The Kelkar Education Trust's

Vinayak Ganesh Vaze College of Arts, Science & Commerce

(AUTONOMOUS)

College with Potential for Excellence

Mithaghar Road, Mulund East, Mumbai-400081, India

Phones :022-21631421, 221631423, 221631004 Fax : 022-221634262

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Syllabus for T. Y. B. Sc. Programme: Mathematics

Syllabus as per **Choice Based Credit System**

(June 2020 Onwards)

Submitted by

Department of Mathematics

Vinayak Ganesh Vaze College of Arts, Science and Commerce

Mithagar Road, Mulund (East) Mumbai-400081. Maharashtra, India.

Tel: 022-21631004, Fax: 022-21634262

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❖ Syllabus as per Choice Based Credit System

1. Name of the Programme	**T. Y. B. Sc. Mathematics : CBCS**	
The T. Y. B. Sc. in Mathematics course is a one Year Full Time Course consisting of two semesters, to be known as Semester V and Semester VI. Each semester consists of four core courses and one Applied component course.		
2. Course Code	SEMESTER-V CODES	SEMESTER-VI CODES
	SMAT501	SMAT601
	SMAT502	SMAT602
	SMAT503	SMAT603
	SMAT504A/B	SMAT604A/B
	SMATAC501	SMATAC601
3. Course Title	Mathematics	
	Computer Programming and System Analysis- AC (Applied components)	
4. Semester wise Course Contents	Copy of the detailed syllabus Enclosed	
5. References and additional references	Enclosed in the Syllabus	
6. No. of Credits per Semester	16 + 4 (for AC) = 20	
7. No. of lectures per Unit	15	
8. No. of lectures per week	03 of each courses and 04 for AC	
9. No. of Practicals per week	01 of each courses and 02 for AC	
10. Scheme of Examination	Semester End Exam: **60 marks** (3 Questions of 20 marks each)	
	Internal Assessment: **40 marks**	
	Class Test : 15 marks	
	Project/ Assignment : 15 marks	
	Class Participation : 10 marks	
11. Special notes, if any	No	
12. Eligibility, if any	As laid down in the College Admission brochure / website	
13. Fee Structure	As per College Fee Structure specifications	
14. Special Ordinances / Resolutions, if any	No	

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Programme Structure and Course Credit Scheme :

Programme: T. Y. B. Sc.	**Semester: V**	**Credits**	**Semester: VI**	**Credits**
Course 1: Maths Paper-I	**Course Code** SMAT501	2.5	**Course Code** SMAT601	2.5
Course 2: Maths Paper-II	**Course Code** SMAT502	2.5	**Course Code** SMAT602	2.5
Course 3: Maths Paper-III	**Course Code** SMAT503	2.5	**Course Code** SMAT603	2.5
Course 4: Maths Paper-IV	**Course Code** SMAT504A/B	2.5	**Course Code** SMAT604A/B	2.5
Course 5: Practicals based on Maths paper I & II	**Course Code** SMATP501	3.0	**Course Code** SMATP502	3.0
Course 6: Practicals based on Maths paper III & IV	**Course Code** SMATP502	3.0	**Course Code** SMATP602	3.0
Course 7: Applied component Computer Programming and System Analysis (CPSA)	**Course Code** SMATAC501	2.0	**Course Code** SMATAC601	2.0
Course 8: Applied component Practicals (CPSA)	**Course Code** SMATACP501	2.0	**Course Code** SMATACP601	2.0

❖ **Semester-wise Details of Mathematics Course**

SEMESTER-V

Course Code	Unit	Topics	Credits	L/week
Paper 1: Multivariable Calculus II				
SMAT501	I	Multiple Integrals	2.5	3
	II	Line Integrals		
	III	Surface Integrals		
Paper 2: Linear Algebra				
SMAT502	I	Quotient Spaces and Orthogonal Linear Transformations	2.5	3
	II	Eigen values and Eigen vectors		
	III	Diagonalization		
Paper 3: Topology of Metric Spaces				
SMAT503	I	Metric spaces	2.5	3
	II	Sequences and Complete metric spaces		
	III	Compact sets		
Paper 4 : Numerical Analysis-I (Elective A)				
SMAT504A	I	Error Analysis	2.5	3
	II	Transcendental and Polynomial equations		
	III	Linear Systems of Equations		
Paper 4 : Number Theory and Its Applications-I (Elective B)				
SMAT504B	I	Congruences and Factorization	2.5	3
	II	Diophantine equations and their solutions		
	III	Primitive Roots and Cryptography		
PRACTICALS				
SMATP501	--	Practicals based on SMAT501 and SMAT502	3	6
SMATP502	--	Practicals based on SMAT503 and SMAT504A/B	3	6
Applied Component : Computer Programming and System Analysis				
SMATAC501	I	Relational Data Base Management System	2	4
	II	Introduction to Java Programming		
	III	Inheritance, Exception Handling		
	IV	Java Applets and Graphics Programming		
PRACTICALS				
SMATPAC501	--	Practical based on SMATAC501	2	4

SEMESTER-VI

Course Code	Unit	Topics	Credits	L/week
Paper 1: Basic Complex Analysis				
SMAT601	I	Introduction to Complex Analysis	2.5	3
	II	Cauchy Integral Formula		
	III	Complex Power Series, Laurent series and isolated singularities		
Paper 2: Algebra				
SMAT602	I	Group Theory	2.5	3
	II	Ring Theory		
	III	Polynomial Rings and Field theory		
Paper 3: Topology of Metric Spaces and Real Analysis				
SMAT603	I	Continuous functions on metric spaces	2.5	3
	II	Connected sets		
	III	Sequences and series of functions		
Paper 4 : Numerical Analysis-II (Elective A)				
SMAT604A	I	Interpolations	2.5	3
	II	Polynomial Approximations and Numerical Differentiation		
	III	Numerical Integration		
Paper 4 : Number Theory and its Applications-II (Elective B)				
SMAT604B	I	Quadratic Reciprocity	2.5	3
	II	Continued Fractions		
	III	Pell's equation, Arithmetic function and Special numbers		
PRACTICALS				
SMATP601	--	Practicals based on SMAT601 and SMAT602	3	6
SMATP602	--	Practicals based on SMAT603 and SMAT604(A/B)	3	6
Applied Component: Computer Programming and System Analysis				
SMATAC601	I	Introduction to Python	2	4
	II	Advanced topics in Python		
	III	Introduction to Sage Math		
	IV	Programming in Sage Math		
PRACTICALS				
SMATPAC601		Practical based on SMATAC601	2	4

SEMESTER - V									
Teaching Scheme (Hrs/Week)				**Continuous Internal Assessment (CIA) 40 marks**			**End Semester Examination Marks**		**Total**
Course Code	**L**	**P**	**C**	**CIA-1**	**CIA-2**	**CIA-3**	**Theory**	**Practical**	
SMAT501	03	01 (1P=3L)	2.5	15	15	10	60	--	100
SMAT502	03	01 (1P=3L)	2.5	15	15	10	60	--	100
SMAT503	03	01 (1P=3L)	2.5	15	15	10	60	--	100
SMAT504A/B	03	01 (1P=3L)	2.5	15	15	10	60	--	100
SMATP501	--	--	3.0	--	--	--	--	100	100
SMATP502	--	--	3.0	--	--	--	--	100	100
SMATAC501	04	02 (1P=2L)	2.0	15	15	10	60	--	100
SMATPAC501	--	--	2.0	--	--	--	--	100	100
Total credits of the course = 10 + 06 + 02+ 02 **= 20**									
Max. Time, End Semester Exam (Theory): 2 .00 Hrs.									

SEMESTER - VI									
Teaching Scheme (Hrs/Week)				**Continuous Internal Assessment (CIA) 40 marks**			**End Semester Examination Marks**		**Total**
Course Code	**L**	**P**	**C**	**CIA-1**	**CIA-2**	**CIA-3**	**Theory**	**Practical**	
SMAT601	03	01 (1P=3L)	2.5	15	15	10	60	--	100
SMAT602	03	01 (1P=3L)	2.5	15	15	10	60	--	100
SMAT603	03	01 (1P=3L)	2.5	15	15	10	60	--	100
SMAT604A/B	03	01 (1P=3L)	2.5	15	15	10	60	--	100
SMATP601	--	--	3.0	--	--	--	--	100	100
SMATP602	--	--	3.0	--	--	--	--	100	100
SMATAC601	04	02 (1P=2L)	2.0	15	15	10	60	--	100
SMATPAC601	--	--	2.0	--	--	--	--	100	100
Total credits of the course = 10 + 06 + 02+ 02 **= 20**									
Max. Time, End Semester Exam (Theory) : 2 .00 Hrs.									

