AC: 02.06.2025 ITEM NO: 23.3

Deccan Education Society's

Kirti M. Doongursee College of Arts, Science and Commerce (AUTONOMOUS)

Affiliated to

UNIVERSITY OF MUMBAI

Syllabus for
Program: Bachelor of Science
Course: T.Y.B.SC.
Subject: Mathematics

Choice Based Credit System (CBCS)
with effect from
Academic Year 2025-2026(NEP)

PROGRAM OUTCOMES

PO	Description
A student completing Bachelor's Degree in **Science** Program will be able to	
PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the disciplines that form a part of a graduate Programme. Execute strong theoretical and practical understanding generated from the specific graduate Programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.
PO3	**Social competence:** Display the understanding, behavioral skills needed for successful social adaptation, work in groups, exhibits thoughts and ideas effectively in writing and orally.
PO4	**Research-related skills and Scientific temper:** Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.
PO5	**Trans-disciplinary knowledge:** Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence:** Performing dependently and collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics:** Demonstrate empathetic social concern and equity centered national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability:** Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.

Deccan Education Society's

Kirti M. Doongursee College (autonomous)

Proposed Curriculum as per Mumbai University

implementation- 2025-26

Name of the Department: Mathematics

Semester	Course Code	Course Title	Vertical	Credit
V	25MAT MJ 511	Paper I:Multivariable Calculus I	Major	2
	25MAT MJ 512	Paper II: Group Theory	Major	2
	25MAT MJ 513	Paper III:Topology of Metric Spaces	Major	2
	25MAT MJ P51	Practical Paper I:Multivariable Calculus I Paper II:Group Theory Paper III: Topology of Metric Spaces	Major Practical	2
	25MAT MJ 514	Major specific IKS(Indian Knowledge system): Glimpses of Ancient Indian Mathematics	Major	2
	25MAT EL 531	First Order Differential Equations/Graph Theory-I	Elective	2
	25MAT EL P51	Practical :First Order Differential Equations/Graph Theory-I	Elective Practical	2
	25MAT MR 521	Linear Algebra I	Minor	2
	25MAT MR P51	Practical-Linear Algebra I	Minor Practical	2
	25MAT VS 541	Advanced PYTHON	VSC	2
	25MAT FP 5	Field Project	FP	2

VI	**25MAT MJ 611**	Paper I: Complex Analysis	Major	2
	25MAT MJ 612	Paper II: Ring Theory	Major	2
	25MAT MJ 613	Paper III: Topology of Metric Spaces and Real Analysis	Major	2
	25MAT MJ 614	Paper IV:Intergral Transforms	Major	2
	25MAT MJ P61	Practical Paper I: Complex Analysis Paper II: Ring Theory Paper III: Topology of Metric Spaces and Real Analysis Paper IV: Intergral Transforms	Major Practical	2
	25MAT EL 631	Numerical Methods/ Graph Theory -II	Elective	2
	25MAT EL P 61	Practical :Numerical Methods/ Graph Theory -II	Elective Practical	2
	25MAT MR 621	Linear Algebra II	Minor	2
	25MAT MR P61	Practical-Linear Algebra II	Minor Practical	2
	25 MAT OJT 6	On Job Training	OJT	4

Course Code	SEM – V - Multivariable Calculus I	Credits	Lectures/Week
25MAT MJ 511	Paper I	2	2

Course Outcomes:

After successful completion of this course, students would be able to

CO1. Define double integral , triple integral , line integral scalar and vector fields over R^n, Gradient ,divergence and curl of Vector fields on R^n

CO2. Understand and explain calculus of vector fields and line integrals with applications.

CO3. Apply multiple integrals , line integral to solve related problems Verify vector integral theorems.

CO4. Evaluate double and triple integrals, and learn their use to compute volume, surface area, etc.

Unit	**Topics**	**No of Lectures**
I	**Multiple Integrals:** 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. Following basic properties of double and triple integrals proved using the Fubini's theorem: (1) 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. (2) 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.) (3) 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**
II	**Line Integrals:** Review of Scalar and Vector fields on R^n , Vector Differential Operators, Gradient, Curl, Divergence. Paths (parameterized curves) in R^n (emphasis on R^2 and R^3), Smooth and piece	**15**

	wise smooth paths. Closed paths. Equivalence and orientation preserving equivalence of paths. Definition of the line integral of a vector field over a piece wise 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. Green's Theorem (proof in the case of rectangular domains). Applications to evaluation of line integrals.	

Reference Books:

1. Apostol, Calculus, Vol. 2, Second Ed., John Wiley, New York, 1969 Section 1.1 to 11.8
2. James Stewart, Calculus with early transcendental Functions - Section 16.5 to 16.9 12
3. Marsden and Jerrold E. Tromba, Vector Calculus, Fourth Ed., W.H. Freeman and Co., New York, 1996 Section 6.2 to 6.4.

Other References :

1. T. Apostol, Mathematical Analysis, Second Ed., Narosa, New Delhi. 1947.
2. R. Courant and F.John, Introduction to Calculus and Analysis, Vol.2, Springer Verlag, New York, 1989.
3. W. Fleming, Functions of Several Variables, Second Ed., Springer-Verlag, New York, 1977.
4. M. H. Protter and C.B.Morrey Jr., Intermediate Calculus, Second Ed., Springer-Verlag, New York, 1995.
5. G. B. Thomas and R.L Finney, Calculus and Analytic Geometry, Ninth Ed. (ISE Reprint), Addison- Wesley, Reading Mass, 1998.
6. D. V. Widder, Advanced Calculus, Second Ed., Dover Pub., New York. 1989.

Course Code	SEM – V- Group Theory	Credits	Lectures/Week
25MAT MJ 512	Paper II	2	2
Course Outcomes: After successful completion of this course, students would be able to CO1. Define Groups , Subgroups, Normal subgroup, Direct product of Groups, Cyclic groups .and Cyclic Subgroups. CO2. Identify subgroups, normal subgroups, orders of elements, Cosets of a subgroup in a group and prove that the identification is correct CO3. Apply the properties of groups to check whether the group is commutative, non- commutative, cyclic, non-cyclic, finite, infinite etc. CO4..Examine Groups ,subgroups, Normal subgroups, Direct products, Cyclic groups and cyclic subgroups.			

Unit	Topics	**No of Lectures**
I	Groups and Subgroups 1. Definition and elementary properties of a group. Order of a group. Subgroups. Criterion for a subset to be a subgroup. Abelian groups. Center of a group. Homomorphisms and isomorphisms. 2. Examples of groups including Z, Q, R, C, Klein 4-group, symmetric and alternating groups, S^1 (= the unit circle in C), GLn(R), SLn(R), On (= the group of n × n nonsingular upper triangular matrices), Bn (= the group of n × n nonsingular upper triangular matrices), and groups of symmetries of plane figures. 3. Order of an element. Subgroup generated by a subset of the group.	**15**
II	Normal subgroups, Direct products and Cayley's Theorem, Cyclic groups 1. Cosets of a subgroup in a group. Lagrange's Theorem. Normal subgroups. Alternating group A_nAn. Listing normal subgroups of A_4, S_3. Quotient (or Factor) groups. Fundamental Theorem of homomorphisms of groups. 2. External direct products of groups. Examples. Relation with internal products such as HK of subgroups H, K of a group. Cayley's Theorem for finite groups. 3. Examples of cyclic groups Properties of cyclic groups and cyclic subgroups.	**15**

References:

1. I. N. Herstein, Topics in Algebra, Wiley Eastern Limied, Second edition.
2. P. B. Bhattacharya, S.K. Jain, S. Nagpaul. Abstract Algebra, Second edition, Foundation Books, New Delhi, 1995.
3. N. S. Gopalkrishnan, University Algebra, Wiley Eastern Limited.
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 References:

1. T. W. Hungerford. Algebra, Springer.
2. D. Dummit, R. Foote. Abstract Algebra, John Wiley & Sons, Inc.
3. I. S. Luther, I.B.S. Passi. Algebra. Vol. I and II.

