THIRD SEMESTER SYLLABUS

M. Sc. MATHEMATICS

BABA GHULAM SHAH BADSHAH UNIVERSITY RAJOURI, J&K, INDIA

COURSE SCHEME

COURSE CODE	COURSE TITLE	NO. OF CREDITS	DISTRIBUTION OF MARKS		
			SA	UE	TOTAL

COMPULSORY COURSES

COURSE CODE	COURSE TITLE	NO. OF CREDITS	SA	UE	TOTAL
MS - 331	Advanced Topics in Topology	4	40	60	100
MS - 332	Theory of Operators	4	40	60	100
MS - 333	Advanced Complex Analysis	4	40	60	100
MS - 334	Environmental Science	2	20	30	50
MS - 335	Lab course on LATEX	2	25	25	50

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Choice based Complementary Electives

(Students are required to choose any two of the following courses)

MS - 336	Differential Geometry	4	40	60	100
MS - 337	Number Theory	4	40	60	100
MS - 338	Module Theory	4	40	60	100
MS - 339	Wavelet Theory	4	40	60	100
MS - 340	Calculus in Rn	4	40	60	100
MS - 341	Abstract Measure Theory and Integration	4	40	60	100
MS - 342	Theory of Partial Differential equations	4	40	60	100
MS - 342	Graph Theory	4	40	60	100
	TOTAL	24	245	355	600

SA: Sessional Assessment

UE: University Examination

SEMESTER - III

Course Title	Advanced Topics in Topology	Maximum Marks	100
Course Code	MS-331	University Examination	60
Credits	4	Sessional Assessment	40
		Duration of Exam.	3 HOURS

Objectives …....................		The aim of this course is to familiarize the students with the advanced topics of topology.
UNIT 01	Compact Spaces	Compactness in Metric spaces - totally bounded set, Bolzano Weierstrass poperty, Lebesgue number, Countably Compact and sequentially Compact spaces, Compact topological spaces; Local compactness; relation between various forms of Compactness.
UNIT 02	Separation and countability Axioms	T0, T1 and T2 Spaces, Regular and Completely Regular Spaces, Normal and Complety Normal Spaces, Lindelof Spaces, Urysohn's Lemma and the Tietze Extension Theorem.
UNIT 03	Compactification, Paracompactness and Metrizibility	Compactification, Stone-Cech Compactification, Urysohn's Metrization Theorem, Paracompactness, Relation of paracompact spaces with regular and normal spaces, The Nagata-Smirnov Metrization Theorem.
UNIT 04	Nets and Filters	Nets, subnets, cluster point of a net, convergence of a net and continuous maps, nets in product spaces, filters and their convergence, filter base, filter in product spaces, Ultra filters, relationship between nets and filters.
UNIT 05	Homotopy of Paths, Fundamental Groups and Knots	Homotopy of Paths and its various properties; The fundamental Group – properties and examples; the concept of Knot – its properties and examples.

COURSE OUTCOMES

On successful completion of this course, we expect that a student

1 explain the totally bounded set, Bolzano Weierstrass property and Lebesgue number.

2 explain the concepts of Countably Compact, Sequentially Compact, Local Compactness and the relation between various forms of Compactness.

3 explain the concepts of T_0, T_1 and T_2 Spaces, Regular and Completely Regular Spaces.

4 Normal and Complety Normal Spaces, Lindelof Spaces and relationship between them.

5 explain the fundamental theorems such as Urysohn's Lemma, the Tietz Extension Theorem, Urysohn's Metrization Theorem and Nagata-Smirnov Metrization Theorem.

6 Explain the concepts of Compactification, Stone-Cec Compactification Para compactness and its relation with regular and normal spaces

7 explain the concepts Nets, subnets, filters, subfilters, their convergence convergence.

8 explain the concepts of Homotopy of Paths, the fundamental Groups and knots.

Note for Paper Setting

The question paper will be divided into two sections. Section A will be compulsory and will contain 10 very short answer type questions eliciting answers not exceeding 20 words/ multiple choice questions/ fill in the blanks, each carrying one mark equally distributed from all units. Section B will contain 10 long answer type questions, two from each unit and the candidate will be required to answer one from each unit. Each question carries 10 marks.

BOOKS RECOMMENDED

TEXT BOOKS

1. **Patty, C.W., (2015),** Foundations of Topology, 2nd Edition, **Jones and Bartlett**

REFERENCE BOOKS

1. **Kelley, J. L., (1975),** General Topology, **Springer.**
2. **Willard S., (2010),** General Topology, **Dover Publications New York.**
3. **Munkers J.R. ,(2000),** Topology, 2nd Edition, **PHI.**

SEMESTER - III

Course Title	Theory of Operators	Maximum Marks	100
Course Code	MS-332	University Examination	60
Credits	4	Sessional Assessment	40
		Duration of Exam.	3 HOURS

