



**K.R. MANGALAM UNIVERSITY**  
THE COMPLETE WORLD OF EDUCATION

**SCHOOL OF BASIC AND APPLIED SCIENCES (SBAS)**

**Master of Science- Mathematics**

**M.Sc. Mathematics**

**Programme Code: 60**

**2022-2024**

**Approved in the 29th Meeting of Academic Council Held on 09**

**August 2022**



  
Registrar  
K.R. Mangalam University  
Sohna Road, Gurugram, (Haryana)



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## PREAMBLE

The objective of any programme at Higher Education Institute is to prepare their students for the society at large. The K. R. Mangalam University visualizes all its programmes in the best interest of their students and in this endeavour; it offers a new vision to all its Postgraduate courses. The credit system to be implemented through this curriculum, would allow students to develop a strong footing in the fundamentals and specialize in the disciplines of his/her liking and abilities. The students pursuing this course would have to develop in depth understanding of various aspects of the subject. The conceptual understanding, development of experimental skills, designing and implementation of novel synthetic methods, developing the aptitude for academic and professional skills, research skills, acquiring basic concepts for structural elucidation with hyphenated techniques, understanding the fundamental biological processes and rationale towards computer assisted drug designing are among such important aspects.

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Vice-Chancellor  
K.R.Mangalam University

## **1. Introduction**

K.R. Mangalam University located on Sohna Road, Gurugram, is one of the fastest growing and most promising upcoming universities in India. It is a State Private University established in 2013 by an act of the legislature of the Haryana Government under Haryana Private Universities Act (Amendment) 8 of 2013. It is recognized by the UGC under Section 2f of the UGC Act, 1956. The primary aim of the University is to promote excellence in basic and professional education while upholding moral values.

KRMU offers various Undergraduate, Postgraduate and Doctoral Degree programs across different disciplines. The group of educational units in the University promote education in the areas of Engineering & Technology, Legal Studies, Basic and Applied Sciences, Management Sciences, Commerce, Journalism and Mass Communication, Hotel Management and Catering Technology, Medical and Allied Sciences, Architecture and Planning, Agriculture, Fashion Designing, Humanities and Education. All the disciplines follow a well-defined curriculum design keeping in view the guidelines of UGC/AICTE and appropriate regulatory bodies like Council of Architecture (COA), Bar Council of India (BCI), Pharmacy Council of India (PCI), National Council for Teachers Education (NCTE) etc., wherever applicable. All courses are semester and credit based.

### **K. R. Mangalam University is unique because of its**

- An enduring legacy of providing education to high achievers who demonstrate leadership in diverse fields.
- Protective and nurturing environment for teaching, research, creativity, scholarship, social and economic justice.

### **Objectives**

- i. To impart undergraduate, post-graduate and Doctoral education in identified areas of higher education.
- ii. To undertake research programmes with industrial interface.
- iii. To integrate its growth with the global needs and expectations of the major stake holders through teaching, research, exchange & collaborative programmes with foreign, Indian Universities/Institutions and MNCs.
- iv. To act as a nodal center for transfer of technology to the industry
- v. To provide job oriented professional education to the pecea student community with particular focus on Haryana.

## **2. About the School**

The school imparts both teaching and research through its various science disciplines viz Mathematics, Chemistry, Physics and Forensic Sciences.

School of Basic and Applied Sciences imparts students disciplinary knowledge, enhances their skills and ability, motivating them to think ingeniously, helping them to act independently and take decisions accordingly in all their scientific pursuits and other endeavours. It strives to empower its students and faculty members to contribute for the development of society and Nation.

The faculty is in constant touch with various experts in the relevant fields and is willing to experiment with latest ideas in teaching and research.

### **School Vision:**

To emerge as a Centre of Excellence by disseminating analytical and scientific knowledge in the disciplines of Mathematics, Physics, Chemistry through fostering interdisciplinary research and innovation.

### **School Mission:**

- Enable students to be scientists/entrepreneurs/academicians by accomplishing fundamental and advanced research in diverse areas of Basic and Applied Sciences.
- Create strong associations with academic organizations/industries for knowledge creation, promotion, and application of scientific fervor.
- Develop a conducive environment for lifelong learning.
- Empower students to be socially responsible and ethically strong individuals through value-based science education.

The school comprises undergraduate, postgraduate and doctorate of Chemistry, Physics and Mathematics.

## **3. Programmes offered by the School**

School offers undergraduate B.Sc. (Hons) Programmes, postgraduate M.Sc. Programmes, and Doctoral Programmes. All these programmes are designed to impart scientific knowledge to the students and are aimed to provide theoretical as well as practical training in their respective fields.

School offers postgraduate M.Sc. Mathematics. This school established in 2013. This course emphasized on hands on practice, innovative thought process and project-based learning.

## **Graduate Attributes**

**GA1:** To demonstrate competence in discipline specific theoretical and practical knowledge

**GA2:** To develop creativity and innovation

**GA3:** To enhance communication and interpersonal skills

**GA4:** To enable critical & logical thinking and investigative research attitude amongst students

**GA5:** To develop ethical values, teamwork and lifelong learning approach

## **Programme Educational Objective (PEOs)**

**PEO1:** Apply their knowledge in modern industry or teaching, or secure acceptance in high-quality graduate programs in mathematics.

**PEO2:** Development in their chosen profession and/or progress toward an advanced degree

**PEO3:** The trust and respect of others as effective and ethical team members.

**PEO4:** Graduates will become effective collaborators and innovators, leading or participating in efforts to address social, technical and business challenges.

**PEO5:** Promote the culture of interdisciplinary research among all disciplines and applied mathematics.

## **Programme Outcomes (POs)**

**PO1** Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.

**PO2** Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.

**PO3** Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.

**PO4** Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.

**PO5** Enhance knowledge mobilization through increased application of mathematics.

**PO6** Able to use the advance knowledge in consultancy to solve real life problems.

**PO7** Learn the subject with curiosity to understand new scientific developments.

**PO8.** Understand international perspective about mathematics.

**PO9** Capability to use appropriate software's to solve mathematical equations.

**PO10** Develop the protocols as per laboratory standards to accomplish the objectives.

## 4. M.Sc. Mathematics

The M.Sc. in Mathematics provides a broad and flexible training in variety of courses tailored to your own interests and needs, ranging from pure mathematics to mathematical modelling, computational mathematics, and applications of mathematics to many research areas.

The programme offers a substantial opportunity for independent study and research in the form of a dissertation. The dissertation is undertaken under the guidance of a supervisor and will typically involve investigating and writing in a particular area of mathematical sciences. A dissertation gives students the opportunity to develop broader transferable skills in the processes of organizing, communicating, and presenting their work, and will equip students well for further research or for a wide variety of other careers.

