ES8903 – Pollution Prevention

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Office Hours: Wednesdays: 1:00 pm – 3:00 pm
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Course Web Page: https://my.ryerson.ca

Class Time: Tuesdays: 2:00 p.m. – 5:00 p.m.
January 19 – April 12, 2016

Class Location: KHE 220

Calendar Course Description:
"The course examines a number of industry-environment interactions. It discusses pollution prevention and industrial ecology, and it presents a survey of environmental concerns including material and energy budgets, life-cycle assessment, and industrial process wastes and their minimization. Design for environmental quality is discussed including energy use and design for energy efficiency. The course explores the future of industrial activity with regard to the environment and it reviews studies in selected industrial applications." (Ryerson University School of Graduate Studies Calendar, 2015).

Course Objectives:
By the end of this course, the participants will be able to:

1. Describe and explain key concepts pertaining to pollution prevention.
2. Demonstrate the critical thinking skills needed to apply the content.
3. Describe and explain the personal and social implications related to this subject.
4. Think about pollution prevention in integrated ways.

Course Materials:

Articles: Several journal articles are required reading. Hard copies will not be provided.

Case: The following case is required reading. A hard copy will not be provided.
- *Sustainability at Millipore* (Revised January 14, 2014) by M.W. Toffel and K. Lee, Harvard Business School Case 9-610-012 (Available for purchase at https://hbr.org/product/Sustainability-at-Millipo/an/610012-PDF-ENG).

Supplements: Two textbooks will be referred to extensively throughout the course:
- *Industrial Ecology and Sustainable Engineering* by T.E. Graedel and B.R. Allenby (2009), ISBN 978-0136008064.
- *Pollution Prevention* by P.L. Bishop (2000), ISBN 1-57766-348-9.

Slides: Lecture slides will be posted on the course web page in PDF format prior to each class. Please bring a copy of the slides to class. Hard copies will not be provided.

Course Schedule:
The course will consist of a combination of lectures, in-class discussions, problem-based learning activities, and oral presentations. The tentative course schedule is provided in the table below. Every attempt is made to provide a syllabus that is complete and that provides an accurate overview of the course. However, circumstances and events may make it necessary to modify the syllabus during the semester. There is no class on February 16 due to the Study Week break.

Week No. & Date	Tentative (!) Lecture Topic	Reading
1 January 19	• Introductions. • Course Outline and Overview. • Introduction to Pollution Prevention.	Articles: 1, 2
2 January 26	• Introduction to Industrial Ecology. • Industrial Activity and the Environment. • Society and Culture.	Articles: 3, 4
3 February 2	• Introduction to Design for Environment. • Industrial Product Design and Development. • Industrial Process Design and Operation.	Articles: 5, 6
4 February 9	• Design for Energy Efficiency. • Design for End of Life. • Choosing Materials.	Articles: 7, 8
5 February 23	• Life Cycle Assessment. • Streamlined Life Cycle Assessments. • Review for Mid-Term Exam.	Articles: 9, 10
6 March 1	• **Mid-Term Exam.**	
7 March 8	• Corporate Industrial Ecology. • Industrial Ecosystems. • Review Solutions to Mid-Term Exam.	Articles: 11, 12
8 March 15	• Indicators and Metrics. • Economics of Pollution Prevention. • Review for Research Presentations and Paper.	Articles: 13, 14
9 March 22	• Systems Analysis. • Context-Based Performance Measurement. • *Research Presentations.*	Article: 15, 16
10 March 29	• Pollution Prevention Planning. • Sustainable Development. • *Research Presentations.*	Articles: 17, 18, 19
11 April 5	• *Research Presentations.*	Articles: None
12 April 12	• Case Study: Sustainability at Millipore. • The Future of Industrial Activity. • Review for Final Exam.	Articles: 20 Case Materials

Course Evaluation:

Component	Weight
Assignments	12%
Research Proposal	1%
Research Paper	15%
Research Presentation	7%
Mid-Term Exam	30%
Final Exam	35%
TOTAL	100%

Assignments: Exercises will be assigned at the end of most sessions. All assignments are equally weighted. Additional details are available on page 4 of the course outline. **The assignments are due Monday at midnight (12:00 a.m.) the following week**. Please note that no late assignments will be accepted.

Proposal: A proposal for the research paper is required. Additional details on the proposal, including possible topic areas, are available on pages 4 and 5 of the course outline. **The proposal is due no later than Monday, February 1 at midnight (12:00 a.m.)**.

Paper: A research paper on the topic of the approved proposal is required. Additional details on the paper are available on page 6 of the course outline. **The paper is due no later than the beginning of class on March 22**.