Objectives …..................		The aim of this course is to study spectral properties of operators on normed spaces.
UNIT 01	Spectral theory of Linear operators in normed spaces	Spectrum and resolvant of a bounded linear operator; non-emptiness, closedness and boundness of the spectrum of bonded linear operator; spectral mapping theorem for polynomials; spectral radius.
UNIT 02	Compact linear operators(CLO) on normed spaces and their spectrum-I	CLO and its connection with continuity, dimension and weak convergence; compactness of limit of a sequence of CLO; separability of range; compactness of extension and adjoint; countability of spectrum; compactness of product of two CLO ; null spaces and range of T- I; relation between spectral value and eigen value
UNIT 03	Compact linear operators on a normed spaces and their spectrum-II	Adjoint of an operator on a normed space and its basic properties; operator equations - existence of solution, bounds on solutions; theorems of Fredholom type; Fredholom alternative –Fredholom alternative for integral equations, compact integral operator
UNIT 04	Spectral theory of bounded self adjoint linear operators -I	Basic properties of eigen values and eigen vectors; resolvent set; realness of spectrum; spectrum bounds and their relation with norm of the operator; emptiness of residual spectrum; positive operator and their product; monotone sequence of operators; square root of a positive operator; projection operators; sum and product of projections
UNIT 05	Spectral theory of bounded self-adjoint linear operators(BSALO)	Difference of projections; monotone sequence of projections; spectral family of (BSALO); projection of +ve and-ve parts of operators; spectral family associated with an operator; spectral theorem for (BSALO); properties of polynomial of a (BSALO); extension properties of the spectral family of (BSALO)

COURSE OUTCOMES

On successful completion of this course, we expect that a student

1 should be able to explain the concept of spectrum of a bounded linear operator(BLO) with examples and properties such as compactness and spectral radius.

2 should be able to explain the spectral mapping theorem for polynomials, concept of compact linear operator(CLO), its basic properties and its connection with BLOs and weak convergence.

3 should be able to explain the compactness of adjoint of CLO and compactness of product of two CLOs.

4 should be able to explain the cardinality of spectrum and relation between spectral values and eigen values of a CLO.

5 should be able to explain the basic spectral properties of a self adjoint BLOs such as realness of the spectrum, spectrum bounds and their relationship with norm of the operator and emptiness of residual spectrum.

6 Should be able to explain the concept and properties of positive operator, square root of a positive operator, projection operators and their properties such as sum, difference and product.

7 should be able to explain the concept and properties of spectral family of a self adjoint BLOs with properties.

8 should be able to explain the concepts of +ve and-ve parts of an operator and their basic properties.

Note for Paper Setting

The question paper will be divided into two sections. Section A will be compulsory and will contain 10 very short answer type questions eliciting answers not exceeding 20 words/ multiple choice questions/ fill in the blanks, each carrying one mark equally distributed from all units. Section B will contain 10 long answer type questions, two from each unit and the candidate will be required to answer one from each unit. Each question carries 10 marks.

BOOKS RECOMMENDED

TEXT BOOKS

1. **Kreyszig, E., (2005),** Introductory Functional Analysis with Applications, 1st edition, **Wiley Student edition.**

REFERENCE BOOKS

1. **Conway, J. B., (2000),** A Course in Operator Theory, 2nd edition, **American Mathematical Society.**

2. **Douglas, R. G., (2008),** Banach Algebra Techniques in Operator Theory, 2nd edition, **Springer.**

SEMESTER - III

Course Title	Advanced Complex Analysis	Maximum Marks	100
Course Code	MS-333	University Examination	60
Credits	4	Sessional Assessment	40
		Duration of Exam.	3 HOURS

Objectives …...................		The aim of this course is to learn the advance topics of complex analysis.
UNIT 01	Some fundamental theorems and direct analytic continuation	Local maximum Modulus; Hadamard three circle theorem, Schwarz's Lemma and its consequences, BorelCaratheodory theorem; Schwarz Pick Lemma; Analytic Continuation.
UNIT 02	Zeros of polynomial and Homotopic curves	Zeros of certain polynomials; Gauss theorem; Analytic Germ; Homotopic curves; Monodromy theorem; Poisson's Integral formula; Poisson Kernel; Harnack's Inequality; Reflection Principle.
UNIT 03	Infinite Products	Meromorphic Functions; Mittag Leffler theorem; Infinite product of complex numbers and analytic functions; sufficient criterion for the convergence of Infinite products.
UNIT 04	Entire Functions	Order of an Entire Function; Factorization of Entire functions; Weierstrass primary factor; Open mapping theorem; Hurwitz theorem; Weierstrass Factorization theorem.
UNIT 05	Univalent function and some fundamental theorems	Basic results on Univalent functions; Area theorem; Biberbach conjecture; Kobes 1/4- theorem; Bloch Landau's theorem (proof not included); Picard's theorem.

COURSE OUTCOMES

On successful completion of this course, we expect that a student

1 explain the concept of Direct analytic continuation and double periodic entire functions.

2 explain Monodromy theorem, Poisson integral formulae, open mapping and Herwitz theorem, Hadamards three circle theorem, Schwarz lemma and its various consequences.

3 explain the concept of infinite sum of meromorphic functions and infinite product of analytic functions.

4 explain factorization of entire functions, the gamma functions, zeta functions, order and the genus of entire functions.

5 explain the concept and basic properties of univalent functions.

6 explain some fundamental theorems such as the Riemann mapping theorem, Biberbach conjecture, the Bloch-Landau theorem, Picard's theorem.

7 explain the concept of order of a meromorphic function.

