NEP: UGCF 2022

B.Sc. (Hons.) Mathematics

Syllabi and *Books* for
Discipline-Specific Core & Elective Courses

<u>Semester-IV</u>

Syllabi (Source File):
21092023_Maths.pdf

(From Page 2)

(The books are hosted on **GitHub** and **Drive**)
Depending on the features of the cited PDF file, either the PDF viewer or the Browser may be invoked.

DSC-X
SEQUENCES AND SERIES OF FUNCTIONS

<u>Unit-I</u> **Sequences of Functions**
♦ Pointwise and uniform convergence of sequence of functions   ♦ The uniform norm
♦ Cauchy criterion for uniform convergence   ♦ Continuity of the limit function of a sequence of functions   ♦ Interchange of the limit and derivative, and the interchange of the limit and integral of a sequence of functions   ♦ Bounded convergence theorem

<u>Unit-II</u> **Series of Functions**
♦ Pointwise and uniform convergence of series of functions
♦ Theorems on the continuity, differentiability and integrability of the sum function of a series of functions   ♦ Cauchy criterion and the Weierstrass M-test for uniform convergence

<u>Unit-III</u> **Power Series**
♦ Definition of a power series   ♦ Radius of convergence   ♦ Absolute convergence (Cauchy−Hadamard theorem)   ♦ Differentiation and integration of power series   ♦ Abel's theorem
♦ Weierstrass's approximation theorem   ♦ The exponential, logarithmic and trigonometric functions: Definitions and their basic properties

Essential Readings

1. Bartle, Robert G. & Sherbert, Donald R. (2011) - Introduction to Real Analysis (4th Edition) - Wiley India Edition (Indian Reprint)
   View/Download (9.18 MB)

2. Ross, Kenneth A. (2013) - Elementary Analysis: The Theory of Calculus (2nd Edition) - Undergraduate Texts in Mathematics, Springer (Indian Reprint)
   View/Download (3.28 MB)

Suggestive Readings

- Bilodeau, Gerald G., Thie, Paul R. & Kenough, G. E. (2010) - An Introduction to Analysis (2nd Edition) - Jones and Bartlett India Pvt. Ltd. Student Edition (Reprinted 2015)
  View/Download (150.07 MB)

- Denlinger, Charles G. (2011) - Elements of Real Analysis - Jones and Bartlett India Pvt. Ltd. Student Edition (Reprinted 2015)
  View/Download (180.95 MB)

DSC-XI
MULTIVARIATE CALCULUS

<u>**Unit-I**</u> **Calculus of Functions of Several Variables**
♦ Basic concepts ♦ Limits and continuity ♦ Partial derivatives ♦ Tangent planes
♦ Total differential ♦ Differentiability ♦ Chain rules ♦ Directional derivatives and the gradient
♦ Extrema of functions of two variables ♦ Method of Lagrange multipliers with one constraint

<u>**Unit-II**</u> **Double and Triple Integrals**
♦ Double integration over rectangular and nonrectangular regions ♦ Double integrals in polar coordinates ♦ Triple integrals over a parallelopiped and solid regions ♦ Volume by triple integrals
♦ Triple integration in cylindrical and spherical coordinates ♦ Change of variables in double and triple integrals

<u>**Unit-III**</u> **Green's, Stokes' and Gauss Divergence Theorem**
♦ Vector field ♦ Divergence and curl ♦ Line integrals and applications to mass and work
♦ Fundamental theorem for line integrals ♦ Conservative vector fields ♦ Green's theorem
♦ Area as a line integral ♦ Surface integrals ♦ Stokes' theorem ♦ Gauss divergence theorem

Essential Reading

1. Strauss, Monty J., Bradley, Gerald L. & Smith, Karl J. (2007) - Calculus (3rd Edition) - Dorling Kindersley (India) Pvt. Ltd., Pearson Education (Indian Reprint)
   [2006, 4th Edition] **View/Download** (345.37 MB)

Suggestive Reading

- Marsden, J. E., Tromba, A. & Weinstein, A. (2004) - Basic Multivariable Calculus - Springer (SIE) (Indian Reprint)
  [1993] **View/Download** (175.26 MB)

