M Sc MATHEMATICS

LOCF SYLLABUS 2023

Department of Mathematics
School of Computing Sciences
St. Joseph's College (Autonomous)
Tiruchirappalli - 620002, Tamil Nadu, India

SCHOOLS OF EXCELLENCE WITH CHOICE BASED CREDIT SYSTEM (CBCS) POSTGRADUATE COURSES

St. Joseph's College (Autonomous), an esteemed institution in the realm of higher education in India, has embarked on a journey to uphold and perpetuate academic excellence. One of the pivotal initiatives in this pursuit is the establishment of five Schools of Excellence commencing from the academic year 2014-15. These schools are strategically designed to confront and surpass the challenges of the 21st century.

Each School amalgamates correlated disciplines under a unified umbrella, fostering synergy and coherence. This integrated approach fosters the optimal utilization of both human expertise and infrastructure. Moreover, it facilitates academic fluidity and augments employability by nurturing a dynamic environment conducive to learning and innovation. Importantly, while promoting collaboration and interdisciplinary study, the Schools of Excellence also uphold the individual identity, autonomy, and distinctiveness of every department within.

The overarching objectives of these five schools are as follows:

1. Optimal Resource Utilization: Ensuring the efficient use of both human and material resources to foster academic flexibility and attain excellence across disciplines.

2. Horizontal Mobility for Students: Providing students with the freedom to choose courses aligning with their interests and facilitating credit transfers, thereby enhancing their academic mobility and enriching their learning experience.

3. Credit-Transfer Across Disciplines (CTAD): The existing curricular structure, compliant with regulations from entities such as TANSCHE and other higher educational institutions, facilitates seamless credit transfers across diverse disciplines. This underscores the adaptability and uniqueness of the choice-based credit system.

4. Promotion of Human Excellence: Nurturing excellence in specialized areas through focused attention and resources, thus empowering individuals to excel in their respective fields.

5. Emphasis on Internships and Projects: Encouraging students to engage in internships and projects, serving as stepping stones toward research endeavors, thereby fostering a culture of inquiry and innovation.

6. Addressing Stakeholder Needs: The multi-disciplinary nature of the School System is tailored to meet the requirements of various stakeholders, particularly employers, by equipping students with versatile skills and competencies essential for success in the contemporary professional landscape.

In essence, the Schools of Excellence at St. Joseph's College (Autonomous) epitomize a holistic approach towards education, aiming not only to impart knowledge but also to cultivate critical thinking, creativity, and adaptability – qualities indispensable for thriving in the dynamic global arena of the 21st century.

Credit system

The credit system at St. Joseph's College (Autonomous) assigns weightage to courses based on the hours allocated to each course. Typically, one credit is equivalent to one hour of instruction per week. However, credits are awarded regardless of actual teaching hours to ensure consistency and adherence to guidelines.

The credits and hours allotted to each course within a programme are detailed in the Programme Pattern table. While the table provides a framework, there may be some flexibility due to practical sessions, field visits, tutorials, and the nature of project work.

For postgraduate (PG) courses, students are required to accumulate a minimum of 110 credits, as stipulated in the programme pattern table. The total minimum number of courses offered by the department is outlined in the Programme Structure.

OUTCOME-BASED EDUCATION (OBE)

OBE is an educational approach that revolves around clearly defined goals or outcomes for every aspect of the educational system. The primary aim is for each student to successfully achieve these predetermined outcomes by the culmination of their educational journey. Unlike traditional methods, OBE does not prescribe a singular teaching style or assessment format. Instead, classes, activities, and evaluations are structured to support students in attaining the specified outcomes effectively.

In OBE, the emphasis lies on measurable outcomes, allowing educational institutions to establish their own set of objectives tailored to their unique context and priorities. The overarching objective of OBE is to establish a direct link between education and employability, ensuring that students acquire the necessary skills and competencies sought after by employers.

OBE fosters a student-centric approach to teaching and learning, where the delivery of courses and assessments are meticulously planned to align with the predetermined objectives and outcomes. It places significant emphasis on evaluating student performance at various levels to gauge their progress and proficiency in meeting the desired outcomes.

Here are some key aspects of Outcome-Based Education:

Course: A course refers to a theory, practical, or a combination of both that is done within a semester.

Course Outcomes (COs): These are statements that delineate the significant and essential learning outcomes that learners should have achieved and can reliably demonstrate by the conclusion of a course. Typically, three or more course outcomes are specified for each course, depending on its importance.

Programme: This term pertains to the specialization or discipline of a degree programme.

Programme Outcomes (POs): POs are statements that articulate what students are expected to be capable of by the time they graduate. These outcomes are closely aligned with Graduate Attributes.

Programme Specific Outcomes (PSOs): PSOs outline the specific skills and abilities that students should possess upon graduation within a particular discipline or specialization.

Programme Educational Objectives (PEOs): PEOs encapsulate the expected accomplishments of graduates in their careers, particularly highlighting what they are expected to achieve and perform during the initial years postgraduation.

LEARNING OUTCOME-BASED CURRICULUM FRAMEWORK (LOCF)

The Learning Outcomes-Centric Framework (LOCF) places the learning outcomes at the forefront of curriculum design and execution. It underscores the importance of ensuring that these outcomes are clear, measurable, and relevant. LOCF orchestrates teaching methodologies, evaluations, and activities in direct correlation with these outcomes. Furthermore, LOCF adopts a backward design approach, focusing on defining precise and attainable learning objectives. The goal is to create a cohesive framework where every educational element is in harmony with these outcomes.

Assessment practices within LOCF are intricately linked to the established learning objectives. Evaluations are crafted to gauge students' achievement of these outcomes accurately. Emphasis is often placed on employing authentic assessment methods, allowing students to showcase their learning in real-life scenarios. Additionally, LOCF frameworks emphasize flexibility and adaptability, enabling educators to tailor curriculum and instructional approaches to suit the diverse needs of students while ensuring alignment with the defined learning outcomes.

Some important terminologies

Core Courses (CC): *These are compulsory courses that students must undertake as essential components of their curriculum, providing fundamental knowledge within their primary discipline. Including core courses is essential to maintain a standardized academic programme, ensuring recognition and consistency across institutions.*

Common Core (CC): *A common core course is a shared educational element encompassing fundamental topics across disciplines within a school. It promotes interdisciplinary comprehension and collaboration among students by providing a foundational understanding of key subjects essential for academic and professional success across diverse fields of study.*

Elective Courses (ES): *Elective courses are offered within the main discipline or subject of study. They allow students to select specialized or advanced options from a range of courses, offering in-depth exposure to their chosen area of study. Typically, ES are more applied in nature and provide a deeper understanding of specific topics.*

Generic Elective Courses (EG): *These elective courses are chosen from disciplines unrelated to the student's main area of study, aiming to broaden their exposure and knowledge base. As per the Choice Based Credit System (CBCS) policy, students may opt for generic elective courses offered by other disciplines within the college, enhancing the diversity of their learning experience.*

Ability Enhancement Course (AE): *AE is designed to enhance skills and proficiencies related to the student's main discipline. It aims to provide practical training and hands-on experience, contributing to the overall development of students pursuing academic programmes.*

Skill Enhancement Course (SE): *SE focus on developing specific skills or proficiencies relevant to students' academic pursuits. While it is open to students from any discipline, SE is particularly beneficial for those within the related academic programme.*

Self-paced Learning (SP): *This course promotes independent learning habits among students and they have to undergo the course outside the regular class hours within a specified timeframe.*

Comprehensive Examinations (CE): *These examinations cover detailed syllabi comprising select units from courses offered throughout the programme. They are designed to assess crucial knowledge and content that may not have been covered extensively in regular coursework.*

Extra Credit Courses: *To support students in acquiring knowledge and skills through online platforms such as Massive Open Online Courses (MOOCs), additional credits are granted upon verification of course completion. These extra credits can be availed across five semesters (2 - 6). In line with UGC guidelines, students are encouraged to enhance their learning by enrolling in MOOCs offered by portals like SWAYAM, NPTEL, and others. Additionally, certificate courses provided by the college are also considered for these extra credits.*

Outreach Programme (OR): *It is a compulsory course to create a sense of social concern among all the students and to inspire them to dedicated service to the needy.*

Course Coding

The following code system (10 alphanumeric characters) is adopted for Postgraduate courses:

23	**UXX**	**0**	**XX**	**00/X**
Year of Revision	PG Department Code	Semester Number	Course Specific Initials	Running Number/with Choice

Course Specific Initials

CC - Core Course
CP - Core Practical
ES - Elective
AE - Ability Enhancement Course
SP - Self-paced Learning
EG - Generic Elective
PW - Project and Viva Voce
CE - Comprehensive Examination
OR - Outreach Programme
IS – Internship

EVALUATION PATTERN
Continuous Internal Assessment

Sl No	Component	Marks Alloted
1	Mid Semester Test	30
2	End Semester Test	30
3	*Three Components (15 + 10 + 10)	35
4	Library Referencing (30 hours)	5
	Total	**100**

Passing minimum: 50 marks

* *The first component is a compulsory online test (JosTEL platform) comprising 15 multiple choice questions (10 questions at K1 level and 5 questions at K2 level); The second and the third components are decided by the course in-charge.*

Question Paper Blueprint for Mid and End Semester Tests

<table>
<tr><td colspan="3">Duration: 2 Hours</td><td colspan="6">Maximum Marks: 60</td></tr>
<tr><td colspan="2" rowspan="2">Section</td><td colspan="6">K levels</td><td rowspan="2">Marks</td></tr>
<tr><td>K1</td><td>K2</td><td>K3</td><td>K4</td><td>K5</td><td>K6</td></tr>
<tr><td colspan="2">A (compulsory)</td><td>7</td><td></td><td></td><td></td><td></td><td></td><td>7 × 1 = 7</td></tr>
<tr><td colspan="2">B (compulsory)</td><td></td><td>5</td><td></td><td></td><td></td><td></td><td>5 × 3 = 15</td></tr>
<tr><td colspan="2">C (either…or type)</td><td></td><td></td><td>3</td><td></td><td></td><td></td><td>3 × 6 = 18</td></tr>
<tr><td rowspan="4">D (2 out of 3)</td><td>For courses with K5 as the highest cognitive level, one K4 and one K5 question is compulsory. (Note: two questions on K4 and one question on K5)</td><td></td><td></td><td></td><td>1</td><td>1*</td><td></td><td rowspan="4">2 × 10 = 20</td></tr>
<tr><td rowspan="3">For courses with K6 as the highest cognitive level: Mid Sem: two questions on K4 and one question on K5; End Sem: two questions on K5 and one question on K6)</td><td></td><td></td><td></td><td colspan="2">Mid Sem</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">End Sem</td></tr>
<tr><td></td><td></td><td></td><td>1</td><td>1</td><td>1*</td></tr>
<tr><td colspan="7">Total</td><td>60</td></tr>
</table>

***** *Compulsory*

Question Paper Blueprint for Semester Examination

Duration: 3 Hours						**Maximum Marks: 100**
UNIT	**Section A** *(Compulsory)*	**Section B** *(Compulsory)*	**Section C** *(Either…or type)*	**Section D** *(3 out of 5)*		
	K1	**K2**	**K3**	**K4**	**K5**	**K6**
UNIT I	2	2	2	2*	2*	1*
UNIT II	2	2	2			
UNIT III	2	2	2			
UNIT IV	2	2	2			
UNIT V	2	2	2			
Marks	**10 × 1 = 10**	**10 × 3 = 30**	**5 × 6 = 30**	**3 × 10 = 30**		

** For courses with K6 as the highest cognitive level wherein one question each on K4, K5 and K6 is compulsory.*
(Note: two questions each on K4 and K5 and one question on K6)

Evaluation Pattern for One/Two-credit Courses

Title of the Course	CIA	Semester Examination	Total Marks
• Ability Enhancement Course	20 + 10 + 20 = 50	50 *(A member from the Department other than the course instructors)*	100
• Self-paced Learning • Comprehensive Examination	25 + 25 = 50	50 *(CoE)*	100
• Internship	100	-	100
• Skill Enhancement Course: Soft Skills	100	-	100
• Project Work and Viva Voce	100	100	100

Grading System

The marks obtained in the CIA and semester for each course will be graded as per the scheme provided in Table - 1.

From the second semester onwards, the total performance within a semester and the continuous performance starting from the first semester are indicated by Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA), respectively. These two are calculated by the following formulae:

$$SGPA \ and \ CGPA = \frac{\sum_{i=1}^{n} C_i Gp_i}{\sum_{i=1}^{n} C_i}$$

$$WAM = \frac{\sum_{i=1}^{n} C_i M_i}{\sum_{i=1}^{n} C_i}$$

Where,

Ci - credit earned for the Course i

Gpi - Grade Point obtained for the Course i

Mi - Marks obtained for the Course i

*n - Number of Courses **passed** in that semester*

WAM - Weighted Average Marks

Table - 1: Grading of the Courses for PG

Mark Range	Grade Point	Corresponding Grade
90 and above	10	O
80 and above and below 90	9	A+
70 and above and below 80	8	A
60 and above and below 70	7	B+
50 and above and below 60	6	B
Below 50	0	RA

Table - 2: Grading of the Final Performance for PG

CGPA	Grade	Performance
9.00 and above	O	Outstanding*
8.00 to 8.99	A+	Excellent*
7.00 to 7.99	A	Very Good
6.00 to 6.99	B+	Good
5.00 to 5.99	B	Above Average
Below 5.00	RA	Re-appear

**The Candidates who have passed in the first appearance and within the prescribed duration of the PG programme are eligible. If the Candidates Grade is O/A+ with more than one attempt, the performance is considered "Very Good".*

Vision

Forming globally competent, committed, compassionate and holistic persons, to be men and women for others, promoting a just society.

