NEP: UGCF 2022

B.Sc. (Hons.) Mathematics

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

Semester-III

Syllabi (Source File):
06062023_87_notification_MathSC.pdf

(From Page 94)

(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-VII
GROUP THEORY

Unit-I **Permutation Groups, Lagrange's Theorem and Normal Subgroups**

♦ Permutation groups and group of symmetries ♦ Cycle notation for permutations and properties
♦ Even and odd permutations ♦ Alternating groups ♦ Cosets and its properties
♦ Lagrange's theorem and consequences including Fermat's Little theorem
♦ Number of elements in product of two finite subgroups ♦ Normal subgroups ♦ Factor groups
♦ Cauchy's theorem for finite Abelian groups

Unit-II **Group Homomorphisms and Automorphisms**

♦ Group homomorphisms, isomorphisms and properties ♦ Cayley's theorem
♦ First, Second and Third isomorphism theorems for groups ♦ Automorphism
♦ Inner automorphism ♦ Automorphism groups ♦ Automorphism groups of cyclic groups
♦ Applications of factor groups to automorphism groups

Unit-III **Direct Products of Groups and Fundamental Theorem of Finite Abelian Groups**

♦ External direct products of groups and its properties
♦ The group of units modulo n as an external direct product
♦ Applications to data security and electric circuits ♦ Internal direct products
♦ Fundamental theorem of finite abelian groups and its isomorphism classes

Essential Reading

1. Gallian, Joseph. A. (2017) - Contemporary Abstract Algebra (9th Edition) - Cengage Learning India Private Limited, Delhi (Indian Reprint 2021)
   View/Download (11.42 MB)

Suggestive Readings

- Artin, Michael (1991) - Algebra (2nd Edition) - Pearson Education (Indian Reprint 2015)
  [2014] **View/Download** (4.64 MB)
- Dummit, David S. & Foote, Richard M. (2016) - Abstract Algebra (3rd Edition) - (Student Edition) Wiley India
  [2004] **View/Download** (34.96 MB)
- Herstein, I. N. (1975) - Topics in Algebra (2nd Edition) - Wiley India (Reprint 2022)
  View/Download (10.4 MB)
- Rotman, Joseph J. (1995) - An Introduction to The Theory of Groups (4th Edition) - Springer Verlag, New York
  View/Download (38.69 MB)

DSC-VIII
RIEMANN INTEGRATION

Unit-I **The Riemann Integral**

♦ Definition of upper and lower Darboux sums ♦ Darboux integral
♦ Inequalities for upper and lower Darboux sums
♦ Necessary and sufficient conditions for the Darboux integrability
♦ Riemann's definition of integrability by Riemann sum and the equivalence of Riemann's and Darboux's definitions of integrability ♦ Definition and examples of the Riemann-Stieltjes integral

Unit-II **Properties of The Riemann Integral and Fundamental Theorems**

♦ Riemann integrability of monotone functions and continuous functions
♦ Properties of Riemann integrable functions
♦ Definitions of piecewise continuous and piecewise monotone functions and their Riemann integrability
♦ Intermediate value theorem for integrals ♦ Fundamental Theorems of Calculus (I and II)

Unit-III **Applications of Integrals and Improper Integrals**

♦ Methods of integration: integration by substitution and integration by parts
♦ Volume by slicing and cylindrical shells
♦ Length of a curve in the plane and the area of surfaces of revolution
♦ Improper integrals of Type-I, Type-II and mixed type ♦ Convergence of improper integrals
♦ The beta and gamma functions and their properties

Essential Readings

1. Ross, Kenneth A. (2013) - Elementary Analysis: The Theory of Calculus (2nd Edition) - Undergraduate Texts in Mathematics, Springer
   View/Download (3.28 MB)
2. Anton, Howard, Bivens, Irl & Davis, Stephens (2012) - Calculus (10th Edition) - John Wiley & Sons, Inc.
   View/Download (22.83 MB)
3. Denlinger, Charles G. (2011) - Elements of Real Analysis - Jones & Bartlett India Pvt. Ltd. (Indian Reprint)
   View/Download (180.95 MB)
4. Ghorpade, Sudhir R. & Limaye, B. V. (2006) - A Course in Calculus and Real Analysis - Undergraduate Texts in Mathematics, Springer (SIE) (Indian Reprint)
   View/Download (4.46 MB)

Suggestive Readings

- Bartle, Robert G. & Sherbert, Donald R. (2015) - Introduction to Real Analysis (4th Edition) - Wiley (Indian Edition)
  [2011] **View/Download** (9.18 MB)
- Kumar, Ajit & Kumaresan, S. (2014) - A Basic Course in Real Analysis - CRC Press, Taylor & Francis Group (Special Indian Edition)
  View/Download (3.59 MB)