Note for Paper Setting

The question paper will be divided into two sections. Section A will be compulsory and will contain 10 very short answer type questions eliciting answers not exceeding 20 words/ multiple choice questions/ fill in the blanks, each carrying one mark equally distributed from all units. Section B will contain 10 long answer type questions, two from each unit and the candidate will be required to answer one from each unit. Each question carries 10 marks.

BOOKS RECOMMENDED

TEXT BOOKS

1 Ponnusamy, S., (1972),Foundation of Complex Analysis, 2nd edition, Narosa Publishing House.

2 Ahlfors, L. R., (1996), Complex Analysis, McGraw Hill.

REFERENCE BOOKS

1 Holland,A. S. B., (1973), Introduction to the Theory of Entire Functions, Academic Press

2 Conway, J. B., (1973), Functions of one complex variable, Springer.

SEMESTER - III

Course Title	Environmental Science	Maximum Marks	100
Course Code	MS-334	University Examination	60
Credits	4	Sessional Assessment	40
		Duration of Exam.	3 HOURS

Objectives		The course provides essential knowledge and cutting edge practical methodologies that are fundamental to the study of environment, uses.
UNIT 01	Concepts and types of Ecosystems	Ecosystems: definition and types; structure and function of an ecosystem: Producers, consumers and decomposers; Ecological succession: Food chains, food webs and ecological pyramids.
UNIT 02	Biodiversity and its importance	Biodiversity: definition and types; Value of biodiversity: consumptive use, productive use, social, ethical aesthetic and option values · Threats to biodiversity: habitat loss, desertyification; Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity
UNIT 03	Environmental pollution	Pollution: definition; causes, effects and control measures of Air pollution; Water pollution; Soil pollution; Marine pollution; Noise pollution; Thermal pollution and Nuclear pollution. Solid waste management: Causes, effects and control measures of urban and industrial wastes.

COURSE OUTCOMES

On successful completion of this course, we expect that a student

1 appreciate the context of environmental science and links between human and natural systems.

2 Understand different types, factors responsible for causing pollutions and effects of different kinds of pollutions.

3 Reflect critically about the roles THAT HE/ She can play in a complex interconnected environment.

Note for Paper Setting

The question paper will be divided into two sections. Section A will be compulsory and will contain 10 very short answer type questions eliciting answers not exceeding 20 words/ multiple choice questions/ fill in the blanks, each carrying one mark equally distributed from all units. Section B will contain 10 long answer type questions, two from each unit and the candidate will be required to answer one from each unit. Each question carries 10 marks.

BOOKS RECOMMENDED

TEXT BOOKS

1 Trivedy, R. K., Goel, P.K. and Trisal, C. L. (1998). Practical Methods in Ecology and Environmental Science. Enviro Media Publishers, Karad Maharashtra.

REFERENCE BOOKS

1 De. A. K., Environmental chemistry, Willey Eastern Pvt. Ltd, New Delhi.

2 Magurran, A. E. (1988). Ecological Diversity and its Measurement. Princeton University Press, USA.

3 Misra, R. (2013). Ecology Workbook. Scientific Publishers, India.

SEMESTER - III

Course Title	Lab course on LATEX	Maximum Marks	50
Course Code	MS-335	University Examination	25
Credits	2	Sessional Assessment	25
		Duration of Exam.	2 HOURS

Objectives .... The objectives of this course is to train the students in LATEX.

* Each student is required to maintain a practical record book.

* Two practical tests, one Internal and one External, are to be conducted.

* Each practical test will be of 25 marks.

* The marks in each practical test will be divided into 4 parts, program code, program execution , Viva-Voce and practical record book.

* The student has to pass both internal and external practical tests separately scoring a minimum of 10 marks in each test

COURSE OUCOMES

On successful completion of this course, we expect that a student have understood

1 Typeset mathematical formulae using latex.

2 Typeset mathematical formulae using latex.

3 Use nested list and enumerate environment within a document.

4 Use tabular and array environment within latex document.

5 Use variuos methods to either create or import graphics in to a Latex document.

SEMESTER - III

Course Title	Differential Geometry	Maximum Marks	100
Course Code	MS-336	University Examination	60
Credits	4	Sessional Assessment	40
		Duration of Exam.	3 HOURS

Objectives ……………………		The aim of this course to study geometry in Euclidean space with the help of calculus.
UNIT 01	Differential calculus in $\mathbb{R}^n$	Differential calculus in ; Diffeomorphism; tangent space of ;vector fields on ; natural frame field; dual vector space; gradient vector field; directional derivative; curve of class C^k.
UNIT 02	Differential forms and manifolds	Integral curve; local flow; derivative map; covariant derivative; cotangent space and differentials forms on ; Lie bracket; charts and atlases; differential manifolds.
UNIT 03	Topology on manifolds	Induced topology on manifolds; functions and maps; some special functions of class; para-compact manifolds; pullback functions; tangent vectors and tangent space; tangent bundle; pullback vector fields.
UNIT 04	Tensors-I	Multi-linear functions and tensors; tensor product; tensor fields; tensors on finite dimensional vector spaces; tensors of type (p,q); connections; torsion tensor; curvature tensor.
UNIT 05	Tensors-II	Contraction; Concepts of symmetric and alternating tensors and basic properties; Bianchi and Ricci identities; concept of geodesics; concept of Riemannian manifold.

