Modeling of dynamical systems

Subject guide

Last update: January 2021

1. General information

Name of the subject	Modeling of dynamical systems
Code	11310040
Type of subject	Compulsory
Number of credits	3
Type of credit	2A + 1B
Weekly work hours with direct teacher guidance	80
Weekly Hours of independent student work	64
Prerequisites	Linear Algebra, Differential Equations
Corequisites	None
Schedule	
leader	Martín Andrade Restrepo
Lounge	

2. Lecturer and monitor information

Name of Lecturer	Martín Andrade Restrepo
professional Profile	
Institutional email	Martin.andrade@urosario.edu.co
Place and hours of attention	Edificio Cabal Of. 402 Wednesdays, Fridays 13:00 – 14:00
Web page or other means (optional)	

Name of assistant professor or monitor	
Professional profile	
Institutional email	
Place and hours of attention:	
Web page, Skype or other means (optional)	

3. Summary and purposes of the course

The course addresses the modeling of dynamical systems using differential and difference equations. This is extremely useful for understanding and predicting the behavior of different physical, social and computational phenomena, etc. Once the generalities of the systems of differential and difference equations have been exposed, the main analysis techniques of linear models are presented, emphasizing the representation in state space. In addition, the student is introduced to the use of specialized software to simulate the behavior of dynamical systems.

4. Fundamental concepts

1. Dynamic models in continuous time
2. Dynamic models in discrete time
3. Simulation of dynamical systems using specialized software
4. Representations in state space
5. Analysis of linear and time-invariant systems
6. Equilibrium points and stability
7. Linearization of dynamic systems

5. Expected learning outcomes (RAE)

1. Learn typical models of systems through differential and difference equations.
2. Simulate the behavior of dynamical systems using specialized software.
3. Understand representations in state spaces of dynamical systems.
4. Manage different methods of analysis of linear systems.
5. Carry out the linearization of a system represented in state space.

6. Course modality

Remote mode: All students will be connected remotely from their homes or locations outside the University.

7. Learning strategies

1. Lectures where the theoretical foundations will be taught.
2. Tasks where students will work independently on the content seen.
3. Laboratories where the methods and algorithms addressed in the Lectures will be implemented.
4. Final project where students must apply the tools learned during the semester to solve a real problem.

8. Evaluations

Topic	Activities	Percentage	Exam dates
Those corresponding to sessions 1 to 7	Individual written evaluation - **First cut**	20	Week 4
Those corresponding to sessions 9 to 19	Individual written evaluation - **Second cut**	20	Week 10
Those corresponding to sessions 21 to 29	Individual written evaluation - **Third cut**	20	Week 15
All sessions	Presentation and document - **Final project**	15	exam week

Laboratories and workshops	Individual Reports and / or group Reports	25	Every week

9. Activity program

Date	Topic	Description of the activity	Independent work of the student	Resources that support the activity (bibliography and other support resources)
Session 1	**Presentation of the course.** **Theory:** Dynamic phenomena. Typical examples	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Lue**, 1.1-1.4]
Session 2	**Laboratory:** introduction to Matlab			
Session 3	**Theory:** Difference equations. Existence and uniqueness of solutions. Examples	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Lue**, 2.1-2.5]
Session 4	**Laboratory:** implementation of difference equations in Matlab			
Session 5	**Theory:** Linear difference equations. Linear equations with constant coefficients	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Lue**, 2.6-2.7]
Session 6	**Laboratory:** linear difference equations			
Session 7	**Theory:** Differential equations. Existence	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing	[**Lue**, 2.8-2.10]

	and uniqueness of solutions. Linear differential equations. Examples		exercises from the section.	
Session 8	**First partial exam**			
Session 9	**Theory:** Systems of first order equations. Representation of systems in state space. Inputs and outputs	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Lue**, 4.1 & 4.2]
Session 10	**Laboratory:** solution of differential equations in Matlab			
Session 11	**Theory:** Dynamic diagrams	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Lue**, 4.3]
Session 12	**Laboratory:** dynamic diagrams and introduction to Simulink			
Session 13	**Theory:** Homogeneous linear systems in discrete time. State transition matrix	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Lue**, 4.4]
Session 14	**Laboratory:** simulation of linear systems in discrete time in Matlab and Simulink			
Session 15	**Theory:** Homogeneous linear systems in continuous time. State transition matrix	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Lue**, 4.6]
Session 16	**Laboratory:** simulation of linear systems in continuous time in Matlab and Simulink			

