CENG S150E Engineering Improv:

An introduction to engineering analysis.

Class schedule: MWF 6:30-8:00pm
Instructor: Michael Loewenberg
Email: michael.loewenberg@yale.edu

Teaching Fellow: TBA
Email: TBA
Recitation: TBA

Description:

Mathematical modeling is not a scripted procedure. Models are constrained by physical principles, including conservation laws and experimental observations but this does not provide a closed description. There is a lot more art in mathematical modeling than is commonly acknowledged and improvisation plays a significant role. The artistic aspects are important and intellectually engaging because they often lead to a deeper understanding.

This course provides a general introduction to engineering analysis and to chemical engineering principles. Material will include the derivation of governing equations from first principles and the analysis of these equations, including underlying assumptions, degrees of freedom, dimensional analysis, scaling arguments, and approximation techniques. The goal of this course is to obtain the necessary skills for improvising mathematical models for a broad range of problems that arise in engineering, science and everyday life. Students from all majors are encouraged to take this course.

Prerequisites: derivative and integral calculus, high school chemistry.

Texts:
Chemical Engineering, An Introduction,
Morton M. Denn, Cambridge.
ISBN 9781107669376.
https://dl.icdst.org/pdfs/files1/ae44fd68aa54af0e29f1112974fd0522.pdf

Chemical Engineering Design and Analysis, An Introduction,
T. Michael Duncan & Jeffrey A. Reimer, Cambridge.
ISBN 9780511803352 (first edition)
ISBN 9781108421478 (second edition)

Exams, homework, and in-class work

4 non-cumulative weekly tests, 60% (15% each)
4 weekly problem sets, 20%
class participation, 20%

Class Website

Log in to the Yale Canvas website with your netID to access lecture videos and lecture notes, problem sets and reading assignments, and other handouts.

Course Expectations

Classes (and active class participation) is essential for learning how to setup and solve the assigned problems. You will be expected to study online course materials (watch videos, read lecture notes and assigned readings) in advance of each class. Collaboration on problem sets is encouraged. The weekly tests are closed book and closed notes.

Topics

1. Mass conservation; constitutive equations.
2. Dimensional analysis; dimensionless variables.
3. Characteristic scales; scaling arguments.
4. Buckingham Pi theorem.
5. Degrees of Freedom.
6. Species conservation; well-mixed systems.
7. Stagewise processes; recycle streams.
8. Chemical reactions, reactors.
9. Energy conservation; first law of thermodynamics; flow processes.
10. Entropy; thermodynamic efficiency; engines and refrigerators.
11. Mass, energy, and momentum fluxes; diffusion.
12. Heat, mass, and momentum transport.

Syllabus

Week 1: June 7-11

Introduction. Mass conservation, constitutive relations: liquid level in tank. characteristic time and level, dimensionless variables. Buckingham Pi theorem.
Species conservation (multicomponent systems), degrees of freedom. Well-mixed systems: Indoor air pollution, Filtration (or dialysis). Recycle streams; stage-wise processes.

Class 1	M 6:30-8:00pm
Class 2	W 6:30-8:00pm
Class 3	F 6:30-8:00pm

Week 2: June 14-18

Problem set 1 due.	W 11:59pm

Species conservation with sources: chemical kinetics. Batch reactors, plug-flow reactors, stirred-tank reactors. Residence time, extent of reaction, yield.

Class 4	M 6:30-8:00pm
Class 5	W 6:30-8:00pm
Test 1	F 6:30-8:00pm

Week 3: June 21-25

Problem set 2 due.	W 11:59pm

Energy conservation: internal energy, enthalpy, heat capacity. Energy conservation equation for flow processes.
Entropy. Thermodynamic efficiency: engines, refrigerators, & heat pumps.
Cyclic processes.

Class 6	M 6:30-8:00pm
Class 7	W 6:30-8:00pm
Test 2	F 6:30-8:00pm

Week 4: June28-July2

Problem set 3 due. W 11:59pm

Buckingham Pi theorem. Dimensionless parameters. Interpretation of experiments. Introduction to heat, mass, and momentum transport. Diffusive transport. Characteristic length and time scales.

Class 8	M 6:30-8:00pm
Class 9	W 6:30-8:00pm
Test 3	F 6:30-8:00pm

Week 5: July 5-9

Problem set 4 due. W 11:59pm

Scaling arguments; order-of-magnitude estimates. Solving steady-state transport problems. Similarity solutions.
Review for test 4.

Class 10	M 6:30-8:00pm
Class 11	W 6:30-8:00pm
Test 4	F 6:30-8:00pm