

## BE 4341: BIOLOGICAL REACTOR SYSTEMS DESIGN

- 2012-13 Catalog Description:** Microbial and biochemical principles used in design of biological reactors for biotransformation; metabolic output and cellular production; design of batch and continuous flow reactors utilizing microbial kinetic models; attached and suspended growth systems and eukaryotic and prokaryotic cells.
- Credit:** 3 hr Credit. 2 hrs. lecture; 3 hrs. lab.
- Prerequisites:** BIOL 2051 and BE 4352.
- Required Textbook:** None required. Partial notes will be passed out before each class. Lecture and lab material may also be posted on moodle (<http://moodle.lsu.edu>). Completed lecture videos from classroom instruction will also be available on moodle.
- References:**
- Asenjo, J. and Merchuk, J. 1995. Bioreactor Systems Design. Marcel Dekker, Inc. NY. ISBN:0824790022
  - Bailey, J., and Ollis. D. 1986. Biochemical Engineering Fundamentals. 2nd Edition, McGraw-Hill, New York, NY. ISBN 0070032122.
  - Van Riet, K. and Tramper, J. 1991. Basic Bioreactor Design. Marcel Dekker, Inc. New York, NY. ISBN 0824784464.
  - Minjnbeek, G., Oosterhuis, N.M.G., Siebel, M.A., van Dam-Mieras, M.C.E., van Der Heijden, R.T.J.M., 1992. Bioreactor Design and Product Yield. Butterworth-Heinemann Ltd. Boston, MA. ISBN 0750615095.
  - Tchobanoglous, G. and Burton F.L. 1991. Wastewater Engineering: Treatment Disposal and Reuse, Metcalf and Eddy Inc. 3<sup>rd</sup> edition. McGraw-Hill, New York, NY. ISBN 0070416907.
  - Standard Methods for the Examination of Water and Wastewater, 20th Edition, APHA, AWWA, WEF, Washington, D.C., 1998. ISBN 0875532357.
- Class Schedule:** **Lecture:** 10:30–11:20 A.M. M, W, Room 115 EB Doran  
**Laboratory:** 1:30–4:20 P.M. Wed 142 Ag. Metal Bldg
- Instructor:** Chandra S. Theegala, Associate Professor, Bio. and Ag. Engineering  
Office Location: Room 161, E.B. Doran Bldg.  
Office Phone: 225-578-1060  
Office Hours: 11:30 AM – 12:30 PM Wednesday  
10:30 AM – 11:30 PM Tuesday  
Other times are ok – Please schedule before you come.  
E-mail: [theegala@lsu.edu](mailto:theegala@lsu.edu)
- Teaching Assistant:** Beatrice Terigar  
Room 102-A2, AgMetals Bldg  
Phone: 578-1086  
Bio. & Ag. Engr. Dept.  
Email: [bterig1@lsu.edu](mailto:bterig1@lsu.edu)
- Student Helper:** TBA

## Purpose of the Course

This is a senior/graduate level course designed to help the students learn to integrate the principles of microbial growth kinetics with the design of biological reactor systems used in wastewater treatment, bioprocessing and biotechnology. The students will also gain relevant hands-on experience through laboratory experiments and project.

## Course Objectives:

1. To introduce students to the general principles, applications and major types of biological reactors.
2. To develop the ability to model and design most commonly used biological reactors.
3. To allow students to gain hands-on experience with biological measurements and several biological reactors.

## Course Topics and Class Schedule\*:

Week of	Lecture Topics (Tue & Thur 10:30 AM)	Laboratory (Wed 1:30PM )
8/20/12	Course description, objective, class schedule, exams/grading, and policies. Biological reactor introduction (definitions & concepts) and bioreactor terminology. [TSS-OD lab - biomass quantification]	Introduction and safety video. Basic lab principles and calculations. Transport Course – Prerequisite material review <sup>#</sup> .
8/27/12	Microorganism classification, useful microbes, microbial composition, bioreactors operation concepts [Statistics review <sup>#</sup> for labs].	Biomass Determination: TSS and Optical Density. Results Summary
9/03/12	<b>Labor Day Holiday September 3<sup>rd</sup> (Monday).</b> Nutritional requirements and nutrient cycles. Biochemical oxygen demand (BOD), chemical oxygen demand (COD), substrate determination. [VSS/Cell Count lab – biomass quantification]	Biomass Determination: VSS and Cell Counts. Results Summary
9/10/12	Bioreactor related stoichiometry. [TRS lab – substrate quantification]	Substrate Determination: TRS. Results Summary.
9/17/12	Microbial metabolism and related biochemistry review <sup>#</sup> . [COD lab –substrate quantification]	Substrate Determination: COD. Results Summary.
09/24/12	Kinetics review <sup>#</sup> . Mass balances, Monod's and substrate limited kinetics, fed batch reactors, models and problems. Exam review. <b>Exam 1 – 9/26/12 (Wed). Swap Lab &amp; Lecture.</b>	Computer Automation/ Data Acquisition for Reactors. No Report or Summary.
10/01/12	Continuous stirred tank reactors, kinetics, models, and problems. [Batch reactor lab]	Batch Productivity. Results Summary.
10/08/12	Plug flow reactors, CSTRs in series, kinetics, models and problems. [Continuous reactor lab]	CSTR Productivity. Results Summary.
10/15/12	Reactor systems with recycle, kinetics, models contaminant mitigation. [Stella modeling lab] <b>Fall Holiday (18<sup>th</sup> -21<sup>st</sup>) – no effect on class.</b>	Bioreactor Modeling. No Report or Summary (just printout).
10/22/12	Oxygen transfer kinetics in reactors. Sterilization. [Product formation lab]	Product Formation. Results Summary.
10/29/12	Exam review. [Data acquisition for bioreactors] <b>Exam 2 – 10/31/12 (Wed). Lab/Lecture swap.</b>	Photobioreactors. Results Summary. Optional Lab.

