07, Bio 162 and 163 will not longer be taught and Bio 171, 172, and 173 WILL be. Sorry for the short notice, but we just heard officially yesterday.

Bob
--
Robert A. Bender, Ph.D.
Professor of MCDBiology and
Assoc. Chair for Undergraduate Studies
2095 Nat. Sci.
University of Michigan
830 N. University Ave.
Ann Arbor, MI 48109-1048

Phone: 734-936-2530
FAX: 734-647-0884

LSA Course Approval Request Form - New Course

Effective Term: Fall 2007

Duration: Indefinitely

Home Department: Biology

Subject: BIOLOGY

Catalog #: 171

Cross-Listing Departments (if any):

Department Chair Approval

Name:	Diarmaid O'Foighil - EEB	**Date:**	9/1/06	**Signature:**	
Name:	Robert Bender - MCDB	**Date:**	9/1/06	**Signature:**	

LSACC Approval:		**Date:**	
LSAXC Approval:		**Date:**	
Non-LSA Unit Approval:		**Date:**	
Rackham Approval:		**Date:**	

Course Title: Introductory Biology - Ecology and Evolution

Transcript Title: Intro Biol - EEB

Time Schedule Title: Intro Biol - EEB

Distributions: NS

Requirements: BS

Course Level: Undergraduate Only

Credit Hours: UG Full 4, UG Half 4

Repeatable: No

Class Component(s): LEC, DIS

Graded Component: LEC

Credit Type: HNRS,Regular

Grading Scheme: A-E

Campus Location: Ann Arbor

Short Course Description: BIO 171 is a one-term introductory course in ecology and evolutionary biology. It will impart factual and conceptual knowledge on the origin and complex interactions of the earth's biodiversity and ecosystems and develop scientific hypothesis-testing, critical-thinking and writing skills. BIO 171 is part of a two-semester introductory unit that

includes BIO 172 and 173.

Extended Course Description: BIO 171 is a one-term course in ecology and evolutionary biology that, together with BIO 172 and 173, collectively form the introductory biology course unit. BIO 171 and 172 can be taken in either order. The two-semester set of BIO 171, 172, and 173 is intended for concentrators in biology, other science programs, or pre-professional studies. Other suitably prepared students wishing detailed coverage of biology are also welcome. The primary aims of BIO 171 are: 1) to provide factual and conceptual knowledge concerning the origin and complex interactions of the earth's biodiversity. 2) to give an integrated overview of biological organization including genes, individuals, kin groups, populations, species, communities, and ecosystems. 3) to engage with biological hypotheses dealing with prominent current issues such as human evolutionary origins, emerging diseases, conservation biology and global change. 4) to develop critical-thinking and writing skills. Topics in BIO 171 are divided among three primary areas: A. Mendelian Genetics and Evolutionary Processes B. Biodiversity, Organismal Biology and the Evolution of Development C. Ecology

Credit Exclusion: Credit for this course will not be granted to those who have completed Biology 162, 163, or 195.

Course Requirements: 85% of the assessment will be based on lecture material and 15% on discussion material. The lecture component of BIO 171 will be offered in two distinct teaching formats and each student will register for a section taught in one of these formats. For the traditional format (three 1 hour lectures/week), the lecture-based assessment will consist of 3 non-cumulative exams with both multiple-choice and short-answer questions. For the active-learning format (two 1.5 hour lectures/week), up to 10% of the lecture-based assessment will occur during class using an interactive audience response system. The instructor will pose conceptual questions to the class and students will work in teams of 3-4 to produce their answers. The remainder of lecture-based assessment will consist of 3 exams with both multiple-choice and short-answer questions. For both teaching formats, 15% of the total grade will be based on three written assignments, concerning the discussion material, graded by the GSIs.

Intended Audience: This course is intended to replace our current introductory biology course, 162, and will have the same target audience of concentrators in biology, other science programs, or pre-professional studies.

Class Format: Three lecture contact hours a week together with 1.5 hours of discussion. GSIs will be responsible for the weekly discussion sessions and for assistance in grading written evaluation material. They will be trained and supervised by the instructor, via weekly preparation sessions.

Expected Class Size: ~1400/year

Instructor Name: Diarmaid O'Foighil and Josepha Kurdziel

Official Title: Assoc. Prof. and Lecturer

Supporting Statement: BIO 171 is part of a new, two-semester introductory unit (along with BIO 172 and the lab course, BIO 173) designed to replace our current introductory biology course, BIO 162. This set of courses provides students with a broad introduction to modern biology with sufficient depth to continue a concentration in any of the biological sciences. The two semesters of lecture (which may be taken in either order) focus on different parts of the general subject, but the set of courses represent an integrated whole. In particular, the laboratory (BIO 173) integrates the molecular and cellular approaches of BIO 172 with the ecological and evolutionary approaches of BIO 171. This three-course set allows a more in-depth presentation of material and approaches than was possible in the compressed format of BIO 162. As a result, students who proceed to succeeding courses in Genetics, Biochemistry, and Evolution will have a

deeper understanding of the concepts and a broader experience of the material, and thus be better prepared to assimilate the more specialized material of these later courses. Students who do not continue in a biological concentration will also have a richer appreciation of biology in the modern world and will be better able to evaluate issues that will arise in the 21st century.

Distribution Supporting Statement: As is presently the case for Biology 162, Biology 171 will meet BS and NS distribution requirements. It will count toward the 60 credits of math/science required for a Bachelor of Science degree.

Syllabus and/or Reading List

An outline of the 40 lecture syllabus is given below. The discussion material is still under development but will focus on recent reviews of prominent topics in contemporary biology, some of which may be slightly controversial, that will engage the students and form the basis for lively and informative discussions. Four possible topics are appended that respectively concern the 1918 flu pandemic, the level of acceptance of evolution in the U.S., the impact of new DNA tests on perceptions of ethnicity and a proposal to restore North America's Pleistocene megafauna.

A standard Introductory text will be used in common for both Biol 171 and 172, such as that presently employed by Bio 162: Biology, 7 th edition, Campbell, Reece, Mitchell (2005). Benjamin Cummings.

Lecture Syllabus

1. Introduction to the Course & the Nature of Science
2. What's Special about Biology?
3. Evolution – the Unifying Theory of Life
4. Meiosis & Sex
5. Mendelian Genetics
6. Chromosomes & Genetic Linkage
7. Genetic Variability & Mutation
8. From Genes to Proteins to Phenotypes
9. Selection: Artificial, Natural & Sexual
10. Population Genetics
11. Genetic Drift & Gene Flow
12. Species & Speciation
13. Approaches to Studying Speciation
14. Phylogenetics & the Tree of Life
15. Origin of Life and the Fossil Record
16. The Prokaryotic World
17. Origins of Eukaryotes & Multicellularity
18. Oceanic and Terrestrial Life
19. Invasions of Land by Plants and Animals
20. Co-evolution of Insects & Plants
21. Co-evolution of Plants & Fungi
22. Highlights of Vertebrate Evolution
23. Evolution of Humans
24. Introduction to Development

25. Evolution of Developmental Programs
26. Your Immune System – How it Works
27. Physiological Ecology & Behavior
28. Sexual Reproduction & Life Cycles
29. An Overview of Ecology
30. Energy Flow and Nutrient Cycling in Ecosystems
31. Role of Biodiversity in Ecosystems
32. Species Interactions–Competition
33. Species Interactions – Predation, Parasitism & Mutualism
34. Population Growth & Dynamics
35. Ecological Landscapes and Metapopulations
36. Community Ecology
37. Species Invasions
38. Conservation Biology
39. Emerging Diseases & Infectious Disease Ecology
40. Global Warming

LSA Course Approval Request Form - New Course

Effective Term: Fall 2007

Duration: Indefinitely

Home Department: Biology

Subject: BIOLOGY

Catalog #: 172

Cross-Listing Departments (if any):

Department Chair Approval

Name:	Robert Bender - MCDB	**Date:**	9/1/06	**Signature:**	
Name:	Diarmaid O'Foighil - EEB	**Date:**	9/1/06	**Signature:**	

LSACC Approval:		**Date:**	
LSAXC Approval:		**Date:**	
Non-LSA Unit Approval:		**Date:**	
Rackham Approval:		**Date:**	

Course Title: Introductory Biology - Molecular, Cellular, and Developmental

Transcript Title: Intro Biol - MCDB

Time Schedule Title: Intro Biol - MCDB

Distributions: NS

Requirements: BS

Advisory Prereqs long description: Prior or concurrent enrollment in CHEM 130

Advisory Prereqs short description: Prior or concurrent enrollment in CHEM 130

Course Level: Undergraduate Only

Credit Hours: UG Full 4, UG Half 4

Repeatable: No

Class Component(s): LEC, DIS

Graded Component: LEC

Credit Type: HNRS,Regular

Grading Scheme: A-E

Campus Location: Ann Arbor

Short Course Description: BIO 172 is a one-term introductory course in molecular, cellular,

and developmental biology. It will impart factual and conceptual knowledge on how cells, organs, and organisms work, and it will develop scientific hypothesis-testing, critical-thinking and writing skills. BIO 172 is part of a two-semester introductory unit that includes BIO 171 and 173.

Extended Course Description: BIO 172 is a one-term course in molecular, cellular, and developmental biology that, together with BIO 172 and 173, collectively form the introductory biology course unit. BIO 171 and 172 can be taken in either order. The two-semester set of BIO 171, 172, and 173 is intended for concentrators in biology, other science programs, or pre-professional studies. Other suitably prepared students wishing detailed coverage of biology are also welcome. Topics in BIO 172 include: the chemistry of the living cell; the structure, function, metabolism, and interaction of animal, plant and bacterial cells; molecular biology; the regulation of gene expression, cell signaling, cell-cell interactions, and the physiology of plants and animals.

Credit Exclusion: Credit for this course will not be granted to those who have completed Biology 162, 163, or 195.

Course Requirements: 85% of the assessment will be based on lecture material and this assessment will consist of 3 non-cumulative exams with both multiple-choice and short-answer questions, and a final exam. 15% of the total grade will be based on three written assignments, concerning the discussion material, graded by the GSIs.