Presentation: A conference-quality presentation of the research paper is required. Additional details on the presentation are available on page 6 of the course outline. **The presentations will be held in class on March 22, March 29, and April 5.**

Exams: The mid-term and final exams are closed-book. Everything covered in class, the lecture slides, the required readings, the assignments, or additional handouts may be tested. Additional details on the exam will be provided prior to the exam date. **The mid-term exam will be held in class on March 1. The final exam will be held during the final examination period (date to be determined).**

Student evaluation will be expressed in raw marks (out of 100% for each evaluation component) during the course delivery. Mark total for the course will be obtained by assigning the component weights given above to the marks obtained in the course, and summing up the weighed marks. The letter grade system will then be applied to the final total mark only. As a guideline, the following grading scale will be used:

A+	90.0 – 100%	B+	77.0 – 79.9%
A	85.0 – 89.9%	B	73.0 – 76.9%
A-	80.0 – 84.9%	B-	70.0 – 72.9%

F < 69.9%

According to Ryerson University Policy, students must receive their final grades only from the Registrar. Final course grades may not be posted or disclosed anywhere (including email) by the instructor.

Assignment Guidelines:
Below are some preliminary guidelines on completing the assignments. Please note that these guidelines may be changed at the discretion of the instructor and additional guidelines may be added if necessary.

1. The solutions to all assignments must be submitted through D2L Brightspace. **The assignment must be submitted in one PDF file (this is mandatory)**.
2. Please ensure that you clearly list your name and student number on the first page of the assignment. A title page is not required.
3. Please make every effort to be neat. Type-written answers are required. Illegible or incoherent answers will not be graded.
4. Please ensure that you answer all components of the question.
5. Complete sentences are required. Bullet points and tables may be used provided there is some (brief) discussion.
6. You may not copy answers from anyone else. Directly copying from someone else is plagiarism.
7. The assignments are equally weighted. Each assignment is worth 1.5% of the overall course mark.
8. Each of the questions in the assignments is equally weighted. For example, if there are two questions in the assignment, each question is worth 50% of that particular assignment.
9. Late assignments will not be accepted unless approval is granted in advance (exceptional circumstances are required).
10. Efforts will be made to grade the assignments promptly. If there will be a delay in the grading of the assignments, students will be informed during class or through an announcement in D2L Brightspace. Grades will be posted in D2L Brightspace.

Proposal Guidelines:
Below are some preliminary guidelines on completing the proposal for the research paper and presentation. Please note that these guidelines may be changed at the discretion of the instructor and additional guidelines may be added if necessary.

1. The proposal should be organized into the following sections:
    - *Title*: A preliminary title for the research paper should be provided.
    - *Introduction*: A brief overview of the issue to be researched, including the motivations for research, should be provided.
    - *Purpose*: This section should provide a statement of the purpose of the research.
    - *Scope*: The scope of the research, including any assumptions and limitations, should be explained.
    - *Approach*: An explanation of how the purpose will be achieved should be provided.
    - *Bibliography*: A preliminary list of sources of information for the project should be provided. References should be cited using the APA style.
2. The primary sources for the paper should include peer-reviewed journal papers, conference papers, and books. Reports, industry magazines, encyclopedias, newspapers, and internet articles verified for accuracy may also be used.
3. The proposal must be typed in the Times New Roman style using 12-point font with 1.5 paragraph spacing.
4. The maximum length of the proposal is two (2) pages, plus a preliminary bibliography. The bibliography is not included in the two page limit.
5. The proposal must be submitted through D2L Brightspace (not email).
6. Grades will be posted in D2L Brightspace.

Research Topic Guidelines:
The research should focus on a thorough examination of published literature and a detailed presentation of critical analysis and synthesis of the available information. A variety of topics are acceptable for the research paper and presentation. Topic areas covered in class may be studied in greater depth. As illustrative examples, the research could focus on specific aspects of: pollution prevention, industrial ecology, life cycle assessment, environmental management systems, indicators and metrics, or sustainable development, among other topics. The topic is your choice, subject to approval by the instructor.

To structure thinking about possible topics, you may decide to use one of several constructs:

1. *Critical Review*: For example: "Corporate industrial ecology: A literature review and research agenda."
2. *Trends Analysis*: For example: "Trends in mandatory reporting by industry sector and country."
3. *Exploratory Research*: For example: "The role of environmental management systems in corporate pollution prevention."
4. *Cause and Effect*: For example: "Does the implementation of environmental performance measurement systems result in improved environmental performance?"
5. *Historical Context*: For example: "The impact of the Bhopal industrial disaster on the development and evolution of voluntary pollution prevention programs."
6. *Compare and Contrast*: For example: "A comparison and critical review of two or more industrial association initiatives that involve membership requirements pertaining to pollution prevention."
7. *Solution to a Problem*: For example: "Implementing pollution prevention programs in publicly owned treatment facilities."
8. *Persuasion*: For example: "Why corporations should apply life cycle assessment in their product design processes."