Course Code	SEM – V - Topology of Metric Spaces	Credits	Lectures/Week
25MAT MJ 513	Paper III	2	2

Course Outcomes:

After successful completion of this course, students would be able to

CO1. Define metric spaces, open set, closed set, interior points, limit points, boundary points, isolated points, various sequences in metric space, complete metric space .

CO2. Explain various types of metrics, properties of open sets, closed sets, complete metric spaces and concept of sequences in metric spaces.

CO3. Apply the idea of metric space, complete metric space space to construct various results and properties.

CO4. Examine the properties of metric spaces, sequences in metric spaces, complete metric space to solve related problems.

Unit	Topics	**No of Lectures**
I	**Metric spaces:** Definition and examples of metric spaces such as R, R^2, R^n with its Euclidean, sup and sum metrics. C (complex numbers). l_1 and l_2 spaces of sequences. C[a, b] the space of real valued continuous functions on [a, b]. Discrete metric space. 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 sets 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 R. Equivalent metrics. Distance of a point from a set, Distance between sets. Diameter of a set. Bounded sets. Closed balls. Closed sets. Examples. Limit point of a set. Isolated point. Closure of a set. Boundary of a set.	15
II	**Sequences, 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 sequences in different 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	**15**

	spaces. Examples of complete metric spaces. Completeness property in subspaces. Nested Interval theorem in R. Cantor's Intersection Theorem. Applications of Cantor's Intersection Theorem: (i) The set of real Numbers is uncountable. (ii) Density of rational Numbers. (iii) Intermediate Value theorem.	

References:

1. S. Kumaresan; Topology of Metric spaces.
2. E. T. Copson; Metric Spaces; Universal Book Stall, New Delhi, 1996.
3. P. K. Jain, K. Ahmed; Metric Spaces; Narosa, New Delhi, 1996.

Additional References:

1. T. Apostol; Mathematical Analysis, Second edition, Narosa, New Delhi, 1974
2. R. R. Goldberg; Methods of Real Analysis; Oxford and IBH Pub. Co., New Delhi 1970.
3. D. Gopal, A. Deshmukh, A. S. Ranadive and S. Yadav; An Introduction to Metric Spaces, Chapman and Hall/CRC, New York, 2020.
4. W. Rudin; Principles of Mathematical Analysis; Third Ed, McGraw-Hill, Auckland, 1976.
5. D. Somasundaram; B. Choudhary; A first Course in Mathematical Analysis. Narosa, New Delhi.
6. G. F. Simmons; Introduction to Topology and Modern Analysis; McGraw-Hi, New York, 1963.
7. Expository articles of MTTS programme.

Course Code	SEM V- Practical 1 (Paper 1 + Paper 2+ Paper 3)	Credits	Lectures/ Week
25MAT MJ P51	Paper I: Multivariable Calculus I Paper II: Group Theory Paper III: Topology of Metric Spaces	2	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1:Describe various properties of line integral,double,triple integrals,Groups,Metric spaces.

CO2:Discuss problems based on line integral,double,triple integrals,vector fields,Groups,Metric spaces.

CO3:solve the problems based on the syllabus.

CO4:Relate mathematics and its applications in pure and applied sciences.

Paper 1: Multivariable Calculus I		
1	Evaluation of double and triple integrals.	
2	Change of variables in double and triple integrals and applications	
3	Line integrals of scalar and vector fields	
4	Green's theorem, conservative field and applications	
5	Conservative field and applications.	
Paper 2: Group Theory		
1	Examples of groups and subgroups .	
2	Orders of elements in a group.Examples of determining centers of different groups,	60
3	Left and right cosets of a group and Lagrange's theorem .	
4	Normal subgroups and quotient groups.	
5	Direct products of groups, cyclic groups.	
Paper 3 : Topology of Metric Spaces		
1	Examples of Metric Spaces, Normed Linear Spaces,	
2	Sketching of Open Balls in R 2 , Open and Closed sets, Equivalent Metrics	
3	Subspaces, Interior points, Limit Points, Dense Sets and Separability, Diameter of a set, Closure.	

4	Limit Points ,Sequences , Bounded , Convergent and Cauchy Sequences in a Metric Space.	
5	Complete Metric Spaces	

References :

1. Apostol, Calculus, Vol. 2, Second Ed., John Wiley, New York, 1969 Section 1.1 to 11.8
2. James Stewart, Calculus with early transcendental Functions - Section 16.5 to 16.9 12
3. Marsden and Jerrold E. Tromba, Vector Calculus, Fourth Ed., W.H. Freeman and Co., New York,
   1996 Section 6.2 to 6.4.
4. I. N. Herstein, Topics in Algebra, Wiley Eastern Limied, Second edition.
5. P. B. Bhattacharya, S.K. Jain, S. Nagpaul. Abstract Algebra, Second edition, Foundation Books, New Delhi, 1995.
6. N. S. Gopalkrishnan, University Algebra, Wiley Eastern Limited.
7. M. Artin, Algebra, Prentice Hall of India, New Delhi
8. J. B. Fraleigh, A first course in Abstract Algebra, Third edition, Narosa, New Delhi.
9. J. Gallian. Contemporary Abstract Algebra. Narosa, New Delhi
10. S. Kumaresan; Topology of Metric spaces.
11. E. T. Copson; Metric Spaces; Universal Book Stall, New Delhi, 1996.
12. P. K. Jain, K. Ahmed; Metric Spaces; Narosa, New Delhi, 1996.

Additional References :

1. T. Apostol, Mathematical Analysis, Second Ed., Narosa, New Delhi. 1947.
2. R. Courant and F.John, Introduction to Calculus and Analysis, Vol.2, Springer Verlag, New York, 1989.
3. W. Fleming, Functions of Several Variables, Second Ed., Springer-Verlag, New York, 1977.
4. M. H. Protter and C.B.Morrey Jr., Intermediate Calculus, Second Ed., Springer- Verlag, New York, 1995.
5. G. B. Thomas and R.L Finney, Calculus and Analytic Geometry, Ninth Ed. (ISE Reprint), Addison- Wesley, Reading Mass, 1998.
6. D. V. Widder, Advanced Calculus, Second Ed., Dover Pub., New York. 1989.
7. T. Apostol; Mathematical Analysis, Second edition, Narosa, New Delhi, 1974
8. R. R. Goldberg; Methods of Real Analysis; Oxford and IBH Pub. Co., New Delhi 1970.
9. D. Gopal, A. Deshmukh, A. S. Ranadive and S. Yadav; An Introduction to Metric Spaces, Chapman and Hall/CRC, New York, 2020.
10. W. Rudin; Principles of Mathematical Analysis; Third Ed, McGraw-Hill, Auckland, 1976.

Course Code	SEM – V – Glimpses of Ancient Indian Mathematics	Credits	Lectures/Week
25MAT MJ 514	Paper : -Major Specific IKS (Indian Knowledge System)	2	2

After successful completion of this course, students would be able to

CO1. Define Indian Knowledge Systems (IKS) and its scope, emphasizing the role of mathematics in the ancient Indian intellectual tradition.

CO2. Describe the history and structure of Vedic Mathematics, including the 16 Sutras (formulas) and their applications.

CO3. Apply Vedic techniques for addition, subtraction, multiplication, and division, recognizing the efficiency and simplicity of these methods in comparison to conventional calculation methods.

CO4.Analyze the role of ancient Indian mathematics in shaping global mathematical systems.