### Programme Specific Outcome (PSOs)

- PSO1** Develop aptitude to formulate concepts based on fundamental axioms of Mathematics.
- PSO2** Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied Mathematics.
- PSO3** Understand demands of the growing field of Mathematics by lifelong learning.
- PSO4** Develop problem-solving skills, critical thinking, and interest through assignments and project work.
- PSO5** Prepare students for competitive examinations such as NET, GATE, and many others.

**Eligibility Criteria:** - He/ She should have passed the B.Sc. (Hons) Mathematics / B.Sc. with Mathematics as a major subject, from a recognized University or equivalent with a minimum of 50% marks in aggregate.

**Course Outline:** - Real Analysis/ Complex Analysis/ Functional Analysis/ Topology/ Advanced Algebra/ Measure and Integration/ Industrial & Applied Mathematics/ Numerical Analysis & Scientific Computing.

**Career Options:** - Opportunities exist in researchers, teachers, or even work in many branches of Engineering, Finance, Physics, Chemistry, Medicine and more.



## 5. Programme Duration

The minimum period required for the M.Sc. Programme offered by the University shall extend over a period of two Academic Years.

The maximum period for the completion of the M.Sc. Programme offered by the University shall be four years.

## 6. Class Timings

The classes will be held from Monday to Friday from 09:10 am to 04:10 pm.

## 7. Scheme of Studies

The syllabi of M.Sc. Mathematics offered by School of Basic and Applied Sciences with scheme of studies are given in the following pages.

### M.Sc. Mathematics Two Years Postgraduate Programme at a Glance

SEMESTER	I	II	III	IV	TOTAL
COURSES	7	7	5	5	24
CREDITS	20	22	22	22	86

### SCHEME OF STUDIES AS PER CHOICE-BASED CREDIT SYSTEM (CBCS) AND LEARNING OUTCOME-BASED CURRICULUM FRAMEWORK (LOCF)

SEMESTER – I							
SN	COURSE CODE	NATURE OF COURSE	COURSE TITLE	L	T	P	C
1	BSMA701A	CC	Linear Algebra	4	0	0	4
2	BSMA703A	CC	Real Analysis	4	0	0	4
3	BSMA707A	CC	Integral Equations and Calculus of Variations	4	0	0	4
4	BSMA711A	CC	Advanced MATLAB Programming	2	0	0	2
5	BSMA713A	CC	Probability and Statistics	4	0	0	4
6	BSMA771A	CC	Advanced MATLAB Programming Lab	0	0	2	1
7	BSMA773A	CC	Probability and Statistics Lab	0	0	2	1
<b>TOTAL</b>				<b>18</b>	<b>0</b>	<b>4</b>	<b>20</b>

SEMESTER – II							
SN	COURSE CODE	NATURE OF COURSE	COURSE TITLE	L	T	P	C
1	BSMA702A	CC	Abstract Algebra-I	4	0	0	4
2	BSMA704A	CC	Topology	4	0	0	4
3	BSMA706A	CC	Complex Analysis	4	0	0	4
4	BSMA708A	CC	Advanced Ordinary Differential Equations	4	0	0	4
5	BSMA712A	CC	Numerical Analysis	4	0	0	4
6	BSMA772A	CC	Numerical Analysis Lab	0	0	2	1
7	BSMA776A	SEC	LaTeX Lab	0	0	2	1
<b>TOTAL</b>				<b>20</b>	<b>0</b>	<b>4</b>	<b>22</b>

SEMESTER – III							
SN	COURSE CODE	NATURE OF COURSE	COURSE TITLE	L	T	P	C
1	BSMA801A	CC	Abstract Algebra-II	4	0	0	4
2	BSMA803A	CC	Measure and Integration	4	0	0	4
3	BSMA805A	CC	Advanced Partial Differential Equations	4	0	0	4
4		DSE	Discipline Elective - I	4	0	2	5
5		DSE	Discipline Elective - II	4	0	2	5
<b>TOTAL</b>				<b>20</b>	<b>0</b>	<b>4</b>	<b>22</b>

SEMESTER – IV							
SN	COURSE CODE	NATURE OF COURSE	COURSE TITLE	L	T	P	C
1	BSMA802A	CC	Functional Analysis	4	0	0	4
2	BSMA804A	CC	Mathematical Programming	4	0	0	4
3		DSE	Discipline Elective - III	4	0	0	4
4		DSE	Discipline Elective - IV	4	0	0	4
5	BSMA852A	SEC	Dissertation	0	0	0	6
<b>TOTAL</b>				<b>16</b>	<b>0</b>	<b>0</b>	<b>22</b>

<b>Total Credits [C]</b>	<b>86</b>
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**Discipline Electives**

<b>Discipline Elective I - II (Choose any two)</b>						
<b>SN</b>	<b>COURSE CODE</b>	<b>COURSE TITLE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
1	BSMA821A	Mathematical Modelling	4	0	0	4
	BSMA871A	Mathematical Modelling Lab	0	0	2	1
2	BSMA823A	Operational Research	4	0	0	4
	BSMA873A	Operational Research Lab	0	0	2	1
3	BSMA825A	Basics of Statistical Inference	4	0	0	4
	BSMA875A	Basics of Statistical Inference Lab	0	0	2	1
4	BSMA827A	Stochastic Processes and Queuing Theory	4	0	0	4
	BSMA877A	Stochastic Processes and Queuing Theory Lab	0	0	2	1
5	BSCA 330A	Network Security & Cryptography	4	0	0	4
	BSCA 372A	Network Security & Cryptography Lab	0	0	2	1
6	BSCS401A	Artificial Intelligence	4	0	0	4
	BSCS 451A	Artificial Intelligence Lab	0	0	2	1

<b>Discipline Elective III - IV (Choose any two courses from one group)</b>						
<b>Group A</b>						
<b>SN</b>	<b>COURSE CODE</b>	<b>COURSE TITLE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
1	BSMA828A	Number Theory	4	0	0	4
2	BSMA830A	Advanced Measure Theory	4	0	0	4
3	BSMA832A	Theory of Bounded Operators	4	0	0	4
4	BSMA834A	Harmonic Analysis	4	0	0	4
<b>Group B</b>						
<b>SN</b>	<b>COURSE CODE</b>	<b>COURSE TITLE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
1	BSMA806A	Fuzzy Sets and Applications	4	0	0	4
2	BSMA809A	Fluid Dynamics	4	0	0	4
3	BSMA812A	Mathematical Biology	4	0	0	4
4	BSMA818A	Discrete Mathematics	4	0	0	4

<b>Course Type</b>	<b>Nomenclature</b>
CC	Core Course
SEC	Skill Enhancement Course
AECC	Ability Enhancement Compulsory Course
GEC	Generic Elective Course
DSE	Discipline Specific Course

## Syllabi of M.Sc. Mathematics

### Semester I

<b>BSMA701A</b>	<b>LINEAR ALGEBRA</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60 hours</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

#### **Course Objectives**

1. To assimilate the brief idea to students of vector spaces, basis.
2. Provide a brief knowledge linear transformation and matrix representation of a linear transformation.
3. Find the Eigen values and eigen vectors of LT. Diagonalization, Cayley Hamilton Theorem.
4. Determined the inner product spaces and Orthonormal basis.
5. Apply the diagonalization of the matrix and Cayley Hamilton methods for appearing in social sciences, physical sciences, life sciences and a host of other disciplines.