COURSE OUTCOMES

On successful completion of this course, we expect that a student

1 explain the concepts of diffeomorphism, tangent space and vector fields on fields onR^n, natural frame field, gradient vector field, and

2 explain the concepts of integral curve, local flow, derivative map, cotangent space and differentials forms on R^n, Lie bracket, charts atlases.

3 explain the concepts of differential manifolds, induced topology on manifolds and para-compact manifolds.

4 explain the concepts of pullback functions, tangent vectors and tangent space, tangent bundle and pullback vector fields.

5 explain the concept of tensor, tensor product, tensor field, torsion tensor; curvature tensor and tensors of type (p, q).

6 explain the properties of tensors on finite dimensional vector spaces.

7 explain the concept of symmetric and alternating tensors and their basic properties

8 explain the Bianchi and Ricci identities and the concept of geodesics and Riemannian manifold.

Note for Paper Setting

The question paper will be divided into two sections. Section A will be compulsory and will contain 10 very short answer type questions eliciting answers not exceeding 20 words/ multiple choice questions/ fill in the blanks, each carrying one mark equally distributed from all units. Section B will contain 10 long answer type questions, two from each unit and the candidate will be required to answer one from each unit. Each question carries 10 marks.

BOOKS RECOMMENDED

TEXT BOOKS

1. Amur, K. S., Shetty, D. J. and Bagewadi, C. S.,(2010),An Introduction to Differential Geometry, Narosa Publishing house.

REFERENCE BOOKS

1. De, U. C. and Shaikh,A. A.,(2009), Differential Geometry of Manifolds, Narosa Pub. House.

2. Neill, B. O., (1966),Elementary Differential Geometry, Academic Press, New York.

3. Thorpe, J. A., (1979),Elementary Topics in Differential Geometry, Undergraduate Text in Mathematics, Springer Verlag.

4. Somasundaram, D., (2010), Differential Geometry: A First Course, Narosa Pub. House.

SEMESTER - III

Course Title	Number Theory	Maximum Marks	100
Course Code	MS-337	University Examination	60
Credits	4	Sessional Assessment	40
		Duration of Exam.	3 HOURS

Objectives ….................... The aim of this course to familiarize the students with numbers and their properties.

UNIT 01	Divisibility	Euclidean algorithm; primes; congruences; Fermat's theorem; Euler's theorem ; Wilson's theorem; Fermat's quotients and their elementary consequences; solutions of congruences; Chinese remainder theorem; Euler's phi-function.
UNIT 02	Congruence	Congruence modulo powers of prime; power residues; primitive roots and their existence; quadratic residues; Legendre's symbol; Gauss lemma about Legendre's symbol; quadratic reciprocity law; proofs of various formulations; Jacobi symbol.
UNIT 03	Arithmetic Functions	Greatest integer function; arithmetic functions; multiplicative arithmetic functions(elementary ones); Mobius inversion formula; convolution of arithmetic functions; group properties of arithmetic functions; recurrence functions; fibonacci numbers and their elementary properties.
UNIT 04	Diophantine equations	Diophantine equations – solutions of $ax + by = c$, $x^2 + y^2 = z^2$, $x^4 + y^4 = z^2$;properties of Pythagorean triplets; sums of two , four and five squares; assorted examples of diophantine equations.
UNIT 05	Continued fractions	Simple continued fractions; finite and infinite continued fractions; uniqueness; representation of rational and irrational numbers as simple continued fractions; rational approximation to irrational numbers; Hurwitz theorem; basic facts of periodic continued fractions and their illustrations (without proofs); Pell's equation.

COURSE OUTCOMES

On successful completion of this course, we expect that a student

1. explain Euclidean algorithm, Euler's Phi function and some fundamental theorems such as Fermat's theorem, Euler's theorem, Wilson's theorem Chinese remainder theorm, Gauss lemma, quadratic reciprocity law.

2. explain the concepts of power residues, Primitive roots, Legendre's symbols and Jocabi symbols.

3. explain the concept and properties of arithmetic functions and Fibonacci numbers.

4. explain Mobius inversion formulae, Diophantine equations, Pythagorean triplets and Fermat's last theorem.

5. explain the simple continued fractions, finite and infinite continued fractions, rational and irrational numbers as simple continued fractions.

6. Explain the Hurwitz theorem, periodic continued fractions and Pell's equation.

Note for Paper Setting

The question paper will be divided into two sections. Section A will be compulsory and will contain 10 very short answer type questions eliciting answers not exceeding 20 words/ multiple choice questions/ fill in the blanks, each carrying one mark equally distributed from all units. Section B will contain 10 long answer type questions, two from each unit and the candidate will be required to answer one from each unit. Each question carries 10 marks.