- L-Lectures
- T - Tutorials
- P - Practical
- C -Credits

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<tr><td colspan="4" align="center">T. Y. B. Sc. MATHEMATICS : Choice Based Credit System</td></tr>
<tr><td colspan="4" align="center">Semester - V</td></tr>
<tr><td colspan="4" align="center">PAPER – I : MULTIVARIABLE CALCULUS II</td></tr>
<tr><td colspan="2">Course Name: Multivariable Calculus II
(45 lectures)</td><td colspan="2">Course Code: SMAT501</td></tr>
<tr><td colspan="2">Periods per week (1 period 48 minutes)</td><td colspan="2" align="center">03</td></tr>
<tr><td colspan="2">Credits</td><td colspan="2" align="center">2.5</td></tr>
<tr><td rowspan="3">Evaluation System</td><td></td><td align="center">Hours</td><td align="center">Marks</td></tr>
<tr><td>Theory Examination</td><td align="center">2.0</td><td align="center">60</td></tr>
<tr><td>Theory Internal</td><td></td><td align="center">40</td></tr>
</table>

Course Objectives:

- ✓ Handle vectors fluently in solving problems involving the geometry of lines, curves, planes, and surfaces in space.
- ✓ Visualize and draw graphs of surfaces in space.
- ✓ Differentiate scaler functions of vectors.
- ✓ Integrate vectors.
- ✓ Calculate extreme values using Lagrange multipliers.
- ✓ Solve double and triple integrals.
- ✓ Translate real-life situations into the symbolism of mathematics and find solutions for the resulting models.

Unit No.	Content	No. of lectures
Unit I	**Multiple Integrals (15 Lectures)** Definition of double (resp: triple) integral of a function and bounded on a rectangle (resp: box). Geometric interpretation as area and volume. Fubini's Theorem over rectangles and any closed bounded sets, Iterated Integrals. Basic properties of double and triple integrals proved using the Fubini's theorem such as (i) Integrability of the sums, scalar multiples, products, and (under suitable conditions) quotients of integrable functions. Formulae for the integrals of sums and scalar multiples of integrable functions. (ii) Integrability of continuous functions. More generally, Integrability of functions with a small set of (Here, the notion of “small sets should include finite unions of graphs of continuous functions.) (iii) Domain additivity of the integral. Integrability and the integral over arbitrary bounded domains. Change of variables formula (Statement only).Polar, cylindrical and spherical coordinates, and integration using these coordinates. Differentiation under the integral sign. Applications to finding the center of gravity and moments of inertia.	**15**

Unit II	**Line Integrals** Review of Scalar and Vector fields on $\mathbb{R}^n$, Vector Differential Operators, Gradient, Curl, Divergence. Paths (parameterized curves) in $\mathbb{R}^n$, (emphasis on $\mathbb{R}^2$, and $\mathbb{R}^3$). Smooth and piecewise smooth paths. Closed paths. Equivalence and orientation preserving equivalence of paths. Definition of the line integral of a vector field over a piecewise smooth path. Basic properties of line integrals including linearity, path-additivity and behaviour under a change of parameters. Examples. Line integrals of the gradient vector field, Fundamental Theorem of Calculus for Line Integrals, Necessary and sufficient conditions for a vector field to be conservative. Greens Theorem (proof in the case of rectangular domains). Applications to evaluation of line integrals.	**15**
Unit III	**Surface Integrals** Parameterized surfaces. Smoothly equivalent parameterizations. Area of such surfaces. Definition of surface integrals of scalar-valued functions as well as of vector fields defined on a surface. Curl and divergence of a vector field. Elementary identities involving gradient, curl and divergence. Stokes theorem (proof assuming the general form of Green's theorem), examples. Gauss Divergence Theorem (proof only in the case of cubical domains), examples.	**15**

List of suggested practicals based on SMAT501:
1. Line integrals of scalar and vector fields 2. Green’s theorem, conservative field and applications 3. Evaluation of surface integrals 4. Stokes and Gauss divergence theorem 5. Pointwise and uniform convergence of sequence of functions 6. Pointwise and uniform convergence of series of functions 7. Miscellaneous theoretical questions based on full paper

Learning Outcomes:

On studying the syllabi, the learner will be able to

- Define line integrals of scalar and vector fields, basic properties and conservative of vector field
- Learn Fundamental Theorems of Calculus for line integrals, Green's theorem and their applications
- Understand the concept of surface integrals for scalar and vector fields and some identities involving gradient, curl and divergence
- Learn the consequence of uniform convergence on limit functions
- To introduce the concept of power series and representation of elementary functions

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Reference Books :

1. Tom M. Apostol, Calculus Vol. 2, second edition, John Wiley, India
2. Jerrold E. Marsden, Anthony J. Tromba, Alan Weinstein, Basic Multivariable Calculus, Indian edition, Springer-Verlag
3. Dennis G. Zill, Warren S. Wright, Calculus Early Transcendentals, fourth edition, Jones and Bartlett Publishers
4. R. R. Goldberg, Methods of Real Analysis, Indian Edition, Oxford and IBH publishing, New Delhi.
5. S.C. Malik, Savita Arora, Mathematical Analysis, third edition, New Age International Publishers, India.
6. Ajit Kumar, S. Kumaresan, A Basic Course in Real Analysis, CRC Press.
7. Charles G. Denlinger, Elements of Real Analysis, student edition, Jones & Bartlett Publishers.
8. M. Thamban Nair, Calculus of One Variable, student edition, Ane Books Pvt. Ltd.
9. Russell A. Gordon, Real Analysis A First Course, Second edition, Addison Wesley.

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T. Y. B. Sc. MATHEMATICS : Choice Based Credit System			
Semester - V			
PAPER – II : LINEAR ALGEBRA			
Course Name: LINEAR ALGEBRA (45 lectures)		Course Code: **SMAT502**	
Periods per week (1 period 48 minutes)		**03**	
Credits		**2.5**	
Evaluation System		**Hours**	**Marks**
	Theory Examination	**2.0**	**60**
	Theory Internal		**40**

Course Objectives :

- ❖ To use mathematically correct language and notation for Linear Algebra.
- ❖ To become computational proficiency involving procedures in Linear Algebra.
- ❖ To understand the axiomatic structure of a modern mathematical subject and learn to construct simple proofs.
- ❖ To solve problems that apply Linear Algebra to Chemistry, Economics and Engineering.

Unit No.	Content	No. of lectures
Unit I	**Quotient Spaces and Orthogonal Linear Transformations** Review of vector spaces over $\mathbb{R}$, subspaces and linear transformation. Quotient Spaces: For a real vector space V and a subspace W, the cosets $v + W$ and the quotient space V/W, First Isomorphism theorem of real vector spaces (fundamental theorem of homomorphism of vector spaces), Dimension and basis of the quotient space V/W, when V is finite dimensional. Orthogonal transformations: Isometries of a real finite dimensional inner product space, Translations and Reflections with respect to a hyperplane, Orthogonal matrices over $\mathbb{R}$, Equivalence of orthogonal transformations and isometries fixing origin on a finite dimensional inner product space, Orthogonal transformation of $\mathbb{R}$, Any orthogonal transformation in $\mathbb{R}$ is a reflection or a rotation, Characterization of isometries as composites of orthogonal transformations and translation. Characteristic polynomial of an nxn real matrix. Cayley Hamilton Theorem and its Applications (Proof assuming the result $A(adjA) = I_n$ for an $n \times n$ matrix over the polynomial ring $\mathbb{R}[t]$.	**15**

Unit II	**Eigenvalues and eigen vectors** Eigen values and eigen vectors of a linear transformation $T : V \to V$, where V is a finite dimensional real vector space and examples, Eigen values and Eigen vectors of $n \times n$ real matrices, the linear independence of eigen vectors corresponding to distinct eigenvalues of a linear transformation. The characteristic polynomial of an nxn real matrix and a linear transformation of a finite dimensional real vector space to itself, characteristic roots, Similar matrices, Relation with change of basis, Invariance of the characteristic polynomial and (hence of the) eigenvalues of similar matrices, Every square matrix is similar to an upper triangular matrix. Minimal Polynomial of a matrix, Examples like minimal polynomial of scalar matrix, diagonal matrix, similar matrix, Invariant subspaces.	**15**
Unit III	**Diagonalization** Geometric multiplicity and Algebraic multiplicity of eigen values of an $n \times n$ real matrix, An $n \times n$ matrix A is diagonalizable if and only if it has a basis of eigenvectors of A if and only if the sum of dimension of eigen spaces of A is n if and only if the algebraic and geometric multiplicities of eigen values of A coincide, Examples of non diagonalizable matrices, Diagonalization of a linear transformation$T: V \to V$, where V is a finite dimensional real vector space and examples. Orthogonal diagonalisation and Quadratic Forms. Diagonalisation of real Symmetric matrices, Examples, Applications to real Quadratic forms, Rank and Signature of a Real Quadratic form, Classification of conics in $\mathbb{R}$ and quadric surfaces in $\mathbb{R}$. Positive definite and semi definite matrices, Characterization of positive definite matrices in terms of principal minors.	**15**

List of Suggested Practicals based on SMAT502
1. Quotient Spaces, Orthogonal Transformations. 2. Cayley Hamilton Theorem and Applications 3. Eigen Values & Eigen Vectors of a linear Transformation/ Square Matrices 4. Similar Matrices, Minimal Polynomial, Invariant Subspaces 5. Diagonalisation of a matrix 6. Orthogonal Diagonalisation and Quadratic Forms. 7. Miscellaneous Theory Questions

Learning Outcomes:

After completing the course, the student should be able to :

- ♣ Define quotient space.
- ♣ Understand first isomorphism theorem.
- ♣ Find the dimension of quotient space.
- ♣ Apply cayley Hamilton theorm
- ♣ Understand the eigen values and eigen vectors of a matrix.
- ♣ Find the minimal polynomial of a matrix.
- ♣ Understand the geometric multiplicity and algebraic multiplicity

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Recommended Books.