DSC-IX
DISCRETE MATHEMATICS

Unit-I **Cardinality and Partially Ordered Sets**

♦ The cardinality of a set ♦ Definitions, examples and basic properties of posets
♦ Order-isomorphisms ♦ Covering relations ♦ Hasse diagrams
♦ Dual of an ordered set ♦ Duality principle ♦ Bottom and top elements
♦ Maximal and minimal elements ♦ Zorn's lemma ♦ Building new ordered sets
♦ Maps between ordered sets

Unit-II **Lattices**

♦ Lattices as ordered sets ♦ Lattices as algebraic structures ♦ Sublattices
♦ Products ♦ Lattice isomorphism
♦ Definitions, examples and properties of modular and distributive lattices
♦ The $M_3 - N_5$ theorem with applications ♦ Complemented lattice
♦ Relatively complemented lattice ♦ Sectionally complemented lattice

Unit-III **Boolean Algebras and Applications**

♦ Boolean algebras ♦ DeMorgan's laws ♦ Boolean homomorphism
♦ Representation theorem ♦ Boolean polynomials ♦ Boolean polynomial functions
♦ Equivalence of Boolean polynomials
♦ Disjunctive normal form and conjunctive normal form of Boolean polynomials
♦ Minimal forms of Boolean polynomials ♦ Quine−McCluskey method
♦ Karnaugh diagrams ♦ Switching circuits and applications
♦ Applications of Boolean algebras to logic, set theory and probability theory

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) Expressing relations as ordered pairs and creating relations.
2) Finding whether or not, a given relation is:
   i. Reflexive
   ii. Anti-symmetric
   iii. Transitive
   iv. Partial order
3) Finding the following for a given partially ordered set
   i. Covering relations.
   ii. The corresponding Hasse diagram representation.

iii. Minimal and maximal elements.

4) Finding the following for a subset S of a given partially ordered set P

   i. Whether a given element in P is an upper bound (lower bound) of S or not.

   ii. Set of all upper bounds (lower bounds) of S.

   iii. The least upper bound (greatest lower bound) of S, if it exists.

5) Creating lattices and determining whether or not, a given partially ordered set is a lattice.

6) Finding the following for a given Boolean polynomial function:

   i. Representation of Boolean polynomial function and finding its value when the Boolean variables in it take particular values over the Boolean algebra $\{0, 1\}$.

   ii. Display in table form of all possible values of Boolean polynomial function over the Boolean algebra $\{0, 1\}$.

7) Finding the following:

   i. Dual of a given Boolean polynomial/expression.

   ii. Whether or not two given Boolean polynomials are equivalent.

   iii. Disjunctive normal form (Conjunctive normal form) from a given Boolean expression.

   iv. Disjunctive normal form (Conjunctive normal form) when the given Boolean polynomial function is expressed by a table of values.

8) Representing a given circuit diagram (expressed using gates) in the form of Boolean expression.

9) Minimizing a given Boolean expression to find minimal expressions.

Essential Readings

1. Davey, B. A. & Priestley, H. A. (2002) - Introduction to Lattices and Order (2nd Edition) - Cambridge University Press, Cambridge
   View/Download (1.66 MB)

2. Goodaire, Edgar G. & Parmenter, Michael M. (2006) - Discrete Mathematics with Graph Theory (3rd Edition) - Pearson Education Pvt. Ltd. (Indian Reprint)
   View/Download (12.9 MB)

3. Lidl, Rudolf & Pilz, Gunter (2004) - Applied Abstract Algebra (2nd Edition) - Undergraduate Texts in Mathematics, Springer (SIE) (Indian Reprint)
   [1998] **View/Download** (7.55 MB)

Suggestive Readings

- Donnellan, Thomas (1999) - Lattice Theory (1st Edition) - Khosla Pub. House (Indian Reprint)
  [1998, Elsevier] **View/Download** (9.81 MB)

- Rosen, Kenneth H. (2019) - Discrete Mathematics and its Applications (8th Edition), Indian adaptation by Kamala Krithivasan - McGraw-Hill Education (Indian Reprint 2021)
  View/Download (8.32 MB)

DSE-I(i)
GRAPH THEORY

Unit-I **Graphs, Paths and Circuits**

♦ Definition, Examples and basic properties of graphs ♦ Subgraphs ♦ Pseudographs ♦ Complete graphs ♦ Bipartite graphs ♦ Isomorphism of graphs ♦ Paths and circuits ♦ Connected graphs ♦ Eulerian circuits ♦ Hamiltonian cycles ♦ Adjacency matrix ♦ Weighted graph ♦ Travelling salesman problem ♦ Shortest path ♦ Dijkstra's algorithm

