

Industrial and Systems Engineering Department
ISEN 689 – M.S. Level Graduate Course
ISEN 689 Systems Thinking and Analysis

INSTRUCTOR

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TEACHING ASSISTANT

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COURSE DESCRIPTION

Introduction to the systems thinking process, systems of systems, and the fundamental considerations associated with the engineering of large-scale systems, or systems engineering. These include systems modeling and design, system development process, needs analysis, concept exploration, concept definition, engineering design, integration and evaluation, and systems engineering management.

PREREQUISITES

MATH 304 or approval of instructor.

COURSE OBJECTIVES

This is an introductory course to systems engineering. The aim of the course is to introduce students to systems engineering and the fundamental considerations associated with the engineering of large-scale complex systems. The course provides a comprehensive understanding of systems ideas and methods to help students achieve success with their future challenging projects regardless of their discipline. The course is suitable for students at the master's level and only requires the student to have basic analytical thinking skills.

The course covers, 1) definitions and classification of systems, hierarchical models of complex systems, and systems of systems (SOS), 2) systems thinking ideas and systems engineering tools, 3) functional and information modeling for complex systems, 4) engineering and design of large scale systems, including the system development process, system life cycle models (DoD, ISO/IEC, NSPE), and systems engineering documents, 5) formulation of issues and constraints, from needs analysis, concept exploration, through to concept definition, 6) design and evaluation of SOS Models, from advanced development, engineering design, to system integration and evaluation, 7) systems engineering and systems management.

The course will also draw on case studies and examples from several fields including engineering, ecology, healthcare, and energy. To keep up with modern systems engineering tools, the students will be introduced to IDEF methods and the Unified Modeling Language (UML). UML will be required to do homework and other course assignments using IBM Rational Software Modeler, which is available on the computers in the student computer lab.

TEXTBOOK AND ADDITIONAL COURSE MATERIAL

Kossiakoff, A. Sweet, W.N., *Systems Engineering Principles and Practice*, 2nd Edition, John Wiley & Sons, New York, NY, 2003. ISBN: 0471234435.

References:

1. Wymore, W. A., *Model-Based Systems Engineering*, CRC Press Inc., Boca Raton FL, Chapter 1 & 2, 1993.
2. Blanchard, B.S. and Fabrycky, W.J., *Systems Engineering and Analysis*, 4th Edition, Prentice Hall, 2005. ISBN: 0131869779.
3. Derek K. Hitchins, *Advanced Systems Thinking, Engineering, and Management*, Artech House Publishers, 2003. ISBN: 1580536190.
4. Gharajedaghi, J., *Systems Thinking, Managing Chaos and Complexity: A Platform for Design Business Architecture*, 2nd Edition, Butterworth Heinemann, 2005. ISBN: 0750679735.
5. Systems Engineering Fundamentals: http://www.dau.mil/pubs/gdbks/sys_eng_fund.asp

DETAILED TOPICAL OUTLINE

(Times are approximate)

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Section I – Basic Concepts (~3 weeks)

1. Introduction to Systems Engineering (Kossiakoff, Ch. 1)
 - 1.1 What is Systems Engineering?
 - 1.2 Identifying and classifying a system
 - 1.3 Systems Engineering tools (modeling, simulation, trade-off analysis)
 - 1.4 The system development process
2. Functional and Information Modeling (Kossiakoff, Ch. 2)
 - 2.1 Structure of complex systems
 - 2.2 Model of a complex system
 - 2.3 System building blocks
 - 2.4 The system environment
 - 2.5 Interfaces and interactions
3. Systems Thinking Tools (Hitchins, Ch. 9)
 - 3.1 Causal loop/Influence modeling
 - 3.2 N² charts
 - 3.3 Systems of systems

Section II – Systems Modeling and Design (~5 weeks)

4. Systems Modeling (Wymore, Ch. 1, 2)
 - 4.1 Discrete (open) systems
 - 4.2 State transition diagrams
 - 4.3 System experiments
 - 4.4 Input, output and state trajectories
 - 4.5 System performance
 - 4.6 Systems theoretical properties of system models
5. Systems Design Requirements
 - 5.1 Input/output requirements
 - 5.2 Technology requirements
 - 5.3 Performance, cost, and trade-off requirements
 - 5.4 System test requirements

