SYLLABUS

Name: ***Introduction to system dynamics (MakAu>SI3ISD19)***
Name in Polish:
Name in English: ***Introduction to system dynamics***

Information on course:

Course offered by department: Faculty of Automatic Control, Electronics and Computer Science
Course for department: Silesian University of Technology

Default type of course examination report:

EGZ

Language:

English

Course homepage:

https://platforma2.polsl.pl/rau2/course/view.php?id=682

Short description:

The aim of the course is making students familiar with problem and methods related to modeling phisical dynamical systems and dynamical systems as engineering constructions.

Description:

ECTS: 5
Total hours: 125h (contact: 65h / self-study: 60h)
* lecture: 30h
* exercises: 15h
* Other (discussion of the report): 20h

Student's self-study work:
Reviewing the literature and preparing for the exercises by solving problems related to the topics presented during the lectures.

Lecture:
1. Introduction, mathematical modeling, what for?, approaches, problems, software projects. Mathematical modeling in physics, chemistry, engineering, biology, economy.
2. Derivation of mathematical models by using the method of balances. Balances of mass, volume, energy, force, momentum, current, voltage. Collection of mathematical models obtained by using the method of balances.
3. Short introduction to variational calculus. Derivation of mathematical models of physical systems by using variational principles. The method of Lagrange equations. Collection of models obtained by using the method of Lagrange equations.
4. Miscellaneous topics. Lagrange equations for the case of mechanical systems with constraints. Hamilton equations.
5. Electro-mechanical analogies of type I and II.
6. Basics of methodology of analysis of systems of linear differential equations. State, input. Modes, modal forms, eigenvalues and eigenvectors of the state matrix. Stability, aperiodicity.
7. Basics of the methodology of the analysis of nonlinear systems. State space. Isoclines.
8. Elements of chaotic dynamics.

Classes:
1. Modeling physical and engineering systems by using the method of balances.
2. Lagrange equations I
3. Lagrange equations II
4. Electromechanical analogies I
5. Electromechanical analogies II
6. Linear systems
7. Nonlinear systems and state space

Bibliography:

Basic:
Robert H Cannon, Dynamics of Physical Systems, McGraw Hill, 1980
Luenberger D.G., Introduction to Dynamic Systems, Wiley, 1979
J. H. Ginsberg, Advanced Engineering Dynamics, Cambridge University Press, 1995
Additional:
Rouche N., Habets P., Laloy M., Stability Theory by Lyuapunov's Direct Method, Springer, 1977
Schuster H.G., Deterministic Chaos, an Introduction, VCH Verlagsgeselschaft, 1988

Learning outcomes:

Knowledge – the student knows and understands:
- The student knows and understands fundamental and advanced concepts related to the formulation and analysis of mathematical models of dynamic systems and physical, chemical, biological, and engineering processes based on differential equations and operator calculus. (K1A_W08, K1A_W03)
- The student knows methods of model derivation using balance principles (mass, energy, momentum, current, etc.) as well as variational calculus and the Lagrange and Hamilton equations. (K1A_W08, K1A_W03)
- The student understands electromechanical analogies and is able to interpret physical phenomena across various domains through their mathematical representation. (K1A_W03)
- The student knows the basics of linear and nonlinear system analysis, including the concepts of state, state vector, eigenvalues and eigenvectors, stability, and state space. (K1A_W08)
- The student understands the fundamental concepts of nonlinear and chaotic dynamics and can relate them to the analysis of complex dynamic systems. (K1A_W08)

Skills – the student is able to
- The student is able to identify, formulate, and solve complex engineering problems related to automation and electronic systems by applying physical principles, mathematical methods, and engineering tools. (K1A_U01)
- The student can construct mathematical models of dynamic systems using balance methods and the Lagrange method for systems with and without constraints. (K1A_U14)
- The student is able to analyze models in the time, operator, and frequency domains, interpret the results, and assess stability and dynamic behavior of systems. (K1A_U01, K1A_U14)
- The student can apply electromechanical analogies to describe and analyze complex physical systems and develop linear and nonlinear models representing their behavior. (K1A_U14)
- The student is capable of solving and interpreting nonlinear and chaotic problems, including qualitative analysis in the state space. (K1A_U14, K1A_U01)
- The student demonstrates the ability to analyze and solve problems under conditions of partial unpredictability, using knowledge of mathematical modeling and system dynamics. (K1A_U01, K1A_U18)

Assessment methods and assessment criteria:

The lecturer on each lecture may organize a short lecture test with short task that will be included in the final mark from subject. Students will be asked to upload solution from short task into either platform or teams (depending on lecturer's decision).

During classes student will be given few tasks to solve. All problems from classes will be available on the platform in the form of test/quiz. Along with the test, students will be obligated to upload copies of solutions (in the form of scan or picture). If copies will not be attached than the test will be marked on 0 points.

The final exam will be organized on the platform in the form of test/quiz and upload of copies os solutions (in the form of scan or picture). If copies will not be attached than the test will be marked on 0 points.

Credit (Each grade (E,C,L) has to have positive mark (at least 3.0)):
Final mark = 0.5 * E + 0.5 * A, where E is an exam and A activities
A = 0.6 * C + 0.4 * L, where C is classes mark and L lecture.

This syllabus is valid from the academic year 2025/26. Its content is not subject to modification during the semester.

Course credits in various terms:

<without a specific program>

Type of credits	Number	First term	Last term
European Credit Transfer System (ECTS)	5	2020/2021-Z	