BOOKS RECOMMENDED

TEXT BOOKS

1 **Niven,I., Zuckerman,H. S. and Montegomery, H. L., (2003),** An Introduction to the Theory of Numbers, 6th edition, **John Wiley and sons, Inc., New York**

2 **Burton,D. M., (2002),Elementary Number Theory, 4th edition, Universal Book Stall,New Delhi.**

REFERENCE BOOKS

1 **Dickson,L. E., (1971),History of the Theory of Numbers , Vol. II, Diophantine Analysis, Chelsea Publishing Company, New York.**

2 **Hardy,G. H. and Wright, E. M., (1998),** An Introduction to the Theory of Numbers, 6th edition, **The English Language Society and Oxford University Press.**

3 **Niven, I., Zuckerman, H. S. , (1993),** An Introduction to the Theory of Numbers, 3rd edition, **Wiley Eastern Ltd., New Delhi.**

SEMESTER - III

Course Title	Module Theory	Maximum Marks	100
Course Code	MS-338	University Examination	60
Credits	4	Sessional Assessment	40
		Duration of Exam.	3 HOURS

Objectives …………………		The aim of this course to study modules and their properties.
UNIT 01	Fundamentals of modules	Left modules and right modules; examples of modules; submodules; intersection, union and sum of sub-modules of a module; finitely generated module; homomorphism; fundamental theorems on homomorphism and quotient modules.
UNIT 02	Free modules-I	Direct sum of modules; equivalent condition for direct sum; free modules; characterization of free modules; cardinality basis of a module; rank of finitely generated free module; simple and semisimple modules.
UNIT 03	Free modules-II	Finitely generated free module over PID; the invariant factor decomposition; structure theorem for finitely generated modulus over a PID; torsion module and torsion free module; condition for a finitely generated module over a PID to be free module; the primary decomposition theorem; Chinese remainder theorem.
UNIT 04	Projective and injective modules	Exact sequences; projective modules; characterization of projective modules; condition for a ring to be semi-simple ring; injective modules; characterization of injective modules; Baer's criterion; injective hall; Northerian rings; necessary and sufficient condition for a ring to be Neotherian ring;
UNIT 05	Simple rings	Simple ring; Schin'slemma; semi-simple modules; the Astin-Wedder Burn theorem; simple modules; Jacobson radical; Astinan ring; Hopkins Levitzki theorem.

COURSE OUTCOMES

On successful completion of this course, we expect that a student

1 explain the concept, examples and basic properties of modules, submodules, quotient modules, simple and semi - simple modules.

2 explain the fundamental theorems on homomorphism between modules.

3 explain the concept of free modules (its various characterizations) and rank of finitely generated free modules.

4 explain the concepts of Finitely generated free module over PID, torsion module and torsion free module and the invariant factor decomposition.

5 explain some fundamental results such as structure theorem for finitely generated modulus over a PID, condition for a finitely generated module over a PID to be free module, the primary decomposition theorem and Chinese remainder theorem.

6 explain the concepts, examples and properties of projective and injective modules.

7 Explain the concept , examples and properties of Simple ring, Northerian rings and semi-simple modules.

8 Explain some fundamental results such as condition for a ring to be semi-simple ring, necessary and sufficient condition for a ring to be Neotherian ring, Baer's criterion, Schin's lemma, Astin-Wedder Burn theorem, Hopkins Levitzki theorem.

Note for Paper Setting

The question paper will be divided into two sections. Section A will be compulsory and will contain 10 very short answer type questions eliciting answers not exceeding 20 words/ multiple choice questions/ fill in the blanks, each carrying one mark equally distributed from all units. Section B will contain 10 long answer type questions, two from each unit and the candidate will be required to answer one from each unit. Each question carries 10 marks.

BOOKS RECOMMENDED

TEXT BOOKS

1. **Grillet, P. A., (2007),** Abstract Algebra: Graduate Texts in Mathematics, 2nd edition, Springer.

REFERENCE BOOKS

1. **Blyth, T.S., (1982), Module Theory: An Approach to Linear Algebra, Oxford University Press.**

2. **Albu, T., Birkenmeier, G.F., Erdogan, A. and Tercan, A., (2010), Rings and Module Theory, Birkhäuser Basel.**

SEMESTER - III

Course Title	Wavelet Theory	Maximum Marks	100
Course Code	MS-339	University Examination	60
Credits	4	Sessional Assessment	40
		Duration of Exam.	3 HOURS

UNIT 01	Introduction	Different ways of constructing wavelets, orthonormal bases generated by a single function, the Balian Low theorem, Smooth projections on L^2 (R) , Local Sine and Cosine bases , Construction of some wavelets.
UNIT 02	Multiresolution Analysis	Unitary folding operators, smooth projectionsMultiresolution analysis, Construction of wavelets, Construction of wavelets from MRA, construction of compactly supported wavelets.
UNIT 03	Band limited wavelets	Orthonormality, completeness, The Lemarie Meyer wavelets, characterizations of some band limited wavelets, Franklin wavelets and spline wavelets in real line.
UNIT 04	Characterization in theory of wavelets	Basic equations, some applications of the basic equations, the characterizations of MRA wavelets, characterization of low pass filters and scaling functions.
UNIT 05	Frames	Reconstruction formula for frames, Balian Low Theorem for frames, frames from translation and dilations, Smoth frames for H^2 (R), Decomposition and reconstruction algorithms for wavelets, wavelet packets.

COURSE OUTCOMES

On successful completion of this course, we expect that a student

1 The different types of wavelet in literature and various ways of constructing them

2 the concepts and various examples of Multiresolution Analysis (MRA)

3 Construction of wavelets from MRA.

4 Various characterizations of MRA wavelets

5 The concept of a frame and its various properties.

6 The concept of wavelet packet.

Note for Paper Setting

The question paper will be divided into two sections. Section A will be compulsory and will contain 10 very short answer type questions eliciting answers not exceeding 20 words/ multiple choice questions/ fill in the blanks, each carrying one mark equally distributed from all units. Section B will contain 10 long answer type questions, two from each unit and the candidate will be required to answer one from each unit. Each question carries 10 marks.

