BE 460

Bioreactor Design and Analysis

Spring 2008

CRN 88908

MWF 13:30 – 14:20; Ag Sci 220

Course Objective

To provide the basic principles of reactor design for bioprocess, biotech, and biomedical applications. This course emphasizes on two interconnected topics: (1) bioreaction kinetics and (2) bioreactor engineering. Upon completion of the course you are expected to:

- comprehend the state of the arts in **bioreactor technology** and its broad range of applications
- develop mathematical descriptions of **reaction kinetics** in enzymatic and cellular systems and their relationships with bioreactor design
- grasp the linkage between **biological phenomena and engineering design** for effective bioreactor operations
- apply basic principles of **mass and energy conservation** to analyze bioreactor systems
- identify the major **engineering parameters** that characterizes the performance of bioreactors and techniques to **measure and control these parameters**

Catalog Description

BE 460 Bioreactor Design and Analysis (3) Application of mass/energy balances and reaction kinetics for the design and analysis of bioreactors for microbial, plant, and animal cell cultures. Pre: 373, CEE 320 or ME 322; or consent. DP

Instructor

Dr. Wei Wen Su
Ag Sci 415O, Tel. 956-3531
e-mail: wsu@hawaii.edu
Office Hour: by appointment (call or e-mail first)

TA

Mr. Kimo Phan: khuyen@hawaii.edu; x69917

Text

- Bioprocess Engineering Principles, by Pauline M. Doran, Academic Press, 1995
- Lecture notes

Course Grade

Grades for the course will be assigned on the following basis:

Two exams	30% each
Design project*	20%
Homework	15%
Attendance	5%

All assignments MUST be turned in by the due date. Failure to comply will result in no grade being assigned.

* design and analysis of polymerase chain reaction (PCR) reactor

Tentative Lecture Schedule

No. of lectures	Topic	References
1	Overview	Chap 1; notes
2	The "bio" in bioreactor design: Intro to microbiology, biochemistry, and molecular biology pertinent to bioreactor design	notes
2	Chemical kinetics: molecularity; elementary vs. non-elementary reactions; Derivation of rate equations; Arrhenius law	Chap 11; notes
1	Enzymes: Introduction	Chap 11; notes
1	Enzymes: Immobilization technology & applications	Chap 11; notes
1	Utilization of enzymes in pretreatment of lignocellulosic biomass for biofuel production	notes
3	Enzyme kinetics: Quasi-steady state vs. rapid equilibrium approaches; Evaluation of kinetic constants; Inhibition of enzymatic reactions	Chap 11; notes
2	Temp.-dependency in enzymatic reactions; Enzyme deactivation	Chap 11; notes
1	Polymerase chain reaction	notes
2	Growth kinetics, kinetics of substrate consumption and product formation	Chap 4,11; notes
4	Cellular metabolism, energetics, stoichiometry, metabolic flux analysis	Chap 4,11; notes
2	Basic bioreactor concepts: Ideal reactor analysis - integrating kinetics with mass & energy balances; model simulation	Chap 4,13; notes
2	Unsteady state mass & energy balances – analysis of bioreactor dynamics	Chap 6; notes
	Exam I	
2	Mass transfer in bioreactors	Chap 9; notes
2	Immobilized bioreactors: mass transfer and kinetics	Chap 12; notes
1	Heat transfer	Chap 8; notes
2	Bioreactor sterilization	Chap 13; notes
2	Instrumentation and control	Chap 13; notes
1	Bioreactor dissolved O_2 & T control: a case study	Chap 13; notes
2	Mixing in bioreactors: mixing time and residence time distribution (RTD)	Chap 7; notes
1	Gas-hold-up; power input calculation	Chap 7; notes
2	Scale up	Chap 7; notes
1	Review	

Course Learning Objectives

	Upon completing this course, the student will be able to:	Level†	BE Outcome‡
i.	apply principles of mass/energy conservation and force balance to derive differential equations for a system	M	a)
ii.	understand the relationship between free energy, entropy, internal energy, and enthalpy	M	c)
iii.	use models of a process to identify the most salient characteristics governing system behavior	M	e)
iv.	understand fundamentals of cell structure and metabolism	D	b)
v.	solve basic problems in kinetics and kinematics	M	d)
vi.	recognize and define the problem to be solved	D	d)
vii.	write structured code to simulate a system	D	f)
viii.	objectively discuss the problem and the merits of possible solutions	D	g)
ix.	formulate an effective strategy for action	D	g)
x.	organize the content of a document according to the informational needs and technical background of audience	M	i)
xi.	communicate facts supported by evidence and/or sufficiently detailed explanation	D	i)
xii.	submit written work without errors in spelling, punctuation, and usage	M	i)
xiii.	understand the social, cultural, political, and environmental impacts of biological engineering practice	D	j)
xiv.	independently research scientific literature and engineering references	D	k)
xv.	understand the role Biological Engineers face in addressing societal challenges	D	l)

† I = Introductory; D = Developmental; M = Mastery.

‡ UH Biological Engineering Course Outcomes:

a) The graduate has the ability to solve problems involving differential equations.

b) *The graduate has the ability to solve physics problems involving mechanics, electromagnetics, and optics; chemistry problems involving inorganic and organic chemistry; problems involving general and micro-biology*.

c) The graduate has the ability to solve engineering problems related to statics, dynamics, fluid mechanics, and thermodynamics.

d) *The graduate has the ability to design a system, component, or process in which biology plays a significant role*.

e) The graduate has the ability to design and conduct experiments to gather information for engineering designs.

f) The graduate has the ability to use modern engineering techniques, skills, and tools to define, formulate, and solve engineering problems.

g) The graduate has the ability to function effectively on multi-disciplinary teams.

h) *The graduate has the ability to identify professional and ethical responsibilities when practicing engineering*.

i) The graduate has the ability to communicate effectively in large and small groups.

j) The graduate has the background to understand the impact of engineering solutions on the surrounding context.

k) The graduate recognizes the need to engage in life-long learning through participation in professional conferences, workshops, and courses, and by reading and writing in the relevant literature.

l) The graduate has the ability to intelligently discuss contemporary issues.