Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon

FACULTY OF SCIENCE AND TECHNOLOGY

Master of Science (M.Sc.)

Semester I, II, III & IV

(As per NEP-2020 Pattern)

With Effect from 2023-2024

M. Sc. Mathematics

Semester-wise Course Structure, Course Code and Credit distribution of Two Years/ One Year M.Sc Programme.

Semester-wise Course Structure, Course Code and Credit distribution of Two Years/ One Year M.Sc. Mathematics Programme as per NEP2020, for Affiliated Colleges w.e.f–June 2023.

SEMESTER–I, Level– 6.0

Course	Course Type	Course Code	Course Title	Credits	Teaching Hours/ Week			Marks (Total100)			
					T	P	Total	Internal (CA)		External (UA)	
								T	P	T	P
DSC-25	DSC	MT-411	Advanced Real Analysis	4	4	--	4	40	--	60	--
DSC-26	DSC	MT-412	Programming in C++	2	2	--	2	20	--	30	--
DSC-27	DSC	MT-413	Topology	4	4	--	4	40	--	60	--
DSC-28	DSC	MT-414	Abstract Algebra	4	4	--	4	40	--	60	--
DSE-5	DSE	MT-415(A)	Partial Differential Equations	4	4	--	4	40	--	60	--
		MT-415(B)	Topics in Graph Theory	4	4	--	4	40	--	60	--
RM	RM	RM-417	Research Methodology	4	4	--	4	40	--	60	--

SEMESTER–II, Level–6.0

DSC-30	DSC	MT -421	Complex Analysis	4	4	--	4	40	--	60	--
DSC-31	DSC	MT-422	Python Programming	2	2	--	2	20	--	30	--
DSC-32	DSC	MT-423	Analytic Number Theory	4	4	--	4	40	--	60	--
DSC-33	DSC	MT-424	Linear Algebra	4	4	--	4	40	--	60	--
DSE-6	DSE	MT-425(A)	Theory of Special Functions	4	4	--	4	40	--	60	--
		MT-425(B)	Classical Mechanics	4	4	--	4	40	--	60	--
OJT	*OJT/Int	MT-426	On Job Training	4	--	8	8	--	40	--	60
CumulativeCreditsForFirstYear–44											

*Students need to complete one month on job training **(OJT)** or internship in any industry related to major subject.

Semester-wise Course Structure, Course Code and Credit distribution of Two Years/ One Year M.Sc. Mathematics Programme as per NEP2020, for Affiliated Colleges w.e.f–June 2023.											
SEMESTER– III, Level–6.5											
Course	**Course Type**	**Course Code**	**Course Title**	**Credits**	**Teaching Hours/ Week**			**Marks (Total100)**			
					T	**P**	**Total**	**Internal (CA)**		**External (UA)**	
								T	**P**	**T**	**P**
DSC-35	DSC	MT-511	Topics in Functional Analysis	4	4	--	4	40	--	60	--
DSC-36	DSC	MT-512	Statistical Techniques	2	2	--	2	20	--	30	--
DSC-37	DSC	MT-513	Numerical Analysis	4	4	--	4	40	--	60	--
DSC-38	DSC	MT-514	Topics in Field Theory	4	4	--	4	40	--	60	--
DSE-7	DSE	MT-515(A)	Lattice Theory	4	4	--	4	40	--	60	--
		MT-515(B)	Fluid Dynamics	4	4	--	4	40	--	60	--
RP	RP	MT-516	Research Project-I	4	--	8	8	--	40	--	60
SEMESTER–IV, Level–6.5											
DSC-40	DSC	MT-521	Linear Integral Equations	4	4	--	4	40	--	60	--
DSC-41	DSC	MT-522	Operations Research	4	4	--	4	40	--	60	--
DSC-42	DSC	MT-523	Commutative Algebra	4	4	--	4	40	--	60	--
DSE-8	DSE	MT-524(A)	Advanced Abstract Algebra	4	4	--	4	40	--	60	--
		MT-524(B)	Algebraic Topology	4	4	--	4	40	--	60	--
RP	RP	MT-525	Research Project-II	6	--	12	12	--	60	--	90
Cumulative Credits For Second Year–44											
2 Years-4 Sem. PG Degree (88credits) after Three Year UG Degree or 1 Year-2 Sem PG Degree (44 credits) after Four Year UG Degree											

Syllabus of M.Sc.-I (Mathematics)
Semester – I

Course Title: Advanced Real Analysis	**Course Category:** MT-411
Total Contact Hours: 60	**Course Credits:** 4
Internal Evaluation (CA) Marks: 40	**End Semester Evaluation(UA) Marks:** 60

Course Objectives:

1. To know the fundamental knowledge of measure theory.
2. To study Countable sets, Zorn's lemma, Well Ordering principle, Vitali covering theorem (lemma), Fundamental theorem for integral calculus for Lebesgue integral.
3. To know Measurable sets and Measurable functions and their applications.

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand Lebesgue outer measure, Riemann and Lebesgue integrals.
2. Explain the Schroeder- Bernstein theorem, Cantors theorem and the continuum Hypothesis, Lebesgue differentiation theorem.
3. Learn the concept of Functions of bounded variation, differentiation of monotone function.