Mission

- Fostering learning environment to students of diverse background, developing their inherent skills and competencies through reflection, creation of knowledge and service.
- Nurturing comprehensive learning and best practices through innovative and value- driven pedagogy.
- Contributing significantly to Higher Education through Teaching, Learning, Research and Extension.

Programme Educational Objectives (PEOs)

1. Graduates will be able to accomplish professional standards in the global environment.
2. Graduates will be able to uphold integrity and human values.
3. Graduates will be able to appreciate and promote pluralism and multiculturalism in working environment.

Programme Outcomes (POs)

1. Graduates will be able to apply assimilated knowledge to evolve tangible solution to emerging problems.
2. Graduates will be able to analyze and interpret data to create and design new knowledge.
3. Graduates will be able to engage in innovative and socially relevant research and effectively communicate the findings.
4. Graduates will become ethically committed professional and entrepreneurs upholding human values.
5. Graduates imbibed with ethical values and social concern will be able to understand and appreciate cultural diversity, social harmony and ensure sustainable environment.

Programme Specific Objectives (PSOs)

Graduate will be able to

1. Appreciate the emphasis given on teaching the fundamentals, the basic concepts, definitions with a variety of examples.
2. Realise the importance given to applications by applying the concepts studied for designing models to solve real life problems.
3. Develop the skill to solve problems which appear in the various examinations based on the concepts learned which in turn will hone the problem solving skills of students and help them to pass competitive examinations including CSIR-NET, SET, IAS, etc
4. Learn application oriented subjects which will impress upon them their responsibility to the society.
5. Get proper orientation that a research degree is not end of learning. They are encouraged to publish papers on a continual basis in the standard journals during and after Ph.D.

PROGRAMME STRUCTURE				
Semester	**Course Specification**	**Number of Courses**	**Hours**	**Credits**
1 - 4	Core Course	13	73	69
1 - 4	Core Practical	-	-	-
1, 2, 4	Elective	4	20	14
1	Ability Enhancement Course	1	2	1
2	Self-paced Learning	1	-	2
2	Skill Enhancement Course	1	4	3
2, 3	Generic Elective	2	8	6
3	Common Core	1	5	4
2 - 4	Extra Credit Course	3	-	(9)
4	Project Work and Viva Voce	1	8	5
4	Comprehensive Examination	1	-	2
2 - 4	Outreach Program	-	-	4
	Total	**28**	**120**	**110(9)**

M Sc MATHEMATICS							
Course Details					Scheme of Exams		
Sem	**Course Code**	**Title of the Course**	**Hours**	**Credits**	**CIA**	**SE**	**Final**
1	23PMA1CC01	**Core Course - 1**: Algebraic Structures	6	6	100	100	100
	23PMA1CC02	**Core Course - 2**: Real Analysis - 1	6	6	100	100	100
	23PMA1CC03	**Core Course - 3**: Ordinary Differential Equations	6	4	100	100	100
	23PMA1ES01	**Elective - 1:** Graph Theory and its Applications	5	3	100	100	100
	23PMA1ES02	**Elective - 2:** Fuzzy Sets and Their Applications	5	3	100	100	100
	23PMA1AE01	**Ability Enhancement Course:** Problem Solving in Advanced Mathematics	2	1	100	-	100
		Total	**30**	**23**			
2	23PMA2CC04	**Core Course - 4**: Advanced Algebra	6	6	100	100	100
	23PMA2CC05	**Core Course - 5**: Real Analysis - 2	5	4	100	100	100
	23PMA2CC06	**Core Course - 6**: Complex Analysis	6	5	100	100	100
	23PMA2SP01	**Self-paced Learning:** History of Mathematics*	-	2	50	50	50
	23PMA2ES03A	**Elective - 3:** Algebraic Number Theory	5	4	100	100	100
	23PMA2ES03B	**Elective - 3:** Optimization Techniques					
	23PSS2SE01	**Skill Enhancement Course:** Soft Skills	4	3	100	-	100
	-	**General Elective - 1: (WS):** Refer ANNEXURE 1	4	3	100	100	100
	-	Extra Credit Courses (MOOC/Certificate Courses) - 1	-	(3)			
		Total	**30**	**27(3)**			
3	23PMA3CC07	**Core Course - 7**: Measure and Integration	6	6	100	100	100
	23PMA3CC08	**Core Course - 8**: Topology	6	6	100	100	100
	23PMA3CC09	**Core Course - 9**: Classical Dynamics	5	5	100	100	100
	23PMA3CC10	**Core Course - 10**: Stochastic Processes	4	4	100	100	100
	23SCS3CC01	**Common Core:** Design and Analysis of Algorithms	5	4	100	100	100
	-	**Generic Elective-2 (BS):** Refer ANNEXURE 2	4	3	100	100	100
	-	Extra Credit Courses (MOOC/Certificate Courses) - 2	-	(3)			
		Total	**30**	**28(3)**			
4	23PMA4CC11	**Core Course - 11**: Functional Analysis	6	6	100	100	100
	23PMA4CC12	**Core Course - 12**: Calculus of Variations and Integral Equations	6	6	100	100	100
	23PMA4CC13	**Core Course - 13**: Partial Differential Equations	5	5	100	100	100
	23PMA4ES04A	**Elective - 4:** Automata Theory	5	4	100	100	100
	23PMA4ES04B	**Elective - 4:** Differential Geometry					
	23PMA4PW01	Project Work and Viva Voce	8	5	100	100	100
	23PMA4CE01	Comprehensive Examination*	-	2	50	50	50
	-	Extra Credit Courses (MOOC/Certificate Courses) - 3	-	(3)			
		Total	**30**	**28(3)**			
2 - 4	23PCW4OR01	Outreach Programme (SHEPHERD)	-	4			
1 - 4		**Total (2years)**	**120**	**110(9)**			

*- for grade calculation 50 marks are converted into 100 in the mark statements

Passed by	***Board of Studies held on 18.12.2023***
Approved by	***48th Academic Council Meeting held on 27.03.2024***

ANNEXURE 1
Generic Elective - 1 (WS)*

Course Details		
School	**Course Code**	**Title of the Course**
SCS	23PCA2EG01	Applied Statistics Using R
	23PDS2EG01	Discrete Mathematics
	23PCS2EG01	Mobile Adhoc Networks (MANET)

**Offered to students from other Departments within School*

ANNEXURE 2
Generic Elective - 1 (BS)*

Course Details		
School	**Course Code**	**Title of the Course**
SBS	23PBI3EG02	First Aid Management
	23PBT3EG02	Food Technology
	23PBO3EG02	Horticulture and Landscaping
SLAC	23PEN3EG02	English for Effective Communication
SMS	23PCO3EG02	Basics of TallyPrime
	23PCC3EG02	Dynamics of Human Behaviour in Business
	23PCP3EG02	Social Psychology
	23PEC3EG02	Managerial Economics
	23PHR3EG02	Counselling and Guidance
SPS	23PCH3EG02	Health Science
	23PEL3EG02	Computer Hardware and Networks
	23PPH3EG02A	Physics for Competitive Exams
	23PPH3EG02B	Nanoscience

**Offered to students from other Schools*

Semester	Course Code	Title of the Course	Hours/Week	Credits
1	23PMA1CC01	**Core Course - 1:** Algebraic Structures	6	5

Course Objectives
To gain a deep understanding of important concepts of class equations and Sylow's theorem in group theory and develop proficiency in their applications.
To investigate the structure and behavior of algebraic systems and classify them based on certain properties, and apply the concepts to solve various mathematical problems in diverse area of studies.
To understand the concepts of linear transformations and their properties, simplifying their representation, and analyzing their behaviors in various mathematical contexts.
To simplify matrix representations while the rational canonical form aims to classify matrices, study minimal polynomials, and compute matrix powers efficiently.
To provide insights into Eigen values and quadratic forms.

UNIT I **(18 Hours)**

Counting Principle - Class equation for finite groups and its applications - Sylow's theorems (For theorem 2.12.1, First proof only).

UNIT II **(18 Hours)**

Solvable groups - Direct products - Finite abelian groups- Modules.

UNIT III **(18 Hours)**

Linear Transformations: Canonical forms -Triangular form - Nilpotent transformations.

UNIT IV **(18 Hours)**

Jordan form - rational canonical form.

UNIT V **(18 Hours)**

Trace and transpose - Hermitian, unitary, normal transformations, real quadratic form.

Teaching Methodology	Chalk and talk, Lectures, Demonstrations, PPT.

Books for Study

1. Herstein, I.N. (1975), *Topics in Algebra,* (2nd Ed.). Wiley Eastern Limited, New Delhi.
   Unit I : Chapter 2: Sections 2.11 and 2.12 (Omit Lemma 2.12.5)
   Unit II : Chapter 5 : Section 5.7 (Lemma 5.7.1, Lemma 5.7.2, Theorem 5.7.1)
   Chapter 2: Section 2.13 and 2.14 (Theorem 2.14.1 only)
   Chapter 4: Section 4.5
   Unit III : Chapter 6: Sections 6.4, 6.5
   Unit IV : Chapter 6 : Sections 6.6 and 6.7
   Unit V : Chapter 6 : Sections 6.8, 6.10 and 6.11 (Omit 6.9)

Books for Reference

1. Artin, M. (1991). *Algebra.* Prentice Hall of India.
2. Bhattacharya, P. B., Jain, S.K., & Nagpaul, S.R. (1997). *Basic Abstract Algebra,* (2nd Ed.). Cambridge University Press (Indian Edition).
3. Luther, S., & Passi, I.B.S. (1999). *Algebra, Vol. I -Groups (1996); Vol. II Rings,* Narosa Publishing House, New Delhi.

4. Malik, D. S., Mordeson, J.N., & Sen, M.K. (1997). *Fundamental of Abstract Algebra*. McGraw Hill (International Edition), New York.
5. Jacobson, N. (1980). *Basic Algebra, Vol. I & II W. H. Freeman.* published by Hindustan Publishing Company, New Delhi.

Website and e-Learning Source

1. http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics,
2. http://www.opensource.org, www.algebra.com

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Levels)**
CO1	Recall basic counting principle, define class equations to solve problems, explain Sylow's theorems and apply the theorem to find number of Sylow subgroups.	**K1**
CO2	Define Solvable groups, define direct products, examine the properties of finite abelian groups, define modules	**K2**
CO3	Define similar Transformations, define invariant subspace, explore the properties of triangular matrix, to find the index of nilpotence to decompose a space into invariant subspaces, to find invariants of linear transformation, to explore the properties of nilpotent transformation relating nilpotence with invariants.	**K3**
CO4	Define Jordan, canonical form, Jordan blocks, define rational canonical form, define companion matrix of polynomial, find the elementary devices of transformation, apply the concepts to find characteristic polynomial of linear transformation.	**K4**
CO5	Define trace, define transpose of a matrix, explain the properties of trace and transpose, to find trace, to find transpose of matrix, to prove Jacobson lemma using the triangular form, define symmetric matrix, skew symmetric matrix, adjoint, to define Hermitian, unitary, normal transformations and to verify whether the transformation in Hermitian, unitary and normal	**K5**
CO6	Interpret and evaluate ideas of theory of Eigen values and quadratic forms.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
1	**23PMA1CC01**			**Core Course - 1:** Algebraic Structures					**6**		**5**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	3	2	1	3	2	3	2	3	**2.5**
CO2	2	3	3	2	2	2	3	2	1	3	**2.3**
CO3	3	2	3	2	2	3	2	2	2	2	**2.3**
CO4	3	3	2	2	2	3	3	3	2	3	**2.6**
CO5	2	3	3	2	1	3	3	2	2	3	**2.4**
CO6	2	3	3	2	1	3	3	2	2	3	**2.4**
										Mean Overall Score	**2.42 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
1	23PMA1CC02	**Core Course - 2:** Real Analysis - 1	6	5

Course Objectives
To enable the students to learn the basic concepts of real analysis.
To understand proof techniques in analysis and be well prepared for the advanced courses like functional analysis and advanced analysis
To work comfortably with functions of bounded variation, Riemann - Stieltjes Integration
To work with Convergence of infinite series and infinite product.
To know uniform convergence and its interplay between various limiting operations

UNIT I **(18 Hours)**

Introduction - Properties of monotonic functions - Functions of bounded variation - Total variation - Additive property of total variation - Total variation on $[a, x]$ as a function of x - Functions of bounded variation expressed as the difference of two increasing functions - Continuous functions of bounded variation - Absolute and conditional convergence - Dirichlet's test and Abel's test - Rearrangement of series - Riemann's theorem on conditionally convergent series.

UNIT II **(18 Hours)**

Introduction - Notation - The definition of the Riemann - Stieltjes integral - Linear Properties - Integration by parts- Change of variable in a Riemann - Stieltjes integral - Reduction to a Riemann Integral - Euler's summation formula - Monotonically increasing integrators, Upper and lower integrals - Additive and linearity properties of upper, lower integrals - Riemann's condition - Comparison theorems.

UNIT III **(18 Hours)**

Integrators of bounded variation-Sufficient conditions for the existence of Riemann-Stieltjes integrals-Necessary conditions for the existence of RS integrals- Mean value theorems -integrals as a function of the interval - Second fundamental theorem of integral calculus-Change of variable -Second Mean Value Theorem for Riemann integral- Riemann-Stieltjes integrals depending on a parameter-Differentiation under integral sign-Lebesgue criteriaon for existence of Riemann integrals.