1. S. Kumaresan, Linear Algebra, A Geometric Approach.
2. Ramachandra Rao and P. Bhimasankaram, Tata McGraw Hill Publishing Company.

Additional Reference Books

1. T. Banchoff and J. Wermer, Linear Algebra through Geometry, Springer.
2. L. Smith, Linear Algebra, Springer.
3. M. R. Adhikari and Avishek Adhikari, Introduction to linear Algebra, Asian Books Private Ltd.
4. K Hoffman and Kunze, Linear Algebra, Prentice Hall of India, New Delhi.
5. Inder K Rana, Introduction to Linear Algebra, Ane Books Pvt. Ltd.

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<tr><td colspan="4">T. Y. B. Sc. MATHEMATICS : Choice Based Credit System</td></tr>
<tr><td colspan="4">Semester - V</td></tr>
<tr><td colspan="4">PAPER – III : TOPOLOGY OF METRIC SPACES</td></tr>
<tr><td colspan="2">Course Name: TOPOLOGY OF METRIC SPACES
(45 lectures)</td><td colspan="2">Course Code: SMAT503</td></tr>
<tr><td colspan="2">Periods per week (1 period 48 minutes)</td><td colspan="2">3</td></tr>
<tr><td colspan="2">Credits</td><td colspan="2">2.5</td></tr>
<tr><td rowspan="3">Evaluation System</td><td></td><td>Hours</td><td>Marks</td></tr>
<tr><td>Theory Examination</td><td>2.0</td><td>60</td></tr>
<tr><td>Theory Internal</td><td></td><td>40</td></tr>
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Course Objectives :

- To isolate the three fundamental properties of distance and base all our deductions on these three properties alone in the treatment of the metric spaces;
- To introduce the students to the definitions of basic terms and concepts in metric space topology;
- To provide students with systematic proofs of theorems using the definitions of basic terms and properties of metrics.
- To treat the various basic concepts of open and closed sets, adherent points, convergent and Cauchy convergent sequences, complete spaces; compactness and connectedness etc. to the students.

Unit No.	Content	No. of lectures
Unit I	**Metric spaces (15 Lectures)** Definition, examples of metric spaces $\mathbb{R}$, $\mathbb{R}^2$,Euclidean space $\mathbb{R}^n$ with its Euclidean, sup and sum metric, $\mathbb{C}$ (complex numbers), the spaces l^1 and l^2 of sequences and the space $C[a\ ,b]$, of real valued continuous functions on $[a, b]$. Discrete metric space. Distance metric induced by the norm, translation invariance of the metric induced by the norm. Metric subspaces, Product of two metric spaces. Open balls and open set in a metric space, examples of open sets in various metric spaces. Hausdorff property. Interior of a set. Properties of open sets. Structure of an open set in $\mathbb{R}$. Equivalent metrics. Distance of a point from a set, between sets,diameter of a set in a metric space and bounded sets. Closed ball in a metric space, Closed sets- definition, examples. Limit point of a set,isolated point, a closed set contains all its limit points, Closure of a set and boundary of a set.	**15**
Unit II	**Sequences and Complete metric spaces** Sequences in a metric space, Convergent sequence in metric space, Cauchy sequence in a metric space, subsequences, examples of convergent and Cauchy sequence in finite metric spaces, $\mathbb{R}^n$ with different metrics and other metric spaces. Characterization of limit points and closure points in terms of sequences. Definition and examples of relative openness/closeness in subspaces. Dense subsets in a metric space and Separability Definition of complete metric spaces, Examples of complete metric spaces, Completeness property in subspaces,	**15**

	Nested Interval theorem in $\mathbb{R}$, Cantor's Intersection Theorem, Applications of Cantors Intersection Theorem: (i) The set of real Numbers is uncountable. (ii) Density of rational Numbers (Between any two real numbers there exists a rational number) (iii)Intermediate Value theorem: Let $f{:}[a\ b] \to \mathbb{R}$ be continuous function , and assume that $f(a)\ and\ f(b)$ are of different signs say, $f(a) < 0\ and$ $f(b) > 0$. Then there exists $c \in (a,b)$ such that$f(c) = 0$.	
Unit III	**Compact sets** Definition of compact metric space using open cover, examples of compact sets in different metric spaces $\mathbb{R}, \mathbb{R}^2, \mathbb{R}^n$, Properties of compact sets: A compact set is closed and bounded, (Converse is not true). Every infinite bounded subset of compact metric space has a limit point. A closed subset of a compact set is compact. Union and Intersection of Compact sets. Equivalent statements for compact sets in $\mathbb{R}$: (i) Sequentially compactness property. (ii) Heine borel property: Let be a closed and bounded interval. Let be a family of Open intervals such that Then there exists a finite subset such that that is, contained in the union of a finite number of open intervals of the given family. (iii) Closed and boundedness property. (iv) Bolzano-Weierstrass property: Every bounded sequence of real numbers has a convergent subsequence.	**15**

List of suggested practicals based on SMAT503:
1. Example of metric spaces, normed linear spaces 2. Sketching of open balls in $\mathbb{R}^2$ and open sets in metric spaces/ normed linear spaces, interior of a set, subspaces 3. Closed sets, sequences in a metric space 4. Limit points, dense sets, separability, closure of a set, distance between two sets. 5. Complete metric space 6. Cantor's Intersection theorem and its applications 7. Miscellaneous theory questions from all unit

Learning Outcomes:

After completing the course, the student should be able to;

- ♦ Define real numbers, identify the convergency and divergency of sequences, explain the limit and continuity of a function at a given point.
- ♦ Construct the geometric model of the set of real numbers.
- ♦ Define the existence of a sequence's limit, if there exists, find the limit.
- ♦ Explain the notion of limit of a function at a given point and if there exists estimate the limit.
- ♦ Define the notion of continuity and obtain the set of points on which a function is continuous.
- ♦ Explain the notion of metric space. Use the open ball on metric spaces, construct the metric topology and define open-closed sets of the space.

Reference books:

1. S. Kumaresan, Topology of Metric spaces.
2. E. T. Copson. Metric Spaces. Universal Book Stall, New Delhi.
3. Expository articles of MTTS programme.

Other References:

1. W. Rudin, Principles of Mathematical Analysis.
2. T. Apostol, Mathematical Analysis, Second edition, Narosa, New Delhi.
3. E. T. Copson, Metric Spaces, Universal Book Stall, New Delhi.
4. R. R. Goldberg Methods of Real Analysis, Oxford and IBH Pub. Co., New Delhi
5. P.K.Jain. K. Ahmed, Metric Spaces, Narosa, New Delhi.
6. W. Rudin, Principles of Mathematical Analysis, Third Ed, McGraw-Hill, Auckland.
7. D. Somasundaram B. Choudhary, A first Course in Mathematical Analysis, Narosa, New Delhi
8. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, New York.
9. W. A. Sutherland, Introduction to metric & topological spaces, Second Edition, Oxford.

T. Y. B. Sc. MATHEMATICS : Choice Based Credit System			
Semester - V			
PAPER – IV : NUMERICAL ANALYSIS – I [Elective A]			
Course Name: Numerical Analysis – I [Elective A] **(45 lectures)**		Course Code: **SMAT504A**	
Periods per week (1 period 48 minutes)		**3**	
Credits		**2.5**	
Evaluation System		**Hours**	**Marks**
	Theory Examination	**2.0**	**60**
	Theory Internal		**40**

Course Objectives :

- To develop the mathematical skills of the students in the areas of numerical methods.
- To teach theory and applications of numerical methods in a large number of engineering subjects which require solutions of linear systems, finding eigen values, eigenvectors, interpolation and applications, solving ODEs, PDEs and dealing with statistical problems like testing of hypotheses.
- To lay foundation of computational mathematics for post-graduate courses, specialized studies and research.