Unit-II **Applications of Paths and Circuits, Trees**

♦ Applications of Path and Circuits: The Chinese Postman Problem, Digraphs, Bellman−Ford Algorithm, Tournaments, Scheduling Problem ♦ Trees ♦ Properties of Trees ♦ Spanning Trees ♦ Minimum Spanning Tree Algorithms

Unit-III **Connectivity and Graph Coloring, Planar Graphs**

♦ Cut-vertices ♦ Blocks and their Characterization ♦ Connectivity and edge-connectivity ♦ Planar graphs ♦ Euler's formula ♦ Kuratowski theorem ♦ Graph coloring and applications ♦ Matchings ♦ Hall's theorem ♦ Independent sets and covers

Essential Readings

1. Goodaire, Edgar G. & Parmenter, Michael M. (2006) - Discrete Mathematics with Graph Theory (3rd Edition) - Pearson Education Pvt. Ltd. (Indian Reprint)
   View/Download (12.9 MB)
2. Chartrand, Gary & Zhang, Ping (2012) - A First Course in Graph Theory - Dover Publications
   View/Download (6.71 MB)

Suggestive Readings

- Bondy, J. A. & Murty, U.S.R. (2008) - Graph Theory - Graduate Texts in Mathematics, Springer
  View/Download (5.21 MB)
- Diestel, Reinhard (2017) - Graph Theory (5th Edition) - Graduate Texts in Mathematics, Springer
  View/Download (2.81 MB)
- West, Douglas B. (2001) - Introduction to Graph Theory (2nd Edition) - Prentice Hall (Indian Reprint) [2002] **View/Download** (62.65 MB)

DSE-I(ii)
MATHEMATICAL PYTHON

Unit-I **Drawing Shapes, Graphing and Visualization**

♦ 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**

♦ `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**
♦ 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

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
   View/Download (17.46 MB)
2. Farrell, Peter and et al. (2020) - The Statistics and Calculus with Python Workshop - Packet Publishing Ltd.
   View/Download (15.48 MB)
3. Saha, Amit (2015) - Doing Math with Python - No Starch Press
   View/Download (6.54 MB)

Suggestive Readings

- Morley, Sam (2022) - Applying Math with Python (2nd Edition) - Packet Publishing Ltd.
  View/Download (17.73 MB)
- 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/

DSE-I(iii)
NUMBER THEORY

Unit-I **Linear Diophantine equation and Theory of Congruences**
♦ The Euclidean Algorithm and linear Diophantine equation ♦ Least non-negative residues and complete set of residues modulo n ♦ Linear congruences, The Chinese remainder theorem and system of linear congruences in two variables ♦ Fermat's little theorem ♦ Wilson's theorem and its converse ♦ Application to solve quadratic congruence equation modulo odd prime p

Unit-II **Number-Theoretic Functions and Primitive Roots**
♦ Number-theoretic functions for the sum and number of divisors ♦ Multiplicative function ♦ Möbius inversion formula and its properties ♦ Greatest integer function with an application to the calendar ♦ Euler's Phi-function ♦ Euler's theorem and some properties of the Phi-function ♦ The order of an integer modulo n and primitive roots for primes ♦ Primitive roots of composite numbers n: when n is of the form 2^k, and when n is a product of two coprime numbers

Unit-III **Quadratic Reciprocity Law and Public Key Cryptosystems**

- ⧫ The quadratic residue and nonresidue of an odd prime and Euler's criterion
- ⧫ The Legendre symbol and its properties ⧫ Quadratic Reciprocity law and its application
- ⧫ Introduction to Cryptography, Hill's cipher, Public-key Cryptography and RSA

Essential Reading

1. Burton, David M. (2011) - Elementary Number Theory (7th Edition) - McGraw-Hill Education Pvt. Ltd. (Indian Reprint 2017)
   View/Download (6.38 MB)

Suggestive Readings

- Andrews, George E. (1994) - Number Theory - Dover Publications Inc., New York
  [1971, Saunders] **View/Download** (11.95 MB)
- Robbins, Neville (2007) - Beginning Number Theory (2nd Edition) - Narosa Publishing House Pvt. Ltd.
  Not Available
- Rosen, Kenneth H. (2011) - Elementary Number Theory and its Applications (6th Edition) - Pearson Education (Indian Reprint 2015)
  View/Download (36.41 MB)