Unit	Topics	**No of Lectures**
I	**Introduction to Indian Knowledge Systems** :Overview of Indian Knowledge Systems,Definition and scope of IKS,Historical and cultural context of mathematical development in India,Role of ancient Indian mathematics in global mathematical systems,Key texts in Indian mathematics (Vedas, Upanishads, Sulba Sutras, etc.) **Vedic Mathematics** :Introduction and History of Vedic Mathematics, The 16 Sutras (formulas) and their significance,The role of mental calculation techniques in ancient India,Simplicity and speed in Vedic methods. **Techniques and Applications:**Addition & Subtraction: Addition from left to right, Addition of list of numbers- Shudh method, Subtraction-Base method,Multiplication, Division, Squaring numbers ending in 5, Squaring decimals and fractions,square roots using Vedic methods.	**15**
II	**The Concept of Zero and Place Value System:**Historical development of the concept of zero in India,Brahmagupta's contributions to zero and negative numbers,Indian place-value system and its global influence. **Classical Indian Mathematical Texts:Aryabhata and His Mathematical Contributions:**Aryabhata's work and contributions to algebra, trigonometry, astronomy,Calculation of pi, sine functions, and approximations of large numbers. **Brahmagupta and Bhaskara::**Brahmagupta's rules for solving quadratic equations. Contributions of Bhaskara to algebra, calculus and infinitesimal mathematics. **Practical Applications of Indian Mathematical Knowledge :**Vedic Mathematics and its applications in modern competitive exams, Use of Sulba Sutras in modern architecture and construction,Practical	**15**

	applications of ancient Indian mathematical techniques in timekeeping, resource allocation, and astronomical observation	

References:

1. "Indian Knowledge Systems" by V. K. Chawla
2. "Vedic Mathematics" by Bharati Krishna Tirthaji
3. "Vedic Mathematics Made Easy" by Dhaval Bathia
4. "Vedic Mathematics for Schools" by James T. Glover
5. "The Sulba Sutras" (Translated by S. K. Venkatarama Iyer)
6. "Mathematics in Ancient India" by S. L. Loney
7. Learn Vedic speed mathematics by Chaitanya Patil

Additional References:

1. Vedic Mathematics for all ages by Vandana Singhal
2. Vedic Mathematics made easy by Dhaval Bhatia
3. The essentials of Vedic Mathematics by Rajesh Thakur
4. Vedic Mathematics New Horizons by Dr. S.K. Kapoor
5. Vedic Mathematics for students by Manu Tripathi
6. Zero: The Biography of a Dangerous Idea" by Charles Seife
7. The Mathematics of India" by K. Ramasubramanian
8. Aryabhatiya" by Aryabhata (translated by P. C. Mahalanobis)
9. Brahmagupta's Brahmasphutasiddhanta" (translated by K. V. Sarma)
10. Bhaskara I and II: Their Contributions to Algebra and Mathematics" by K. K. Ghosh

Course Code	SEM – V – Elective (I)	Credits	Lectures/Week
25MAT EL 531	**Paper : - First Order Differential Equations**	2	2)

After successful completion of this course, students would be able to

CO1. Define differential equations their order, degree, Exact and non-exact differential equations with Integrating factors.
CO2. Identify various types of differential equations.
CO3. Solve exact differential equations.
CO4. Examine first order differential equations to model problems of physics, engineering and population studies.

Unit	Topics	**No of Lectures**
I	**First order First degree Differential equations** Definition of a differential equation, Order, degree, Ordinary differential equation and Partial differential equation, Linear and non-linear ODE. Solution of homogeneous and non-homogeneous differential equations of first order and first degree. Notion of partial derivatives. i) Exact Equations: General solution of Exact equations of first order and first degree. Necessary and sufficient condition for $Mx + Ny = 0$ to be exact. Non-exact equations: Rules for finding integrating factors (without proof) for non-exact equations, such as 1) $\frac{1}{Mx+Ny}$ is and I.F if $Mx + Ny \neq 0$ and $Mx + Ny = 0$ is homogeneous. 2) $\frac{1}{Mx-Ny}$ is and I.F if $Mx - Ny \neq 0$ and $Mx + Ny = 0$ is of the form $f_1(x, y)y\, dx + f_2(x, y)x\, dy = 0$. $e^{\int f(x)dx}\left(resp\ e^{\int g(y)dy}\right)$ is an I.F. if N≠0 (resp M ≠0) and $\frac{1}{N}\left(\frac{\partial M}{\partial y} - \frac{\partial N}{\partial x}\right)\left(resp\ \frac{1}{M}\left(\frac{\partial M}{\partial y} - \frac{\partial N}{\partial x}\right)\right)$ is a function of x (resp y) alone, say f(x) (resp g(y)).	**15**
II	**Applications of First order Linear Differential Equations** Linear and reducible linear equations of first order, finding solutions of first order differential equations of the type for applications to orthogonal trajectories, population growth, and finding the current at a given time.	**15**

References
1. G. F. Simmons, Differential Equations with Applications and Historical Notes, McGraw Hill, 1972.
2. E. A. Coddington , An Introduction to Ordinary Differential Equations.Prentice Hall, 1961.

Additional References:
1. D. A. Murray, Introductory Course in Differential Equations, Longmans, Green and Co., 1897.
2. A. R. Forsyth, A Treatise on Differential Equations, MacMillan and Co.,1956

Course Code	SEM V- – Elective(I) Practical	Credits	Lectures/ Week
25MAT EL P51	**First Order Differential Equations**	2	4

Course Outcomes:

After successful completion of this course, students would be able to

- CO1.Describe order and degree of differential equations,Homogeneous, Linear, Bernoulli's differential equations
- CO2.Discuss problem based on differential equations.
- CO3.Analyze and solve the problems based on the syllabus.
- CO4.Relate mathematics and its applications in pure and applied sciences.

Sr. No.	Practical Details	
1	**Order and degree of differential equation, first order and first degree differential equation**	
2	**Homogeneous differential equations**	
3	**Solving exact differential equations**	
4	**Non exact differential equations and integrating factors Rule I & Rule II**	
5	**Non exact differential equations and integrating factors Rule III & Rule IV**	
6	**Linear differential Equations**	
7	**Differential equations reducible to linear form,Bernoulli's Equations**	
8	**Applications of first order differential equations –Orthogonal trajectory**	
9	**Applications of first order differential equations Electric circuits**	
10	**Applications of first order differential equations population growth.**	
11	**More problems based on applications**	

12	**Miscellaneous Theory Questions**	
References 1. G. F. Simmons, Differential Equations with Applications and Historical Notes, McGraw Hill, 1972. 2. E. A. Coddington , An Introduction to Ordinary Differential Equations.Prentice Hall, 1961. **Additional References:** **1.** D. A. Murray, Introductory Course in Differential Equations, Longmans, Green and Co., 1897. 2. A. R. Forsyth, A Treatise on Differential Equations, MacMillan and Co.,1956		

Course Code	SEM – V – Elective (II)	Credits	Lectures/Week
25MAT EL 531	**Paper : -**Graph Theory-I	2	2
After successful completion of this course, students would be able to CO1.Define general graph, types of graphs, walk,tail,circuit,path,cycle and tree etc., CO2.Identify various types graphs CO3.Solve problems based on graphs and trees. CO4.Analyze and differentiate between various types of graphs explaining their structural properties and real-world applications.			