Unit No.	Content	No. of lectures
Unit I	**Errors Analysis and Transcendental & Polynomial Equations** Measures of Errors: Relative, absolute and percentage errors. Types of errors: Inherent error, Round-off error and Truncation error. Taylors series example. Significant digits and numerical stability. Concept of simple and multiple roots. Iterative methods, error tolerance, use of intermediate value theorem. Iteration methods based on first degree equation: Newton-Raphson method, Secant method, Regula-Falsi method, Iteration Method. Condition of convergence and Rate of convergence of all above methods.	**15**

Unit II	**Transcendental and Polynomial Equations** Iteration methods based on second degree equation: Muller method, Chebyshev method, Multipoint iteration method. Iterative methods for polynomial equations; Descarts rule of signs, Birge-Vieta method, Bairstrow method. Methods for multiple roots. Newton-Raphson method. System of non-linear equations by Newton- Raphson method. Methods for complex roots. Condition of convergence and Rate of convergence of all above methods.	15
Unit III	**Linear System of Equations** Matrix representation of linear system of equations. Direct methods: Gauss elimination method. Pivot element, Partial and complete pivoting,Forward and backward substitution method, Triangularization methods-Doolittle and Crouts method, Choleskys method. Error analysis of direct methods. Iteration methods: Jacobi iteration method, Gauss-Siedal method. Convergence analysis of iterative method. Eigen value problem, Jacobis method for symmetric matrices Power method to determine largest eigenvalue and eigenvector.	**15**

List of suggested practicals based on SMAT504A:
1. Newton-Raphson method, Secant method, Regula-Falsi method, Iteration Method 2. Muller method, Chebyshev method, Multipoint iteration method 3. Descarts rule of signs, Birge-Vieta method, Bairstrow method 4. Gauss elimination method, Forward and backward substitution method, 5. Triangularization methods-Doolittles and Crouts method, Choleskys method 6. Jacobi iteration method, Gauss-Siedal method Eigen value problem: Jacobis method for symmetric matrices and Power method to determine largest eigenvalue and eigenvector 7. Miscellaneous theoretical questions from all units

<u>Learning Outcomes</u>

At the end of this course, the student will able to

- Understand Newton-Raphson method, Secant method, Regula-Falsi method, and their rate of convergence.
- Learn Iteration methods: Muller method, Chebyshev method, Multipoint iteration method and their rate of convergence
- Learn Doolittle and Crouts method, Choleskys method, Jacobi iteration method, Gauss-Siedal method and convergence analysis

Recommended Books

1. Kendall E. and Atkinson, An Introduction to Numerical Analysis, Wiley.
2. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publications.

3. S.D. Conte and Carl de Boor, Elementary Numerical Analysis, An algorithmic approach, McGraw Hill International Book Company.
4. S. Sastry, Introductory methods of Numerical Analysis, PHI Learning.
5. Hildebrand F.B., Introduction to Numerical Analysis, Dover Publication, NY.
6. Scarborough James B., Numerical Mathematical Analysis, Oxford University Press, New Delhi.

T. Y. B. Sc. MATHEMATICS : Choice Based Credit System

Semester - V

PAPER – IV : NUMBER THEORY AND ITS APPLICATIONS – I [Elective B]

Course Name: Number Theory and its applications – I [Elective B] **(45 lectures)**		Course Code: **SMAT601**	
Periods per week (1 period 48 minutes)		**3**	
Credits		**2.5**	
Evaluation System		**Hours**	**Marks**
	Theory Examination	**2.0**	**60**
	Theory Internal		**40**

Course Objectives :

- To define and interpret the concepts of divisibility, congruence, greatest common divisor, prime, and prime-factorization.
- To apply the Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues.
- To Formulate and prove conjectures about numeric patterns.
- To Produce rigorous arguments (proofs) centred on the material of number theory, most notably in the use of Mathematical Induction and/or the Well Ordering Principal in the proof of theorems.
- Evaluate trigonometric and inverse trigonometric functions.
- Solve trigonometric equations and applications.
- Apply and prove trigonometric identities.

Unit No	Content	No. of lectures
Unit I	**Congruences and Factorization** Review of Divisibility, Primes and the fundamental theorem of Arithmetic. Congruences, Complete residue system modulo m, Reduced residue system modulo m, Fermat's little Theorem, Euler's generalization of Fermat's little Theorem, Wilson's theorem, Linear congruences, Simultaneous linear congruences in two variables. The Chinese remainder Theorem, Congruences of Higher degree, The Fermat-Kraitchik Factorization Method.	**15**

Unit II	**Diophantine equations and their solutions** The linear Diophantine equation $ax + by = c$.The equation $x^2 + y^2 = z^2$ Primitive Pythagorean triple and its characterisation. The equations $x^4 + y^4 = z^2$ and $x^2 + y^2 = z^4$ have no solutions(x, y, z) with $xyz \neq 0$. Every positive integer n can be expressed as sum of squares of four integers, Universal quadratic forms $x^2 + y^2 + z^2 = t^2$. Assorted examples: section 5.4 of Number theory by Niven- Zuckermann-Montgomery.	**15**
Unit III	**Primitive Roots and Cryptography** Order of an integer and Primitive Roots. Basic notions such as encryption (enciphering) and decryption (deciphering), Cryptosystems, symmetric key cryptography, Simple examples such as shift cipher, Affine cipher, Hillll's cipher, Vigenere cipher. Concept of Public Key Cryptosystem; RSA Algorithm. An application of Primitive Roots to Cryptography.	**15**

List of suggested practicals based on SMAT504B:
1. Fermat's theorem, Wilson's theorem, Euler's theorem 2. Chinese remainder theorem, linear and higher order congruences, factorization 3. Linear Diophantine equations 4. Pythagorean triples, sum of two squares, three squares, four squares 5. Primitive roots, shift cipher, affine cipher, Hill cipher 6. Vigenere Cipher, Digraph transformations, Public key cryptosystems 7. Miscellaneous theoretical questions from all units

Learning Outcomes

On studying the syllabi, the learner will be able to
- find quotients and remainders from integer division
- apply Euclid's algorithm and backwards substitution
- understand the definitions of congruences, residue classes and least residues
- add and subtract integers, modulo n, multiply integers and calculate powers, modulo n
- determine multiplicative inverses, modulo n and use to solve linear congruences.

Recommended Books:

1. Niven, H. Zuckerman and H. Montogomery, An Introduction to the Theory of Numbers, John Wiley & Sons. Inc.
2. David M. Burton, An Introduction to the Theory of Numbers, Tata McGraw Hill Edition.
3. G. H. Hardy and E.M. Wright. An Introduction to the Theory of Numbers. Low priced edition. The English Language Book Society and Oxford University Press.
4. Neville Robins, Beginning Number Theory, Narosa Publications.
5. S.D. Adhikari, An introduction to Commutative Algebra and Number Theory, Narosa Pub House.
6. N. Koblitz, A course in Number theory and Cryptography, Springer.
7. M. Artin, Algebra, Prentice Hall.
8. K. Ireland, M. Rosen, A classical introduction to Modern Number Theory, Second edition, Springer Verlag.
9. William Stallings, Cryptology and network security, Pearson Education.

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T. Y. B. Sc. MATHEMATICS : Choice Based Credit System			
Semester – V			
APPLIED COMPONENT : COMPUTER PROGRAMMING AND SYSTEM ANALYSIS			
Course Name: COMPUTER PROGRAMMING AND SYSTEM ANALYSIS **(60 lectures)**		Course Code: **SMATAC501**	
Periods per week (1 period 48 minutes)		**04**	
Credits		**02**	
Evaluation System		**Hours**	**Marks**
	Theory Examination	**2.0**	**60**
	Theory Internal		**40**

Course Objectives :

- ✓ Provide for mass storage of relevant data
- ✓ Eliminate redundantly (Duplicate) d data.
- ✓ Allow multiple users to be active at one time.
- ✓ Provide data integrity.
- ✓ Protect the data from physical harm and unauthorized access.
- ✓ Serving different types of users.
- ✓ Provide security with a user access privilege.
- ✓ To learn why Java is useful for the design of desktop and web applications.
- ✓ To learn how to implement object-oriented designs with Java.
- ✓ To identify Java language components and how they work together in applications.
- ✓ To learn how to design a graphical user interface (GUI) with Java Swing.
- ✓ To understand how to use Java APIs for program development.
- ✓ To learn how to use exception handling in Java applications.
- ✓ To understand how to design GUI components with the Java Swing API.
- ✓ To learn Java generics and how to use the Java Collections API.
- ✓ To understand how to design applications with threads in Java.
- ✓ To learn how to read and write files in Java.