BOOKS RECOMMENDED

TEXT BOOKS

1. Hernandez, E., and Weiss, G.,(1996), A First Course on Wavelets, CRC Press, New York.

REFERENCE BOOKS

1 Daubechies, I.,(1992), Ten Lectures on Wavelets, CBS-NSF Regional Conferences in Applied Mathematics, 61, SIAM, Philadelphia, PA.

2 Teolis, A., (1998), Computation Signal Processing with Wavelets, 1st edition, Birkhauser, Boston, Basel.

3 Bachman. G, Narici. L, Beckenstein. E (2010), Fourier and Wavelet Analysis, Springer

4 Siddiqi, A. H., (2004), Applied Functional Analysis, Marcel-Dekker, New York.

SEMESTER - III

Course Title	Calculus in $\mathbb{R}^n$	Maximum Marks	100
Course Code	MS-340	University Examination	60
Credits	4	Sessional Assessment	40
		Duration of Exam.	3 HOURS

Objectives …..................		The aim of this course is to introduce the students differential and integral calculus in R^n with an introduction to distribution theory.
UNIT 01	Differential Calculus-I	Directional derivatives, PartialDerivatives, Total Derivatives and their connection with continuity, The Jacobian matrix; Chain rule, mean value theorem; connection between total & Partial derivatives; Equality of Partial derivatives.
UNIT 02	Differential Calculus-II	Taylor's formula for real valued functions of several variables; Properties of functions with non-zero Jacobion determinant; Inverse function and implicit function theorems; Extremum of real valued functions for several variables- 2^{nd} derivative test; Langrange's multipliers.
UNIT 03	Integral calculus -I	Iterated integrals; multiple Riemann integral; equality of iterated and multiple integral; basic properties of Riemann integral; Leibnitz rule; change of variable
UNIT 04	Integral calculus and test functions	Definition and examples of improper Riemann integral; independence of the value of improper integral over a sequence of sets; comparison tests for the existence of improper integral; Definition and examples of test functions; convergence in the space D(R^n) of test functions
UNIT 05	Distributions	Definition and examples of distributions---regular; Dirac delta; Heaviside distribution; derivative of a distribution; convergence of distributions; product of a C^∞ (R^n) function and a distribution; convolution of a test function and a distribution.

COURSE OUTCOMES

On successful completion of this course, we expect that a student

1 the concept of continuity, directional, partial and total derivatives and their relationships with each other.

2 the fundamental theorems such as Chain rule, mean value theorem, Taylor's theorem, Inverse and Implicit function theorems and their applications.

3 The concept of the Jacobian matrix, the condition of equality of mixed partial derivatives, the concept of Extreme-Values of multi-variable functions and Lagrange's multipliers.

4 The concept and properties of multiple integrals, iterated integrals and relationship between them.

5 The concept of improper integrals and various convergence tests such as the comparison test.

6 The concept and examples of test functions, distributions such as regular, Dirac delta, Heaviside.

7 The concepts of derivative of a distribution and convergence of distributions.

8 The product of a C^∞ (R^n) function and a distribution and convolution of a test function with a distribution.

Note for Paper Setting

The question paper will be divided into two sections. Section A will be compulsory and will contain 10 very short answer type questions eliciting answers not exceeding 20 words/ multiple choice questions/ fill in the blanks, each carrying one mark equally distributed from all units. Section B will contain 10 long answer type questions, two from each unit and the candidate will be required to answer one from each unit. Each question carries 10 marks.

BOOKS RECOMMENDED

TEXT BOOKS

1 **Apostol, Tom M., (2002), Mathematical Analysis, 1st edition, Narosa Publishing House.**

2 **Cheney, W., (2000),** Analysis for Applied Mathematics, **Springer, New York.**

REFERENCE BOOKS

1. **Richard, E. W., Richard, H. R. and Hale, F. T., (1972), Calculus of Vector Functions, 3rd edition, Prentice Hall.**

2. **Ghorpade, S.R and Limaye, V.B.,(2010),** A course in Multivariable calculus and Analysis, **Springer.**

3. **Rudin, W., (1976), Principles of Mathematical Analysis, 3rd edition, McGraw Hill International Edition.**

SEMESTER - III

Course Title	Abstract Measure Theory and Integration	Maximum Marks	100
Course Code	MS-341	University Examination	60
Credits	4	Sessional Assessment	40
		Duration of Exam.	3 HOURS