Unit	Topics	**No of Lectures**
I	**Basics of Graphs** Definition of general graph, Directed and undirected graph, Simple and multiple graph, Types of graphs- Complete graph, Null graph, Complementary graphs, Regular graphs Sub graph of a graph, Vertex and Edge induced sub graphs, Spanning sub graphs. Basic terminology- degree of a vertex, Minimum and maximum degree, Walk, Trail, Circuit, Path, Cycle. Isomorphism between the graphs and consequences of isomorphism between the graphs, Self complementary graphs, Connected graphs, Connected components. Matrices associated with the graphs – Adjacency and Incidence matrix of a graph- properties, Bipartite graphs and characterization in terms of cycle lengths. Degree sequence and HavelHakimi	**15**

	theorem, Distance in a graph- shortest path problems, Dijkstra's algorithm.	
II	**Trees** Cut edges and cut vertices and relevant results, Characterization of cut edge, Definition of a tree and its characterizations, Spanning tree, Recurrence relation of spanning trees and Cayley**17** formula for spanning trees of K_n , Algorithms for spanning tree-BFS and DFS, Binary and m-ary tree, Prefix codes and Huffman coding, Weighted graphs and minimal spanning trees - Kruskal's algorithm for minimal spanning trees.	**15**

References:

1. Bondy and Murty; Graph Theory with Applications.
2. Balkrishnan and Ranganathan; Graph theory and applications.
3. Douglas B. West, Introduction to Graph Theory, 2nd Ed., Pearson, 2000

Additional References:

1. Behzad and Chartrand; Graph theory.
2. Choudam S. A.; Introductory Graph theory.

Course Code	SEM V- – Elective (II) Practical	Credits	Lectures/ Week
25MAT EL P51	Graph Theory-I	2	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1.Define general graph, types of graphs, walk,tail,circuit,path,cycle and tree etc.,

CO2.Identify various types graphs

CO3.Solve problems based on graphs and trees.

CO4.Analyze and differentiate between various types of graphs explaining their structural properties and real-world applications.

Sr. No.	Practical Details	
1	Directed and undirected graph,Simple and multiple graph	
2	Complete graph, Null graph, Complementary graphs, Regular graphs Sub graph of a graph,Vertex and Edge induced sub graphs, Spanning sub graphs.	

3	Degree of a vertex, Minimum and maximum degree, Walk, Trail, Circuit, Path, Cycle.	**60**
4	Isomorphism between the graphs and consequences of isomorphism between the graphs	
5	Self complementary graphs, Connected graphs, Connected components.	
6	Matrices associated with the graphs – Adjacency and Incidence matrix of a graph,Bipartite graphs and characterization in terms of cycle lengths.	
7	Degree sequence and HavelHakimi theorem, Distance in a graph- shortest path problems, Dijkstra's algorithm.	
8	Cut edges and cut vertices and relevant results, Characterization of cut edge, tree and its characterizations	
9	Spanning tree, Recurrence relation of spanning trees and Cayley17 formula for spanning trees of K_n	
10	Weighted graphs and minimal spanning trees - Kruskal's algorithm for minimal spanning trees.	
11	**Miscellaneous theory questions on unit I**	
12	**Miscellaneous theory questions on unit II**	

References:

1. Bondy and Murty; Graph Theory with Applications.
2. Balkrishnan and Ranganathan; Graph theory and applications.
3. Douglas B. West, Introduction to Graph Theory, 2nd Ed., Pearson, 2000

Additional References:

1. Behzad and Chartrand; Graph theory.
2. Choudam S. A.; Introductory Graph theory.

Course Code	SEM – V - Linear Algebra I	Credits	Lectures/Week
25 MAT MR 521	**Minor**	**2**	**2L**

Course Outcomes:

After successful completion of this course, students would be able to

- CO1. Define system of homogeneous, non homogeneous linear equations, elementary row and column transformations, determinant of matrix and Cramer's rule.
- CO2. Explain Matrix representations of homogeneous , non homogeneous linear equations, Gaussian elimination, determinants and linear equations.
- CO3. Apply row and column transformations, row echelon form etc. to solve system of linear equations, Determinants and linear equations to find inverse ,rank and system of equations .
- CO4. Examine system of equations, matrices, linear equations to solve related problems.

Unit	Topics	No of Lectures
I	**System of Equations, Matrices** 1. Systems of homogeneous and non-homogeneous linear equations, Simple examples of finding solutions of such systems. Geometric and algebraic understanding of the solutions. Matrices (with real entries), Matrix representation of system of homogeneous and non homogeneous linear equations. Algebra of solutions of systems of homogeneous linear equations. A system of homogeneous linear equations with number of unknowns more than the number of equations has infinitely many solutions. 2. Elementary row and column operations. Row equivalent matrices. Row reduction (of a matrix to its row echelon form). Gaussian elimination. Applications to solving systems of linear equations. Examples. 3. Relation between the solutions of a system of non-homogeneous linear equations and the associated system of homogeneous linear equations. Necessary and sufficient condition for a system of non-homogeneous linear equations to have a solution [viz., the rank of the coefficient matrix equals the rank of the augmented matrix [A|B]. Equivalence of statements (in which A denotes an n × n matrix) such as the following.	15

	(i) The system Ax = b of non-homogeneous linear equations has a unique solution. (ii) The system Ax = 0 of homogeneous linear equations has no nontrivial solution. (iii) A is invertible. (iv) det A $\neq$ 0. 1. (v) rank(A) = n 4. Elementary matrices. Relation of elementary row operations with elementary matrices. Invertibility of elementary matrices. Consequences such as (i) a square matrix is invertible if and only if its row echelon form is invertible. (ii) invertible matrices are products of elementary matrices. Examples of the computation of the inverse of a matrix using Gauss elimination method.	
II	**Matrices ,Determinants.** 1. Inductive definition of the determinant of a n × n matrix (e. g. in terms of expansion along the first row). Example of a lower triangular matrix. Laplace expansions along an arbitrary row or column. 2. Basic properties of determinants (Statements only); (i) det A = det A^T . (ii) Multilinearity and alternating property for columns and rows. (iii) A square matrix A is invertible if and only if det A $\neq$ 0. (iv) Minors and cofactors. Formula for A^{-1} when det A $\neq$ 0. (v) det(AB) = det A det B. 3. Row space and the column space of a matrix as examples of vector space. Notion of row rank and the column rank. Equivalence of the row rank and the column rank. Invariance of rank upon elementary row or column operations. Examples of computing the rank using row reduction. 4. Cramers Rule. LU Decomposition. If a square matrix A is a matrix that can be reduced to row echelon form U by Gauss elimination without row interchanges, then A can be factored as A = LU where L is a lower triangular matrix.	**15**

References:
1. **Howard Anton, Chris Rorres, Elementary Linear Algebra, Wiley Student Edition).**
2. **Serge Lang, Introduction to Linear Algebra, Springer.**
3. **S Kumaresan, Linear Algebra - A Geometric Approach, PHI Learning**

Additional References:
1. **Sheldon Axler, Linear Algebra done right, Springer.**
2. **Gareth Williams, Linear Algebra with Applications, Jones and Bartlett Publishers.**
3. **David W. Lewis, Matrix theory.**

<table>
<tr><td>Course Code</td><td>SEM V - Practical Minor</td><td>Credits</td><td>Lectures/ Week</td></tr>
<tr><td>25MAT MR P51</td><td>Practical: Linear Algebra I</td><td>2</td><td>4</td></tr>
<tr><td colspan="4">Course Outcomes:
After successful completion of this course, students would be able to
CO1.Explain various properties systems of linear equations, echelon form, rank of a matrix
CO2.Solve problem based on systems of linear equations, Echelon form. Minors and cofactors, Cramer’s rule.
CO3.Analyze and solve the problems based on the syllabus.
CO4.Relate mathematics and its applications in pure and applied sciences.</td></tr>
</table>

1	**Problems on systems of homogeneous linear equations.**
2	**Problems on systems of non-homogeneous linear equations.**
3	**Problems on homogeneous linear equations with number of unknowns more than the number of equations.** **Problems on non-homogeneous linear equations with number of unknowns more than the number of equations.**
4	**Elementary row/column operations and Elementary matrices.**
5	**Echelon form of a matrix.Problems on Gauss elimination method.**
6	**Problems based on properties of Determinant and determinant some standard matrices.**
7	**Minors and Cofactors of a matrix**
8	**Problems based on row space, column space and Rank of a matrix.**
9	**Solution to a system of linear equations.**
10	**Problems on Cramer’s Rule.**
11	**Problems on LU decomposition.**
12	**Miscellaneous Theory Questions .**

Textbooks:

1. Howard Anton, Chris Rorres, Elementary Linear Algebra, Wiley Student Edition).
2. Serge Lang, Introduction to Linear Algebra, Springer.
3. S Kumaresan, Linear Algebra - A Geometric Approach, PHI Learning

Additional References:

1. Sheldon Axler, Linear Algebra done right, Springer.
2. Gareth Williams, Linear Algebra with Applications, Jones and Bartlett Publishers.

