Advanced Systems Engineering

Special Subjects
Elective 2 credit

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1. Course Description

"System" means a whole set of interacting components. Ecological systems in the natural world consist of interacting living creatures, and network-connected computer systems consist of computers communicating to each other. ‘Systems engineering’ deals with investigation, analysis, planning and operation of various systems. It has become more important as economic developments and advancing technologies have more impact on the natural environment and make artificial systems more complicated and influential.
This course consists of lectures in the classroom with exercises of practical problems, and laboratory work in the computer laboratory (CL). Important contents to be learned in this course are:
1. Introduction to system engineering, modeling principles
2. Mathematical models: static/dynamic, deterministic/stochastic, linear/nonlinear, etc.
3. Graphical models: block diagrams, state transition diagrams
4. Mathematical modeling 1: differential equations, state equations, transfer functions,
5. Mathematical modeling 2: multiple regression, least square method
6. Simulation of differential equations
7. System optimization: linear/nonlinear programming
Students are expected to acquire the knowledge and techniques of DP1.

2. Course Objectives

- Understanding the concept of system and system engineering
- Understanding the mathematical system modeling and its variations and process
- Understanding the numerical solution of differential equations
- Understanding the regression analysis and least square method
- Understanding the optimization
- Understanding the computer simulation through the hands-on exercises

3. Grading Policy

- Attendance: more than 2/3 (Requirements to take End-term exam.)
- Homework: 60%
- End-term Report: 40%
Detail solutions of homework will be shown in LMS and be given feedback at lecture.

4. Textbook and Reference

Textbook
Lecture materials will be provided from LMS. (If needed, printed materials will be distributed at lecture).
Recommended references are the following;
Reference
田村 坦之(編著)「システム工学」(オーム社)、ISBN-13: 978-4274131677

5. Requirements(Assignments)

Pre-condition: Students must understand the fundamental topics of linear algebra, differential equations though the previous lectures "Linear Algebra" and “A Treatise on Differential Equations” at a first-year undergraduate.
Preparation (1.5 hours): Students must read through the lecture materials and check in advance for any questions summarize them in a notebook.
Review (1.5 hours): Student must recheck the lecture materials, make reports or homework for better understanding.

6. Note

- Students will give presentations on homework assignments in the classes.
- Lecture contents may change depending on progress.
- Recommended items to bring to lecture: Devices to access Internet (like note PC, tablet PC, and smartphone, etc.)
- Open education tool : Todai OpenCourseWare (The University of Tokyo Online Educaiton Tool)
https://ocw.u-tokyo.ac.jp/course_11258/

7. Schedule

[1]	Introduction, What is “system”?
[2]	System analysis, expression of system
[3]	System Modeling
[4]	Mathematical models (1): modeling with differential equations, Laplace transform, and transfer functions
[5]	Mathematical models (2): numerical methods to solve differential equations, Euler's method, and Runge-Kutta’s method
[6]	Mathematical models (3): fundamentals of statistics
[7]	Mathematical models (4): regression analysis, multiple regression analysis, least squares method
[8]	Laboratory hands-on(1): introductions of tools – spreadsheet software (Excel, Google Spreadsheet)

[9] Laboratory hands-on (2): introductions of tools – Python (Google Colaboratory)
[10] Laboratory hands-on (2): Exercise of tools – Python (Google Colaboratory)
[11] Laboratory hands-on (3): numerical solutions of queuing system
[12] Laboratory hands-on (4): System optimization - linear programming (LP)
[13] Laboratory hands-on (5): System optimization - nonlinear programming (NLP)
[14] Laboratory hands-on (6): Genetic algorithm and Applicaitons for Data Science
[15] Summary, Guidance of Final Report