UNIT IV **(18 Hours)**

Double sequences - Double series - Rearrangement theorem for double series - A sufficient condition for equality of iterated series - Multiplication of series - Cesaro summability - Infinite products - Multiplication of power series - The Taylor's series generated by a function - Bernstein's theorem - Abel's limit theorem - Tauber's theorem

UNIT V **(18 Hours)**

Pointwise convergence of sequences of functions - Examples of sequences of real - valued functions - Uniform convergence and continuity - Cauchy condition for uniform convergence - Uniform convergence of infinite series of functions - Riemann - Stieltjes integration - Non-uniform Convergence and Term-by-term Integration - Uniform convergence and differentiation - Sufficient condition for uniform convergence of a series - Mean convergence.

Book for Study

1. Apostol, T.M. (1974). *Mathematical Analysis*, (2nd Ed.). Addison-Wesley Publishing Company Inc. New York.
   Unit - I *Chapter 6(Sec 6.1 - 6.8) and Chapter 8 (8.8, 8.15, 8.17, 8.18)*
   Unit - II *Chapter 7 (Sec 7.1 - 7.14)*

Unit - III *Chapter 7(Sec 7.15 - 7.26)*
Unit - IV *Chapter 8(Sec 8.20 - 8.26) and Chapter 9 (9.14 9.15, 9.19, 9.20, 9.22, 9.23)*
Unit - V *Chapter -9 (Sec 9.1 to 9.6, 9.8,9.9,9.10,9.11, 9.13)*

Books for Reference

1. Bartle, R.G. (1976). *Real Analysis*, John Wiley and Sons Inc.
2. Rudin, W. (1976). *Principles of Mathematical Analysis*, (3rd Ed.). McGraw Hill Company, New York.
3. Malik, S.C., & Arora, S. (1991). *Mathematical Analysis*, Wiley Eastern Limited. New Delhi.
4. Arora, S., & Lal, B. (1991). *Introduction to Real Analysis.* Satya Prakashan, New Delhi.
5. Gelbaum, B.R., & Olmsted, J. (1964). *Counter Examples in Analysis.* Holden day, San Francisco.
6. Gupta, A.L., & Gupta, N.R. (2003). *Principles of Real Analysis*, Pearson Education, (Indian print).

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K - Levels)**
	On successful completion of this course, students will be able to	
CO1	acquire knowledge of functions of bounded variation, Riemann-Stieltjes, and uniform convergence	**K1**
CO2	understand the concepts of Riemann- Stieltjes integral, uniform convergence and its properties.	**K2**
CO3	apply the properties of bounded variation, Riemann integral in convergence of sequence of functions.	**K3**
CO4	evaluate the properties of convergence of series and Riemann integrability of functions	**K4**
CO5	analyze the functions of bounded variation, Riemann integral and double series.	**K5**
CO6	construct proofs and examples of Riemann- Stieltjes integration, convergence of sequence of functions and double series	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
1	**23PMA1CC02**			**Core Course - 2: Real Analysis - 1**						**6**	**5**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	3	3	3	2	3	3	3	3	2	**2.7**
CO2	3	2	3	3	2	2	3	2	3	3	**2.6**
CO3	3	3	3	2	3	3	3	2	3	3	**2.8**
CO4	3	2	3	3	2	3	2	3	3	3	**2.7**
CO5	3	3	3	2	3	3	3	3	3	3	**2.9**
CO6	3	3	3	3	2	2	3	2	2	3	**2.6**
										Mean Overall Score	**2.7 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
1	23PMA1CC03	**Core Course - 3:** Ordinary Differential Equations	6	4

Course Objectives
Develop strong background on finding solutions to linear differential equations with constant and variable coefficients and also with singular points
Understanding the concepts of Linear dependence and independence, Wronskian, Singular points, Bessel function, Lipschitz condition, etc.,
Develop strong background on finding solutions to Legendre equation, Euler equation, Exact equation and its applications
Give a depth knowledge of solving initial value problems in ordinary differential equations
Skill to study the existence and uniqueness of solution in first and higher order differential equations

UNIT I: Linear equations with constant coefficients **(18 Hours)**

Second order homogeneous equations-Initial value problems-Linear dependence and independence - Wronskian and a formula for Wronskian - Non-homogeneous equation of order two.

Chapter 2: Sections 1 to 6

UNIT II: Linear equations with constant coefficients **(18 Hours)**

Homogeneous and non-homogeneous equation of order n - Initial value problems - Annihilator method to solve non-homogeneous equation - Algebra of constant coefficient operators.

Chapter 2: Sections 7 to 12

UNIT III: Linear equation with variable coefficients **(18 Hours)**

Initial value problems - Existence and uniqueness theorems - Solutions to solve a non-homogeneous equation - Wronskian and linear dependence - reduction of the order of a homogeneous equation - homogeneous equation with analytic coefficients - The Legendre equation.

Chapter: 3 Sections 1 to 8 (Omit section 9)

UNIT IV: Linear equation with regular singular points **(18 Hours)**

Euler equation - Second order equations with regular singular points - Exceptional cases - Bessel Function.

Chapter 4: Sections 1 to 4 and 6 to 8 (Omit sections 5 and 9)

UNIT V **(18 Hours)**

Existence and uniqueness of solutions to first order equations: Equation with variable separated - Exact equation - method of successive approximations - the Lipschitz condition - convergence of the successive approximations and the existence theorem.

Chapter 5: Sections 1 to 6 (Omit Sections 7 to 9)

Teaching Methodology	Chalk and talk, Lectures, Demonstrations, PPT.

Books for Study

1. Coddington, E.A. (1987). *A introduction to ordinary differential equations*, (3rd Printing) Prentice-Hall of India Ltd., New Delhi.

Books for Reference

1. Boyce, W.E., & Prima, R.D.CI. (1967). *Elementary differential equations and boundary value problems*. John Wiley and sons, New York.
2. Simmons, G.F. (1974). *Differential equations with applications and historical notes*. Tata McGraw Hill, New Delhi.

3. Lebedev, N.N. (1965). *Special functions and their applications*, Prentice Hall of India, New Delhi.
4. Reid, W.T. (1971). *Ordinary Differential Equations*. John Wiley and Sons, New York.
5. Raisinghania, M.D. (2001). *Advanced Differential Equations*. S. Chand & Company Ltd. New Delhi.
6. Rai, B., Choudary, D.P., & Freedman, H.I. (2002). *A Course in Ordinary Differential Equations*, Narosa Publishing House, New Delhi.

Website and eLearning Source

1. http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics
2. http://www.opensource.org
3. www.mathpages.com

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Levels)**
CO1	establish the qualitative behaviour of solutions of systems of differential equations	**K1**
CO2	recognize the physical phenomena modelled by differential equations and dynamical systems.	**K2**
CO3	analyse solutions using appropriate methods and give examples	**K3**
CO4	formulate Wronskian for initial value problems	**K4**
CO5	understand and use various theoretical ideas and results that underlie the mathematics in this course.	**K5**
CO6	formulate and solve the different kinds of ordinary differential equations.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**				**Hours**		**Credits**	
1	**23PMA1CC03**			**Core Course -3:** Ordinary Differential Equations				**6**		**4**	
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	3	3	3	3	3	2	3	**2.8**
CO2	2	2	2	3	3	3	3	3	2	3	**2.6**
CO3	2	2	3	3	3	3	3	3	3	3	**2.8**
CO4	3	3	2	3	3	3	3	3	2	3	**2.8**
CO5	2	2	3	2	3	2	3	3	2	3	**2.5**
CO6	2	2	3	3	3	3	3	3	3	3	**2.8**
										Mean Overall Score	**2.7 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
1	23PMA1ES01	**Elective - 1:** Graph Theory and its Applications	5	3

Course Objectives
To introduce the basic concepts of graphs and digraphs.
To introduce the notion of connectivity in graphs and the concept of trees.
To familiarize on the ideas of independent sets, coverings, matchings and factors.
To acquaint on Eulerian, Hamiltonian and planar graphs and the concept of graph colorings, and the notion of duality in graphs.
To develop the skill of formulating real life problems to graphical models and finding solutions.

UNIT I **(15 Hours)**

Basic concepts - Subgraphs - Degrees of vertices - Paths and connectedness - Operations on graphs - Directed graphs: Basic concepts.

UNIT II: **(15 Hours)**

Vertex cuts and Edge cuts - Connectivity and Edge - Connectivity - Trees: Definition, Characterization and Simple Properties - Applications : Prim's Algorithm.

UNIT III **(15 Hours)**

Vertex Independent sets and Vertex Coverings - Edge Independent sets - Matching's and Factors - Eulerian graphs - Hamiltonian graphs.

UNIT IV **(15 Hours)**

Vertex colorings - Applications of Graph Coloring - Critical graphs - Edge colorings of graphs.

UNIT V **(15 Hours)**

Planar and nonplanar graphs - Euler formula and its consequences - K_5 and $K_{3,3}$ are nonplanar Graphs - Dual of a plane Graph - The Four-Color theorem and the Heawood Five-Color theorem.

Note: Theorems, propositions and results which are starred in the book are to be omitted.

Teaching Methodology	Chalk and Talk and PPT

Books for Study

1. Balakrishnan, R. & Ranganathan, K. (2000). *A Textbook of Graph Theory*, Springer (India) Private Limited, New Delhi.
   Unit-I : *Chapter I: 1.1 - 1.4, 1.7, Chapter II: 2.1, 2.2*
   Unit-II : *Chapter III: 3.1, 3.2, Chapter IV: 4.1, 4.3, 4. 4, Chapter X: 10.3*
   Unit-III: *Chapter V: 5.1 to 5.3, Chapter VI: 6.1, 6.2*
   Unit-IV: *Chapter VII: 7.1, 7.2, 7.4*
   Unit-V : *Chapter VIII: 8.1 to 8.5*

Books for Reference

1. Bondy, J. A., Murty, U. S. R. (1976). *Graph Theory with Applications.* Macmillan Press Ltd.
2. Harary, F. (1969). *Graph Theory*. Addison - Wesley Publishing Company, Inc.
3. Chartrand, G., Lesniak, L., & Zhang, P. (2010). *Graphs and Digraphs*. CRC press.

Website and e-Learning Source

1. https://onlinecourses.nptel.ac.in/noc20_ma05/preview
2. https://onlinecourses.swayam2.ac.in/cec20_ma03/preview

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Levels)**
CO1	acquire in-depth knowledge on vital concepts in graph theory.	**K1**
CO2	understand the graphs, its types and on the theory of connectivity, colorings and planarity.	**K2**
CO3	apply the imbibed knowledge on the concepts to categorize graphs.	**K3**
CO4	analyze and infer properties of graphs and its associated concepts.	**K4**
CO5	evaluate various parameters of a graph.	**K5**
CO6	construct graphs with specific properties.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
1	**23PMA1ES01**			**Elective - 1:** Graph Theory and its Applications					**5**		**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	3	3	2	3	3	2	2	2	3	**2.5**
CO2	3	2	2	3	2	2	3	2	2	3	**2.4**
CO3	2	3	2	2	2	3	3	3	2	2	**2.4**
CO4	2	2	3	2	2	2	2	3	3	2	**2.3**
CO5	3	2	2	3	2	3	2	2	2	3	**2.4**
CO6	3	2	3	3	2	2	3	2	2	2	**2.4**
Mean Overall Score											**2.4 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
1	23PMA1ES02	**Elective - 2:** Fuzzy Sets and Their Applications	5	3

Course Objectives
To enable the students to understand the concept of fuzzy logic, fuzzy sets, properties of α-cuts, extension principles.
To enable the students to understand the generalized concepts of fuzzy complements, t-norm and t-conorm.
To provide the idea of fuzzy numbers, fuzzy relations, fuzzy equivalence relations.
To distinguish possibility theory and probability theory
To understand the decision making process and apply them to real life problems.

UNIT I: Basics of Fuzzy sets **(15 Hours)**

Fuzzy sets - introduction, Basic types and Basic concepts, Additional properties of α-cuts, Representation of fuzzy sets, Extension principles

UNIT II: Operations on fuzzy sets **(15 Hours)**

Type of operators on fuzzy sets and fuzzy complements, Fuzzy intersection and fuzzy unions, Combination of operations

UNIT III: Fuzzy arithmetic and fuzzy relations **(15 Hours)**

Fuzzy numbers, arithmetic operations on intervals, Arithmetic operations on fuzzy numbers, Fuzzy equations, fuzzy relations: Binary fuzzy relations and binary relation on a single set, Fuzzy equivalence relations

UNIT IV: Possibility theory **(15 Hours)**

Fuzzy measures - Evidence theory - Possibility theory - Fuzzy sets and Possibility theory - Possibility theory versus Probability theory

UNIT V: Fuzzy Decision making **(15 Hours)**

Introduction, Individual Decision Making, Multiperson decision Making, Multicriteria decision Making, Fuzzy ranking methods

Teaching Methodology	Chalk and Talk , PPT

Books for Study

1. Klir, G.J., & Yuan, B. (1997). *Fuzzy Sets and Fuzzy logic - Theory and Applications*. Prentice Hall India, New Delhi.
   - **Unit - I** *Chapter 1 and Chapter 2: Sections 1.3,1.4, 2.1 to 2.3*
   - **Unit - II** *Chapter 3: Sections 3.1 to 3.5*
   - **Unit - III** *Chapter 4 and Chapter 5: Sections 4.1, 4.3, 4.4, 5.1 to 5.5*
   - **Unit - IV** *Chapter 7: Sections 7.1 to 7.5*
   - **Unit - V** *Chapter 15: Sections 15.1 to 15.6*

Books for Reference

1. Zimmermann, H.J. (1987). *Fuzzy sets, Decision making and expert systems*. Kluwer, Bosten.
2. Chen, S. J., & Hwang, C.L. (1992). *Fuzzy Multiple Attributes Decision Making*. Springer Verlag, Berlin Heidelberg.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Levels)**
CO1	acquire the knowledge of various types of fuzzy sets, α-cuts and its properties and extension of functions.	**K1**
CO2	understand various operations (fuzzy complements, fuzzy intersections and fuzzy unions) on fuzzy sets and symbolic computations.	**K2**
CO3	apply the concepts of fuzzy decision making methods in engineering and management problems.	**K3**
CO4	distinguish possibility theory and probability theory	**K4**
CO5	Explain various fuzzy related concepts	**K5**
CO6	Create the fuzzy relations and identify the different types of fuzzy relations and their applications numbers, divisors, modulo arithmetic, primitive roots and quadratic residues.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
1	**23PMA1ES02**			**Elective - 2:** Fuzzy Sets and Their Applications					**5**		**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	2	1	2	2	3	2	2	3	3	**2.2**
CO2	2	1	2	1	2	2	3	3	3	2	**2.1**
CO3	1	2	2	3	1	2	3	3	3	2	**2.2**
CO4	3	2	1	2	3	2	3	3	2	1	**2.2**
CO5	2	3	2	3	1	3	3	2	3	3	**2.5**
CO6	1	2	2	3	1	2	3	3	3	2	**2.2**
										Mean Overall Score	**2.2 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
1	23PMA1AE01	**Ability Enhancement Course:** Problem Solving in Advanced Mathematics	2	1

Course Objectives
To understand the concepts in Real Analysis, Algebra and Ordinary differential equations
To recall the fundamental ideas in various interpretations of the problems
To create many examples to justify the answers
To analyze and apply the results and techniques to get solutions
To train the students in problem-solving as a preparatory to NET/SET

UNIT I **(6 Hours)**

Sets - open - closed - compact - connected - Sequences and series.