David W. Lewis, Matrix theory.

Course Code	SEM – V - VSC	Credits	Lectures/Week
KUSMAT24505	ADVANCED PYTHON	2	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1. Define fundamentals of python language.

CO2. Explain Keywords , Identifiers, Data types, Control structures, Graphics, Folders, Files, Functions of python language.

CO3. Apply various graphics, clauses, conditional statements, looping statement to write different programs of python.

CO4. Examine various methods , control statements, data types, functions of python and plotting functions.

Unit	Topics	**No of Lectures**
1	Introduction-Variables, expressions, statements, data types-Set, List, Tuples, Dictionary, Zip.	**60**
2	Conditional Iteration- The while Loop –with True condition, the break Statement. Random Numbers. Loop Logic, errors and testing, Nested Conditionals: if, if-else, if-elif-else, nested if, nested if-else, compound Boolean Expressions.	
3	Strings- Operations on strings, Searching a substring with the 'in' Operator, Tranversing string using while and for.	
4	Math module- sin(), cos(), exp(), sqrt(), constants- pi, e.	
5	Design with functions- Defining Simple functions, Boolean Functions. Defining a main function. Defining and tracing recursive functions.	
6	Graphics: Elementary Python Graphics-To create a window, To add a label, To draw shapes (line, rectangle, triangle, oval, circle)	
7	Folders(directories) and Files-Creating a file object and directory, Opening, Writing, Closing a file in different mode and specific directory.	
8	Exception handling-Programs using exception handling: try-except	
9	Doing Math with Python-Working with numbers: Calculating the Factors of an Integer. Generating Multiplication Tables , Converting units of Measurement, Finding the roots of a Quadratic Equation.	

10	Algebra and Symbolic Math with SymPy-symbolic math using the SymPy library. Defining Symbols and Symbolic Operations, factorizing and expanding expressions, Substituting in Values, Summing Series, Solving single- variable Inequalities.	
11	Converting strings to Mathematical expressions, Solving equations, Solving Quadratic equations. Solving for one variable in terms of others.	
12	Solving a system of linear equations, Plotting using SymPy, Plotting expressions input by the user, Plotting multiple functions.	

References:

1. Fundamentals of Python First programs 2nd edition - Kenneth A Lambert, Cengage Learning India.
2. Doing Math with Python - Amit Saha, No starch ptress,

Additional References:

1. Problem solving and Python programming- E. Balgurusamy, TataMcGrawHill.
2. The Python Language Reference Manual (version 3.2), Guido van Rossum, and Fred L. Drake, Jr. (Editor) ,ISBN: 1906966141,Network Theory Ltd, 120 pages (Revised November 2006)

3.Simplifying Regular Expression Using Python by Abhishek Singh, ISBN: 1094777978, April 2019, 79 pages.
4.Python in a Nutshell, 3rd Edition by Alex Martelli, ISBN: 144939292X, O'Reilly Media, May 2017, 654 pages.
5.Python Pocket Reference, 5th Edition by Mark Lutz, ISBN: 1449357016, O'Reilly Media, February 2014, 264 pages.

Course Code	SEM – VI - COMPLEX ANALYSIS	Credits	Lectures/Week
25MAT MJ 611	Paper I	2	2

Course Outcomes:

After successful completion of this course, students would be able to

CO1. Define and Understand limits ,continuity, differentiability, Cauchy-Riemann equations, Linear fractional transformation, Complex power series, Laurent series and isolated singularities..

CO2. Understand and explain basic concepts involved in calculus of functions of complex variables.

CO3..Apply the concept and consequences of analyticity and the Cauchy-Riemann equations and of results on harmonic and entire functions.

CO4 Analyze and make use of the techniques regarding power series to solve the integrals, Represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues , evaluate complex integrals using the residue theorem.

Unit	Topics	No of Lectures
I	Introduction to Complex Analysis: Complex Numbers, Revision, Algebra of complex numbers, Exponential Form, Products and powers in exponential form, Arguments of products and quotients, Roots of complex numbers, Roots of unity, Examples. Analytic functions of Complex Variables, Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulas, Cauchy - Riemann Equations, Sufficient Conditions for differentiability, Polar coordinatesand Harmonic functions Elementary Functions, The Exponential functions, The Logarithmic function, Branches and derivatives of logarithms, Some identities involving logarithms, Complex exponents, Trigonometric functions, Hyperbolic functions, Inverse trigonometric and hyperbolic functions	**15**
II	Integrals Derivatives of functions, Definite integrals of functions,Contours, Contour integral, Cauchy- Goursat Theorem (without proof), Simply and multiply Collected domains. Cauchy integral formula. Derivatives of analytic functions. Liouville Theorem and Fundamental Theorem of Algebra, Maximum modulus principle(without proof),Taylor Series (without proof), examples, Laurent Series (without proof), region of convergence, examples Residues and Poles Cauchy residue theorem, using a single residue,Three types of isolated singular points, Residues at	**15**

	poles, Zeros of analytic functions, Applications to real integrals.	

References:

1. J.W. Brown and R.V. Churchill, Eighth Edition, Complex variables and Applications :
2. Sections 18, 19, 20, 21, 23, 24, 25, 28, 33, 34, 47, 48, 53, 54, 55 , Chapter 5, page 231 section 65, define residue of a function at a pole using Theorem in section 66 page 234, Statement of Cauchy's residue theorem on page 225, section 71 and 72 from chapter 7.

Additional References:

1. COMPLEX VARIABLES: THEORY AND APPLICATIONS. By H. S. KASANA
2. Robert E. Greene and Steven G. Krantz, Function theory of one complex variable
3. T.W. Gamelin, Complex analysis.
4. Functions of One Complex Variable by John B. Conway, Sringer-Verlag, New York, Heidelberg, Barlin.
5. Complex Variables with Applications by S. Ponnusamy, Herb Silverman.

Course Code	SEM – VI - Ring Theory	Credits	Lectures/Week
25MAT MJ 612	Paper II	2	2

Course Outcomes:

After successful completion of this course, students would be able to

CO1.Define ring , commutative ring, Integral domain , field , units in ring , Ideals etc

CO2.Describe the fundamental concepts in ring theory such as elementary properties of rings, ideals, quotient rings, integral domains ,fields;

CO3.Apply fundamental concept of Rings, Fields, subrings, integral domains and the corresponding morphisms to solve related problems.

CO4.Examine Integral domains, Ideals , homomorphism , isomorphism of rings and irreducibility .

Unit	Topics	No of Lectures
I	(1)Definition and elementary properties of rings (where the definition should include the existence of unity), commutative rings, integral domains and fields. Examples, including Z, Q, R, Z/nZ, C, Mn(R), Z[i], Z[$\sqrt{2}$], Z[$\sqrt{-5}$], Z[X], R[X], C[X],(Z/nZ)[X]. (2) Units in a ring. The multiplicative group of units in a ring R [and, in particular, the multiplicative group $F*$ of nonzero elements of a field F]. Description of the units in Z/nZ. Results such as: A finite integral domain is a field. Z/pZ, where p is a prime, as an example of a finite field. (3) Characteristic of a ring. Examples. Elementary facts such as: the characteristic of an integral domain is either 0 or a prime number.	**15**
II	Ideals and special rings (1) Ideals in a ring. Sums and products of ideals. Quotient rings. Examples. Prime ideals and maximal ideals. Characterization of prime ideals and maximal ideals in a commutative ring in terms of their quotient rings. Description of the ideals and the prime ideals in Z, R[X] and C[X]. (2) Homomorphisms and isomorphism of rings. Kernel and the image of a homomorphism. Fundamental Theorem of homomorphism of a ring. (3) Notions of Euclidean domain (ED), principal ideal domain (PID). Examples such as Z, Z[i], and polynomial rings. Relation between these two notions (ED $\Longrightarrow$ PID), Divisibility in a ring. Irreducible and prime elements.	**15**

	Examples, Notion of unique factorization domain (UFD). Elementary properties.	