Intended Audience: BIO 172 is part of new, two-semester introductory unit designed to replace our current introductory biology course, 162. It is intended for concentrators in all of the biological concentrations, other science programs, and pre-professional studies.

Class Format: Three lecture contact hours a week together with 1.5 hours of discussion. GSIs will be responsible for the weekly discussion sessions and for assistance in grading written evaluation material. They will be trained and supervised by the instructor, via weekly preparation sessions.

Expected Class Size: ~1400/year

Instructor Name: Faculty in MCDB, including Pamela Raymond and Steven Clark

Official Title: Professors and Lecturers

Supporting Statement: BIO 172 is part of a new, two-semester introductory unit (along with BIO 171 and the lab course, BIO 173) designed to replace our current introductory biology course, BIO 162. This set of courses provides students with a broad introduction to modern biology with sufficient depth to continue a concentration in any of the biological sciences. The two semesters of lecture (which may be take in either order) focus on different parts of the general subject, but the set of courses represent an integrated whole. In particular, the laboratory (BIO 173) integrates the molecular and cellular approaches of BIO 172 with the ecological and evolutionary approaches of BIO 171. This three-course set allows a more in-depth presentation of material and approaches than was possible in the compressed format of BIO 162. As a result, students who proceed to succeeding courses in Genetics, Biochemistry, and Evolution will have a deeper understanding of the concepts and a broader experience of the material, and thus be better prepared to assimilate the more specialized material of these later courses. Students who do not continue in a biological concentration will also have a richer appreciation of biology in the modern world and will be better able to evaluate issues that will arise in the 21st century.

Distribution Supporting Statement: As is presently the case for BIO 162, BIO 172 will meet BS and NS distribution requirements. It will count toward the 60 credits of math/science required for a Bachelor of Science degree.

Biology 172 Introduction to Biology – MCDB
Proposed Syllabus

Lecture Hours	Running Total	Topic
1	1	Intro to Biology
6	7	Chemistry/Macromolecules – Carbohydrates, Lipids, Nucleic Acids, Proteins including Enzymes
4	11	Cell Structure/Function
4	15	Metabolism – Glycolysis, Respiration, Photosynthesis
5	20	DNA – Structure, Replication, Transcription, Translation
2	22	Gene Regulation –Prokaryotic
3	25	Gene Regulation – Eukaryotic
3	28	Reproduction – Prokaryotic & Eukaryotic
2	30	Development – Eukaryotic
2	32	Molecular Biology – Technology
2	34	Physiology – Plants
4	38	Physiology – Animals Thermoregulation, Osmoregulation, Circulation, Nerve/Muscle Function, including hormonal control mechanisms
2	40	Microbiology & Immunology

LSA Course Approval Request Form - New Course

Effective Term: Fall 2007

Duration: Indefinitely

Home Department: Biology

Subject: BIOLOGY

Catalog #: 173

Cross-Listing Departments (if any):

Department Chair Approval

Name:	Diarmaid O'Foighil - EEB	**Date:**	9/1/2006	**Signature:**	
Name:	Robert Bender - MCDB	**Date:**	9/1/2006	**Signature:**	

LSACC Approval:		**Date:**	
LSAXC Approval:		**Date:**	
Non-LSA Unit Approval:		**Date:**	
Rackham Approval:		**Date:**	

Course Title: Introductory Biology Laboratory

Transcript Title: Intro Biol Lab

Time Schedule Title: Intro Biol Lab

Distributions: NS

Requirements: BS

Advisory Prereqs long description: Students should have completed one of the two introductory lecture courses, 171 and 172, and be enrolled in the other, to take 173.

Advisory Prereqs short description: Prior completion of 171 or 172, and concurrent enrollment in 171 or 172

Course Level: Undergraduate Only

Credit Hours: UG Full 2, UG Half 2

Repeatable: No

Class Component(s): LEC, LAB

Graded Component: LEC

Credit Type: Regular

Grading Scheme: A-E

Campus Location: Ann Arbor

Short Course Description: BIO 173 is an integrative, project-based, one-term introductory laboratory course intended for concentrators in any of the biological science, other science programs, and pre-professional studies. Students should minimally have completed one of the two introductory biology lecture courses, BIO 171 or 172, and be enrolled in the other.

Extended Course Description: BIO 173 is an integrative, project-based, one-term introductory laboratory course intended for concentrators in any of the biological sciences, other science programs, and pre-professional studies. The primary aims of BIO 173 are: 1) to introduce fundamental methods in biological research; 2) to provide an integrated perspective of experimental biology; 3) to foster hypothesis-based analytical approaches to experimental data; 4) to enhance thinking and writing skills. Topics in BIO 173 are divided among four primary areas: A) Biochemistry, B) Molecular Genetics, C) Evolution and Phylogenetics, D) Ecology.

Credit Exclusion: Credit for this course will not be granted to those who have completed Biology 162 or 163.

Course Requirements: 60% of the assessment will be based on four formal laboratory reports, one for each 4-week module. Two of the reports will be written assignments in scientific format (title, abstract, introduction, materials and methods, results, discussion, literature cited, labeled figures) typically 6-8 pages in length. One report will have a scientific poster format and the remaining report will be an oral presentation. This combination will give the students experience of the three primary methods of scientific communication (paper, poster, talk). GSIs will grade the reports and they will receive detailed scoring rubrics to ensure consistency. The remaining 40% of the assessment will consist of short within-laboratory and within-lecture quizzes, graded by the GSIs, that will test the students' conceptual understanding of the experimental approaches employed.

Intended Audience: BIO 173 is one of the 3 new introductory courses (171, 172, 173) designed to replace our current introductory course, 162. It will have the same target audience: concentrators in biology, other science programs, or pre-professional studies, with the modification noted in the statement below.

Class Format: Four contact hours a week composed of a three hour laboratory session and a one hour lecture. The former will be led by GSIs, the latter by an instructor.

Expected Class Size: ~1400/year

Instructor Name: Marc Ammerlaan

Official Title: Lecturer IV

Supporting Statement: BIO 173 is one of the 3 new introductory biology courses (171, 172, 173) designed to replace our current introductory biology course (162). It will have the same target audience with one notable modification. Currently biology concentrators with AP biology credit are not required to take the 5 credit hour BIO 162 course. For the new introductory sequence, the AP students will receive dispensation for the two 4 credit hour lecture courses (171 and 172), but they will be required to take the new 2 credit hour lab course, 173. This change reflects the doubling of credit hours in the new introductory courses and the qualitatively enhanced laboratory experience that 173 will offer in the form of integrated, project-based modules. In contrast to traditional labs, where students essentially follow recipes that lead them to some anticipated result, students in this course will have input into the design of research questions. Students will devise methods to test their ideas, they will collect, analyze and interpret data and learn how to present their research both orally and in writing. The aims of the weekly lecture in BIO 173 will be to provide students with the conceptual background necessary

to plan, execute and interpret their laboratory projects. Lectures will engage retrospectively with data obtained in the previous laboratory session in addition to setting the stage for the subsequent session. More broadly, the laboratory projects themselves will aim to integrate the general principles of biological subfields such as ecology, evolution, cell biology, molecular biology, metabolism, and gene regulation, that the students will have covered in the parallel lecture courses (171 and 172). GSIs will be responsible for the 3 hour weekly laboratory sessions and for grading written evaluation material. They will be trained and supervised by the instructor, via weekly preparation sessions. We anticipate that the course will be first offered in Fall '07 to a restricted audience of biology concentrators with AP Biology - approximately 60-90 students wthat will be exempted from taking the new companion lecture courses (171 and 172). This pilot-scale offering will allow us to fine tune the course prior to its unrestricted enrollment launch in Winter '08.

Distribution Supporting Statement: As is presently the case for Biology 162, Biology 173 will meet NS distribution requirements. It will count toward the 60 credits of math/science required for a Bachelor of Science degree.

Syllabus and/or Reading List

Bio 173 will consist of 4 modules, each three weeks in duration, that will focus on the following 4 broad topic areas in biology:

1. Biochemistry
2. Molecular Genetics
3. Evolution and Phylogenetics
4. Ecology

Within each module, students will engage in a series of project-based laboratory sessions designed to give them an authentic exposure to the actual business of doing science. Students will work in small teams and, with instructor/GSI guidance, they will have input into composing researchable strategic questions (given the constraints of time and material) germane to the subfield of biology being considered in that module. Typically, the questions addressed will involve making predictions that will be tested experimentally over a three-laboratory sequence, results from one laboratory session leading to new emergent questions that may be addressed in turn with a different experimental approach. The instructor and GSIs will provide the students with the required background in the various experimental and analytical techniques they will need to perform the experiments and to interpret and communicate the results. For example, this might involve learning how to perform a series of enzyme kinetics assays, simple statistical analyses of the results and writing up a formal report in scientific format.

Although the details of the project-based laboratory exercises are presently under development, the proposed module sequence has been designed to promote maximum complimentarity. For instance, students will learn the polymerase chain reaction (PCR) technique in the Molecular Genetics module. They will subsequently revisit this technique, in a completely different experimental context, during the Evolution and Phylogenetics module where one of the primary goals will be to identify source species of diverse anonymous tissue samples. Students will achieve this goal using DNA sequences they will generate themselves from the study material via PCR, reference sequences they will obtain from GenBank and computerized molecular phylogenetic programs. Such methodological linkages among modules will greatly enhance the students' comprehension of how scientific fields collectively provide an integrated perspective of how nature works.

A new introductory laboratory manual will be developed for Biol 173.

