Program	Type of studies (cycle)	Third cycle – doctoral studies
	Name of the program	Doctoral Studies in Mathematical and Computer Science

Course

Course title	**Mathematical Biology**			
Course code	Semester	Course status	ECTS credits	Contact hours
AMAT 602	II	elective	10	30

Aims and intended learning outcomes	This course develops advanced skills in mathematical modeling, analysis, and interpretation of biological systems. It addresses the formulation and investigation of models in population biology, ecology, epidemiology, biochemistry, and evolutionary dynamics. It emphasizes the relationship between biological assumptions, model structure, and the resulting conclusions. The course also covers models of species interactions, including predator–prey, host–parasitoid, plant–herbivore, competition, and mutualism, as well as biological mechanisms such as the Allee effect, refuge effects, immigration, harvesting, saturation, seasonality, time delays, and spatial heterogeneity. The course gives students the skills needed to qualitatively and numerically analyze stability, persistence, extinction, coexistence, oscillations, and bifurcations, and to critically interpret the biological significance of these models.

Course content/topics

- **Fundamentals of mathematical modeling in biology:** biological assumptions, state variables, parameters, discrete and continuous time, equilibria, stability, survival, extinction, persistence, and coexistence.
- **Population growth models:** exponential and logistic growth, carrying capacity, discrete population models, Beverton–Holt and Ricker models, Allee effect, immigration, emigration, harvesting, and extinction thresholds.
- **Predator–prey models and functional responses:** Lotka–Volterra and Rosenzweig–MacArthur models, Holling functional responses, predator saturation, predator interference, stability, oscillations, and coexistence.
- **Refuge effects and modifications of ecological models:** constant, proportional, density-dependent, and spatial refuges, available prey population, fear effects, supplementary food, time delays, seasonality, and system stabilization.
- **Host–parasitoid and plant–herbivore models:** Nicholson–Bailey model, escape functions, parasitoid aggregation, refuge effects, plant biomass growth, herbivory, defoliation, plant recovery, herbivore saturation, and coexistence.
- **Competition, mutualism, and more complex interactions:** competitive exclusion, species coexistence, mutualism, symbiosis, limited resources, multiple equilibria, and bistability.
- **Epidemiological models:** SI, SIS, SIR, and SEIR models, basic reproduction number, disease-free equilibrium, endemic equilibrium, vaccination, quarantine, loss of immunity, and discrete epidemiological models.
- **Biochemical kinetics and gene regulation:** law of mass action, Michaelis–Menten kinetics, enzyme saturation, Hill functions, feedback mechanisms, biological switches, and oscillators.
- **Structured populations, evolutionary dynamics, and spatial models:** Leslie matrices, stage-structured models, metapopulations, migration, replicator dynamics, diffusion, reaction–diffusion models, and spatial patterns.
- **Analysis and simulation of biological models:** equilibria, linearization, local stability, phase plane analysis, nullclines, bifurcations, numerical simulations, parameter sensitivity, and model validation.

LITERATURE

[1] Murray, J. D. Mathematical Biology I: An Introduction. 3rd ed., Springer, 2002.
[2] Edelstein-Keshet, L. Mathematical Models in Biology. SIAM, 2005.
[3] Brauer, F., Castillo-Chavez, C. Mathematical Models in Population Biology and Epidemiology. 2nd ed., Springer, 2012.
[4] Kot, M. Elements of Mathematical Ecology. Cambridge University Press, 2001.
[5] de Vries, G., Hillen, T., Lewis, M., Müller, J., Schönfisch, B. A Course in Mathematical Biology: Quantitative Modeling with Mathematical and Computational Methods. SIAM, 2006.
[6] Allen, L. J. S. An Introduction to Mathematical Biology. Pearson/Prentice Hall, 2007.
[7] Murdoch, W. W., Briggs, C. J., Nisbet, R. M. Consumer-Resource Dynamics. Princeton University Press, 2003.

Grading

	Criterion	Points	Cut-off points
1.	Assignments and short quizzes	20	13
2.	Project	30	17
3	Final exam	50	25
Total		100	55