Unit 1: Countable and uncountable sets **09 H**

Countable and uncountable sets, Infinite sets and the axioms of choice, Cardinal numbers and their arithmetic, Schroeder- Bernstein theorem, Cantors theorem and the continuum Hypothesis, Zorn's lemma, Well Ordering principle, Cantor set, Cantor like sets, The Lebesgue functions.

Unit 2: Measure on the real line **16 H**

Lebesgue outer measure, Measurable sets, Regularity, Measurable functions, Borel sets and Lebesgue measurability.

Unit 3: Integration of functions of a real variable **16 H**

Integration of nonnegative function, The general integral, Integration of series, Riemann and Lebesgue integrals.

Unit 4: Differentiation **09 H**

The four derivatives, Functions of bounded variation, Lebesgue differentiation theorem, Differentiation and Integration.

Unit 5: Differentiation of monotone function **10 H**

Vitali covering theorem (lemma), Fundamental theorem for integral calculus for Lebesgue integral, Absolutely continuous functions.

Reference Books:

1. Barra G. de (2000), Measure Theory and Integration, New Age International (p) Limited, New Delhi.(Chapter 1- Art 1.5,1.7, Chapter 2- Art 2.1, 2.5, Chapter 3- Art 3.1 to 3.4 Chapter 4- Art 4.1, 4.3 to 4.5 Chapter 9- Art 9.3)
2. Royden H. L. (2009), Real analysis, Prentice-Hall of India (P) Limited, New Delhi, 4th Edition. (Chapter Art-1).
3. Halmos P. R. (1914), Measure Theory, Springer international student Edition, Narosa Publishing House, New Delhi.
4. RudinWalter (1986), Real and Complex Analysis, Tata McGraw- Hill New York.

Course Title: Programming in C++	**Course Category:** MT-412
Total Contact Hours: 30	**Course Credits:** 2
Internal Evaluation(CA) Marks: 20	**End Semester Evaluation(UA) Marks:** 30

Course Objectives:

1. To understand how C++ improves C with object-oriented features.
2. To learn how to write inline functions for efficiency and performance.
3. To learn how to design C++ classes for code reuse and to learn how to overload functions and operators in C++.

Course Outcomes:

On completion of this course, the student will be able to:

1. Visualize the features of C++ supporting object-oriented programming.
2. Construct how to produce object-oriented software using C++.
3. Survey the major object-oriented concepts to implement object-oriented programs in C++, encapsulation, inheritance and polymorphism.

Unit-1: Principles of Objective Oriented Programming **10 H**

Object oriented programming paradigm, basic concepts of object oriented programming, benefits of object oriented programming, object oriented languages, applications of object oriented programming in C++.

Unit-2: Token Expressions and Control Structures **10 H**

Tokens, keywords, identifiers and constants, data types, type compatibility, variables, operators in C++, implicit conversions, operator overloading, operator precedence, control structures.

Unit-3: Functions in C++, Classes and Objects. **10 H**

The main function, function prototyping, call by reference, return by reference, inline functions, function overloading, friend and virtual functions, specifying a class, member functions, arrays within a class, static member functions, arrays of objects, friendly functions.

Reference Books:

1. Hubbard John R. (2002), Programming with C++, Schaum's outline series.
2. VedamurthyV.N. and Iyengar N.Ch.S.N., (2008), Numerical methods, Vikas Publishing House.
3. Deital H.M. and Deital P.J. (1998), C++ How to program, Prentice Hall of India.
4. Capper D.M. (1994), Introducing C++ for Scientists, Engineers and Mathematicians, Springer Verlag.

Course Title: Topology	**Course Category:** MT-413
Total Contact Hours: 60	**Course Credits:** 4
Internal Evaluation(CA) Marks: 40	**End Semester Evaluation (UA) Marks:** 60

Course Objectives:

1. Students will learn the concept of topology, topology generated by basis.
2. Students will learn, subspaces, closed sets, limit points of a set.
3. Students will learn continuous functions on topological spaces, product topology, metric topology.
4. Students will learn connectedness of a set, compactness and separation axioms.

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand the definition of topology, examples, basis, order topology.
2. Understand the subspaces, closed sets, limit points of a set.
3. Understand continuous functions on topological spaces, product topology, metric topology.
4. Understand connectedness of a set, compactness and separation axioms.

Unit-1: **12 H**

Topological Spaces, Basis for a Topology, The Order Topology, The Product Topology on $X \times Y$, The Subspace Topology, Closed Sets and Limit Points

Unit-2: **12 H**

Continuous Functions, The Product Topology, The Metric Topology, The Quotient Topology.

Unit-3: **12 H**

Connected Spaces, Connected Subspaces of the Real Line, Components and Local Connectedness.

Unit-4: **12 H**

Compact Spaces, Compact Subspaces of the Real Line, Limit Point Compactness, Local Compactness.

Unit-5: **12 H**

The Countability Axioms, The Separation Axioms, Normal Spaces, The Urysohn Lemma, The Tietze Extension Theorem.

Reference Books:

1. Munkres J. R.(1992), Topology (A first course), Prentice Hall of India Ltd. (Sections 12-17, 18-20, 22-33, 35).
2. Joshi K. D. (1983), Introduction to general topology, New Age International Private Limited.
3. Patty C. Wayne (2009), Foundations of Topology, Jones and Bartlett Publishers, Inc; 2nd edition.