From: "Douglas C. Noll" <dnoll@umich.edu>
To: "'susan bitzer'" <sbitzer@eecs.umich.edu>
Subject: FW:
Date: Wed, 3 Jan 2007 13:13:44 -0500
Thread-Index: AccvRR9vUT36ZBsRQ1yhxsuDUfXoqAAHRxTw
X-Virus-Scan: : UVSCAN at UoM/EECS

Susan,
For the UEC. Dan is proposing a new course that would cover the same material as Bio 172 (which, minus the lab, will be replacing Bio 162). Assuming it goes through, I think this would be a preferred alternative to Bio 172, though that is technically a matter for the UEC to look at.
Doug

-----Original Message-----
From: Dan Klionsky [mailto:klionsky@umich.edu]
Sent: Wednesday, January 03, 2007 9:39 AM
To: rlarson@umich.edu; dnoll@umich.edu
Cc: pwoolf@umich.edu
Subject:

Dear Ron and Doug,

I have attached a draft course approval form for the course I have been describing, introductory biology for engineers. I would appreciate it if you could take a look at this form and make comments/suggestions for changes. In particular, I want to be sure that I am not stating anything, or have not omitted anything, that is important for the CoE. For example, I have indicated that Chemistry 130 is the only prerequisite for this course because my understanding is that it is preferable to have minimal prerequisites so that CoE students can take the course early in their curriculum. When I submit this form to the Associate Chair of Curriculum of MCDB I would like to be able to state that the chairs of BME and CHE approve of the course as outlined.

To expedite the approval process, I have specifically left out details concerning the participation of faculty members from the CoE (although it is possible that MCDB will request additional information). Dr. Peter Woolf has expressed interest in this course, and I am including him on this e-mail. I have indicated to Dr. Woolf that I will be very happy to have him participate and plan to discuss this in further detail at our earliest opportunity (following my NIH grant submission). As I have mentioned previously, I am quite open to modifications in the course that would make it more applicable/appealing to students in the CoE, but I think we can begin to work out those details (including the extent of CoE faculty involvement) after the course is approved, so that we can "get it on the books" for winter term of the 2007/2008 academic year.

Please let me know if you have any questions and I look forward to hearing back from you.

Sincerely,

Dan

MCDB Crse Appr Form 2007.doc

NEW COURSE APPROVAL REQUEST

DEPARTMENT OF MOLECULAR, CELLULAR AND DEVELOPMENTAL BIOLOGY

(Revised Fall 2003)

The following information is needed to request new courses or course changes. Note that this file must be completed and submitted electronically to the Associate Chair for Undergraduate Studies of MCDB.

I. GENERAL INFORMATION

1. Instructor name(s) and official title(s):

Daniel J. Klionsky
Abram Sager Collegiate Professor of Life Sciences

2. Course title:

Introductory Biology—Active Learning

3. Course number (or level, if new; i.e., 100, 200, 300, 400, graduate)

Biology 174 (100 level course)

4. Suggested crosslisting with other units (if any):

5. Repeatability: Is the course repeatable for credit? If yes, answer the following:

   i.) Max times it can be elected _2__ OR max number of credits _____

   ii.) Is departmental permission required to repeat?

   Yes

   iii.) Can it be elected more than once in same term?

   No

6. Prerequisites: Indicate your advisory prerequisites (recommended but not required) and your enforced prerequisites (and whether these should be enforced electronically.) Give reasons for these recommendations.

Advisory prerequisites:

Enforced prerequisites:

Prior or concurrent enrollment in Chemistry 130

7. Credit Exclusions (conditions for no credit granted/sequence rules):
Not open for credit to students who have completed Bio 162 or Bio 172.

8. Course Level (check one)

___X___Undergraduate only

_____Undergraduate/Rackham Grad with additional work

9. Number of credit hours:

Undergraduate (Min, Max)	Undergraduate/Rackham Grad (Min, Max)
4	

10. In which term(s) should this course be offered? Fall, Winter, Spring, Spring-Summer, Summer?

Winter

11. At what frequency should this course be offered? Yearly, Alternate Years, Infrequently?

Yearly

12. Short Course Description (50-word):

Introductory Biology—Active Learning covers fundamental topics in biochemistry, cellular and molecular biology. Students will gain an appreciation for how biology fits into their daily lives. Learning will occur through a problem-solving collaborative approach rather than a lecture format. The course is geared toward students in the College of Engineering.

13. Expanded Course Description (@250 words). Attach syllabus and/or reading list if available.

A one-term introductory course intended primarily for students majoring in Engineering. Open to other qualified students at the instructor's discretion; this course will satisfy the requirement for Bio 172. This course will cover topics in biochemistry, cellular and molecular biology. The focus of the course is to develop thinking skills in biological sciences with an emphasis on conceptual understanding of the material.

Students are required to attend four hours of class each week. Students purchase a course pack consisting of a syllabus and lecture notes; the textbook is optional. Students are expected to complete the assigned reading prior to each class. A reading quiz will be administered at the start of each session and will constitute approximately 40% of the course grade. Lectures will be minimal and are designed to briefly cover difficult topics with the assumption that students have read the appropriate material. Students will work in groups to solve problems designed to instill a practical understanding of the topics being covered. Participation in the groups is mandatory. Group work will be followed by an additional short lecture designed to emphasize connections/relevance to engineering. An additional approximately 50% of the course grade will be based on quizzes that reflect the in-class problems. These quizzes will be cumulative in their coverage of material. There will be no midterms. A cumulative final exam will count for a maximum of 10% of the course grade.

14. Course Requirements (basis for evaluating student performance; e.g., number and type of exams, reports, projects, and/or papers of specified length).

As noted above, the course grade is predominantly based on reading and concept quizzes. There are typically two quizzes per class session. A final exam will constitute a maximum of 10% of the course grade. The frequent quizzes ensure that students keep up in the course and also provide frequent feedback for both the students and instructor regarding student comprehension of the material.

15. Intended audience (student level, concentration, interests, etc.)

The primary audience will be students in the College of Engineering (particularly those in Biomedical Engineering, Chemical Engineering and Materials Science and Engineering)

in their freshman or sophomore year. The course will also be of interest to students in the College of LS&A who prefer a more in depth, problem-solving approach to biology.

16. Expected class size

100 students.

17. Supporting Statement (explain how course fits into current departmental offerings as well as into LSA undergraduate education as a whole)

The Departments of Molecular, Cellular, and Developmental Biology and Ecology and Evolutionary Biology do not offer an Introductory Biology course that emphasizes engineering. The University has indicated a desire to increase the number of interdisciplinary courses. Very few such courses are offered at present. Many students in the College of Engineering need to take a course in biology to fulfill their curricular interests. A course that is specifically designed to demonstrate the relevance of biology to engineering will be optimal for this purpose. To some extent, this course needs to be viewed beyond the limits of the college of LS&A. The university is entering into a new era where cross-college, not just cross-departmental, courses will become standard. The development of this course is being supported in part by a grant from the Howard Hughes Medical Institute-Undergraduate Science Education Program to Dr. Klionsky.

The material in this course will be similar to that covered in the new Bio 172 course and accordingly will satisfy LS&A requirements for this course. One of the primary differences is that Bio 174 will be taught through an active-learning, problem-solving format (see section IV for further details) instead of the lecture/note-taking format used in Bio 172. In addition, the emphasis will be on depth rather than breadth of coverage.

The instructor for this course, Dr. Klionsky, has pioneered the active-learning format for introductory biology. He was recognized for these efforts by receiving the National Science Foundation Director's Award for Distinguished Teaching Scholars.

II. CLASS FORMAT

1. Lectures per week (and hours per lecture):

Two class sessions per week, Tuesday and Thursday for two hours per session.

2. Laboratory section:

There will not be a laboratory specifically associated with this course. Students who complete Bio 171 and Bio 174 are eligible to take the Bio 173 laboratory course (either Bio 171 or Bio 174 may be taken concurrently with Bio 173).

Meeting day(s) per week:

Hour(s) per meeting:

Section(s) per week:

3. Discussion sections:

There are no discussion sections associated with this course (see Section IV for additional information.

Meeting day(s) per week:

Hour(s) per meeting:

Section(s) per week:

4. GSI Involvement:

One GSI per every fifty students will be involved in the course to grade quizzes and provide office hour instruction.

III. MCDB CURRICULAR CONSIDERATIONS

1. Into which of the concentrations currently administered by the Dept. of MCDB (including interdepartmental concentrations) will this course fit?

Biology, General Biology, and Cell and Molecular Biology

2. Please give your evaluation of the need for this course in these concentrations.

The Departments of MCDB and EEB currently offer Bio 162. This course will be modified starting in fall 2007 to become a two-term course (Bio 171/172) with an associated lab (Bio 173). The Bio 162 course relies on a lecture/note-taking format. Accordingly, Bio 163 was developed to provide an alternative approach that used active learning. Bio 171/172 will also use a lecture-based format and Bio 163 has been eliminated from the curriculum. Thus, there is currently no course that teaches introductory biology through active learning. Bio 174 will rely on problem solving (see section IV for further details). Students will work in groups in a smaller class size and will have more time with the faculty instructor (54 hours instead of 40 hours). The course will not rely on GSIs for any essential aspects of the learning process, and depth will be strongly emphasized over breadth of coverage.

3. Please comment on the relationships of your proposed course to extant courses. Would it compete for students with, or complement, other courses? Which courses?

This course will offer minimal competition with the Bio 172 course for two reasons. First, Bio 174 will be geared toward Engineering students. Second, Bio 174 will be more demanding than Bio 172, equivalent to an honors course. Relatively few students in LS&A are interested in an honors course of this nature. Finally, Bio 174 will be capped at 100 students. Bio 172 will enroll over 1,000 students each year. Hence, Bio 174 will have a minimal impact in terms of drawing students away from Bio 172.

4. Please comment on the curricular reasons for the term you chose for offering this course.

This course has a prerequisite of Chemistry 130. The College of Engineering prefers that its students take Bio 174 as soon as possible, compatible with any prerequisites. This means that winter term is the optimal time for offering this course.

5. Will the teaching of this course affect your availability for the teaching of the Department's core concentration courses?

Yes. This course is being designed with approximately 54 hours of classroom time. This constitutes a teaching commitment that is at least equivalent to the standard introductory course.

6. For laboratory courses: What room(s) have you identified (in consultation with the Associate Chair for Undergraduate Studies) for the teaching of your laboratory exercises?

