SYLLABI AND EVALUATION SCHEME

for

Master of Science in Mathematics

TWO-YEARS FULL-TIME PROGRAMME
(Effective from session 2020-21)

First Year

INVERTIS
UNIVERSITY BAREILLY
Established by Govt. of U.P. u/s 2F of UGC Act, 1956 vide U.P. Act 22 of 2010.

Department of Applied Sciences & Humanities

INVERTIS UNIVERSITY

Invertis Village
Bareilly-Lucknow NH-24, Bareilly-243123, India

Dean
Faculty of Science
Invertis University, Bareilly (U.P.)
15/10

VICE CHANCELLOR
INVERTIS UNIVERSITY
BAREILLY

15/10/20.
Head

15/10/2020

Programme Outcome

PO-1: Critical Thinking: Inculcate critical thinking to carry out scientific investigation objectively. Formulate coherent arguments; critically evaluate practices, policies and theories by following scientific approach to knowledge development. Critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective.

PO-2: Knowledge Skill: Equip the student with skills to analyse problems, formulate an hypothesis, evaluate and validate results, and draw reasonable conclusions thereof. Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems, rather than replicate curriculum contentknowledge.

PO-3: Scientific Communication Skills: Imbibe effective scientific and / or technical communication in both oral and writing. Ability to show the importance of the subject as precursor to various scientific developments since the beginning of the civilization.

PO-4: Ethics: Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in the subject concerned. Ability to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adoptive objective, unbiased and truthful actions in all aspects.

PO-5: Enlightened Citizenship: Create awareness to become an enlightened citizen with commitment to deliver one's responsibilities within the scope of bestowed rights and privileges

PO-6: Analytical Reasoning: Ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others; analyse and synthesise data from a variety of sources; draw valid conclusions and support them with evidence andexamples, and addressing opposing viewpoints.

PO-7: Multicultural Competence: Development of a set of competencies in order to enhance and promote the growth of multicultural sensitivity within universities. Integrating multicultural awareness such as race, gender, physical ability, age, income and other social variables, and by creating an environment that is, "welcomingfor all students".

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PO-8: Lifelong Learning: Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning throughout life, through self-paced and self- directed learning aimed at personal development, and adapting to changing academic demands of work place through knowledge/ skill development/ reskilling.

PO-9: Leadership Qualities: Capability for mapping out the tasks of a team or an organization, and setting direction, formulating an inspiring vision, building a team who can help achieve the vision, motivating and inspiring team members to engage with that vision and using management skills to guide people to the right destination in a smooth and efficient way.

PO-10: Research Skills: Prepare students for pursuing research or careers in industry in concerned subjects and allied fields. Capability to use appropriate software to solve various problems and to apply programming concepts of C++ and Mathematica/Matlab to various scientific investigations, problem solving and interpretation.

PO-11: Modern Tool Usage: Create, select and apply appropriate techniques, resources and modern scientific tools including prediction and modeling to complex activities with an understanding of the limitations.

PO-12: Project Management & Finance: Demonstrate knowledge and understanding of scientific and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

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Programme Specific Outcomes -PG Mathematics

PSO-1: **Strong Foundation in Knowledge:** Have strong foundation in core areas of Mathematics, and able to communicate Mathematics effectively.

PSO-2: **Abstract Skills:** Evaluate hypotheses, theories, methods and evidence within theirproper contexts.

PSO-3: **Problem Solving**: Solve complex problems by critical understanding, analysis andsynthesis.

PSO-4: **Proficiency in Interdisciplinary Skills:** Select, interpret and critically evaluate information from a range of sources that include books, scientific reports, journals, casestudies and internet.

PSO-5: **Application and Research Efficiency:** Provide a systematic understanding of the concepts and theories of mathematics and their application in the real world- to an advanced level, and enhance career prospects in a huge array of fields, viz. in industry,commerce, education, finance and research.

PSO-6: **Lifelong Practical Knowledge**: Recognize the need to engage in lifelong learning through continuous education, and research leading to higher degrees like PhD, DSc

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M.Sc. Mathematics

The proposed PG course structure in mathematics along with detailed syllabus shall be governed by the department of Applied sciences and Humanities, Invertis University, Bareilly.

