Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science & Commerce, Baramati

(*Empowered Autonomous*)

Three/Four Year Honours/Honours with Research B.Sc. (Comp. Sci.) Degree Program

(Faculty of Science)

CBCS Syllabus

S.Y.B.Sc. (Comp. Sci.) Mathematics

For Department of Mathematics

NEP-2.0

Choice Based Credit System Syllabus

(2024 Pattern)

(As Per NEP-2020)

To be implemented from Academic Year 2025-26

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. (Comp. Sci.) Mathematics (2024 Pattern)

Name of the Programme	**:** B.Sc. (Comp. Sci.) Mathematics
Program Code	**:** USCS
Class	**:** S.Y.B.Sc. (Comp. Sci.)
Semester	**:** III
Course Type	**:** Minor
Course Name	**:** Groups and Coding Theory
Course Code	**:** COS-206-MN(B)
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

1. To introduce concept of relation.
2. To introduce basic algebraic properties of groups.
3. Use algebraic techniques to construct efficient codes.
4. Apply Euclid's lemma to solve problems related to divisibility.
5. Provide a clear definition of groups and offer examples to illustrate the concept.
6. Introduce the fundamentals of public-key cryptography and its connection to group theory.
7. Enhance mathematical reasoning and logic through the application of abstract algebraic concepts.

Course Outcomes:

CO1: Students will revise the concept of equivalence relations and learn to apply them to congruence relations on the set of integers.
CO2: Students will have a thorough understanding of integers, including the division algorithm, G.C.D. computation using the Euclidean algorithm, and the application of Euclid's lemma.
CO3: Students will understand the concept of groups, including binary operations, and will be able to identify and provide examples of groups.
CO4: Understand basic terminologies related to finite groups and subgroups, including the subgroup test and properties of cyclic groups.
CO5: Gain a thorough understanding of cosets, properties associated with them, and the Lagrange theorem that relates the order of a group to the order of its subgroups.
CO6: Apply group theory concepts to coding theory, including coding of binary information, error detection, decoding, error correction, and an introduction to public-key cryptography.
CO7: Develop problem-solving skills and critical thinking abilities through the application of mathematical concepts in coding theory and related areas.

Topics and Learning Points

	Teaching Hours
Unit 1: Integers	**08**
1.1 Division algorithm.	
1.2 G.C.D. and Euclidean algorithm.	
1.3 Euclid's lemma.	
1.4 Equivalence relation (revision)	
1.5 Congruence relation on set of integers.	
Unit 2: Groups	**07**
2.1 Binary Operation	
2.2 Group: Definition and Examples	
2.3 Elementary Properties of Groups	
Unit 3: Finite Groups and Subgroups	**07**
3.1 Basic terminologies	
3.2 Subgroup test	
3.3 Cyclic groups	
3.4 Properties of cyclic groups	
3.5 Classification of subgroups of cyclic groups	
3.6 Permutation groups	
Unit 4: Groups and Coding Theory	**08**
4.1 Coding of Binary Information and Error detection	
4.2 Decoding and Error Correction	
4.3 Public Key Cryptography	

Text Books:

1. J. A. Gallian, *Contemporary Abstract Algebra*, Narosa, 7th Edition.
   Unit 1: Chapter 0
   Unit 2: Chapter 2
   Unit 3: Chapters 3, 4, 5
2. Bernard Kolman, Robert C. Busby and Sharon Ross, *Discrete Mathematical Structures*, Pearson Education Publication, 6th Edition.
   Unit 4: Chapter 11

Reference Books:

1. N. S. Gopalakrishnan, *University Algebra*, New Age International (P) Ltd, Publishers, 2nd Edition (1986).
2. P. B. Bhattacharya, S. K. Jain, S. R. Nagpaul, *Basic Abstract Algebra*, Cambridge University Press, 2nd Edition (1994).
3. I. N. Herstein, *Topics in Algebra*, Wiley, 2nd Edition.
4. J. B. Fraleigh, A. *First Course in Abstract Algebra*, Narosa Publishing House.
5. M. Artin, *Algebra*, Prentice Hall of India, New Delhi.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	2	3	2	2	2	3	3
PO03	1	1	1	1	1	2	2
PO04	1	2	2	2	2	3	3
PO05	2	3	3	3	3	3	3
PO06	1	1	1	1	1	2	2
PO07	1	2	2	2	2	3	3
PO08	2	2	2	2	2	3	3
PO09	1	1	1	1	1	2	2
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	2	2	2	2	2	2	3
PO13	1	1	1	1	1	1	2

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - All COs involve core theoretical concepts of number theory and group theory, forming the foundation of abstract algebra. Hence, each CO is strongly aligned with PO01.