#### **Course Outcomes**

On completion of this course, the students will be able to

- CO1. Applied the methods vector and matrix algebra, including linear dependence / independence, basis and dimension of a subspace, rank and nullity, for analysis of matrices and systems of linear equations.
- CO2. Appreciate how functions can be used linear transformations of finite dimensional vector spaces and compose their matrices in specific bases.
- CO3. Recognize the characteristic polynomial to compute the eigenvalues and eigenvectors of a square matrix and use them to diagonalise matrices when this is possible; discriminate between diagonalizable and non-diagonalizable matrices.
- CO4. Learn the concepts of Orthogonally diagonalize symmetric matrices and quadratic forms and apply the concepts to solve problems.
- CO5. Determine the concept of the diagonalization and higher power of the matrix by using Gauss Jordan method.
- CO6. Apply the methods of matrix algebra to compose the change-of-basis matrix with respect to two bases of a vector space.

## Catalog Description

This is a one semester introductory course in linear algebra. This course includes, but is not limited to, the study of systems of linear equations, matrices, determinants, vectors and vector spaces, linear transformations, eigenvalues and eigenvectors, and their applications. Important objectives of the linear algebra are to develop and strengthen the students' problem-solving skills and to teach them to read, write, speak, and think in the language of mathematics. In particular, students learn how to apply the tools of calculus to a variety of problem situations.

## Course Content

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**Unit I:** **16 lecture hours**

**Vector Space and Subspace:** Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear dependence and independence, basis and dimension, dimension of subspaces.

**Unit II:** **16 lecture hours**

**Linear transformations:** Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations.

**Unit III:** **16 lecture hours**

**Basis and Eigen Spaces:** Change of basis. Dual spaces, bi dual space and natural isomorphism, Adjoint of Linear Transformation, Bilinear, Quadratic and Hermitian forms. Eigen values and eigen vectors of LT. Diagonalization, Cayley Hamilton theorem, Annihilator of a subspace

**Unit IV:** **12 lecture hours**

**Inner product spaces:** Inner product spaces, Cauchy-Schwarz inequality, orthogonal vectors, Orthonormal basis, Bessel's inequality, Gram-Schmidt Orthogonalization process

### Text Books

1. A. R. Vasishtha, J.N. Sharma, A. K. Vasishtha; Linear Algebra; Krishna Prakashan, Meerut.
2. Kenneth Hoffman, Ray Alden Kunz; Linear Algebra; Prentice-Hall of India Pvt.

### Reference Books/Materials

1. Joseph A. Gallian; Contemporary Abstract Algebra; Narosa Publishing House.
2. S. Lang; Introduction to Linear Algebra; Springer.
3. S. Kumaresan; Linear Algebra- A Geometric Approach; Prentice Hall of India.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**  
**Examination Scheme:**

<b>Components</b>	<b>Quiz</b>	<b>Attendance</b>	<b>Mid Term Exam</b>	<b>Presentation/ Assignment/ etc.</b>	<b>End Term Exam</b>
<b>Weightage (%)</b>	<b>10</b>	<b>10</b>	<b>20</b>	<b>10</b>	<b>50</b>

**Relationship between the Course Outcomes (COs) and Program Outcomes (POs)**

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Applied the methods vector and matrix algebra, including linear dependence / independence, basis and dimension of a subspace, rank and nullity, for analysis of matrices and systems of linear equations.	<b>PO1</b>
<b>CO2</b>	Appreciate how functions can be used linear transformations of finite dimensional vector spaces and compose their matrices in specific bases.	<b>PO8</b>
<b>CO3</b>	Recognize the characteristic polynomial to compute the eigenvalues and eigenvectors of a square matrix and use them to diagonalise matrices when this is possible; discriminate between diagonalizable and non-diagonalizable matrices.	<b>PO2</b>
<b>CO4</b>	Learn the concepts of Orthogonally diagonalize symmetric matrices and quadratic forms and apply the concepts to solve problems.	<b>PO4</b>
<b>CO5</b>	Determine the concept of the diagonalization and higher power of the matrix by using Gauss Jordan method.	<b>PO3</b>
<b>CO6</b>	Apply the methods of matrix algebra to compose the change-of-basis matrix with respect to two bases of a vector space.	<b>PO1</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 701A	Linear Algebra	2	3	3	2				2			3		3		3
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work.	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped



Programme and Course Mapping															
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
C01	2										3	2	1	1	2
C02								2			3	2	1	1	2
C03		3									3	2	1	1	2
C04				2							3	2	1	1	2
C05			3								3	2	1	1	2
C06	3										3	2	1	1	2
1=lightly mapped					2= moderately mapped					3=strongly mapped					

<b>BSMA703A</b>	<b>REAL ANALYSIS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60 hours</b>				
<b>Pre-requisites/Exposure</b>	<b>Graduate level knowledge of mathematical analysis</b>				
<b>Co-requisites</b>	<b>--</b>				

### Course Objectives

After successful completion of this course students will be able to

1. Learn basic properties and theorems of Real Numbers
2. Differentiate between Riemann Integral and Lebesgue integral
3. Know about higher order derivative and their application
4. Explain Chain rule and Taylor's theorem for multivariate function
5. Analyse inverse and implicit function theorem

### Course Outcomes

On completion of this course, the students will be able to

- CO1. Remember and understand important concepts of Riemann integration, upper sum, lower sum, higher order derivative, Jacobian.
- CO2. Apply these concepts on other interrelated topics
- CO3. Analyze and correlate difference between theorem, lemma and corollary.
- CO4. Formulate and solve problems based upon higher order derivative.
- CO5. Formulate and solve problems based upon partial differentiation and extremum value.

### Catalog Description

This course imparts the basic concepts of Riemann integration and Directional derivatives. It enables students to differentiate between inverse and implicit function theorem. This course helps students in variety of ways to solve the problems based upon extremum value, jacobians, partial differentiation efficiently. The course introduces the basic concepts about mean value theorem and Taylor's theorem. It also explain concept of Directional derivative.