DSC-XII
NUMERICAL ANALYSIS

Unit-I **Methods for Solving Algebraic and Transcendental Equations**
♦ Rate and order of convergence   ♦ Bisection method, Method of false position, Fixed point iteration method, Newton's method, and Secant method, their order of convergence and convergence analysis

Unit-II **Techniques to Solve Linear Systems and Interpolation**
♦ LU decomposition and its applications   ♦ Iterative methods: Gauss−Jacobi, Gauss−Seidel methods
♦ Lagrange and Newton interpolation   ♦ Piecewise linear interpolation

Unit-III **Numerical Differentiation and Integration**
♦ First and higher order approximation for the first derivative
♦ Approximation for the second derivative   ♦ Numerical integration by closed Newton−Cotes formulae: Trapezoidal rule, Simpson's rule and its error analysis   ♦ Euler's method to solve ODEs
♦ Modified Euler method   ♦ Runge−Kutta Method (fourth-order)

Note: Non-programmable scientific calculator may be allowed in the University examination.

Practical

Practical/Lab work to be performed in a Computer Lab using any of the Computer Algebra System Software such as Mathematica/MATLAB/Maple/Maxima/Scilab/SageMath etc., for the following problems based on:

1) Bisection Method.

2) Newton−Raphson Method.

3) Secant Method.

4) LU Decomposition Method.

5) Gauss−Jacobi Method.

6) Gauss−Seidel Method.

7) Lagrange Interpolation.

8) Newton Interpolation.

9) Trapezoidal Rule.

10) Simpson's Rule.

11) Euler's Method.

12) Runge−Kutta Method (fourth-order).

Essential Reading

1. Bradie, Brian (2006) - A Friendly Introduction to Numerical Analysis - Pearson Education India, Dorling Kindersley (India) Pvt. Ltd. (Third impression 2011)
   View/Download (31.33 MB)

Suggestive Readings

- Gerald, Curtis F. & Wheatley, Patrick O. (2007) - Applied Numerical Analysis (7th Edition) - Pearson Education, India
  [2004] **View/Download** (21.7 MB)

- Jain, M. K., Iyengar, S. R. K. & Jain, R. K. (2012) - Numerical Methods for Scientific and Engineering Computation (6th Edition) - New Age International Publisher, India
  [2016] **View/Download** (152.96 MB)

DSE-II(i)
BIOMATHEMATICS

__Unit-I__ **Mathematical Modelling for Biological Processes**
♦ 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**
♦ 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 Modelling Molecular Evolution**
♦ Bifurcation   ♦ Bifurcation of a limit cycle   ♦ Discrete bifurcation and period-doubling   ♦ Chaos
♦ Stability of limit cycles   ♦ Introduction of the Poincaré plane
♦ Modelling molecular evolution: Matrix models of base substitutions for DNA sequences,
Jukes−Cantor and Kimura models, Phylogenetic distances

Essential Readings

1. Robeva, Raina S., et al. (2008) - An Invitation to Biomathematics - Academic Press
   View/Download (5.37 MB)

2. Jones, D. S., Plank, M. J. & Sleeman, B. D. (2009) - Differential Equations and Mathematical Biology (2nd Edition) - CRC Press, Taylor & Francis Group
   View/Download (5.52 MB)

3. Allman, Elizabeth S. & Rhodes, John A. (2004) - Mathematical Models in Biology: An Introduction - Cambridge University Press
   View/Download (1.31 MB)

Suggestive Readings

- Allen, Linda J. S. (2007) - An Introduction to Mathematical Biology - Pearson Education
  [2006] **View/Download** (13.08 MB)

- Murray, J. D. (2002) - Mathematical Biology: An Introduction (3rd Edition) - Springer
  View/Download (4.31 MB)

- Shonkwiler, Ronald W. & Herod, James (2009) - Mathematical Biology: An Introduction with Maple and MATLAB (2nd Edition) - Springer
  View/Download (10.83 MB)

DSE-II(ii)
MATHEMATICAL MODELLING

Unit-I **Mathematical Epidemiological and Dieting Models**
◆ Modelling concepts and examples   ◆ Scaling of variables, and approximations of functions
◆ SIR and SEIR models for disease spread: Methodology, Standard and solvable SIR models, Basic reproduction number   ◆ Dieting model with analysis and approximate solutions

