1. Instructor and Teaching Assistants

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2. Course Description

The course is intended to introduce students to the interaction between the human and natural environment, focusing on how the anthropogenic activities have altered the natural environment and provide an overview on the emerging science of sustainability. This course will identify the impacts associated with resource consumption and environmental pollution, and present the quantitative tools that assess environmental impacts and can be used to design for sustainability. At the end of the course, the students are expected to be cognizant about the concept of sustainability, the metrics of sustainability and be able to use the principles of sustainability in their respective field of practice.

The Course Content and Recommended Readings are outlined below. As we progress through the class, some of these items may change or be rearranged to adjust for our progress or any updated information. Furthermore, some readings will be mandatory. You will be informed of these changes in class and via Canvas.

3. Key Learning Points

The key learning objectives include:
- Sustainability Indicators
- Earth Systems Engineering and Management
- Integration of the Environmental, Social, and Economic Issues
- Lifecycle Analysis
  - Lifecycle Inventory
  - Risk and Impact Assessment
- Material Flow Analysis
  - Urban Metabolism
- Target Plots That Can Be Used to Determine Chemical Safety
- Industrial Ecology
- Urban Sustainability / Infrastructure Ecology
- Dynamics of Sustainability in the Developed and Developing World
- Agent-Based Modeling
- Geoengineering
- Business Models of Sustainability

Engineering Working Definition of Sustainable Development:
Our socioeconomic system is far from sustainable and this may cause us guilt and perhaps frustration and so there may be a tendency to just give up. Consequently, we will use this definition for this class.
Roy F. Weston: “Sustainable Development is a process of change in which the
direction of investment, the orientation of technology, the allocation of resources, and
the development and functioning of institutions transition toward longer-term
sustainable activities. Longer term sustainable development will meet present needs
and aspirations without endangering the natural ecosystems and their capacity to
absorb the effects of human activities, and without compromising the ability of future
generations to meet their own needs and aspirations.”

A simpler working definition of sustainable engineering can be as follows:

Sustainable Engineering is the design of human and industrial systems such that they
ensure that humankind’s use of the natural resources and cycles do not lead to
diminished quality of life due to either losses in future economic opportunities or to
adverse impacts on social conditions, human health, and the environment.

These requirements reflect that social conditions, economic opportunity, and environmental quality are
essential if we are to reconcile society’s development goals with international environmental limitations.

4. Class Operation

This course involves active learning on part of the students. The class will be broken up into groups.
Each group will work together on homework and the final project.

Prerequisites:
This course is meant to be taken by both engineering and non-engineering students. It requires basic
mathematical skills, and the willingness to conduct quantitative analyses. Especially for the group
project, students with different backgrounds may be called upon to contribute in different ways.

Attendance:
Students should sign in at the beginning of each class. A sign-in sheet will be provided by the instructor.

Grading:
Homework and Class Participation 25%
Mid-term Exam 25%
Journal Article Critique 10%
Class Project* 40%
*The class project will be a group effort. Therefore, an individual’s class-project grade is contingent on
a participation “weight” that will reflect their contributions by anonymous evaluation of the
individual’s peers.

There will be no final exam in this course. The class project will take the place of the final
examinations.
Homework
Homework is to be done individually (unless stated otherwise) but you may certainly seek advice from your group and others.

Format:
- Unless the problems are very short, begin each problem on a new sheet.
- Always restate the problem indicating the given information, desired information, and explain your method. Make liberal use of comments.
- Make liberal use of sketches
- Always use units in your calculations and on graphs. For quantitative problems, please underline, box, or highlight the final answers
- Above all, BE EXTREMELY NEAT.

Journal Critique
The journal critique will be worked on individually. In this assignment, you will find a journal article on a sustainability topic, and use what you have learned in the course to discuss and criticize the content. The article you choose to critique must come from a peer-reviewed scientific journal that has been published within the past 5 years. You may use the library search engine to find some articles related to sustainability topics. A few journals are suggested in the syllabus. It's also easier if it's something you find interesting.

