Sustainability in Civil Engineering CE G9800 / CE 59903 /
Sustainable Infrastructure SUS 7800B

Instructor: Prof. Nir Krakauer (nkrakauer@ccny.cuny.edu, 212-650-8003)
Office hours: Tu 3-5 (or by appointment)
Course website: https://nirkrakauer.net/classes/sustain/
3 hrs./wk., 3 cr.
Weekly readings are on the course website
Spring 2023: Tu 6:30-9:00, Shepard S-203

Objectives:
1) Understand the major impacts of contemporary and historic infrastructure on planetary energy, water, and nutrient flows, biodiversity, and climate
2) Appreciate the principles behind widely-used sustainability measures, know some of their applications, and be aware of their limitations
3) Recognize the physical basis, promises, and limitations of key emerging/innovative technologies to meet human needs sustainably
4) Develop awareness of nontechnical factors that influence design and construction choices as relevant to sustainability
5) Prepare an engineering design to address sustainability concerns
6) Discover resources for further collaboration and training in an area of interest related to civil engineering for sustainability.

Topics by week (approximate):
1) Introduction and overview: Global challenges in historical perspective; sustainability as today's engineering imperative; what does sustainability mean?; some examples, definitions, concepts
2) Thermodynamics: Forms of energy; heat and temperature; the First Law of Thermodynamics; work and exergy; entropy; Second Law; adiabatic and isothermal processes; heat engine efficiency; energy carriers; energy density
3) Ecology: Solar and thermal radiation, the greenhouse effect, weather; transformations of energy by life; greenhouse gas sources; observed and predicted global warming impacts; strategies to limit climate-changing emissions (mitigation); adaptation; geoengineering; ecological footprints
4) Engineered systems: Industrial ecology; life cycle analysis; footprint analysis; system boundaries
5) Energy Supply: Fossil fuels, solar-based, and geothermal systems; origin, history, availability, current applications, prospects; energy storage, demand management
6) Water Supply: Water requirements; the water cycle; water stocks and flows; water collection and storage; desalination – *project proposal due*
7) Waste: Wastewater contamination and purification; public health and ecology impacts; solid waste management; zero-waste approaches
8) Agriculture: Agroecology; soil erosion; nutrient loss; synthetic fertilizer; irrigation; greenhouse gas and climate impacts
9) Building: Materials and methods; building comfort; passive solar; solar water heating; building integrated photovoltaics; green building; LEED and other standards
10) Work on project
11) Transportation: Growth and impact by mode; fuels and energy sources; reducing demand (walkable communities, localization) – *project first draft due*
12) Implementing sustainability: Transition theory (paradigms, barriers, niches, crises); changing governments, professional associations, corporations, households; finance
13-14) Make project presentations

Grading is based on class participation and presentations (20%), short essay assignments (20%), term project (40%), and a take-home final exam (20%).

Class participation and presentations: This class will be of most value if everyone completes the readings and contributes from their experience and knowledge to the discussion. Questions and comments are encouraged during lecture. Everyone will take turns leading discussions based on your choice of a recent article or other item that relates to the previous or current week's topic. When it's your turn to lead a discussion, prepare a few slides highlighting what you see as the most relevant or interesting aspects and a few questions that can serve as a jumping-off point for discussion; plan for a total of about 15 minutes of presentation and discussion.

Short essays: Each week, you will be asked to solve quantitative problems or write short reaction essays of about 1-2 pages based on some of the readings. The essays should touch on how the readings related to material we've previously discussed and/or to what you learned elsewhere. Try to build on what classmates already posted, if possible. Upload your assignments on the Blackboard discussion forum before class starts. Assignments will be graded based on whether you engage with the readings and with previously-covered class material and make valid use of quantitative analysis whenever appropriate.

Term project: Consider a specific engineering project (proposed, under construction, or implemented – it can be one you have been involved in or know about from colleagues or from the news media) intended to solve a particular problem, or compare two or more alternative plans or proposals for solving a problem. Based on the principles discussed in the course, you should study the problem and the proposed or implemented solution(s) from a sustainability point of view. Your analysis should be quantitative (including appropriate measures such as life-cycle energy efficiency, greenhouse gas emissions, cost, etc.) and integrative (consider several sustainability-related aspects of a single project). You'll submit a written report (at least 15 pages double-spaced), and give a 15-minute talk in one of the last class sessions to summarize your project and main findings. Your report should aim to be of the quality of a consulting engineer's report to a client, with all sources properly cited (follow the ASCE guidelines) and with attention to spelling and typography. A team may work together on a single project; in that case, your written report should be correspondingly longer and include an introductory page specifying who worked on what, and you'll give a longer team presentation.

The term project must include a dissemination component, such as submitting an article to a newspaper or journal, giving a talk to a general audience, or writing an Appropedia article based on your findings. In your report, you should summarize the dissemination activity you carried out and give copies or links to it.

The project process will start with submitting a 1-2 page project proposal and arranging to meet with the instructor during office hours to discuss your topic. The next step will be to write a first draft, including all sections and main arguments, and submit it to the instructor for comments. Due dates and procedures for each step will be given in class.

Some possible general topics for projects:
Municipal or agricultural water supplies
Dam/reservoir construction or removal
Small-scale water purification
Concentrating solar thermal
Electricity or heat storage methods
Integration of renewable energy in the power grid

Green roofs
Net-positive buildings
Community disaster resilience
Open-source architecture or engineering designs

Final exam: This will include some short essays and quantitative problems similar to the assignment questions and possibly also based on the term project presentations.