### Course Content

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#### Unit I:

**14 lecture hours**

#### Basics of Metric Spaces

Review of basic concepts of real numbers: Archimedean property, Completeness. Metric spaces, compactness, connectedness, (with emphasis on  $\mathbb{R}^n$ ).

**Unit II:** **16 lecture hours**

**Riemann Integral**

Definition and existence of Riemann Stieltjes integral, properties of the integral, integration and differentiation, the fundamental theorem of integral calculus, integration by parts, integration of vector-valued functions, Rectifiable curves.

**Unit III:** **16 lecture hours**

**Function of Several Variables**

Functions of several variables: linear transformations, Derivative in an open subset of  $R^n$ , Chain rule, Partial derivatives, directional derivatives, the contraction principle, Banach fixed point theorem. Taylor's theorem for a function of several variables, Directional derivative.

**Unit IV:** **14 lecture hours**

**Higher Order Derivatives**

Inverse function theorem, Implicit function theorem, Jacobians, extremum problems with constraints, Lagrange's multiplier method, Derivatives of higher order, mean value theorem for real functions of two variables, interchange of the order of differentiation, Differentiation of integrals.

**Textbooks**

1. Walter Rudin; *Principles of Mathematical Analysis*, McGraw-Hill
2. T. Apostol; *Mathematical Analysis*, Narosa Publishers.
3. K. Ross; *Elementary Analysis: The Theory of Calculus*, Springer Int. Edition.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

**Examination Scheme:**

<b>Components</b>	<b>Quiz</b>	<b>Attendance</b>	<b>Mid Term Exam</b>	<b>Presentation/ Assignment/ etc.</b>	<b>End Term Exam</b>
<b>Weightage (%)</b>	<b>10</b>	<b>10</b>	<b>20</b>	<b>10</b>	<b>50</b>

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Remember and understand important concepts of Riemann integration and Directional derivatives	<b>PO1,PO7</b>
<b>CO2</b>	Apply these concepts to extremum value, jacobians, partial differentiation	<b>PO5,PO7</b>
<b>CO3</b>	Analyze and correlate difference between inverse and implicit function theorem	<b>PO8,PO7</b>
<b>CO4</b>	Formulate and solve problems based upon Directional derivative.	<b>PO4,PO7</b>
<b>CO5</b>	Formulate and solve problems based upon Taylor's theorem	<b>PO10,PO7</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 703A	Real Analysis	1			2	2		3	2		1	3	3	1	3	3
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped  
 2= moderately mapped  
 3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO 10</b>	<b>PSO 1</b>	<b>PSO 2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>CO1</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO2</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO3</b>										<b>3</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO4</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO5</b>						<b>3</b>					<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO6</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA707A</b>	<b>INTEGRAL EQUATIONS AND CALCULUS OF VARIATIONS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>	<b>Ordinary Differential Equations</b>				
<b>Co-requisites</b>	<b>--</b>				

### Course Objectives:

The course will enable the students to:

1. Understand more advanced concepts of linear integral equations
2. Solve problems of calculus of variations

### Course Outcomes:

On completion of this course, the students will be able to

- CO1. solve Volterra integral equations of second kind using iterated kernels
- CO2. Apply successive approximation to solve Fredholm integral equation
- CO3. construct the Green's function using various techniques
- CO4. Use Euler's equation to solve problems in calculus of variations

### Catalog Description:

This course aims to deal with the solution of linear integral equations using some important techniques like Laplace transform and iterated kernels. The course begins with a review of some basic identities and integral equations with definitions and examples. Resolvent kernel, separable kernels and the Green's function are the key concepts in this learning programme. Moreover, some fundamental results and methods from calculus of variations are also considered in the plan of action.

### Course Content

#### Unit I:

**16 lecture hours**

#### Integral Equations

Linear integral equations, Some basic identities, Initial value problems reduced to Volterra integral equations, Methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, Iterated kernels and Neumann series for Volterra equations. Resolvent kernel as a series, Laplace transform method for a difference kernel, Solution of a Volterra integral equation of the first kind.

**Unit II:****16 lecture hours****Boundary Value Problems**

Boundary value problems reduced to Fredholm integral equations, Methods of successive approximation and successive substitution to solve Fredholm integral equations of second kind, Iterated kernels and Neumann series for Fredholm integral equations. Resolvent kernel as a sum of series, Fredholm resolvent kernel as a ratio of two series, Fredholm equations with separable kernels, Approximation of a kernel by a separable kernel, Non homogenous Fredholm equations with degenerate kernels.

**Unit III:****14 lecture hours****Green's Function**

Green's function, Use of method of variation of parameters to construct the Green's function for a non-homogeneous linear second order boundary value problem, Basic four properties of the Green's function, Orthogonal series representation of Green's function, Alternate procedure for construction of the Green's function by using its basic four properties. Reduction of a boundary value problem to a Fredholm integral equation with kernel as Green's function, Hilbert-Schmidt theory for symmetric kernels.

**Unit IV:****14 lecture hours****Isoperimetric Problem**

Motivating problems of calculus of variations, Shortest distance, Minimum surface of revolution, Brnchistochrone problem, Isoperimetric problem, Geodesic. Fundamental lemma of calculus of variations, Euler's equation for one dependant function and its generalization to 'n' dependant functions and to higher order derivatives, Conditional extremum under geometric constraints and under integral constraints.

**Textbooks**

1. J. Jerri; Introduction to Integral Equations with Applications, Wiley-Interscience Pub.
2. Abdul-Majid wazwaz; A first course in Integral Equations, World Scientific Pub.
3. J. M. Gelfand and S.V. Fomin; Calculus of Variations, Prentice Hall, New Jersey.