A few suggestions and guidelines to follow:
- Write between 500-600 words discussing the good points and bad points of the article.
- A 100-150 word summary on the article can provide a great amount of context. Don't write more than 150 words summarizing the article. This is not meant to be a summary, it's a critique.
- A good way to critique the article is also to compare it to results and methods of similar studies.
- Why did the results differ? How to the results agree?
- How did this article expand or fail to expand on a subject?
- How do the studies complement each other?
- Do NOT regurgitate their caveats.
- Papers submitted, longer than 600 words will not be graded (not including references).
- Submit the original article with your critique
- Try your best to use good english. Go to the student writing center if you need help http://www.communicationcenter.gatech.edu/
- Format: Double-spaced, 12-point Times New Roman
- Citation Style: Nature (Will be easy if you use Mendeley - Mendeley is a free reference manager)

Class Project
The class project is to be worked on as a group. This project represents a group effort and each group will submit a final report. Sustainable solutions will require coordinated collective efforts with stakeholders who have diverse opinions and objectives. The group projects should be considered an opportunity to explore this approach.
Your class project will be divided into three (3) parts. For each part, your group will make an 8 to 12-minute presentation and submit a short write-up (2-4 pages) that highlights your progress from the previous submittal. In one way, your final report will be a culmination of these three write-ups. A more detailed rubric for your three write-ups and your final report will be provided in the future.

Your final report should not be unnecessarily long (20 pages max, excluding references and appendices), but should contain the following elements:

**Abstract.** Most technical journals require abstracts which summarize the content of a paper in one paragraph (~200-250 words). The abstracts may be written in the form used in scientific journals. Please include concluding remarks in the abstract. A good format is: (1) background / motivation / problem (optional), (2) objectives, (3) scope (optional), (4) methods, (5) results, and (6) significance of results. Every statement in the conclusion should be capable of undergoing careful scrutiny. Be concise, clear, and direct.

**Introduction.** The introduction should provide the reader with a concise statement of the theoretical and rational basis. It would be appropriate to follow the form frequently used in scientific journals for the introduction and succeeding sections. The introduction should explain what you have done and what the reader is to expect in the following sections. In other words, tell the reader what you have done and the relationship between what has been done by others and your work.

**Materials and Methods.** The material and methods that were used to gather, analyze and synthesize a solution to the issue should be discussed in this section. If this section is written correctly, the results and discussion section will be more concise and will focus only on the presentation of the results and interpretation the results. Additionally, this section should contain the goal and scope definition and the Life Cycle Inventory (LCI) phase of the lifecycle assessment (LCA). The LCI data should be provided in the appendix, and not in the main body of the paper. Finally, you must include your LCA rationale – what particular method did you use, and why?

**Results and Discussion.** Results should be summarized, tabulated, or plotted neatly. Particular attention should be paid to the units employed. S.I. units are preferred. **Sample calculations should be shown in the appendix.** Also reference the 12 Principles of Green Engineering. This section of the report gives greatest insight into the integrity of the writers. It is very easy to over interpret results. Caution should be observed in interpreting the results and alternatives should be considered.

**Conclusion, Future Research and/or Investigation.** Most good investigations raise additional questions that cannot be addressed without additional time, talent and resources. The section should help focus the reader on what should be undertaken next. Your conclusion should be short paragraph about your recommendations and rationale without repeating what you stated in the results/discussion section.

**References Cited.** Please refer to the American Chemical Society guideline for the format that should be used and the manner in which references are cited

(http://pubs.acs.org/userimages/ContentEditor/1246030496632/chapter14.pdf).

**General Formatting.** To keep the report easier to read, keep a 1.5 line spacing. The report must be a maximum of 20 pages, excluding references and appendices. **Reports longer than 20 pages**
(excluding references and appendices) will be returned without grading. If a revised report is not resubmitted prior to the submission deadline, the report will be graded up to the 20th page, meaning that all sections that follow (e.g., results and conclusion) will not contribute toward your final score. Additionally, you will receive 10 marks off your final project grade.