The above constructs are suggestions and additional constructs may be possible. Due to Ryerson University ethics regulations regarding research with human subjects, you should contact the professor in advance of the proposal deadline if you intend to focus on specific individual applications and/or examples from local industry.

If you have any questions on possible topics, please do not hesitate to contact the instructor prior to the proposal due date.

Paper Guidelines:
Below are some preliminary guidelines on completing the research paper. Please note that these guidelines may be updated at the discretion of the instructor.

1. There is some flexibility on the structure of the paper. However, the following guidelines should be applied:
    - *Title Page*: A title page with the title of the paper.
    - *Abstract*: A 150-word abstract should briefly summarize the issue studied, the purpose, scope, approach, results, and conclusions/recommendations.
    - *Introduction*: The introduction should provide some context for the rest of the paper, including a concise overview of the topic, the need for the research, the purpose, the scope, the key assumptions, and the approach. A summary of the remaining sections in the paper should be provided.
    - *Main Body*: The main body should be appropriately structured in light of your approach. It could contain a survey of the literature, discussions, analysis, results, and/or proposed solutions.
    - *Conclusions*: A strong and compelling conclusion is required. The main contributions of the research paper should be highlighted and, if appropriate, clear recommendations for further work or research should be provided.
    - *References*: The paper should contain no less than 8 references, with an emphasis on peer-reviewed journal papers, conference papers, and books. References should be cited in the APA style.
    - *Appendices*: Appendices are not required, but may be included if necessary.
2. The paper must be typed in the Times New Roman style using 12-point font with 1.5 paragraph spacing.
3. The paper must be between **10 – 12 pages** in length, plus a references section and any appendices. The title page, references, and appendices are not included in the page limit.
4. A hardcopy of the paper is required in addition to the regular submission through D2L Brightspace. On the hardcopy, the paper may be printed on both sides.
5. Grades will be posted in D2L Brightspace.

Presentation Guidelines:
Below are some preliminary guidelines on delivering the research presentation. Please note that these guidelines may be updated at the discretion of the instructor.

1. There is some flexibility on the structure of the presentation. However, the following guidelines should be applied:
    - *Outline*: The presentation should begin with a brief outline.
    - *Topic Overview*: Background on the topic should be provided, including what it is, why it is important, and what needs to be done.
    - *Research Introduction*: A brief overview of the purpose, scope, and approach used in the research should be provided.
    - *Main Body*: The main section of the presentation should be appropriately structured in light of your approach. It could contain a discussion of key findings and/or proposed solutions.
    - *Conclusions*: Key conclusions should be concisely presented. If appropriate, recommendations for further work or research should be provided.
2. The duration of the presentation is **8 - 10 minutes**. Please do not exceed the time limit.
3. The presentation will be followed with a brief question and discussion session. The presenter should be prepared to lead the discussion if necessary.
4. Grades will be posted in D2L Brightspace.

Literature Review Guidelines:
All research projects will require a survey of peer-reviewed literature. Several excellent resources on academic writing are provided by the Ryerson University Writing Centre (http://writingcentre.blog.ryerson.ca/), including information on documenting references using the APA style and conducting a review of professional literature. Information on conducting a search of academic databases is provided by the Ryerson University library (http://library.ryerson.ca/guides/), including a brief introduction to some of the most widely used academic databases.

Feedback:
Questions, comments, and suggestions regarding the course are welcomed.

Electronic means of communication are preferred for discussions regarding lectures, assignments, and exams. To foster promptness in responding, please send questions from a Ryerson University account with "ES8903" in the message subject line. If you do not receive a response within one business day, please feel free to send a follow-up email.

Class Attendance:
Class attendance is expected, but no attendance is taken. If for some reason a student should miss a class, it is the student's responsibility to:

1. Inform themselves of any administrative announcements (e.g., schedule changes) discussed during a session.
2. "Make-up" any of the course material covered in the session. This is of particular importance as there will be material presented in the sessions that may not be covered adequately in the assigned readings and course slides.

It is not necessary to inform me of an absence should a situation arise where attendance is not possible. Please note however, that I reserve the right not to provide extensive information about what transpired in a class.

Class Participation:
Participation in class discussions and exercises is expected.

Class Conduct:
Please make every attempt to be in class on time. For the sake of your colleagues, please do not hold private conversations or eat any food in class. If the need to talk or eat is overwhelming, please exit discretely.

Academic and Non-Academic Conduct:
All participants in the course are required to adhere to all relevant Ryerson University policies. Students are particularly encouraged to familiarize themselves with the Ryerson University Student Codes of Academic Conduct and Non-academic Conduct.