**Reference Books/Materials**

4. P. David and S. G. David Stirling; Integral Equations, Cambridge University Press.
5. Weinstock; Calculus of Variations, McGraw Hill



**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination/ Examination Scheme:**

<b>Components</b>	<b>Quiz</b>	<b>Attendance</b>	<b>Mid Term Exam</b>	<b>Presentation/ Assignment/ etc.</b>	<b>End Term Exam</b>
<b>Weightage (%)</b>	<b>10</b>	<b>10</b>	<b>20</b>	<b>10</b>	<b>50</b>

**Relationship between the Course Outcomes (COs) and Program Outcomes (POs)**

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Solve Volterra integral equations of second kind using iterated kernels	<b>PO1</b>
<b>CO2</b>	Apply successive approximation to solve Fredholm integral equation	<b>PO4</b>
<b>CO3</b>	Construct the Green's function using various techniques	<b>PO9</b>
<b>CO4</b>	Use Euler's equation to solve problems in calculus of variations	<b>PO10</b>

BSMA 707A	Integral Equations and Calculus of Variations	Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5		
				Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.		
				3	3					3			2		3				2	

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>CO1</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO2</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO3</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO4</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO5</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO6</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
1=lightly mapped						2= moderately mapped					3=strongly mapped				

<b>BSMA711A</b>	<b>ADVANCED MATLAB PROGRAMMING</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 2.0</b>		<b>2</b>	<b>0</b>	<b>0</b>	<b>2</b>
<b>Total Contact Hours</b>	<b>30</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### Course Objectives

1. Understanding the large-scale data by conduct experiments, as well as to analyse and interpret data.
2. Introduced and identify, formulate, and solve engineering problems, function on multidisciplinary teams
3. Understanding of professional and ethical responsibility.
4. Recognition of the need for, and an ability to engage in life-long learning.
5. Understand the design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

### Course Outcomes

On completion of this course, the students will be able to

1. Applied the knowledge and understanding to design and conduct experiments, as well as to analyse and interpret data.
2. Applied the concept of different type of function in multidisciplinary area.
3. Able to identify, formulate, and solve engineering problems.
4. Recognize and determined of professional and ethical responsibility.
5. Recognition of the need for, and an ability to engage in life-long learning.
6. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

### Catalog Description

The course is aimed for participants working or conducting research in scientific computing. Covered topics in scientific computing will include numerical linear algebra, numerical optimization, ODEs, and PDEs. Participants will be introduced to advanced MATLAB features, syntaxes, and toolboxes not traditionally found in introductory courses. Material will be reinforced with in-lecture examples, demos, and homework assignment involving topics from

scientific computing. MATLAB topics will be drawn from: advanced graphics (2D/3D plotting, graphics handles, publication quality graphics, animation), MATLAB tools (debugger, profiler), code optimization (vectorization, memory management), object-oriented programming, compiled MATLAB (MEX files and MATLAB coder), interfacing with external programs, toolboxes (optimization, parallel computing, symbolic math, PDEs). In exact, students learn how to apply the tools of calculus to a variety of problem situations.

## Course Content

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### **Unit I:** **06 lecture hours**

**Introduction to MATLAB:** Starting and ending MATLAB session, MATLAB environment, MATLAB help, types of files, search path, some useful MATLAB commands, data types, constant and variables, Arithmetic, Relational and Logical Operators, built-in functions, Import and export of data, Working with files and directories.

### **Unit II:** **08 lecture hours**

**MATLAB Programming and Graphics:** Function files, sub functions, global variations, loops, branches and control flow. Two-dimensional plots, multiple plots, style options, legend command, subplots , three-dimensional plots, Mesh and surface plots..

### **Unit III:** **08 lecture hours**

**Advanced Functions:** Differentiation, Integration, Double integration, First and second order ODE, Publishing a report.

### **Unit IV:** **08 lecture hours**

**Symbolic Processing With MATLAB:** Symbolic Expressions and Algebra, Algebraic and Transcendental Equations, Calculus, Symbolic Linear Algebra, ordinary and partial differential equation, Symbolic Tutors.

## Reference Books/Materials

1. L.F. Shampine, I Gladwell, S. Thompson; Solving ODE's with MATLAB, Cambridge University Press.
2. Rudra Pratap; Getting Started with MATLAB 7, Oxford Press.
3. S.R. Otto and J.P. Denier, An Introduction to Programming and Numerical Methods in MATLAB, Springer.
4. Won Young Yang, Tae-Sang-Chung, John Morris; Applied numerical Methods using MATLAB, John Wiley and Sons.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination  
Examination Scheme:**

<b>Components</b>	<b>Quiz</b>	<b>Attendance</b>	<b>Mid Term Exam</b>	<b>Presentation/ Assignment/ etc.</b>	<b>End Term Exam</b>
<b>Weightage (%)</b>	<b>10</b>	<b>10</b>	<b>20</b>	<b>10</b>	<b>50</b>

**Relationship between the Course Outcomes (COs) and Program Outcomes (POs)**

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Applied the knowledge and understanding to design and conduct experiments, as well as to analyse and interpret data.	<b>PO1</b>
<b>CO2</b>	Applied the concept of different type of function in multidisciplinary area.	<b>PO8</b>
<b>CO3</b>	Able to identify, formulate, and solve engineering problems.	<b>PO2</b>
<b>CO4</b>	Recognize and determined of professional and ethical responsibility.	<b>PO4</b>
<b>CO5</b>	Recognition of the need for, and an ability to engage in life-long learning.	<b>PO3</b>
<b>CO6</b>	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	<b>PO1</b>

		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work.	Prepare students for competitive examinations such as NET, GATE, and many others.
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 711A	Advanced MATLAB Programming	2	3	3	2				3	3		3		3	2	

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>	<b>PO 6</b>	<b>PO 7</b>	<b>PO 8</b>	<b>PO 9</b>	<b>PO 10</b>	<b>PS O 1</b>	<b>PS O 2</b>	<b>PSO 3</b>	<b>PSO 4</b>	<b>PSO 5</b>
<b>CO 1</b>					2						3	2	1	1	2
<b>CO 2</b>								2			3	2	1	1	2
<b>CO 3</b>		3									3	2	1	1	2
<b>CO 4</b>							2				3	2	1	1	2
<b>CO 5</b>			3								3	2	1	1	2
<b>CO 6</b>	3										3	2	1	1	2
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															



<b>BSMA713A</b>	<b>PROBABILITY AND STATISTICS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 2.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>	<b>Basic algebra</b>				
<b>Co-requisites</b>	<b>--</b>				

### Course Objectives

- 1 To understand probability theory at basic and advance level, random variables and also their convergences at weak and strong levels.
- 2 To solve probabilistic problems
- 3 To understand different probability distributions and their implementation at realistic models.
- 4 To understand the process of hypothesis testing.

### Course Outcomes

On completion of this course, the students will be able to know

- CO1 Concept of discrete and continuous random variables and their probability distributions.
- CO2 Central Limit Theorem and its applications.
- CO3 basic concepts of hypothesis testing, including framing of null and alternative hypothesis.
- CO4 about important inferential aspects such as estimation, test of hypotheses and associated concepts.
- CO5 about order statistics and associated distributions.
- CO6 to obtain estimator of the population parameter on the basis of selected sample and study its properties.

### Catalog Description

In this course, descriptive and inferential statistical concepts shall be explained at the beginner level. In addition, how probability is used in inferential statistics shall be demonstrated in real-world situations.