PO2: ***Practical, professional, and procedural knowledge*** - CO1 to CO5 provide essential procedural skills such as applying Euclidean algorithms, verifying subgroup properties, etc. and CO6 and CO7 demonstrate applications of abstract algebra to real-world scenarios like coding theory and cryptography, adding a practical edge.

PO3: ***Entrepreneurial mindset and knowledge*** **-** While most COs focus on theoretical understanding, CO6 and CO7 encourage innovation and applied thinking in coding theory, slightly contributing to entrepreneurial knowledge.

PO4: ***Specialized skills and competencies*** - CO2 to CO5 foster problem-solving techniques essential to higher mathematical reasoning. Also, CO6 and CO7 integrate advanced group theory into applied areas, demonstrating specialized competency.

PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - All COs, particularly CO2 to CO7, develop structured logical thinking and application of theoretical knowledge to solve mathematical and coding problems.

PO6: ***Communication skills and collaboration*** - While primarily theory-based, some COs (especially CO6 and CO7) may involve teamwork or project-based problem solving (like decoding and encryption), requiring moderate communication.

PO7: ***Research-related skills*** - CO6 and CO7 open pathways to cryptographic and mathematical research and CO2 to CO5 support foundational research in abstract algebra.

PO8: ***Learning how to learn skills*** - All COs build independent learning skills and abstract reasoning ability. CO6 and CO7 especially involve interdisciplinary learning and adaptation to new mathematical tools.

PO9: ***Digital and technological skills*** - CO6 and CO7 involve understanding of coding theory, public-key cryptography, and binary systems, which touch on technological applications of math.

PO10: ***Multicultural competence, inclusive spirit, and empathy*** - Minimal direct connection, though abstract mathematics like group theory is universal and encourages appreciation of diverse intellectual traditions.
PO11: ***Value inculcation and environmental awareness*** - Minimal connection; some indirect ethical implications may arise in the context of cryptography (e.g., data privacy), but not a focus.
PO12: ***Autonomy, responsibility, and accountability*** - Most COs require individual problem-solving, logical thinking, and independent work, especially CO7, which focuses on critical thinking and application.
PO13: ***Community engagement and service*** - Some indirect relevance through CO6 and CO7, where students learn about encryption and coding theory, which can impact secure communication and public service technologies.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. (Comp. Sci.) Mathematics (2024 Pattern)

Name of the Programme	**:** B.Sc. (Comp. Sci.) Mathematics
Program Code	**:** USCS
Class	**:** S.Y.B.Sc. (Comp. Sci.)
Semester	**:** III
Course Type	**:** Minor
Course Name	**:** Groups and Coding Theory Practical using SageMath Software
Course Code	**:** COS-207-MN(B)
No. of Teaching Hours	**:** 60
No. of Credits	**:** 2

Course Objectives:

1. To understand and implement the division algorithm, compute GCD using the Euclidean algorithm, and verify Euclid's Lemma using SageMath.
2. To introduce binary operations and explore their role in group theory.
3. To verify group properties like closure, identity, and inverses using SageMath.
4. To understand cyclic groups, their subgroups, and their applications in algebra and number theory.
5. To test and verify subgroup properties within finite groups.
6. To implement binary error detection and correction in coding theory.
7. To apply basic public key cryptography algorithms for secure communication.