1. There shall be four semesters in the two-year M.Sc. course in Mathematics.
2. Each paper will be of 100 marks. This will include an internal assessment of 30 marks. Duration for examination of a paper will be 3hours.
3. Three lectures and one tutorial per week are to be allotted to each paper.
4. A Project work/Dissertation Examination of 200 marks will be held during Semester IV. The Board of Examiners will consist of one External and two internal examiners recommended for appointment by the BOS. The Chairman of the Board will be the senior-most from amongst the internal examiners.
5. There shall be 600 marks for I, II, III, IV semester. Thus for the entire course it comes out to be a total of 2400 marks.

The course prescribed for various semesters shall be the following and marks distribution is described in the table.

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I Semester

			Teaching Scheme			Marks Distribution			
PAPER	CODE	SUBJECT	L	T	P	MSM	ESM	Total	Credit
Paper 1	MMA101	Algebra	3	1	0	30	70	100	4
Paper 2	MMA102	Analysis	3	1	0	30	70	100	4
Paper 3	MMA103	Theory of ODE& PDE	3	1	0	30	70	100	4
Paper 4	MMA104	Fundamental of Computer and C Programming	3	1	0	30	70	100	4
Paper 5	MMA105	Numerical Methods	3	1	0	30	70	100	4
	MMA151	C-Programming Lab	0	0	2	30	70	100	2
Total			15	5	2	180	42 0	600	22

IInd Semester

PAPER	CODE	SUBJECT	L	T	P	MSM	ESM	Total	Credit
Paper 6	MMA201	Linear Algebra	3	1	0	30	70	100	4
Paper 7	MMA202	Complex Analysis	3	1	0	30	70	100	4
Paper 8	MMA203	Topology	3	1	0	30	70	100	4
Paper 9	MMA204	Statistical Analysis (SEC)	3	1	0	30	70	100	4
Paper 10	MMA205	Optimization Techniques	3	1	0	30	70	100	4
	MMA251	Statistical Analysis Lab with R-Programming (SEC)	0	0	2	30	70	100	2
Total			15	5	2	180	420	600	22

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SEMESTER I

MMA 101: ALGEBRA

Course Objectives: To make the students understand the concepts of groups, rings and fields by giving more emphasis to their applications.

Detailed Syllabus

Group actions: Cauchy's theorem, Index theorem, Cayley's theorem, conjugacy relation, conjugacy in S_n,The class equation, Cauchy`s theorem, Sylow p-subgroups, Direct product of groups. Structure theorem for finitely generated abelian groups.*p*-groups, Sylow's theorems and consequences. Definition and examples of simple groups, non-simplicity tests, Composition series, Jordan-Holder theorem,Normal and subnormal series. solvable groups. Insolvability of Sn for $n \geq 5$.

Extension fields. Finite, algebraic, and transcendental extensions. Splitting fields. Simple and normal extensions. Perfect fields. Primitive elements. Algebraically closed fields. Automorphisms of extensions. Galois extensions. Fundamental theorem of Galois theory.Galois group over the rationals.

Course Outcomes:

After studying these topics, the students will be able to

- Know various groups and their subgroups.
- Understand the direct product of groups and its applications.
- Learn the properties of rings, ideals and fields.
- Find the field and normal extensions.
- Construct finite fields.

References:

1. I. N. Herstein, Topics in Algebra, Wiley Eastern,1975.
2. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, Basic Abstract Algebra (2nd Edition), Cambridge University Press, Indian Edition1977.
3. Ramji Lal, Algebra, Vol.1, Shail Publications, Allahabad2001.
4. VivekSahai and VikasBist, Algebra, Narosa Publishing House1999.
5. D. S. Malik, J. N. Mordeson, and M. K. Sen, Fundamentals of Abstract Algebra, McGraw-Hill International Edition,1997.
6. Joseph A. Gallian, *Contemporary Abstract Algebra* (4^{th} Edition), Narosa Publishing House, New Delhi,1999.

MMA 102: ANALYSIS

Course Objectives: To make the students understand the concepts of sequences, metric spaces, continuity, uniform continuity, uniform convergence and integration.