### Course Content

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#### UNIT-I

**14 lecture hours**

#### Bayes' theorem

Sample spaces and probability, conditional probability and Bayes' theorem.

**UNIT-II****16 lecture hours****Distributions**

Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution. The Central Limit Theorem.

**UNIT-III****14 lecture hours****Measure of central tendency**

Measures of central tendency, measures of dispersion, confidence interval, estimating a population proportion, estimating a population mean, estimating a population standard deviation or variance.

**UNIT-IV****16 lecture hours****Hypothesis testing**

Steps in hypothesis testing, P-value method for hypothesis testing, Hypothesis test- t, Z and chi-square, analysis of variance (ANOVA).

**Reference Books/Materials**

1. W.W. Hines, D.C. Montgomery, D.M. Goldsman, and C.M. Borror; *Probability and Statistics in Engineering*; John Wiley & Sons.
2. E.J. Dudewicz & S.N. Mishra; *Modern Mathematical Statistics*, John Wiley & Sons.
3. J.S. Milton and J.C. Arnold; *Introduction to Probability and Statistics*, McGraw-Hill.
4. H.J. Larsen; *Introduction to Probability Theory and Statistical Inference*, John Wiley & Sons.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

**Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	concept of discrete and continuous random variables and their probability distributions.	<b>PO5</b>
<b>CO2</b>	Central Limit Theorem and its applications.	<b>PO6</b>
<b>CO3</b>	basic concepts of hypothesis testing, including framing of null and alternative hypothesis.	<b>PO2</b>
<b>CO4</b>	about important inferential aspects such as estimation, test of hypotheses and associated concepts.	<b>PO7</b>
<b>CO5</b>	about order statistics and associated distributions.	<b>PO4</b>
<b>CO6</b>	to obtain estimator of the population parameter on the basis of selected sample and study its properties.	<b>PO3</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 713A	Probability and Statistics		3	3	2	2	2	3					3	1	3	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped  
 2= moderately mapped  
 3=strongly mapped

Programme and Course Mapping																
CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	P O 1	PS O 2	PSO 3	PSO 4	PSO 5	
CO 1	2											3	2	1	1	2
CO 2								2				3	2	1	1	2
CO 3		3										3	2	1	1	2
CO 4				2								3	2	1	1	2
CO 5			3									3	2	1	1	2
CO 6	3											3	2	1	1	2
1=lightly mapped			2= moderately mapped						3=strongly mapped							

<b>BSMA771A</b>	<b>ADVANCED MATLAB PROGRAMMING LAB</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>
<b>Total Contact Hours</b>	<b>15</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	<b>MATLAB SOFTWARE</b>				

### **Course Objectives**

The purpose of these labs is to help students talk and write in meaningful ways about mathematics. Specifically to describe quantities and changes in quantities clearly in terms of context, to make rigorous arguments about how such quantities are related, and to make connections between these features in the contexts and on graphs

### **Course Outcomes**

On completion of this course, the students will be able to

- CO1. Test program output for accuracy using hand calculations and plotting the different type of the graphs.
- CO2. Analyses, the applicability and accuracy of matrix numerical solutions to linear systems of equations.
- CO3. Analyses and applied the matrix method for finding the higher power of the matrix.
- CO4. Demonstrate understanding of common numerical programing for finding the solution of Laplace and Wave equations
- CO5. Write efficient, well-documented MATLAB code and present numerical results in an informative way of different real-life problems.

### **Catalog Description**

The course is aimed for working or experiential coding or conducting research in scientific computing. Covered topics in scientific computing will include numerical linear algebra, numerical optimization, ODEs, and PDEs. Participants will be introduced to advanced MATLAB features, syntaxes, and toolboxes not traditionally found in introductory courses. Material will be reinforced with in-lecture examples, demos, and homework assignment involving topics from scientific computing. MATLAB topics will be drawn from: advanced graphics (2D/3D plotting, graphics handles, publication quality graphics, animation), MATLAB tools (debugger, profiler), code optimization (vectorization, memory management), object-oriented programming, compiled MATLAB (MEX files and MATLAB coder), interfacing with external programs, toolboxes (optimization, parallel computing, symbolic math, PDEs). In exact, students learn how to apply the tools of calculus to a variety of problem situations.

## List of practical

1. Compute the sum of n integers.
2. Find the factorial of n numbers.
3. Plot the graph of any function.
4. Solutions of simultaneous linear equations.
5. Solution of algebraic / transcendental equations.
6. To find the largest Eigen value of a matrix using power-method.
7. Inversion of matrices
8. Numerical differentiation
9. Numerical integration
10. Solution of ordinary differential equations
11. Statistical problems on central tendency and dispersion
12. Fitting of curves by least square method.
13. To find the numerical solution of Laplace equation.
14. To find the numerical solution of Wave equation

**NOTE:** Ten experiments are to be performed, out of which at least seven experiments should be performed from above list. Remaining three experiments may either be performed from the above list or designed & setup by the concerned person as per the scope of the syllabus.

## Reference Books/Materials

1. Rudra Pratap; Getting Started with MATLAB 7, Oxford Press.
2. S.R. Otto and J.P. Denier, An Introduction to Programming and Numerical Methods in MATLAB, Springer.
3. Won Young Yang, Tae-Sang-Chung, John Morris; Applied numerical Methods using MATLAB, John Wiley and Sons.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination Examination Scheme:**

Components	Conduct of Experiment	Attendance	Lab Record/ Quiz/ Viva-Voce	End Term Practical Exam
Weightage (%)	20	10	20	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Test program output for accuracy using hand calculations and plotting the different type of the graphs	<b>PO9</b>
<b>CO2</b>	Analyses the applicability and accuracy of matrix numerical solutions to linear systems of equations	<b>PO9</b>
<b>CO3</b>	Analyses and applied the matrix method for finding the higher power of the matrix	<b>PO9</b>
<b>CO4</b>	Demonstrate understanding of common numerical programing for finding the solution of Laplace and Wave equations	<b>PO9</b>
<b>CO5</b>	Write efficient, well-documented MATLAB code and present numerical results in an informative way of different real-life problems.	<b>PO9</b>



Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 771A	Advanced MATLAB Programming-Lab									3	3	3	3	2	3	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work.	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped  
 2= moderately mapped  
 3=strongly mapped

Programme and Course Mapping															
CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 11	PS O 1	PS O 2	PS O3	PS O4	PS O5
CO 1	2										3	2	1	1	2
CO 2								2			3	2	1	1	2
CO 3					3						3	2	1	1	2
CO 4				2							3	2	1	1	2
CO 5			3								3	2	1	1	2
CO 6						3					3	2	1	1	2
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA773A</b>	<b>PROBABILITY AND STATISTICS LAB</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>
<b>Total Contact Hours</b>	<b>15</b>				
<b>Pre-requisites/Exposure</b>	<b>MS EXCEL</b>				
<b>Co-requisites</b>	<b>STATISTICAL SOFTWARE</b>				

### Course Objectives

- 1 To acquire knowledge of important discrete and continuous distributions such as Binomial, Poisson, Geometric, Negative Binomial and Hyper-geometric, normal, uniform, exponential, beta and gamma distributions.
- 2 To understand the concept of sampling distributions and their applications in statistical inference.
- 3 To understand the process of hypothesis testing.
- 4 To have a clear understanding of when to apply various tests of hypothesis about population parameters using sample statistics and draw appropriate conclusions from the analysis.