This is not a laboratory course. It would be optimal if the course were taught in a room that did not have fixed seating to facilitate group interactions.

7. If you would like your course to have an enrollment limit (either upper or lower), please comment on its size and the reasons for it.

The enrollment limit is 100 students. The optimal enrollment minimum is 30 students. The format I am proposing can be used on larger enrollment classes; however, the cohesiveness of the groups and the amount of time available to interact with the instructor depend on the size of the class. Also, the physical ability to form into groups with approximately four to five students per group places certain constrictions on the size of the class relative to the room. Accordingly, it is desirable that the class size not exceed 100 students. In order to achieve the appropriate atmosphere for collaborative interactions, it is preferable that the class size be a minimum of 30 students.

IV. EDUCATIONAL CONSIDERATIONS

1. Please comment on evaluative procedures you will use.

The course grade will be based primarily on quizzes written by the instructor(s) and taken during the scheduled class meetings. There will be approximately 40 quizzes total. Half of the quizzes will be based on the assigned reading from the notes. The questions on the reading quizzes will be primarily fact based and are designed to ensure that the students read the assigned material before coming to class, thus eliminating the need for extensive lectures. The other half of the quizzes will be based on the in-class problem solving exercises. The questions on these quizzes will be more conceptual in nature. The quiz questions will be a combination of short answer (75%) and multiple choice (25%). A comprehensive final exam will constitute a maximum of 10% of the course grade. Please see the accompanying papers for a further description:

Klionsky, D.J. 2001/2002. Constructing knowledge in the lecture hall. J. Coll. Sci. Teach., 31: 246-251.

Klionsky, D.J. 2004. Talking biology: Teaching outside the textbook, and the lecture. Cell Biol. Ed., 3: 204-211.

2. Will GSIs be used in this course? If so, what will be their duties? What training and supervision will they receive prior to and during the course? Will there be meetings between GSIs and faculty while the course is being taught? Who will make the course assignments and assign the final grade?

One GSI will be used per every fifty students. The GSIs will be responsible for grading the quizzes and will also offer office hours to provide peer instruction. The GSIs will be trained and supervised by Dr. Klionsky, who will meet with the GSIs throughout the course to discuss the coverage of the material. The instructor(s) will assign the final grades.

3. Will your course have need for any non-standard equipment, such as computers or special laboratory equipment? If so, please comment on your attempts to obtain these items.

The course is designed to avoid the need for computers or non-standard equipment. Slides and videos will be used at certain points in the course.

4. Will computer-assisted instruction be employed? If so, in what ways?

No. One goal of this course is to facilitate collaborative learning. Computer-assisted instruction tends to be an isolating experience so I have purposefully avoided it throughout this course.

5. Do you plan to ask students to write in this course? If so, how much writing and

what kinds of writing? Would you consider having your course fulfill the LS&A Junior/Senior writing requirement?

The writing requirement will be in the form of short answers (maximum five to six sentences) on the quizzes. This course will not fulfill the LS&A writing requirement.

6. In what ways will students participate actively in this course (as opposed to passive intake of information?

This is where Bio 174 differs the most from Bio 172. Bio 174 is designed to facilitate active learning. The instructor(s) will spend a minimal amount of time lecturing (approximately ten to fifteen minutes per two-hour session). The reading quizzes (along with guideline questions in the notes) are designed to encourage students to keep up and come to class prepared. Having the students prepared obviates most of the need to lecture. By eliminating the lecture/note-taking format the course moves away from the standard passive-learning mode. The course will rely on a constructivist method of learning by having the students work with the information. As an example, in my experience most students in introductory biology are taught the equivalent of the definition of a door and a doorknob but if you showed them a door they would not be able to open it. So much time is spent in class defining the meaning of "door" and "knob" that there is no time left to learn how to put those objects together. In Bio 174 it will be assumed that the students have read the notes and know what a door and a doorknob are when they come to class. These definitions are simple enough that students can understand them on their own if they are held accountable for doing so (which is not the case in the typical lecture course). The elimination of lectures affords us the time to discuss ways of using the doorknob so that the students walk out of the class seeing the practical application of the material. Because they work with the information rather than simply memorize it they are also likely to retain it better. Please see the following in the attachments for additional information about the proposed application of problem-solving approaches to Introductory Biology-Active Learning:

Klionsky, D.J. 2001/2002. Constructing knowledge in the lecture hall. J. Coll. Sci. Teach., 31: 246-251.

Klionsky, D.J. 2004. Talking biology: Teaching outside the textbook, and the lecture. Cell Biol. Ed., 3: 204-211.

Klionsky, D.J. and J.J. Tomashek. 1999. An interactive exercise to learn eukaryotic cell structure and organelle function. Amer. Biol. Teacher, 61: 539-542.

To: Homer C. Rose
Assistant Dean
Horace H. Rackham School of Graduate Studies

From: Gregory A. Keoleian
Associate Professor
School of Natural Resources and Environment

Steven J. Skerlos
Associate Professor
Mechanical Engineering

Re: Dual MS/MSE program in Engineering Sustainable Systems between CoE and SNRE

Date: February 22, 2007

We are pleased to submit our proposal to establish a new dual degree MS program in Engineering Sustainable Systems between the College of Engineering and the School of Natural Resources and Environment. The proposal has been approved by faculty in participating departments of CoE including Chemical Engineering, Civil and Environmental Engineering, and Mechanical Engineering and the faculty of the School of Natural Resources and Environment. The CoE Curriculum Committee will be reviewing the proposed program on March 6 and we will share with you the results of that meeting.

The proposal appendices include letters of support from Dean Bierbaum and Dean Munson and members of the External Advisory Board of the Center for Sustainable Systems. We have also investigated your question regarding the difference between the MS and MSE in Engineering. Most departments grant MSE degrees and some offer an M Engineering (non-Rackham). One exception is the Electrical Engineering and Computer Science department which state in their degree program guidelines: "The M.S.E. and M.S. degree programs are identical except for admission requirements. Students desiring admission to the M.S.E. program must have an earned bachelor's degree in computer engineering." In addition, the CoE bulletin makes no distinction between the two degrees.

We look forward to your feedback on this proposal as well as feedback from the Rackham Executive Committee. Please let us know if you have any questions regarding the proposed Engineering Sustainable Systems dual degree program.

CC: Dean Rosina Bierbaum, SNRE
Dean David Munson, CoE
Associate Dean James Diana, SNRE
Associate Dean Stella Pang, CoE
Other Program Faculty Coordinators:
Prof. Jonathan Bulkley, SNRE/CoE(CEE)
Prof. Levi Thompson, CoE(ChE)
Prof. Wiley, SNRE
Prof. Wright, CoE(CEE)

Proposal to Create a Dual Degree Program in Engineering and Natural Resources and the Environment

The Engineering Sustainable Systems (ESS) Program

February 22, 2007

Submitted by:

Associate Professor Gregory A. Keoleian (gregak@umich.edu) – Sustainable Systems
School of Natural Resources and Environment ESS Coordinator
Associate Professor Steven J. Skerlos (skerlos@umich.edu) – Mechanical Engineering
College of Engineering ESS Coordinator

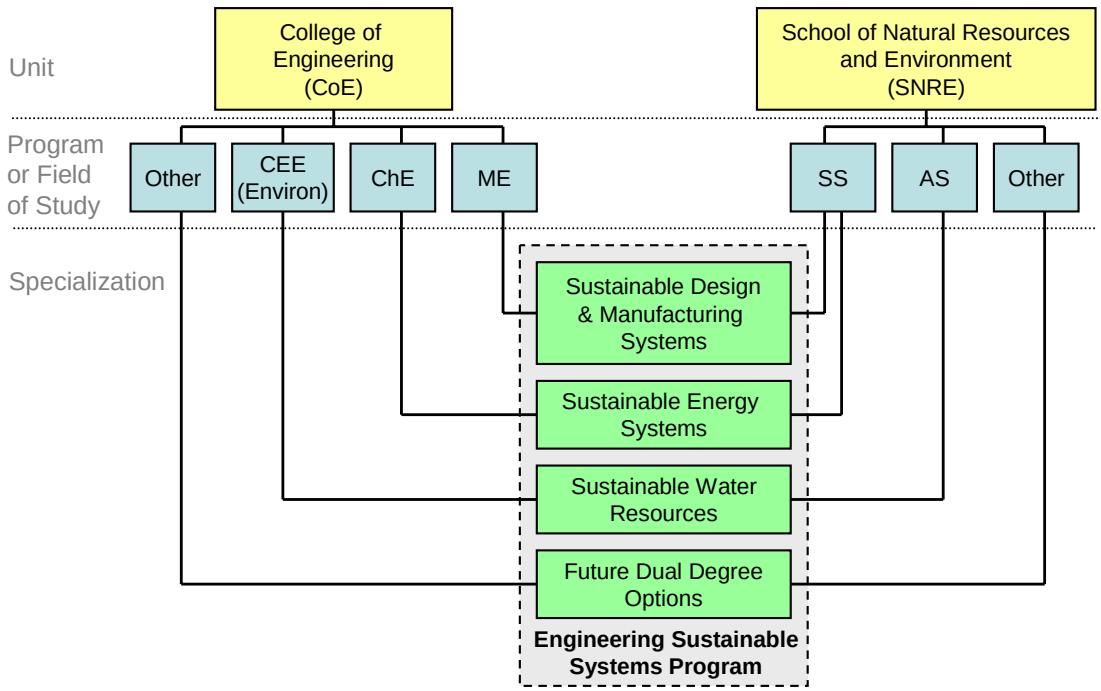
Professor Jonathan W. Bulkley (jbulkley@umich.edu) – Sustainable Systems
Professor Levi T. Thompson (ltt@umich.edu) – Chemical Engineering
Professor Michael J. Wiley (mjwiley@umich.edu) – Aquatic Sciences
Professor Steven J. Wright (sjwright@umich.edu) – Civil and Environmental Engineering

Contents:

1.0 Program Overview

Faculty from the College of Engineering (CoE) and the School of Natural Resources and the Environment (SNRE) propose the establishment of a dual master's degree program to train graduate students who will create engineered systems that are socially, environmentally, and economically sustainable. The Engineering Sustainable Systems (ESS) Program described in this proposal brings curricula and faculty together from CoE and SNRE and organizes them within a structure that builds upon core educational elements of individual CoE departments (e.g., Mechanical Engineering, Chemical Engineering, Civil and Environmental Engineering) and SNRE fields of study (e.g., Sustainable Systems, Aquatic Sciences).