Objectives …...................		The aim of this course to study measure theory and integration in abstract setting.
UNIT 01	Abstract integration	Measureable space, sets and function; fundamental operations on measureable functions; measure and its elementary properties; integration of simple functions; integration of positive functions.
UNIT 02	Abstract integration and positive Boral measure	Lebsgue monotone convergence theorem; Fatou's lemma; integration of complex functions, Lebsgue dominated convergence theorem ; role played by sets of measure zero, Riesz representation theorem (statement only); properties of Borel measure; existance of Lebsgue measure on R (statement only) ; Lusin's and Vitli-coratheodory theorems (statements only).
UNIT 03	L^P s-paces and complex Measure	Convex functions and Jensen's inequality; L^P spaces and their completeness; approximation by continuous functions, complex measure and its total variation; positive and negative variations; absolute continuity; theorem of Lebsgue-Radon-Nikodym (statement only)and its consequences; Hahn decomposition .
UNIT 04	Complex measures and differentiation	Bounded linear functionals on L^P ; Riesz representation theorem (statement only), derivatives of measures; Lebsgue points; nicely shrinking sets; fundamental theorem of calculus.
UNIT 05	Integration on product spaces	Measurability on cartesian product; product measures, Fubni's theorem; completion of product measure; convolutions; distributions functions

COURSE OUTCOMES

On successful completion of this course, we expect that a student

1 explain the concept, examples and properties of Measureable space, measureable sets, measureable functions, measures and Borel sets.

2 explain the concept, examples and properties of integral of measureable function.

3 explain some fundamental theorems such as Lebsgue monotone convergence theorem, Fatou's lemma, Lebsgue dominated convergence theorem, Riesz representation theorem, Lusin's and Vitli-coratheodory theorems, Jensen's inequality

4 expalins the concepts of L^p-space and its various features such as completeness and Bounded linear functionals on it.

5 explain the concepts of complex measure, total variation, positive and negative variations, absolute continuity and some fundamental results such as Lebsgue-Radon-Nikodym(with consequences) and Hahn decomposition theorem.

6 explain the concepts of derivatives of a measure, Lebsgue points, nicely shrinking sets.

7 explain the concepts of product measures, completion of product measure, convolutions and distributions functions.

8 explain some fundamental theorems such as fundamental theorem of calculus,Fubni's theorem with applications.

Note for Paper Setting

The question paper will be divided into two sections. Section A will be compulsory and will contain 10 very short answer type questions eliciting answers not exceeding 20 words/ multiple choice questions/ fill in the blanks, each carrying one mark equally distributed from all units. Section B will contain 10 long answer type questions, two from each unit and the candidate will be required to answer one from each unit. Each question carries 10 marks.

BOOKS RECOMMENDED

TEXT BOOKS

1. **Rudin, W.,(1987),** Real and Complex Analysis, 3rd Edition, **Tata Mcgraw-Hill Edition.**

REFERENCE BOOKS

1. **Royden, H.L., (2006),Real Analysis, 3rd edition, Prentice-hall of India Private Limited.**

2. **Yeh, J., (2000),** Lectures on Real Analysis**, World Scientific.**

SEMESTER - III

Course Title	Theory of Partial Differential	Maximum Marks	100
Course Code	MS-342	University Examination	60
Credits	4	Sessional Assessment	40
		Duration of Exam.	3 HOURS

Objectives		The aim of this course is to introduce students to the techniques of solving various Partial differential equations
UNIT 01	Formation of PDEs	First order PDE in two or more independent Variables, Derivation of PDE by elimination of arbitrary constants and arbitrary functions; Langranges first order linear PDE, Charpit's method for non-linear PDE of first order; classification of Second order PDE; canonical form: parabolic, hyperbolic and elliptic.
UNIT 02	Elliptic Differential equation	Derivation of Laplace equation, Method of separation of Variable for Laplace equation, Dirichlet problem for a Rectangle, The Neumann Problem for a Rectangle, Interior Dirichlet Problem for a circle, Exterior Dirichlet Problem for a circle, Solution of Laplace equation in Cylindrical coordinates, Solution of Laplace equation in Spherical coordinates.
UNIT 03	Parabolic Differential Equation	Boundary Conditions, Elementary solution of Diffusion Equation, Dirac Delta Function, Separation of Variables method, Solution of Diffusion Equation in Cylindrical coordinates, Solution of Diffusion Equation in Spherical coordinates.
UNIT 04	Hyperbolic Differential Equation I	Derivation of one dimensional Wave Equation, Initial Value Problem; D' Alembert's Solution, Vibrating String- Variables Separable Solution, Forced Vibrations- Solution of Non-homogenous Equation, Boundary and Initial value Problem for Two-dimensional Wave Equations- Method of Eigen function.
UNIT 05	Hyperbolic Differential Equation II	Periodic Solution of one dimensional Wave Solution in Cylindrical Coordinates, Periodic Solution of one dimensional Wave Solution in Cylindrical Coordinates, Vibration of a circular Membrane, Uniqueness of the solution for the Wave Equation, Duhamel's Principle.

COURSE OUTCOMES

On successful completion of this course, we expect that a student

1 Explain the method of formation of a partial differential equations and the methods of finding solutions of linear and non – linear(such as Charpit's method) of partial differential equations.

2 Explain various classes of second order Partial Differential equations.

3 Explain the methods of solutions of Laplace equations by the method of separation of variables.

4 Explain the methods of solutions of Heat and wave equations in Cylindrical and spherical coordinates.

5 Periodic Solution of one dimensional Wave Solution in Cylindrical Coordinates

Note for Paper Setting

The question paper will be divided into two sections. Section A will be compulsory and will contain 10 very short answer type questions eliciting answers not exceeding 20 words/ multiple choice questions/ fill in the blanks, each carrying one mark equally distributed from all units. Section B will contain 10 long answer type questions, two from each unit and the candidate will be required to answer one from each unit. Each question carries 10 marks.