**Figure Formatting.** Embed all tables and figures within the text. Do not provide them at the end of the main body of the paper. Make sure that the text in the figures, if any, is legible. The smallest font for embedded figures is size 9. REDRAW FIGURES IF NECESSARY. All figures and tables must be referred to in the main text body. We will discuss figures more in the class, but some examples are below.

**Example of a Bad Figure.** The following figure (Figure 3: Comparison of Midpoint Impacts) was submitted in a previous class report. Can you read any of the values? Can you read any of the categories? All fonts should be legible and easy to read, otherwise, your figure is useless. As you plot your figures, ask yourself, is this the best way to represent the data: do I need all this ink, can I read it, do the colors add to the representation of the data. Finally, the caption does nothing to tell me what is being shown on the figure. Captions should be descriptive and explain the figure, explain trends, and anything else that would make the understanding the figure easy.

![Figure 3: Comparison of Midpoint Impacts](image)


Notice that the caption is descriptive. The caption describes what each of the different layers signify in this plot (i.e., the dashed line, the solid bars, and the crosshatched pattern). Even though
the figure was reduced in size for the publication, it is still legible. The figure also makes use of patterns to add an extra layer onto the figure to show the additional change to emissions levels when existing buildings are also considered in the analysis. Finally, it makes use of different plot types (i.e., a line) to provide the reader with the baseline emissions for the study.

Criticisms. In retrospect, we should have chosen a sans-serif font, especially since it scales better (easier to read when resized to a smaller size). Moreover, some of the abbreviations used in the figure are described in the paper; however, should a person simply look at the figure, there is no explanation of what terms like MCG mean – this should have been reiterated in the caption. Finally, when printed in black and white, the dark purple and dark orange may be difficult to distinguish, making the use of color pointless for mass distribution.

![Figure 5](image)

**Figure 5.** Total annual CO₂ and NOₓ emissions of the 13-county Atlanta Metropolitan region, from energy consumption commercial and residential buildings for two growth scenarios. The dashed line represents the CO₂ and NOₓ emission levels in the base year (2005). The solid bars represent the total emissions for existing and new buildings when only new buildings have CCHP systems. The crosshatched pattern indicates the CO₂ and NOₓ emission levels if all buildings, existing and new, have CCHP systems.

Etiquette during classes, honor code, disabilities, and special arrangements
When you are in class you need to be focused: cellphones must be silenced and not used. Laptops and tables are allowed to take notes, but it is strictly forbidden to use them for other purposes. Each time a student is caught browsing the internet, emailing or following social media, her/his participation grade will be reduced by 5 percent.

All assignments and exams are strictly individual. Compliance with the Georgia Tech Academic Honesty Policy and Honor Code will be strictly enforced in the class. The text of the honor code can be found at: [http://www.deanofstudents.gatech.edu/integrity/page.php?acadcode.htm](http://www.deanofstudents.gatech.edu/integrity/page.php?acadcode.htm).

Plagiarism, fundamentally, is representing someone else’s work as one’s own. Reproducing (even a small piece) of someone else’s text exactly or restating someone’s original ideas without attribution is strictly prohibited. It is always appropriate to cite the source or to use a quotation with proper attribution. It is also appropriate to credit any charts, graphs or other graphics (pictures, etc.) if they are not original, including when they have been slightly modified from the original.

There is a zero-tolerance policy for any violations of these rules. All violations are reported to the Georgia Tech Office for Academic Misconduct. If you have a documented disability and wish to discuss academic accommodations, please contact me as soon as possible. Please also let me know if you are an athlete with special requirements.
### 5. Course Content

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## 6. Recommended Readings

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| 1, 2 | 2      | Energy and Climate Change | Chow, J., Kopp, R.J., Portney, P.R. Energy resources and global development. *Science* 2003, 302, 1528-1531.  
Kauppi, P; Sedjo, R; Technological and Economic Potential of Options to Enhance, Maintain, and Manage Biological Carbon Reservoirs and Geo-engineering, Chapter 4, *Climate Change 2001: Mitigation, IPCC Third Assessment Report*, 2001, 301-344  
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7. Useful Links

