INDUSTRIAL ECOLOGY (EAS 557 & CEE 586)
Winter Term 2018
SYLLABUS

Time 2:30-4:00pm Tuesdays & Thursday
Location 1040 Dana
Instructor Shelie Miller, Associate Professor, School for Environment and Sustainability
sheliem@umich.edu
Office Hours 3532 Dana Bldg.
Tuesdays 11-12; Wednesdays 10:30-11:30

GSI Brent Heard
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Office Hours 1540 Dana Bldg.
Wednesdays 2:30pm - 3:30pm, Thursdays 10:30am-11:30am

***Please include “NRE 557” in the subject line for all email correspondence. Note that emails may not be answered until the end of the next business day.***

COURSE DESCRIPTION
Industrial ecology is the systematic analysis of global, regional and local material and energy flows and uses that are associated with products, processes, industrial sectors, and economies. Energy consumption, non-renewable and renewable materials consumption, air pollutant emissions, waterborne pollutant effluents and solid waste generation associated with human activities are tracked. These analyses are the foundation of industrial ecology, which seeks to design and manage products and services that meet human needs in a sustainable manner.

COURSE FORMAT
Concepts, principles and methodologies will be introduced by lecture and discussed in a seminar format. Case studies will be used throughout the course to demonstrate concepts and principles and highlight accomplishments and practical limitations of life cycle assessment and life cycle design. Class participation is essential for understanding multi-disciplinary perspectives. In conjunction with this course, we will schedule one or two optional field trips to industrial sites to complement the course and provide you with the opportunity to visit industrial facilities.

COURSE RESOURCES
Powerpoints that supplement the lectures will be available on Canvas. Please note that the Powerpoint slides supplement course material and are not considered comprehensive course notes. It is recommended that you bring these materials to class in either electronic or paper format. There is no textbook for this course. Required and recommended readings for each class will be posted on Canvas, at least one week prior.

COURSE REQUIREMENTS AND EVALUATION
Attendance at regularly scheduled class meetings is expected, as well as regular participation in class discussions. Academic honesty is expected. Any violation of University of Michigan policy as described in the Student Handbook will not be tolerated and will result in a failing grade on the assignment. Repeated offenses will result in failing the course. It is expected that all assignments and exams will be completed without consulting solutions from prior years.

Assignments
Weekly homework will be assigned throughout the semester. Unless otherwise indicated, homework sets may be completed by groups no larger than three, with a single solution set handed in. Assignments are required to be turned in at the beginning of class as a hard copy or through the Canvas portal, unless otherwise indicated. E-mailed submissions will receive an automatic 10% “processing fee” deduction. Late homework will receive an automatic 10% deduction for every day overdue, starting at 2:30 on the due date.
Course Blog

There will be student-led class discussions once per week in conjunction with a blog on special topics. You are required to either: 1) Respond to four blog posts, or 2) Serve one time as a class discussion leader and respond to one blog post. Sign-ups will be done via the Course Wiki spreadsheet, which can be accessed in the Collaborations tab on Canvas.

Term Project
A term project will be assigned by the end of January and project groups will be formed to facilitate interdisciplinary collaboration. Your group will choose a product and apply industrial ecology principles and tools to assess the environmental impacts associated with the product and identify opportunities for improvement. The term project will culminate in a final poster presentation.

Exams
Exams for the course will consist of a midterm and a final.

Grading Breakdown

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<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Class participation</td>
<td>5%</td>
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<tr>
<td>Assignments</td>
<td>25%</td>
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<tr>
<td>Term Project</td>
<td>20%</td>
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<tr>
<td>Mid-Term Exam</td>
<td>25%</td>
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<tr>
<td>Final Exam</td>
<td>25%</td>
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* Class participation will include contributions to the class blog (responses or as discussion leader), active participation in the class including Q/A, sharing news and info, and attendance (allowing for two absences for any reason).