UNIT II **(6 Hours)**

Continuity - uniform continuity - differentiability - mean value theorems - Riemann integral - Uniform convergence.

UNIT III **(6 Hours)**

Groups - subgroups - normal subgroups - cyclic groups - quotient groups - homomorphisms - permutation groups.

UNIT IV **(6 Hours)**

Cayley's theorem - class equations - Sylow theorems - Rings - ideals - quotient rings - prime and maximal ideals.

UNIT V **(6 Hours)**

Wronskian - Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations.

Teaching Methodology	Chalk and talk, Lectures, Demonstrations, PPT.

Books for Study

1. Singh, A.P. (2017). *Info Study's Real Analysis*. Info study Publications
   Unit I: *Chapter 1*: 1.1, 1.24 - 1.40, *Chapter 2*: 2.1 - 2.2
   Unit II: *Chapter 3*: 3.1 - 3.3, 3.5.3,
   Chapter 2: 2.3, *Chapter 5*: 5.1
2. Singh, A.P. (2017). *Info Study's Modern Algebra,* Info study Publications
   Unit III: *Chapter 1*: 1.1 - 1.2, 1.5 - 1.7, 1.10
   Chapter 2: 2.1 - 2.4
   Unit IV: *Chapter 2*: 2.5 - 2.7, 3.5.3,
   Chapter 3: 3.1 - 3.8, 3.10, 3.11, 3.15.6, 3.15.7
3. Singh, A.P. (2017). *Info Study's Differential Equation*, Info study Publications
   Unit V: *Chapter 2*: 2.10, *Chapter 3*: 3.1

Books for Reference

1. Rudin, W. (1976). *Principles of Mathematical Analysis*, (3rd Ed.). Mc Graw-Hill International Book Company, New York.
2. Gallian, J.A. (2012). *Contemporary Abstract Algebra*, (7th Ed.). Katherine Tegan Books.
3. Coddington, E.A. (1992). *An Introduction to Ordinary Differential Equations*, Prentice-Hall of India, New Delhi.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Levels)**
CO1	acquire knowledge of fundamental concepts on Analysis, Algebra and Differential Equations.	**K1**
CO2	understand the nuances of problem-solving approach in Real Analysis and Algebra and Differential equations.	**K2**
CO3	identify and apply the relevant techniques to solve problems in pure and applied mathematics.	**K3**
CO4	analyze the efficiency of a specific technique when solving a problem.	**K4**
CO5	evaluate various interpretations of the problems	**K5**
CO6	develop new problem-solving methodology to tackle problems in Advanced Mathematics	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**				**Hours**		**Credits**	
1	**23PMA1AE01**			**Ability Enhancement Course:** Problem Solving in Advanced Mathematics				**2**		**1**	
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	1	2	2	1	3	2	3	3	3	**2.2**
CO2	2	2	2	2	2	3	3	3	2	2	**2.3**
CO3	1	2	2	2	2	3	3	3	2	3	**2.3**
CO4	2	2	2	2	1	3	3	3	2	3	**2.3**
CO5	1	3	2	1	1	2	3	3	1	2	**1.9**
CO6	2	2	2	2	2	3	3	3	2	2	**2.3**
										Mean Overall Score	**2.2 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PMA2CC04	**Core Course - 4:** Advanced Algebra	6	6

Course Objectives
To gain deep understanding of important concepts of extension fields and roots of Polynomials, field theory and develop proficiency in their applications.
To investigate the structure and behavior of algebraic systems and classify them based on certain properties, and apply the concepts to solve various mathematical problems in diverse areas of studies.
To understand the concepts of Hermitian, unitary and normal linear transformations and their properties, simplifying their representation, and analyzing their behaviors in various mathematical contexts.
Tosimplifyrealquadraticformsandtoclassifyvariouslineartransformationsefficiently.
To provide insights into finite fields and finite division rings.

UNIT I **(18 Hours)**

Extension fields - The Transcendence of e.

UNIT II **(18 Hours)**

Roots of Polynomials - More about roots

UNIT III **(18 Hours)**

Elements of Galois theory.

UNIT IV **(18 Hours)**

Finite fields - Wedderburn's theorem on finite division rings.

UNIT V **(18 Hours)**

Solvability by radicals - A theorem of Frobenius - Integral Quaternions and the Four - Square theorem.

Teaching Methodology	Chalk and talk, Lectures, Demonstrations, PPT.

Books for Study

1. Herstein, I. N. (1975), *Topics in Algebra* (2nd Ed.) Wiley Eastern Limited.
   Unit I Chapter 5: Section 5.1 and 5.2
   Unit II Chapter 5: Sections 5.3 and 5.5
   Unit III Chapter 5: Section 5.6
   Unit IV Chapter 7: Sections 7.1 and 7.2 (Theorem 7.2.1 only)
   Unit V Chapter 5: Section 5.7 (omit Lemma 5.7.1, Lemma 5.7.2 and Theorem 5.7.1), Chapter 7: Sections 7.3 and7.4

Books for Reference

1. Artin, M. (1991). *Algebra.* Prentice Hall of India.
2. Bhattacharya, P. B., Jain, S. K., & Nagpaul, S.R. (1997). *Basic Abstract Algebra* (2nd Ed.). Cambridge University Press.
3. Luther, I. S. & Passi, I. B. S. (1996). *Algebra, Vol. I -Groups; Vol. II Rings*, Narosa Publishing House.
4. Malik, D. S., Mordeson, J. N., & Sen, M. K. (1997). *Fundamental of Abstract Algebra*, McGraw-Hill.
5. Jacobson, N. (1980). *Basic Algebra, Vol. I & II W.H. Freeman.* Hindustan Publishing Company.

Website and eLearning Sources

1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics,
3. http://www.opensource.org
4. www.algebra.com

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K- Levels)**
CO1	recall basic concepts on Vector spaces, define finite extension, define the number, define Hermitian, unitary and normal transformations, define Galois groups and finite fields	**K1**
CO2	classify the roots of a polynomial, summarize remainder theorem, understand the characteristics of a field, summarize Wedderburn's theorem and Frobenius theorem.	**K2**
CO3	relate solve ability for Galois groups, prove e is transcendental, relate unitary linear transformation to orthonormal basis	**K3**
CO4	illustrate Hermitian, unitary and normal linear transformations with examples.	**K4**
CO5	demonstrate knowledge and understanding of fundamental concepts including extension fields, Algebraic extensions, Finite fields, Class equations and Sylow's theorem.	**K5**
CO6	develop new results based on Wedderburn's theorem, Frobenius theorem and the Four-square theorem.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
2	**23PMA2CC04**			**Core Course - 4:** Advanced Algebra						**6**	**6**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	3	2	1	3	2	3	2	3	**2.5**
CO2	2	3	3	2	2	2	3	2	1	3	**2.3**
CO3	3	2	3	2	2	3	2	2	2	2	**2.3**
CO4	3	3	2	2	2	3	3	3	2	3	**2.6**
CO5	2	3	3	2	1	3	3	2	2	3	**2.4**
CO6	2	3	3	2	1	3	3	2	2	3	**2.4**
									Mean Overall Score		**2.42 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PMA2CC05	**Core Course - 5:** Real Analysis - 2	5	4

Course Objectives
To give the students a thorough knowledge of the various aspects of real line and metric spaces.
To train the students for advanced learning in pure mathematics
To give the students the knowledge of analyzing and approaching life
To train the students to apply pure mathematics to applied problems
To train the students in problem-solving as a preparatory to NET/SET

UNIT I **(15 Hours)**

Finite, Countable and Uncountable Sets - Metric Spaces - Compact Sets - Perfect Sets - Connected Sets.

UNIT II **(15 Hours)**

The Root and Ratio Tests- Power Series - Summation by Parts - Absolute Convergence - Continuous functions - Continuity and Compactness - Continuity and Connectedness-Mean Value Theorems - L 'Hospital's Rule-Taylor's Theorem

UNIT III **(15 Hours)**

Power Series - The Exponential and Logarithmic Functions -The Trigonometric Functions-The Algebraic Completeness of the Complex Field.

UNIT IV **(15 Hours)**

Fourier Series - Parseval's Theorem-The Gamma Function.

UNIT V **(15 Hours)**

Linear Transformations - Differentiation - The Contraction Principle - The Inverse Function Theorem.

Teaching Methodology	Chalk and Talk, PPT

Book for Study

1. Rudin, W. (1976). *Principles of Mathematical Analysis,* (3rd Ed.). McGraw-Hill.

Unit I *Chapter 2*
Unit II *Chapter 3 (Sec: 3.33 - 3.46),*
Chapter 4 (Sec: 4.5 - 4.24)
Chapter 5 (Sec: 5.7-5.11, 5.13, and 5.15)
Unit III *Chapter 8 (Sec:8.1 - 8.8)*
Unit IV *Chapter 8 (Sec: 8.9 - 8.22)*
Unit V *Chapter 9 (Sec:9.1 - 9.25)*

Books for Reference

1. Apostol, T.M. (1974). *Mathematical Analysis.* Addison, Wesley Publishing Company.
2. Goldberg, R. R. (1970). *Methods of Real Analysis.* Oxford & IBH Publishing Company.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	gain knowledge of concepts of modern analysis such as convergence, continuity, completeness and compactness in the Euclidean space and more general metric spaces.	**K1**
CO2	understand the properties of some special functions and the limits and how they used in convergence properties of sequence and series, continuity and derivative of real functions.	**K2**
CO3	identify the applications of integration, linear transformation And power series.	**K3**
CO4	analyze the abstract ideas and various methods in mathematical analysis and apply them to practical problems.	**K4**
CO5	construct mathematical proofs for basic results as associated with the Continuity and differentiability of real valued functions.	**K5**
CO6	evaluate problems on the concepts learned.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
2	**23PMA2CC05**			**Core Course - 5:** Real Analysis - 2						**5**	**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	2	1	1	1	2	2	2	1	1	**1.5**
CO2	3	2	2	1	1	3	2	2	1	1	**1.8**
CO3	1	1	3	3	1	2	2	3	3	1	**2**
CO4	2	3	2	2	1	2	2	2	2	1	**1.9**
CO5	2	2	2	1	1	2	1	3	2	2	**1.8**
CO6	2	2	1	2	2	2	3	3	2	2	**2.1**
										Mean Overall Score	**1.85 (Medium)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PMA2CC06	**Core Course - 6:** Complex Analysis	6	5

Course Objectives
To develop Knowledge and understand the fundamental concepts of Analytic Functions
To enhance problem-solving skills with line integrals
To enable the use of singularities
To enrich a proper understanding of definite integrals
To develop Knowledge about power series expansion

UNIT I **(18 Hours)**

Concept of Analytic Function, Limits and Continuity - Analytic Functions - Polynomials-Rational Functions- Power series - Abel's Limit Theorem.

UNIT II **(18 Hours)**

Complex Integration - Fundamental Theorems - Line Integrals - Rectifiable arcs - Line integrals as Functions of Arcs - Cauchy's Theorem for a Rectangle - Cauchy's Theorem in a Disk.

UNIT III **(18 Hours)**

Cauchy's Integral Formula - The index of appoint with respect to a closed curve - The integral formula- Higher Derivatives - Removable Singularities Taylor's Theorem.

UNIT IV **(18 Hours)**

The Maximum principle - The Calculus of Residues - The Residue theorem - The Argument principle- Evaluation of Definite Integrals.