Detailed Syllabus

Introduction: Elementary Real analysis

Metric Spaces: Open and closed sets, Interior, Closure and limit points of a set, Subspaces, Continuous functions on metric spaces, Convergence in a metric space, Complete metric spaces, Compact metric spaces, Compactness and uniform continuity, Connected metric spaces, Totally boundedness, Finite intersection property.

Sequence and Series of Functions: Pointwise and uniform convergence, Cauchy criterion for uniform convergence, Weierstrass M-test, Abel's and dirichlet's tests for uniform convergence, Uniform convergence and continuity, Uniform convergence and differentiation, Weierstrass approximation theorem.

Riemann-Stieltje's Integral: Definition and existence of Riemann-Stieltje's integral, Properties, Integration and differentiation, Fundamental theorem ofcalculus.

Lebesgue Measure: Introduction Borel sets and their measurability, Measurable and Non-measurable sets. **Measurable Functions:** Definition and properties of measurable functions, Step functions, Characteristic functions, Simple functions Littlewood's three principles,

Lebesgue Integral: Lebesgue integral of bounded function, Integration of non-negative functions, General Lebesgue integrals, Integration of series, Comparison of Riemann and Lebesgue integrals.

Course Outcomes:

After studying these topics, the students will be able to

- Learn sequences of real numbers.
- Know continuity and uniform continuity.
- Understand continuity, compactness, connectedness and completeness.
- Determine the Riemann integrability of a function.
- Recognize the difference between pointwise and uniform convergence of a sequence of functions.
- Use tests for uniform convergence.

References:

1. Walter Rudin, *Principle of Mathematical Analysis* (3rd edition) McGraw-Hill Kogakusha, 1976, International Student Edition.
2. K. Knopp, *Theory and Application of Infinite Series*.
3. T. M. Apostol, *Mathematical Analysis*, Narosa Publishing House, New Delhi,1985.
4. *Simmons G. F., Introduction to Topology and Modern Analysis, Tata McGraw Hill(2008).*
5. *Malik, S.C. and Arora, S., Mathematical Analysis, Wiley Eastern(2010).*
6. *Jain, P. K., Ahmad Khalil, Metric Spaces, Alpha Science Publishers(2004).*

M.Sc. Mathematics

MMA103: THEORY OF ODE AND PDE

Course Objectives: To make the students understand the concepts of initial value and boundary value problems and their application to find the stability of dynamical systems.

Detailed Syllabus

Theoretical Considerations: Picard's method of successive approximations, Lipschitz condition, existence and uniqueness for first order and first degree of ordinary differential equation with initial condition, existence and uniqueness solutions, singular solutions, p - discriminant and c – discriminant of differential equations and its family of solutions. Linear Differential Equations I: Introduction, Linearly dependent and independent functions, second order linear equations: general theory, Homogeneous linear equations of second order with constant coefficients, Nonhomogeneous linear differential equations of second order: method of variation of parameters, the method of undetermined coefficients. Linear Differential Equations II: Homogeneous and Nonhomogeneous linear differential equations of arbitrary order, Euler Cauchy equations, System of Differential Equations: Introduction, existence and uniqueness of solutions for system of equations, equations of higher order, linear system, linear system with constant coefficients. Critical point & stabilitytheory.

Power Series Methods: Introduction, A Review of Power Series, Series solutions of first order equations, second order linear equations. Ordinary point, solutions near a singular regular point: The method of Frobenius and the indicial equation, regular solutions near a singular point, logarithmic solutions near a regular singular point, Legendre's and Bessel's equations, theoretical justification for the power series method.

Formation of P.D.E.'s, First order P.D.E.'s, Classification of first order P.D.E.'s, Complete, general and singular integrals, Lagrange's or quasi-linear equations, Integral surfaces through a given curve, Orthogonal surfaces to a given system of surfaces, Characteristic curves. Pfaffian differential equations, Compatible systems, Charpit's method, Jacobi's Method. Linear equations with constant coefficients, Reduction to canonical forms, Classification of second order P.D.E.'s. Method of separation of variables: Laplace, Diffusion and Wave equations in Cartesian, cylindrical and spherical polar coordinates, Boundary value problems for transverse vibrations in a string of finite length and heat diffusion in a finite rod.