BOOKS RECOMMENDED

TEXT BOOKS

1. **Rao, K. S. (2013),** Introduction to Partial Differential equation, **PHI Learning Private limited.**

2. **Sneddon, I.N. (1957),** Elements ofPartial Differential equation **,Mcgraw Hill Book Company.**

REFERENCE BOOKS

1. **C. Johnson(2009), Numerical Solution of Partial Differential Equations by the Finite Element Methods, Dover Publications.**

2. **K.W. Morton and D.F. Mayers(2011),** Numerical Solution of Partial Differential Equations**, Second Edition, Cambridge University Press, 2011.**

3. **J.C. Strikwerda(2004),** Finite Difference Schemes & Partial Differential Equations**, Second Edition, SIAM.**

SEMESTER - III

Course Title	Graph Theory	Maximum Marks	100
Course Code	MS-343	University Examination	60
Credits	4	Sessional Assessment	40
		Duration of Exam.	3 HOURS

Objectives …...................		The aim of this course is to introduce students fundamentals of Graph Theory and their applications to real world problems.
UNIT 01	Fundamentals of a graph	Graphs; vertices and edges of a graph; order and size of a graph; isomorphisms of graphs; complete graphs; matrices associated with a graph; subgraph; induced subgraph; clique and maximal clique; clique number of a graph ;bipartite and R-partite graphs ;complement of a graph: union, intersection, join and cartesian product of two graphs; degree of vertex; graphical and valid graphical collection of integers.
UNIT 02	Walks, paths and cycles	Basic ideas of walks; paths and cycles; a necessary and sufficient condition for a graph to be bipartite; radius ,diameter, eccentricity, girth and circumference of a graph; weighted distance; shortest path problem; Euler walks; necessary and sufficient condition for a graph to be Eulerian graph; Hamiltonian cycles and Hamiltonian graphs; ore's theorem; Dirac's theorem; the travelling salesman problem; connected graphs; cut-point and cut edge of a graph; vertex connectivity and edge connectivity of a graph and relation between them.
UNIT 03	Trees, vector spaces associated with a graph	Trees, characterization of trees, spanning trees, counting of spanning trees in a graph, problem of finding minimal spanning trees, basics of finite field and vector spaces, the power set as a vector space, the vector space associated with a graph, the cycle subspace, the cutest subspace and their bases.
UNIT 04	Factorizations, graph colorings and planarity	One factorization of a graph; standard factorization of a complete bipartite graph; one factorization theorem; factorization of regular graphs; Petersen's theorem and its generalization; vertex coloring; greedy algorithm for vertex coloring Zrook's theorem(without proof);counting of vertex colorings and chromatic polynomial and its basic results; edge-coloring; chromatic index; and k-paintings of a graph; edge coloring of a bipartite graph; Relationship of edge chromatic number with maximum degree of graph; representations of a graph; crossing number of a representation; planar graph; Euler's formula ;five color problem & four color problem.
UNIT 05	Digraphs and network flows	Basics ideas; orientations, tournaments and directed Euler walks; transportation networks and flows; maximal flow in a network; the maximal flow minimal cut theorem; the max flow min cut algorithm.

COURSE OUTCOMES

On successful completion of this course, we expect that a student

1 the concept of a graph and fundamental ideas connected to the graph such as vertices, edges, order and size of a graph, sub graph, clique and maximal clique, complement of graph, union, intersection, join and Cartesian of two graphs.

2 the concept of walk, Euler walk, path, cycle and their basic properties.

3 the concept of a connected graph, vertex connectivity, edge connectivity and relation between them.

4 the concept of a tree, spanning tree, minimal spanning tree, vector space associated with a graph.

5 the concept of factorization of a graph, standard factorization of complete bipartite graph, Petersen's theorem and its generalization.

6 the concept of vertex coloring, chromatic polynomial, chromatic index, crossing numbe, planar graph and edge-coloring.

7 the concept of directed graphs and transportation networks and flows.

8 some basic results such as relationship of edge chromatic number with maximum degree of graph, Euler's formula, Five color problem, four color problem, greedy algorithm for vertex coloring and Zrook's theorem, the maximal flow minimal cut theorem; the max flow min cut algorithm.

Note for Paper Setting

The question paper will be divided into two sections. Section A will be compulsory and will contain 10 very short answer type questions eliciting answers not exceeding 20 words/ multiple choice questions/ fill in the blanks, each carrying one mark equally distributed from all units. Section B will contain 10 long answer type questions, two from each unit and the candidate will be required to answer one from each unit. Each question carries 10 marks.

BOOKS RECOMMENDED

TEXT BOOKS

1. **Gary, C. and Ping, Z.,(2005),** Introduction to graph theory, **McGraw Hill.**

2. **Wallis, W.D., (2006),** A Beginner's guide to graph theory, 2nd edition, **Springer**.

REFERENCE BOOKS

1. **Deo, N., (2007), Graph Theory with Applications to Engineering and Computer Science, Prentice Hall of India Pvt. Ltd. New Delhi.**

2. **West**,**D. B., (2005),** Introduction to Graph Theory, 2nd edition, **Prentice Hall of India Pvt. Ltd. New Delhi.**