UNIT V **(18 Hours)**

Harmonic functions, Power Series expansion - Poisson's Formula - Schwarz's Theorem - Weier strass's Theorem - The Taylor series -The Laurent series

Teaching Methodology	Chalk and Talk, PPT

Book for Study

1. Ahlfors, L.V. (2013). *Complex Analysis: An Introduction to the Theory of Analytic Functions of One Complex Variable,* (3rd Ed.). Mac Millan Publishers.
   UNIT-I *Chapter 2 (sec:1.1-1.4,2.4 & 2.5 Pages 21-33, 38-42)*
   UNIT-II *Chapter 4 (sec1.1-1.5 Pages 101-114)*
   UNIT-III *Chapter 4 (sec2.1-2.3, 3.1 Pages 114-126)*
   UNIT-IV *Chapter 4 (sec3.4,5.1-5.3 Pages 133-137,148-161)*
   UNIT-V *Chapter 4 (sec 6.3 & 6.4) Chapter 5 (sec 1.1-1.3 Pages 166-172, 175-186)*

Books for Reference

1. Conway, J.B. (1978). *Function of one Complex Variable.* (2nd Ed.). Springer Graduate Texts in Mathematics.
2. Ponnusamy, S. (2005). *Foundations of Complex Analysis*, (2nd Ed.). Narosa Publishing House.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	acquire knowledge on fundamental concepts of Analyticity, Complex integration and Harmonic Functions.	**K1**
CO2	understand the behavior of Analytic Functions, Taylor's and Laurent's Series expansions.	**K2**
CO3	apply C-R equations, Residue Theorem in solving problems involving complex function theory.	**K3**
CO4	demonstrate a good understanding of Mathematical reasoning through Cauchy's Theorem.	**K4**
CO5	evaluate integrals, region of convergence and contour integrals.	**K5**
CO6	analyze sequence and series of analytic functions, types of convergence, apply the concept and consequences of harmonic function, represent functions as Taylor and Laurent series	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
2	**23PMA2CC06**			**Core Course - 6:** Complex Analysis						**6**	**5**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	2	1	2	2	3	2	3	2	3	**2.3**
CO2	3	2	2	2	2	3	2	2	2	2	**2.2**
CO3	3	2	2	2	2	2	2	3	2	3	**2.3**
CO4	2	2	2	2	2	2	2	2	2	3	**2.1**
CO5	2	2	2	2	2	2	2	3	2	3	**2.2**
CO6	2	2	2	2	2	2	2	3	2	2	**2.2**
										Mean Overall Score	**2.2 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PMA2SP01	**Self-paced Learning:** History of Mathematics	-	2

Course Objectives
Knowledge on the History of Decimals and Limits
Acquaintance with the development of Algebra
Familiarity of Invention of Differential Calculus
The lives of Eratosthenes and Dirichlet
The lives of Henri Poincare and Emmy Noether

UNIT I

The Ancient Greeks - Pythagoras- Introduction to Pythagorean Ideas-Euclid - Introduction to Euclid - Archimedes - The Genius of Archimedes-Zeno's Paradox and the Concept of Limit- The Context of the Paradox? - Consideration of the Paradoxes - Decimal Notation and Limits -Infinite Sums and Limits-Finite Geometric Series.

UNIT II

The Arabs and the Development of Algebra - The Development of Algebra Al-Khwarizmi and the Basics of Algebra- The Life of Al- Khwarizmi- Omar Khay yam and the Resolution of the Cubic- Cardano, Abel, Galois, and the Solving of Equations - A Particular Equation - The General Case - The Brief and Tragic Lives of Abel and Galois - The Work of Abel and Galois in Context- Rene Descartes and the Idea of Coordinates- Introductory Remarks-The Life of Rene Descartes - The Real Number Line- The Cartesian Plane - Coordinates in Three- Dimensional Space.

UNIT III

The Invention of Differential Calculus - The Life of Fermat - Fermat's Method-Fermat's Lemma and Maximum/Minimum Problems - Complex Numbers and Polynomials-Progenitors of the Complex Number System - Cardano - Argand - Cauchy - Riemann - Complex Number Basics - The Fundamental Theorem of Algebra - Finding the Roots of a Polynomial- Cauchy and the Foundations of Analysis - Why Do We Need the Real Numbers?

UNIT IV

The Prime Numbers - The Sieve of Eratosthenes- The Infinitude of the Primes -Dirichletand How to Count - The Life of Dirichlet - The Pigeonhole Principle - Riemann and the Geometry of Surfaces-Introduction- Georg Cantor and the Orders of Infinity-Introductory Remarks- An Uncountable Set-Countable and Uncountable-The Existence of Transcendental Numbers.

UNIT V

Henri Poincare, Child Prodigy - Introductory Remarks - Emmy Noether and Algebra - The Life of Emmy Noether- Emmy Noether and Abstract Algebra: Groups-Emmy Noether and Abstract Algebra: Rings - The Idea of an Ideal-Cryptography- What is Cryptography?

Teaching Methodology	JosTEL

Books for Study

1. Krantz, S.G. (2010). *An Episodic History of Mathematics.* The Mathematical Association of America.

   Unit I Sec: 1.1,1.1.1, 1.2, 1.2.1, 1.3,1.3.1, 2.1, 2.3, 2.4-2.6.
   Unit II Sec: 4.2,4.2.1, 4.2.2, 4.2.4, 5.6,5.7, 5.7.1, 5.7.2, 5.8.1, 5.9, 6.0-6.3, 6.5.
   Unit III Sec: 7.1,7.2, 7.4, 8.2, 8.2.1-8.2.5,8.3, 8.4, 8.5, 10.1,10.2.
   Unit IV Sec: 11.1,11.2, 12.1, 12.2,13.0,14.1, 14.2.1, 14.2.2,14.3.
   Unit V Sec: 16.1,18.1, 18.2,18.3, 18.3.1, 20.3.

Books for Reference

1. Boyer, C.B., Merzbach, U. (2011). *History of Mathematics,* (3rd Ed.). John Wiley & Sons.
2. Bell, E. T. (1986). *Men of Mathematics*. Simon & Schuster.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	acquire knowledge on the history of mathematics	**K1**
CO2	understand the inter relations among the various branches of mathematics.	**K2**
CO3	predict the dynamic nature of mathematics including recent development in pure and applied mathematics.	**K3**
CO4	identify various proof techniques used in theorems.	**K4**
CO5	assess creative and flexible thinking by studying historical evidences that there are different ways to view a mathematical concept.	**K5**
CO6	construct abstract characterization of ideas from known examples.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
2	**23PMA2SP01**			**Self-paced Learning:** History of Mathematics						**-**	**2**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	1	2	3	1	2	2	3	3	2	3	**2.2**
CO2	1	2	3	1	2	2	3	3	2	3	**2.2**
CO3	2	3	3	1	1	3	1	3	2	3	**2.2**
CO4	2	3	2	1	2	2	3	3	1	3	**2.2**
CO5	2	2	2	1	2	2	3	3	3	3	**2.3**
CO6	2	2	3	1	2	2	3	2	1	3	**2.1**
Mean Overall Score											**2.2 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PMA2ES03A	**Elective - 3:** Algebraic Number Theory	5	4

Course Objectives
To understand the basic concepts such as divisibility, primes, congruences and solutions in congruences
To know some techniques of abstract algebra to study integers
To highlight the knowledge on Quadratic residues
To highlight some of the Applications of the Theory of Numbers.
To get the more knowledge on Diophantine Equations

UNIT I **(15 Hours)**

Introduction - Divisibility - Primes - The Binomial Theorem - Congruences Euler's totient - Fermat's, Euler's and Wilson's Theorems - Solutions of Congruences - The Chinese Remainder theorem.

UNIT II **(15 Hours)**

Prime power Moduli - Primitive roots and Power Residues - Number theory from an Algebraic Viewpoint- Groups, rings and fields.

UNIT III **(15 Hours)**

Quadratic Residues - Quadratic Reciprocity - The Jacobi Symbol - Binary Quadratic Forms-Equivalence and Reduction of Binary Quadratic Forms-sum of two squares.

UNIT IV **(15 Hours)**

Greatest integer Function - Arithmetic Functions - The Mobius Inversion Formula Recurrence Functions-Combinatorial number theory

UNIT V **(15 Hours)**

Diophantine Equations - The equation $ax + by = c$ - Simultaneous Linear Diophantine Equations- Pythagorean Triangles- Assorted examples

Teaching Methodology	Chalk and Talk, PPT, Video Lecture

Book for Study

1. Niven, I., Zuckerman, H.S., & Montgomery, H.L. (2004). *An Introduction to the Theory of Numbers*, (5th Ed.). John Wiley & Sons Inc.
   Unit- I *Chapter 1 and Chapter 2: Sections 2.1 to 2.3*
   Unit- II *Chapter 2: Sections 2.6 to 2.11*
   Unit- III *Chapter 3: Sections 3.1 to 3.6*
   Unit- IV *Chapter 4*
   Unit- V *Chapter 5: Sections 5.1 to5.4*

Books for Reference

1. Jones, G.A., & Jones, M. J. (2005). *Elementary Number Theory*. Springer Verlag,
2. Burton, D.M. (2007). *Elementary Number Theory*, (6th Ed.). McGraw-Hill.
3. Andrews, G. (1971). *Theory of Numbers.* Saunders.
4. William, J. (1977). *Fundamentals of Number Theory*, Leveque, Addison-Wesley.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	have knowledge of divisibility, prime numbers, congruences, quadratic reciprocity and Diophantine equations.	**K1**
CO2	understand the concept of number theory toper form numerical and symbolic computations.	**K2**
CO3	solve problems and give short proofs associated with prime numbers, divisors, modulo arithmetic, primitive Roots and quadratic residues.	**K3**
CO4	analyze the theory of congruences, Power Residues, The Jacobi Symbol, The Mobius Inversion Formula and linear Diophantine equations.	**K4**
CO5	evaluate and produce rigorous arguments centered on the material of number theory, most notably in the use of mathematical Induction and/or the Well Ordering Principal in the proof of theorems.	**K5**
CO6	construct and produce rigorous arguments centered on the material of number theory in the proof of theorems.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
2	**23PMA2ES03A**			**Elective - 3:** Algebraic Number Theory					**5**		**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	2	1	2	2	3	2	2	3	3	**2.2**
CO2	2	1	2	1	2	2	3	3	3	2	**2.1**
CO3	1	2	2	3	1	2	3	3	3	2	**2.2**
CO4	3	2	1	2	3	2	3	3	2	1	**2.2**
CO5	2	3	2	3	1	3	3	2	3	3	**2.5**
CO6	3	2	1	2	3	2	3	3	2	1	**2.2**
										Mean Overall Score	**2.23 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PMA2ES03B	**Elective - 3:** Optimization Techniques	5	4

Course Objectives
To explain the concepts and to simultaneously develop an understanding of problem Solving methods
To study the basic components of an optimization problem.
Formulation of design problems as mathematical programming problems
To highlight some of the Applications of the optimization techniques
To impart Optimization Techniques

UNIT I **(15 Hours)**

Optimization of functional - Gateaux and Fréchet Differentials - Fréchet derivatives - Extrema-Euler - Lagrange Equations- Problems with variable end points.

UNIT II **(15 Hours)**

Convex and concave functionals - Conjugate convex, concave functional - Dual optimization problems- Min - Max theorem of game theory.

UNIT III **(15 Hours)**

Lagrange multiplier theorem - Inverse function theorem- Equality and Inequality constraints – Kuhn - Tucker theorem.

UNIT IV **(15 Hours)**

Methods of solving equations - Successive approximation - Newton's method - Descent methods- Steepest descent.

UNIT V **(15 Hours)**

Conjugate gradient method - Methods for solving constrained problems - Projection method -The Primal - Dual method - Penalty Functions.

Teaching Methodology	Chalk and Talk, PPT, Video Lecture

Book for Study

1. Luenberger, D.G. (1997). *Optimization by Vector Space Methods.* Wiley Professional Paperback series.
   Unit- I *(Sec7.1-7.6 Pages 169-184)*
   Unit- II *(Sec7.8, 7.10-7.13 Pages 190, 191,195-208)*
   Unit-III *(Sec9.1-9.4 Pages 239-253)*
   Unit-IV *(Sec10.1-10.5 Pages 271-289)*
   Unit- V *(Sec10.8-10.11 Pages 294-307)*

Books for Reference

1. Dorney, C.N. (1986). *A Vector Space Approach to Models and Optimization.* Robert Krieger Publishing Co.
2. Mohan, C. & Deep, K. (2010). *Optimization Techniques.* New Age International.
3. Hamley, A. & Taha. (2011). *Operations Research: An introduction,* (19th Ed.). Prentice Hall.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	relate the concepts of theory of optimization while solving problems.	**K1**
CO2	understand the theory behind optimization techniques.	**K2**
CO3	apply suitable theory in the optimal problem.	**K3**
CO4	compare the uses of different theories and methods available.	**K4**
CO5	evaluate the optimal solution for the given function.	**K5**
CO6	create some new techniques for optimization	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
2	**23PMA2ES03B**			**Elective - 3:** Optimization Techniques						**5**	**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	2	2	1	2	3	2	2	2	2	**2.1**
CO2	2	3	1	2	2	3	2	3	2	2	**2.2**
CO3	3	3	2	2	2	3	2	3	1	2	**2.3**
CO4	2	2	3	3	2	2	1	2	2	2	**2.1**
CO5	3	2	2	2	1	3	2	3	2	3	**2.3**
CO6	3	3	2	2	2	3	2	3	1	2	**2.3**
									Mean Overall Score		**2.2 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PSS2SE01	**Skill Enhancement Course:** Soft Skills	4	3

Course Objectives
To provide a focused training on soft skills for students in colleges for better job prospects
To communicate effectively and professionally
To help the students take active part in group dynamics
To familiarize students with numeracy skills for quick problem solving
To make the students appraise themselves and assess others

Unit I: Effective Communication & Professional Communication **(12 Hours)**

Definition of communication, Barriers of Communication, Non-verbal Communication; Effective Communication - Conversation Techniques, Good manners and Etiquettes; Speech Preparations & Presentations; Professional Communication.