### Course Outcomes

On completion of this course, the students will be able to

- CO1 knowledge to conceptualize the probabilities of events including frequentist and axiomatic approach.
- CO2 knowledge of various types of data, their organization and evaluation of summary measures such as measures of central tendency and dispersion etc.
- CO3 knowledge of other types of data reflecting quality characteristics including concepts of independence and association between two attributes.
- CO4 knowledge about inferences from Binomial, Poisson and Normal distributions as illustrations,
- CO5 Hypothesis testing based on a single sample and two samples using both classical and p value approach.
- CO6 Testing of significance and confidence intervals for single proportion and difference of two proportions

## Catalog Description

This course aims to provide an understanding of the basic concepts in probability, conditional probability and independent events. It will also focus on the random variable, mathematical expectation, and different types of univariate and bivariate distributions. In this course, student will learn how to describe relationships between two numerical quantities and characterized these relationships graphically, in the form of summary statistics, and through simple linear regression models.

## Course Content

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### List of Practicals

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.
6. Fitting of polynomials, exponential curves.
7. Testing of significance and confidence intervals for single proportion and difference of two proportions
8. Fitting of binomial distributions for  $n$  and  $p = q = \frac{1}{2}$ .
9. Fitting of binomial distributions for given  $n$  and  $p$ .
10. Fitting of binomial distributions after computing mean and variance.
11. Fitting of Poisson distributions for given value of  $\lambda$ .
12. Fitting of Poisson distributions after computing mean.
13. Fitting of negative binomial.
14. Application problems based on binomial distribution.
15. Application problems based on Poisson distribution.
16. Application problems based on negative binomial distribution.
17. Problems based on area property of normal distribution.
18. To find the ordinate for a given area for normal distribution.
19. Application based problems using normal distribution.
20. Fitting of normal distribution when parameters are given.
21. Fitting of normal distribution when parameters are not given.
22. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit

### Reference Books/Materials

1. Robert V. Hogg, Joseph W. McKean & Allen T. Craig (2013). *Introduction to Mathematical Statistics* (7th edition), Pearson Education.
2. Irwin Miller & Marylees Miller (2014). *John E. Freund's Mathematical Statistics with Applications* (8th edition). Pearson. Dorling Kindersley Pvt. Ltd. India.
3. Jim Pitman (1993). *Probability*, Springer-Verlag.
4. Sheldon M. Ross (2014). *Introduction to Probability Models* (11th edition). Elsevier.
5. A. M. Yaglom and I. M. Yaglom (1983). *Probability and Information*. D. Reidel Publishing Company. Distributed by Hindustan Publishing Corporation (India) Delhi.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination Examination Scheme:**

Components	Conduct of Experiment	Attendance	Lab Record/ Quiz/Viva-Voce	End Term Practical Exam
Weightage (%)	20	10	20	50

**Relationship between the Course Outcomes (COs) and Program Outcomes (POs)**

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
CO1	knowledge to conceptualize the probabilities of events including frequentist and axiomatic approach.	PO1
CO2	knowledge of various types of data, their organization and evaluation of summary measures such as measures of central tendency and dispersion etc.	PO10
CO3	knowledge of other types of data reflecting quality characteristics including concepts of independence and association between two attributes.	PO3
CO4	knowledge about inferences from Binomial, Poisson and Normal distributions as illustrations,	PO9
CO5	Hypothesis testing based on a single sample and two samples using both classical and p value approach.	PO2
CO6	Testing of significance and confidence intervals for single proportion and difference of two proportions	PO4

		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 773A	Probability and Statistics Lab	2	3	2	3					3	3	1		2	2	

1=weakly mapped

2= moderately mapped

3=strongly mapped

**Programme and Course Mapping**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
<b>C01</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C02</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C03</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C04</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C05</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C06</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

## Semester II

<b>BSMA702A</b>	<b>ABSTRACT ALGEBRA - I</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>	<b>Group Theory</b>				
<b>Co-requisites</b>	<b>--</b>				

### **Course Objectives:**

The course will enable the students to:

1. Understand some more advanced concepts in group theory.
2. Describe finite groups of order upto 15.
3. Know the fundamental concepts in ring theory such as Extension of fields
4. Learn in detail about Galois theory and insolvability of polynomials

### **Course Outcomes:**

On completion of this course, the students will be able to

- CO1. Understand the concept of normal and subnormal series
- CO2. Connect Sylow theorems with simple applications
- CO3. Apply the notions Splitting fields, Algebraically closed fields, Perfect fields.
- CO4. Understand Galois extensions, Normal extensions and their properties

### **Catalog Description:**

This course particularly deals with some more advanced algebra concepts, and it is laid on a preliminary course in algebra. The course begins with concepts of normal and subnormal series with definition and examples of it. Sylow's theorems with simple applications are the key concepts in this learning programme. Moreover, the concept of field extensions and some concepts from insolvability of polynomials are also considered in the plan of action.



## Course Content

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**Unit I:** **14 lecture hours**

### Groups

Groups : Zassenhaus lemma, Normal and subnormal series, Composition series, Jordan- Holder theorem, Solvable series, Derived series, Solvable groups, Solvability of  $S_n$  – the symmetric group of degree  $n \geq 2$ .

**Unit II:** **16 lecture hours**

### Sylow Groups

Nilpotent group: Central series, Nilpotent groups and their properties, Equivalent conditions for a finite group to be nilpotent, Upper and lower central series, Sylow-p sub groups, Sylow theorems with simple applications. Description of group of order  $p^2$  and  $pq$ , where  $p$  and  $q$  are distinct primes (In general survey of groups upto order 15).

**Unit III:** **14 lecture hours**

### Fields

Field theory, Extension of fields, algebraic and transcendental extensions. Splitting fields, Separable and inseparable extensions, Algebraically closed fields, Perfect fields.