The Student Code of Academic Conduct is available at:
http://www.ryerson.ca/senate/policies/pol60.pdf

The Student Code of Non-academic Conduct is available at:
http://www.ryerson.ca/senate/policies/pol61.pdf

Other Ryerson University policies, including the course management policy, are available at:
http://www.ryerson.ca/senate/policies

Articles:
The following articles are required reading. Please review them in accordance with the course schedule provided on page 2. Some of the articles will not be formally addressed in the assignments or in the course slides, but they will provide a basis for discussion and reflection in the lectures.

1. Glavic, P. and Lukman, R. 2007, "Review of sustainability terms and their definitions", *Journal of Cleaner Production*, Vol. 15, pp. 1875-1885.

2. Chertow, M.R. 2001, "The IPAT equation and its variants: changing views of technology and environmental impact", *Journal of Industrial Ecology*, Vol. 4, No. 4, pp. 13-29.

3. Korhonen, J. 2001, "Four ecosystem principles for an industrial ecosystem", *Journal of Cleaner Production*, Vol. 9, pp. 253-259.

4. Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O., and Ludwig, C. 2015, "The trajectory of the Anthropocene: The Great Acceleration", *The Anthropocene Review*, Vol. 2, No. 1, pp. 81-98.

5. Kuo, T-C., Huang, S.H., and Zhang, H-C. 2001, "Design for manufacture and design for 'X': concepts, applications and perspectives", *Computers and Engineering*, Vol. 41, pp. 241-260.

6. Hauschild, M.Z., Jeswiet, J., and Alting, L. 2004, "Design for environment – do we get the focus right?" *CIRP Annals - Manufacturing Technology*, Vol. 53, No. 1, pp. 1-4.

7. Lovins, A.B. 2007, "Energy myth nine – energy efficiency improvements have already reached their potential", in *Energy and American Society – Thirteen Myths* (edited by Sovacool, B.K. and Brown, M.A.), Springer Netherlands, pp. 239-263.

8. Tanskanen, P. and Takala, R. 2006, "A decomposition of the end of life process", *Journal of Cleaner Production*, Vol. 14, pp. 1326-1332.

9. Reap, J., Roman, F., Duncan, S. and Bras, B. 2008, "A survey of unresolved problems in life cycle assessment: part 1: goal and scope and inventory analysis", *International Journal of Life Cycle Assessment*, Vol. 13, pp. 290-300.

10. Reap, J., Roman, F., Duncan, S. and Bras, B. 2008, "A survey of unresolved problems in life cycle assessment: part 2: impact assessment and interpretation", *International Journal of Life Cycle Assessment*, Vol. 13, pp. 374-388.

11. O'Rourke, D. 2014, "The science of sustainable supply chains", *Science*, Vol. 344, No. 6188, pp. 1124-1127.

12. Gibbs, D. and Deutz, P. 2007, "Reflections on implementing industrial ecology through eco-industrial park development", *Journal of Cleaner Production*, Vol. 15, pp. 1683-1695.

13. Roca, L. and Searcy, C. 2012, "An analysis of indicators disclosed in corporate sustainability reports", *Journal of Cleaner Production*, Vol. 20, No. 1, pp. 103-118

14. Cucek, L., Klemes, J.J., and Kravanja, Z. 2012, "A review of footprint analysis tools for monitoring impacts on sustainability", *Journal of Cleaner Production*, Vol. 34, pp. 9-20.

15. Finnveden, G. and Moberg, A. 2005, “Environmental systems analysis tools – an overview”, *Journal of Cleaner Production*, Vol. 13, pp. 1165-1173.

16. Steffen, W. et al. 2015, “Planetary boundaries: Guiding human development on a changing planet”, *Science*, Vol. 347, No. 6223, pp. 736.

17. Granek, F. and Hassanali, M. 2006, “The Toronto Region Sustainability Program: insights on the adoption of pollution prevention practices by small to medium-sized manufacturers in the Greater Toronto Area (GTA)”, *Journal of Cleaner Production*, Vol. 14, pp. 572-579.

18. Chittock, D.G. and Hughey, K.F.D. 2011, “A review of international practice in the design of voluntary pollution prevention programs”, *Journal of Cleaner Production*, Vol. 19, pp. 542-551.

19. Robert, K-H, Schmidt-Bleek, B., Aloisi de Larderel, J., Basile, G., Jansen, J.L., Kuehr, R., Price Thomas, P., Suzuki, M., Hawken, P., and Wackernagel, M. 2002, “Strategic sustainable development – selection, design, and synergies of applied tools”, *Journal of Cleaner Production*, Vol. 10, pp. 197-214.

20. Hardin, G. 1968, “The tragedy of the commons”, *Science*, Vol. 162, pp. 1243-1248

