Engineering Faculty Document No. 41-23
December 2, 2022

TO: The Faculty of the College of Engineering
FROM: The Division of Environmental and Ecological Engineering
SUBJECT: New Graduate Course, EEE 55000 Physico-Chemical Processes In Environmental Engineering I; and cross-list with CE 55000 Physico-Chemical Processes In Environmental Engi-neering I

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 55000: Physico-Chemical Processes In Environmental Engineering I
Sem. 1, Lecture 3, Credits 3
Prerequisites: no

Course description:
Students in this class will learn fundamental principles of physico/chemical processes that are commonly used by Environmental Engineers. Examples will be given from many applications, but the emphasis will be on water and wastewater treatment. The principles that are taught in this class have broad application in Environmental Engineering, and in other disciplines. As such, the focus will be on fundamental concepts, so as to prompt their application in a wide range of settings, encourage questions and discussion, and to promote creativity.

This course has been taught has CE 55000 for a number of years.

Reasons: Creating a new course.

John W. Sutherland

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

EEE 55000: Physico-Chemical Processes In Environmental Engineering I (EFD 41-23)

Level: Graduate

Course Instructor: Ernest Blatchley III

Course Description
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Learning Outcomes & Learning Objectives

1. Learn fundamental principles of physico/chemical processes that are commonly used by Environmental Engineers with an emphasis on water treatment.
2. Understand principles that have a broad application in Environmental Engineering and other disciplines.
3. Focus on fundamental concepts so as to prompt application in a wide range of settings and to promote creativity.

Previous Teaching:
This course has been taught as CE 55000. What follows is the total enrollment and EEE portion of it.

Fall 2022 – total enrollment 9 with 5 EEE students
Fall 2021 – total enrollment 15 with 8 EEE students
Fall 2020 – total enrollment 6 with 3 EEE students
Fall 2019 – total enrollment 7 with 4 EEE students
Fall 2018 – total enrollment 14 with 9 EEE students

The syllabus for Fall 2022 follows.

CE/EEE 55000 Fall 2023; CE 550-EPE; CE 550-OL1
Physico/Chemical Processes of Environmental Engineering
Online

Instructor:	E.R. Blatchley III	HAMP 2129
	Ph. 40316	email = blatch@purdue.edu

Office Hours/Recitation: Thursdays 7-8 PM (eastern time zone; U.S.); Zoom
Thursdays 9-10 AM (HAMP 2129)

Required Text: Montgomery/Watson/Harza (MWH) (2012) *Water Treatment: Principles and Design, 3rd Edition*, John Wiley & Sons, New York.

Recommended Text: Stumm, W. and Morgan, J.J. (1996) *Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters*, John Wiley & Sons, New York.

Course Objectives: Students in this class will learn fundamental principles of physico/chemical processes that are commonly used by Environmental Engineers. Examples will be given from many applications, but the emphasis will be on water and wastewater treatment. The principles that are taught in this class have broad application in Environmental Engineering, and in other disciplines. As such, the focus will be on fundamental concepts, so as to prompt their application in a wide range of settings, encourage questions and discussion, and to promote creativity.

Grading Policy: 3 exams @ 20% each; quizzes 15% (see below); homework 25%. A semester composite score will be developed for each student based on this algorithm. The mean of these composite scores will define the A/B cutoff; the width of each grade zone will be defined by the standard deviation of semester composite scores. Therefore, students with a composite score above the mean will receive an A; students with a composite score below the mean by not more than one standard deviation will receive a B; students with a composite score between one and two standard deviations below the mean will receive a C, and so on. Assignments turned in late will be penalized 10% per day or fraction thereof (unless prior consent has been given, see below). Grade appeals on assignments (homework, quizzes, exams) must be made within one week of an assignment being returned to you. Grade appeals must be made by direct communication with the instructor.

Homework: Homework assignments will be distributed electronically, usually on Fridays. Assignments will usually be due one week after the assignment is given, and must be submitted electronically. Instructions for submission of assignments will be given electronically. Students are welcome to work on homework individually or in groups, but each student must turn in their own work. The computer is a tool that you will probably use often for these assignments. You will have considerable freedom to choose among software platforms and computer-based methods for solving problems. However, it is your responsibility to provide a clear indication of how the computer was used by you in completing these calculations, in the form of example calculations, clear descriptions of equations or algorithms, etc. As a guideline, you should provide as part of your homework assignment enough detail about the methods you used to conduct the calculations to allow a peer to repeat (reproduce) your work. For homework assignments, as well as all other assignments given in this class, it is expected that students will report answers with an appropriate number of significant digits.

