School of Civil and Environmental Engineering

Term 3, 2020

GSOE9740
INDUSTRIAL ECOLOGY AND SUSTAINABLE ENGINEERING

COURSE DETAILS

Units of Credit	6
Contact hours	This is a **100% online course** which will be fully delivered via Moodle. As such there are no set contact hours. However, note that there will be two live online discussion forums with compulsory attendance. It is expected that you invest **at least 6 hours per week** of private study in this course.
Class	100% online, no face-to-face classes
Workshop	100% online, no face-to-face classes
Course Coordinator, Lecturer and Demonstrator	Assoc. Prof. Tommy Wiedmann email: t.wiedmann@unsw.edu.au office: Room 312, School of Civil & Environmental Engineering (Bld H20) phone: 02 9385 0142
Lecturer and Demonstrator	Dr Soo Huey Teh email: soohuey.teh@unsw.edu.au

INFORMATION ABOUT THE COURSE

This course will introduce students to the concepts and methods of sustainable engineering and industrial ecology and their application in work practice and research. Industrial ecology is a rapidly growing field that uses natural systems as a model for designing sustainable industrial systems. It helps to redesign the uses and flows of resources, materials and energy in a way that minimises environmental impacts and waste. Building upon the principles of the industrial ecology framework, the course introduces fundamental tools for assessing sustainability quantitatively such as input-output analysis, hybrid life cycle assessment and environmental footprint assessment. The focus will be on environmental impacts, but economic and social impacts will be dealt with as well.

The course assumes familiarity with environmental and sustainability issues and will involve computational activities. Familiarity with matrix algebra is beneficial. Microsoft Office Excel will be used in exercises and assignments.

Prerequisites: Knowledge of life cycle assessment (LCA) is **essential**; courses that teach LCA and are recognised as prerequisites are CVEN9892, GSOE9340 and SOLA9015. Students must have successfully completed one of these courses or provide evidence of equivalent training in LCA.

Please note that this course will be delivered **100% online** via Moodle. It has the usual weekly structure and you need to **complete all tasks on Moodle every week** to keep up with the course progress!

HANDBOOK DESCRIPTION

Sustainability means living well within the limits of a finite planet. More than ever, engineers need to find holistic and effective solutions to currently unsustainable practices of production and consumption, to protect our vital life support systems and meet the social and economic needs of a growing human population at the same time.

This course teaches concepts and methods to analyse and assess the environmental impacts of industrial systems and economies. It aims to equip students with the ability to understand challenges of sustainability from a local to global scale, to think critically, holistically and with a life cycle perspective and to apply sustainability assessment methods and tools (such as input-output analysis, hybrid life cycle assessment and environmental footprint assessment) in real-world examples.

http://www.handbook.unsw.edu.au/postgraduate/courses/2020/GSOE9740.html

OBJECTIVES

The aim of the course is to introduce students to the concepts and quantitative methods of sustainable engineering and industrial ecology and their application in work practice and research. Through lectures, workshops, group discussions and presentations, group assignments and the final exam, students will learn to:

- consider the interactions between technical, ecological, social and economic systems and avoid shifting problems from one area to the other;
- define, evaluate and help to resolve issues of sustainability in engineering problems;
- apply quantitative methods, interpret results and understand uncertainty;
- make more informed decisions towards increased sustainable outcomes.

Further outcome attributes of the course include:

- An in-depth engagement with the concepts of industrial ecology and sustainable engineering and their inter-disciplinary context
- Capacity for analytical and critical thinking, life cycle thinking and creative problem solving
- Ability to engage independent and reflective learning
- Skills for collaborative and multi-disciplinary work
- A respect for ethical practice and social responsibility
- Skills for effective communication

TEACHING STRATEGIES

The following teaching strategies will be used in this course. Students are encouraged to direct their own learning to get the most out of their participation in this course.

