UNIVERSITY OF CALIFORNIA, MERCED
ENVE 176 – Water and Wastewater Treatment (3 units)
Spring 2017
CLSSRM 263, MW 2:00-3:20 pm

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Office Hours: M 3:30-5:00 pm SE1 210, or by appointment

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I. Course Description: The course focuses on biological wastewater treatment – a branch of environmental engineering that examines the applied science and engineering of the treatment of wastewaters using microorganisms. The course is split into four sections including: (1) Introduction to Wastewater Treatment and Characteristics; (2) Sedimentation; (3) Biological Wastewater Treatment; and (4) Anaerobic Treatment and Treatment Wetlands. Specific topics covered in the class include: reactor kinetics, mass balance analysis, biochemical oxygen demand, sedimentation, microbial energetics, aerobic activated sludge treatment, nitrification and denitrification, anaerobic digestion, and treatment wetlands.

II. Course Goals and Outcomes:

a. ***Course Goals:*** The general goals of this course are tied to the educational objectives of the Environmental Engineering program at UC Merced. The first goal is to enhance student's fundamental knowledge of wastewater engineering through application of basic math, science and engineering principles. The second goal is to enhance student's critical thinking skills through the application of engineering principles and reasoning to solve wastewater related problems. The third goal is to enhance basic design skills of students in the context of wastewater treatment unit processes including sedimentation, activated sludge, anaerobic digestion, and treatment wetlands. Students will achieve these goals through a rigorous program of lectures, reading, in-class problems, homework sets, exams, and field trips.

b. ***Learning Outcomes:*** Select learning outcomes are listed below. Specific learning outcomes tied to course lectures are listed in the course schedule at the end of the syllabus. By the end of this course, you will be able to:

- Develop and solve mass balance equations for batch and completely mixed reactors with zero, first and saturation kinetics.
- Describe key physical, inorganic, organic and biological constituents in wastewater.
- Perform calculations related to biochemical oxygen demand in wastewater.
- Use Newton's Law and Stokes' Law to assess particle settling.
- Design a primary sedimentation basin.
- Describe microbial processes including aerobic respiration, anaerobic respiration and fermentation.
- Estimate biomass yield and oxygen requirements for aerobic treatment systems based on stoichiometry and energetics.
- Design a completely mixed activated sludge process.
- Calculate key anaerobic digestion metrics including sludge production and methane production.
- Design a single-stage high-rate anaerobic digester.
- Describe key removal mechanisms for nitrogen and phosphorus in wetlands.
- Design a treatment wetland to remove nitrogen and phosphorus from secondary effluent.

III. Course Format: The course is mainly structured as interactive lectures in which material is presented in real time on the board by me, with students being asked to help explain and interpret the lecture material. Lectures will be supplemented with PowerPoints of key figures and tables from the text book. During select class periods, students will perform example problems from the text on the board. Course material will be made available in a timely manner via CatCourses. Students are strongly encouraged to ask questions during lectures and share any insights or appropriate comments they may about the lecture material.

The course is tightly structured around the required text book (Wastewater Engineering: Treatment and Resource Recovery, 5th Edition), so it is important that students have the text book. In addition, it is critical that students do assigned reading before lectures. Reading is needed to prepare for daily questions, a set of questions that students will be randomly asked during lecture. Finally, it is important for students to engage with the course material by taking notes (i.e., copying down what is put on the board and what is said by the professor and students) as the lectures unfold. Finally, work load expectations are around 2.5 hours per week per course unit. Thus you are expected to study around 7.5 hours per week outside of class time for this 3 unit course.

IV. Course Requirements:

a. ***Class attendance and participation policy:*** Your active participation during lecture is a critical component of the course and is important to both its success and your ability to learn course material. To optimize your learning effectiveness, it is critical that you take detailed notes during lecture as we develop and discuss course material on the board. Your discussions in class, your response to daily questions, your effectiveness at doing in-class problems, your note taking activities, and your attendance will be recorded. Course participation will be worth 10% of your grade. The following rubric will be used to assess your level of participation in the course:
   - Excellent (A): Regularly makes thoughtful and appropriate contributions to discussions that seek to broaden understanding and application of material. Actively taking detailed notes and engaged in lectures. Minimal absences.
   - Good (B): Occasionally makes thoughtful and appropriate contributions to discussions that seek to broaden understanding and application of material. Actively taking detailed notes and engaged in lectures. Occasional absences.
   - Fair (C): Infrequently makes contributions to discussions with only a basic attempt to broaden understanding and application of material. Taking some notes and passive engagement with lectures. Modest number of absences.
   - Poor (D/F): Almost never makes contributions to discussions with superficial or off-topic comments that do not broaden understanding and application of material. Taking no notes and not engaging with lectures. Frequent absences.

b. ***Course readings:*** Wastewater Engineering: Treatment and Resource Recovery, 5th Edition, Metcalf & Eddy/AECOM, 2014. The soft cover two volume international edition is acceptable as long as it is the 5th edition. This book is mandatory for the class. Perform the assigned reading before lectures and in consultation with the daily questions so that you are prepared to answer the daily questions in class.

c. ***Course assignments and projects:*** Course assignments and projects include: (i) daily questions, (ii) in-class example problems, (iii) four homework assignments, (iv) three course exams, and (v) two fieldtrips. These are outlined below.
   - Daily Questions (DQs) related to upcoming lecture topics will be distributed to the class prior to lectures. DQs are meant to help students understand what material in the text to focus on, as well as prepare for lectures and exams. During lecture, random students will be

asked to address DQs and the quality of responses will be recorded and applied to your course participation grade.