Quizzes: Quizzes will be given on (roughly) a weekly basis. Quizzes will be pre-announced and will be distributed electronically, usually on Fridays. Quizzes will be timed assignments, meaning that students will have a pre-defined period of time to upload their quiz solutions electronically from the time the quiz is downloaded.

Exams: Three exams will be given in the class, each of which be focused on material from a course module (see class schedule below). The first exam will focus on fundamental tools used in process engineering (Module 1); the second exam will focus on physical separation processes (Module 2); the third exam will focus on interphase transfer and transformation processes (Module 3). Exams will be timed assignments, meaning that students will have a pre-defined period of time to upload their exam solutions electronically from the time the exam is downloaded.

Participation Policy: Students are expected to view and take notes from all recorded lectures. Files used to prepare lecture content will be made available to students, usually in the form of a PowerPoint file. Students are encouraged to use these files as an aid while taking notes from recorded lectures. A recitation section is scheduled for Wednesdays (7-8 PM, eastern time); recitations will be held on zoom to provide opportunities for on-campus and off-campus students to meet together with the instructor. Recitations will provide students with opportunities to ask a wide range of questions, including any issues related to lecture materials, course assignments, quizzes, exams, or applications of material from class. Participation in recitations is optional, but strongly encouraged.

Class Schedule: A tentative listing of topics and their order of presentation for the class is presented on the following pages. It is the responsibility of students to keep up with this schedule. Students are welcome to view lecture videos at any time and as often as you like; the schedule below indicates the timing for when videos should be reviewed to stay on-track with course assignments.

Fall 2022, CE 550 Tentative Course Outline (subject to change). File names used to build recorded lectures, in the forms of video recordings and accompanying PowerPoint files, are defined using the subsection-unit as defined below. Dates listed in left column are target dates to complete viewing and note-taking from the videos.

Please note that suggested readings from Stumm & Morgan are intended as supplementary information. You will benefit by reading these materials, but they are not a requirement to capture the basic concepts that are presented in this class.

Date	Subsection	Units	Suggested Readings
22 August	Introduction	Course Content and Introductions; Teaching Philosophy; Course Logistics and Grading Policies; Course Philosophy; Examples of Contemporary Environmental Problems; Categories of Processes	MWH Chapters 1-4 Stumm & Morgan Chapter 1
24 August	Mass Balances	Fundamental Definitions, Terminology, and Basic Forms; Methodical Approach to Mass Balance Problem Solving	Handout MWH Chapter 7 Stumm & Morgan Chapter 5
26 August	Fundamental Transport Phenomena	Definitions; Advection; Diffusion; Dispersion	
29 August	Interphase Transport	Formal Definition; Examples of Interphase Transport Processes; Concepts Involved in Interphase Transport of Heat; Hooke's Law Analogy to Interphase Transport	
31 August		Gas-Liquid Transfer, Two-Film Theory; Dynamics in a Semi-Batch Reactor	
2 September	Reaction Kinetics	Kinetic Expressions I; Kinetic Expressions II	Handout MWH Chapter 5, 6 Stumm & Morgan Chapter 2
5 September	**Labor Day: No Classes (University Holiday)**		
7 September	Basic Reactor Models	Reactor Models Overview; Batch Reactor; Ideal CFSTR; Ideal CFSTR at Steady-State; Conversion in an Ideal CFSTR	
9 September		Ideal PFR; Ideal PFR at Steady-State; Conversion in an ideal PFR	
12 September		CFSTR Cascade; PF with Longitudinal (Axial) Dispersion, Assumptions, Schematic, Model Development; Plug Flow with Longitudinal Dispersion; Model Interpretation and Implications	
14 September	Residence Time Distribution Functions	RTD Concept; RTD Characteristics	
16 September		Experimental Methods, Pulse $(\bar{C})$ Test; Experimental Methods, Step (F) Test; Experimental Methods, Data Interpretation	
19 September	Reactor Simulation Methods	Segregated Flow Model; Numerical Models **End of Module 1**	
21 September	Solid: Fluid Separation Processes	Basic Principles; Particle Characterization	Chapter 10
23 September	Gravity-Based Separation	Gravity Separation; Type I: Discrete Particle Settling; Turbulent Settling and Laminar Settling; A Note on Drag Forces	
26 September	**Exam #1**		
28 September	Ideal Settling Tank Model	Model Characteristics, Assumptions; Trajectory Approach; Particle Separation Efficiency; Model Assumptions and Limitations	
30 September	Centrifuges	Overview; Ideal Centrifuge Model	
3 October	Coagulation/ Flocculation	Basic Principles; Particle Surface Chemistry I; Particle Surface Chemistry II; Colloidal Stability	MWH Chapter 9 Paper by Stumm and O'Melia (1968) Stumm & Morgan Chapter 9 (esp. section 9.5)
5 October		Colloidal Destabilization Mechanisms; Coagulation with Metal Salts; Jar Testing Background; Jar Test Results	
7 October		Flocculation Basics; Smoluchowski Equation; Collision Frequency Functions; Fluid Shear	
10-11 October	**October Break: No Classes (University Holiday)**		
12 October	Coagulation/ Flocculation	Paddle Flocculators and Jar Test Apparatus	MWH Chapter 9
14 October	Filtration	Filter Types; Slow and Rapid Sand Filters; Filter Media	MWH Chapter 11
17 October		Isolated Single Sphere Model; Contact Efficiency; Filter "Window"; Filter Modeling	