Course Title: Abstract Algebra	**Course Category:** MT-414
Total Contact Hours: 60	**Course Credits:** 4
Internal Evaluation (CA) Marks: 40	**End Semester Evaluation (UA) Marks:** 60

Course Objectives:

1. To know the concept and applications of Finite groups.
2. To study well known theorems for finite groups: Cauchy's Theorem, Sylow's Theorem, Jordan - Holder Theorem.
3. To know concepts of particular types of integral domains: ED, PID, UFD.

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand class equation for finite groups and its applications.
2. Explain Sylow theory and solvable groups.
3. Learn Euclidean domains, Principal ideal domains, unique factorization domains, Noetherian rings and the Hilbert Basis Theorem.

Unit-1: Finite groups **12 H**

Direct products, External direct product of groups, Conjugate classes, Class equation, Cauchy's Theorem.

Unit-2: Sylow theorems and solvable groups **15 H**

Sylow p-subgroups, Sylow theorems, Solvable group, Normal series, Composition series, Jordan-Holder Theorem.

Unit-3: Integral domains **15 H**

Greatest common divisor, prime element, irreducible element, Euclidean domain, principal ideal domain, Factorization domain, Unique Factorization domain.

Unit-4: Polynomial rings **12 H**

Polynomial rings, Roots of polynomials, Eisenstein's criterion, primitive polynomial, Gauss lemma, Gauss theorem, factorization of polynomials.

Unit-5: Noetherian rings **6 H**

Finitely generated ideals, Chain conditions, Noetherian rings, Hilbert basis theorem.

Reference Books:

1. Gopalakrishnan N. S. (2018), University Algebra, Wiley Eastern Limited, New Delhi. (Sec. 1.10, 1.12, 1.13, 1.14, Sec. 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16).
2. Gopalakrishnan N. S. (2016), Commutative Algebra, Universities Press (India) Pvt. Ltd. (Sec. 3.1).
3. Herstein I. N. (1975), Topics in Algebra, John Wiley and Sons, New Delhi.
4. Jacobson N. (2012), Basic Algebra-I, Second Edition, Hindustan Publishing Corporation.
5. Fraleigh J. B. (2003), A first Course in Abstract Algebra, Pearson.
6. Bhattacharya P.B., Jain S.K. and Nagpaul S.R. (1994), Basic Abstract Algebra, Cambridge Press.

Course Title: Partial Differential Equations	**Course Category:** MT-415(A)
Total Contact Hours: 60	**Course Credits:** 4
Internal Evaluation (CA) Marks: 40	**End Semester Evaluation (UA) Marks:** 60

Course Objectives:

1. To understand the concepts and applications of differential equations.
2. To improve problem solving and logical thinking abilities of students.
3. To use the concepts of Differential equations to develop mathematical skills.

Course Outcomes:

Student will be able to

1. Find solutions of partial differential equations and determine the existence, uniqueness of soluti on of partial differential equations.
2. Apply the concepts of partial differential equations to solve problems in allied fields.
3. Know the important theorems and their applications.

Unit 1: Partial Differential Equations of First Order **15 H**

First order PDE, classification of integrals, Linear equations of first order, Pfaffian differential equations, compatible systems, Cauchy Problem, Integral surfaces through a given curve for partial differential equations, Charpit's method, Jacobi's method.

Unit 2: Partial Differential Equations of Second Order **15 H**

Origin of second order partial differential equation, Linear equations with constant coefficients, Equations with variable coefficients, Method of separation of variables, Nonlinear equations of the second order.

Unit 3: Laplace's Equation **10 H**

The occurrence of Laplace's equation in physics, Elementary solution of Laplace's equation , Families of equipotential surfaces, Boundary value problems, Method of separation of variables.

Unit 4: The Wave Equation **10 H**

The occurrence of wave equation in physics, Elementary solutions of the one-dimensional wave equation, Riemann-Volterra solution of the one- dimensional wave equation, Method of separation of variables.

Unit 5: The Diffusion Equation **10 H**

The occurrence of the diffusion equation in physics, Elementary solutions of the diffusion equation, Separation of variables

Reference Books:

1. SneddonI. N. (1957), Elements of Partial Differential Equations, McGraw Hill, New York 2.
2. Amarnath T. (2008), An Elementary Course in Partial Differential Equations, 2nd Edition, Narosa Publishing House.
3. John F. (1982), Partial Differential Equations, Springer-Verlag, New York.

Course Title: Topics in Graph Theory	**Course Category:** MT-415(B)
Total Contact Hours: 60	**Course Credits:** 4
Internal Evaluation (CA) Marks: 40	**End Semester Evaluation (UA) Marks:** 60

Course Objectives:

1. To know the concept and applications of Graph theory.
2. To study basic concepts of Graphs, trees and connectivity, Eulerian and Hamiltonian graphs.
3. To know the matching, coloring of graphs and Cayley's graphs.

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand the algorithms: Kruskal's Algorithm, Prim's Algorithm, Breadth First Search (BFS) algorithm, Backtracing algorithm, Dijkstra's Algorithm, Hungarian algorithm.
2. Explain the well known theorems: Cayley's Theorem, Dirac theorem, Bondy and Chavatal theorem, Travelling salesman problem.
3. Learn the Planar graphs and Coloring of graphs.