Course Outcomes:

After studying these topics, the student will be able to

- Apply initial and boundary values to find particular solutions to first-order, second-order and higher order homogeneous and non-homogeneous differential equations.
- Use Green's function for the solution of boundary value problems.
- Find the stability of linear and non-linear dynamical systems.

Recommended Books:

1. B.Rai, D.P.Choudhary&H.I.Freedman: A Course in Ordinary Differential Equations, Second Edition 2013, Narosa Publishing House Pvt.Ltd, NewDelhi.
2. George F.Simmons& John S. Robertson: Differential Equations with Applications & Historical Notes, Second Edition, McGraw Hill Education (India) PvtLetd.
3. E.A.Conddington: An Introduction to Ordinary Differential Equations, Prentice Hall of India, New Delhi
4. I. N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1957.
5. T. Amaranath, An Elementary Course in Partial Differential Equations, Narosa Publishing House, New Delhi, 2005.

MMA104: FUNDAMENTAL OF COMPUTER AND C PROGRAMMING

Course Objectives:

Detailed Syllabus

General Concepts: Introduction to basic computer architecture, Categories of software – System software, Application software, Compiler, Interpreter, Utility program, Operating System and its significance. Binary arithmetic for integer and fractional numbers.

C Programming: Introduction to algorithm, Flow charts, Problem solving methods, C character set, Identifiers and keywords, Data types, Declarations, Statement and symbolic constants, Input-output statements, Preprocessor commands, Operators, expressions and library functions, decision making and loop control statements, Functions, Storage Classes, Arrays, Strings, Pointers, Structure and union, File handling.

Course Outcomes:

Recommended Books:

1. Norton, P., Introduction to Computers, Tata McGraw Hill(2008).

2. Shelly, G.B., Cashman T.J., Vermaat M.E., Introduction to Computers, Cengage India Pvt Ltd(2008).

3. Kerninghan, B. W. and Ritchie D.M., The C Programming Language, PHI(1989)

4. Kanetkar, Y., Let Us C, BPB(2007).

5. Forouzan, A., Structured Programming Approach Using C, Cengage India Pvt Ltd(2008).

MMA105: Numerical Methods

Course Objectives: To make the students understand the interpolation by divided differences, solve integrations numerically; apply iterative methods for solving simultaneous equations and find numerical solution of differential equations by giving more emphasis to their applications in numerous fields of sciences and engineering.

Detailed Syllabus

MODULE I

Basics: Algorithms, Convergence, Mathematics on the Computer Floating Point Number Systems, Mathematics on the Computer: Floating Point Arithmetic; Root Finding: The Bisection Method, The method of False Position, Fixed Point Iteration Schemes, Newton's Method, Secant Method, Accelerating Convergence, Roots of Polynomials.

MODULE II

Systems of Equations: Linear Algebra Review, Gaussian Elimination, Pivoting Strategies, Vector and Matrix Norms, Error Estimates and Condition Number, *LU* Decomposition, Direct Factorization, Special Matrices, Iterative Techniques for Linear Systems: Basic Concepts and Methods, Conjugate Gradient Method, Nonlinear Systems of Equations.

MODULE III

Eigen Values and Eigen Vectors: The Power Method, The Inverse Power Method, Deflation, Reduction to Symmetric Tridiagonal Form, Eigen values of Symmetric Tridiagonal Matrices.

MODULE IV

Interpolation: Lagrange Form of the Interpolating Polynomial, Neville's Algorithm, The Newton Form of the Interpolating Polynomial, Optimal Points for Interpolation, Piecewise Linear Interpolation, Cubic Spline Interpolation, Hermite and Hermite Cubic Interpolation, Regression, Numerical Differentiation, Richardson Extrapolation, Numerical Integration- The Basics and Newton-Cotes Quadrature, Composite Newton-Cotes Quadrature, Gaussian Quadrature, Romberg Integration, Adaptive Quadrature, Improper Integrals and other Discontinuities.Numeric for ordinary differential equations, one step methods, Multi-step methods.

