INSTITUTO POLITÉCNICO DE BRAGANÇA

Course Unit	Modeling and Simulation			Field of study	Mathematics and Statistics		
Bachelor in	Environmental Engineering			School	School of Agriculture		
Academic Year	2022/2023	Year of study	2	Level	1-2	ECTS credits	6.0
Type	Semestral	Semester	2	Code	9099-309-2204-00-22		

Workload (hours)	162	Contact hours	T	TP	PL	TC	S	E	OT	O
			30	-	30	-	-	-	20	-

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s): Luís Filipe de Sousa Teixeira Nunes

Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:
1. Apply fundamental numerical methods to specific simulation problems.
2. Analyze the results from numerical simulations.
3. Be aware of methodologies for the modeling of ecological and environmental problems.
4. Develop and apply models using computational tools.

Prerequisites

Before the course unit the learner is expected to be able to:
Basic knowledge in Mathematics and Statistics. Concepts of Ecology and Systems Dynamics.

Course contents

Introduction to modeling and simulation. Fundamentals of mathematical modeling: mathematical models and its classification; developing process of mathematical models. Mathematical methods and tools for modeling applications: static and dynamic formulations; analytical and numerical methods. Continuous simulation models: conceptual formulation; numerical specification; model evaluation and model use; Simulation problems applied to Ecology and Environment. Statistical modeling and simulation.

Course contents (extended version)

1. Basic concepts of systems analysis and simulation:
   - system, system analysis, model, and simulation.
2. Theoretical phases of systems analysis:
   - conceptual-model formulation,
   - quantitative-model specification,
   - model evaluation,
   - model use, and model validation.
3. Conceptual-model formulation:
   - defining objectives for the model,
   - bounding the system of interest,
   - components of the system, state and driving variables, constants, auxiliary variables,
   - material and information transfers, sources and sinks,
   - relationships among components of interest, sub-models
   - representation of the conceptual model, description of expected patterns of model behavior.
4. Statistical modeling: regression as a modeling tool
   - linear and non-linear regression models,
   - concepts on biological growth and yield, growth and yield models.
5. Quantitative-model specification:
   - quantitative structure of the model (difference equations and general compartment-model structure),
   - time units for the simulations,
   - functional forms of the model, parameterization,
   - baseline simulations.
6. Model evaluation:
   - reasonableness of the model structure and interpretability of functional relationships,
   - correspondence between model behaviour and the expected patterns of model behaviour,
   - correspondence between model predictions and real data, sensitivity analysis.
7. Model use: experimental design for the simulations, analysis and interpretation of the results.

Recommended reading

1. Ford, A. , 2010. Modeling the Environment. 2nd edition. Island Press.
2. Grant W. E. , Pedersen, E. K. , Marín, S. L. , 1997. Ecology and natural resource management. Systems analysis and simulation. John Wiley & Sons.
3. Bala, B. K. , Arshad, F. M. , Noh, K. M. , 2017. System Dynamics, Modelling and Simulation, Springer.
4. Hannon, B. , Ruth, M. , 2014. Modeling dynamic biological systems. 2nd edition, Springer.
5. Nirmalakhandan, N. , 2002. Modeling Tools for Environmental Engineers and Scientists. CRC Press.

Teaching and learning methods

Oral presentations with multimedia support. Individual/group practical assignments. Project work for most of the semester. Literature research, conventional and online resources. E-learning resources available to access presentations and other documentation.

Assessment methods

1. Regular students - (Regular) (Final, Supplementary, Special)
   - Final Written Exam - 50% (final exam)
   - Practical Work - 15% (labs)
   - Projects - 35% (project)
2. Workers - (Student Worker) (Final, Supplementary, Special)
   - Projects - 50% (project)
   - Final Written Exam - 50% (final exam)

Language of instruction

Portuguese, with additional English support for foreign students.

Electronic validation

Luís Filipe de Sousa Teixeira Nunes	João Carlos Martins de Azevedo	Artur Jorge de Jesus Gonçalves	Maria Sameiro Ferreira Patrício
06-12-2022	19-12-2022	20-12-2022	21-12-2022