- During some lectures, students will solve example problems from the text book in class on the board (see course schedule at end of syllabus for dates). Students will be told in advance that they are responsible for a given problem. All students will also turn in a written solution to the example problem on the day that the problem is worked out in class. Performance on your in-class examples, both on the board and in written form, will be reflected in your course participation grade.
- Students are responsible to submit four intensive homework assignments, corresponding to the four sections in the course, on the due dates noted on the course schedule at end of syllabus: Section 1 homework due Feb. 8; Section 2 homework due Feb. 27; Section 3 homework due April 10; Section 4 homework due May 3. No late assignments will be accepted. Start the assignments early, work with other students within the constraints noted below in the Academic Integrity section, and meet with me and Byran in office hours to discuss questions related to the assignments before they are due. Homework accounts for 15% of your grade.
- The course includes three exams, each worth 25% of your final grade, as detailed in the course schedule at end of syllabus for dates. Exam 1 (March 1) will cover Sections 1 and 2. Exam 2 (April 12) will cover section 3. Exam 3 (May 6) will cover Section 4. Students will be allowed one page of notes for each exam (8 ½ inches by 11 inches). Students are expected to take all exams at the scheduled time. Failure to do so will result in an exam score of zero.
- We will also have two mandatory field trips, one to the City of Merced municipal wastewater treatment plant near the beginning of the course and another to an industrial wastewater treatment plant at the Gallo Winery facility in Livingston near the end of the class. More details on the field trips will be given at a later date.

V. Grading Procedures: Final grades will be estimated based on the following breakdown: class participation, 10%; homework, 15%; three exams, 75%. Note that you must get 73% or higher on the exam component of the course to get a C or better in the class. Final grades will be assigned on the following standard scale. I may adjust the scale accordingly at the end of the semester to ensure that an appropriate allocation of grades is obtained.

97 to 100	A+	87 to 89.9	B+	77 to 79.9	C+	60 to 66.9	D
93 to 96.9	A	83 to 86.9	B	73 to 76.9	C	below 60	F
90 to 92.9	A-	80 to 82.9	B-	70 to 72.9	C-		

VI. Academic Integrity:

a. Each student in this course is expected to abide by the University of California, Merced’s Academic Honesty Policy. Any work submitted by a student in this course for academic credit will be the student's own work.

b. You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else, in the form of an electronic or hard copy. Should copying occur, both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Policy can also be extended to include failure of the course and University disciplinary action.

c. During examinations, you must do your own work. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

VII. **Accommodations for Students with Disabilities:** The University of California Merced is committed to ensuring equal academic opportunities and inclusion for students with disabilities based on the principles of independent living, accessible universal design and diversity. I am available to discuss appropriate academic accommodations that may be required for student with disabilities. Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances. Students are encouraged to register with Disability Services Center to verify their eligibility for appropriate accommodations.

VIII. **Tentative Course Schedule**: See the following two pages for a detailed course schedule. Note that key weekly learning outcomes linked to course activities are also listed. The schedule is subject to change.

IX. **Commercial Use of Course Materials.** All course materials are my intellectual property and are protected by copyright. Selling course material or notes through commercial services, without my written advance permission, may be viewed as copyright infringement and/or an academic integrity violation.