References:

1. N. Herstein; Topics in Algebra; Wiley Eastern Limited, Second edition
2. P. B. Bhattacharya, S. K. Jain, and S. R. Nagpaul; Abstract Algebra; Second edition, Foundation Books, New Delhi, 1995.
3. N. S. Gopalakrishnan; University Algebra; Wiley Eastern Limited.
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 References:

1. S. 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.
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.

Course Code	SEM – VI - Topology of Metric Spaces and Real Analysis	Credits	Lectures/Week
25MAT MJ 613	Paper III	2	2

Course Outcomes:

After successful completion of this course, students would be able to

CO1. Define continuity and uniform continuity in metric space, connected, disconnected and path connected sets.

CO2. Explain continuity, uniform continuity, connected and disconnected metric spaces.

CO3. Apply the idea of continuity, uniform continuity to discuss the images of compact sets and connected set and their properties and various test to discuss pointwise and uniform convergence of sequence and series of functions.

CO4. Analyse continuity, uniform continuity, compact set, connected set, path connected set, sequence and series of functions to solve related problems.

Unit	Topics	No of Lectures
I	**Compact spaces** Definition of a compact metric space using open cover. Examples of compact sets in different metric spaces such as R, R^2, R^n with Euclidean metric. Properties of compact sets: A compact set is closed and bounded, (Converse is not true). Every infinite	**15**

	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 R with usual metric: (i) Sequentially compactness property. (ii) Heine-Borel property. (iii) Closed and boundedness property. (iv) Bolzano-Weierstrass property.	
II	**Connected spaces** Separated sets- Definition and examples. Connected and disconnected sets. Connected and disconnected metric spaces. Results such as: A subset of 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 R^n , definition and examples. A path connected subset of R^n is connected, convex sets are path connected. Connected components. An example of a connected subset of R^n which is not path connected.	**15**

References:

1. R. R. Goldberg; Methods of Real Analysis; Oxford and International Book House (IBH) Publishers, New Delhi.
2. S. Kumaresan; Topology of Metric spaces.
3. E. T. Copson; Metric Spaces; Universal Book Stall, New Delhi, 1996.
4. Robert Bartle and Donald R. Sherbert; Introduction to Real Analysis; Second Edition, John Wiley and Sons.

Additional References:

1. W. Rudin, Principles of Mathematical Analysis; Third Ed, McGraw-Hill, Auckland, 1976.

2 T. Apostol; Mathematical Analysis; Second edition, Narosa, New Delhi, 1974

3 P. K. Jain. K. Ahmed, Metric Spaces. Narosa, New Delhi, 1996.

4.D. Somasundaram, B. Choudhary; A first Course in Mathematical Analysis. Narosa, New Delhi

5. G. F. Simmons; Introduction to Topology and Modern Analysis, McGraw-Hi, New York, 1963.

Course Code	SEM – VI - Integral Transforms	Credits	Lectures/ Week
25MAT MJ 614	Paper IV	2	2

Course Outcomes:

After successful completion of this course, students would be able to

- CO1. Define Laplace, Fourier transform and their various properties.
- CO2. Describe the relationship between the Laplace, Fourier transform and their various properties.
- CO3. Apply the concepts of Laplace transform to solve one dimensional heat and wave equation, Fourier transform to solve initial and boundary value problem.
- CO4. Analyse Laplace and Fourier transform to solve related problems.

Unit	Topics	**No of Lectures**
I	**Laplace Transform** Definition of Laplace Transform, theorem, Laplace transforms of some elementary functions, Properties of Laplace transform, Laplace Transform of derivatives and integrals, Initial and final value theorem, Inverse Laplace Transform, Properties of Inverse Laplace Transform, Convolution Theorem, Inverse Laplace Transform by partial fraction method, Laplace transform of special functions: Heaviside unit step function, Dirac-delta function and Periodic function. Application of Laplace Transform to solve Ordinary Differential Equations.	**15**
II	**Fourier Transform** Fourier integral representation, Fourier integral theorem, Fourier Sine & Cosine integral representation, Fourier Sine & Cosine transform pairs, Fourier transform of elementary functions, Properties of Fourier Transform, Convolution Theorem, Parseval's Identity.Relation between the Fourier and Laplace Transform.	**15**

References:

1. Lokenath Debnath and Dambaru Bhatta, Integral Transforms and their Applications, CRC Press Taylor & Francis.
2. I. N. Sneddon, Use of Integral Transforms, Tata-McGraw Hill.

Additional references:

1. L. Andrews and B. Shivamogg, Integral Transforms for Engineers, Prentice Hall of India.

<table>
<tr><td>Course Code</td><td>SEM VI - Practical I
(Paper 1 + Paper 2+paper 3 +Paper 4)</td><td>Credits</td><td>Lectures/ Week</td></tr>
<tr><td>25MAT MJ P61</td><td>Paper I: Complex Analysis
Paper II: Ring Theory
Paper III: Topology of Metric Spaces and Real Analysis
Paper IV: Intergral Transforms</td><td>2</td><td>4</td></tr>
<tr><td colspan="4">Course Outcomes:
After successful completion of this course, students would be able to
CO1.Describe complex variables, Rings, Metric Spaces.
CO2.Discuss Problems based on complex variables, Rings, Metric Spaces.
CO3.Analyze and solve the problems based on the syllabus.
CO4.Relate mathematics and its applications in pure and applied sciences.</td></tr>
<tr><td colspan="4">Paper 1: Complex Analysis(Any four)</td></tr>
<tr><td>1</td><td colspan="3">Limit continuity and derivatives of functions of complex variables.</td></tr>
<tr><td>2</td><td colspan="3">Steriographic Projection , Analytic function, finding harmonic conjugate.</td></tr>
<tr><td>3</td><td colspan="3">Contour Integral, Cauchy Integral Formula ,Mobius transformations.</td></tr>
<tr><td>4</td><td colspan="3">Power Series , Radius of Convergence, Laurents Series.</td></tr>
<tr><td>5</td><td colspan="3">Finding isolated singularities- removable, pole and essential, Cauchy Residue theorem.</td></tr>
<tr><td colspan="4">Paper 2: Ring Theory (Any four)</td></tr>
<tr><td>1</td><td colspan="3">Examples of rings (commutative and non-commutative), integral domains and fields</td></tr>
<tr><td>2</td><td colspan="3">Units in various rings. Determining characteristics of rings.</td></tr>
<tr><td>3</td><td colspan="3">Prime Ideals and Maximal Ideals, examples on various rings</td></tr>
<tr><td>4</td><td colspan="3">Euclidean domains and principal ideal domains (examples and non-examples)</td></tr>
<tr><td>5</td><td colspan="3">Examples if irreducible and prime elements.Applications of division algorithm and Eisenstein’s criterion.</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">Paper III: Topology of Metric Spaces and Real Analysis (Any four)</td></tr>
<tr><td>1</td><td colspan="3">Continuity in a Metric Spaces</td></tr>
<tr><td>2</td><td colspan="3">Uniform Continuity, Contraction maps, Fixed point theorem</td></tr>
<tr><td>3</td><td colspan="3">Connected Sets , Connected Metric Spaces</td></tr>
<tr><td>4</td><td colspan="3">Path Connectedness, Convex sets, Continuity and Connectedness</td></tr>
<tr><td>5</td><td colspan="3">Pointwise and uniform convergence of sequence functions, properties,Point wise and uniform convergence of series of functions and properties</td></tr>
</table>

Paper IV	Intergral Transforms (Any four)
1	Find the Laplace transform of Elementary functions.
2	Laplace Transform of derivatives and integrals,
3	Find the inverse Laplace transform by the partial fraction method.
4	Find the Fourier integral representation of given functions.
5	Find the Fourier Sine / Cosine integral representation of given functions

Course Code	ELECTIVE(I)	Credits	Lectures/ Week
25MAT EL 631	NUMERICAL METHODS	2	2
Course Outcomes: After successful completion of this course, students would be able to CO1:Describe the types of errors and the theory of Algebric and Transcendental equations, Interpolation,numerical integration . CO2:Identify the common numerical methods and use them to obtain approximate solutions CO3:Apply numerical methods to obtain approximate solutions to mathematical problems and solve the problems of interpolation, numerical integration. CO4:Analyze and apply different types of methods to solve problems related to algebraic and transcendental equations.			