UN website:
http://www.un.org/esa/sustdev/index.html (UN Division of Sustainable Development)
http://www.unep.org/ (UN Environment Programme)

Indicators:
http://www.epa.gov/indicate/ (US EPA)
http://www.iisd.org/measure/ (International Institute for Sustainable Development)
http://themes.eea.eu.int/all_indicators_box (European Union)
http://themes.eea.eu.int/index_html#Sectors_and_activities (European Union)
www.sustainable-development.gov.uk/indicators/index.htm (United Kingdom)
http://www.epa.gov/iwi/ (Watersheds)
http://www.epa.gov/ost/biocriteria/index.html (Biocriteria)
http://www.worldbank.org/data/wdi2001/ (World Development Indicators)
http://www.met-office.gov.uk/research/hadleycentre/ (Climate Prediction & Research)

Construction:
http://www.rethinkingconstruction.org/ (Constructing Excellence)
http://www.cbpp.org.uk/ (Best Practices)
http://www.m4i.org.uk (Movement for Innovation)
http://www.ciria.org.uk/ (Indicators)

Waste:
http://www.epa.gov/osw/ (US EPA)
http://ewasteguide.info/ (Electronic Wastes)

Energy:
http://www.esource.com/public/default.asp (Energy Business Intelligence)
http://www.eren.doe.gov/ (Renewable Energy)
http://www.cee1.org/home.html (Consortium of Energy Efficiency)

LCA:
http://iac.rutgers.edu/database/ (14,000+ Assessment)
http://hpb-1a.nrel.gov/lcii/ (US LCI database)
http://www.epa.gov/nrmrl/lcaccess/ (US EPA)
http://www.life-cycle.org/ (LCA Links)
http://www.eiolca.net/ (CMU EIOlCA)

Listing of World Wide Environmental Agencies / NGO’s:
http://www.gemi.org/ (Global Environmental Management Initiative)
http://www.sustainablebusiness.com/ (Sustainable Business)
http://www.wbcsd.org/ (World Business Council on Sustainable Development)
http://www.ceres.org/ (Coalition for Environmentally Responsible Economies)
http://www.globalreporting.org/ (Global Reporting Initiative)
http://www.ulsf.org/  (University Leaders for a Sustainable Future)
http://www.sdcn.org/  (Sustainable Development Communications Network)
http://www.environmentalsustainability.info/  (Environment Portal & Search Engine)
http://www.secondnature.org/  (Second Nature – Sustainable Education)
http://www.sustainableliving.org/  (Sustainable Living Network)
http://www.ucsus.org/  (Union of Concerned Scientists)
http://www.epa.gov/oppt/greenengineering/  (The Green Engineering Program)
http://www.epa.gov/dfe/  (Designing for Environment Program)
http://www.epa.gov/cpg/  (Comprehensive Procurement Guidelines Program)
http://www.epa.gov/sectors/  (The Industry Partners Program)
http://www.epa.gov/epaoswer/hazwaste/minimize/  (The P2 Program)
http://www.epa.gov/oppt/p2framework/  (The Product Stewardship Program)
http://www.epa.gov/epaoswer/non-hw/reduce/epr/  (The P2 Program)

Sustainability-related Journals:
http://pubs.acs.org/journal/esthag  (Environmental Science & Technology)
http://www.elsevier.com/locate/jclepro  (Journal of Cleaner Production)
http://www.elsevier.com/locate/ecolecon  (Ecological Economics)
http://www.elsevier.com/locate/energy  (Energy)
http://www.elsevier.com/locate/enpol  (Energy Policy)
http://www.elsevier.com/locate/jenvman  (Journal of Environmental Management)
http://www.springerlink.com/content/100370  (Environmental Management)
http://www.springerlink.com/content/120154  (Sustainability Science)
http://www.elsevier.com/locate/resconrec  (Resources, Conservation and Recycling)