Unit-1: Graphs, Paths and Circuits **15 H**

Graph, Finite and Infinite Graphs, Incidence and Degree, Isolated Vertex, Pendant Vertex, and Null Graph, Isomorphism, Subgraphs, Walks, Paths, and Circuits, Connected Graphs, Disconnected Graphs, and Components, Euler Graphs, Operations on Graphs, More on Euler Graphs, Hamiltonian Paths and Circuits, The Traveling Salesman Problem.

Unit-2: Trees and Cut-Sets **15 H**

Trees, Some Properties of Trees, Pendant Vertices in a Tree, Distance and Centers in a Tree, Rooted and Binary Trees, On Counting Trees, Spanning Trees, Fundamental Circuits, Finding All Spanning Trees of a Graph, Spanning Trees in a Weighted Graph, Cut-Sets, Some Properties of a Cut-Set, All Cut-Sets in a Graph, Fundamental Circuits and Cut-Sets, Connectivity and Separability, 1-Isomorphism, 2-Isomorphism.

Unit-3: Planar Graphs and Matrix Representation **15 H**

Planar Graphs, Kuratowski's Two Graphs, Different Representations of a Planar Graph, Detection of Planarity, Geometric Dual, Combinatorial Dual, Incidence Matrix, Submatrices of $A(G)$, Circuit Matrix, Fundamental Circuit Matrix and Rank of B, Cut-Set Matrix, Relationships among Af,Bf,Cf, Path Matrix, Adjacency Matrix.

Unit-4: Coloring, Covering and Partitioning **7 H**

Chromatic Number, Chromatic Partitioning, Chromatic Polynomial, Matchings, Coverings, The Four-Color Problem.

Unit-5:Directed Graphs **8 H**

Directed Graph, Some Types of Digraphs, Digraphs and Binary Relations, Directed Paths and Connectedness, Euler Digraphs, Trees with Directed Edges, Fundamental Circuits in Digraphs, Matrices A and C of Digraphs, Adjacency Matrix of a Digraph.

Reference Books:

1. Deo N. (2015), Graph Theory with applications to Engineering and Computer Science, Prentice Hall of India.
   Chapter 1, Art. 1.1-1.6, Chapter 2, Art. 2.1-2.10, Chapter 3, Art. 3.1-3.10, Chapter 4, Art. 4.1-4.8, Chapter 5, Art. 5.1-5.7, Chapter 7, Art. 7.1-7.9, Chapter 8, Art. 8.1-8.6 and Chapter 9, Art. 9.1-9.11.
2. West Douglas B. (1999),Introduction to Graph Theory, Prentice- Hall, New Delhi.
3. Clarke John and Holton D.A. (1991), A First Look at Graph Theory, Allied Publisher.
4. Harsfield Nora and Ringel Gerhard (1990), Pearls Theory, Academic Press.

Course Title: Research Methodology	**Course Category:** RM-417
Total Contact Hours: 60	**Course Credits:** 4
Internal Evaluation (CA) Marks: 40	**End Semester Evaluation (UA) Marks:** 60

Course Objectives: To make the students familiar with,

1. To learn the basics of science, scientific research and its importance.
2. To learn the Ethics and plagiarism precautions to be taken while doing research.
3. To understand the detailed referencing and literature review procedure before beginning the research.
4. To understand the process of writing research papers, research project report and research proposal.
5. To learn various advanced tools useful for the science and aware about the laboratory safety.

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand the basic concept of science and scientific research.
2. Learn and follow the ethical guidelines while doing research avoid plagiarism in research publications.
3. Write a comprehensive literature review on a given research topic.
4. Write a crisp research proposal or research project independently.
5. Learn most advanced chemistry tools for the efficient research work.
6. Acquire knowledge about various hazardous chemical handling procedures and implement it while working in the laboratory.

Unit 1: Science and Scientific Research **12 H**

What is Science? Characteristics of Science, Technology and techno-science, Meaning of Research, Characteristics and types of research, Importance of research activities, Principles of quality research work, Problems in research, Scientific attitude and temper, Qualities of good researcher, Scientific community, Non-science and Pseudoscience, Scientific realism.

Unit 2: Design and Criteria of Scientific Research **14 H**

Introduction, Research planning and design, Selection of research topic, Criteria for good research problem, Source of research Idea, Principles of good research, Criteria of good research, Guidelines for research skill and awareness, Research validity and reliability, Artefact and bias in research.

Scientific methodology: Rules and principles of scientific methods, Research methods versus methodology, Hypothesis and testing of hypothesis.

Research ethics: Principles and values.

Plagiarism: its types and how to avoid it.

Unit 3: **14 H**

Literature Survey: Literature review, Approaching the literature, Scholarly literature, Data provenance and evaluation, Intellectual property.

Sources of information: Primary, Secondary, Tertiary sources, Patents, Journals (Print and e-journal), Type of Journals, Conference Proceedings.

Journal Impact Factor, Citation index, h-index.

Understanding of literature: Reading a Scientific Paper, Abstracts, Current titles, Reviews, Monographs, Books, Current contents, Cross referencing, Indian patent database.

Tools for Digital Literature Survey: Scientific databases, e-journals, INFLIBNET, Shodsindhu, Shodhganga, Google/Google Scholar, Research Gate, Pub Med, finding and citing Information.