Unit	**Topics**	**No of Lectures**
I	**Solution of Algebraic and Transcendental Equations** 1. Measures of Errors: Relative, absolute and percentage errors, Accuracy and precision: Accuracy to n decimal places, accuracy to n significant digits or significant figures, Rounding and Chopping of a number, Types of Errors: Inherent error, Round-off error and Truncation error. 2. Iteration methods based on first degree equation: Newton-Raphson method. Secant method. Regula-Falsi method. Derivations and geometrical interpretation and rate of convergence of all above methods to be covered. 3. General Iteration method: Fixed point iteration method.	**15**
II	**Interpolation, Curve fitting, Numerical Integration** 1. Interpolation: Lagrange's Interpolation. Finite difference operators: Forward Difference operator, Backward Difference operator. Shift operator. Newton's forward difference interpolation formula. Newton's backward difference interpolation formula. Derivations of all above methods to be covered. 2. Curve fitting: linear curve fitting. Quadratic curve fitting. 3. Numerical Integration: Trapezoidal Rule. Simpson's 1/3 rd Rule. Simpson's 3/8th Rule. Derivations all the above three rules to be covered.	**15**

References:

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. Sastry; Introductory methods of Numerical Analysis; PHI Learning.

Additional References:

1. S.D. Comte and Carl de Boor; Elementary Numerical Analysis, An algorithmic approach; McGrawHillll International Book Company.
2. Hildebrand F.B.; Introduction to Numerical Analysis; Dover Publication, NY.
3. Scarborough James B.; Numerical Mathematical Analysis; Oxford University Press, New Delhi.

Course Code	PRACTICAL ELECTIVE(I)	Credits	Lectures/ Week
25MAT ELP61	PRACTICAL NUMERICAL METHODS	2	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Understand different types of methods to solve problems related to algebraic and transcendental equations.

CO2: Discuss numerical methods to obtain approximate solutions to mathematical problems and solve the problems of interpolation, numerical integration.

CO3: solve the problems based on the syllabus.

CO4: Relate mathematics and its applications in pure and applied sciences.

The Practical no. 1 to 5 should be performed either using non-programable scientific calculators

Sr. No.	Practical Details	**No of Lectures/ Hours**
1	Measures of Errors: Relative, absolute and percentage errors,Accuracy and precision, Types of Errors	
2	**Newton-Raphson method**	
3	**Secant method**	
4	**Regula-Falsi method, Fixed point Method.**	
5	**Miscellaneous Theory Questions based on Unit I**	
6	**Interpolating polynomial by Lagrange's Interpolation.**	**60**
7	Finite difference operators: Forward Difference operator, Backward Difference operator. Shift operator.	
8	**Newton forward and backward difference Interpolation.**	
9	Curve fitting: linear curve fitting. Quadratic curve fitting	
10	Numerical Integration **:Trapezoidal Rule, Simpson's 1/3rd Rule, Simpson's 3/8th Rule.**	
11	**More problems on practical 12**	
12	**Miscellaneous Theory Questions based on Unit II**	

References:

4 Kendall E. and Atkinson; An Introduction to Numerical Analysis; Wiley.
5 M. K. Jain, S. R. K. Iyengar and R. K. Jain; Numerical Methods for Scientific and Engineering Computation; New Age International Publications.
6 S. Sastry; Introductory methods of Numerical Analysis; PHI Learning.

Additional References:

4 S.D. Comte and Carl de Boor; Elementary Numerical Analysis, An algorithmic approach; McGrawHillll International Book Company.
5 Hildebrand F.B.; Introduction to Numerical Analysis; Dover Publication, NY. Scarborough James B.; Numerical Mathematical Analysis; Oxford University Press, New Delhi**.**

<table>
<tr><td>Course Code</td><td>SEM – VI – Elective (II)</td><td>Credits</td><td>Lectures/Week</td></tr>
<tr><td>25MAT EL 631</td><td>Paper : - Graph Theory -II</td><td>2</td><td>2</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">After successful completion of this course, students would be able to
CO1.Define Eulerian graph, Hamiltonian graph, Vertex coloring, critical graph, Vertex chromatic Number,complete bipartite graph etc.
CO2.Identify various types of graphs
CO3.Solve problems based on graphs and Colorings of graph.
CO4.Analyze and differentiate between various types of graphs explaining their structural properties and real-world applications.</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Unit</td><td colspan="2">Topics</td><td>No of Lectures</td></tr>
<tr><td>I</td><td colspan="2">Eulerian and Hamiltonian graphs

Eulerian graph and its characterization- Fleury's Algorithm-(Chinese postman problem), Hamiltonian graph, Necessary condition for Hamiltonian graphs using $G \setminus S$ where S is a proper subset of $V(G)$, Sufficient condition for Hamiltonian graphs- Ore's theorem and Dirac's theorem, Hamiltonian closure of a graph, Cube graphs and properties like regular, bipartite, Connected and

Hamiltonian nature of cube graph, Line graph of graph and simple results.</td><td>15</td></tr>
<tr><td>II</td><td colspan="2">Colorings of graph

Vertex coloring- evaluation of vertex chromatic number of some standard graphs, critical graph.

Upper and lower bounds of Vertex chromatic Number- Statement of Brooks theorem. Edge colouring- Evaluation of edge chromatic number of standard graphs such as complete graph, complete bipartite graph, cycle. Statement of Vizing Theorem. Chromatic polynomial of graphsRecurrence Relation and properties of Chromatic polynomials. Vertex and edge cuts, vertex and

edge connectivity and the relation between vertex and edge connectivity. Equality of vertex and edge connectivity of cubic graphs. Whitney's theorem on 2-vertex connected graphs.</td><td>15</td></tr>
<tr><td colspan="4">References:
1.Bondy and Murty; Gragh Theory with Applications.

2. Balkrishnan and Ranganathan; Graph theory and applications.</td></tr>
</table>

3. Douglas B. West, Introduction to Graph Theory,

Additional References:

1. Behzad and Chartrand; Graph theory.

2. Choudam S. A.; Introductory Graph theory;

<table>
<tr><td>Course Code</td><td>SEM V- – Elective (II) Practical</td><td>Credits</td><td>Lectures/ Week</td></tr>
<tr><td>25MAT EL P61</td><td>Graph Theory -II</td><td>2</td><td>4</td></tr>
<tr><td colspan="4">Course Outcomes:
After successful completion of this course, students would be able to
CO1.Define Eulerian graph, Hamiltonian graph, Vertex coloring, critical graph, Vertex chromatic Number,complete bipartite graph etc.
CO2.Identify various types of graphs
CO3.Solve problems based on graphs and Colorings of graph.
CO4.Analyze and differentiate between various types of graphs explaining their structural properties and real-world applications.</td></tr>
<tr><td>Sr. No.</td><td colspan="3">Practical Details</td></tr>
<tr><td>1</td><td colspan="2">Eulerian graph and its characterization- Fleury's Algorithm-(Chinese postman problem),</td><td></td></tr>
<tr><td>2</td><td colspan="2">Hamiltonian graph, Necessary condition for Hamiltonian graphs using $G \backslash S$ where S is a proper subset of $V(G)$</td><td></td></tr>
<tr><td>3</td><td colspan="2">Sufficient condition for Hamiltonian graphs- Ore's theorem and Dirac's theorem</td><td></td></tr>
<tr><td>4</td><td colspan="2">Hamiltonian closure of a graph, Cube graphs and properties.</td><td></td></tr>
<tr><td>5</td><td colspan="2">Line graph of graph and simple results.</td><td></td></tr>
<tr><td>6</td><td colspan="2">Vertex coloring</td><td></td></tr>
<tr><td>7</td><td colspan="2">Edge colouring</td><td></td></tr>
<tr><td>8</td><td colspan="2">Complete bipartite graph, cycle.</td><td></td></tr>
<tr><td>9</td><td colspan="2">Chromatic polynomial of graphsRecurrence Relation and properties of Chromatic polynomials.</td><td></td></tr>
<tr><td>10</td><td colspan="2">Vertex and edge cuts, vertex and edge connectivity and the relation between vertex and edge connectivity.</td><td></td></tr>
<tr><td>11</td><td colspan="2">Equality of vertex and edge connectivity of cubic graphs.Whitney's theorem on 2-vertex connected graphs.</td><td></td></tr>
<tr><td>12</td><td colspan="2">Miscellaneous Theory Questions</td><td></td></tr>
<tr><td colspan="3">References:
1. Bondy and Murty; Graph Theory with Applications.
2. Balkrishnan and Ranganathan; Graph theory and applications.
3. Douglas B. West, Introduction to Graph Theory, 2nd Ed., Pearson, 2000</td><td></td></tr>
</table>

Additional References: 1.Behzad and Chartrand; Graph theory. 2. Choudam S. A.; Introductory Graph theory	

Course Code	MINOR	Credits	Lectures/ Week
25MAT MR 621	LINEAR ALGEBRA II	2	2

Course Outcomes:

After successful completion of this course, students would be able to

- CO1:Understand the concepts of vector spaces, subspace, Direct sums of vector spaces,Quotient space, Basis of a vector space over R , linear transformation , Kernel and Range of Linear transformation and isomorphism.
- CO2:Explain Examples of vector spaces, . Intersections and sums of subspaces, . Linear combination of vectors, . Basis of a vector space , elementary properties of Linear Transformations, Rank Nullity theorem.
- CO3:Apply the concepts vector spaces , Linear transformations to solve related problems .
- CO4:Relate Vector spaces, matrices and linear transformations.

Unit	Topics	No of Lectures
I	**Vector space over R** 1. Definition of a vector space over R. Subspaces; criterion for a nonempty subset to be a subspace of a vector space. Examples of vector spaces, including the Euclidean space R^n , lines, planes and hyperplanes in R^n passing through the origin, space of systems of homogeneous linear equations, space of polynomials, space of various types of matrices, space of real valued functions on a set. 2. Intersections and sums of subspaces. Direct sums of vector spaces. Quotient space of a vector space by its subspace. 3. Linear combination of vectors. Linear span of a subset of a vector space. Definition of a finitely generated vector space. Linear dependence and independence of subsets of a vector space. 4. Basis of a vector space. Basic results that any two bases of a finitely generated vector space have the same number of elements. Dimension of a vector space. Examples. Bases of a vector space as a maximal linearly independent sets and as minimal generating sets.	**15**
II	**Linear Transformations** 1. Definition of a linear transformation of vector spaces; elementary properties. Examples. Sums and scalar multiples of linear transformations. Composites of linear transformations. A Linear transformation of $V \rightarrow W$, where V, W are vector spaces over R and	**15**

	V is a finite-dimensional vector space is completely determined by its action on an ordered basis of V. 2. Null-space (kernel) and the image (range) of a linear transformation. Nullity and rank of a linear transformation. Rank-Nullity Theorem (Fundamental Theorem of Homomorphisms). 3. Matrix associated with linear transformation of V → W where V and W are finite dimensional vector spaces over R.. Matrix of the composite of two linear transformations. Invertible linear transformations (isomorphisms), Linear operator, Effect of change of bases on matrices of linear operator.	

References:

1 Howard Anton, Chris Rorres; Elementary Linear Algebra; Wiley Student Edition).
2 Serge Lang; Introduction to Linear Algebra; Springer.
3 S Kumaresan; Linear Algebra - A Geometric Approach; PHI Learning.
4 Gareth Williams; Linear Algebra with Applications; Jones and Bartlett Publishers.

Additional References:

1 David W. Lewis; Matrix theory
2 Sheldon Axler; Linear Algebra done right; Springer.

Course Code	PRACTICAL MINOR	Credits	Lectures/ Week
25MAT MR P61	LINEAR ALGEBRA II	4	8

Course Outcomes:

After successful completion of this course, students would be able to

CO1:Describe basic results to verify Reimann integrability and various techniques to verify integral convergence, the concepts vector spaces , Linear transformations

CO2:Understand various tests for integrable functions for creating counter examples and support the theory with applicable examples, Vector spaces, matrices and linear transformations

CO3: solve the problems based on the syllabus.

CO4:Relate mathematics and its applications in pure and applied sciences.

LINEAR ALGEBRA II

Sr. no.	Practical Details	**No of Lectures/ Hours**
LINEAR ALGEBRA II		
1	**Problems on vector spaces .**	**60**
2	**Subspace of a vector space**	
3	**Problems on intersections and sums of subspaces, direct sums of vector spaces and quotient space of a vector space by its subspace.**	
4	**Problems on linear combination of vectors and Linear span of a subset of a vector space.**	
5	**Problems on linear dependence and linear independence.**	
6	**Problems on Basis and Dimension.**	
8	**Linear transformation of vector space.** Composites of linear transformations	
9	**Problems on Kernel, Image and Rank-Nullity Theorem.**	
10	**Linear Isomorphism, Matrix associated with Linear transformations**	
11	Invertible linear transformations and linear operator. Problems on effect of change of bases on matrices of linear operator.	
12	**Miscellaneous Theory Questions**	

References:

1. Howard Anton, Chris Rorres; Elementary Linear Algebra; Wiley Student Edition).
2. Serge Lang; Introduction to Linear Algebra; Springer.
3. S Kumaresan; Linear Algebra - A Geometric Approach; PHI Learning.

Additional References:

1. David W. Lewis; Matrix theory
2. Sheldon Axler; Linear Algebra done right; Springer.

Evaluation Scheme for Second Year (UG) under NEP (2 credits)

I. Internal Evaluation for Theory Courses – 20 Marks

1) Continuous Internal Assessment(CIA) Assignment - Case Study/ Project / Presentations– 10 marks

2) Continuous Internal Assessment(CIA) ONLINE Unit Test – 10 marks

II. External Examination for Theory Courses – 30 Marks

Duration: 1 Hour

Theory question paper pattern: All questions are compulsory.

Question	**Based on**	**Marks**
Q.1	Unit I	15
Q.2	Unit II	15

- All questions shall be compulsory with internal choice within the questions.
- Each Question may be sub-divided into sub questions as a, b, c, d, etc. & the allocation of Marks depends on the weightage of the topic.

III. Practical Examination

- Each core subject carries 50 Marks.
- Duration: 2 Hours for each practical course.
- Minimum 80% practical from each core subjects are required to be completed.
- Certified Journal is necessary for appearing at the time of Practical Exam

NOTE: To pass the examination, attendance is compulsory in both Internal & External (Theory + Practical) Examinations.

PASSING STANDARD NEP Second Year : · The learners /students shall obtain minimum of 40% marks in the Internal Assessment and External Assessment (Semester End Examination) COMBINED, to pass the course in a particular semester. A learner / student will be said to have passed the course if He/She passes the Internal Assessment + Semester End Examination COMBINED.

****