DISCIPLINE SPECIFIC ELECTIVE COURSE – 3(i): BIOMATHEMATICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biomathematics	4	3	1	0	Class XII pass with Mathematics	Discipline A-3: Differential Equations

Learning Objectives: The main objective of this course is to:
- Develop and analyse the models of the biological phenomenon with emphasis on population growth and predator-prey models.
- Interpret first-order autonomous systems of nonlinear differential equations using the Poincaré phase plane.
- Apply the basic concepts of probability to understand molecular evolution and genetics.

Learning Outcomes: The course will enable the students to:
- Get a better comprehension of mathematical models, utilised in biology.
- To identify and explain the findings from models of population studies, species' communication, adaptation, and dynamics of disorder.
- Create a basic model of molecular evolution by making use of probability and matrices.

SYLLABUS OF DSE-3(i)

UNIT – I: Mathematical Modeling for Biological Processes   (15 hours)
Formulation a model through data, A continuous population growth model, Long-term behavior and equilibrium states, The Verhulst model for discrete population growth,

Administration of drugs, Differential equation of chemical process and predator-prey model (Function response: Types I, II and III).

UNIT – II: Epidemic Model: Formulation and Analysis   (15 hours)
Introduction to infectious disease, The SIS, SIR and SEIR models of the spread of an epidemic, Analyzing equilibrium states, Phase plane analysis, Stability of equilibrium points, Classifying the equilibrium state; Local stability, Limit cycles, Poincaré-Bendixson theorem.

UNIT – III: Bifurcation, Chaos and Modeling Molecular Evolution   (15 hours)
Bifurcation, Bifurcation of a limit cycle, Discrete bifurcation and period-doubling, Chaos, Stability of limit cycles, Introduction of the Poincaré plane; Modeling molecular evolution: Matrix models of base substitutions for DNA sequences, Jukes-Cantor and Kimura models, Phylogenetic distances.

Essential Readings
4. Robeva, Raina S., et al. (2008). An Invitation to Biomathematics. Academic press.
5. Jones, D. S., Plank, M. J., & Sleeman, B. D. (2009). Differential Equations and Mathematical Biology (2nd ed.). CRC Press, Taylor & Francis Group.
6. Allman, Elizabeth S., & Rhodes, John A. (2004). Mathematical Models in Biology: An Introduction. Cambridge University Press.

Suggestive Readings
- Linda J. S. Allen (2007). An Introduction to Mathematical Biology. Pearson Education.
- Murray, J. D. (2002). Mathematical Biology: An Introduction (3rd ed.). Springer.
- Shonkwiler, Ronald W., & Herod, James. (2009). Mathematical Biology: An Introduction with Maple and MATLAB (2nd ed.). Springer.

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DISCIPLINE SPECIFIC ELECTIVE COURSE-3(ii): MATHEMATICAL PYTHON

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CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Mathematical Python	4	3	0	1	Class XII pass with Mathematics	Basic knowledge of Python

Learning Objectives: The Learning Objectives of this course are as follows:
- To be able to model and solve mathematical problems using Python Programs.
- To experience utility of open-source resources for numerical and symbolic mathematical software systems.

Learning Outcomes: This course will enable the students to use Python:

- For numerical and symbolic computation in mathematical problems from calculus, algebra, and geometry.
- To tabulate and plot diverse graphs of functions and understand tracing of shapes, geometries, and fractals.
- To prepare smart documents with LaTeX interface.

SYLLABUS OF DSE - 3(ii)

Theory

UNIT – I: Drawing Shapes, Graphing and Visualization   (15 hours)

Drawing diverse shapes using code and Turtle; Using matplotlib and NumPy for data organization, Structuring and plotting lines, bars, markers, contours and fields, managing subplots and axes; Pyplot and subplots, Animations of decay, Bayes update, Random walk.

UNIT – II: Numerical and Symbolic Solutions of Mathematical Problems   (18 hours)

NumPy for scalars and linear algebra on n-dimensional arrays; Computing eigenspace, Solving dynamical systems on coupled ordinary differential equations, Functional programming fundamentals using NumPy; Symbolic computation and SymPy: Differentiation and integration of functions, Limits, Solution of ordinary differential equations, Computation of eigenvalues, Solution of expressions at multiple points (lambdify), Simplification of expressions, Factorization, Collecting and canceling terms, Partial fraction decomposition, Trigonometric simplification, Exponential and logarithms, Series expansion and finite differences, Solvers, Recursive equations.