Lectures	• Find out what you must learn. • Watch **all** lecture, exercise and workshop videos and answer the questions therein. • Participate in online discussions and work out provided example problems. • Ask questions online on how the content of lectures applies to assignment questions. • Read announcements on course changes.
Workshops	• Work actively through all exercises provided online. • Be guided by auxiliary material and additional reading. • Attempt all questions in practice quizzes. • Practice solving set problems. • Ask questions and discuss solutions with other students via Moodle.
Private Study	• Review lecture material, reference books, and resources on UNSW Moodle. • Work in groups on online assignments. • Reflect on set problems and assignments. • Download and work through additional readings provided. • Join Moodle discussions of problems. • Keep up with notices and find out marks via Moodle.

Assessments (quizzes, assignments, group discussions and presentations etc.)	• Take all quizzes at the set time! These are **summative** assessments and count towards your final course mark. • Demonstrate your knowledge and skills in online discussions and assignments. • Demonstrate ability to work effectively in a group by completing the group assignment. • Demonstrate higher understanding and problem solving on real world problems in hypothetical, but realistic problem settings in online workshops.

EXPECTED LEARNING OUTCOMES

At the end of this course, students will be able to critically evaluate sustainability problems (practiced in quizzes, presentations and assignments) and decide which method to choose for quantitative sustainability assessment. They will be able to describe and contrast different quantitative evaluation methods and conduct simple life cycle, footprint and input-output analyses (practiced in online workshops and assignments). They will also be able to interpret the outcomes from each sustainability assessment method, know the limitations inherent in the different approaches and make recommendations towards more sustainable decision-making processes. Students will get to know the basic principles of industrial ecology and sustainable engineering and their application in work practice and research and formulate reasonable suggestions based on sustainability assessment activities.

This course is designed to address the learning outcomes below and the corresponding Engineers Australia Stage 1 Competency Standards for Professional Engineers as shown. The full list of Stage 1 Competency Standards can be found in Appendix A.

After successfully completing this course, you should be able to:

Learning Outcome		EA Stage 1 Competencies
LO1	Discuss the basic principles of industrial ecology and sustainable engineering and their application in work practice and research and formulate reasonable suggestions based on sustainability assessment activities.	PE1.1, PE1.3, PE1.4, PE1.6, PE2.1, PE3.1
LO2	Critically evaluate sustainability problems (practiced in presentations and/or assignments).	PE1.1, PE1.6, PE2.1, PE2.4, PE3.2
LO3	Describe and contrast different quantitative evaluation methods and conduct simple life cycle, footprint and input-output analyses.	PE1.2, PE2.1, PE2.4, PE3.2
LO4	Decide which method to choose for quantitative sustainability assessment.	PE1.6, PE2.2, PE2.4
LO5	Work together in groups to investigate the environmental sustainability of households, companies and projects.	PE2.1, PE3.1, PE3.2, PE3.3, PE3.6
LO6	Interpret the outcomes from each assessment method, formulate the limitations inherent in the different approaches and make recommendations towards more sustainable decision-making processes.	PE1.2, PE1.6, PE2.4, PE3.1, PE3.5

COURSE PROGRAM

A table of online lectures, workshops and activities is provided below. Please note that this course will be delivered **100% online** via Moodle. It has the usual weekly structure and you need to **complete all tasks on Moodle every week** to keep up with the course progress!

Term 3, 2020

Date	Lecture content	Workshop and other online activities
14/09/2020 (Week 1)	Introduction to sustainability concepts, definitions and principles	IPAT activity
21/09/2020 (Week 2)	Input-Output Analysis I (basics, mathematics, environmental extensions)	**Live** Online Discussion Forum on supply chain / life-cycle thinking (attendance compulsory); Online Practice Quiz
28/09/2020 (Week 3)	Input-Output Analysis II (production layer decomposition)	IOA and PLD exercises; Assignment 1 briefing; **1st Online Quiz**
06/10/2020 (Week 4)	Fundamental programming concepts (loops, scripts, functions, strings, etc.)	Matlab basics
12/10/2020 (Week 5)	Input-Output Analysis III, Industrial Ecology and Sustainable Engineering	IELab; Assignment 2 briefing; **Assignment 1 due**
19/10/2020 (Week 6)	***Flexibility week for all courses***	***(non-teaching)***
26/10/2020 (Week 7)	Advanced analytical techniques of Industrial Ecology I (structural path analysis and mixed-unit IOA)	SPA and MU-IOA exercises; **Peer-marking of Assignment 1** and **Assignment 2 due** (oral presentation)
02/11/2020 (Week 8)	Practical tools and models: Triple Bottom Line tool for the water industry	Assignment 3 briefing; **2nd Online Quiz**
09/11/2020 (Week 9)	Advanced analytical techniques of Industrial Ecology II (hybrid LCA)	Matrix Augmentation exercise; **3rd Online Quiz**
16/11/2020 (Week 10)	Industrial Ecology Practice (**Live** Online Webinar, attendance compulsory)	Hybrid LCA exercise; **Assignment 3 due**

