Tecnológico de Costa Rica
Escuela de Ingeniería Electrónica
Ingeniería en Electrónica
EI-4419: Análisis y Control de sistemas lineales
Profesor: Ing. Juan Luis Guerrero Fernández, PhD

Tarea 1
Fecha de entrega:
06/10/2025 - 12 m.d

Modeling and Simulation of an Electromechanical System

This assignment involves the selection, modeling, construction, and simulation of an electromechanical system of intermediate complexity. The objective is to integrate the concepts, techniques, and tools covered throughout the course by applying them to a relevant real-world or industry-inspired case study. The simulation should allow for evaluation of the system's behavior under different operating scenarios.

The selected system must involve at least **two coupled physical domains** (e.g., electrical-mechanical, electrical-thermal, electrical-hydraulic, etc.) and must be implemented using simulation platforms such as **Simulink and Simscape**.

Objectives

Upon completing this assignment, students will be able to:

- Formulate a mathematical and computational model of an electromechanical system, capturing the interaction between at least two relevant physical domains.
- Implement the model using appropriate simulation tools, ensuring the validity of assumptions and system conditions.
- Analyze the dynamic behavior of the system under different operating conditions.

General Instructions

- The assignment must be completed in groups of up to three students.
- Each group must notify the instructor of its members no later than the end of the fourth week of the course. This must be done via email with the subject line "Solicitud de Creación de Grupo – Análisis y Control de Sistemas Lineales" and must include the full names of all group members.
- Students who are not registered in a group by the end of the fourth week will be required to work individually.
- Each group is responsible for proposing its own system variant. No default variants will be provided by the instructor.
- Variants must not be repeated within the same course group. Approval will follow a "first come, first assigned" policy.

- Variants used in previous semesters are not allowed.
- The chosen system must have an intermediate level of modeling complexity.
- Students must complete the official online training modules: **Simulink Onramp** and **Simscape Onramp**. The corresponding certification PDFs must be included with the submission.

Assignment Instructions

- For the selected system, each group must:
  - Draw a functional block diagram.
  - Derive a state-space model directly from the physical description.
  - Derive the input-output transfer function independently from the same physical model.
  - Build a Simscape model of the system using Simulink.
  - Simulate its operation for at least two scenarios.
  - In case the open-loop system is unstable, the group must use a Compensator (the simpliest one possible) to stabilise it . Transient response is not of importance at this stage.
- The state-space model and transfer function must be derived independently. Using one to derive the other is strictly prohibited and will result in a failing grade.
- Simulate the system using Simulink. First, demonstrate that the responses of all three models (state-space, transfer function, and Simscape) — whether to a step input or another appropriate test function — are consistent and match the expected analytical behavior. Then, simulate the system under at least two different operating scenarios. If discrepancies arise at any stage, students must analyze and document their cause. Submissions with inconsistent responses and no explanation will be considered incomplete and will not be graded.
- A clear and technically sound written report in PDF format must be submitted. The report must follow an IEEE journal template (e.g., those available on Overleaf) and include all mathematical derivations, simulation results, and a step-by-step explanation of how the model was developed from the physical system. Proper use of engineering language, structure, and formatting is required. Handwritten content will not be accepted.
- All figures must be clearly titled, with labeled axes and units. Each figure must be accompanied by a brief technical interpretation. Use vector graphics whenever possible. MATLAB plots may be exported to '.txt' files and recreated in LaTeX to ensure quality.
- All MATLAB scripts and Simulink models must be well-organized, commented, and fully functional by the submission date. Submissions will be reviewed using MATLAB version 2025a.
- Submit a compressed (.zip) file to tecDigital containing:
  - PDF report
  - MATLAB simulation files, including:
    - Simulink models (.slx)

    * MATLAB scripts (.m) used for modeling, simulation, and validation

- Submissions that do not include the corresponding simulation files will not be graded and will automatically receive the minimum grade (zero).
- Late submissions will not be accepted.
- Spelling, grammar, and technical writing style will be evaluated as part of the final grade.

Grading Rubric: Modeling and Simulation of an Electromechanical System

Criteria	Points
1. System Compliance	**5**
The proposed system involves two coupled physical domains, presents intermediate modeling complexity, and is an original (non-repeated) variant.	
2. Mathematical Modeling	**30**
• Functional block diagram is clear, complete, and well-labeled.	10
• State-space model is correctly derived from physical laws.	10
• Transfer function is derived independently from the physical model.	10
3. Simscape Implementation	**15**
The Simscape model accurately reflects the physical system and is functional.	
4. Simulation and Validation	**15**
• Step response of all models (SS, TF, Simscape) are consistent.	10
• At least two operating scenarios are simulated and interpreted.	5
• If system is unstable, a minimal compensator is used for stabilization. If stable, demonstrated it through analysis.	5
5. Report Quality and Presentation	**15**
• Report uses IEEE template and is well-structured.	5
• Technical writing is clear and grammatically correct.	5
• Figures are titled, labeled with units, and include brief interpretation.	5
6. Code Quality and Documentation	**5**
MATLAB scripts and Simulink models are organized, commented, and functional (MATLAB 2025a).	
7. Certification Submission	**10**
Valid **Simulink Onramp** and **Simscape** certificates are included.	
Deductions (Automatic)	
• Missing simulation files.	–100
• Late submission. Not accepted.	–100
• TF derived from SS or vice versa. Failing grade.	–100
Total	**100 pts**