COURSE OUTLINE (subject to change)

I. Industrial Ecology and Sustainability Frameworks

Jan. 4 **Introductions, Industrial Ecology Framework**
Definition, Goals, Analytical Components, and Tools
Industrial vs. Ecological Economy

Jan. 9 **Environmental Management and Sustainability Frameworks**
IPAT Equation
Changes in Environmental Management
Definitions and Drivers for Sustainability
Sustainability Indicators

Jan. 11 **State of the Environment: Resource Sustainability Challenges and Opportunities**
Energy & Material Resources
Waste and Pollution
Sustainability Thresholds

Jan. 16 **Industrial Ecology: Exploring the Metaphor and Systems Analysis for Sustainability**
Industrial and Natural Ecosystems
Industrial Symbiosis and Circular Economy
Biomimicry
Systems Analysis (Material and Energy Flows) and Metrics: MFA, LCA
Material & Energy Auditing / Mass & Energy Balances
Waste-to-Product Ratios

Jan. 18 **Material Flow Analysis**
Natural vs Anthropogenic Pollutant Cycles
II. Life Cycle Assessment

Jan. 23 Life Cycle Assessment (LCA): Components and Applications
Components: Goal Definition and Scoping, Life Cycle Inventory Analysis (LCI), Life Cycle Impact Assessment (LCIA), Life Cycle Interpretation
Functional unit of analysis

Jan 25 Life Cycle Inventory Analysis
System Boundaries
Process Flow Diagram
Intro to LCA Software

Jan 30 Life Cycle Inventory Analysis
EIO-LCA Modeling Exercise
Issues of Data Collection

Feb 1 Energy and Transportation Modeling
Energy
  Primary energy
  Feedstock, Process Fuels and Transportation Fuels
  Electricity Generation
  Emission Factors
Transportation
  Energy – Combustion and Precombustion (upstream processes)
  Emission Factors

Feb. 6 Materials Production Phase
Processes
  Acquisition
  Material Processing and Refinement
Material Production Energy

Feb. 8 Materials Production Phase (con’t)

Feb. 13 Manufacturing Phase
Manufacturing Processes
Co-Product Allocation Rules

Feb. 15 Use Phase
Processes
  Operation (use)
  Service (maintenance, repair)

Feb 20 End-of-Life Management Phase
Options
  Remanufacturing & Product Takeback
  Recycling
  Disposal

Feb 22 Mid-term Exam

Feb. 26-Mar. 2 – Spring Break
March 6  Life Cycle Impact Assessment I
Methodology
Impact Potentials – GWP and ODP

Mar. 8  Life Cycle Impact Assessment II
Acidification, Smog, and Others
Human Health and Ecosystem Health

March 13  Life Cycle Impact Assessment III
Water Footprint and Water Stress Index
Land Use
Resource Depletion Impact
Social LCA
Material Criticality Issues: scarcity, substitutability, supply risk
Conflict Minerals

III. Improvement Stage:  Life Cycle Design and Management

Mar. 15  Life Cycle Design Framework and Design Requirements
Life Cycle Management
Life Cycle Design Process

Mar. 20  Design Strategies
Product Life Extension
Dematerialization
Rebound Effect

Mar. 22  Life-Cycle Costing
Purchase, ownership, disposition
Private and social costs

Mar. 27  Life Cycle Management and Green Supply Chains
Environmental Accounting
Internal costs: conventional, hidden, liability, less tangible costs; external costs
Activity Based Accounting and Cost allocation
Revisit Sourcing Decisions
Extended Producer Responsibility
E Waste

March 29  Corporate Decision Making and Life Cycle Framework for Environmental Marketing
Decision-making Frameworks
Success stories
Environmental Marketing & Labeling

IV. Sustainable Systems (Production and Consumption)

April 3  Food-Water-Energy Nexus
Sustainability Indicators for the US Food System
Environmental, Economic, and Social
Material Flows and Food Waste
Life Cycle Energy Consumption

April 5  Sustainable Mobility and Built Environment
Trends, Technology, Environmental Impacts, Economics, Policy
Plug-In Hybrid Electric Vehicles (PHEV) LCA, Autonomous Vehicles
Apr. 10  Industrial Ecology Symposium: Term Project Presentations
Apr. 12  Industrial Ecology Symposium: Term Project Presentations
Apr. 17  Course Wrap-Up & Concluding Remarks
          Course Review and Evaluations

**Final Exam:** Friday April 20, 4-6pm