ASSESSMENT

There will be no final examination in this course. Instead, there will be three online quizzes, worth 30% of the total course mark, one individual assignment (30%) with an individual presentation (10%) and one group assignment (30%). Details are shown below:

- **Quizzes (3x 10%)**: There will be three online quizzes throughout the course, each worth 10% of the total course mark. The quizzes will test the students' ability to synthesise the overall course, demonstrate understanding of main principles and implement them in given situations. They may include calculations. All material presented during the session will be examinable in the quizzes unless otherwise noted.
- **Individual Assignments (report 30% + presentation 10%)**: Each student will individually develop a research topic relevant to the course, conduct the research, and present the research in a journal-style paper (30% of total course mark) and an online video presentation (10%). The paper will be peer reviewed and marked by at least two other students and/or lecturers.
- **Group Assignment (30%):** Sustainability assessment of an engineering project (group assignment). Major assignment for small groups of students. Includes quantitative and qualitative evaluation, following the triple-bottom-line methodology. For the online group assignment (worth 30% of the total course mark) students must actively project-manage their group assignment works in order to gain a good mark. Students should expect to spend a significant amount of time working with their team online to develop their work.

Students who perform poorly in exercises and assignments are recommended to discuss progress with the lecturers during the semester. Note: The course coordinator reserves the right to adjust the final scores by scaling if agreed by the Head of School.

Details of each assessment component, the marks assigned to it, the criteria by which marks will be assigned, and the dates of submission are set out below.

Marking criteria: All assignments will be marked on the basis of whether the student demonstrates an understanding of the material. Where numerical errors can be identified as simple slips, penalties will not be as large as when errors appear to be a result of a conceptual misunderstanding, or the source of the error is difficult to determine from the working. The group assignment will be additionally assessed with respect to the depth of the analysis, the breadth of its consideration of the question at hand and the clarity of the way in which the answer is presented. The use of tables and diagrams is encouraged. **Please make sure you do not exceed the imposed page limits.**

PENALTIES

Penalties for late submissions of all assignments apply. Late work will be penalised at the rate of 20% per day after the due time and date have expired.

ASSESSMENT OVERVIEW

Item	Length	Weighting	Learning outcomes assessed	Assessment Criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
3 Quizzes	3 x 15mins	3x 10%	LO1, LO3, LO4, LO6	The quizzes will test the student's ability to synthesise the material taught, demonstrate understanding of main principles and apply them in a given context.	Wednesdays, 30 Sept, 4 Nov, 11 Nov 2020, 8pm	same day & time	same day & time
Assignment 1. Peer-reviewed research "paper" (individual)	6 pages	30%	LO1, LO2, LO6	A marking rubric based on the following criteria is made available to the students with the assignment: • Introduction / context / background (16.7%) • Methods & data section (16.7%) • Results/presentation/discussion (16.7%) • Presentation / formatting (16.7%) • Conclusions (16.7%) • Overall clarity and quality (16.7%)	Friday, 16 October 2020, 8pm	three days later	two weeks later
				Peer-marking of Assignment 1 deadline:	Friday, 30 Oct 2020, 8pm	same day & time	same day & time
Assignment 2. Oral presentation of research paper (individual, via video)	5 minutes	10%	LO2, LO3, LO6	A marking rubric based on the following criteria is made available to the students before the presentation: • Development and explanation of topic (25%) • Organisation and structure (specific introduction and conclusion, sequenced material within the body, and transitions; 25%) • Delivery (Use of technology, posture, gesture, eye contact, and vocal expressiveness; max. 25%) • Ability to answer audience questions (25%)	Friday, 30 Oct 2020, 8pm	one week later	two weeks later
Assignment 3. Sustainability assessment of an engineering project (group)	10 pages	30%	LO1, LO2, LO5, LO6	A marking rubric based on the following criteria is made available to the students with the assignment: • Abstract / introduction / background (10%) • Understanding of TBL/LCA Framework and application to water resources management (20%) • Description of three WSOs and the technologies involved (20%) • MCDA application, calculations and results (20%) • Final conclusions and consideration of uncertainty and future research needs (20%) • Overall clarity and quality (10%)	Monday, 16 November 2020, 8pm	one week later	two weeks later