Figure 1 illustrates the overall structure. The ESS Program will be initially launched with three specializations: *Sustainable Design and Manufacturing* (Mechanical Engineering + Sustainable Systems), *Sustainable Energy Systems* (Chemical Engineering + Sustainable Systems) and S*ustainable Water Resources* (Civil and Environmental Engineering + Aquatic Sciences). Given the modular structure of the ESS program, many opportunities exist for program growth through the addition of specializations such as sustainable materials systems (Materials Science and Engineering/Chemical Engineering/Mechanical Engineering + Sustainable Systems) and sustainable infrastructure systems (Civil and Environmental Engineering and Sustainable Systems).



Acronyms
CEE – Department of Civil & Environmental Engineering (CoE)
ChE – Department of Chemical Engineering (CoE)
ME – Department of Mechanical Engineering (CoE)
SS – Sustainable Systems Area of Study (SNRE)
AS – Aquatic Sciences: Research and Management Area of Study (SNRE)

Figure 1.1 The Engineering Sustainable Systems (ESS) Program Structure

The M.S. in Engineering degree has a 30 credit hour requirement while the M.S. in NRE degree requires 42 credit hours for completion. CoE M.S. in Engineering students typically can earn a master's degree in 1 to 1.5 years whereas NRE M.S. students take 2 years. Standard Rackham guidelines for double counting allow up to 1/6 of combined credits for each degree. Therefore, 72 (30 + 42) total credits yields 12 (72 ÷ 6) double counted credits with a total credit hour requirement of 60 credits (72 -12). Dual degree students would be expected to complete all M.S. in NRE and M.S. in engineering requirements in six semesters (on average 10 credits per semester). However, expecting master's degree engineering students to commit to an additional 1.5 – 2 years to complete master's dual degree requirements is unrealistic. Engineering faculty, including the Dean of Engineering, have indicated that double counting of additional credits is essential for the success of the ESS Program.

Therefore, we are proposing a 54 credit program in accordance with a modified double counting formula (subject to Rackham approval) allowing up to 1/4 of combined credits for each degree. In this case, 72 (30 + 43) total credits yields 18 (72 ÷ 4) double counted credits with a total credit hour requirement of 54 credits (72 -18). This will allow most students to complete all credit requirements for the dual degree in 2 – 2.5 years.

In addition to reducing the need for students to enroll in spring/summer courses, the reduction of required hours from 60 to 54 is rooted in the common overlap between SNRE and CoE science-based and analytics-based curricula. Currently, three courses are cross-listed between SNRE and CoE. With the implementation of the ESS Program, we expect to see this number increase. Additionally, 11 other CoE courses which are not currently cross-listed can fulfill SNRE degree requirements in either the Aqutic Sciences or Sustainable Systems (SNRE) fields of study. In total, this accounts for 42 credit hours offered between SNRE and CoE which are potentially part of the *current* degree requirements for a student in either SNRE or CoE . Allowing ESS Program students to take full advantage of this unique cross-disciplinary atmosphere by double counting one quarter of required credits increases student attraction to the program while not reducing the quality of education.

Since incoming ESS students are required to have an accredited undergraduate engineering degree prior to acceptance into the program, the opportunity to double count one quarter of earned credits will not dilute the strong analytics and scientific skills expected from master's graduates of the University of Michigan College of Engineering or School of Natural Resources and Environment. Increased double counting allows for official double recognition of work *currently* recognized for degree credit individually by both the College of Engineering and the School of Natural Resources and Environment.

The ESS program brings together nationally recognized programs in CoE and SNRE:

College of Engineering: The College of Engineering at the University of Michigan is consistently ranked among the top engineering schools in the world. All of its undergraduate degree programs and nearly all of its graduate degree programs are top-ranked nationwide. Approximately 1,000 bachelor's degrees and 1,100 master's and doctoral degrees are awarded annually. These students may select from more than 1,000 engineering courses offered at UM. The College of Engineering strives to provide a continuously improving educational and research environment that educates students to lead, to have impact, and to make contributions to their professions, industry, government, academia and society.

School of Natural Resources and Environment: The study of natural resources and environmental problems has been part of the University for over 100 years. In 1950 UM formally established the

School of Natural Resources, the first school of its kind in the world, with an overarching objective to contribute to the protection of the earth's resources and the achievement of a sustainable society. SNRE is a focal point for interdisciplinary research and education on sustainability. There are 18 joint faculty appointments between SNRE and seven other Schools and Colleges. Through research, teaching, and outreach, NRE's faculty, staff, and students are devoted to generating knowledge and developing policies, techniques and skills to help practitioners manage and conserve natural and environmental resources to meet the full range of human needs on a sustainable basis.

1.1 Provisions for Expanding the ESS Dual Degree Program

As outlined in Figure 1.1, additional future academic partners within the College of Engineering and School of Natural Resources and Environment are expected to be included to create additional ESS specializations over time based on proven success of the overall ESS program and a demonstrated interest on behalf of faculty and students for new specializations. As mentioned previously, such future specializations may be sustainable materials systems (Materials Science and Engineering/Chemical Engineering/Mechanical Engineering + Sustainable Systems) and sustainable infrastructure systems (Civil and Environmental Engineering and Sustainable Systems).

The process for establishing new specializations in the ESS program is defined as a 5 step process.

1. Assess general undergraduate student interest for the proposed dual-degree specialization.
2. Assemble core faculty members in the proposed specialization department(s).
3. Approval from the Department Chair or Program Chair.
4. Approval from each Academic Unit Dean (College of Engineering and School of Natural Resources and Environment).
5. Approval from the Dean of the Rackham School of Graduate Studies.

2.0 Need and Competitive Advantage

Global climate change, energy security, ecological degradation, environmental threats to human health, and resource scarcity are critical sustainability challenges for the 21st century. Technology can be both the cause of and the solution to many of these problems. The success of sustainable technologies is based upon their ability to meet societal needs within the context of economic and ecological constraints. The design and application of new technologies - a focal point of CoE - plays a key role in addressing these complex challenges through research and education in engineering design and the applied sciences. SNRE serves to provide a comprehensive understanding of technology limitations, opportunities, and consequences, systems thinking and ecological principles, and the mechanisms which bring about social change. This is accomplished through research and education in sustainability sciences, policy, and ecology. Both elements provided by CoE and SNRE are necessary to develop technology based solutions to the complex sustainability challenges of the 21st Century. The synthesis of CoE and SNRE curricula towards addressing contemporary sustainability challenges is shown in Figure 2.

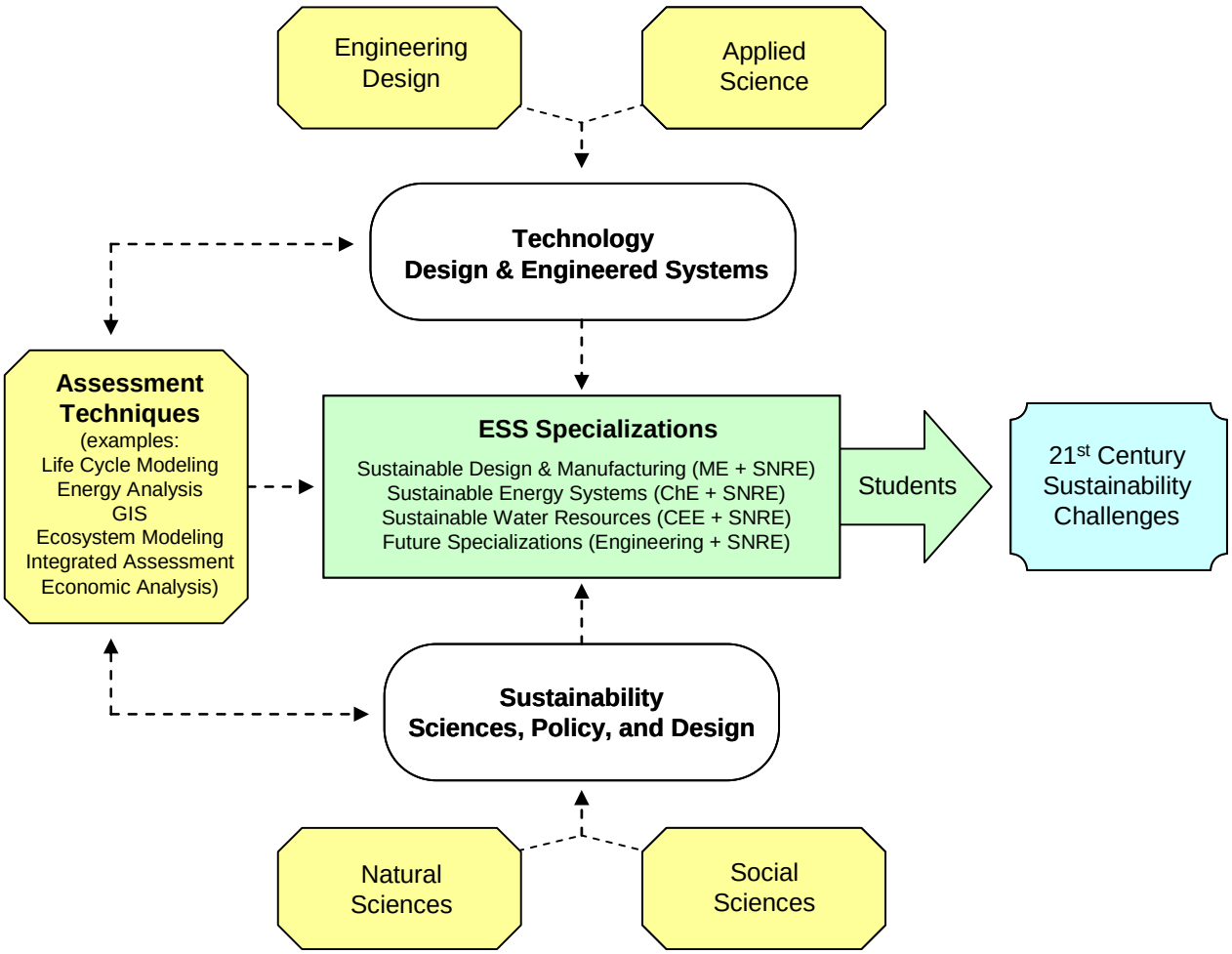


Figure 2.1 Engineering Sustainable Systems (ESS) Dual Degree Curriculum Synthesis

As outlined in the College of Engineering's *2006 Annual Bulletin*, engineers seek to advance society through the processes of invention, design, manufacture and construction. While performing these activities and increasing the standard of living, significant water, air, and land pollution consequences have resulted from power stations, automotive highways and transportation, coastal developments, chemical and semiconductor manufacturing facilities, etc. For the whole world to utilize technology at the rate of the United States, it would require quadrupling our annual global productivity. As an academic program to address these issues, the ESS program will equip engineers with the knowledge to understand ecological impacts of engineering design decisions and will provide engineers with tools that achieve sustainable design. This set of knowledge and tools will be provided through an integrated and focused curriculum in technology development (CoE) and sustainability science (SNRE).