Unit No	Content	No. of lectures
Unit I	**RELATIONAL DATA BASE MANAGEMENT SYSTEM** **Introduction to Data base Concepts**: Database, Overview of data base management system. Data base Languages- Data Definition Languages (DDL) and Data Manipulation Languages (DML). 2. Entity Relation Model: Entity, attributes, keys, relations, Designing ER diagram, integrity Constraints over relations, conversion of ER to relations with and without constrains. 3. SQL Commands and functions a) Creating and altering tables: CREATE statement with constraints like KEY, CHECK, DEFAULT, ALTER and DROP statement. b) Handling data using SQL: selecting data using SELECT statement, FROM clause, WHERE clause, HAVING clause, ORDERBY, GROUP BY,DISTINCT and ALL predicates, Adding data with INSERT statement, changing data with UPDATE statement, removing data with DELETE statement. c) Functions: Aggregate functions- AVG, SUM, MIN, MAX and COUNT, Date functions-	**15**

	ADD_MONTHS(),CURRENT_DATE(),LAST_DAY(),MONTHS_BETWEEN (), NEXT_DAY() . String functions- LOWER(), UPPER(), LTRIN(), RTRIM(), TRIN(), INSERT(), RIGHT(), LEFT(), LENGTH(),SUBSTR(). Numeric functions: ABS(),EXP(),LOG(),SQRT(),POWER(),SIGN(), ROUND(). d) Joining tables: Inner, outer and cross joins, union.	
Unit II	**INTRODUCTION TO JAVA PROGRAMMING** 1. **Object-Oriented approach:** Features of object-orientations: Abstraction, Inheritance, Encapsulation and Polymorphism. 2. **Introduction:** History of Java features, different types of Java programs, Differentiate Java with C. Java Virtual Machine. 3. **Java Basics:** Variables and data types, declaring variables, literals numeric, Boolean, character and string literals, keywords, type conversion and casting. Standard default values. Java Operators, Loops and Controls. 4. **Classes:** Defining a class, creating instance and class members: creating object of a class, accessing instance variables of a class, creating method, naming method of a class, accessing method of a class, overloading method, 'this' keyword, constructor and Finalizer: Basic Constructor, parameterized constructor, calling another constructor, finalize() method, overloading constructor. 5. **Arrays:** one and two – dimensional array, declaring array variables, creating array objects, accessing array elements. 6. **Access control:** public access, friendly access, protected access, private access.	**15**
Unit III	**Inheritance, Exception Handling (15 Lectures)** a) **Inheritance:** Various types so inheritance, super and sub classes, keywords- 'extends', 'super', over riding method, final and abstract class: final variables and methods, final classes, abstract methods and classes. Concepts of inter face. b) **Exception Handling and Packages:** Need for Exceptional Handling, Exception Handling techniques: try and catch, multiple catch statements, finally block, us age of throw and throws. Concept of packages. Inter class method: parseInt().	**15**
Unit IV	**JAVA APPLETS AND GRAPHICS PROGRAMMING** **1. Applets:** Difference of applet and application, creating applets, applet life cycle, passing parameters to applets. **2. Graphics, Fonts and Color:** The graphics class, painting, repainting and updating an applet, sizing graphics. Font class, draw graphical figures-lines and rectangle, circle and ellipse, drawing arcs, drawing polygons. Working with Colors: Color methods, setting the paint mode. **3. AWT package:** Containers: Frame and Dialog classes, Components: Label; Button; Checkbox; Text Field, Text Area.	**15**

Learning Outcomes:

Upon successful completion of this course, students should be able to:

- ♦ Describe the fundamental elements of relational database management systems
- ♦ Explain the basic concepts of relational data model, entity-relationship model, relational database design, relational algebra and SQL.
- ♦ Design ER-models to represent simple database application scenarios
- ♦ Convert the ER-model to relational tables, populate relational database and formulate SQL queries on data.
- ♦ Use an integrated development environment to write, compile, run, and test simple object-oriented Java programs.
- ♦ Read and make elementary modifications to Java programs that solve real-world problems.
- ♦ Validate input in a Java program.
- ♦ Identify and fix defects and common security issues in code.

References:

1. Programming with Java: A Primer 4th Edition by E.Balagurusamy, Tata McGraw Hill.
2. Java The Complete Reference,8th Edition , Herbert Schildt, Tata McGraw Hill

Additional References:

5. Eric Jendrock, Jennifer Ball, DCarsonand others, The Java EE5 Tutorial, Pearson Education, Third Edition,2003.
6. Ivan Bay Ross, Web Enabled Commercial Applications Development Using Java2, BPB Publications, Revised Edition, 2006
7. Joe Wigglesworth and Paula McMillan, Java Programming: Advanced Topics, Thomson Course Technology(SPD),ThirdEdition,2004
8. The Java Tutorials of Sun Microsystems Inc. http://docs.oracle.com/javase/tutorial

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T. Y. B. Sc. MATHEMATICS : Choice Based Credit System

Semester - VI

PAPER – I : BASIC COMPLEX ANALYSIS

Course Name: Basic Complex Analysis **(45 lectures)**		Course Code:	**SMAT601**
Periods per week (1 period 48 minutes)		**03**	
Credits		**2.5**	
Evaluation System		**Hours**	**Marks**
	Theory Examination	**2.0**	**60**
	Theory Internal		**40**

Course Objectives :

- Understand how complex numbers provide a satisfying extension of the real numbers
- Learn techniques of complex analysis that make practical problems easy (e.g. graphical rotation and scaling as an example of complex multiplication);
- Appreciate how mathematics is used in design (e.g. conformal mapping)
- Learn how to find radius of convergences, disc of convergence.

Unit No.	Content	No. of lectures
Unit I	**Introduction to Complex Analysis** Review of complex numbers: Complex plane, polar coordinates, exponential map, powers and roots of complex numbers, De Moivres formula, $\mathbb{C}$as a metric space, bounded and unbounded sets, point at infinity-extended complex plane, sketching of set in complex plane (No questions to be asked). Limit at a point, theorems on limits, convergence of sequences of complex numbers and results using properties of real sequences. Functions $f:\mathbb{C}\to\mathbb{C}$real and imaginary part of functions, continuity at a point and algebra of continuous functions. Derivative of $f:\mathbb{C}\to\mathbb{C}$ comparison between differentiability in real and complex sense, Cauchy-Riemann equations, sufficient conditions for differentiability, analytic function, f,g analytic then $f+g, f-g, fg$ and f/g are analytic, chain rule. Theorem: If $f(z) = 0$ everywhere in a domain D, then $f(z)$ must be constant throughout D Harmonic functions and harmonic conjugate.	15
Unit II	**Cauchy Integral Formula** Explain how to evaluate the line integral $\int f(z)dz$over$\|z-z_0\| = r$ and prove the Cauchy integral formula : If f is analytic in $B(z_0,r)$ then for any w in$B(z_0,r)$ we have $f(w)=\frac{1}{2\pi i}\int\frac{f(z)}{z-w}dz$,over $\|z-z_0\| = r$. Taylors theorem for analytic function, Mobius transformations: definition and examples Exponential function, its properties, trigonometric function, hyperbolic functions.	15

Unit III	**Complex power series, Laurent series and isolated singularities** Power series of complex numbers and related results following from Unit I, radius of convergences, disc of convergence, uniqueness of series representation, examples. Definition of Laurent series , Definition of isolated singularity, statement (without proof) of existence of Laurent series expansion in neighbourhood of an isolated singularity, type of isolated singularities viz. removable, pole and essential defined using Laurent series expansion, examples Statement of Residue theorem and calculation of residue.	15

List of suggested practicals based on SMAT601:
1. Limit and continuity and sequence of complex numbers 2. Derivatives of complex functions , analyticity, harmonic functions 3. Elementary functions and Mobius transformation 4. Complex integration, Cauchy integral formula and Cauchy integral theorem 5. Taylor's series, Laurent series and singularities 6. calculation of residues and applications 7. Miscellaneous theoretical questions based on three units

Learning Outcomes

On studying the syllabi, the learner will be able to:

- Define the concepts of derivation of analytic functions.
- Calculate the analytic functions.
- Express the Cauchy's Derivative formulas.
- Define the concept of Cauchy-Goursat Integral Theorem
- Evaluate complex integrals by using Cauchy-Goursat Integral Theorem
- Define the simple and multiple connected domains.
- Define the concept of sequences and series of the complex functions.
- Express concepts of convergence sequences and series of the complex functions.
- Express concepts of absolute and uniform convergence of power series.
- Define the concepts of Taylor and Laurent series.
- Find Taylor series of a function.
- Define the concept of Laurent series.