Unit II: Resume Writing & Interview Skills **(12 Hours)**

Resume Writing: What is a résumé? Types of résumés, - Chronological, Functional and Mixed Resume, Purpose and Structure of a Resume, Model Resume.

Interview Skills: Types of Interviews, Preparation for an interview, Attire, Body Language, Common interview questions, Mock interviews & Practicum

Unit III: Group Discussion & Personal effectiveness **(12 Hours)**

Basics of Group Discussion, Parameters of GD, Topics for Practice, Mock GD & Practicum & Team Building.

Personal Effectiveness: Self Discovery; Goal Setting with questionnaires & Exercises

Unit IV: Numerical Ability **(12 Hours)**

Introducing concepts Average, Percentage; Profit and Loss, Simple Interest, Compound Interest; Time and Work, Pipes and Cisterns.

Unit V: Test of Reasoning **(12 Hours)**

Introducing Verbal Reasoning: Series Completion, Analogy; Data Sufficiency, Assertion and Reasoning; and Logical Deduction. Non-Verbal Reasoning: Series; and Classification

Teaching Methodology	Chalk and talk, Lectures, Demonstrations, PPT.

Book for study

1. Melchias G., Balaiah, J. & Joy, J. L. (Eds). (2018). *Winner in the Making: A Primer on soft Skills.* Trichy, India: St. Joseph's College.

Books for Reference

1. Aggarwal, R. S. (2010). *A Modern Approach to Verbal and Non-Verbal Reasoning.* S. Chand.
2. Covey, S. (2004). *7 Habits of Highly effective people.* Free Press.
3. Gerard, E. (1994). *The Skilled Helper* (5th Ed.). Brooks/Cole.
4. Khera, S. (2003). *You Can Win.* Macmillan Books.
5. Murphy, R. (1998). *Essential English Grammar*, (2nd Ed.). Cambridge University Press.
6. Sankaran, K., & Kumar, M. (2010). *Group Discussion and Public Speaking* (5th Ed.). M.I. Publications.
7. Trishna, K. S. (2012). *How to do well in GDs & Interview*s? (3rd Ed.). Pearson Education.
8. Yate, M. (2005). *Hiring the Best: A Manager's Guide to Effective Interviewing and Recruiting*

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	recall various soft skill sets	**K1**
CO2	understand personal effectiveness in any managerial positions	**K2**
CO3	apply verbal and non-verbal reasoning skills to solve problems	**K3**
CO4	differentiate problems at work and home; and design solutions to maintain work-life balance	**K4**
CO5	assess growth and sustainability and infuse creativity in employment that increases professional productivity	**K5**
CO6	construct plans and strategies to work for better human society	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
2	**23PSS2SE01**			**Skill Enhancement Course:** Soft Skills					**4**		**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	3	3	2	3	2	3	2	3	**2.7**
CO2	3	3	3	2	3	3	3	3	3	3	**2.9**
CO3	3	2	2	3	3	3	3	3	3	3	**2.8**
CO4	3	3	2	2	3	3	3	3	3	3	**2.8**
CO5	3	3	3	2	2	3	3	3	3	3	**2.8**
CO6	3	3	3	2	2	3	3	3	3	3	**2.8**
										Mean Overall Score	**2.8 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	23PMA3CC07	**Core Course -7:** Measure and Integration	6	6

Course Objectives
To describe the approach of the construction of Lebesgue measure and Lebesgue integral of a function and measure spaces.
To Know principal theorems and their proofs and be able to use them in the investigation of examples.
To prove simple propositions concerning measure spaces, Lebesgue measure and integration.
To gain understanding of abstract measure theory and definition and main properties of the integral.
To construct Lebesgue's measure on the real line and in n-dimensional Euclidean space.

UNIT I: Lebesgue Measure **(18 Hours)**

Lebesgue Measure - Outer measure - measurable sets and Lebesgue measure -properties - A non-measurable set - measurable functions - Little wood's three principles. (Proofs of Egoroff's theorem and Lusin's theorem to be omitted)

UNIT II: Lebesgue Integral **(18 Hours)**

Lebesgue Integral of simple function - bounded measurable function - of a nonnegative function - Fatou's lemma - Monotone convergence theorem - General Lebesgue integral - Lebesgue convergence theorem - Convergence in measure.

UNIT III: Differentiation **(18 Hours)**

Differentiation of monotone functions - Vitali's lemma - Integral of derivative - Functions of bounded variation - Differentiation of an integral - absolute continuity-Convex functions- Jensen's inequality.

UNIT IV: Measure spaces **(18 Hours)**

Measure spaces - Measurable functions - Integration - Signed measure - Hahn decompositiontheorem - Jordan decomposition theorem - Radon Nikodym theorem- Lebesgue decompositiontheorem.

UNIT V: Measures and Outer Measures **(18 Hours)**

Outer measure and Measurability - Extension theorem - product measures - Fubini's theorem - Tonelli's theorem.

Teaching Methodology	Chalk and talk, Lectures, Problem Solving, PPT.

Book for Study

1. Royden, H.L. (2007). *Real Analysis.* (3rd Ed.). Prentice Hall of India, New Delhi.
   Unit-I *Chapter 3 Sec. 1 - 6*
   Unit-II *Chapter 4 Sec. 1 - 5*
   Unit-III *Chapter 5 Sec. 1 - 5*
   Unit-IV *Chapter 11 Sec.1- 6*
   Unit-V *Chapter 12 Sec. 1, 2,4*

Books for Reference

1. De Barra, G. (2008). *Measure Theory and Integration*. New Age International Publishers, New Delhi.
2. Rudin, W. (1970). *Real and Complex Analysis*. Mc-Graw Hill Book Company, New York.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Levels)**
CO1	have knowledge of integration using measures.	**K1**
CO2	understand analysis in abstract situations.	**K2**
CO3	identify integral of derivative with differentiation of an integral.	**K3**
CO4	analyze the basic results associated to Measurable functions,Integration Signed measure, decomposition theorems.	**K4**
CO5	evaluate the Outer measure and Measurability by applyingExtension theorems	**K5**
CO6	develop the concepts of outer measure into product measures inFubini's theorem and Tonelli's theorem.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
3	**23PMA3CC07**			**Core Course -7: Measure and Integration**					**6**		**6**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes(PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	1	2	2	1	3	2	3	3	3	2.2
CO2	2	2	2	2	2	3	3	3	2	2	2.3
CO3	1	2	2	2	2	3	3	3	2	3	2.3
CO4	2	2	2	2	1	3	3	3	2	3	2.3
CO5	1	3	2	1	2	2	3	3	1	2	2.0
CO6	2	1	2	3	2	3	2	3	1	2	2.1
										Mean Overall Score	**2.2 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	23PMA3CC08	**Core Course - 8:** Topology	6	6

Course Objectives
To understand metric spaces as a motivation to topology
To understand compactness and connectedness in topological spaces
To acquire sufficient knowledge and skill in the subject that will make them competent invarious areas of Mathematics.
Advance concepts in topology and sufficient conditions for metrizability of a topologicalspace
To stimulate the analytical mind of the students

UNIT I **(18 Hours)**

Topological spaces - Basis for a topology - The order topology - The producttopology on $X \times Y$ - The subspace topology - Closed sets and limit points - Continuous functions.

UNIT II **(18 Hours)**

The Product topology - The Metric Topology - Connected Spaces - Connected Subspaces of the Real line - Components and local connectedness.

UNIT III **(18 Hours)**

Compact spaces - Compact subspaces of the real line - Limit point compactness.

UNIT IV **(18 Hours)**

The Countability axioms - The Separation axioms - Normal spaces.

UNIT V **(18 Hours)**

The Urysohn lemma - The Urysohn Metrization Theorem - Tietz Extension theorem.

Teaching Methodology	Chalk and Talk, PPT

Books for Study

1. Munkres, J. R. (2009). *Topology*, (2nd Ed.). PHI Learning Pvt Ltd., New Delhi.
   - **Unit-I** *Chapter 2 (Sec 12-18)*
   - **Unit-II** *Chapter 2 (Sec 19-21) and Chapter 3 (Sec 23-25)*
   - **Unit-III** *Chapter 3 (Sec 26-28)*
   - **Unit-IV** *Chapter 4 (Sec 30-32)*
   - **Unit-V** *Chapter 4 (Sec 33-35*

Books for Reference

1. Dugundji, J. (1966). *Topology*. Allyn & Bacon.
2. Sze-TsenHu. (1964). *Elements of General Topology*. Holden - Day Series in Mathematics.

Website and e-Learning Source

1. http://www.mdudde.net/books/ma/ma-maths/1st/topology-final.pdf

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	acquire knowledge about various types of topological spaces andtheir properties.	**K1**
CO2	understand the definitions with examples of fundamental conceptsand results in general topology.	**K2**
CO3	apply the properties of open sets, closed sets, interior points, accumulation points and derived sets in deriving the proofs ofvarious theorems.	**K3**
CO4	explain the basic concepts of topological spaces such as continuity,compactness, connectedness, regular spaces, normal spaces and theextension theorems.	**K4**
CO5	appraise topological properties in the given space.	**K5**
CO6	compile various concepts of topology to establish theorems	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
3	**23PMA3CC08**			**Core Course - 8:** Topology						**6**	**6**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	3	2	1	3	2	3	2	3	**2.5**
CO2	2	3	3	2	2	2	3	2	1	3	**2.3**
CO3	3	2	3	2	2	3	2	2	2	2	**2.3**
CO4	3	3	3	2	2	3	3	3	2	3	**2.6**
CO5	2	3	3	2	1	3	3	2	2	3	**2.4**
CO6	2	3	2	2	1	3	3	2	2	3	**2.4**
									Mean Overall Score		**2.42 (High)**

Semester	Course Code	Title of the Course	Hours /Week	Credits
3	23PMA3CC09	**Core Course - 9:** Classical Dynamics	5	4

Course Objectives
To understand the concept of motion of particles.
To give a detailed knowledge about the mechanical system of particles.
To study the applications of Lagrange's equations and Hamilton's equations as well as thetheory of Hamilton-Jacobi Theory.
To study the behavior of Variational principles.
To demonstrate the relation between velocity and potential.

UNIT I **(15 Hours)**

The mechanical system - Generalized coordinates - Constraints - Virtual work -Energy and momentum.

UNIT II **(15 Hours)**

Derivation of Lagrange's equations - examples - Integrals of motion.

UNIT III **(15 Hours)**

Rayleigh's Dissipation function - Impulsive motion - Velocity dependent potentials.

UNIT IV **(15 Hours)**

Hamilton's principle, Hamilton equations, other variational principles.

UNIT V **(15 Hours)**

Hamilton's Principal function - The Hamilton - Jacobi equation, separability.

Teaching Methodology	Chalk and Talk, PPT

Book for Study

1. Greenwood, G.T. (1985). *Classical Dynamics.* Prentice Hall of India Pvt.Ltd, New Delhi.
   Unit - I Chapter I (Sec 1.1,1.2,1.3,1.4 and 1.5) Unit -II Chapter II (Sec 2.1,2.2 and2.3) Unit - III Chapter III (Sec 3.1, 3.2 and 3.4) Unit - IV Chapter IV (Sec 4.1,4.2 and 4.3) Unit - V Chapter V (Sec 5.1,5.2 and 5.3)

Books for Reference

1. Synge, J.L., & Griffith, B.A. (1959). *Principles of Mechanics*. (3rd Ed.). McGraw - Hill Book, New York.
2. Goldstein, H., Poole, C.P., & Safko (2002). *Classical Mechanics*.Addison-Wesley Press Inc.
3. Thornton, S., & Marion, J. (2013). *Classical Dynamics of particles andsystems,* (5th Ed.). Brooks pub.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	acquire knowledge about the mechanical system of particles.	**K1**
CO2	explain the conservation principles involving momentum, angularmomentum and energy.	**K2**
CO3	classify Lagrange's equation, Hamilton equationand Hamilton Jacobi Theory.	**K3**
CO4	examine the existence of solution to a mechanical system.	**K4**
CO5	evaluate the path of the motion using Euler-Lagrange equation.	**K5**
CO6	construct the equations of motion using Lagrange's andHamilton's equations.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
3	**23PMA3CC09**			**Core Course - 9: Classical Dynamics**						**5**	**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	3	2	2	2	3	3	2	2	3	**2.4**
CO2	2	2	3	2	3	2	2	2	3	2	**2.3**
CO3	3	2	2	3	2	2	3	2	2	3	**2.4**
CO4	3	2	3	2	2	3	3	2	2	3	**2.5**
CO5	3	2	3	2	3	2	3	2	3	3	**2.6**
CO6	2	3	2	2	3	2	3	2	2	2	**2.3**
									Mean Overall Score		**2.4 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	23PMA3CC10	**Core Course - 10:** Stochastic Processes	4	3

Course Objectives
To understand the fundamental concepts of probability theory
To study the basic behaviors of Markov chain, Poisson, renewal and queueing processes
To impart knowledge on stochastic processes with discrete and continuous time.
To develop analytical skills to formulate simple stochastic process models
To apply the stochastic processes techniques and solve problems.

UNIT I **(12 Hours)**

Stochastic processes - Specification of Stochastic processes -Stationary processes - Markovchain - Transition probabilities - Random walk

UNIT II **(12 Hours)**

Higher transition probabilities - Classification of states - Transient and recurrent states.

UNIT III **(12 Hours)**

Poisson process - Generalizations of Poisson process - Pure birth process - Yule-Furryprocess - Birth-Immigration process.