3.0 Program Objectives

The specific objectives which have been identified for the proposed program are as follows:

1. Provide graduate engineers with a comprehensive understanding of major sustainability challenges facing society in the 21st century, including global climate change, energy scarcity, ecological degradation, environmental threats to human health, and resource scarcity.
    - Students will achieve scientific literacy related to air, water, and land pollution as well as ecological systems, energy systems, and important regional/global cycles (e.g., material, nutrient, carbon, and hydrologic).
2. Educate students in the engineering design approaches for products, processes, and services that facilitate the sustainable application of technology.
    - Examples of sustainable design approaches include life cycle minimization of carbon intensity, remanufacturing, use of renewable materials, dematerialization, etc.
    - To be successful, these approaches must be compatible with market and public policy constraints while also encouraging patterns of sustainable consumption.
3. Provide students with the scientific knowledge and methods required to evaluate the sustainability of engineered systems.
    - Examples of necessary scientific knowledge include formation and transport of pollutants in air, water, and on land, impact of pollutants on humans, ecosystems, and infrastructure, and the evaluation of resource scarcity.
    - Examples of evaluation methods include life cycle modeling, energy analysis, integrated assessment, ecosystem modeling, GIS, materials flows analysis, and economic analysis.
4. Provide students with successful examples of sustainable technology design and offer students opportunities to practice sustainable design.
    - Successful examples of sustainable technologies currently in practice include renewable energy technologies, biorefineries, development of water-free and petroleum-free manufacturing facilities, advanced bio-based composites, etc.
    - Core classes in the ESS program, along with independent study and research opportunities, will offer students the opportunities to conduct and learn from sustainable design projects.

4.0 Related Programs

4.1 Programs at the University of Michigan

Engineers typically lack knowledge of scientific sustainability concepts and principles due to capacity constraints of the engineering curricula at both the graduate and undergraduate levels. This is not unique to UM and is true for most universities in the US. ConsEnSus, a master's concentration in environmental sustainability currently offered within CoE, begins to address this need through twelve (12) credit hours of coursework within the thirty (30) credit hour M.S. in Engineering degree. Similar to ConsEnSus, the Rackham Graduate Certificate Program in Industrial Ecology is a fifteen (15) credit hour curriculum specifically directed at engineering and NRE graduate students interested in sustainable engineering concepts. While these programs have the advantage of not increasing the amount of time a graduate student spends earning his or her master's degree, they have inherent trade-

offs of breadth vs. depth. For instance, a ConsEnSus student in Mechanical Engineering has no freedom to take engineering courses outside the required curriculum, and generally cannot structure his or her experience around central themes such as manufacturing, automotive design, energy conversion, or materials development. The Engineering Sustainable Systems program is being proposed to provide greater breadth and depth of academic training for graduate engineering students in sustainability sciences, policy, and ecological design through completion of both an M.S. in Engineering and an M.S. in Natural Resources and Environment. ESS students will structure their experience around a sustainability challenge (e.g., sustainable energy systems) and fully embed themselves within the culture of CoE and SNRE rather than remaining within one culture or the other.

4.2 Programs at Other Institutions

The proposed program is unique among peer institutions both for its mission and for its foundation in engineering (CoE) and sustainability (SNRE). Other programs that address technology and sustainability issues have been established at Carnegie Mellon University and the University of Maryland. However, these dual programs exist between engineering and public policy rather than between engineering and NRE. They lack the extensive training in sustainability sciences that we can and propose to offer at the University of Michigan. Other peer institutions with strong environmental sciences programs (e.g., Yale University and Duke University) do not currently offer dual degrees with engineering and do not focus on specific sustainability challenges of engineering technology.

5.0 Employment Opportunities

The proposed ESS dual master's degree program between CoE and SNRE is designed for students who seek employment in the private, public or non-profit sector. Private sector employment opportunities include activities within environmental health and safety, product design, and process engineering. Positions within engineering consulting firms, research and development labs, and entrepreneurial startups will also be available for ESS Graduates. One example of targeted corporate opportunities for ESS Graduates is the General Electric Ecoimagination Program (http://ge.ecoimagination.com).

Within the public sector, potential career opportunities include government agencies and laboratories such as the National Renewable Energy Lab, US Environmental Protection Agency, US Department of Energy, state level Departments of Transportation, and state level Departments of Environmental Quality. Numerous students that have informally structured their master's experiences at UM in a manner roughly aligned with the ESS program are currently succeeding in these agencies already. Potential employers of ESS Graduates also include non-profit and non-governmental organizations (NGOs) such as Environmental Defense and the Union of Concern Scientists.

Typical roles for ESS graduates in industry will include product and process environmental evaluation, corporate environmental strategic planning, research and development of sustainable technologies, design for the environment, pollution prevention, and ISO 14000 compliance. Multi-national companies that compete in the EU and Japan are especially interested in students with these skills due to legislation in these countries requiring strict chemical management, environmental evaluation, and producer responsibility for product recycling and remanufacturing. Industries hiring graduates with these skills include some of the largest in the world.

6.0 Participating Faculty

The strength of the ESS Program lies in its outstanding faculty from across the University of Michigan with great expertise and commitment to the success of the program and its graduates. Faculty members from both CoE and SNRE presently offer courses that will be key components of the proposed program. Many faculty members in both CoE and SNRE hold dual appointments in departments across campus, leveraging additional departmental expertise. Additionally, nine SNRE faculty members have engineering educational backgrounds ranging from bachelor's to doctoral degrees.

CoE and SNRE have identified a number of faculty members who have expressed commitment to the ESS program. These faculty members are willing to serve on admissions committees, to mentor students, and to advise students on research projects when appropriate. The collaboration fostered between faculty of CoE and SNRE is viewed as a benefit for all participants. Additionally, students within the ESS program serve as a pool of highly capable potential doctoral students interested in interdisciplinary research between CoE and SNRE. To date, SNRE and CoE faculty have collaborated on a number of large interdisciplinary research projects within which these students would be highly successful, including two current National Science Foundation biocomplexity grants on sustainable infrastructure (http://sitemaker.umich.edu/muses) and automotive greenhouse gas emission policy (http://sitemaker.umich.edu/autopolicydesign). Faculty in SNRE and CoE are also currently collaborating on hydrogen and fuel cell curriculum development sponsored by NextEnergy.

The following faculty members will be active participants in the proposed Engineering Sustainable Systems program:

6.1 Invited College of Engineering Faculty

6.1.1 Mechanical Engineering

Professor Steven J. Skerlos - eco-design and manufacturing, environmental systems analysis, recycling and energy recovery technology systems, design for life cycle energy minimization

Professor Panos Papalambros - design optimization, large-scale system synthesis, automotive systems design, including hybrid vehicles, eco-design, and product design

Professor Arvind Atreya - combustion, heat and mass transfer, energy conservation, soot and NO_x formation and oxidation in diffusion flames, flame spread, and diesel engine combustion

Professor Dennis Assanis - thermal and fluid sciences in automotive design, internal combustion engine processes, friction in spark-ignition engines, and unburned hydrocarbon mechanisms

6.1.2 Chemical Engineering

Professor Levi Thompson – renewable energy systems, hydrogen production and conversion technologies, novel micro-cell fuels and micro-reactors, nanostructured catalysts and electrocatalysts

Professor Phil Savage - sustainable chemical synthesis and energy production, reaction kinetics and mechanisms, applications in degradation of hazardous chemicals and green chemistry

Professor Johannes Schwank - heterogeneous catalysis, thin films, and chemical sensors, surface structure of materials and their reactivity

Professor Henry Wang - sustainable bioprocesses, manufacture of biofuels, specialty chemicals and pharmaceuticals, delivery systems for environmental restoration

Professor Walter Weber - principles, modeling, and design of process dynamics in sustainable environmental systems, with a principal focus on water resources. This includes engineered processes for development of new water sources, advanced technologies for water treatment and reclamation, and natural processes occurring in ground water, river, lake, and ocean systems.

6.1.3 Civil and Environmental Engineering

Professor Steven Wright - stability of contaminated fine-grained marine sediments, controls on total mixing from marine discharge of wastewater, physical processes associated with the rapid filling of stormwater conduits, and mitigation of impacts in Great Lakes harbors

Professor Jeremy Semrau (dual appointment in SNRE) - molecular biology, biochemistry, and kinetics of enzymatic systems, biodegration of clorinated solvents, contaminant transport, bioavailability of metals in subsurface

Professor Peter Adriaens (dual appointment in SNRE) - remediation design, microbial sensing, sustainable industrial practice, development of innovative technology platforms for cleanup of industrial process streams and natural systems, and microbial and chemical sensing and control

Professor Aline Cotel - stream restoration and pollutants transport in geophysical environments. Particular emphasis is the application of optical techniques to the measurement of physical parameters in a variety of environments in both field and laboratory settings.