Section III – Systems Engineering Processes (~5 weeks)

6. Systems engineering tools
 - 6.1 Overview of IDEF Methods
 - 6.2 Introduction to object oriented analysis and Unified Modeling Language (UML)
 - 6.3 IBM Rational Software Modeler (will use it for design assignments)
7. The system development process (Kossiakoff, Ch. 3, 4)
 - 7.1 System life cycle models (DoD, ISO/IEC, NSPE)
 - 7.2 Concept development phases
 - 7.3 Engineering development phases
 - 7.4 Systems Engineering Documents
8. Formulation of Issues and Constraints (Kossiakoff, Ch. 5, 6, 7)
 - 8.1 Needs analysis
 - 8.2 Concept exploration
 - 8.3 Concept definition
9. Design and Evaluation of Systems Models (Kossiakoff, Ch. 8, 9,10)
 - 9.1 Advanced development
 - 9.2 Engineering design
 - 9.3 System integration and evaluation

SEMESTER TEAM PROJECT

Students will form semester 'teams' comprising of 1-3 students. Each team is going to work on an interesting real-life problem of their choice and apply the systems engineering approach to model, analyze and design a system for the problem. Students are encouraged to work on problems from their thesis or dissertation. Distance learning (DL) students are encouraged to work on problems related to their current job. Each team will learn to use IBM Rational Software Modeler to develop most of their systems engineering documents for the project. Finally, each team will write a project report (due May 5th) and will do a class presentation (time-permitting) the last week of class. DL students are not required to do an in-class presentation but must submit their presentation.

CLASS SCHEDULE

Lectures: TR 8:00 – 9:15 AM (but will do 8:15 – 9:30 AM)

Classroom: 301 Zachry.

GRADING

The grade for the course will be based homework, exams, semester project, and on the level and quality of your participation during class. *No* late assignments will be accepted. There will be a midterm and a final in-class exam based on the material covered in class, homework and reading assignments. The two exams will constitute 50% of the grade while the other 50% will come from the homework and class participation (25%) and semester project (25%). Grades will be assigned as follows: A (90-100%), B (80-89.9%), C (70-79.9%), D (60 – 69.9%), F (< 60%).

Midterm (25%): Thursday, March 12 (tentative).

Final Exam (25%): May 11, Monday, 1-3 p.m.

COURSE WEB SITE: eLearning: <http://elearning/>. The instructor has created a course website to showcase students' projects at <http://ise.tamu.edu/INEN689/>.

DISTANCE LEARNING

A link will be provided to distance learning (DL) students for downloading recorded course lectures.

PROFESSIONAL COMPONENT

This course provides fundamental concepts, theory and procedures for modeling, solving and analyzing problems using the systems engineering process. The knowledge learned in this course is used to develop a semester team project and will help the student achieve success with their future challenging interdisciplinary projects.

The Americans with Disabilities Act

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities, in Room 126 of the Koldus Building or call 845-1637.

ACADEMIC INTEGRITY:

“An Aggie does not lie, cheat, or steal or tolerate those who do.” It is the responsibility of students and instructors to help maintain scholastic integrity at the university by refusing to participate in or tolerate dishonesty. (<http://www.tamu.edu/aggiehonor>)

PROGRAM OUTCOMES

The instructor expects the following to be student critical factors for a systems engineering education:

- A. An ability to formulate, analyze, and interpret issues; issue formulation, analysis, and interpretation, and problem solving and design.
 - B. An ability to use the techniques, skills, and modern computer engineering tools necessary for engineering practice.
 - C. Ability to understand knowledge practices, principles and perspectives to enable breadth and depth in a meaningful professional area.
 - D. Fundamental understanding of all of the foundation areas of general education.
 - E. An ability to function in multidisciplinary teams.
 - F. An ability to communicate ideas, verbally and in writing.
 - G. High professional and ethical standards.
 - H. Mature, responsible, creative, quality conscious mind.
 - I. Motivation for and capability of achieving a lifetime of learning.
 - J. Knowledge of management strategies and human behavior motivations.
 - K. Appreciation of national and global issues from a variety of perspectives.
- C. Outcome summary: The student should be able to state, formulate, analyze, and interpret issues using systems thinking, and be able to design complex systems.

PREPARED BY: Dr. Lewis Ntaimo

DATE: 01-19-09