Università degli Studi di L'Aquila - Dipartimento di Ingegneria e Scienze dell'Informazione e Matematica

Course catalogue

Page compiled on 17/07/2019

Programme of Module "Biomathematics"

- Code: DT0262
- Type of course unit: Elective (Master Degree in Mathematical Engineering curriculum Comune)
- Level of course unit: Postgraduate Degrees
- Semester: 1

Number of ects credits: (Master Degree in Mathematics) 6 (workload 150 hours)

Teachers: Marco Di Francesco, Cristina Pignotti (pignotti@univaq.it)

1	**Course objectives**	1) To learn the basics in the mathematical modelling of population dynamics. 2) To provide a mathematical description of ODE models in population dynamics and the intepretation of the qualitative behaviour of the solutions. 3) To get the basic notions in mathematical models in epidemiology and reaction kinetics. 4) To learn the mathematical modelling of population models in heterogeneous environment, described by partial differential equations. 5) To deal with advanced models in biology such as chemotaxis models and structured dynamics equations. 6) To get a sound background in reaction diffusion phenomena, Turing instability, and pattern formation.
2	**Course content and learning outcomes (dublin descriptors)**	Topics of the module include: • Continuous Population Models for Single Species. Continuous Growth Models. Delay models. Linear Analysis of Delay Population Models: Periodic Solutions. • Continuous models for Interacting Populations. PredatorPrey Models: Lotka-Volterra Systems. Realistic Predator–Prey Models. Competition Models: Principle of Competitive Exclusion. Mutualism or Symbiosis • Reaction kinetics. Enzyme Kinetics: Basic Enzyme Reaction. Transient Time Estimates and Nondimensionalisation. Michaelis-Menten Quasi-Steady State Analysis • Dynamics of Infectious Diseases: Epidemic Models and AIDS. Simple Epidemic Models (SIR, SI) and Practical Applications. Modelling Venereal Diseases. AIDS: Modelling the Transmission Dynamics of the Human Immunodeficiency Virus (HIV). • Time-space dependent models: PDEs in biology. Diffusion equations. Diffusion and Random walk. The gaussian distribution. Smoothing and decay properties of the diffusion operator. Nonlinear diffusion • Reaction–diffusion models for one single species. Diffusive Malthus equation and critical patch size. Travelling waves. Fisher–Kolmogoroff equation. • Reaction–diffusion systems. Multi species waves in Predator-Prey Systems. Turing instability and spatial patterns. • Chemotaxis modelling. Diffusion vs. Chemotaxis: stability vs. instability. Diffusion vs. Chemotaxis: stability and blow–up. Chemotaxis with nonlinear diffusion. Models with maximal density • Nonlocal interaction models in biology. Mathematical models of swarms. Approximation with interacting particle systems. Asymptotic behaviour. • Structured population dynamics. An example in ecology: competition for resources. Continuous traits. Evolutionary stable strategy in a continuous model. On successful completion of this module, the student should : • Be able to construct simple mathematical models in population dynamics in homogeneous and heterogeneous environments, non only in biological applications, but also in social sciences. Get to know the qualitative behaviour os models with many species. Be able to interpret simple mathematical results in the corresponding applied contexts. Get the basic knowledge of advanced mathematical modelling in cell biology, population biology, ecology, chemistry. Know how to use basic tools in ordinary differential equations and partial differential equations to determine the asymptotic behaviour of the solutions.
3	**Course prerequisites**	Basic calculus and analysis (differential and integral calculus with functions of many variables). ORdinary differential equations. Basics in finite dimensional dynamical

		systems. Elementary methods for the solution of linear partial differential equations (separation of the variables).
4	**Teaching methodsand language**	Chalk and board lectures. **Language**: English **Reference textbooks** • James D. Murray, ***Mathematical Biology I: an introduction***. Springer. • James D. Murray, ***Mathematical Biology II: Spatial models and biomedical applications*** . Springer. • Benoit Perthame, ***Transport equations in biology***. Birkaeuser.
5	**Assessment methods**	Written test with open question on the material covered in the course. The questions contains mathematical problems and examples which have to be solved rigorously.