6.2 Invited School of Natural Resources and Environment Faculty

6.2.1 Sustainable Systems

Professor Jonathan Bulkley (dual appointment in CEE)- development and application of quantitative and qualitative means to help policy makers and decision makers attain improved planning, evaluation, and management of natural resources, especially water resources to achieve sustainability, risk analysis, resource policy, and sustainable water resource systems

Professor Gregory Keoleian - life cycle design and assessment, life cycle optimization, technology assessment of renewable energy, transportation and building sectors, sustainability metrics and indicators

Research Investigator Duncan Callaway – renewable energy technologies, integration of renewable electricity resources into the electrical power grid, and building energy efficiency

Professor Tom Princen - behavioral and institutional requirements for ecological and social sustainability, overconsumption, sufficiency, ecological economics, institutional design, transnational relations, business and environment, and water quantity

Professor Gloria Helfand - pollution control instruments in various settings, distributional effects of environmental policies, issues relating to management of federally owned lands

Professor Michael Moore - economics of environmental markets, federal water policy and water allocation conflicts between environmental and consumptive uses of river systems, economic aspects of biodiversity and species conservation

6.2.2 Aquatic Sciences

Professor David Allan - ecology of aquatic ecosystems, especially rivers; effects of land use on stream health, river restoration, watershed management.

Professor Paul Webb – ecology and biology of fishes, hydrodynamics, predator-prey interactions, physiological ecology.

Professor Ed Rutherford- estuarine ecology, salmonine biology, bioenergetic modeling, anadromous species management

Professor Sara Adlerstein- biometrics, statistical modeling of fisheries, population and community interactions

Professor (adjunct) Kevin Werhley- fish ecology and management, thermal ecology, lake ecosystem management
Professor Jim Breck- population and community modeling, lake ecosystem dynamics and management
Professor Michael Wiley - ecological processes in aquatic systems, application of ecological knowledge to practical problems of resource management, trout stream food webs, modeling complex systems, and fisheries management
Professor James Diana - behavioral ecology and production of natural populations, energy accumulation in natural populations or controlled aquaculture systems, conservation of natural resources
Professor Donald Scavia - effects of land use choices on estuarine and Great Lakes nutrient over enrichment, ecological response models for the Gulf of Mexico, the Chesapeake Bay, and the Great Lakes, and human impacts to the nitrogen cycle
Professor William Currie - ecosystem modeling, terrestrial ecology, biogeochemistry, ecosystem responses to environmental change related to energy production

7.0 Admissions and Advising

Applicants must satisfy the requirements for admission to each unit. The admissions process to the dual master's degree program will be overseen by the respective CoE Departmental Graduate Chair and the Director of the Office of Academic Programs at SNRE and takes the following course:

1. Interested students should follow all necessary application requirements to apply to both CoE and SNRE. This entails two separate applications with supporting documents to the Rackham Graduate School, one for each respective school (CoE and SNRE).

2. The ESS admissions committee for each unit will evaluate the application as it would any other. Each committee will make its admission decision independent of the decision in the other unit.

3. Students granted admission to both programs will have the option to move into the dual degree program.

4. Students currently enrolled in the first year of either program may also apply for admission to the dual degree program. Admission is not open to students who have already completed either degree.

5. Faculty members from both CoE and SNRE will advise the student throughout his/her program of study and assure that an appropriate curriculum is selected in accordance with the ESS Program

Due to the stringent entrance requirements of both participating academic units, it is expected that admission to the dual master's degree program will be very selective. It is expected that individuals applying to this program have an undergraduate engineering degree (B.S.E.). The expected enrollment in the ESS program after its first 5 years of time is 25 students.

8.0 Program of Study

The dual degree program leading to an M.S. in Engineering and M.S. in NRE offers an economical and comprehensive program that addresses growing conflicts between technology development and sustainability. Normally, this combined program would require 30 credit hours from engineering and 42 credit hours from NRE for a total of 72 credit hours. The minimum number of credit hours for the dual master's degree program is 54 credit hours (double counting 1/4 of total credit hours). Thus students may complete the requirements for both degrees in four semesters. The 54 credit hour minimum includes the core program of both units and electives. Students will progress through the program with the advice of faculty advisors who will assure that the chose course meets the student's particular goals and the core requirements of the dual degree.

Faculty advisors of exceptional students in the ESS Program will encourage them to pursue an opus in SNRE or a research thesis in CoE. Students who succeed in master's level ESS research will be further encouraged to apply to the doctoral program in SNRE, CoE or both as a joint NRE/Engineering program. Six students are already enrolled or have completed a joint doctoral program between Civil and Environmental Engineering and Natural Resources and Environment. The first joint doctoral graduate from CoE/NRE is now a faculty member at Yale and has been employed at EPA. This is one indication of the potential success of students who pursue doctoral research in the direction of the ESS program. We aim through the ESS program to create a larger cohort of such students.

The strength of the Engineering Sustainable Systems Program lies in its integration of two strong academic units, offering the students the opportunity to participate in a new community of collaborative scholars. Through the course of the program, students may choose to take courses from other academic units to meet elective requirements. These electives will be selected with the help of advising faculty to guarantee their relevance to the program.

To complete the requirements for the CoE/SNRE dual degree program, students must fulfill requirements for their respective department in CoE (varies by department) and SNRE field of study (varies by field). For illustration, the requirements which must be fulfilled for the specializations of Sustainable Design and Manufacturing (Mechanical Engineering (ME) + Sustainable Systems (SS)), Sustainable Energy Systems (Chemical Engineering (ChE) + Sustainable Systems (SS)), or Sustainable Water Resources (Civil and Environmental Engineering (CEE) + Aquatic Sciences (AS)) are provided:

8.1 Specialization in Sustainable Design and Manufacturing

For ME (CoE):

Coursework Only Option:

1. Twelve (12) credit hours in ME courses at the 5xx or 6xx level
2. Six (6) credit hours in ME courses at the 4xx level or above
3. Six (6) credit hours in non-ME courses at the 4xx level or above in a related engineering area
4. Six (6) credit hours in mathematics or equivalent courses (from ME Acceptable Math list)

For SS (SNRE):

1. Fifteen (15) credit hours in Sustainable Systems Core
    A. Six (6) credit hours in Systems Analysis for Sustainability
    B. Nine (9) credit hours in Sustainable Design and Technology and Sustainable Enterprise
        1. Minimum 3 credits in Sustainable Design and Technology
        2. Minimum 3 credits in Sustainable Enterprise
2. Thirteen (13) credit hours in SNRE Core Requirements
    A. Ten (10) credit hours in core courses
    B. Three (3) credit hours in analytics (from SNRE Acceptable Analytics list)
3. Six (6) credit hours in Opus Option Additional Coursework
    A. Three (3) credit hours of Sustainable Systems Core
    B. Three (3) credit hours of related coursework approved by advisor
4. Eight (8) credit hours in electives
5. Includes four (4) credit hours of cognates outside SNRE (satisfied by dual degree standing)

The basic structure of the dual master's degree program is as follows:

ME (CoE) Program		**SNRE Program**	
500 level or higher ME Courses	12 credits	Sustainable Systems Core	15 credits
400 level or higher ME Courses	6 credits	SNRE Core Requirements	13 credits
Mathematics or equivalent	6 credits	Opus Coursework Option	6 credits
400 level or higher non-ME Courses	6 credits	Electives	8 credits
ME (CoE)	30 credits	SNRE	42 credits

Minimum required credit hours to complete program: 30 + 42 – 18 (double counting) = 54 credits

The following is a SAMPLE PLAN and represents only a guide for prospective students enrolled in the ESS dual master's degree program with specialization in Sustainable Design and Manufacturing (Mechanical Engineering + Sustainable Systems). The specific plan toward degree will be different depending on the chosen specialization (i.e. Sustainable Energy Systems, Sustainable Water Resources, etc.)

Coursework Only Option

Year 1			**Year 2**		**Year 3**
Fall	*Winter*	*Spring*	*Fall*	*Winter*	*Fall*
ME 589	ME 599: MSM	STAT 412	NRE 571	ME 587	ME 599: APD
NRE 574	ME 501	NRE 512	NRE 509	CEE 589	ME 577
ME 581	CEE 586		NRE 510	NRE 580	ME 563
	NRE 735		NRE 507		OMS 742
Total Credits 9	10.5	5	10	9	10.5

YEAR 1

Fall Term (9 credit hours)

ME 589 - EcoDesign and Manufacturing (3)
NRE 574 - Sustainable Energy Systems (3)
ME 581 - Global Product Development (3)

Winter Term (10.5 credit hours)

ME 599 - Management for Sustainable Manufacturing (3)
ME 501 - Analytical Methods in Mechanics (3)
CEE 586 - Industrial Ecology (3)
NRE 735 – Environmental Management Topics (1.5)

Spring Term (5 credit hours)

STAT 412 - Introduction to Probability and Statistics (3)
NRE 512 – Ethics Corporate Management (2)

YEAR 2

Fall Term (10 credit hours)

NRE 571 - Environmental Economics (3)
NRE 509 - Ecology: Science of Context and Interaction (3)
NRE 510 - Environmental Governance, Choices, Institutions, and Outcomes (3)
NRE 507 - Laboratory in Social and Natural Science (1)

Winter Term (9 credit hours)

ME 587 - Global Manufacturing Systems (3)
ME 589 - EcoDesign and Manufacturing (3)
NRE 580 - Integrated Problem Solving (3)

YEAR 3

Fall term (10.5 credit hours)

ME 599 - Analytical Product Design (3)
ME 577 – Materials in Manufacturing and Design (3)
ME 563 - Time Series Modeling, Analysis, Forecasting (3)
OMS 742 – Sustainable Manufacturing (1.5)

8.2 Specialization in Sustainable Energy Systems

For ChE (CoE):

