UNIVERSITY OF GUELPH

ENGG*4380 BIOREACTOR DESIGN (3, 2)

Winter 2011

Instructor: V.J. Davidson **Office**: Room 2333, Thornbrough
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Lectures: Mon., Wed., Fri. 1:30 -2:20 pm (MACK 308)
Design Lab: Tuesday 3:00 – 4:50 pm (SCIE 2101)
Assignments/Due dates: See "Assessment" section

Course Description:
Bioreactors are controlled environments for microbiological and biochemical reactions that generate value-added products or breakdown waste streams. Typical processes include fermentations to produce antibiotics, wine and yoghurt, enzymatic reactors to create ingredients such as high fructose corn syrup and natural bio-systems such as composting operations and biofilters. Bioreactor design requires the integration of microbiology, biochemistry, process engineering and economic analysis. The aim of bioreactor design is to generate product(s) with specific quality attributes at minimum cost.

ENGG*4380 introduces biological engineering students to modelling and design of batch and continuous bioreactors based on biological growth kinetics and mass balances. Additional design topics include: energy and gas-transfer, instrumentation and scale-up. Finally reactor design is integrated with upstream and downstream processing operations using commercial software tools.
Prerequisite: ENGG*3160 Biological Engineering Systems II

Objectives:
Students who successfully complete this course will be able to:

1. Describe and specify reactors used in industrial bioprocesses.
2. Develop mathematical models for bioreactors, analyse their behaviour (dynamic and steady state) and specify operating parameters.
3. Design complete bioreactor systems integrated with upstream and downstream processing operations.
4. Use modelling and simulation tools to evaluate costs and environmental impact of a complete bio-process.

Topics:

1. Introduction to bioreactor design

2. Modelling reaction kinetics (quick review of basics + more complex models)
   - kinetics of cell growth
   - enzyme kinetics
   - estimating kinetic parameters

3. Ideal bioreactors
   - stirred tank reactors
     - batch operation
     - continuous (reactors in series, reactors with recycle)

4. Industrial operations
   - process design & scale-up
     - large-scale reactors
     - sterilization & containment – sanitary design
     - energetics and gas transfer
     - instrumentation & control
     - economics
   -GMP and process validation

5. Biotech industries – case studies
   1. Bioproducts from renewable resources - biodiesel production from soybean oil
   2. Antibiotics/biopharmaceuticals – monoclonal antibody production

Textbook:
Mosier, N.S. and Ladisch, M.R. 2009. "Modern Biotechnology: Connecting Innovations in Microbiology and Biochemistry to Engineering Fundamentals" , John Wiley & Sons, Inc.

Some additional references

Bioprocess Engineering Principles Pauline Doran, Academic Press, London, 1995.
Bioprocess Engineering Basic Concepts (2nd edition) 2002. Michael L. Shuler and Fikret Kargi, Prentice Hall, Upper Saddle River, NJ
Biochemical Engineering. Harvey W. Blanch and Douglas S. Clark. Marcel Dekker, Inc. 1997.
Biochemical Engineering Fundamentals. 2nd edition. James E. Bailey and David F Ollis. McGraw-Hill 1986.
Chemical Reaction Engineering. 2nd edition. O. Levenspiel. John Wiley and Sons, Inc., New York 1972.
Basic Bioreactor Design. K. van't Riet and J. Tramper. Marcel Dekker, Inc., New York 1991.

Assessment:
Design Assignments (individual): There are four assignments that include calculations for different aspects of bioreactor analysis and design. Design lab time is available to work on the assignments, consult with the instructor and make use of software tools on the School's network. Assignments are due on the following dates: **January 26, February 9, March 16 and March 30.**

Case studies (pairs): Use software tools to evaluate two commercial-scale bioprocesses: biodiesel production from soybean oil and monoclonal antibody production. Specific details for

each assignment will be provided in class.
Case study due dates: **February 28 and April 8**.

Design assignments (4)	60 %
Case studies (2)	40 %
TOTAL	100 %

Note:
Requests for academic consideration because of illness or of a compassionate nature must be made in writing and accompanied by certification whenever possible.