UNIT – III: Document Generation with Python and LaTeX   (12 hours)

Pretty printing using SymPy; Pandas API for IO tools: interfacing Python with text/csv, HTML, LaTeX, XML, MSExcel, OpenDocument, and other such formats; Pylatex and writing document files from Python with auto-computed values, Plots and visualizations.

Practical (30 hours): Software labs using IDE such as Spyder and Python Libraries.

- Installation, update, and maintenance of code, troubleshooting.

- Implementation of all methods learned in theory.

- Explore and explain API level integration and working of two problems with standard Python code.

Essential Readings
1. Farrell, Peter (2019). Math Adventures with Python. No Starch Press. ISBN Number: 978-1-59327-867-0.
2. Farrell, Peter and et al. (2020). The Statistics and Calculus with Python Workshop. Packet Publishing Ltd. ISBN: 978-1-80020-976-3.
3. Saha, Amit (2015). Doing Math with Python. No Starch Press. ISBN: 978-1-59327-640-9

Suggestive Readings

- Morley, Sam (2022). Applying Math with Python (2nd ed.). Packet Publishing Ltd. ISBN: 978-1-80461-837-0
- Online resources and documentation on the libraries, such as:
  - https://matplotlib.org
  - https://sympy.org
  - https://pandas.pydata.org
  - https://numpy.org
  - https://pypi.org
  - https://patrickwalls.github.io/mathematicalpython/

Note: **Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

DISCIPLINE SPECIFIC ELECTIVE COURSE-3(iii): MECHANICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Mechanics	4	3	1	0	Class XII pass with Mathematics	Discipline A-1: Topics in Calculus Discipline A-3: Differential Equations

Learning Objectives: The main objective of this course is to:
- Starting Newtonian laws, learning various technical notions which explains various states of motion under given forces.
- Deals with the kinematics and kinetics of the rectilinear and planar motions of a particle including constrained oscillatory motions of particles, projectiles, and planetary orbits.
- Understand hydrostatic pressure and thrust on plane surfaces.

Learning Outcomes: This course will enable the students to:
- Understand necessary conditions for the equilibrium of particles acted upon by various forces and learn the principle of virtual work for a system of coplanar forces.
- Apply the concepts of center of gravity, laws of static and kinetic friction.
- Learn that a particle moving under a central force describes a plane curve and know the Kepler's laws of the planetary motions.
- Evaluate the hydrostatic pressure at any given depth in a heavy homogeneous liquid at rest under gravity.

SYLLABUS OF DSE-3(iii)

UNIT – I: Statics   (15 hours)

Fundamental laws of Newtonian mechanics, Law of parallelogram of forces, Equilibrium of a particle, Lamy's theorem, Equilibrium of a system of particles, External and internal forces, Couples, Reduction of a plane force system, Work, Principle of virtual work, Potential energy and conservative field, Mass centers, Centers of gravity, Friction.

UNIT – II: Dynamics   (18 hours)

Kinemetics of a particle, Motion of a particle, Motion of a system, Principle of linear momentum, Motion of mass center, Principle of angular momentum, Motion relative to mass center, Principle of energy, D'Alembert's principle; Moving frames of reference, Frames of reference with uniform translational velocity, Frames of reference with constant angular velocity; Applications in plane dynamics- Motion of a projectile, Harmonic oscillators, General motion under central forces, Planetary orbits.

UNIT – III: Hydrostatics   (12 hours)

Shearing stress, Pressure, Perfect fluid, Pressure at a point in a fluid, Transmissibility of liquid pressure, Compression, Specific gravity, Pressure of heavy fluid- Pressure at all points in a horizontal plane, Surface of equal density; Thrust on plane surfaces.

Essential Readings

3. Synge, J. L., & Griffith, B. A. (2017). Principles of Mechanics (3rd ed.). McGraw-Hill Education. Indian Reprint.
4. Ramsey, A. S. (2017). Hydrostatics. Cambridge University Press. Indian Reprint.

Suggestive Readings

- Roberts, A. P. (2003). Statics and Dynamics with Background Mathematics. Cambridge University Press.
- Ramsey, A. S. (1985). Statics (2nd ed.). Cambridge University Press.