2-Year Master's Program in Mathematics (NEP-2020)

APPLIED MATHEMATICAL MODELLING

Masters Mathematics (2nd Semester) Total Credits: 04
Course Code: MMTHDMM226 (15 hours per credit) Total Marks: 100
Continuous Assessment: Marks 30, Theory: Marks 70 Time Duration: 2½ hrs

Course Learning Outcomes(CLO's): After successful completion of this course, students will be able to:

CLO1. Understand the fundamental concepts, types, and processes of mathematical modelling, including formulation, validation, and limitations of models.
CLO2. Develop and analyze mathematical models using ordinary differential equations and systems of equations for problems in physical, biological, and economic contexts.
CLO3. Construct and solve discrete models using difference equations and apply graph-theoretic and network-based approaches to real-world problems.
CLO4. Apply basic modelling techniques to physical and biological systems, including compartment models, diffusion processes, and simple chemical reaction models.

Unit-I:
Fundamentals of Mathematical Modeling: Introduction to mathematical modelling: definition, scope, and significance in science, engineering, economics, and life sciences. Steps in the modelling process: problem identification, assumptions, formulation, analysis, validation, and interpretation. Classification of mathematical models: deterministic vs stochastic, discrete vs continuous, linear vs nonlinear, static vs dynamic models. Model validation, Sensitivity analysis, and limitations of models. Elementary mathematical models in physical sciences: Simple harmonic motion, Projectile motion, Newton's law of gravitation.

Unit-II:
Differential Equation Models: Mathematical modelling using ordinary differential equations (ODEs). Formulation of first-order and higher-order differential equation models. Systems of differential equations and their applications in modelling. Applications: Single-species population models (exponential and logistic growth), Multi-species interactions (introductory concepts), Modelling of communicable diseases (basic epidemic models), Economic growth models, Mechanical systems and oscillations.

Unit–III:
Discrete and Network Models: Discrete-time modelling and difference equations. Linear difference equations with constant coefficients and their solutions. Applications: Population models in discrete time, Financial and investment models , Inventory and resource management , Graph-theoretic and network models: Basic concepts of graphs, Applications in transportation and communication networks, Social network modelling, Introduction to probabilistic models and Markov processes.

Unit–IV:
Physical and Biological Models: Introduction to compartmental modelling in biological systems. One- and two-compartment models and their interpretations. Multi-compartment systems with applications to pharmacokinetics (basic idea). Physical and biological models: Heat conduction and diffusion (Fourier law), Diffusion in biological tissues (introductory concepts), Chemical

reaction models: law of mass action and basic kinetics, Introduction to parameter estimation and model fitting.

CLO-PLO Mapping Matrix (Strength version)

CLO ↓	PLO →	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	Average CLO
MMTHDRM226.1		3	3	3	3	3	3	3	3	**3**
MMTHDRM226.2		3	3	3	3	2	3	3	3	**2.87**
MMTHDRM226.3		3	1	3	1	1	1	2	3	**1.88**
MMTHDRM226.4		3	2	3	1	2	3	1	3	**2.25**
Average PLO		**3**	**2.25**	**3**	**2**	**2**	**2.5**	**2.25**	**3**	**2.5**

Books Recommended:

1. J. N. Kapur, Mathematical Modelling, New Age International Publishers.
2. Neil Gerschenfeld : The nature of Mathematical modeling, CambridgeUniversity Press, 1999.
3. MA Khanday, Introduction to modeling and Biomathematics, Dilpreet Pub’s, New Delhi, 2016.
4. A. C. Fowler : Mathematical Models in Applied Sciences, CambridgeUniversity Press, 1997.
5. M. R. Cullen, Linear Models in Biology, Ellis Harwood Ltd.
6. J.N. Kapur, Mathematical Model in Biology and Medicines.