Course Outcomes:

After studying these topics, the students will be able to

- Apply different formulae to find the integration numerically
- Solve system of linear equations by direct and iterative methods
- Find the eigenvalues of symmetric tridiagonal matrices
- Understand the use of single step and multi-step methods in solving ODE numerically
- Interpolate the function defined in unevenly spaced points

References:

1. B. Bradie ; " A Friendly Introduction to Numercal Analysis" , Pearson Prentice Hall,2007.
2. C. F. Gerald and P. O. Wheatley; "Applied Numerical Analysis", , Addison Wesley, 5th Edn.,1994.
3. C. E. Froberg; "Introduction to Numerical Analysis", Addison Wesley.
4. G. M. Phillips and P. J. Taylor; "Theory and Applications of Numerical Analysis", Academic Press, 2nd Edn., 1965.
5. M. K. Jain , S. R. K. Iyengar, & R. K. Jain; "Numerical Methods for Scientific and Engg. Computation".,Wiley Eastern, 1985.
6. V. S.Ryaben'kii, S. V.Tsynkov, "A Theoretical Introduction to Numerical Analysis", Chapman & Hall ,2007.
7. W. H. Press, B. P. Flannery, S. A. Teukolsky, W. T. Vetterling;"Nu

MMA 151 – C Programming Lab

Course Objectives:
1. To Define fundamental concept computer i.e. hardware and software.
2. To describe basic knowledge of operating system, algorithms and number system.
3.To introduce the principles of designing structured programs
4. To develop the programming skills of students
5. To write basic programs using conditional statements, iteration statements, functions, pointers, arrays, strings, and file handling.

Assignments for lab classes are as follows:
1.Introduction of Computer System: I/O devices, storage devices.
2.Getting familiar with software: OS and C compiler.
3.Write a program to print Hello.
4.Write a program to add two integers.
5.Write a program to compute factorial of a number.
6.Write a program to determine whether a number is prime or not.
7.Write a program to print Fibonacci series. .
8.Write a program in C to check whether a given number is Armstrong or not?
9.Write a program to calculate factorial of an integer using recursion.
10. Show with example (program) how arguments are passed using „Call by value" and „Call by reference" respectively.
11. Write a program to print the sum of all values of an array.
12 Write a program in C that accepts N x N matrix as input and prints transpose of this matrix.
13.Write a program to add the elements of two arrays in to third array using dynamic memory allocation.
14. Write a program in C to calculate the sum of series up to first 10 terms 1^ 4+ 2^4+ 3^4 + 4^4 + 5^4 + 6^4 + 7^4……10 terms.
15. Write a program in C that takes input from a file and write it into another file.
16.Write a program to implement stack operation (Push & Pop).
17.Write a program to create a link list.

Reference Books:
1. Jeri R. Hanly, Elliot B. Koffman, "Problem Solving and Program Design in C", Pearson Addison-Wesley, 2006.
Victor Alvarado, Mocygo San Jose,"M. S. Office For ME Word, Excel, Power Point, CA" 3.Balagurusamy, "Programming in ANSI „C", TMH, 3rd Edition".

Out Come of course

1. Develop small applications using c programming knowledge.
2. Design various application software components and also easily understand other programming concepts.
3. Design programs connecting decision structures, Write, Compile and Debug programs in C language
4. Develop simple C Programs using pointers and Functions

M.Sc. Mathematics

SEMESTER – II

MMA 201: LINEAR ALGEBRA

Course Objectives: To make the students understand the concepts of vector spaces, linear transformations, diagonalizability, Gram-Schmidt orthogonalization process, Jordan, rational and bilinear forms by giving more emphasis to their applications.

Detailed Syllabus

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combinations and systems of linear equations, linear span, linear independence, basis and dimension, dimensions of subspaces, linear transformations, null space, range, rank and nullity of linear transformations, matrix of a linear transformation, algebra of linear transformations, isomorphism, Isomorphism theorems, invertibility and isomorphisms, change of basis, canonical forms, diagonal forms, triangular forms, Jordan blocks and Jordan form. Similarity of linear transformations. Invariant subspaces. Reduction to triangular forms. Nilpotent transformations. Index of nilpotency. Invariants of a nilpotent transformation. The primary decompositiontheorem.

Dual spaces, dual basis, double dual, transpose and its matrix in the dual basis, annhilators, eigenvalues and eigenvectors, characteristic polynomial, diagonalizability, invariant subspaces and the Cayley-Hamilton theorem, the minimal polynomial for a linear transformation.

Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, adjoints of linear operators, least square approximations, minimal solutions to system of linearequations.

Quadratic forms, reduction and classification of quadratic forms.

Course Outcomes:

After studying these topics, the students will be able to

- Understand vector spaces and their subspaces.
- Find rank and nullity of a linear transformation.
- Calculate characteristic and minimal polynomials.
- Find orthogonal vectors using Gram-Schmidt orthogonalization process.
- Know rational and Jordan forms for a given matrix.
- Learn bilinear forms and their applications.

References:

1. I. N. Herstein, *Topics in Algebra*, Wiley Eastern, 1975.
2. Hoffman and Kunje, *Linear Algebra* Low Price Edition, NewDelhi
3. Ramji Lal, *Algebra,* Vol.1,II, Shail Publications, Allahabad 2001.
4. Schaum's Series Outline, Linear Algebra, Mc GraHillPublication.
5. Stephen H. Friedberg, Arnold J. Inseland Lawrence E. Spence, *Linear Algebra* (4th Edition), Prentice-Hall of India Pvt. Ltd., New Delhi,2004.
6. Joseph A. Gallian, *Contemporary Abstract Algebra* (4th Edition), Narosa Publishing House, New Delhi, 1999.
7. Serge lang, *Introduction to linear algebra*, Springer,2002.

MMA202: COMPLEX ANALYSIS

Course Objectives: To develop in a rigorous and self-contained manner the elements of complex variables and to furnish an introduction to applications and residues and conformal mappings.

Detailed Syllabus

Analytic Functions: Review of complex numbers and its geometry, Function of a complex variable, Mapping, Limits, Continuity, Derivatives, Cauchy Riemann equations, sufficient conditions, Analytic functions, Harmonic functions.

Elementary Functions: Review of Exponential and Trigonometric functions. Logarithmic function and its branches, Inverse trigonometric and hyperbolic functions.

Complex Integration and Series: Cauchy's integral theorem, Cauchy integral formula, Higher derivative, Removable singularities, Morera theorem, Liouville theorem, Maximum-Modulus principle, Schwarz lemma, Power series, Taylor and Laurent series, General form of Cauchy's theorem. Cauchy residue theorem, Zeros and poles, Evaluation of definite integrals using residue theorem, Weierstrass theorem, Residue at infinity.

Conformal Mapping: Elementary conformal maps, Bilinear transformation, Analytic continuation, Method of analytic continuation by power series.

Course Outcomes:

After studying these topics, the student will be able to

- Effectively write mathematical solutions in a clear and concise manner. This will be assessed through class assignments and exams.
- Effectively locate and use the information needed to prove theorems and establish mathematical results. This will be assessed through assignments and exams.
- Demonstrate the ability to integrate knowledge and ideas of complex differentiation and complex integration in a coherent and meaningful manner and use appropriate techniques
- Demonstrate the ability to think critically by proving mathematical conjectures and establishing theorems from complex analysis. This will be assessed through tests and a final exam.

References:

1. J. B. Conway, Functions of One Complex Variable, Narosa Publishing House, New Delhi,2002.
2. S. Ponnusamy and H. Silverman, Complex Variables, Birkhäuser, Inc., Boston,MA,2006.
3. J. Bak, Complex Analysis, Springer,1996.
4. V. Ahlfors, Complex Analysis (Third Edition), McGraw-Hill,1979.
5. A. R. Shastri, An Introduction to Complex Analysis, Macmillan India Ltd.,1999.
6. *Kasana, H.S., Complex Variables: Theory and Applications, PHI(2006).*

MMA 203: TOPOLOGY

Course Objectives: To make the students understand the concepts of topological spaces, continuous functions, connected, compact and countability axioms and separation axioms.

Detailed Syllabus

Definition and examples of topological spaces. Closed sets. Closure. Dense sets. neighborhoods, interior,exterior, and boundary. Accumulation points and derived sets. Bases and sub-bases. Subspaces and relative topology. Alternative methods of defining a topology in terms of Kuratowski closure operator and neighborhood systems.Continuous functions and homeomorphism. First and second countable space. Lindelöf spaces. Separable spaces.The separation axioms *T0*, *T1*, *T2*, *T3½*, *T4*; their characterizations and basic properties. Urysohn's lemma. Tietze extension theorem.