RELEVANT RESOURCES

UNSW Moodle

All material required for this course will be provided on UNSW Moodle. It is compulsory for all students to access this resource: https://moodle.telt.unsw.edu.au/login/index.php

Textbook and Readings

There is not compulsory textbook for this course. However, we strongly recommend the following two:

- Murray, J. and Wood, R. (Eds.). 2010. ***The Sustainability Practitioner's Guide to Input-Output Analysis***. Common Ground Publishing LLC, Champaign, Illinois, USA. http://onsustainability.cgpublisher.com/product/pub.197/prod.3
  Note from the UNSW Bookshop: If you would like to order a copy, the book is printed to order locally in Sydney, so it would only take a week to supply.
- Peters, G. and Svanström, M. 2019. ***Environmental Sustainability for Engineers and Applied Scientists***. Cambridge University Press, Cambridge. https://doi.org/10.1017/9781316711408 [Available through UNSW Library at https://www.library.unsw.edu.au].

Readings will be posted on Moodle, unless a URL is provided in the syllabus. Students are required to be familiar with the required reading materials prior the class.

Useful literature

- Suh, S., ed. 2009. Handbook of Input-Output Economics in Industrial Ecology. Vol. 23, Series: Eco-Efficiency in Industry and Science: Springer. http://www.springer.com/earth+sciences/geostatistics/book/978-1-4020-4083-2
- Thijs ten Raa (Ed.) 2017 Handbook of Input–Output Analysis. Edward Elgar Publishing. http://dx.doi.org/10.4337/9781783476329
- Hoekstra, A. Y. and T. O. Wiedmann. 2014. Humanity's unsustainable environmental footprint. Science 344(6188): 1114-1117. http://dx.doi.org/10.1126/science.1248365
- Hellweg, S. and L. Milà i Canals. 2014. Emerging approaches, challenges and opportunities in life cycle assessment. Science 344(6188): 1109-1113. http://www.sciencemag.org/content/344/6188/1109.abstract
- Duchin, F. and Levine, S. H. 2014. Industrial Ecology. In: *Reference Module in Earth Systems and Environmental Sciences*, Elsevier. http://dx.doi.org/10.1016/B978-0-12-409548-9.09407-0
- Weisz, H., Suh, S. and Graedel, T. E. 2015. Industrial Ecology: The role of manufactured capital in sustainability. *Proceedings of the National Academy of Sciences*, **112**(20), 6260-6264. http://www.pnas.org/content/112/20/6260.short
- Dowling, D., A. Carew, and R. Hadgraft. 2012. *Engineering Your Future: An Australasian Guide*. 2nd Edition ed. Vol. November 2012. http://au.wiley.com/WileyCDA/WileyTitle/productCd-EHEP002525.html

Useful databases for academic journals (accessible via UNSW Library)

- http://www.sciencedirect.com
- http://www.scopus.com
- http://scholar.google.com

DATES TO NOTE

Refer to MyUNSW for Important Dates available at:

https://student.unsw.edu.au/dates

PLAGIARISM

Beware! An assignment that includes plagiarised material will receive a 0% Fail, and students who plagiarise may fail the course. Students who plagiarise are also liable to disciplinary action, including exclusion from enrolment.