UNIT IV **(12 Hours)**

Renewal process in discrete time - Renewal process in continuous time - Renewal equation - Renewal theorems.

UNIT V **(12 Hours)**

Queueing processes - Steady state behaviour of M/M/1 queueing model - Non-Markovianqueueing models - Queues with Poisson input (M/G/1)

Teaching Methodology	Chalk and Talk, PPT

Book for Study

1. Medhi. (1994). *Stochastic Processes*, (2nd Ed.). New Age International Publishers, New Delhi.
   Unit I Chapter 2: Sections 2.1, 2.2, 2.3 and Chapter 3: Section 3.1
   Unit II Chapter 3: Sections 3.2 and 3.4
   Unit III Chapter 4: Sections 4.1, 4.3 (omit 4.3.5 - 4.3.7)
   Unit IV Chapter 6: Sections 6.1.1 - 6.1.3, 6.2(omit example 2(b)), 6.3, 6.5(omit 6.5.2))
   Unit V Chapter 10: Sections 10.1 (omit 10.1.4), 10.2 (omit 10.2.3.1), 10.7 (omit Examples 7(a), 7(b) and Sections 10.7.3, 10.7.4).

Books for Reference

1. Bhat, U.N. (1972). *Elements of Applied Stochastic Processes*, (2nd Ed.).John Wiley & Sons, New York.
2. Prabhu, N.V. *Stochastic Processes*. MacMillan, New York.
3. Ross, S.M. (1996). *Stochastic Processes*, (2nd Ed.). John Wiley & Sons,New York.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will beable to	**Cognitive Levels (K - Level)**
CO1	acquire knowledge of the stochastic models for many real lifeprobabilistic situations.	**K1**
CO2	understand the concepts of Markov chain, Poisson process,Renewal process and Queueing process	**K2**
CO3	apply the stochastic models for many real life probabilisticsituations.	**K3**
CO4	analyze the behaviour of the states in Markov chain and thesteady state probabilities of Queueing models	**K4**
CO5	evaluate different types of stochastic models	**K5**
CO6	create methodologies to solve stochastic problems	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**						**Hours**		**Credits**
3	**23PMA3CC10**		**Core Course - 10:** Stochastic Processes						**4**		**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes(PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	3	3	2	3	2	2	3	2	2	**2.4**
CO2	2	3	3	2	2	2	3	2	2	2	**2.3**
CO3	3	2	3	2	3	3	2	2	2	2	**2.3**
CO4	3	3	2	2	2	3	2	3	2	2	**2.4**
CO5	2	3	3	2	1	3	3	2	2	3	**2.4**
CO6	2	3	3	2	1	2	3	3	2	2	**2.3**
Mean Overall Score											**2.4 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
3	23SCS3CC01	**Common Core:** Design and Analysis of Algorithms	5	4

Course Objectives
To develop the ability to analyze the running time and prove the correctness of basicalgorithms.
To impart the students the knowledge of design and analysis of algorithms
To give importance in finding the complexity (order) of algorithms.
To understand searching and sorting methods.
To design algorithms for the various mathematical problems

UNIT I: Introduction to Algorithms **(15 Hours)**

Algorithm Definition - Algorithm Specification: Pseudo Code Conventions, Recursive Algorithms - Performance Analysis: Space Complexity, Time Complexity, Asymptotic Notations.

UNIT II: Divide and Conquer **(15 Hours)**

Binary Search - Finding the Maximum and Minimum - Merge Sort - Quick Sort.

UNIT III: The Greedy Method **(15 Hours)**

Knapsack Problem - Job Sequencing with Deadlines - Minimum CostSpanning Trees: Prims Algorithm, Kruskal's Algorithm - Single Source Shortest Paths

UNIT IV: Dynamic Programming **(15 Hours)**

Multistage Graphs - All Pairs Shortest Paths - Optimal Binary Search Trees - 0/1-knapsack - Reliability Design - The Traveling Salesperson Problem.

UNIT V: Basic Traversal, Search Techniques and Backtracking **(15 Hours)**

Techniques for Graphs: Breadth First Search and Transversal, Depth First Search and Transversal-Backtracking: The General Method -The 8- Queens Problem.

Teaching Methodology	Chalk and Talk, PPT

Book for Study

1. Horowitz, E., Sahni, S., & Rajasekaran, S. (2009). *Fundamentalsof Computer Algorithms,* (2nd Ed.). Universities Press.

Unit-I - *Chapter 1 Sec 1.1,1.2, 1.3.1- 1.3.3*
Unit-II - *Chapter 3 (Sec 3.2-3.5)*
Unit-III - *Chapter 4 (Sec 4.2,4.4,4.5.1,4.5.2,4.8)*
Unit-IV - *Chapter 5 (Sec 5.2,5.3,5.5,5.7,5.8,5.9)*
Unit-V - *Chapter 6,7(Sec 6.2.1, 6.2.2,7.1, 7.2)*

Books for Reference

1. Bhasin, H. (2015). *Algorithms Design and Analysis.* Oxford University Press.
2. Shukla. R.K. (2015). *Analysis and Design of Algorithm, A Beginner's Approach.* Wiley.
3. Cormen, T.H., Leiserson, C.E., Rivest, R.L., & Stein, C. (2012). *Introduction to Algorithms.* (3rd Ed.). PHI Learning Private Limited.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	Choose the algorithmic procedure to determine the computationalcomplexity of algorithms	**K1**
CO2	Explain the stepwise procedure to solve the sorting andsearching problems	**K2**
CO3	Develop a deeper understanding of the building blocks ofalgorithms	**K3**
CO4	Analyze an algorithm to discover its suitability for variousapplications	**K4**
CO5	Explain various algorithms and methods of analysis	**K5**
CO6	Design the algorithms for solving different types of problems	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
3	**23SCS3CC01**			**Common Core**: Design and Analysis of Algorithms					**5**		**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes(PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	2	2	3	3	2	2	2	**2.4**
CO2	3	3	2	2	2	3	3	2	2	2	**2.4**
CO3	3	3	2	2	2	3	3	3	2	2	**2.5**
CO4	3	3	2	2	2	3	3	3	2	2	**2.5**
CO5	3	3	2	2	2	3	2	2	2	2	**2.3**
CO6	3	3	2	2	2	3	2	2	2	2	**2.3**
									Mean Overall Score		**2.4 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
4	23PMA4CC11	**Core Course - 11:** Functional Analysis	6	6

Course Objectives
Introducing algebraic topology using norm on linear space
Understanding the Hahn Banach theorem and their consequences.
Application of uniform boundedness principle and related theorems
Concept of Orthogonality and Riesz theorem.
Concept of Banach Algebra and operators on Banach algebra

UNIT I **(18 Hours)**

Normed Linear Spaces - Continuity of Linear Space - Operations and Norm - Schauder Basis - Continuity and Boundedness of Linear Mappings - Equivalent Norms - Finite DimensionalNormed Linear Spaces - Spaces of Bounded Linear Maps - Dual Spaces.

UNIT II **(18 Hours)**

Hahn-Banach Theorem - General Form - Complex Form - Continuous Extension Form - Second Dual and Natural Embedding - Reflexive Spaces - Dual of ✓[0,1] - The Conjugate ofan Operator - Separation Form of Hahn-Banach Theorem.

UNIT III **(18 Hours)**

Uniform Boundedness Principle - Weak Convergence - The Open Mapping Theorem - TheClosed Graph Theorem.

UNIT IV **(18 Hours)**

Inner Product Space and Hilbert Space - Parallelogram Law - Orthogonality - OrthonormalSets - Complete Orthonormal Sets - Riesz Representation Theorem - Dual Spaces.

UNIT V **(18 Hours)**

Introduction to Banach Algebra - Adjoin to fan Operator - Isometric Operator - UnitaryOperator - Self - Adjoint Operator - Normal Operator - Projection Operator and its Properties.

Teaching Methodology	Chalk and talk, group discussion, application and extension concepts.

Book for Study

1. Bose, S.C. (1992). *Introduction to Functional Analysis.* MacMillan Publishers India, Delhi.
   Unit-I *Chapter 3*
   Unit-II *Chapter 4 (Sec: 1 - 7)*
   Unit-III *Chapter 5 (Sec: 1, 3) and Chapter 6 (Sec 1, 3)*
   Unit-IV *Chapter 7*
   Unit-V *Chapter 8*

Books for Reference

1. Somasundaram, D. (2008). *A First Course in Functional Analysis.* Narosa Book Distributors Private Ltd.
2. Simmons, G. F. (2006). *Introduction to Topology and Modern Analysis.* Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
3. Rudin, W. (2006). *Functional Analysis.* Tata McGraw-Hill publishing Co. Ltd.,New Delhi.

Web Resources/e-content

1. http://www.math.nsc.ru/LBRT/g2/english/ssk/fa_e.pdf
2. https://people.math.ethz.ch/~salamon/PREPRINTS/funcana.pdf

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	acquire knowledge on certain linear topology such as normed linear spaces, Banach spaces, Hilbert spaces and inner productspaces.	**K1**
CO2	understand the main properties of bounded operations betweenBanach and Hilbert spaces.	**K2**
CO3	illustrate the duals of some normed linear spaces and the orthogonal sets by applying some specific techniques and applyimportant results	**K3**
CO4	analyze the basic results associated to different types ofconvergence in normed linear spaces.	**K4**
CO5	estimate the norm and convergence and bounds for functions andorthonormal basis	**K5**
CO6	summarize the various concepts functional analysis to provetheorems and solve problems.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
4	**23PMA4CC11**			**Core Course -11:** Functional Analysis						**6**	**6**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	3	2	1	3	2	3	2	3	**2.5**
CO2	2	3	3	2	2	2	3	2	1	3	**2.3**
CO3	3	2	3	2	2	3	2	2	2	2	**2.3**
CO4	3	3	2	2	2	3	3	3	2	3	**2.6**
CO5	2	3	3	2	1	3	3	2	2	3	**2.4**
CO6	2	3	3	2	1	3	3	2	2	3	**2.4**
										Mean Overall Score	**2.42 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
4	23PMA4CC12	**Core Course - 12:** Calculus of Variations and Integral Equations	6	6

Course Objectives
To know functionals and the construction of Euler's equation.
To understand variational methods for solving differential equations.
To analyze variational problems with moving boundaries.
To understand Green's function in reducing boundary value problems to integral equations.
To Know methods of finding infinite Fourier transforms and Fourier integrals.

UNIT I **(15 Hours)**

The variation and its properties - Euler equation - Functionals involving derivatives of higherorder - Functionals depending on functions of several independent variables.

UNIT II **(15 Hours)**

Simplest problem with movable boundaries - Problems with movable boundaries - Extremalswith cups - One-sided variations - Mixed problems.

UNIT III **(15 Hours)**

Fields of extremals - The function E(x,y,p,y') - Ritz's method - Kantorovich's method.

UNIT IV **(15 Hours)**

Basic concepts - Relationship between Linear differential equations and Volterra integral equations - Resolvent kernel of Volterra integral equation - The method of successive approximation - Convolution type Equations - Volterra integral equation.

UNIT V **(15 Hours)**

Fredholm equations of second kind - Iterated kernels - Integral equations with degenerate kernels - Characteristic numbers and Eigenfunctions - Solution of homogeneous integral equations with degenerate kernels with separable kernels - Nonhomogeneous symmetric equations - Fredholm alternative.

Teaching Methodology	Black board, chalk and talk, PPT

Books for Study

1. Elsgolc, L.D. (2007). *Calculus of Variations.* Dover Publications, New York.
   Unit-I *Chapter 1 (Sec 1,2,3,4 and 5)*
   Unit-II *Chapter 2 (Sec 1,2,3,4,5 and 6)*
   Unit-III *Chapter 3 (Sec 1 and 2) and Chapter 5 (Sec 3 and 4)*
2. Krasnov. M., Kiselev. A., & Makarenko, G. (2018). *Problems and Exercise in Integrals Equations.* Manakin Press.
   Unit- IV *Chapter 1(Sec 1,2,3,4,5,6,7,8 and 11*)
   Unit-V *Chapter 2 (Sec 12,13,14,15,16,17,18 and 19)*

Books for Reference

1. Krasnov. M., Kiselev, A., & Makarenko, G. (1971). *Problems and Exercise in Calculus of Variations*. MIR Publishers.
2. Francis. B., Hildebrand. (1968). *Methods of Applied Mathematics*, (2nd Ed.). Prentice - Hall ofIndia Pvt. Ltd. New Delhi.
3. Kanwal, R.P. (1971). *Linear Integral Equations - Theory and Techniques.* Academic press, New York.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	describe the concepts viz, functional, variations and integralequations.	**K1**
CO2	identify various methods in variations and integral equations.	**K2**
CO3	understand the real life problem and find solution by applyingsuitable method	**K3**
CO4	examine the existence of solution to a problem.	**K4**
CO5	evaluate the extremal curves and determine the solution ofintegral equations.	**K5**
CO6	formulate variation problem relevant to a real life situation.	**K6**

Relationship Matrix											
Semester	**Course Code**				**Title of the Course**					**Hours**	**Credits**
4	**23PMA4CC12**				**Core Course - 12:** Calculus of Variations and Integral Equations					**6**	**6**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	3	2	2	2	3	3	2	2	3	**2.4**
CO2	2	2	3	2	3	2	2	2	3	2	**2.3**
CO3	3	2	2	3	2	2	3	2	2	3	**2.4**
CO4	3	2	3	2	2	3	3	2	2	3	**2.5**
CO5	3	2	3	2	3	2	3	2	3	3	**2.6**
CO6	2	3	2	2	3	2	3	2	2	2	**2.3**
										Mean Overall Score	**2.4 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
4	23PMA4CC13	**Core Course - 13:** Partial Differential Equations	5	5

Course Objectives
To have knowledge on to classify partial differential equations.
To have knowledge on solving different types of partial differential equations.
To explore the knowledge on applying first and second order partial differential equations in mathematical physics.
To have knowledge on analyze the solutions of partial differential equations.
To understand the concept of evaluating the solutions of second order partialdifferential equations-elliptic, parabolic and hyperbolic

UNIT I **(15 Hours)**

Partial differential equations - origins of first order partial differential equations - Cauchy's problem for first order equations - Linear equations of the first order Integral surfaces Passing through a given curve surfaces - Orthogonal to a given system of surfaces - Non linear partial differential equations of the first order.