Unit 4: **12 H**

Scientific Writing: Introduction to scientific writing, writing science laboratory Notebook.

Writing Research Paper: Title, Abstracts, Keywords, Introduction, Material and Methods, Results and discussion, Conclusion, Acknowledgement, References and Supplementary data.

Difference between research communication and Review article, Reply to Referee comments for science research paper.
Preparation of Poster and Oral Presentation
Writing Proposals: Research grant and its various components.

Unit 5:Advanced Scientific Tools and Laboratory Safety 8 H

A) Advanced Tools: Tools for citing and referencing: Mendeley, Zotero, Endnote etc.
Styles of referencing: Referencing from reputed publishing houses National and International.
Online searching Databases: Sci Finder, Scopus, Web of Science, ACM Digital Library, Pro Quest Biological Sciences (All the databases only introduction).
B) Laboratory Safety: Laboratory safety, Laboratory manual, Lab as a safe place: habits, Cause of accidents and What to do in case of an accident, Personal protective equipment, Emergency equipment for general purpose. Laboratory ventilation.

Reference Books:

1. Prathapan K. (2019), Research Methodology for Scientific Research, I.K. International Pvt. Ltd., New Delhi – 110002. (Unit 1: pages-1-24 , 49-54, Unit-2: pages-1-24, 55-92 and 233-262, Unit-3: pages-148-180, Unit-4: pages-180-229)
2. Pruzan Peter (2016), Research Methodology: The Aims, Practices and Ethics of Science, Springer International Publishing. (Unit 1: pages-1-71)
3. Kothari C.R.(2004), Research Methodology: Methods and Techniques, 3rd edition, Published by New Age International (P) Ltd., Publishers. (Unit 1: pages-1-21, Unit-3: pages-24-52)
4. Pecorari Diane (2013), Teaching to Avoid Plagiarism: How To Promote Good Source, Use-Open University Press. (Unit-3: pages-299-317)
5. Smith Michael B. and March Jerry(2013), APPENDIX A: The Literature of Organic Chemistry March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Seventh Edition, Copyright John Wiley & Sons, Inc.. (Unit-3: pages-1569-1603)
6. Isac-García Joaquín, Dobado José A., Calvo-Flores Francisco G., Martínez-García Henar(2016), Experimental Organic Chemistry laboratory manual, Academic Press. (Unit-4: pages-29-43)
7. Tyowua A.(2023), T.A Practical Guide to Scientific Writing in Chemistry Scientific Papers, Research Grants and Book Proposals, CRC Press is an imprint of Taylor & Francis Group, LLC. (Unit 4: Relevant pages)
8. Currano J. N., Roth D. L.(2014),Chemical Information for Chemists: A Primer, Publisher The Royal Society of Chemistry.(Unit 5: Relevant pages)
9. Handbook of Safety in Science Laboratories Education Bureau Kowloon Tong Education Services Centre, Hong Kong(2013). (Unit 5: Relevant pages)
10. Alvi M. H. (2016), A Manual for Referencing Styles in Research. (Unit 5: Relevant pages)
11. https://academic.oup.com/pages/authoring/books/preparing-your-manuscript/referencing-styles
12. https://revvitysignals.com/products/research/chemdraw
13. Kottwitz Stefan, LaTeX Beginner's Guide, Packt Publishing, http://static.latexstudio.net/wp-content/uploads/2015/03/LaTeX_Beginners_Guide.pdf
14. Falagas M.E., Pitsouni E.I., Malietzis G.A. and Pappas G. (2008), Comparison of Pub Med, Scopus, Web of Science, and Google Scholar: strengths and weaknesses. The FASEB Journal, 22: 338-342. https://doi.org/10.1096/fj.07-9492LSF
15. AlviM. H., Plagiarism, Citation and Referencing: Issues and Styles, A Manual for Referencing Styles in Research, DOI: 10.13140/RG.2.1.5149.6408 http://bit.ly/46nFwYi
16. Dhiraj Kumar, Gyankosh: Citation tools: Easing up the researchers' efforts, The Journal of Lib. & Info. Management Vol 4 No. 2 Jul-Dec, 2013.

17. Citation Management: How to use citation managers such as End Note and Zotero. URL: https://guides.lib.uchicago.edu/citationmanagement
18. https://pubs.acs.org/doi/full/10.1021/acsguide.40303
19. https://edu.rsc.org/resources/how-to-reference-using-the-rsc-style/1664.article
20. https://www.springer.com/gp/authors-editors/journal-author/journal-author-helpdesk/preparation/1276
21. https://service.elsevier.com/app/answers/detail/a_id/28224/supporthub/publishing/
22. End Note: A comprehensive guide to the reference management software End Note. URL: https://aut.ac.nz.libguides.com/endnote
23. Zotero: Learn how to use the reference management software Zotero. URL: https://aut.ac.nz.libguides.com/zotero
24. Mendeley: Learn how to use the reference management programme Mendeley. URL: https://aut.ac.nz.libguides.com/mendeley
25. Grammarly User Guide, https://bpb-ap se2.wpmucdn.com/blogs.auckland.ac.nz/dist/3/316/files/2020/02/Grammarly-Manual-Feb-2020-1.pdf
26. Online Resources: Publishers, Chemical Societies, Electronic Journals etc.: https://www-jmg.ch.cam.ac.uk/data/c2k/cj/
27. https://scholar.google.com/
28. https://shodhganga.inflibnet.ac.in/
29. https://patents.google.com/
30. https://ipindia.gov.in/history-of-indian-patent-system.htm
31. https://www.cas.org/about-us
32. https://clarivate.com/products/scientific-and-academic-research/research-discovery-and-workflow-solutions/webofscience-platform/
33. https://www.mendeley.com/guides