Reference books:

1. James Ward Brown, Ruel V. Churchill, Complex variables and applications, seventh edition, McGraw Hill
2. Alan Jeffrey, Complex Analysis and Applications, second edition, CRC Press
3. Reinhold Remmert, Theory of Complex Functions, Springer
4. S. Ponnusamy, Foundations of Complex Analysis, second edition, Narosa Publishing House
5. Richard A. Silverman, Introductory Complex Analysis, Prentice-Hall, Inc.
6. Dennis G. Zill, Patrick D. Shanahan, Complex Analysis A First Course with Applications, third edition, Jones & Bartlett
7. H.S. Kasana, Complex Variables Theory and Applications, second edition, PHI Learning Private Ltd.
8. Jerrold E. Marsden, Michael Hoffman, Basic Complex Analysis, third edition, W.H. Freeman, New York

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<tr><td colspan="5">T. Y. B. Sc. MATHEMATICS : Choice Based Credit System</td></tr>
<tr><td colspan="5">Semester - VI</td></tr>
<tr><td colspan="5">PAPER – II: ALGEBRA</td></tr>
<tr><td colspan="3">Course Name: ALGEBRA (45 lectures)</td><td colspan="2">Course Code: SMAT602</td></tr>
<tr><td colspan="3">Periods per week (1 period 48 minutes)</td><td colspan="2">03</td></tr>
<tr><td colspan="3">Credits</td><td colspan="2">2.5</td></tr>
<tr><td rowspan="3" colspan="2">Evaluation System</td><td></td><td>Hours</td><td>Marks</td></tr>
<tr><td>Theory Examination</td><td>2.0</td><td>60</td></tr>
<tr><td>Theory Internal</td><td></td><td>40</td></tr>
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Course Objectives :

- Present the relationships between abstract algebraic structures with familiar numbers systems such as the integers and real numbers.
- Present concepts of and the relationships between operations satisfying various properties (e.g. commutative property).
- Present concepts and properties of various algebraic structures.
- Discuss the importance of algebraic properties relative to working within various number systems.

Unit No.	Content	No. of lectures
Unit I	**Group Theory** Review of Groups, Subgroups, Abelian groups, Order of a group, Finite and infinite groups, Cyclic groups, The Center $Z(G)$ of a group G. Cosets, Lagrangestheorem, Group homomorphisms, isomorphisms, automorphisms, inner automorphisms (No questions to be asked). Normal subgroups: Normal subgroups of a group, definition and examples including center of a group, Quotient group, Alternating groupA_n Cycles. Listing normal subgroups of A_4 , S_3 . First Isomorphism theorem (or Fundamental Theorem of homomorphisms of groups), Second Isomorphism theorem, third Isomorphism theorem, Cayley's theorem, External direct product of a group, Properties of external direct products, Order of an element in a direct product, criterion for direct product to be cyclic, Classification of groups of order $\leq$ 7.	15
Unit II	**Ring Theory** Motivation: Integers & Polynomials. Definitions of a ring (The definition should include the existence of a unity element), zero divisor, unit, the multiplicative group of units of a ring. Basic Properties & examples of rings, including $\mathbb{Z}$, $\mathbb{Q}$, $\mathbb{R}$, $\mathbb{C}$, $\mathcal{M}_n(\mathbb{R})$, $\mathbb{Q}[X]$, $\mathbb{R}[X]$, $\mathbb{C}[X]$, $\mathbb{Z}[i]$, $\mathbb{Z}[\sqrt{2}]$, $\mathbb{Z}[\sqrt{-5}]$, $\mathbb{Z}_n$. Definitions of Commutative ring, integral domain (ID), Division ring, examples. Theorem such as: A commutative ring R is an integral domain if and only if for $a, b, c \in R$ with $a \neq 0$ the relation $ab = ac$ implies that $b = c$. Definitions of Subring, examples. Ring homomorphisms, Properties of ring homomorphisms, Kernel of a ring homomorphism, Ideals, Operations on ideals and Quotient rings, examples. Factor theorem, First and second Isomorphism theorems for rings, Correspondence Theorem for rings (If $f: R \to R'$ isa surjective ring	15

	homomorphism, then there is a $1-1$ correspondence between the ideals of R containing the $ker f$ and the ideals of R. Definitions of characteristic of a ring, Characteristic of an ID.	
Unit III	**Polynomial Rings and Field theory** Principal ideal, maximal ideal, prime ideal, characterization of the prime and maximal ideals in terms of quotient rings. Polynomial rings, $R[X]$ when R is an integral domain/field. Divisibility in an Integral Domain, Definitions of associates, irreducible and primes. Prime (irreducible) elements in $\mathbb{R}[X], \mathbb{Q}[X], \mathbb{Z}_p[X]$. Eisenstein's criterion for irreducibility of a polynomial over $\mathbb{Z}$. Prime and maximal ideals in polynomial rings. Definition of field, subfield and examples, characteristic of fields. Any field is an ID and a finite ID is a field. Characterization of fields in terms of maximal ideals, irreducible polynomials. Construction of quotient field of an integral domain (Emphasis on $\mathbb{Z}$, $\mathbb{Q}$). A field contains a subfield isomorphic to $\mathbb{Z}_p$ or $\mathbb{Q}$.	15

List of suggested Practicals based on SMAT602:
1. Normal Subgroups and quotient groups
2. Cayleys Theorem and external direct product of groups
3. Rings, Subrings, Ideals, Ring Homomorphism and Isomorphism
4. Prime Ideals and Maximal Ideals
5. Polynomial Rings
6. Fields
Miscellaneous Theoretical questions on Unit 1, 2 and 3

Learning Outcomes :

At the end of this course, the student will be able to

- Examine symmetric and permutation groups.
- Explain Normal subgroup.
- Identify factor group.
- Write precise and accurate mathematical objects in ring theory
- For checking the irreducibility of higher degree polynomials over rings.
- Understand the concepts like ideals and quotient rings.
- Understand the concept of ring homomorphism.
- Apply Eisenstein's criterion for irreducibility of a polynomial
- Construct quotient field.

Recommended Books

1. P. B. Bhattacharya, S. K. Jain, and S. R. Nagpaul, Abstract Algebra, Second edition, Foundation Books, New Delhi.
2. N. S. Gopalakrishnan, University Algebra, Wiley Eastern Limited.
3. I. N. Herstein. Topics in Algebra, Wiley Eastern Limited, Second edition.
4. M. Artin, Algebra, Prentice Hall of India, New Delhi.
5. J. B. Fraleigh, A First course in Abstract Algebra, Third edition, Narosa, New Delhi.
6. J. Gallian, Contemporary Abstract Algebra, Narosa, New Delhi.

Additional Reference Books:

1. S. D. Adhikari, An Introduction to Commutative Algebra and Number theory, Narosa Publishing House.
2. T.W. Hungerford, Algebra, Springer.
3. D. Dummit, R. Foote, Abstract Algebra, John Wiley & Sons, Inc.
4. I.S. Luthar, I.B.S. Passi, Algebra Vol. I and II, Narosa publication.
5. U. M. Swamy, A. V. S. N. Murthy, Algebra Abstract and Modern, Pearson.
6. Charles Lanski, Concepts Abstract Algebra, American Mathematical Society.
7. Sen, Ghosh and Mukhopadhyay, Topics in Abstract Algebra, Universities press.

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T. Y. B. Sc. MATHEMATICS : Choice Based Credit System			
Semester - VI			
PAPER – III : TOPOLOGY OF METRIC SPACES AND REAL ANALYSIS			
Course Name: Topology of Metric Spaces and Real Analysis **(45 lectures)**		Course Code: **SMAT603**	
Periods per week (1 period 50 minutes)		**03**	
Credits		**2.5**	
Evaluation System		**Hours**	**Marks**
	Theory Examination	**2.0**	**60**
	Theory Internal		**40**
Course Objectives : To introduce the notion of metric spaces and extend several theorems and concepts about the real numbers and real valued functions, such as convergence and continuity, to the more general setting of these spaces.			