1. Twenty one (21) credit hours in ChE courses at 5xx or 6xx level or higher which *must* include
   A. ChE 595 – Research Survey
   B. ChE 527 – Fluid Flow
   C. ChE 528 – Reactor Analysis
   D. ChE 542 – Heat and Mass Transport

E. ChE 538 – Statistical Thermodynamics
F. And one of the following – ChE 507/508/509/510/544
G. May include up to six (6) credit hours of ChE 695- Research

2. Four (4) to nine (9) credit hours of cognate graduate credits of relevant 2, 3, or 4 credit hour courses

For SS (SNRE):

1. Fifteen (15) credit hours in Sustainable Systems Core
   A. Six (6) credit hours in Systems Analysis for Sustainability
   B. Nine (9) credit hours in Sustainable Design and Technology and Sustainable Enterprise
      1. Minimum 3 credits in Sustainable Design and Technology
      2. Minimum 3 credits in Sustainable Enterprise
2. Thirteen (13) credit hours in SNRE Core Requirements
   A. Ten (10) credit hours in core courses
   B. Three (3) credit hours in analytics (from SNRE Acceptable Analytics list)
3. Six (6) credit hours in Opus Option Additional Coursework
   A. Three (3) credit hours of Sustainable Systems Core
   B. Three (3) credit hours of related coursework approved by advisor
4. Eight (8) credit hours in electives
5. Includes four (4) credit hours of cognates outside SNRE (satisfied by dual degree standing)

The basic structure of the dual master's degree program is as follows:

ChE (CoE) Program		**SNRE Program**	
500 level or higher ChE Courses	21+ credits	Sustainable Systems Core	15 credits
400 level or higher Cognate Courses	4-9 credits	SNRE Core Requirements	13 credits
		Opus Coursework Option	6 credits
		Electives	8 credits
ChE (CoE)	30 credits	SNRE	42 credits

Minimum required credit hours to complete program: 30 + 42 – 18 (double counting) = 54 credits

The following is a SAMPLE PLAN and represents only a guide for prospective students enrolled in the ESS dual master's degree program with specialization in Sustainable Energy Systems (Chemical Engineering + Sustainable Systems). The specific plan toward degree will be different depending on the chosen specialization (i.e. Sustainable Design and Manufacturing, Sustainable Water Resources, etc.)

Coursework Only Option

Year 1			**Year 2**		**Year 3**
Fall	Winter	Spring	Fall	Winter	Fall
ChE 528	ChE 538	STAT 412	ChE 50x/554	NRE 527	NRE 5xx (SS Core)
ChE 542	NRE 557	NRE 600	NRE 507	NRE 580	ChE 5xx
ChE 595	NRE 550		NRE 509	Elective 1 CR +	ChE 527
NRE 574			NRE 510	ChE 686	
Total Credits 10	9	6	10	10	9

YEAR 1

Fall Term (10 credit hours)
ChE 528 – Reactor Analysis (3)
ChE 542 – Heat and Mass Transport (3)
ChE 595 – Research Survey (1)
NRE 574 – Sustainable Energy Systems (3)

Winter Term (9 credit hours)
ChE 538 – Statistical Thermodynamics (3)
NRE 557 – Industrial Ecology (3)
NRE 550 – Systems Thinking for Sustainable Development and Enterprise (3)

Spring Term (6 credit hours)
STAT 412 – Introduction to Probability and Statistics (3)
NRE 600 - Directed Research and Special Problems (3)

YEAR 2

Fall Term (10 credit hours)
ChE 50x/554 – Math/Modeling/Thermodynamics Electives (3)
NRE 507 – Laboratory in Social and Natural Science (1)
NRE 509 – Ecology: Science of Context and Interaction (3)
NRE 510 – Environmental Governance, Choices, Institutions, and Outcomes (3)

Winter Term (10 credit hours)
ChE 686 – Case Studies in Sustainable Engineering (3)
NRE 580 – Integrated Problem Solving (3)
NRE 527 – Social Institutions for Energy Production (3)
Free Elective – (1+)

YEAR 3

Fall Term (9 credit hours)
NRE 5xx – Sustainable Systems Core (3)
ChE 5xx – 500-level Chemical Engineering Elective (3)
ChE 527 – Fluid Flow (3)

8.3 Specialization in Sustainable Water Resources

For CEE (CoE):

1. Twenty four (24) credit hours in CEE courses (no more than twelve (12) credit hours at 4xx level):
   A. A minimum of fifteen (15) credit hours must be CEE courses
   B. A minimum of nine (9) credit hours must be Environmental and Water Resources Engineering related electives
   C. Up to six (6) of these credits may come from Directed Study (CEE 622,682,921,980)

2. Six hours of cognate (non-CEE) courses
   A. Three (3) credit hours in mathematics, probably, statistics, or mathematical programming
   B. Three (3) credit hours of non-CEE related engineering courses

For AS (SNRE):

1. Fourteen (14) credit hours from Aquatic Sciences field of study courses
2. Ten (10) credit hours in SNRE Core Requirements
3. Eight (8) credit hours in analytics (from SNRE Acceptable Analytics list)
4. Six (6) credit hours in AS approved Opus Option Additional Coursework
5. Includes four (4) credit hours of cognates outside SNRE (satisfied by dual degree standing)

The basic structure of the dual master's degree program is as follows:

ChE (CoE) Program		**SNRE Program**	
CEE courses	24 credits	Aquatic Sciences Requirements	14 credits
400 level or higher Cognate Courses	6 credits	SNRE Core Requirements	10 credits
		Analytics Requirement	8 credits
		Opus Coursework Option	6 credits
		Field of Study Requirements and Cognates	4 credits
ChE (CoE)	30 credits	SNRE	42 credits

Minimum required credit hours to complete program: 30 + 42 – 18 (double counting) = 54 credits

The following is a SAMPLE PLAN and represents only a guide for prospective students enrolled in the ESS dual master's degree program with specialization in Sustainable Water Resources (Civil and Environmental Engineering + Aquatic Sciences). The specific plan toward degree will be different depending on the chosen specialization (i.e. Sustainable Design and Manufacturing, Sustainable Energy Systems, etc.)

Coursework Only Option

Year 1			**Year 2**		**Year 3**
Fall	Winter	Spring	Fall	Winter	Fall
NRE 509	NRE 580	NRE 700/701	NRE 508	CEE 590	STAT 412
NRE 510	NRE 520	NRE 601	CEE 522	NRE 538	CEE 587
NRE 507	NRE 409		NRE 511	GEOSCI 477	CEE 527
CEE 521				NRE 539	
Total Credits 10	10	8	10	10	9

<u>YEAR 1</u>

Fall Term (10 credit hours)

NRE 509 – Ecology: Science of Context and Interaction (3)
NRE 510 – Environmental Governance, Choices, Institutions, and Outcomes (3)
NRE 507 – Laboratory in Social and Natural Science (1)
CEE 521 – Flow in Open Channels (3)

Winter Term (10 credit hours)

NRE 580 – Integrated Problem Solving (3)
CEE 520 – Deterministic and Stochastic Models in Hydrology (3)
NRE 409–Ecology of Fishes (4)

Spring/Summer Term (8 credit hours)

Thesis Research or Group Project Research (6) and/ or approved course work (2-8)

YEAR 2

Fall Term (10 credit hours)

NRE 508 – Wetland Ecology (3)
CEE 522 – Sediment Transport (3)
NRE 511 – Fluvial Ecosystems (4)

Winter Term (10 credit hours)

CEE 590 – Stream Lake and Estuary Analysis (3)
NRE 538 – Linear Statistical Models (3)
GEOSCI 477 – Hydrogeology (3)
NRE 539 – Seminar (1)

YEAR 3

Fall Term (9 Credits)

CEE/NRE 587 – Water Policy (3)
STAT 412 – Introduction to Probability and Statistics (3)
CEE 527 – Coastal Hydraulics (3)

9.0 Financial Aid

The Center for Sustainable Systems provides fellowships from DaimlerChrysler Corporation and Ford Motor Company for dual degree and joint degree graduate students between SNRE (Sustainable System Field of Study) and CoE. These fellowships will be extended to ESS students (they are on the order of $5 - $10k) and provide one indication of the relevance of the proposed ESS program to industry. ESS students will also be encouraged to apply for Graduate Student Instructor (GSI) positions in departments where positions are available. However, ESS students working as a GSI will likely have to take a reduced course load thereby lengthening the program.

In presenting the ESS concept to industry and government stakeholders, we have received strong encouragement leading to the development of the ESS program as proposed here. We are convinced that the ESS program can serve as a major development opportunity for UM by leveraging initiatives such as the Graham Environmental Sustainability Institute and the Michigan Memorial Phoenix Energy Institute.

10.0 Conclusion

The ESS dual master's degree program between CoE and SNRE will expand the University of Michigan's capabilities in the education of a new generation of engineers prepared to solve critical sustainability challenges. Affiliated ESS faculty are leaders in prominent UM sustainability programs such the Center for Sustainable Systems (CSS), the Hydrogen Technology Laboratory, the Environmental and Sustainable Technologies Laboratory (EAST), Michigan Sea Grant, the Cooperative Institute of Limnology and Ecosystems Research (CILER), the Institute for Fisheries Research (IFR), the Automotive Research Center, and the Transportation Energy Center. Due to the large number of faculty committed to supporting this program, the interest of corporate and government stakeholders, and the existing set of graduate students already enrolled in joint degrees between CoE and SNRE, we anticipate that an outstanding group of graduate students will be enthusiastic about enrolling in the Engineering Sustainable Systems program.

Both Deans of SNRE and CoE fully support the ESS program and are committed to its success. The creation of this dual degree program aligns with primary goals of the University as outlined by former Provost Edward M. Gramlich:

> "Perhaps the most important challenge facing our society today is to sustain our natural resources and environment. The problems of environmental sustainability are complex and multi-faceted and often can be solved only through the combined efforts of experts in many fields. That is why leading research universities like the University of Michigan, with its range of programs that address these issues, are uniquely suited and have an obligation to engage environmental issues."