INC 234 System Modelling and Analysis

Semester: 2/2023
Schedule: Wed 13.30–17.30 (AE) Thu 15.30–17.30 (A-B) **Classroom:** 40609(AE) 40605(A-B)
Instructors:

- Asst. Prof. Dr.-Ing. Sudchai Boonto
- **Email:** `sudchai.boo@kmutt.ac.th` **Office:** CB40601 **Tel.** 02-470-9091

Required pre-requisites:
Circuit Analysis, Differential Equations, Basic Programming Skill

Course Description:

Introduction to System Dynamics, Linear Models. Modelling of Mechanical, Electrical, Fluid, Thermal System and Inter-Domain Systems. Solution methods for dynamic models. Differential equation, Laplace transform. State-Variable Models and Simulation Methods. Transient response. Block diagram. Stability analysis. Steady state error analysis. Introduction to feedback control.

Course Objectives

- To teach students basic mathematical and computational tools for modelling and analysis of dynamic systems
- To train students to identify, model analyze, design, and simulate dynamic systems in various engineering disciplines using a unified approach.

Learning Outcomes:

- Be able to use mathematic and engineering rules to construct engineering system models and address the system's behavior in the time domain.
- Be able to apply algebra to analyze and evaluate the response of linear systems.
- Be able to use calculated numerical programs to display the behavior of the linear system.

The criterion using in class are:
Level 5: Excellent ($80 - 100\%$), Level 4: Good ($70 - 79\%$), Level 3: Expected ($60 - 69\%$), Level 2: Fair ($50 - 59\%$), Level 1: Poor/Minimal Pass $40 - 49\%$

CLOs	Performance Indicator (PI)	Level
CL01: Be able to apply algebra to analyze and evaluate the response of linear systems.	PI1: Construct static models from the data sets in an affine, power, and exponential form.	5: Able to show how to apply affine, power, and exponential function to fit the data set. Can use the model to interpolate the missing data point and predict the new data point.
		4: Able to show how to apply affine, power, and exponential function to fit the data set with some minor mistakes. Can use the model to interpolate the missing data point and predict the new data point.
		3: Able to show how to apply affine, power, and exponential function to fit the data set with some mistakes. Can use the model to interpolate the missing data point and predict the new data point.
		2: Able to show how to apply affine, power, and exponential function to fit the data set with some mistakes. Cannot use the model to interpolate the missing data point and predict the new data point.
		1: Able to show how to apply affine, power, and exponential function to fit the data set but cannot explain why
CLO2: Be able to use mathematic and engineering rules to construct engineering system models and address the system's behavior in the time domain.	PI1: Construct a model of mechanical, electrical, pneumatic, and hydraulic systems in the differential equation form.	5: Able to use the first principle lows to construct the models without any mistakes.
		4: Able to use the first principle laws to construct the models with some minor mistakes.
		3: Able to use the first principle laws to construct the models with some mistakes.
		2: Able to build models of at least three systems.
		1: Able to build models of only two systems.
	PI2: Solve the differential equations by using the time-domain technique.	5: Able to solve all the ODEs with constant coefficients.
		4: Able to solve all the ODEs with constant coefficients. However, there are some minor mistakes.
		3: Able to solve all the ODEs with constant coefficients. However, there are some mistakes.
		2: Able to solve all the ODEs with constant coefficients. Show the misunderstanding in the construction.
		1: Able to solve one of three types of the response.
	PI3: Solve the differential equations by using Laplace transform.	5: Able to use the Laplace transform technique to solve the ODEs without any mistakes.
		4: Able to use the Laplace transform technique to solve the ODEs with minor mistakes.
		3: Able to use the Laplace transform technique to solve the ODEs with mistakes.
		2: Able to use the Laplace transform technique to solve the ODEs by adapting the given examples.
		1: Able to use the Laplace transform technique to solve the ODEs by adapting the given examples with some mistakes.
CLO3: Be able to use calculated numerical programs to display the behavior of the linear system.	PI1: o Use Matlab to build a model of mechanical, electrical, pneumatic, and hydraulic systems.	5: Able to use Matlab to build all systems and plot the systems' responses correctly.
		4: Able to use Matlab to build all systems and plot the systems' responses with some minor mistakes.
		3: Able to use Matlab to build all systems and plot the systems' responses with some mistakes.
		2: Could adapt examples of Matlab code.
		1: Could adapt examples of Matlab code with some minor mistakes.
	PI2: Use SIMULINK and Simscape to build a model of mechanical, electrical, pneumatic, and hydraulic systems.	5: Able to use SIMULINK and Simscape to build all systems and plot the systems' responses correctly.
		4: Able to use Matlab to build all systems and plot the systems' responses with some minor mistakes.
		3: Able to use SIMULINK and Simscape to build all systems and plot the systems' responses with some mistakes.

CLOs	Performance Indicator (PI)	Level
		2: Could adapt examples of SIMULINK and Simscape code. 1: Could adapt examples of SIMULINK and Simscape code with some minor mistakes.

Learning Activities: The courses activities include lectures, computer laboratory modelling tutorials, presentations, group discussions, assignments and reports on case studies.

Learning Resources: Website `https://inc.kmutt.ac.th/~sudchai.boo/Teaching/inc341s/inc341s.html`, and facebook group. This can include lecture material, supplementary course notes, problem sheets and solutions, and useful references.

Course text:

- Ramin S. Esfandiari, and Bei Lu, *Modeling and Analysis of Dynamic Systems*, 3nd Edition, CRC Press, 2018.

- W. J. Plam III, *System Dynamics*, 3rd Edition, McGraw Hill, 2014

Reference:

- K. Ogata, *System Dynamics*, 4th Edition, Prentice-Hall, 2004.

Project:
Each student is required to formulate a real mechanical system, to do analysis and design for the problem using the course material.

Grading scheme:
In class activities: 15% Midterm (Quizzes) Exam: 35% Final (Quizzes) Exam: 35% term assignments: 15%

Course Schedule (Tentative)

Week	Topic	Date (AE, A-B)	Lecturer
1	Introduction to System Modelling	17,18 Jan 24	Sudchai

Week	Topic	Date (AE, A-B)	Lecturer
2	Modelling of Rigid-Body Mechanical System I	24, 25 Jan 24	Sudchai
3	Modelling of Rigid-Body Mechanical System II	31, 1 Jan-Feb 24	Sudchai
3	Modelling of Rigid-Body Mechanical System III	7,8 Feb 24	Sudchai
4	Spring and Damper Element	14, 15 Feb 24	Sudchai
4	Exam Week	19-23 Feb 22	Sudchai
5	Continuous-Time System Analysis I	28,29 Feb 24	Sudchai
6	Continuous-Time System Analysis II	6,7 Mar 24	Sudchai
7	Laplace Transform I	13, 14 Mar 24	Sudchai
9	Laplace Transform II	20, 21 Mar 24	Sudchai
10	Midterm Exam	4 Apr 24 (9.00-12.00)	
10	Electrical and Electromechanical Systems I	10, 11 April 24	Sudchai
8	Special Vacations Week	10-17 Apr 24	
11	Electrical and Electromechanical Systems II	17, 18 Apr 24	Sudchai
12	Fluid Systems I	24, 25 Apr 24	Sudchai
13	Fluid Systems II	1, 2 May 24	Sudchai
14	Thermal Systems I	8, 9 May 24	Sudchai
15	Thermal Systems II	15, 16 May 24	Sudchai

Week	Topic	Date (AE, A-B)	Lecturer
16	Final Exam	29 May 24 (9.00-12.00)	Sudchai

Note: All topics and timetable may be changed!