Unit No.	Content	No. of lectures
Unit I	**Continuous functions on metric spaces** Epsilon-delta definition of continuity at a point of a function from one metric space to another. Characterization of continuity at a point in terms of sequences, open sets and closed sets and examples, Algebra of continuous real valued functions on a metric space. Continuity of composite continuous function. Continuous image of compact set is compact, uniform continuity in a metric space, definition and examples (emphasis on $\mathbb{R}$). Let (X, d) and (Y, d) be metric spaces and $f: X \to Y$ be continuous, where (X, d) is a compact metric	**15**

	space, then $f: X \to Y$ is uniformly continuous. Contraction mapping and fixed point theorem, Applications.	
Unit II	**Connected sets** Separated sets- Definition and examples, disconnected sets, disconnected and connected metric spaces, connected subsets of a metric space, Connected subsets of $\mathbb{R}$. A subset of $\mathbb{R}$ is connected if and only if it is an interval. A continuous image of a connected set is connected. Characterization of a connected space, viz. a metric space is connected if and only if every continuous function from X to $\{1, -1\}$ is a constant function. Path connectedness in $\mathbb{R}^n$, definition and examples. A path connected subset of $\mathbb{R}^n$ is connected, convex sets are path connected. Connected components. An example of a connected subset of $\mathbb{R}^n$ which is not path connected.	**15**
Unit III	**Sequence and series of functions** Sequence of functions - pointwise and uniform convergence of sequences of real- valued functions, examples. Uniform convergence implies pointwise convergence, example to show converse not true, series of functions, convergence of series of functions, Weierstrass M-test. Examples. Properties of uniform convergence: Continuity of the uniform limit of a sequence of continuous function, conditions under which integral and the derivative of sequence of functions converge to the integral and derivative of uniform limit on a closed and bounded interval. Examples. Consequences of these properties for series of functions, term by term differentiation and integration. Power series in $\mathbb{R}$ centered at origin and at some point in $\mathbb{R}$, radius of convergence, region (interval) of convergence, uniform convergence, term by-term differentiation and integration of power series, Examples. Uniqueness of series representation, functions represented by power series, classical functions defined by power series such as exponential, cosine and sine functions, the basic properties of these functions.	**15**

List of suggested practicals based on SMAT603
1. Compact sets in various metric spaces 2. Compact sets in $\mathbb{R}^n$ 3. Continuity in a metric space 4. Uniform continuity, contraction maps, fixed point theorem 5. Connectedness in metric spaces 6. Path connectedness 7. Miscellaneous theory questions on all units

Learning Outcomes :

At the end of this course, the student will be able to

- ✦ Define real numbers, identify the convergency and divergency of sequences, explain the limit and continuity of a function at a given point.
- ✦ construct the geometric model of the set of real numbers.
- ✦ define the existence of a sequence's limit, if there exists, find the limit.
- ✦ explain the notion of limit of a function at a given point and if there exists estimate the limit.
- ✦ define the notion of continuity and obtain the set of points on which a function is continuous.
- ✦ express the notion of metric space, construct the topology by using the metric and using this topology identify the continuity of the functions which are defined between metric spaces.
- ✦ explain the notion of metric space.
- ✦ use the open ball on metric spaces, construct the metric topology and define open-closed sets of the space.
- ✦ identify the continuity of a function which is defined on metric spaces, at a given point and identify the set of points on which a function is continuous.
- ✦ define the notion of topology.

References for Units I, II, III:

1. S. Kumaresan, Topology of Metric spaces.
2. E. T. Copson. Metric Spaces. Universal Book Stall, New Delhi.
3. Robert Bartle and Donald R. Sherbert, Introduction to Real Analysis, Second Edition, John Wiley and Sons.
4. Ajit Kumar, S. Kumaresan, Basic course in Real Analysis, CRC press 5. R.R. Goldberg, Methods of Real Analysis, Oxford and International Book House (IBH) Publishers, New Delhi.

Other references:

1. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill,New York.
2. W. A. Sutherland, Introduction to metric & topological spaces, Second Edition, Oxford.
3. T. Apostol, Mathematical Analysis, Second edition, Narosa, New Delhi.
4. P.K.Jain, K. Ahmed, Metric Spaces, Narosa, New Delhi.
5. W. Rudin, Principles of Mathematical Analysis, Third Ed, McGraw-Hill, Auckland.
6. D. Somasundaram, B. Choudhary, A first Course in Mathematical Analysis,Narosa, New Delhi.

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T. Y. B. Sc. MATHEMATICS : Choice Based Credit System

Semester - VI

PAPER – IV : NUMERICAL ANALYSIS – II [Elective A]

Course Name: Numerical Analysis – II [Elective A] **(45 lectures)**		Course Code: **SMAT604A**	
Periods per week (1 period 48 minutes)		**03**	
Credits		**2.5**	
Evaluation System		**Hours**	**Marks**
	Theory Examination	**2.0**	**60**
	Theory Internal		**40**

Course Objectives :
To provide the student with numerical methods of solving the non-linear equations, interpolation, differentiation, and integration.
To improve the student's skills in numerical methods by using the numerical analysis software and computer facilities.

Unit No.	Content	No. of lectures
Unit I	**Interpolation** Interpolating polynomials, Uniqueness of interpolating polynomials. Linear, Quadratic and Hillgher order interpolation. Lagranges Interpolation. Finite difference operators: Shift operator, forward, backward and central difference operator, Average operator and relation between them. Difference table, Relation between difference and derivatives. Interpolating polynomials using finite differences Gregory-Newton forward difference interpolation, Gregory-Newton backward difference interpolation, Stirlings Interpolation. Results on interpolation error.	**15**
Unit II	**Polynomial Approximations and Numerical Differentiation** Piecewise Interpolation: Linear, Quadratic and Cubic. Bivariate Interpolation: Lagranges Bivariate Interpolation, Newtons Bivariate Interpolation. Numerical differentiation: Numerical diferentiation based on Interpolation, Numerical differentiation based on finite differences (forward, backward and central), Numerical Partial differentiation.	**15**
Unit III	**Numerical Integration** Numerical Integration based on Interpolation. Newton-Cotes Methods, Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule. Determination of error term for all above methods. Convergence of numerical integration: Necessary and sufficient condition (with proof). Composite integration methods; Trapezoidal rule, Simpson's rule.	**15**

List of suggested practicals based on SMAT604A:
1. Linear, Quadratic and Hillgher order interpolation, Interpolating polynomial by Lagranges Interpolation 2. Interpolating polynomial by Gregory-Newton forward and backward difference Interpolation and Stirling Interpolation. 3. Bivariate Interpolation: Lagranges Interpolation and Newtons Interpolation 4. Numerical differentiation: Finite differences (forward, backward and central), Numerical Partial differentiation 5. Numerical differentiation and Integration based on Interpolation 6. Numerical Integration: Trapezoidal rule, Simpsons 1/3rd rule, Simpsons 3/8th rule Composite integration methods: Trapezoidal rule, Simpsons rule 7. Miscellaneous theory questions on all units

Learning Outcomes:

At the end of this course, the student will be able to

- ♦ Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.
- ♦ Apply numerical methods to obtain approximate solutions to mathematical problems.
- ♦ Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations.
- ♦ Analyse and evaluate the accuracy of common numerical methods.

Reference Books:

1. Kendall E, Atkinson, An Introduction to Numerical Analysis, Wiley.
2. M. K. Jain, S. R. K. Iyengar and R. K. Jain,, Numerical Methods for Scientific and Engineering Computation, New Age International Publications.
3. S.D. Conte and Carl de Boor, Elementary Numerical Analysis, An algorithmic approach, McGraw Hill International Book Company.
4. S. Sastry, Introductory methods of Numerical Analysis, PHI Learning.
5. Hildebrand F.B, .Introduction to Numerical Analysis, Dover Publication, NY.
6. Scarborough James B., Numerical Mathematical Analysis, Oxford University Press, New Delhi.

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T. Y. B. Sc. MATHEMATICS : Choice Based Credit System			
Semester - VI			
PAPER – IV : NUMBER THEORY AND ITS APPLICATIONS – II [Elective B]			
Course Name: Number Theory and its applications – II [Elective B] **(45 lectures)**		Course Code: **SMAT604B**	
Periods per week (1 period 48 minutes)		**03**	
Credits		**2.5**	
Evaluation System		**Hours**	**Marks**
	Theory Examination	**2.0**	**60**
	Theory Internal		**40**

Course Objectives:

Identify and apply various properties of and relating to the integers including the Well-Ordering Principle, primes, unique factorization, the division algorithm, and greatest common divisors.
Identify certain number theoretic functions and their properties.
Understand the concept of a congruence and use various results related to congruences including the Chinese Remainder Theorem.
Solve certain types of Diophantine equations.
Identify how number theory is related to and used in cryptography.