Compactness. Basic properties of compactness. Compactness and finite intersection property. Sequential,countable, and B-W compactness. Local compactness. One-point compactification.

Connected spaces and their basic properties. Connectedness of the real line. Components. Locally connected spaces. Tychonoff product topology in terms of standard sub-base and its characterizations.Product topology and separation axioms, connected-ness, and compactness (incl. the Tychonoff's theorem), product spaces. Nets and filters, their convergence, and interrelation. Hausdorffness and compactness in terms of net/filterconvergence.

Course Outcomes:

After studying these topics, the students will be able to

- Understand topology, topological spaces and topology generated by basis and sub basis
- Determine the nature of different points of a set
- Characterize the connected and compact spaces
- Know separation axioms and basic properties

References:

1. J. L. Kelley, *General Topology*, Van Nostrand,1995.
2. K. D. Joshi, *Introduction to General Topology*, Wiley Eastern,1983.
3. James R. Munkres, *Topology*, 2nd Edition, Pearson International,2000.
4. J. Dugundji, *Topology*, Prentice-Hall of India, 1966.
5. George F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill,1963.
6. N. Bourbaki, *General Topology*, Part I, Addison-Wesley,1966.
7. S. Willard, *General Topology*, Addison-Wesley,1970.
8. S.W. Davis *Topology*, Tata McGraw Hill,2006

M.Sc. Mathematics

MMA204: STATISTICAL ANALYSIS

Course Objectives: The course objectives are as follows:

1. Understand the types of questions that the statistical method addresses;
2. Apply the method to other examples and situations;
3. Implement the method using statistical software (e.g., R);
4. Interpret the results in a way that addresses the question of interest;
5. Communicate the purposes of the analyses, the findings from the analysis, and the implications of those findings.

Detailed Syllabus

Introduction to Statistical Analysis: What is statistics? Types of Statistics, Population, Sample, basic terminology, Measurement & Scaling: characteristics.

Types of Variables: Nominal and Ordinal, Interval & ratio scales, Quantitative variables, Qualitative or categorical variables.

Data: Sources of Data, cross-section data, Time-series data.

Measures of Quartile Deviation: Measures of position-quartiles and interquartile range, Quartiles, deciles, Percentiles.

Data representation and Simple Probability: Graphical presentation of qualitative data, Graphical quantitative data, Frequency distributions, relative frequency and percentage distributions, Cumulative frequency distributions, Probability concepts, Simple and compound events, Classical probability, Complementary events, Discrete Random Variables.

Probability Distributions: Binomial, Poisson and Normal Distribution.

Correlation and Regression Analysis: Covariance, Pearson correlation coefficient, Computing a correlation, Correlation coefficient, correlation analysis, Scatter plots, Extreme data values, Correlation Matrix, ANOVA, Regression.

Testing Hypothesis I: Population distribution, Sampling and Non sampling Errors, point estimate, Interval estimation, The t Distribution, Testing Hypothesis, Chi-Square Distribution, The F-Distribution.

Testing Hypothesis II: Non Parametric tests, Chi-squared goodness-of-fit test, Chi-square test of independence.

Course Outcomes:

By the completion of this course, students will learn to:

- Concept of various statistical methods which can be applied on data analysis and other real problems.
- Applying the methods to actual quantitative data and interpreting the results of the analysis.
- Applying the testing of hypothesis on various problems.

Text Books:

- SC Gupta & VK Kapoor "Fundamentals of Mathematical Statistics", Sultan Chand and Sons.
- G. Jay Kerns: "Introduction to Probability and Statistics Using R", 2014.

MMA 205: OPTIMIZATION TECHNIQUES

Course Objectives: To make the students understand the concepts of quantitative techniques for effective decision making, model formulation and their applications.

Detailed Syllabus

Linear Programming Problems (LPP): The origin of OR, Definition and scope of Operation Research, Classification of OR models, Formulation of Linear-programming model, graphical solution, Simplex method. Big-M method, two-phase method, Duality, Dual Simplex method, Sensitivity Analysis.

