Approval: 22nd Senate Meeting

Course Name : **Modeling Population Dynamics**
Course Number : MA 621
Credit : 3-0-0-3
Prerequisites : MA 513 Ordinary Differential Equations Students intended for : M.Sc./B.Tech/M.S./M.Tech/Ph.D. Elective or core : Elective
Semester : Odd/Even

Course Description:
The major goals of this course are to develop techniques of computational and differential equation modeling in ecology. This course is an introduction to synthesis of mathematical models and empirical ecology. Why do organisms become extremely abundant one year, and then apparently disappear a few years later? Why population outbreaks in certain species in certain locations happen more or less regularly, while in other locations such eruptions are irregular? This course will provide answers to such questions. This course will begin with a detailed examination of the dynamics of individual populations and go on to consider how interspecific interactions impact populations. While this course is strongly focused on the underlying theories of population ecology and the mathematical formulations that accompany these theories, the ultimate goal is always the better understanding of real populations. This course will introduce a number of modeling approaches that are widely used in applications to life sciences and age-structured model. From this course, students will gain a better understanding of population dynamics in general.

Course Content:

Module 1:

Introduction:
Modeling Nature: History and General philosophy of the modeling approach. The demand for Reliable Prediction and Latest Development in Mathematical Modeling. Advantages and Demerits of Mathematical Modeling while Dealing with Real world's Problems. [2 hours]

Module 2: Unstructured Population Models:
Population Dynamics from the first principle, Single-Species Models with Exponential and Logistic growth, Self Limitation, Consumer Resource Oscillation. Application of theory of Difference Equations to Population Growth models. Introduction to Discrete- time Models. Linear Models, Growth Models, Harvest Models: Bifurcation and Breakpoints. Delayed Differential models, Exogenous Drivers. [8 hours]

Module 3: Introduction to Continuous Models:

Models for Single Species Populations: Malthus Model, Logistic Growth, Allee Effect. Predator-Prey System and the Lotka-Volterra Equations, Populations in Competition, Multiple-Species Communities and the Routh-Hurwitz Criteria, Qualitative Stability Types of Models: Continuous-time, Discrete-time, Delayed Differential models, Exogenous Drivers. [10 hours]

Module 4: Age and Stage-Structured Models In Ecology:

Discrete Time Models with Age and Stage classes, Leslie Matrices, Estimating the Transition Matrix From Empirical Data, fisheries and Insect Populations as Prototype Example. [6 hours]

Module 5: Population Interactions:

Functional response, Aggregative response, Numerical Response, Competetion Models, Mutualism Models, Lotka Volterra Model, Anatomy of Predator Prey Cycle, Grazing systems, pathogens and parasites, Tritrophic Models . [8 hours]

Module 6: Empirical Approaches:

Analysis of Population fluctuations, Time Series Analysis, Fitting Models to Data, Fitting Mechanistic Models
[8 hours]

Text Books:

1. Introduction to Population Ecology, Larry L. Rockwood, Blackwell Publishing Limited, 2nd Edition, 2015.

Reference Books:

1. Mathematical Models, Richard Haberman, SIAM, 5th edition, 2013.
2. Mathematical Models in Biology, Leah Edelstein Keshet, SIAM, 2005
3. Complex Population Dynamics: A Theoretical Empirical Synthesis, Peter Turchin, Princeton University Press, 2003.
4. Environmental Modelling: An Introduction, Jo Smith and Pete Smith, Oxford University Press, 2007.
5. Elements Of Mathematical Ecology, Mark Kot, Cambridge University Press, Ist Edition, 2001.