Unit No.	Content	No. of lectures
Unit I	**Quadratic Reciprocity** Quadratic residues and Legendre Symbol, Gauss' Lemma, Theorem on Legendre Symbols and , Quadratic Reciprocity law and its applications, The Jacobi Symbol and law of reciprocity for Jacobi Symbol. Quadratic Congruences with Composite moduli.	**15**
Unit II	**Continued Fractions** Finite continued fractions. Infinite continued fractions and representation of an irrational number by an infinite simple continued fraction, Rational approximations to irrational numbers and order of convergence, Best possible approximations. Periodic continued fractions. Pell's equations and their solutions.	**15**
Unit III	**Pells equation Arithmetic function and Special numbers** Pell's equation $x^2dy^2 = n$, where d is not a square of an integer. Solutions of Pell's equation.(The proofs of convergence theorems to be omitted).Arithmetic functions of number theory: $d(n), \sigma(n), \sigma_k(n), \omega(n)$ and their properties, $\mu(n)$ and the Mobius inversion formula. Special numbers: Fermat numbers, Mersenne numbers, Perfect numbers, Amicable numbers, Pseudoprimes, Carmichael numbers.	**15**

List of suggested practicals based on SMAT604B
1. Legendre Symbol, Gauss' Lemma, quadratic reciprocity law
2. Jacobi Symbol, quadratic congruences with prime and composite moduli
3. Finite and infinite continued fractions
4. Approximations and Pell's equations
5. Arithmetic functions of number theory
6. Special numbers
7. Miscellaneous

Learning Outcomes:

At the end of this course, the student will be able to

- To understand use concepts and uses of finite continued fractions
- To learn relation between irrational numbers and infinite continued fractions
- Solving quadratic congruence using Legendre and Jacobi symbols
- To understand number theoretic functions such as sigma, tau, Euler's

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Recommended Books

1. Niven, H. Zuckerman and H. Montogomery, An Introduction to the Theory of Numbers, John Wiley & Sons. Inc.
2. David M. Burton, An Introduction to the Theory of Numbers, Tata McGraw Hill Edition.
3. G. H. Hardy and E.M. Wright, An Introduction to the Theory of Numbers, Low priced edition, The English Language Book Society and Oxford University Press.
4. Neville Robins, Beginning Number Theory, Narosa Publications.
5. S.D. Adhikari, An introduction to Commutative Algebra and Number Theory, Narosa Publishing House.
6. N. Koblitz. A course in Number theory and Cryptography, Springer.
7. M. Artin, Algebra, Prentice Hall.
8. K. Ireland, M. Rosen. A classical introduction to Modern Number Theory. Second edition, Springer Verlag.
9. William Stallings, Cryptology and network security, Pearson Education.
10. T. Koshy, Elementary number theory with applications, 2nd edition, Academic Press.
11. A. Baker, A comprehensive course in number theory, Cambridge.

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T. Y. B. Sc. MATHEMATICS : Choice Based Credit System			
Semester – VI			
APPLIED COMPONENT : COMPUTER PROGRAMMING AND SYSTEM ANALYSIS			
Course Name: COMPUTER PROGRAMMING AND SYSTEM ANALYSIS **(60 lectures)**		Course Code: **SMATAC601**	
Periods per week (1 period 48 minutes)		**04**	
Credits		**02**	
Evaluation System		**Hours**	**Marks**
	Theory Examination	**2.0**	**60**
	Theory Internal		**40**

Course Objectives :

- Master the fundamentals of writing Python scripts
- Learn core Python scripting elements such as variables and flow control structures
- Discover how to work with lists and sequence data
- Write Python functions to facilitate code reuse
- Use Python to read and write files
- Make their code robust by handling errors and exceptions properly
- Work with the Python standard library
- Explore Python's object-oriented features

Unit No	Content	No. of lectures
Unit I	**Introduction to Python** i. A brief introduction about Python and installation of anaconda. ii. Numerical computations in Python including square root, trigonometric functions using math and cmath module. Different data types in Python such as list, tuple and dictionary. iii. If statements, for loop and While loops and simple programmes using these. iv. User-defined functions and modules. Various use of lists, tuple and dictionary. v. Use of Matplotlib to plot graphs in various format.	**15**
Unit II	**Advanced topics in Python** i. Classes in Python. ii. Use of Numpy and Scipy for solving problems in linear algebra and calculus, differential equations. iii. Data handling using Pandas.	**15**
Unit III	**Introduction to Sage Math** i. Sage installation and use in various platforms. Using Sage Math as an advanced calculator. ii. Defining functions and exploring concept of calculus. iii. Finding roots of functions and polynomials. iv. Plotting graph of 2D and 3D in Sage Math. v. Defining vectors and matrices and exploring concepts in linear algebra.	**15**

Unit IV	**Programming in Sage Math** i. Basic single and multi-variable calculus with Sage. ii. Developing Python programmes in Sage to solve same problems in numerical analysis and linear algebra. iii. Exploring concepts in number theory.	**15**

Learning Outcomes:

- Write, Test and Debug Python Programs
- Implement Conditionals and Loops for Python Programs
- Use functions and represent Compound data using Lists, Tuples and Dictionaries

References:

1. Fundamentals of Python First programs 2nd edition - Kenneth A Lambert, Cengage, Learning India.
2. Doing Math with Python - Amit Saha, No starch Press,
3. Problem solving and Python programming- E. Balgurusamy, Tata McGraw Hill.
4. Computational Mathematics with SageMath- By Paul Zimmermann.
5. Introduction to Programming using SageMath- Razvan A. Mezei, Publisher Wiley, 2021

THEORY EXAMINATION PATTERN

Que.1 A)	Attempt Any One:	(8 Marks)
	i) Theory Question based on Unit-I	
	ii) Theory Question based on Unit-I	
B)	Attempt Any Two:	(12 Marks)
	i) Problems based on Unit-I	
	ii) Problems based on Unit-I	
	iii) Problems based on Unit-I	
Que.2 A)	Attempt Any One:	(8 Marks)
	i) Theory Question based on Unit-II	
	ii) Theory Question based on Unit-II	
B)	Attempt Any Two:	(12 Marks)
	i) Problems based on Unit-II	
	ii) Problems based on Unit-II	
	iii) Problems based on Unit-II	
Que.3 A)	Attempt Any One:	(8 Marks)
	i) Theory Question based on Unit-III	
	ii) Theory Question based on Unit-III	
B)	Attempt Any Two:	(12 Marks)
	i) Problems based on Unit-III	
	ii) Problems based on Unit-III	
	iii) Problems based on Unit-III	

Semester End Examinations Practicals: There shall be a Semester-end practical examinations of three hours duration and 100 marks for each of the courses SMATP501 of Semester V and USMTP601 of semester VI.
Marks for Journals and Viva: For each course SMAT501, SMAT502, SMAT503, USMT504A/B, SMAT601, SMAT602, SMAT603, and SMAT604A/B **1. Journals: 5 marks.** **2. Viva: 5 marks.** Each Practical of every course of Semester V and VI shall contain 10 (ten) problems out of which minimum 05 (five) have to be written in the journal. A student must have a certified journal before appearing for the practical examination.

PRATICAL EXAMINATION PATTERN

Que.1	Attempt any 8 objectives out of 12 from the following:	(8 x 3=24 Marks)
Que.2	Attempt any two from the following:	(8 x 2 =16 Marks)
	a) Based on unit-I	
	b) Based on unit-II	
	c) Based on unit-III	

THEORY AND PRACTICAL EXAMINATION PATTERN FOR APPLIED COMPONENT PAPER.

APPLIED COMPONENT THEORY EXAMINATION PATTERN

Que.1	**Attempt Any Three:**	**(15 Marks)**
	i) Question based on Unit-I	
	ii) Question based on Unit-I	
	iii) Question based on Unit-I	
	iv) Question based on Unit-I	
	v) Question based on Unit-I	
Que.2	**Attempt Any Three:**	**(15 Marks)**
	i) Question based on Unit-II	
	ii) Question based on Unit-II	
	iii) Question based on Unit-II	
	iv) Question based on Unit-II	
	v) Question based on Unit-II	
Que.3	**Attempt Any Three:**	**(15 Marks)**
	i) Question based on Unit-III	
	ii) Question based on Unit-III	
	iii) Question based on Unit-III	
	iv) Question based on Unit-III	
	v) Question based on Unit-III	
Que.4	**Attempt Any Three:**	**(15 Marks)**
	i) Question based on Unit-IV	
	ii) Question based on Unit-IV	
	iii) Question based on Unit-IV	
	iv) Question based on Unit-IV	
	v) Question based on Unit-IV	

Semester End Examinations Practicals:

There shall be a Semester-end practical examinations of three hours duration and 100 marks for each of the courses SMATACP501 of Semester V and USMATACP601 of semester VI.

Marks for Journals and Viva:

1. Journals: 10 marks. **2. Viva: 10 marks.**

A student must have a certified journal before appearing for the practical examination.

APPLIED COMPONENT PRATICAL EXAMINATION

Que.1	Question based on Unit-I	(20 Marks)
Que.2	Question based on Unit-II	(20 Marks)
Que.3	Question based on Unit-III	(20 Marks)
Que.4	Question based on Unit-IV	(20 Marks)