11/05/12	Attached growth reactors. [ <i>Project report and presentation format</i> ].	Work on Project.
11/12/12	Bioreactor applications. Advanced topics.	Work on Project.
11/19/12	Wastewater treatment applications. <i>Thanksgiving Holiday (Wed 21<sup>st</sup> 12:30 PM– 25<sup>th</sup>)</i>	No Lab.
11/26/12	Wastewater treatment applications. Final exam review. Project presentations.	Project Presentations. Field Trip
12/03/12	<b>Final Exam: Monday Dec 5<sup>th</sup>, 2012. 12:30 – 2:30 PM</b>	

\*Note: Instructor reserves the right to alter the schedule during the course of the semester. However, any alterations will be clarified in the class.

# Review will cover quickly a lot of topics you learned earlier in other courses. However, complete notes will be provided. Students are responsible for reading/learning the material covered in notes.

[*Italics*] Lab related coverage in lecture class.

### Important Dates to Remember:

Aug 28: Last day to drop w/o “W” grade.

Aug 29: Last day to add courses and make section changes.

Nov 2: Last day for resigning from the University and/or dropping courses (with “W”)

Dec 1: Last Day of Class

### Exam Schedule:

According to Fall 2012 Class Schedule:

Final Exam Date: Monday, December 5<sup>th</sup>, 2012. Time: 12:30 – 2:30 PM

Tentative Dates for Exam I and Exam II:

Exam I: Sep 26<sup>th</sup>, 2012.

Exam II: October 31<sup>st</sup>, 2012.

### Grading Scale:

90 - 100%	A
80 - 89%	B
70 - 79 %	C
60 - 69 %	D
Below 60%	F

### Grading Policy:

1.	Homeworks (~5%), Quizzes (announced and un-announced ~10) and Attendance/ Participation (~5%)	20%
2.	Exam I	20%
3.	Exam II	20%
4.	Lab Participation* and Lab Results Summary Sheets** (6 One-Page Results Summary Sheets, Individual Effort)	6%
5.	Project Report (8%)/Presentation (6%) (Group)	14%
6.	Final Exam #	20%

\*\*\*\*\*

100%

\* Will include attendance, readiness for lab, lab safety compliance, and cleanup.

\*\* Templates will be provided to save you time on lab reports and one page summary sheets.

# Note: Instructor reserves the right to make the final an optional final, or alter the final exam grades to accommodate a lab final exam or design problem.

(e.g.: Final = 15%, Lab Final Exam 5%)

## **Course Policies:**

**Attendance Policy:** Attendance is expected. Lateness beyond 5 minutes will be considered absent. Regular lateness will not be allowed, unless you have a valid excuse. Attendance and class participation will carry up to 4-5% of grade (at instructor's discretion). Attendance in lab will also be counted. Regular sleeping/napping in class period will be considered as absent (zero participation). Texting or attending to non-class related work during class period will be considered as absent. Use of laptops or ipads or similar equipment during lecture must be justified.

**Submission Policy:** Homework, results summary sheets, and project report must be turned in regularly and will be due on the due date announced (usually before the beginning of a class period). The format for the results summary sheets and project report will be discussed in class. Penalty for late submission will be 5% for each working day (valid until graded assignment is returned).

**Make-up Exam/Quiz/Lab Policy:** No make-up exams or quizzes will be given for scheduled exams/quizzes unless the student has a legitimate excuse documented properly (e.g. letter from court clerk that he/she must appear in a court, or a letter from a physician stating that he/she is/was sick). If you know that you will be missing a class or lab, let me know in advance. Notification ahead of time is very important! You have to work with TA for making up a missed lab.

**Graduate Students:** Graduate students will be required to prepare a relevant presentation and/or handout that will be useful for the entire class. Depending on the topics of the graduate students' lectures, the instructor will decide if that particular material is valid for the exam.

