INDUSTRIAL ENGINEERING DEPARTMENT
IE 350
Systems Science and Engineering
Spring 2017

Type: Required from a pool (Specialization course)
Credits/ECTS: 3 Credits / 6 ECTS
Prerequisite(s): Basic differential equations
Class/Laboratory/PS schedule: Monday 13:30-15:00 - Class lecture
Wednesday 09:30-11:00 - Class lecture
TBA: One hour occasional problem sessions

Instructor: Yaman Barlas
Room M4045, tel. 6407
Office Hours: Tuesday 14:00 - 16:30
Wednesday 14:00 - 16:00
Assistant: Gizem Aktaş (& Şirag Erkol), SESDYN Lab.

Course Description: An introduction to dynamical systems, systems science and engineering. The fundamental concepts, philosophy and historical development of systems science are reviewed. Analogical dynamic systems are first illustrated on electrical, hydraulic and mechanical examples. The generality of systems analogy is then demonstrated on industrial, socio-economic and managerial modeling examples. Analysis tools for linear dynamic systems are reviewed. Non-linear structures and mathematical solution difficulties are discussed and equilibrium and stability analysis is presented. Simulation method and software are introduced to analyze large scale, time-delayed, non-linear dynamic models. Stock-flow modeling and formulation principles are discussed to model socio-technical problems.

Reference Texts:

1- Burghes, D.N. and M.S. Borrie.Modeling With Differential Equations. Chichester, England: Ellis Horwood, 1982.
2- Palm III, William J. System Dynamics. McGraw-Hill, U.S.A., 2005.
3- Ogata, Katsuhiko. System Dynamics. Prentice-Hall, U.S.A. 1998.
4- Sterman, J. Business Dynamics. Systems Thinking and Modeling for a Complex World. McGraw-Hill, U.S.A., 2000.
5- Barlas, Y. "System Dynamics: Systemic Feedback Modeling for Policy Analysis" in Knowledge for Sustainable Development - An Insight into the Encyclopedia of Life Support Systems, UNESCO-Eolss Publishers, Paris, Oxford, UK. 2002, pp.1131-1175.

Course objectives (and program outcomes):

- To present the students the fundamental concepts, assumptions, philosophical foundations, and major threads of systems sciences
- To discuss the analogies of dynamic systems first on electrical, hydraulic and mechanical examples, then on industrial, managerial and socio-economic problems.
- To review and discuss mathematical analysis of linear dynamic systems
- To introduce simulation approach and software to analyze large scale, time-delayed, non-linear models, particularly in industrial, managerial and socio-economic domains.

By seeking the above objectives, this course mainly addresses the following student outcomes of the industrial engineering undergraduate program:

- *Student Outcome (a):* An ability to apply knowledge of mathematics, science, and engineering
- *Student Outcome (c):* An ability to design diverse systems including manufacturing, service, logistics, financial and information, to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- *Student Outcome (h):* The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- *Student Outcome (k):* An ability to use the techniques, skills, and modern engineering tools necessary for industrial engineering practice

TOPICS OUTLINE

WEEK	
1	Course Objective, Organization and Overview
1	"Systems" concepts, philosophy and history
2	Systems analogies: 1st order dynamic systems
2, 3	Electrical-hydraulic-mechanical analogies
3	Industrial, socio-economic, managerial analogies
4	Systems analogies: 2nd order dynamic systems
4, 5	Electrical-hydraulic-mechanical analogies
5	Industrial, socio-economic, managerial examples
6	Higher order linear dynamic systems
7	Non-linear systems and limits of mathematical analysis
7	Midterm exam 1
7, 8	Simulation method and software
8, 9	Equilibrium and stability analysis
10	Typical non-linear structures and formulations
11	Time delays in dynamic systems
11	Midterm exam 2
12	Formulation principles for large-scale socio-technical systems
13	Large scale stock-flow modeling examples
13	Systems Science and Systems Approach in a Complex World

GRADING: Assignments: 15%
Two Midterm Exams: 50% (2x25%)
Final Exam: 35%

ASSIGNMENTS: There will be 5-6 small assignments. Due date of each assignment will be announced ahead of time. All homeworks are to be worked on individually by each student. NO Homework is accepted after the due date.

EXAMS: There will be two in-class midterm exams and one in-class comprehensive final exam* at the end of the semester. More specific information on the nature of these exams will be provided during the semester.

* To be admitted to the final exam, a student must have taken both midterm exams and must have accumulated at least 20% of the total point from midterms and assignments.