M.Sc. I, Semester – II

Course Title: Complex Analysis	**Course Category:** MT-421
Total Contact Hours: 60	**Course Credits:** 4
Internal Evaluation (CA) Marks: 40	**End Semester Evaluation (UA) Marks:** 60

Course Objectives:

1. To make student aware of advances in complex analysis.
2. To know Mobius transformation and conformal mappings.
3. To Improve the logical thinking ability to find applications.

Course Outcomes:

On completion of this course, the student will be able to:

1. Acquire useful knowledge of complex analysis
2. understand the concept of power series about complex analysis
3. solve the complex integration in various forms
4. gain the knowledge of singularities
5. prepare themselves for competitive examinations: SET, NET, GATE etc.

Unit-1: **10 H**

Power series, Analytic functions, Branch of a logarithm, Mobius (Bilinear) Transformations and Conformal Mappings.

Unit-2: **15 H**

Riemann-Stieltjes Integrals, Power Series representation of analytic functions, Taylor's Theorem, Cauchy's Estimate, Zeros of an analytic function, Liouville's theorem, Fundamental Theorem of Algebra, Maximum Modulus Theorem.

Unit-3: **10 H**

Index of a closed curve, Cauchy's theorem, Cauchy's Integral Formula, Higher order derivatives, Morera's Theorem, The Homotopic version of Cauchy's Theorem and simple connectivity, Counting of Zeros, The Open mapping theorem, Goursat's theorem.

Unit-4: **15 H**

Singularities, Classification of Singularities, Laurent's series, Casorati-Weierstrass theorem, Residues, Cauchy's residue theorem, Evaluation of integrals, Meromorphic functions, The Argument principle, Rouche's theorem, Schwartz lemma.

Unit-5: **10 H**

Convex functions and Hadamard's three circles theorem, The space of continuous functions, Spaces of analytic functions, The Riemann mapping theorem.

Reference Books:

1. Conway J. B.(1995),Functions of One Complex variable, Springer Int. Student Edition.
2. Ponnusammy S. and Silverman H.(2006),Complex Variables with Applications, Birkhauser.
3. Ponnusammy S., Foundations of Complex Analysis, 2nd edition Alpha, Narosa Publishing House.
4. Ahlfors L. V.(1996),Complex Analysis, McGraw-Hill Book Co.

Course Title: Python Programming	**Course Category:** MT-422
Total Contact Hours: 30	**Course Credits:** 2
Internal Evaluation (CA) Marks: 20	**End Semester Evaluation (UA) Marks:** 30

Course Objectives:

1. To acquire proficiency in using different functions and capabilities of Python.
2. To learn how to write loops and decision statements in Python.
3. To demonstrate the use of Python for plotting.

Course Outcomes:

On completion of this course, the student will be able to:

1. Acquire skill in Python package particularly basics of Python.
2. Represents data with the help of plotting in Python.
3. Create an application with the support of graphics in Python.

Unit-1: **6 H**

Installing Python, IDLE, Typing, Getting input, Printing, Variables.

Unit-2: **12 H**

For loop, numbers, Math operator, math functions, if, else-if statements, strings, lists, while loop, Functions, arguments, local variables.

Unit-3: **12 H**

Visualing data with graphs: Understanding the Cartesian Coordinate Plane, Working with Lists and Tuples, Creating Graphs with Matplotlib, Customizing Graphs, Plotting with Formulas, Newton's Law of Universal Gravitation, Projectile Motion.

Reference Books:

1. Heinold Brian (2012), A Practical Introduction to Python Programming, Licensed under a Creative Commons Attribution-Non commercial-Share Alike 3.0 Unported License Available online. (Ch: 1-4, 6-7, 9, 13)
2. Shah Amit, (2015), Doing Math with Python, No Starch Press Inc. William Pollock, USA.(Ch:2)

Course Title: Analytic Number Theory	**Course Category:** MT-423
Total Contact Hours: 60	**Course Credits:** 4
Internal Evaluation (CA) Marks: 40	**End Semester Evaluation (UA) Marks:** 60

Course objectives:

1. To know concept of arithmetic functions.
2. To study congruences and quadratic residues.
3. To know the concepts of primitive root theory.

Course Outcomes(COs):

On completion of this course, the student will be able to:

1. Understand the concept of Mobius function $\boldsymbol{\mu(n)}$, The Euler totientfunction $\boldsymbol{\varphi(n)}$, Mangolt function $\boldsymbol{\Lambda(n)}$, Liouvilles function $\boldsymbol{\lambda(n)}$, The divisor function $\boldsymbol{\sigma(n)}$, Bell series.
2. Explain Residue classes, Lagrange's theorem and its applications, Polynomial congruences with prime power moduli.
3. Learn Quadratic residues, existence and non-existence of primitive roots.