Unit-II **Modelling with Nonlinear Systems and Phenomena**
◆ Stability and the phase plane   ◆ Almost linear systems   ◆ Ecological models: Predators and competitors, Critical points, Oscillating populations, Survival of single species, Peaceful coexistence of two species, Interaction of logistic populations, Wildlife conservation preserve
◆ Nonlinear mechanical systems: Hard and soft spring oscillations, Damped nonlinear vibrations

Unit-III **Simulation and Optimization Modelling**
◆ Monte Carlo simulating deterministic and probabilistic behavior   ◆ Generating random numbers
◆ Linear programming model: Geometric and algebraic solutions, Simplex method and its tableau format, Sensitivity analysis

Practical

Practical/Lab work to be performed in a Computer Lab:

Modeling of the following problems using R/Python/SageMath/Mathematica/MATLAB/Maple/Maxima/Scilab etc.

1) a) Simulation of SIR model and its variants using some initial parameter values, and finding basic reproduction number for analysis.

    b) Analysis of the dieting process, which includes both body-mass loss and gain.

2) Nonlinear Systems and Phenomena

    a) Plot phase plane portraits and solutions of first-order equations

    b) Obtain interesting and complicated phase portraits for almost linear systems.

    c) Discuss large wildlife conservation preserve model and obtain: (i) The period of oscillation of the rabbit and fox populations, (ii) The maximum and minimum numbers of rabbits and foxes.

    d) Discuss the Rayleigh and van der Pol models.

3) (i) Random number generation and then use it for the following:
       a) Simulate area under a given curve.
       b) Simulate volume under a given surface.
    (ii) [2] Chapter 7 (Projects 7.4 and 7.5).

Essential Readings

1. Mickens, Ronald E. (2022) - Mathematical Modelling With Differential Equations - CRC Press, Taylor & Francis Group
   View/Download (7.52 MB)

2. Edwards, C. Henry, Penney, David E. & Calvis, David T. (2023) - Differential Equations and Boundary Value Problems: Computing and Modeling (6th Edition) - Pearson
   [2015, 5th Edition] **View/Download** (9.02 MB)

3. Giordano, Frank R., Fox, William P. & Horton, Steven B. (2014) - A First Course in Mathematical Modeling (5th Edition) - Brooks/Cole, Cengage Learning India Pvt. Ltd.
   [2013] **View/Download** (11.79 MB)

Suggestive Readings

- Barnes, Belinda & Fulford, Glenn R. (2015) - Mathematical Modelling with Case Studies. Using Maple, MATLAB (3rd Edition) - CRC Press, Taylor & Francis Group
  View/Download (4.33 MB)

- Ross, Shepley L. (2014) - Differential Equations (3rd Edition) - Wiley India Pvt. Ltd.
  [1984] **View/Download** (43.28 MB)

- Simmons, George F. (2017) - Differential Equations with Applications and Historical Notes (3rd Edition) - CRC Press, Taylor & Francis Group
  View/Download (3.77 MB)

DSE-II(iii)
MECHANICS

Unit-I **Statics**
- ◆ 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**
- ◆ 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**
- ◆ Shearing stress   ◆ Pressure   ◆ Perfect fluid   ◆ Pressure at a point in a fluid
- ◆ Transmissibility of liquid pressure   ◆ Compression   ◆ Specific gravity
- ◆ Pressure of heavy fluids: Pressure at all points in a horizontal plane, Surface of equal density
- ◆ Thrust on plane surfaces

Essential Readings

1. Synge, J. L. & Griffith, B. A. (2017) - Principles of Mechanics (3rd Edition) - McGraw-Hill Education (Indian Reprint)
   [1942, 1st Edition] **View/Download** (517.07 MB)

2. Ramsey, A. S. (2017) - Hydrostatics - Cambridge University Press (Indian Reprint)
   [1936] **View/Download** (80.27 MB)

Suggestive Readings

- Roberts, A. P. (2003) - Statics and Dynamics with Background Mathematics - Cambridge University Press
  View/Download (1.81 MB)

- Ramsey, A. S. (1985) - Statics (2nd Edition) - Cambridge University Press
  [1945, Edition N/A] **View/Download** (362.63 MB)