Integer Linear Programming Problems: Integer Programming Problems, Mixed Integer Programming Problems, Cutting Plane Method, Branch and Bound Method.

Assignment and Transportation Problems: Assignment problem and its mathematical formulation, solution of assignment problem (Hungarian method), Transportation problem and its mathematical formulation. Initial basic feasible solution of transportation problem by North-West corner rule, Lowest-Cost Entry method and Vogel's Approximation method, optimal solution of transportation problem.

Game Theory: Two Persons Zero Sum Game, Solution With/Without Saddle Point, Dominance Rule, Different Methods Like Algebraic, Graphical, Linear Programming Methods. Approximation Method for Solution of Game.

Sequencing Problem: Introduction, Assumption, Johnson's Procedure for N Jobs on Two Machines and N Jobs on Three Machines.

CPM and PERT: Network Diagram-Events and Activities- Project Planning Reducing Critical Events and Activities-Critical Path Calculations-Examples- Resources and Man Power Leveling. Sequencing Problems-Travelling Salesman Problems –Machine Scheduling Problem (Job-Shop).

Inventory Models: General inventory model, static economic order quantity (EOQ) Models, Deterministic inventory models-production model-Buffer stock

Queuing Theory:

Introduction to Queues, Basic Elements of Queuing Models, Queue Disciplines, Memory less Distribution,
Role of Exponential and Poisson Distributions, Markovian Process, Erlang Distribution, Symbols and Notations, Distribution of Arrivals, Distribution of Service Times, Definition of Steady and Transient State, Poisson Queues.

Course Outcomes:

After studying these topics, the student will be able to

- Solve various linear programming problems
- Construct operation research models from the description of the real systems
- Learn the mathematical tools to solve various optimization problems
- Understand the theoretical working of different methods of operation research

References:

1. H. A. Taha, *Operations Research –An Introduction*, Macmillan.
2. Kanti Swaroop, P. K. Gupta and Man Mohan, *Operations Research*, Sultan Chand & Sons, New Delhi.
3. S. S. Rao, *Optimization Theory and Applications*, Wiley Eastern.

Suggested References:

1. F. S. Hiller and G. J. Leiberman, *Introduction to Operations Research* (6th Edition), McGraw-Hill International Edition, 1995.
2. G. Hadley, *Nonlinear and Dynamic Programming*, Addison Wesley.
3. Edwin K. P. P. Chong, Stanislaw H. Zak, An Introduction to Optimization, Johan Welly & Sons Inc 2001.
4. M. C. Joshi & K.M. Moudgalya, Optimization Theory & Practice, Narosa Publ. New Delhi, 2004.
5. N. S. Kambo, *Mathematical Programming Techniques*, Affiliated East-West Press Pvt. Ltd., New Delhi.

MMA251 Statistical Analysis Lab with R-Programming (SEC)

Objectives: Students will be able to learn the data objects, produce graphics, analyze data using common statistical methods, and generate reproducible statistical reports. With the following programming in R

- Introduction and Basics of R
- Introduction to Data frames in R
- Merging and Importing Data in R
- Handing Numerical and categorical variables
- Data manipulation in R
- Data Preprocessing in R
- Plotting of Histogram and Pie chart
- Plotting Bar charts and Scatter plot
- Probability Distribution in R
- Statistical tests in R

Correlation & Regression

Learning Outcomes:

After studying these topics, the students will be able to

- Use of RStudio, read R documentation, and write R scripts.
- Import, export and manipulate data.
- Produce statistical summaries of continuous and categorical data.
- Produce basic graphics using standard functions, and produce more advanced graphics using the
- lattice and gplot2 packages.
- Perform common hypothesis tests, and run simple regression models in R
- Produce reports of statistical analyses in R Markdown.

Reference Books:

- Paul Teetor. R Cookbook: Proven recipes for data analysis, statistics, and graphics. O'Reilly
- Media, Inc., 2011.
- Norman Matloff. The art of R programming: A tour of statistical software design. No Starch
- Press, 2011.
- Winston Chang. R graphics cookbook. O'Reilly Media, Inc., 2012.
- Hadley Wickham and Garrett Grolemund. R for data science. (2016).
- Phil Spector. Data manipulation with R. Springer Science & Business Media, 2008.