Plagiarism is the unacknowledged use of other people's work, including the copying of assignments written by other students or material found on The Web. Plagiarism is considered a serious offence by the University and severe penalties may apply. Any plagiarism may be referred to the Head of School for further action.

When it is necessary or desirable to use other people's material you should adequately acknowledge whose words or ideas they are and where you found them (giving the complete reference details, including page number(s)). The Learning Centre provides further information on what constitutes Plagiarism at: **https://student.unsw.edu.au/plagiarism**.

ACADEMIC ADVICE

For information about:

- Notes on assessments and plagiarism;
- Special Considerations: student.unsw.edu.au/special-consideration;
- General and Program-specific questions: The Nucleus: Student Hub
- Year Managers and Grievance Officer of Teaching and Learning Committee, and
- CEVSOC/SURVSOC/CEPCA

Refer to Academic Advice on the School website available at:

https://www.engineering.unsw.edu.au/civil-engineering/student-resources/policies-procedures-and-forms/academic-advice

APPENDIX A

Definition of Industrial Ecology

Industrial ecology is a rapidly growing field that systematically examines local, regional and global materials and energy uses and flows in products, processes, industrial sectors and economies. The name industrial ecology was coined to emphasize how natural systems can serve as a model for designing sustainable industrial systems. Industrial Ecology places human technological activity – industry in the widest sense – in the context of the larger ecosystems that support it, examining the sources of resources used in society and the sinks that may act to absorb or detoxify wastes.

Industrial Ecology provides a solution-oriented engineering approach to environmental and sustainability problems. Robert White, the former president of the US National Academy of Engineering, summarised these elements by defining industrial ecology as "… the study of the flows of materials and energy in industrial and consumer activities, of the effects of these flows on the environment, and of the influences of economic, political, regulatory, and social factors on the flow, use, and transformation of resources" (White 1994).

The field Industrial Ecology has grown fast in the last years and now several initiatives are taken for education programmes in this area (ISIE flyer 2014). The Journal of Industrial Ecology (since 1997, published by MIT Press, http://mitpress.mit.edu/JIE) and the International Society for Industrial Ecology (since 2001, http://www.yale.edu/is4ie) give Industrial Ecology a strong position in the international scientific community. With the publication of a special section in the top journal *PNAS* in 2015, Industrial Ecology has become a mainstream field of research.

Rationale including Industrial Ecology in the Course Program

Industrial Ecology (and Sustainability Assessment) as an umbrella term and overarching subject is suitable for post-graduate teaching at UNSW for the following reasons:

- IE encompasses and summarises in one term topics and methods that are important to Environmental Engineering. It is based to on a life cycle perspective and on the analysis of materials and energy flows – both longstanding principles of teaching and research at UNSW.
- IE has a focus on industrial activities (viewing firms as agents for environmental improvement) which goes well with UNSW engineering background and relationship to industry.
- IE is not well established at Australian Universities – UNSW occupies an important niche of teaching and research. Internationally there are half a dozen Universities that have significant Master programs in Industrial Ecology.
- IE requires and is well suited for multidisciplinary and interdisciplinary research and analysis – these are increasingly required to solve complex problems.

Appendix B: Engineers Australia (EA) Competencies

Stage 1 Competencies for Professional Engineers

	Program Intended Learning Outcomes
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing
	PE1.3 In-depth understanding of specialist bodies of knowledge
	PE1.4 Discernment of knowledge development and research directions
	PE1.5 Knowledge of engineering design practice
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving
	PE2.2 Fluent application of engineering techniques, tools and resources
	PE2.3 Application of systematic engineering synthesis and design processes
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability
	PE3.2 Effective oral and written communication (professional and lay domains)
	PE3.3 Creative, innovative and pro-active demeanour
	PE3.4 Professional use and management of information
	PE3.5 Orderly management of self, and professional conduct
	PE3.6 Effective team membership and team leadership