Unit-1: Arithmetic functions **12 H**

The Mobius function $\boldsymbol{\mu(n)}$, The Euler totient function$\boldsymbol{\varphi(n)}$, Dirichlet product of arithmetic functions, Dirichlet inverses and the Mobius inversion formula. The Mangolt function $\boldsymbol{\Lambda(n)}$,Multiplicative functions.

Unit-2:Dirichlet multiplication and Formal power series **12 H**

Dirichlet multiplication, The inverse of a completely, multiplicative function, Liouvilles function$\boldsymbol{\lambda(n)}$, The divisor function $\boldsymbol{\sigma(n)}$, Generalized convolutions. Formal powerseries, Bell series of an arithmetical function, Bell series and Dirichlet multiplication, Derivatives of arithmetical functions, The Selberg identity.

Unit-3: Congruences **12 H**

Residue classes, Complete and reduced residue systems and Euler-Fermat's theorem, Polynomial congruences $mod\ p$. Lagranges theorem and its applications, Polynomial congruences with prime power moduli. The principle of cross classification.

Unit-4: Quadratic residues and Quadratic Reciprocity law **12 H**

Quadratic residues, Legendre's symbol and its properties, Evaluation of $(-1|p)$ and $(2|p)$, Gauss lemma, The Quadratic Reciprocity law and its applications, The Jacobi Symbol. Applications to Diophantine equations.

Unit-5: Primitive roots **12 H**

The exponent of a number modulo m, Primitive roots,Primitive roots and reduced residue systems, The non-existence of primitive roots $mod\ p^n$ and $2p^n$ for odd primes p and $n \geq 1$. The nonexistence of primitive roots in the remaining cases. The number of primitive roots $mod\ m$. The primitive roots and quadratic residues. The index calculus.

Reference Books:

1. Apostol T. M. (1972), Introduction to Analytic Number Theory, Springer International Student Edition. (Sec. 2.1 - 2.19, Sec. 5.2, 5.4, 5.5, 5.6, 5.9, 5.10, Sec. 9.1 to 9.8, Sec. 10.1to 10.10).
2. Burton D. M. (1980), Elementary Number Theory, Universal Book Stall.
3. Silverman Joseph H. (2001), A Friendly Introduction to Number Theory(Second Edition), Prentice Hall.
4. Niven Ivan, Zuckerman Herbert S. and Montgomery Hugh L. (1991), An introduction to the theory of numbers(Fifth Edition), John Wiley and sons.

Course Title: Linear Algebra	**Course Category:** MT-424
Total Contact Hours: 60	**Course Credits:** 4
Internal Evaluation (CA) Marks: 40	**End Semester Evaluation (UA) Marks:** 60

Course Objectives:

1. To develop skills and to acquire knowledge of Linear Algebra, Rings and Modules.
2. To prepare students for further courses in mathematics and/or related disciplines (e.g. Commutative algebra, homological algebra, etc.).
3. To develop the ability to demonstrate underlying principles of the subject and the ability to solve unseen mathematical problems.

Course Outcomes:

On completion of this course, the student will be able to:

1. Understand and interpret the concepts of modules and submodules, Homomorphism and isomorphism in modules, types of modules and group theorem.
2. Understand the concepts of Jordan and Rational canonical forms and use them to solve problems involved in matrix theory and computer algebra.
3. Understand the concepts of Local rings and modules, Noetherian modules, Primary decomposition for modules.

Unit-1: **14H**

Modules, Submodules, R-homomorphism, Isomorphism.

Unit-2: **14 H**

Cyclic modules, Faithful modules, Direct sum of modules, free modules, Rank.

Unit-3: **16 H**

Torsion and Torsion free modules, Structure theorem for finitely generated modules over PID, Application to group Theorem.

Unit-4: **16 H**

Jordan and Rational Canonical forms, Noetherian Modules, primary decomposition for modules.

Reference Books:

1. Gopalkrishnan N. S. (1988), University Algebra, Wiley–Eastern. (Sec. 3.6, 3.7, Sec. 5.10).
2. Musli C. S. (2001), Introduction to Rings & Modules**,** Cambridge University Press.
3. Herstein I. N. (1988), Topics in Algebra, Wiley–Eastern.
4. Atiyah M. F. and MacDonald I. G. (2018), Algebra, CRC Press, Boca Raton.
5. Lambek J. (1966), Lectures on Rings and Modules, Blaisdell Publications, Massachusetts.

Course Title: Theory of Special Functions	**Course Category:** MT-425(A)
Total Contact Hours: 60	**Course Credits:** 4
Internal Evaluation (CA) Marks: 40	**End Semester Evaluation (UA) Marks:** 60

Course Objectives:

1. To analyze properties of special functions by their integral representations and symmetries.
2. To determine properties of Legendre polynomials, Rodrigue's formula, Generating function and Fourier Legendre's series which may be solved by application of special functions.
3. To determine properties of solution of Bessel's differential equation and Bessel's functions, Bessel's function of first kind and second kind, Orthogonality of Bessel's functions, The Hypergeometric Functions.
4. Study of Hypergeometric series, Euler's Integral Representation, the Hypergeometric equation, the Barnes Integral for the Hypergeometric function

Course Outcomes: Student will be able to:

1. list the basic concept of integral calculus and special functions of various engineering problem and to know the application of some basic mathematical methods via all these special functions.
2. Explain the applications and the usefulness of these special functions.
3. Justify the use of gamma function, beta function special functions, Hypergeometric function and Hypergeometric series to: evaluate different types of integral calculus problems and solve differential equations.