19 October		Flow Through Porous Media; Energy Losses Through Porous Media	
21 October		Fluidization; Effects of Size Classification; Practical Issues **End of Module 2**	
24 October	**Exam #2**		
26 October	Adsorption	Basic Principles; Langmuir Isotherm; BET Isotherm	MWH Chapter 15 Stumm & Morgan Chapter 9 (especially sections 9.1-9.3)
28 October		Process Dynamics, Practical Issues	
31 October	Ion Exchange	Basic Principles; Media Types; Equilibria and Selectivity	MWH Chapter 16
2 November		Ion Exchange Dynamics; Ideal Ion Exchange Behavior, Deionization	
4 November	Disinfection	Basic Principles; Characteristic of Microbial Pathogens; Multiple-Barrier Concept; Indicator Organisms	
7 November		Halogen Equilibria; Halogen Electrochemistry; Effective Henry's Law Constant	
9 November		Substitution Reactions Between Chlorine and Ammonia; Redox Reactions Between Chlorine and Ammonia	
11 November		Chloramination and Breakpoint Chlorination; Simulation of Chloramination and Breakpoint Chlorination	MWH Chapters 13, 19 The subject of disinfection processes relies heavily on the principles of reactor theory discussed earlier in the class. However, currently available texts do not adequately cover this topic. As a result, supplementary readings will be provided to augment this portion of the course.
14 November		DBPs; Dechlorination	
16 November		Fundamental Chlorine Disinfection Kinetics; Deviations from Chick-Watson; Chlorine Disinfection Process Dynamics	
18 November		Disinfection with Peracids; Physical Chemistry of Peracids; Mechanisms of Disinfection with Peracids; Practical Aspects of Disinfection with Peracids	
21 November		Fundamental Principles and the Laws of Photochemistry; Photochemical Kinetics	
23 November	**Thanksgiving Break: No Classes (University Holiday)**		
25 November			
28 November	Disinfection	Fundamental UV Disinfection Kinetics; Deviations from Single-Event Model	MWH Chapters 13, 19 Stumm & Morgan Chapter 12
30 November		UV Dose Distribution Concept; Simulation of UV Disinfection	
2 December	Gas: Liquid Transfer	Equilibrium Principles in Gas: Liquid Systems; Henry's Law	MWH Chapter 14 plus additional reading
5 December		Two-Film Model; Air Stripping	
7 December		Air Stripping Process Dynamics; Air Stripping Process Behavior	
9 December	**Review Session (Zoom)**		
10-16 December	**Exam #3, Date TBD**		

In the event of a major campus emergency, course requirements, deadlines and grading procedures are subject to changes that may be necessitated by a revised semester calendar or other circumstances. Information about these changes to this class will be communicated by e-mail.