ENVE 176 Spring 2017 - Course Schedule

Week	Day	Lecture Topic	Key Learning Outcomes	Text Reading	Daily Question	Student In-Class Problems and Homework
Week 1 Jan 16-20	**Section 1. Introduction to Wastewater Treatment and Characteristics**					
	W	Course Introduction; Introduction to Wastewater Treatment	(1) Describe the USEPA minimum national standards for secondary treatment. (2) Draw a schematic of a conventional biological wastewater treatment system.	1-1 to 1-6		
Week 2 Jan 23-27	M	Mass Balance Analysis	(1) Develop mass balance governing statement for a batch and completely mixed reactor. (2) Describe in mathematical terms zero-order, first-order and saturation kinetics. (3) Solve mass balance for a given reactor and kinetics scenario.	1-7 to 1-11	DQ1	
	W	Mass Balance Analysis		1-7 to 1-11	DQ2	**Mass balances in DQ2**
Week 3 Jan 30-Feb 3	M	Wastewater Properties; Inorganics; Nitrogen; Phosphorus; Metals	(1) Describe a key physical, inorganic, organic and biological constituent in wastewater. (2) Describe common forms of nitrogen and phosphorus found in wastewater. (3) Describe typical types of microorganisms and indicator organisms found in wastewater.	2-1 to 2-5	DQ3	
	W	Organics; Biological Constituents		2-7 to 2-10	DQ4	
Week 4 Feb 6-10	M	Biochemical Oxygen Demand; Chemical Oxygen Demand	(1) Define and calculate BOD, COD and ThOD. (2) Develop and apply the equation for BOD exerted as a function of time. (3) Describe how BOD5 is measured and perform calculations required to implement a BOD5 analysis.	2-6	DQ5	**Example 2-9: BOD values; Example 2-10: Theoretical oxygen demand**
	W	BOD Class Project		2-6	DQ6	**Section 1 HW Due**
Week 5 Feb 13-17	**Section 2. Sedimentation**					
	M	Screening; Flocculation; Settling	(1) Derive and apply Newton's Law and Stokes' Law for settling particles. (2) Use overflow rate to predict the percent particle removal in a settling basin. (3) Describe the three types of settling for flocculent particles.	5-1 to 5-4	DQ7	**Example 5-4: Settling velocity**
	W	Settling; Grit Removal		5-4 and 5-5	DQ8	**Example 5-5: Sedimentation removal efficiency**
Week 6 Feb 20-24	M	Presidents Day Holiday				
	W	Primary Sedimentation	(1) Calculate surface loading rate and detention time for a primary sedimentation basin. (2) Design a primary sedimentation basin. (3) Estimate BOD and TSS removal in a primary sedimentation basin.	5-6	DQ9	
Week 7 Feb 27-Mar 3	M	Primary Sedimentation; Review		5-6	DQ10	**Example 5-9: Sedimentation basin design; Section 2 HW Due**
	W	**Exam 1**				
Week 8 Mar 6-10	**Section 3. Biological Wastewater Treatment**					
	M	Suspended and Attached Growth Processes; Microorganisms	(1) Compare and contrast suspended growth and attached growth processes. (2) Define microbial metabolism terms such as chemo-, hetero-, auto-, and litho-trophic. (3) Compare and contrast aerobic respiration, anaerobic respiration and fermentation.	7-1 to 7-3	DQ11	
	W	Microbial Growth and Energetics		7-4	DQ12	**Example 7-1: Biomass yield and oxygen consumption**

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Week	Day	Lecture Topic	Key Learning Outcomes	Text Reading	Daily Question	Student In-Class Problems and Homework
Week 9 Mar 13-17	M	Microbial Growth and Energetics	(1) Estimate biomass yield and oxygen requirements from stoichiometry. (2) Estimate biomass yield from bioenergetics. (3) Develop equations for substrate utilization rate and net biomass growth rate.	7-4	DQ13	**Example 7-3: Biomass yield using energetics**
	W	Microbial Growth Kinetics		7-5	DQ14	**Example 7-5: Biomass and solids yields**
Week 10 Mar 20-24	M	Suspended and Attached Growth Treatment; Aerobic Oxidation	(1) Describe the stoichiometry and growth kinetics of aerobic biological oxidation. (2) Describe the attached growth process. (3) Develop biomass and substrate mass balances for the activated sludge process.	7-6 to 7-8	DQ15	
	W	Suspended Growth Treatment		7-6	DQ16	
		Spring Recess & Cesar Chavez Holiday, March 27-31				
Week 11 April 3-7	M	Suspended Growth Treatment	(1) Design a completely mixed activated sludge (AS) process. (2) Calculate AS metrics including F/M ratio, sludge production, and oxygen requirements. (3) Describe the nitrogen treatment processes nitrification, denitrification and anammox.	7-6	DQ17	**Example 7-6: CMAS design**
	W	Nitrification; Denitrification; ANAMMOX		7-9 to 7-11	DQ18	
Week 12 Apr 10-14	M	Review				**Section 3 HW Due**
	W	**Exam 2**				
Week 13 Apr 17-21		**Section 4. Anaerobic Treatment and Treatment Wetlands**				
	M	Anaerobic Fermentation and Oxidation	(1) Describe the three steps in anaerobic oxidation of wastes. (2) Calculate key anaerobic digestion metrics including sludge production and methane production. (3) Design a single-stage high-rate digester.	7-14	DQ19	
	W	Anaerobic Treatment		13-9	DQ20	**Example 13-5: Single-stage high-rate digester**
Week 14 Apr 24-28	M	Anaerobic Treatment	(1) Estimate heating requirements for an anaerobic digester. (2) Describe the three main types of treatment wetlands. (3) Calculate residence time and hydraulic loading rate for a treatment wetland.	13-9	DQ21	**Example 13-7: Digester heating**
	W	Treatment Wetlands		Mitsch Text	DQ22	
Week 15 May 1-5	M	Nitrogen Removal in Treatment Wetlands	(1) Describe key removal mechanisms for N and P in a treatment wetland. (2) Use a loading curve to size a treatment wetland. (3) Use P-k-C* model to design a treatment wetland to remove N and P from wastewater.	Mitsch Text	DQ23	
	W	Phosphorus Removal in Treatment Wetlands; Review		Mitsch Text	DQ24	**Section 4 HW Due**
	Exam 3, Saturday, May 6, 11:30-2:30 pm					