Unit 1: **12 H**

The Gamma & Beta Functions: The Gamma and Beta integrals, Functions and their properties, The Euler Reflection formula, Riemann Zeta functions, Gauss's multiplication formula for $\Gamma(mx)$, Integral representation for Log $\Gamma(mx)$, The Bohr-Mollerup theorem.

Unit 2: **12 H**

Legendre's Polynomials: Solution of Legendre's differential equation and Legendre's polynomials, Rodrigue's formula, Generating function, Recurrence relations.

Unit 3: **12 H**

Orthogonal and orthonormal functions, Orthogonal property of Legendre's polynomials, Fourier Legendre's series.

Unit 4: **12 H**

Bessel's Functions: Solution of Bessel's differential equation and Bessel's functions, Bessel's function of first kind and second kind, Orthogonality of Bessel's functions, Fourier Bessel's series.

Unit 5: **12 H**

The Hypergeometric Functions: The Hypergeometric series, Euler's Integral Representation, the Hypergeometric equation, the Barnes Integral for the Hypergeometric function.

Reference Books:

1. Andrews George E., Askey Richard and Roy Ranjana (2010), Special Functions, Cambridge University Press. (Chapter 1; 1.1, 1.2, 1.3, 1.5, 1.6, 1.9, Chapter 2; 2.1,2.2, 2.3, 2.4)
2. Jain R. K. and Iyengar S. R. K. (2008), Advanced Engineering Mathematics, Narosa Publishing House, New Delhi. (Chapter 7;7.1, 7.2, Chapter 7; 7.4, 7.5)
3. Pinsky Mark A., Partial Differential Equations and Boundary Value Problem with Applications, McGraw - Hill, Ins. (Chapter 4; 4.2, Chapter 3; 3.2)
4. Rainville Earl D. (1960), Special Functions, Chelsea Publishing Company, New York.
5. Srivastava H. M., A Treatise, On Generating Functions, John Wiley & Sons, New York.

Course Title: Classical Mechanics	**Course Category:** MT-425(B)
Total Contact Hours: 60	**Course Credits:** 4
Internal Evaluation (CA) Marks: 40	**End Semester Evaluation (UA) Marks:** 60

Course objectives:

1. Gain deeper conceptual understanding of classical mechanics.
2. To understand how to represent the equations of motion for complicated mechanical systems using the Langrangian and Hamiltonian formulations of classical mechanics.
3. Advance skills and capability for formulating and solving problems.

Course Outcomes:

On completion of this course, the student will be able to:

1. Define and understand basic mechanical concepts related to advanced problems of classical mechanical systems and application of Langrangian formation.
2. Derived the Lagrange's equation and Hamilton principle.
3. Demonstrate knowledge and understanding of fundamental concept, the Cayley-Klein parameters, linear & angular momentum, Tensors, dyadic and Principle axis transformations.
4. Understand the concept of Legendre's transformation and apply to derived the Hamilton's Equation.
5. Understand the concept of canonical transformation and apply to derived Poisson's Identity & Poisson's Bracket's.

Unit-1: 10 H

Mechanics of particle, Mechanics of the system of particle, constraints and their type, D'Alembert's principle and Lagrange's equations, velocity dependent potential and the dissipation function, simple applications of the Langrangian formations.

Unit-2: 10 H

Hamilton's principle some techniques of the calculus of variations, Derivation of Langrangian equations from Hamilton's principle, Generalized coordinates, Holonomic & Non-holonomic systems, Extension of Hamilton's principle to non-holonomic system, Lagranges Equations of first kind and second kind, uniqueness of solution, conservation theorems and symmetry properties.

Unit-3: 15H

The independent co-ordinates of a rigid body, orthogonal transformations Formal properties of the transformations matrix, The Euler angles, The Cayley-Klein parameters and related quantities finite rotations, Rate of the change of a vector, linear momentum, Angular momentum and Kinetic energy of motion about a point. Tensors and dyadics, The inertia tensor and the moment of inertia, The eigen values of the inertia tensor and Principle axis transformations.

Unit-4: 10 H

Legendre transformations and the Hamilton equation of motion, cyclic coordinates and conservation theorems, Routh's equations, Derivation of Hamilton's equation from a variational principle, The principle of least action.

Unit-5: 15 H

The equations of canonical transformations, Generating Functions, Examples of Canonical transformations, Conditions for a transformation to be Canonical, Bilinear invariant conditions, Definition, Identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity (statement only), Poisson Brackets, properties, Invariance of Poisson Bracket's with respect to Canonical transformations, Poisson's identity.

Reference Books:

1. Goldstein H.(2011), Classical Mechanics, Narosa Publishing Home, New Delhi. (1.1-1.6, 2.1-2.7, 4.1-4.5,4.9,5.1-5.4, 8.1-8.6, 9.1-9.6).
2. Carban and Steble, Classical Mechanics, John Wiley press Cambridge.
3. Marian, (1970),Classical Dynamics of particle & system, Academic Press.
4. Sudarsan and Mukunda,(2015), Classical Mechanics, World Scientific Publishing Co Piv Ltd.
5. Upadhyaya J. C.(2019), Classical Mechanics, Himalaya Publishing House.