DEPARTMENT OF CHEMICAL & MATERIALS ENGINEERING

Winter 2012

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Course Schedule:

- Tuesday and Thursday, 9:30-10:50 am, MEC 3-1.
- No regular classes February 27, 2012 - March 3, 2012. The normal lecture periods during this week may be used for intensive tutorial sessions on material where weaknesses were shown during the midterm exam. Make-up lectures will be given during the seminar slots on Friday January 13 and 20. We may add other make-up lectures as required.
- Experimental labs will be scheduled between March 19, 2012 and March 30, 2012.

Course Description:

This course will cover both *first-principles* and *empirical* modelling of dynamic processes. A detailed understanding of process behaviour is essential for: process simulation and design, process control and optimization, process operator training, process troubleshooting, capital investment studies, and so forth. The main purpose of this course is to promote the student's understanding of a variety of processes and how such knowledge can be employed to develop high quality mathematical models to represent process behaviour. Such skills are an important part of an engineer's toolbox, since industry has identified process modelling as a key activity for improving profitability and have invested significant resources in this activity.

The focus of this course will be development of a student's ability to efficiently formulate process models, which are suitable for a wide range of engineering tasks. Finally, through a series of problem sets and labs, the students will gain exposure to engineering software such as MATLAB / SIMULINK.

Course Objectives:

Upon completion of this course, each student will be able to perform the following:

- develop *first-principles* process models for a wide range of processes,
- determine unknown model parameters using properly gathered plant data,
- identify *empirical* process models from dynamic process data,
- understand how plant experiments should be designed for process identification.

Pre- / Co-requisites: CHE 314, 318 and 345.

Recommended Text:

Bequette, B. Wayne, *Process Dynamics: Modeling, Analysis and Simulation,* Prentice-Hall, 1998.

Selected References:

Basmadjian, D., *The Art of Modeling in Science and Engineering,* Chapman & Hall, 1999.
Box, G.E.P, Jenkins, G.M., *Time Series Analysis: Forecasting and Control*, Holden-Day, 1976.
Denn, M.M., *Process Modeling*, Longman, 1984.
Draper, N., Smith, H., *Applied Regression Analysis*, Wiley, 1966.
Felder, R.M., Rousseau R., *Elementary Principles of Chemical Processes*, Wiley, 1986.
Ljung, L., T. Glad, *Modeling of Dynamic Systems*, Prentice-Hall, 1994.
Luyben, W.L., *Process Modeling, Simulation and Control for Chemical Engineers*, McGraw-Hill, 1990.

Course Outline:

	Reading
1) Introduction	ch. 1 & 2
- process models and their uses.	
- types of process models and modeling objectives.	
- model development strategies.	
2) *First-Principles* Models	ch. 5
- state-space methods:	
➢ general form,	
➢ linearization,	ch. 6
➢ solution techniques.	ch. 7
- transfer function methods:	
➢ Laplace transform review,	ch. 8
➢ review of first-order systems and integrators,	ch. 9
➢ review of higher-order systems,	ch. 10
➢ matrix transfer functions,	ch. 11
➢ review of block diagrams.	ch. 12
- discrete time representation.	
➢ distributed parameter processes	
	mod. 3
3) Parameter Estimation & Model Fitting	
- least-squares regression:	
➢ linear regression review,	
➢ nonlinear regression.	
4) Linear *Empirical* Models	
- plant vs. noise models.	
- general forms.	
- plant testing:	
➢ power spectra & signal vs. noise,	
➢ pulse & step testing,	
➢ "optimal" tests.	
- Introduction to time series analysis:	
➢ auto- & partial auto-correlation,	
➢ cross-correlation,	
➢ process identification.	

Teaching Approach & Expectations:

I believe that each student is ultimately responsible for learning the material in a course. On the other hand, each instructor is responsible for presenting the course material in a manner that facilitates learning as much as possible for the class as a whole. I think that these two statements capture the essence of the implicit contract that exists between each student and instructor.

In fulfilling this contract, I expect that during the course you will *actively and constructively participate* in the course. This means that you will:

- ask questions whenever something is not clear,
- help each other understand the course material,
- **perform all assigned reading on time**.
- arrive on-time for class,
- be courteous to each other and me,
- provide me with feedback / suggestions as to how the course and my delivery can be improved,
- adhere to the *Code of Student Behaviour* (see §25 in the University of Alberta Calendar). Please note that: "*The University of Alberta is committed to the highest standards of academic integrity and honesty. Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect. Students are particularly urged to familiarize themselves with the provisions of the Code of Student Behaviour (online at www.governance.ualberta.ca) and avoid any behaviour which could potentially result in suspicions of cheating, plagiarism, misrepresentation of facts and/or participation in an offence. Academic dishonesty is a serious offence and can result in suspension or expulsion from the University*."

In return you should expect me to:

- treat each of you with courtesy and respect,
- be committed to help you master the course material,
- be available for out of class assistance,
- provide competent teaching assistants,
- work to continually improve the course,
- treat each question or concern seriously and answer these to the best of my ability.

The class structure I prefer is very informal. I would like to encourage class discussion and student participation as much as possible. My objective is to create "enjoyable" classes that are a combination of lectures, discussions and activities.

Grading:

	Weight	Dates / Locations
assignments	20%	
labs	20%	
midterm exam #1	25%	Thursday February 9, 2012
final exam	35%	Friday April 20, 2012

Note: The conversion of the percentage grade into a final letter grade will be performed using a combination of relative and absolute measures taking into account the quality of work submitted in the recent past and University policy on the distribution of grades. Grades are unofficial until confirmed by Faculty Council or its representative.

Please Note:

1. Although each student is expected to hand in their own assignment solutions, I encourage you to collaborate. However, if you work in a group to complete a homework assignment, please indicate all the people you worked with on your assignment. (Assignment copying is considered an academic offense and will be dealt with appropriately). Finally, it is not acceptable to hand in computer print-out as your solution to an assignment problem. Please summarize your results (a suggested style is provided in this handout) and append any pertinent computer output to the summary.

2. Labs will be performed in groups. As a result, I expect only one lab report per group, with all of the group members names on it. Each group member is expected to contribute fully to the lab work and the report.

3. Due dates for assignments and labs will be chosen after conferring with the class. These materials must be handed-in to me at the end of the class period on the day they are due. All assignments or labs handed in late, without an acceptable excuse, will be penalized. My approach to grading late labs and assignments is as follows:
   - late by 24 hours or less, the grade will be reduced by a factor of one-half.
   - late by more than 24 hours, a zero grade will be assigned.

4. A final word about the differences you will find between my homework assignments and exams. Tests, by their very nature, are restricted to a limited time. As a result, I can only ask relatively simple questions on an exam in an attempt to discern your level of understanding of the course material. Such exam questions tend toward a textbook example style. Assignments, on the other hand, are not as time limited. This allows more "real-life" questions to be assigned for homework. With this in mind, it should not surprise you that there is a significant difference in the style of test and homework questions.

Suggested Solution Style: