પરિપત્ર:

ભક્તકવિ નરસિંહ મહેતા યુનિવર્સિટીની સાયન્સ વિદ્યાશાખાનાં અભ્યાસક્રમ ચલાવતી તમામ સંલગ્ન કોલેજોનાં આચાર્યશ્રીઓને સવિનય જણાવવાનું કે સાયન્સ વિદ્યાશાખા હેઠળનો NEP-૨૦૨૦ અંતર્ગત મેથેમેટિક્સ વિષય સેમેસ્ટર-૬નો અભ્યાસક્રમ આ સાથે સામેલ છે.

માનનીય કુલપતિશ્રીની મંજુરી અનુસાર સદર અભ્યાસક્રમ શૈક્ષણિક વર્ષ જુન,૨૦૨૫ થી અમલવારી કરવાની રહે છે. સાયન્સ વિદ્યાશાખાનાં અભ્યાસક્રમ ચલાવતી તમામ સંલગ્ન કોલેજો ધ્વારા તેની અમલવારી કરવા જણાવવામાં આવે છે.

Bhakta Kavi Narsinh Mehta University Junagadh.

ખાસ ફરજ પરના અધિકારી
(એકેડેમિક)

ક્રમાંક/બીકેએનએમયુ/ એકેડેમિક/૭૪૬/૨૦૨૫
ભક્તકવિ નરસિંહ મહેતા યુનિવર્સિટી,
સરકારી પોલીટેકનિક કેમ્પસ,
ભક્તકવિ નરસિંહ મહેતા યુનિવર્સિટી રોડ,
ખડીયા, જૂનાગઢ-૩૬૨૨૬૩
તા.૦૩/૧૧/૨૦૨૫

પ્રતિ,

- ભક્તકવિ નરસિંહ મહેતા યુનિવર્સિટી સંલગ્ન સાયન્સ વિદ્યાશાખાનાં અભ્યાસક્રમો ચલાવતી તમામ કોલેજોના આચાર્યશ્રીઓ તરફ....

નકલ સાદર રવાના:-

- માન.કુલપતિશ્રી/ કુલસચિવશ્રીનાં અંગત સચિવશ્રી.
- પરીક્ષા નિયામકશ્રી, ભક્તકવિ નરસિંહ મહેતા યુનિવર્સિટી, જુનાગઢ

નકલ રવાના જાણ તથા યોગ્ય કાર્યવાહી અર્થે:

- સીસ્ટમ મેનેજરશ્રી, આઇ.ટી.સેલ વિભાગ (વેબસાઇટ ઉપર પ્રસિદ્ધ થવા અર્થે.)

BHAKTA KAVI NARSINH MEHTA UNIVERSITY

JUNAGADH

BOARD OF STUDIES

FACULTY OF SCIENCE

SYLLABUS FOR MATHEMATICS (HONOURS)

PROGRAMME (SEMESTER- VI)

EFFECTIVE FROM JUNE, 2025

BHAKTA KAVI NARSINH MEHTA UNIVERSITY
Syllabus of B.Sc. (Honors) as per NEP - 2020
Faculty of Science
Effective from June 2025
Subject: Mathematics
SEMESTER - VI

SUMMARY OF THE SYLLABUS

Sem No.	Sr. No.	Category of Course	Course Title	Course Level	Credit	Teaching Hrs. per week	SEE Marks	CCE Marks	Total Marks	SEE Exam Duration
Semester – VI	1	Major-14	Abstract Algebra – II	5.5	4	4	50	50	100	02:00 Hours
	2	Major-15	Real Analysis – II and Complex Analysis – II	5.5	4	4	50	50	100	02:00 Hours
	3	Major-16	Indian Knowledge System and Evolution of Mathematics	5.5	4	4	50	50	100	02:00 Hours
	4	Minor-6	**Applied Mathematics – III (Graph Theory)** (For students having Major subject as Mathematics)	5.5	4	4	50	50	100	02:00 Hours
		Minor-6	**Vector Calculus and Multiple Integrals** (For students having Major subject **other than** Mathematics)							
				Total	16					

BHAKTA KAVI NARSINH MEHTA UNIVERSITY
Syllabus of B.Sc. (Honors) as per NEP - 2020
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Effective from June 2025
Subject: Mathematics
SEMESTER - VI

Course Level	5.5		**Internal Marks**	50
Programme	B.Sc. Mathematics (Hon.)		**External Marks**	50
Semester	VI		**Practical Internal**	---
Category of Course	Major Course – 14		**Practical External**	---
Course Credit	4		**Prac. External Exam Duration**	---
Teaching Hours	4 Hours/week		**Total (SEE+CCE)**	100
Course Code			**Exam Duration**	02:00 Hours
Course Title	**Abstract Algebra – II**			

Course objectives: This course aims to introduce students to a more advanced course on Abstract Algebra with two binary operations i.e. Ring theory. It aims to equip students with a foundational understanding of key algebraic structures, including rings, ideals and polynomial rings and the ability to apply fundamental theorems and concepts within these areas. It has the following list of objectives:

- Demonstrate a comprehensive understanding of group homomorphisms and isomorphisms and explain the significance of the kernel of a homomorphism.
- Apply the First Fundamental Theorem of Homomorphism to analyze group structures and state and use Cayley's theorem.
- Analyze the properties of endomorphisms and automorphisms and classify groups of order four and six.
- Define and provide examples of rings, integral domains and fields and differentiate between these algebraic structures.
- Analyze and distinguish the properties of specific rings, such as the Gaussian Ring, Boolean Ring and the Ring of real Quaternions.
- Identify zero divisors and determine the characteristic of a given ring.
- Define and explain the properties of ideals and principal ideals.
- Solve problems involving ring homomorphisms and state and apply their fundamental properties.
- Perform arithmetic operations (sum, product, division) on polynomials and apply the Division Algorithm theorem for polynomials.
- Calculate the greatest common divisor (G.C.D.) of polynomials.
- Determine the reducibility or irreducibility of polynomials using theorems such as the Factor and Remainder theorem and Eisenstein's criterion.
- Demonstrate an understanding of the Unique Factorization theorem for polynomials.

Course Learning Outcomes: The learning outcomes for Abstract Algebra – II focuses on developing students' theoretical and applied understanding of fundamental algebraic structures such as Rings, Ideals, Fields and Polynomial Rings. Upon successful completion of the course, student will be able to:

- Define and differentiate between group Homomorphisms, Isomorphisms, Endomorphisms and Automorphisms.
- Demonstrate an understanding of the kernel of a Homomorphism and its properties.
- Apply the First Fundamental Theorem of Homomorphism and prove Cayley's theorem.
- Identify and verify the properties of Rings, Subrings, Integral domains and Fields.
- Analyze specific ring structures such as the Gaussian Ring and Boolean Ring.
- Determine the characteristic of a Ring and identify zero divisors.
- Construct and analyze Ideals and Principal ideals within a Ring.
- Apply the concepts and properties of Ring Homomorphism to solve related problems.
- Perform division of polynomials and utilize the Division Algorithm theorem to find the quotient and remainder.
- Compute the Greatest Common Divisor (G.C.D.) of polynomials.
- Apply the Factor and Remainder theorem and Eisenstein's criterion to determine if a given polynomial is reducible or irreducible.

Course Contents:

Sem	Unit No	Syllabi	Teaching Hours
6	1	**Homomorphism and Isomorphism of Groups** Definition of homomorphism of groups and its examples, Kernel of homomorphism and its properties, First fundamental theorem of homomorphism, Endomorphism, Cayley's theorem, Isomorphism of groups and properties, Automorphism, Groups of order four and six.	**Approx. 14 Hours**
	2	**Rings and Integral Domains** Definition of Ring and its examples, Properties of Ring, Ring of real Quaternions, Gaussian Ring, Boolean Ring, [**OMIT:- Euclidean Ring**], Subring, Characteristic of a Ring, Zero divisor of a Ring, Integral domains and examples, Division Ring (**Wedderburn's theorem - only statement**), Definition of field and its relation with Integral domain.	**Approx. 16 Hours**
	3	**Ideals and Ring Homomorphisms** Definition of Ideal and its examples, Properties of Ideals, Principal Ideal and its examples, [**OMIT:- Quotient ring, Prime & Maximal ideal**], Homomorphism of Rings and its examples, Properties of Ring homomorphism, Homomorphism from Z to a	**Approx. 16 Hours**

		Ring with unity.	
	4	**Polynomial Rings** Polynomial, Degree of polynomial, Sum - Product and division of polynomials, Division algorithm theorem of polynomial, G.C.D. of polynomials, Factorization of polynomials (**Unique Factorization theorem without proof**), Factor and remainder theorems of polynomials, Reducible and irreducible polynomials, Eisenstein's criterion for irreducibility and related examples.	**Approx. 14 Hours**

Suggested References:

1. **Abstract Algebra** by Dr. I.H. Sheth, PHI, New Delhi.
2. **Topics in Algebra** by I.N. Herstein, Willey Eastern Limited, New Delhi.
3. **A Textbook of Modern Abstract Algebra** by Shantinarayan, S. Chand & Co., New Delhi.
4. **Fundamentals of Abstract Algebra** by D.S. Malik, J.N.Mordoson & M.K.Sen, McGraw Hill.
5. **University Algebra** by M.S. Gopalakrishna, Willey Eastern Limited.
6. **A First Course in Abstract Algebra** by John B. Fraleigh, Pearson Education.
7. **Algebra** by Michael Artin, PHI, New Delhi.

Course Level	5.5		**Internal Marks**	50
Programme	B.Sc. Mathematics (Hon.)		**External Marks**	50
Semester	VI		**Practical Internal**	---
Category of Course	Major Course – 15		**Practical External**	---
Course Credit	4		**Prac. External Exam Duration**	---
Teaching Hours	4 Hours/week		**Total (SEE+CCE)**	100
Course Code			**Exam Duration**	02:00 Hours
Course Title	**Real Analysis – II and Complex Analysis – II**			

Course objectives: This course aims to introduce students to a more advanced course on Real analysis and Complex analysis. It has the following list of objectives:

- Introduce the concept of metric spaces as a generalization of Euclidean spaces.
- Develop a clear understanding of open and closed sets, neighbourhoods and limit points in metric spaces.
- Familiarize students with closure, interior and boundary of sets and their topological significance.
- Enable learners to understand and apply the concepts of compactness and connectedness in metric spaces.
- Illustrate the importance of the Bolzano–Weierstrass theorem and countability in topology.
- Strengthen understanding of analytic functions and their higher-order derivatives.
- Explain and prove key results like Morera's theorem, Cauchy's inequality and Liouville's theorem.
- Demonstrate the Fundamental Theorem of Algebra and explore its implications in complex analysis.
- Introduce and classify singularities, poles and residues of complex functions.
- Apply the Residue Theorem to evaluate improper and definite integrals, particularly trigonometric ones.

Course Learning Outcomes: Upon successful completion of the Real analysis – II and Complex analysis – II course, student will be able to:

- Define and identify examples of metric spaces, open and closed sets and limit points.
- Differentiate between closure, interior, boundary and derived sets within a metric space.
- Analyze and prove properties of open and closed sets using definition and examples.
- Apply the concepts of compactness and connectedness to determine whether sets in metric spaces possess these properties.

- Demonstrate understanding of the Bolzano–Weierstrass theorem and use it to discuss convergence and accumulation points.
- Compute higher-order derivatives of analytic functions and verify conditions of analyticity using Morera's theorem.
- Utilize Cauchy's inequality and Liouville's theorem to derive bounds and properties of entire functions.
- Prove and interpret the Fundamental Theorem of Algebra and its role in determining zeros of polynomials.
- Classify singular points of complex functions and calculate residues and poles.
- Evaluate improper real integrals and trigonometric integrals using the Cauchy Residue Theorem effectively.

Course Contents:

Sem	Unit No	Syllabi	Teaching Hours
6	1	**Metric Spaces** Definition and examples of metric space, neighborhood, limit points, interior points, Open and closed sets and its properties, Closure, derived set and interior, boundary points. Dense sets.	**Approx. 18 Hours**
	2	**Compact and Connected Sets in Metric Space** Cover, Open cover, Finite sub-cover, Compact set, Properties of compact sets, connected set, Properties of connected sets, Separated sets, Bolzano-Weierstrass theorem, Countable set and its examples.	**Approx. 12 Hours**
	3	**Fundamental Theorem of Algebra** Higher order derivative of analytic function, Morera's theorem, Cauchy's inequality and Liouville's theorem, Fundamental theorem of algebra, Maximum modulus theorem.	**Approx. 12 Hours**
	4	**Residues and Poles** Definition of a singular point, isolated singular points, Zeros of complex functions, Poles and residues of complex function, Cauchy's residue theorem, Evaluation of improper real integrals by residue theorem and evaluation of definite integral of trigonometric functions by residue theorem.	**Approx. 18 Hours**

Suggested References:

1. **Mathematical Analysis** by S.C. Malik & Savita Arora, New Age International, ISBN
2. 9788122403237.
3. **Mathematical Analysis** by Tom M. Apostol, Addison Wesley/Pearson, ISBN 9780201002881.
4. **Methods/Real Analysis** by R.R. Goldberg, Wiley, ISBN 9788120417571.
5. **A course of Mathematical Analysis** by Shantinarayan & P.K. Mittal, S.Chand & Sons, ISBN
6. 9788121904728.
7. **Metric Spaces** by E.T. Copson, Cambridge University Press, ISBN 9780521357326.
8. **Metric Spaces** by P.K. Jain & Khalil Ahmad, Narosa Publishing House, ISBN 9781842651704.
9. **Real Analysis** by J.N. Sharma & A.R. Vasishtha , Krishna Prakashan, Meerut, ISBN
10. 9788182835771.
11. **Mathematical Analysis** by Dr. Goyal & Gupta, Krishna Prakashan, Meerut.
12. **Complex Variables and Applications** by James W. Brown & Ruel V. Churchill, McGraw Hill
13. ISBN 9780073383170.
14. **Functions of a Complex Variable** by J.N. Sharma, Krishna Prakashan, ISBN 9788182831414.

Course Level	5.5		**Internal Marks**	50
Programme	B.Sc. Mathematics (Hon.)		**External Marks**	50
Semester	VI		**Practical Internal**	---
Category of Course	Major Course – 16		**Practical External**	---
Course Credit	4		**Prac. External Exam Duration**	---
Teaching Hours	4 Hours/week		**Total (SEE+CCE)**	100
Course Code			**Exam Duration**	02:00 Hours
Course Title	**Indian Knowledge System and Evolution of Mathematics**			

Course objectives: This course has the following list of objectives:

- To introduce students to the historical, philosophical and textual sources of mathematical knowledge within the broader framework of Indian Knowledge Systems (IKS).
- To examine the role of Indian philosophical schools, particularly Nyaya logic and epistemology in shaping the methods and reasoning of mathematical development.
- To provide an in-depth understanding of the development and global significance of the decimal place-value system and the concept of zero as formulated in ancient India.
- To study the key contributions of Indian mathematicians like Brahmagupta and Bhaskara II in the areas of linear, quadratic and indeterminate equations.
- To analyze the geometric constructions and principles found in the ŚulbaSūtras, including the understanding and application of the Pythagorean theorem.
- To detail the groundbreaking contributions of Aryabhaṭa to trigonometry, specifically the creation of the sine function and sine tables.
- To illustrate how mathematical models and concepts were applied in ancient Indian astronomical texts (Siddhantas) for calculating celestial events.
- To investigate the ideas of infinitesimals and early forms of calculus developed by the Kerala School of Mathematics and compare them with later global developments.
- To introduce the ancient Indian concepts and applications of permutations and combinations as found in texts on prosody and poetry.
- To encourage critical reflection on the modern-day relevance and potential applications of Indian mathematical concepts in contemporary fields like number theory and computational Mathematics.

Course Learning Outcomes: Upon successful completion of this course, student will be able to:

- Explain the interdisciplinary connection between Indian Knowledge Systems (IKS) and the development of mathematical thought by referencing primary textual sources like the Vedas and ŚulbaSūtras.
- Analyze the logical and epistemological frameworks of the Nyaya school and demonstrate how they influenced mathematical proofs and reasoning.
- Evaluate the historical and mathematical significance of the Indian place-value system and the invention of zero based on the works of Brahmagupta and others.
- Apply the algorithms and principles of Vedic Mathematics to solve problems in mental arithmetic and explain the underlying mathematical rules.
- Solve simple linear, quadratic and indeterminate equations using the methods developed by ancient Indian algebraists like Bhaskara II.
- Reconstruct the basic geometric altar constructions described in the ŚulbaSūtras and demonstrate the geometric proof of the Pythagorean theorem (Baudhāyana ŚulbaSūtra).
- Utilize the contributions of Aryabhaṭa's sine tables to perform basic trigonometric calculations and explain their application in ancient Indian astronomy.
- Differentiate the key ideas of the Kerala School's early forms of calculus (infinitesimals) from the later European developments of the subject.
- Calculate and demonstrate the concepts of permutations and combinations as applied in ancient Indian texts on prosody and Mathematics.
- Critique the holistic problem-solving approach of IKS and propose areas where concepts from Indian Mathematics could inspire research in modern computational Mathematics.

Course Contents:

Sem	Unit No	Syllabi	Teaching Hours
6	1	**Foundations of Indian Mathematics and Philosophy** Introduction to IKS and Mathematics: Explore the interdisciplinary nature of Indian knowledge systems and their connection to mathematical thought. Sources of Indian Mathematics: Study primary texts such as the Sulbasutras, which contain geometric principles for altar construction, and the contributions found in the Vedas and other ancient scriptures. Indian philosophical schools and Logic: Introduce the Nyaya school of philosophy and its contributions to logic and epistemology. Discuss how logical frameworks developed in these schools influenced mathematical reasoning.	**Approx. 15 Hours**
	2	**Number Systems, Algebra and Arithmetic** The Indian number system: Examine the development of the	**Approx. 15 Hours**

		decimal place-value system and the concept of zero from texts by Brahmagupta and others. Discuss the historical significance of this innovation. Vedic Mathematics: Explore the principles and applications of Vedic Mathematics, as compiled by Swami Bharati Krishna Tirtha, focusing on its algorithms for mental arithmetic and their underlying Mathematical principles. Algebraic contributions: Study the works of Brahmagupta and Bhaskara II (Lilavati and Bijagaṇita) on linear and quadratic equations, indeterminate equations and the development of algebraic notation.	
	3	**Geometry, Trigonometry and Astronomy** Geometry and the ŚulbaSūtras: Analyze the geometric principles in the ŚulbaSūtras, including the construction of right angles and the geometric proof of the Pythagorean theorem (Baudhāyana ŚulbaSūtra). Trigonometry and Sine tables: Explore the contributions of Aryabhaṭa to trigonometry, including the development of the sine function and the construction of sine tables. Discuss their application in Astronomy. Mathematical Astronomy: Study the Mathematical models used in ancient Indian Astronomy (Siddhantas), including the works of Aryabhaṭa, Varahamihira and Bhaskara II, to calculate planetary positions, eclipses and the length of the day.	**Approx. 15 Hours**
	4	**Mathematical Traditions and Modern Relevance** Calculus and its origins: Examine the ideas of infinitesimals and early forms of calculus found in the works of the Kerala School of Mathematics and compare them with the later development of calculus in Europe. Combinatorics and Probability: Explore the concepts of permutations and combinations as discussed in texts by Mahavira and Bhaskara II, and their application in ancient Indian poetry and prosody. Modern relevance of IKS in Mathematics: Discuss how concepts from Indian Mathematics can be a source of inspiration for modern-day research in areas like number theory, algorithms and computational Mathematics. Encourage students to reflect on the holistic approach of IKS to problem-solving.	**Approx. 15 Hours**

Suggested References:

1. **A Modern Introduction to Ancient Indian Mathematics** by T.S. Bhanu Murthy, New Age International(P) Ltd., New Delhi, ISBN 9788122403718. … (Unit-1)
2. **Indian Mathematical Luminaries – Part 1: Indian Knowledge System (IKS) Series** by Dr. Bhargabjyoti Saikia, Notion Press, Chennai, ISBN 9798893221206. … (Unit-1)
3. **History of Mathematics in India** by Kim Plofker, Princeton University Press, ISBN 9780691120676. … (Unit-2,3 & 4)
4. **The Crest of the Peacock: Non-European Roots of Mathematics** by George Gheverghese Joseph, Princeton University Press, ISBN 9780691135267. … (Unit-4)
5. **Introduction to Indian Knowledge System: Concepts and Applications** by B. Mahadevan, V.R. Bhat & R.N. Nagendra Pavana, PHI Learning, ISBN 9789391818203.
6. **Indian Mathematics: Engaging with the World from Ancient to Modern Times** by George Gheverghese Joseph, World Scientific Publishing, ISBN 9781944660307.
7. **The History and Philosophy of Science: An Indian Perspective** by S.M. Bhattacharya et al., Routledge India, ISBN 9780367471064.
8. **A Critical Survey of Indian Philosophy** by Chandradhar Sharma, Motilal Banarsidass Publishing House, ISBN 9788120803657.
9. **Aspects of Science and Technology in Ancient India** by Arun Kumar Jha & Seema Sahay, Routledge India, ISBN 9781032441382.

Course Level	5.5		**Internal Marks**	50
Programme	B.Sc. Mathematics (Hon.)		**External Marks**	50
Semester	VI		**Practical Internal**	---
Category of Course	Minor Course – 6		**Practical External**	---
Course Credit	4		**Prac. External Exam Duration**	---
Teaching Hours	4 Hours/week		**Total (SEE+CCE)**	100
Course Code			**Exam Duration**	02:00 Hours
Course Title	**Applied Mathematics – III (Graph Theory)**			

Course objectives: This course aims to equip students with a comprehensive understanding of Graph Theory. It has the following list of objectives:

- To introduce the fundamental terminology, notation, and basic structures of Graph Theory.
- To develop a strong understanding of various graph types, properties and basic graph operations.
- To explore the theoretical concepts and conditions related to Eulerian and Hamiltonian circuits.
- To establish the properties of trees and the concept of spanning trees within general graphs.
- To analyze graph resilience through concepts like cut-sets, connectivity and separability.
- To teach the necessary conditions for planarity and the use of Euler's formula and Kuratowski's theorem.
- To explain the principles of graph colouring, the Chromatic Number and their real-world implications.
- To impart knowledge of representing graph structures using matrices (Adjacency, Incidence, Path).
- To connect graph structures with concepts from Linear Algebra, including Vector spaces, Circuit subspace and Orthogonal spaces.
- To prepare students to model real-world problems (e.g., routing, networking) using the core principles of Graph Theory.

Course Learning Outcomes: The learning outcomes for Graph theory focuses on core concepts, structures, operations, circuits, trees, planarity, colouring, matrices and its Linear Algebra connections. Upon successful completion of the course, student will be able to:

- Define and classify various graph structures, including directed, undirected, complete and regular graphs and calculate the degree and incidence relations.
- Determine whether a given graph contains an Eulerian path or a Hamiltonian cycle by applying relevant theorems.

- Prove fundamental properties of trees and efficiently find a spanning tree for any connected graph.
- Identify and analyze the cut-sets and cut-vertices in a graph to determine its connectivity and separability.
- Apply Euler's formula to planar graphs and determine whether a graph is planar or non-planar using the concepts of Kuratowski's graphs.
- Calculate the Chromatic number of a graph and perform basic graph partitioning based on colouring principle.
- Construct and interpret the Adjacency, Incidence and Path matrices for any given graph.
- Formulate the Vector space associated with a graph and define its circuit and cut-set subspaces.
- Relate the algebraic properties of the graph's matrices to its structural properties (e.g., rank of matrices to connectivity).
- Apply the learned graph theory concepts to model and analyze simple network problems.

Course Contents:

Sem	Unit No	Syllabi	Teaching Hours
6	1	**Fundamentals of Graph Theory** Basic definitions and properties: Basic definitions and simple examples, Incidence relation and degree of the graph. Types of Graphs: Directed, Undirected, Multi-graph, Mixed graph, Empty, Complete, Regular graphs. Subgraphs and Connectivity: Subgraph, Connected and disconnected graphs. Walk and unilateral components. Graph Operations.	**Approx. 10 Hours**
	2	**Paths, Cycles and Trees** Eulerian and Hamiltonian Circuits: Euler graphs (Eulerian path / circuit), Unicursal graph, Hamiltonian paths and cycles. Tree and Spanning tree: Definition of a tree, Properties of trees, Binary tree, Spanning tree. Advanced connectivity and Separability: Cut-set, connectivity and separability.	**Approx. 18 Hours**
	3	**Planar Graphs and Graph Coloring** Planar graphs: Planar graphs and their different representations, Dual of a planar graph, Euler's formula for planar graph. Non-planar graphs: Kuratowski's first and second graphs. Graph coloring: Vertex coloring, Chromatic number, Index number and partition.	**Approx. 18 Hours**
	4	**Matrix Representation and Vector Spaces** Matrix representation: Matrix representation of a graph, Adjacency	**Approx. 14 Hours**

		matrix, Incidence matrix, Path matrix. Rank of the adjacency matrix. Vector spaces and cyclic Properties: Vector space associated with a graph, Circuit subspace and cut sets subspace, Orthogonal space, Cyclic graph and decyclization of cyclic graphs.	

[**Omitted Topics: 1-isomorphism, 2-isomorphism, Circuit matrix, Fundamental circuit matrix and cut set matrix, and related concepts**]

Suggested References:

1. **Graph Theory with Applications to Engineering and Computer Science** by Narsingh Deo, Dover Publications, ISBN 978-0486807935.
2. **Introduction to Graph Theory** by Douglas B. West, Pearson, ISBN 978-9332549654.
3. **Graph Theory** by J.A. Bondy and U.S.R. Murty, Springer, ISBN 978-1849966900.
4. **Introduction to Graph Theory** by Richard J. Trudeau, Dover Publications, ISBN 978-0486678709.
5. **A First Course in Graph Theory** by Gary Chartrand and Ping Zhang, Dover Publications, ISBN 978-0486483688.

The whole syllabus is covered from the following chapters of book no: 1

Chapter 1: Introduction (**Omit: Initial historical context, e.g. beyond basic mention of Euler**).
Chapter 2: Paths and Circuits (**Omit: Traveling Salesman Problem**)
Chapter 3: Trees and Fundamental Circuits (**Omit: Detailed counting of trees**)
Chapter 4: Cut-sets and Cut-vertices (**Omit: Detailed focus on Fundamental Cut-sets should be minimized)**
Chapter 5: Planar and Dual Graphs (**Omit: 1-Isomorphism, 2-Isomorphism**)
Chapter 6: Vector Spaces of a Graph (**Omit: Union and Intersection of** W_c & W_S)
Chapter 7: Matrix Representation of Graphs (**Omit: Circuit Matrix, Fundamental Circuit Matrix (and its rank), Cut-Set Matrix and the Relationships among these matrices** (A_f, B_f & C_f)
Chapter 8: Coloring, Covering and Partitioning (**Omit: Covering and Partitioning concepts other than coloring/chromatic number**)
Chapter 9: Directed Graphs (**Omit: Tournaments and advanced matrices for directed graphs**)

BHAKTA KAVI NARSINH MEHTA UNIVERSITY
Syllabus of B.Sc. (Honors) as per NEP - 2020
Faculty of Science
Effective from June 2025
Subject: Mathematics
SEMESTER - VI

Course Level	5.5		**Internal Marks**	50
Programme	B.Sc. Mathematics (Hon.)		**External Marks**	50
Semester	VI		**Practical Internal**	---
Category of Course	Minor Course – 6		**Practical External**	---
Course Credit	4		**Prac. External Exam Duration**	---
Teaching Hours	4 Hours/week		**Total (SEE+CCE)**	100
Course Code			**Exam Duration**	02:00 Hours
Course Title	**Vector Calculus and Multiple Integrals**			

Course objectives: This course aims to equip students with the essential vector calculus and multiple integral tools for analyzing and modeling physical systems in three-dimensional space. It has the following list of objectives:

- Fundamental vector operations: To establish a thorough understanding of the algebraic and geometric foundations of vector addition, scalar multiplication, dot product and cross product.
- Geometric interpretation of products: To help students visualize and interpret the geometrical meaning of the vector products, specifically the projection, area of a parallelogram/triangle, and the volume of a parallelepiped (using the scalar triple product).
- Introduction to Fields and Differentiation: To introduce the concepts of scalar point functions (scalar fields) and vector point functions (vector fields) and the essential rules for differentiating vector-valued functions.
- Define and interpret vector operators: To clearly define and explain the physical and geometrical interpretations of the primary vector differential operators: Gradient ($\nabla\phi$), Divergence ($\nabla\cdot F$) and Curl ($\nabla\times F$).
- Analyze field properties: To enable students to use the divergence and curl operators to identify and characterize specific field types, such as solenoidal and irrotational fields.
- Explore second order operators: To introduce and analyze the Mathematical significance of the Laplace operator and other second-order differential operations like $\nabla\cdot(\nabla\phi)$, $\nabla\times(\nabla\phi)$, and $\nabla\cdot(\nabla\times F)$.
- Master multiple integration techniques: To provide the necessary skills for the successful evaluation of double and triple integrals over various types of rectangular and general regions using iterated integrals.
- Understand coordinate transformations: To teach the method of changing variables in multiple integrals, emphasizing the role of the Jacobian in transforming integrals between coordinate systems (Cartesian, Polar, Cylindrical and Spherical).

- Introduce line and surface integrals: To define and demonstrate the evaluation of line integrals (both scalar and vector fields) and surface integrals and relate line integrals to the concept of work done.
- Apply fundamental theorems of vector calculus: To introduce Green's theorem (in the plane), emphasizing its geometric intuition and its use in transforming line integrals into double integrals.

Course Learning Outcomes: Upon successful completion of the course, student will be able to

- Calculate the dot product, cross product and scalar triple product of vectors and geometrically interpret their results (e.g. volume, area, angle).
- Differentiate vector point functions with respect to a single variable and apply the standard rules of differentiation.
- Determine the Gradient ($\nabla\phi$) of a scalar field and explain its geometric meaning as the vector normal to a level surface.
- Compute the Divergence ($\nabla\cdot F$) and Curl ($\nabla\times F$) of a vector field and classify the field as solenoidal or irrotational based on the results.
- Evaluate multiple integrals, specifically double and triple integrals, over defined rectangular and general regions using iterated integration.
- Apply double and triple integrals to calculate physical quantities such as the area of a plane region and the volume of a solid.
- Transform double and triple integrals between Cartesian, Polar, Cylindrical and Spherical coordinates using the appropriate Jacobian.
- Evaluate the line integral of both scalar and vector fields and calculate the work done by a force field along a specified path.
- Identify a conservative vector field by using the necessary and sufficient conditions and determine the corresponding potential function.
- Apply Green's Theorem in the plane to transform a line integral over a simple closed curve into an equivalent double integral, simplifying the calculation.

Course Contents:

Sem	Unit No	Syllabi	Teaching Hours
6	**1**	**Vector Algebra** Addition of vectors, Scalar multiplication of a vector, Dot product, Cross product and their geometric interpretation (projection, area of parallelogram/triangle). Scalar triple product (Box product): Definition and geometric interpretation (volume of parallelepiped) and properties. Vector triple product: Definition and expansion formula.	**Approx. 10 Hours**

	2	**Vector Differentiation** Vector point and Scalar point functions: Definition, domain and range. Visualization of scalar and vector fields. Vector differentiation: Derivatives of vector point functions of a single variable, rules of differentiation. Gradient ($\nabla\phi$): Definition, geometric interpretation (normal to a surface). Divergence ($\nabla\cdot F$): Definition, geometric interpretation - Solenoidal fields. Curl ($\nabla\times F$): Definition, geometric interpretation (rotation), Irrotational fields. Laplace Operator (∇) and Second order differential operators: $\nabla\cdot(\nabla\phi)$, $\nabla\times(\nabla\phi)$, $\nabla\cdot(\nabla\times F)$.	**Approx. 15 Hours**
	3	**Multiple Integral** Double and triple integrals: Evaluation over rectangular and general regions, iterated integrals. Its application to calculate area in the plane, volume under a surface. Change of variables: Jacobian and its role in transformation. Change of variables in double integrals: Cartesian to polar co-ordinates. Change of variables in triple integrals: Cartesian to cylindrical co-ordinates and spherical co-ordinates.	**Approx. 20 Hours**
	4	**Line Integral** Line integral: Definition, evaluation of line integrals of scalar and vector fields. Work done by a force. Line integral independent of path. Conservative vector fields: Potential function, necessary and sufficient conditions for a conservative field. Surface integral: Definition and evaluation. Green's theorem (in the plane): Statement, geometric intuition and problems transforming line integral to double integral (without proof).	**Approx. 15 Hours**

Suggested References:

1. **Advanced Engineering Mathematics** by Ervin Kreyszig, Wiley India, ISBN 9788126554234.
2. **Engineering Mathematics** by B.S. Grewal, Khanna Publishers, ISBN 9789381066018.
3. **Vector Calculus** by Susan J. Colley, Pearson Education, ISBN 9780321780652.
4. **Vector Algebra and Calculus** by HariKishan, Atlantic Publishers and distributors, ISBN 9788126908075.
5. **Calculus Vol-II** by Tom Apostol, John Wiley and sons, ISBN 9870471000075.

BHAKTA KAVI NARSINH MEHTA UNIVERSITY
Syllabus of B.Sc. (Honors) as per NEP - 2020
Faculty of Science
Effective from June 2025
Subject: Mathematics
SEMESTER - VI

INTERNAL EVALUATION SCHEME		
NO	**Particulars**	**Marks**
1	**Mid Semester Exam (Mandatory)**	**25**
2	Class Test	05
3	Open book exam/test	05
4	Open note exam/test	05
5	Self-test/ Online test	05
6	Essay/Article writing	05
7	Quizzes/Objective test	05
8	Class assignment	05
9	Home assignment	05
10	Reports Writing	05
11	Research/Dissertation	05
12	Case Studies	05
13	Viva/Oral exam	05
14	Group Discussion	05
15	Role Play	05
16	Paper presentation/Seminar	05
17	Language Lab work	05
18	Interview	05
19	Craft work	05
20	Co-curricular work	05
21	Field Assignment	05
22	Poster Presentation	05
23	Attendance	05
24	Project Work	05
	Total	**50**

Note: Sr. No. 1 is mandatory. Select any five from Sr. No. 2 to 24.
Each contains five marks. Student should secure 18 Marks for passing in internal Exam.

Paper Style

Paper Style for SEE of Major Courses –14, 15 & 16 and Minor Course–6

Que. No.	Particulars	From which Unit	Marks
1	Answer any TWO out of THREE	**1**	**10**
2	Answer any TWO out of THREE	**2**	**10**
3	Answer any TWO out of THREE	**3**	**10**
4	Answer any TWO out of THREE	**4**	**10**
5	Answer any TWO out of THREE	**From all four Units**	**10**
		Total Marks	**50**