Engineering Faculty Document No. 84-19
March 6, 2019

TO: The Faculty of the College of Engineering
FROM: The Division of Environmental and Ecological Engineering
SUBJECT: New Undergraduate Course, EEE 38000, Environmental Chemodynamics

The Faculty of the Division of Environmental and Ecological Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

EEE 38000: Environmental Chemodynamics
Sem. 2, Lecture 3, Credits 3
Prerequisites: MA 26100, D- or better

Course description:
Introduction to chemical thermodynamics and general equilibrium processes in environmental and ecological engineering systems. Introduction to the first and second laws of thermodynamics; properties of pure substances; ideal and real gases; thermodynamic cycles and processes; heat transfer and combustion; and chemical equilibrium in aquatic solutions, including equilibria between phases and reaction equilibria. Emphasis is on understanding and conceptualizing important processes, and competency in thermodynamic calculations.

Reasons: Environmental and Ecological Engineering students need knowledge of thermodynamics in the context of environmental systems.

John W. Sutherland

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John W. Sutherland, Professor and Fehsenfeld Family Head
Division of Environmental and Ecological Engineering

EEE 38000: Environmental Chemodynamics (EFD 84-19)

Level: Undergraduate

Course Instructor(s): Inez Hua or Chad Jafvert

Course Outline:

Part 0. Introduction
- A. Course guidelines and objectives
- B. Review of units and unit conventions

Part 1. Molecular Structure and Nomenclature
- Environmental Organic Chemistry
  - A. Orbitals, and hybrid orbits, the 4 quantum numbers
  - B. Types of functional groups, classes of pollutants

Part 2. Environmental Chemodynamics
- Gibbs Free Energy and the definition of the appropriate standard state
  - A. Free energies of formation
  - B. Relationships between chemical potentials, Gibbs excess partial free energy, and equilibrium constants.
  - C. Ideal and Real Gases – Henry's Law and Raoult's Law
  - D. The Relationship between kinetic and equilibrium constants
  - E. Types of equilibrium reactions involving inorganic species
  - F. Solving systems of equations (equilibrium problems)
  - G. Redox Reactions – Relationships between pε, E_H, and Gibbs Free energy
  - H. pε- pH diagrams (why do reactions occur in certain environments)
  - I. Applications to Biological Systems
  - J. Biological Cycles (TCA and electron transport)

Part 3. Thermodynamics
- I. Thermodynamic Systems Definitions (Chapter 1, Moran et al.)
- II. First Law of Thermodynamics (Chapter 2, Moran et al.)
  - A. U, H, W, Q relationships and definition of Cp and Cv
- III. Chemical Properties (Chapter 3, Moran et al.)
  - A. Properties of Ideal and Real Gases
  - B. Properties of pure substances (i.e., compressibility)
- IV. Second Law of Thermodynamics
  - A. Reversible vs. irrev. processes, Entropy, Carnot Cycle (Chapters 5 & 6, Moran et al.)
  - B. Processes (P, V, T, S, relationships, Maxwell relations (Chapter 11, Moran et al.)
  - C. Other Cycles (Refrigeration, Rankine, etc. (parts of Chapters 8, 9, 10, 12 in Moran))
- V. Heat Transfer and Combustion
  - A. Conduction, Convection, Radiation (Chapter 2 Moran et al.)
  - B. Combustion (Chapter 13)

Case Studies
- A. The flow of energy in an anaerobic digester
- B. Energy efficiency in aerobes compared to iron bacteria, sulfate reducers, etc.
- C. The energy content of different fuels.
- D. Life (or the lack there of) on Mars.
- E. Other applications

Course Objectives:

The course directly supports these EEE Program Outcomes (for undergraduate majors):

1. An ability to apply knowledge of mathematics, science, and engineering.
2. An ability to identify, formulate, and solve engineering problems.
3. A knowledge of contemporary issues.

Learning Outcomes:

1. Apply the First and Second Laws of thermodynamics to closed and open systems.
2. Understand, identify, and quantify the environmental impacts of closed and open systems, based on mass and energy transfer.
3. Analyze full-scale systems, and compare actual and theoretical operation.
4. Understand the structure and reactivity of environmentally relevant organic compounds.
5. Calculate concentrations of different components in equilibrium and non-equilibrium environmental systems.

Textbooks and readings:
Recommended textbook: Fundamentals of Engineering Thermodynamics (8th Edition), Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, Margaret B. Bailey.

Grading:

a) Homework assignments (20%)
b) Final exam (30%)
c) Term Project (30%).
d) Class participation and in-class work (20%)

Previous Teaching:

This course has been taught as EEE 39500EC each spring semester since 2016.
Enrollment Spring 2016 = 41
Enrollment Spring 2017 = 29
Enrollment Spring 2018 = 42
Enrollment Spring 2019 = 41