Course Outcomes:

CO1: Student will be able to implement and apply the division algorithm, calculate GCD using the Euclidean algorithm, and verify Euclid's Lemma in integer number theory. This will enhance their ability to manipulate integers and solve related problems efficiently.
CO2: Student will be able to define and work with binary operations, explore their properties, and understand how binary operations form the basis for group theory, thereby developing a foundational understanding of group theory.
CO3: Student will demonstrate the ability to verify and apply the fundamental properties of groups, such as closure, identity, and invertibility, using SageMath. This will deepen their understanding of abstract algebraic structures.
CO4: Student will explore and analyse cyclic groups and their properties, gaining an understanding of how cyclic groups are fundamental to group theory and their role in mathematical structures and cryptography.
CO5: Student will be able to identify and classify subgroups, apply subgroup tests, and verify subgroup properties in finite groups, which are essential skills in group theory and its applications.
CO6: Student will gain hands-on experience in implementing error detection methods, such as parity checks, and will be able to decode and correct errors in binary data transmission, developing a strong foundation in coding theory.
CO7: Student will be able to implement and explore basic cryptographic techniques, particularly public-key cryptography, using SageMath, thus acquiring practical knowledge applicable to modern cryptography and secure communication.

Topics and Learning Points

	Teaching Hours
List of Practical's:	**60**

1. Division Algorithm Implementation in SageMath
2. Calculating GCD Using the Euclidean Algorithm
3. Verifying Euclid's Lemma with SageMath
4. Defining Binary Operations in SageMath
5. Verifying Group Properties Using SageMath
6. Understanding Basic Terminologies of Groups in SageMath
7. Subgroup Test and Verification
8. Exploring Cyclic Groups and Their Structure
9. Classifying Subgroups of Cyclic Groups
10. Implementing Error Detection in Binary Information
11. Decoding and Correcting Errors in Coding Theory
12. Exploring Public Key Cryptography Algorithms

CO-PO Mapping

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PO11	1	1	1	1	1	1	1
PO12	2	2	2	2	2	3	3
PO13	1	1	1	1	1	2	2

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - All COs (CO1–CO7) directly involve key theoretical concepts in number theory, group theory, and cryptography. The course builds deep foundational understanding across various algebraic structures and coding principles.

PO2: ***Practical, professional, and procedural knowledge*** - The use of algorithms (like Euclidean algorithm), SageMath software, cryptographic methods, and error correction techniques provides a strong practical and procedural base, especially in CO3, CO6, and CO7.

PO3: ***Entrepreneurial mindset and knowledge*** **-** While entrepreneurship is not a central focus, CO6 and CO7 (related to coding and cryptography) align with modern industry needs in cybersecurity and communication systems.

PO4: ***Specialized skills and competencies*** - The course offers specialized skills in abstract algebra, error detection, and cryptographic systems. SageMath implementation also supports CO3 and CO7 with technical specialization.

PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - All COs involve solving mathematical problems, constructing and analyzing structures, and applying theorems in practical contexts (like cryptography and coding).

PO6: ***Communication skills and collaboration*** - While the course does not directly emphasize communication, the usage of SageMath and potential collaborative work during lab sessions fosters moderate development in CO3, CO6, and CO7.

PO7: ***Research-related skills*** - CO3, CO6, and CO7 support exploratory and analytical activities, encouraging independent thinking and experimentation, especially with tools like SageMath.

PO8: ***Learning how to learn skills*** - The course promotes independent learning of abstract algebra and applications in cryptography, pushing students to explore computational tools and deepen understanding.

PO9: ***Digital and technological skills*** - SageMath usage and algorithm implementation in CO3, CO6, and CO7 strongly support digital skill development. Other COs contribute indirectly through conceptual foundations.

PO10: ***Multicultural competence, inclusive spirit, and empathy*** - This PO has a minimal direct connection with the course content, as the focus is purely technical and mathematical.

PO11: ***Value inculcation and environmental awareness*** - Similar to PO10, this outcome has limited relevance in a mathematical and computational theory course.
PO12: ***Autonomy, responsibility, and accountability*** - Students are expected to independently use software tools, apply theory to problems, and manage learning goals—especially in CO6 and CO7 which involve practical components.
PO13: ***Community engagement and service*** - Limited scope for community engagement, but CO6 and CO7 could have applications in public cybersecurity or digital safety education.