UNIT II **(15 Hours)**

Cauchy's method of characteristics - compatible systems of first order equations - Charpits method - Special types of first order equations - Solutions satisfying given condition - Jacobi's method.

UNIT III **(15 Hours)**

Partial differential equations of the second order. The origin of second order equations second order equations in Physics - Higher order equations in Physics - Linear partial differential equations with constant co-efficient-Equations with variable co-efficient-Characteristic curves of second order equations.

UNIT IV **(15 Hours)**

Characteristics of equations in three variables - The solution of Linear Hyperbolic equations - Separation of variables. The method of Integral Transforms - Non Linear equations of the second order.

UNIT V **(15 Hours)**

Laplace equation: Elementary solutions of Laplace's Equations - Families of equipotential Surfaces Boundary value problems - Separation of variables - Problems with Axial Symmetry.

Teaching Methodology	Black board, chalk and talk, PPT

Book for Study

1. Sneddon, I.N. (2006). *Elements of Partial Differential Equations.* Dover Publication INC, New York.

   Unit-I *Ch.II, Sec.1-7* **Unit-II** *Ch.II, Sec.8-13* **Unit-III** *Ch.III, Sec.1-6*
   Unit-IV *Ch.III, Sec.7-11*
   Unit-V *Ch.IV, Sec.2-6*

Books for Reference

1. Raisinghania, M.D. (2005). *Ordinary and Partial Differential Equations.* S. Chand &Co.
2. Copson, E.T. (1975). *Partial Differential Equations.* Cambridge University Press.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K- Level)**
CO1	have knowledge to classify partial differential equations and solve linear and non-linear partial differential equations usingvarious methods.	**K1**
CO2	understand different methods of solving partial differentialequations.	**K2**
CO3	apply the first, second and higher order partial differentialequations in mathematical physics.	**K3**
CO4	formulate partial differential equations and analyze their solutions.	**K4**
CO5	identify the three main classes of second order partial differential equations-elliptic, parabolic and hyperbolic andevaluating their solutions.	**K5**
CO6	construct the second order PDE in mathematical physics	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
4	**23PMA4CC13**			**Core Course - 13:** Partial Differential Equations						**5**	**5**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	3	3	3	3	3	2	3	**2.8**
CO2	2	2	2	3	3	3	3	3	2	3	**2.6**
CO3	2	2	3	3	3	3	3	3	3	3	**2.8**
CO4	3	3	2	3	3	3	3	3	2	3	**2.8**
CO5	2	2	3	2	3	2	3	3	2	3	**2.5**
CO6	2	2	3	3	3	3	3	3	3	3	**2.8**
									Mean Overall Score		**2.7 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
4	23PMA4ES04A	**Elective- 4:** Automata Theory	5	4

Course Objectives
To introduce the concept of finite automata, its types and familiarize in designing them.
To enlighten on the concept of regular expressions and its uses; acquaint on generating and recognizing languages; explore the Chomsky hierarchy; familiarize on the relation betweendifferent language classes.
To enlighten on the importance of ambiguity resolution in parsing; to introduce the conceptof pushdown automata and its relation with Context Free Grammars.
To introduce the concept of lexical analysis and comprehend its role in compiler designing.
To demonstrate on applying state minimization techniques, explore different parsingtechniques, acquaint on the role of parsers and familiarize in constructing parsers.

UNIT I **(15 Hours)**

Finite Automata and Regular expressions - Definitions and examples - Deterministic and Non deterministic finite Automata - Finite Automata with □-moves.

UNIT II **(15 Hours)**

Context free grammar - Regular expressions and their relationship with automation - Grammar - Ambiguous and unambiguous grammars - Derivation trees - Chomsky Normalform.

UNIT III **(15 Hours)**

Pushdown Automata - Definition and examples - Relation with Context free languages.

UNIT IV **(15 Hours)**

Finite Automata and lexical analysis - Role of a lexical analyzer - Minimizing thenumber of states of a DFA - Implementation of a lexical analyzer.

UNIT V **(15 Hours)**

Basic parsing techniques - Parsers - Bottom up Parsers - Shift reduce - Operatorprecedence- Top down Parsers - Recursive descent - Predictive parsers.

Teaching Methodology	Black board, chalk and talk, PPT

Books for Study

1. Hopcroft, J. E., & Ullman, J.D. (2000). *Introduction to Automata theory,Languages and Computations*. Narosa Publishing House, Chennai.
   Unit - I *Chapter 2 (Sec 2.1 - 2.4)*
   Unit - II *Chapter2 (Sec 2.5) and Chapter 4 (Sec 4.1 - 4.3, 4.5)*
   Unit - III *Chapter 5 (Sec 5.2, 5.3)*
2. Aho, A.V. & Ullman, J.D. (2002). *Principles of Compiler Design*. Narosa Publishing House, Chennai.
   Unit - IV *Chapter 3 (Sec 3.1 - 3.8)*
   Unit - V *Chapter 5 (Sec 5.1 - 5.5)*

Books for Reference

1. Lewis, H.R., & Papadimitriou, C.H. (1997). *Elements of the Theory ofComputation*, (2nd Ed.). Prentice Hall.
2. Aho, A.V., Lam, S.M., Sethi, R., & Ullman, J.D. *Compilers: Principles, Techniques and Tools*, (2nd Ed.). Addison-Wesley.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	enhance their knowledge in Mathematical notions of computation, such as computability, decidability and reducibility of the theory of formal languages and automata.	**K1**
CO2	perceive the techniques of computations including finite state automata, grammars and regular expressions and their relations.	**K2**
CO3	design and explain finite automata without moves, derivationtrees, pushdown automata and the lexical analyzer to the compilers.	**K3**
CO4	analyze and recognize the patterns of automata and grammarsusing regular expressions.	**K4**
CO5	evaluate the basic parsing techniques in arithmetic manner.	**K5**
CO6	state and explain Normal Forms of Grammar and Parsingtechniques and implement the stack applications.	**K6**

Relationship Matrix											
Semester	**Course Code**	**Title of the Course**								**Hours**	**Credits**
4	**23PMA4ES04A**	**Elective - 4:** Automata Theory								**5**	**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	3	2	2	2	3	3	2	2	3	**2.4**
CO2	2	2	3	2	3	2	2	2	3	2	**2.3**
CO3	3	2	2	3	2	2	3	2	2	3	**2.4**
CO4	3	2	3	2	2	3	3	2	2	3	**2.5**
CO5	3	2	3	2	3	2	3	2	3	3	**2.6**
CO6	2	3	2	2	3	2	3	2	2	2	**2.3**
									Mean Overall Score		**2.4 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
4	23PMA4ES04B	**Elective - 4:** Differential Geometry	5	4

Course Objectives
To explain the various intrinsic concepts of Differential Geometry
To understand the theory of Differential Geometry.
To introduce difference surfaces and their uses
To appreciate the application of the Gauss equation
To study Euler's theorem in Differential Geometry

UNIT I **(15 Hours)**

Analytical representation - Arc length - Tangent - Oscillating plane - Torsion - Formulae for Frenet contact.

UNIT II **(15 Hours)**

Natural equations - Helices - General solution of natural equations - Evolutes and involutes - Imaginary curves - Ovals.

UNIT III **(15 Hours)**

Analytical representation - First fundamental theorem - Normal, tangent plane - Develop able surfaces - Second fundamental form - Meusrier's theorem - Euler's theorem.

UNIT IV **(15 Hours)**

Dupin's indicatrix - Some surfaces - A geometrical interpretation of a symptotic and curvature lines conjugate directions - Triply orthogonal system of surfaces.

UNIT V **(15 Hours)**

Gauss - The equations of Gauss - Weingarten - The theorem of Gauss and the equations of Codazzi curvilinear coordinates in space - Some applications of the Gauss and the Codazzi equations - The fundamental theorem of surface theory.

Teaching Methodology	Black Board, chalk and talk, PPT

Book for Study

1. Dirk J. Struik, Lectures on Classical Differential Geometry, Addison Wesley Publishing Company, 1950.
   - **Unit - I** Chapter 1(Sec 1.1-1.7)
   - **Unit -II** Chapter 1(Sec 1.8-1.13)
   - **Unit - III** Chapter 2(Sec 2.1-2.6)
   - **Unit - IV** Chapter 2(Sec 2.7-2.11)
   - **Unit - V** Chapter 3(Sec 3.1-3.6)

Books for Reference

1. Willmore, T.J. (1959). *An introduction to Differential Geometry*. Oxford University Press, New York.
2. O'Neill, B. (2006). *Elementary Differential Geometry*, (2nd Ed.). Academic Press.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K- Level)**
CO1	recall the geometrical ideas over the surfaces, the normals and tangents, curvature and related equations of evolutes and involutes.	**K1**
CO2	understand the interrelation between derivatives and Geometry.	**K2**
CO3	apply the concept learned from Differential geometry in mechanic and also apply the techniques of differential calculus in the field of geometry.	**K3**
CO4	analyse the analytical representation of normal, tangent place and develop surfaces.	**K4**
CO5	evaluate the solutions of the problems in the field of differential geometry.	**K5**
CO6	construct mathematical models for some real life problems.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
4	**23PMA4ES04B**			**Elective - 4:** Differential Geometry						**5**	**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	2	2	2	2	3	2	3	2	2	**2.3**
CO2	2	3	2	2	2	3	2	2	2	2	**2.2**
CO3	3	2	2	3	2	3	3	2	2	2	**2.4**
CO4	2	3	3	2	2	2	2	3	3	2	**2.4**
CO5	2	2	3	3	2	2	2	3	3	2	**2.4**
CO6	2	2	3	3	2	2	2	3	3	2	**2.4**
									Mean Overall Score		**2.35 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
4	23PMA4CE01	Comprehensive Examination	-	2

Course Objectives
To attain deep understanding of the concept of Group theory, Rings and the elements of Galois Theory.
To understand the concepts of Countable and uncountable sets, Metric spaces, Sequence and Series, Continuous functions and uniform convergence and thereby solving problems based on these topics
To provide deeper understanding of Analytic functions and their properties, Complex integration and their properties.
To understand the important concepts of Topology and Functional Analysis.
To develop problem solving skills.

UNIT I: Algebra

Groups - A Counting Principle-Homomorphism- Another Counting Principle -Sylow's theorem – Ideals and Quotient rings - Polynomial Rings - The elements of Galois Theory

UNIT II: Real Analysis

Countable and Uncountable Sets - Metric Spaces -Cauchy Sequences -Series -Continuous functions - Infinite Limits and Limits at Infinity - Mean Value Theorems - Uniform Convergence - Power series

UNIT III: Complex Analysis

Analytic Functions - Complex Integration - The integral formula - Zeroes and Poles - The Residue theorem - Evaluation of Definite Integrals - Power Series expansion

UNIT IV: Topology

Basis for a topology - Continuous functions - The Metric Topology - Connectedness and Compactness -The Countability axioms - The Separation axioms -The Urysohn lemma

UNIT V: Functional Analysis

Normed Linear Spaces - Continuity and Boundedness of Linear Mappings - Dual Spaces -Hahn-Banach Theorem -Dual of C[0,1] -The Open Mapping Theorem -Inner Product Space and Hilbert Space - Riesz Representation Theorem

Books for Study

1. Herstein, I.N. (1992). T*opics in Algebra*. Wiley Eastern Limited, New Delhi.
2. Rudin, W. (1976). *Principles of Mathematical Analysis*, (3rd Ed.). McGraw-Hill International Book Company, New York.
3. Ahlfors, L.V. (2013). *Complex Analysis: An Introduction to the Theory of Analytic Functions of One Complex Variable*, (3rd Ed.). Mac Millan Publishers India, Delhi.
4. Munkres, J.R. (2009). *Topology*, (2nd Ed.). PHI Learning Pvt Ltd., New Delhi,
5. Bose, S.C. (1992). *Introduction to Functional Analysis.* MacMillan Publishers India, Delhi,

Books for Reference

1. Lang, S. (2002). *Algebra*, (3rd Ed.). Springer Graduate Texts in Mathematics, New York.
2. Apostol, T.M. (1974). *Mathematical Analysis*. Addison-Wesley Publishing Company
3. Ponnusamy, S. (2005). "*Foundations of Complex Analysis*, (2nd Ed.). Narosa Publishing House.
4. Dugundji, J. (1966). *Topology*. Allyn & Bacon.
5. Simmons, G.F. (2006). *Introduction to Topology and Modern Analysis*, Tata McGraw-Hill
6. Publishing Co. Ltd., New Delhi.

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	acquire the knowledge on basic concepts, definitions and ideas with examples in Algebra, Analysis, and Topology	**K1**
CO2	understand basic mathematical concepts and computational skills	**K2**
CO3	articulate mathematical concepts and use it in solving problems in Algebra, Analysis, and Topology	**K3**
CO4	compare the concepts of various subjects in Mathematics	**K4**
CO5	develop creativity in communicating and solving mathematical problems	**K5**
CO6	solve problems in competitive examinations	**K6**