Session 17	**Theory:** Calculation of the state transition matrix for linear systems with constant coefficients using square matrix functions	Lecturer, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Bay**, 5.4]
Session 18	**Laboratory:** square matrix functions			
Session 19	**Theory:** Linear systems with inputs: superposition principle	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Lue**, 4.5 & 4.7]
Session 20	**Second partial exam**			
Session 21	**Theory:** Linear systems with constant coefficients. Eigenvalues and eigenvectors of the matrix of the system	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Lue**, 5.1 & 5.2]
Session 22	**Laboratory:** values and eigenvectors of the system matrix			
Session 23	**Theory:** Change of bases and diagonalization of systems	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Lue**, 5.3]
Session 24	**Laboratory:** systems diagonalization			
Session 25	**Theory:** Non-diagonalizable systems. Diagonalization test	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Bay**, 4.4]

Session 26	**Theory:** Canonical form of Jordan I:structure	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Bay**, 4.4]
	Laboratory: structure of the canonical form of Jordan			
Session 27	**Theory:** Canonical form of Jordan II: generalized eigenvectors	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Bay**, 4.4]
Session 28	**Theory:** Jordan III canonical form: chains of generalized eigenvectors and generalized modal matrix	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Bay**, 4.4]
Session 29	**Laboratory:** generalized modal matrix			
Session 30	**Third partial exam**			
Session 31	**Theory:** Jordan IV canonical form: calculation of the state transition matrix	Masterclass, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Bay**, 4.4]
Session 32	**Theory:** Introduction to the analysis of nonlinear systems. Balance points.linearization	Lecture, discussion, exercises.	Previously read the section (s). Complement the class by doing exercises from the section.	[**Lue**, 9.1 - 9.4]

10. Success factors for this course

A series of actions are suggested below that can contribute significantly to the achievement of goals and consequently promote a successful experience in this course:

1. Plan and organize the individual work time that you will dedicate to it. to the course

2. Organize the study site and materials

3. Have a study group, seek the support of colleagues

4. Cultivate discipline and perseverance, work weekly, do not allow topics or work to accumulate

5. Constantly carry out a Self-evaluation, determine if the actions carried out are productive or if, on the contrary, strategies should be changed

6. Attend the teacher's consultation hours, participate in class, never be left with doubts

7. Use the spaces for consultation and resolution of doubts, such as Sala Gauss and Sala Knuth

8. Promote spaces for rest and mental hygiene, try to have good sleep habits

9. Have present at all times values such as honesty and sincerity, in the end it is not just about passing an exam, it is about learning and acquiring knowledge. Fraud is self-deception

11. Bibliography and resources

[**Lue**] D. Luenberger, Introduction to Dynamic Systems: Theory, Models & Applications. Wiley & Sons. 1979

12. Bibliography and supplementary resources

[**Bay**] J. Bay, Fundamentals of linear state space systems. McGraw-Hill, 1999.

[**Oga**] K. Ogata, System Dynamics. Prentice-Hall. 1987.

13. Agreements for the development of the course

GENERAL RULES

Lectures will be given in English. Questions and comments by students are allowed in Spanish but will be answered in English unless not understood previously. Homeworks will be solved in English and Exams will be allowed to be solved in Spanish.

There will be no approximation of grades at the end of the semester. The grades will only be

changed based on TIMELY claims within the time limits determined by the Academic Regulations. If for reasons of force majeure, the student misses a partial or quiz, he / she must follow the regular procedure determined by the Academic Regulations to present substitutes. There will be no informal agreements in this regard. No student will be exempted from any exam. The course does not have any type of Bonus. The monitoring is not regular but on demand. The monitoring schedule can be used to make up classes and / or exams.

If the student shows up 20 minutes after starting a partial or final evaluation, he / she will not be able to present it and must request a supplementary one following the institutional regulations.

DISCIPLINARY PROCESSES-FRAUD IN EVALUATIONS

Taking into account the training-preventive and disciplinary regulations of the Universidad del Rosario, and the certainty that fraudulent actions go against the teaching and learning processes, any corrupt act related to this subject will be notified to the corresponding academic secretariat so that the due disciplinary process begins. It is recommended that students read these regulations to know the reasons, procedures and consequences that this type of actions may cause, as well as their rights and duties associated with this type of procedure.

14. Respect and non-discrimination

If you have a disability, whether it is visible or not, and require some type of support to be on an equal footing with other students, please inform your teacher to that reasonable adjustments to the course can be made as soon as possible. Likewise, if you do not have the technological resources required for the development of the course, please inform the Academic Secretary of your program or the Student Office in a timely manner, so that your request can be met on time.

Remember that it is the duty of all people to respect the rights of those who are part of the Rosarista community. Any situation of harassment, sexual harassment, discrimination or bullying, whether in person or virtual, is unacceptable. Anyone who feels in any of these situations can report its occurrence by contacting the team of the Coordination of Psychology and Quality of Life of the Dean of the University Environment (Telephone or WhatsApp 322 2485756).