**Academic Misconduct Policy:** Cheating and plagiarism will not be tolerated. The Code of Student Conduct defines cheating and plagiarism. I suggest each of you obtain a copy of this document and be familiar with its contents (<http://saa.lsu.edu/code-student-conduct>). If you have any questions/concerns about plagiarism, feel free to ask me. It is my professional, ethical obligation, as a faculty member to uphold its standards. I take this responsibility seriously and will forward the case to respective officials at LSU. Keep in mind that as a faculty I can only report (cannot take things into my hands)

**Disruptive Behavior Policy:** Absolutely no cell phones and texting. Avoid going in and out during class. Any behavior that will disturb the attention of fellow students or instructor should be avoided. Texting during class is not allowed and repeat violators may be penalized on the class participation component on the grade as decided by the instructor.

**Lab Safety:** The laboratory is potentially dangerous. A concise set of safety rules is given below. Additionally, the TA will go over safety related issues. Safety rules will be strictly enforced. Violations of safety rules can lead to dismissal from the laboratory. In case of an accident call Campus Safety or Emergency for help (contact numbers given below). All accidents (even minor ones) are to be reported to Dr. Theegala or Ms. Beatrice Terigar or department's front office staff immediately.

### **Contact Numbers: Emergency: 911**

Campus Safety: 578-5640

LSU Emergency Help: 578-4357

Dr. Theegala: 578-1060

Ms. Beatrice Terigar: 578-1086

### **Safety Rules**

1. Never add water to acid.
2. Wear safety glasses at all times.

3. Wear lab coat or appropriate clothing in the lab (no sandals, no shorts).
4. Never mouth pipette.
5. Use boiling beads to avoid spill over when doing distillation.
6. All volatiles, explosives, strong acids or bases must be handled only in the fume hood. Wear gloves while handling these compounds.
7. Do not work alone in the lab.
8. Do not eat, drink, or smoke in the lab.
9. Keep working area clean.
10. No horseplay.

***Other Helpful Information (No particular order)***

- Use a 1" or 1.5" ring binder for keeping class material (front for lecture; back for lab handouts).
- Focus on coverage in class. All tests will be based on the material covered. Study guide for each exam will be handed to you.
- Try to understand the concept. Not just the problem solved in the class.
- Do not feel shy to ask a simple or basic question. I strongly believe in proper foundation. (Last semester, I discussed my views on this subject).
- Turn all homework assignments, lab results summary sheets, and project report on time.
- Do not count on curving at the end (jump clear). Do not shoot at the low end of a particular grade (Example: shoot for 85 or higher instead of 80 for a B).
- Keep track of your grade. Ask for excel calculator after midterm if need help computing your present grade. Also, you are required to keep the graded quizzes, homework assignments, exams till the semester is over.
- Every single point counts and will add to your grade. So pay attention to homework assignments, quizzes, exams, project report/presentation, and attendance.
- You are required to keep exams, quizzes, homework assignments, and lab reports/summaries till the semester is over. I will need proof if you dispute a grade at the end.
- Understand the instructors teaching philosophy (will discuss in class) and past grades.
- Moodle and emails will be used extensively for this course. So learn to use it (announcements, downloading course material, discussion forums, etc). Make sure you have provided the correct email address.
- All lab related topics will be covered in the lecture class before the lab. However, do not expect the labs and lectures to be perfectly coordinated. This is due to the fact that we cover significantly more topics in the lecture class (labs are basic ones – biomass quantification, substrate quantification, and basic reactors). Furthermore, aligning the lecture coverage with lab will affect the flow.
- Templates for lab results summary will be provided. Mainly to have uniformity and save you time.
- Results summary sheets will be graded by the TA. All lab results summary sheets will be due on the second Wednesday after the lab (14 days time from lab, in lecture class).
- You are expected to know basic biochemistry/microbial metabolism, biological kinetics (covered in BE 4352) and basic statistics. Notes will be provided. But these topics will not be covered in detail in class. However, certain portions may be included on the exam or quiz.
- You are expected to know basic chemistry and chemistry lab procedures. We need this for bioreactor related stoichiometric calculations.

- Pay attention to what you learn in the lab. You are expected to do all the experiments independently without your group member's (or members') help. .
- May not cover everything in class handout on the same day. Will slow down if needed.
- Read lab handout before lab. May be tested with a quiz. Important.
- Be on time to class (especially "regularly late" students). You will lose attendance.
- Will not be allowed to turn in lab summary sheet if you were absent to the lab. You have to makeup a missed lab. You have to work with the TA.
- What did the previous students say? Time and topics.
- Remember the labs are "biological" labs and hence do not expect perfect results like chemistry or electrical labs.
- STELLA software (modeling) and DASyLab (data acquisition) software will be used. Basics will be taught in lab or class period.
- Planning to include: Field trips and mammalian cell culture lab, Time??