**Unit IV:** **16 lecture hours**

### Galois theory

Finite fields, Automorphism of extensions, Fixed fields, Galois extensions, Normal extensions and their properties, Fundamental theorem of Galois theory, Insolvability of the general polynomial of degree  $n \geq 5$  by radicals. Text Books

### Textbooks

1. Michael Artin (2014). Algebra (2nd edition). Pearson.
2. P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul (2003). Basic Abstract Algebra (2nd edition). Cambridge University Press.

### Reference Books/Materials

3. I. N. Herstein (2006). Topics in Algebra (2nd edition). Wiley India.
4. David S. Dummit & Richard M. Foote (2008). Abstract Algebra (2nd edition). Wiley.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination/ Examination Scheme:**

<b>Components</b>	<b>Quiz</b>	<b>Attendance</b>	<b>Mid Term Exam</b>	<b>Presentation/ Assignment/ etc.</b>	<b>End Term Exam</b>
<b>Weightage (%)</b>	<b>10</b>	<b>10</b>	<b>20</b>	<b>10</b>	<b>50</b>

**Relationship between the Course Outcomes (COs) and Program Outcomes (POs)**

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Understand the concept of normal and subnormal series	<b>PO2</b>
<b>CO2</b>	Connect Sylow's theorems with simple applications	<b>PO5</b>
<b>CO3</b>	Apply the notions Splitting fields, Algebraically closed fields, Perfect fields.	<b>PO10</b>
<b>CO4</b>	Understand Galois extensions, Normal extensions and their properties	<b>PO3</b>

		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.														
		Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.														
		Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.														
		Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.														
		Enhance knowledge mobilization through increased application of mathematics.														
		Able to use the advance knowledge in consultancy to solve real life problems.														
		Learn the subject with curiosity to understand new scientific developments.														
		Understand international perspective about mathematics.														
		Capability to use appropriate software's to solve mathematical equations.														
		Develop the protocols as per laboratory standards to accomplish the objectives.														
		Develop aptitude to formulate concepts based on fundamental axioms of mathematics.														
		Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.														
		Understand demands of the growing field of Mathematics by lifelong learning.														
		Develop problem-solving skills, critical thinking, and interest through assignments and project work														
		Prepare students for competitive examinations such as NET, GATE, and many others.														
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 702A	Abstract Algebra - I			3	3			2	3				3		2	

1=weakly mapped

2= moderately mapped

3=strongly mapped

**Programme and Course Mapping**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO11	PSO1	PSO2	PSO3	PSO4	PSO5
C01					2						3	2	1	1	2
C02								2			3	2	1	1	2
C03		3									3	2	1	1	2
C04				2							3	2	1	1	2
C05						3					3	2	1	1	2
C06	3										3	2	1	1	2
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA704A</b>	<b>TOPOLOGY</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 2.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>	<b>Graduate level knowledge of mathematical analysis</b>				
<b>Co-requisites</b>	<b>--</b>				

### Course Objectives

After successful completion of this course students will be able to

1. Continue more advanced study in this area.
2. Understand different types of topological spaces and their properties.
3. Differentiate between Net and Filters.
4. Differentiate between compact and complete topological spaces.

### Course Outcomes

On completion of this course, the students will be able to

- CO1. Remember and understand important concepts of Closed sets, Closure, dense sets, neighborhoods, interior, exterior, and boundary points, accumulation points, derived sets, bases and sub-bases, subspaces and relative topology.
- CO2. Apply these concepts on other interrelated topics.
- CO3. Analyze and correlate difference between theorem, lemma and corollary.
- CO4. Solve problems based upon Net and Filter.

### Catalog Description

This course imparts the basic concepts of topological spaces and their properties. It enables students to differentiate between Net and Filter. This course helps students in variety of ways to solve the problems based upon compact and complete metric space. The course introduces the basic concepts about separable space.

### Course Content

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#### Unit I:

**14 lecture hours**

#### Topological Spaces

Definition and examples of topological spaces. Closed sets. Closure. Dense sets. neighborhoods, interior, exterior, and boundary. Accumulation points and derived sets. Bases and sub-bases. Subspaces and relative topology. Alternative methods of defining a topology in terms of Kuratowski closure operator and neighborhood systems.

**Unit II:** **16 lecture hours**

**Separation Axioms**

Continuous functions and homeomorphism. First and second countable space. Lindelöf spaces. Separable spaces. The separation axioms  $T_0$ ,  $T_1$ ,  $T_2$ ,  $T_{3\frac{1}{2}}$ ,  $T_4$ ; their characterizations and basic properties. Urysohn's lemma. Tietze extension theorem.

**Unit III:** **16 lecture hours**

**Compactness and Connectedness**

Compactness. Basic properties of compactness. Compactness and finite intersection property. Sequential, countable, and B-W compactness. Local compactness. One-point compactification. Connected spaces and their basic properties. Connectedness of the real line. Components. Locally connected spaces.

**Unit IV:** **14 lecture hours**

**Tychonoff Product Topology**

Tychonoff product topology in terms of standard sub-base and its characterizations. Product topology and separation axioms, connected-ness, and compactness (incl. the Tychonoff's theorem), product spaces. Nets and filters, their convergence, and interrelation. Hausdorffness and compactness in terms of net/filter convergence.

**Textbooks**

1. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill.
2. J. L. Kelley, General Topology, Van Nostrand,
3. K. D. Joshi, Introduction to General Topology, Wiley Eastern.
4. James R. Munkres, Topology, 2nd Edition, Pearson International.
5. J. Dugundji, Topology, Prentice-Hall of India, 1966.
6. N. Bourbaki, General Topology, Part I, Addison-Wesley.
7. S. Willard, General Topology, Addison-Wesley.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

**Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Remember and understand important concepts of Closed sets, Closure, dense sets, neighborhoods, interior, exterior, and boundary points, accumulation points, derived sets, bases and sub-bases, subspaces and relative topology	<b>PO1,PO7</b>
<b>CO2</b>	Apply these concepts on other interrelated topics.	<b>PO5,PO7</b>
<b>CO3</b>	Analyze and correlate difference between theorem, lemma and corollary.	<b>PO8,PO7</b>
<b>CO4</b>	Solve problems based upon Net and Filter.	<b>PO4,PO7</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 704A	Topology	2			2	2	2	3	1			2	3	1	3	3
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.



1=weakly mapped

2= moderately mapped

3=strongly mapped

**Programme and Course Mapping**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
C01	2										3	2	1	1	2
C02								2			3	2	1	1	2
C03		3									3	2	1	1	2
C04				2							3	2	1	1	2
C05			3								3	2	1	1	2
C06	3										3	2	1	1	2

1=lightly mapped                      2= moderately mapped                      3=strongly mapped

<b>BSMA706A</b>	<b>COMPLEX ANALYSIS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### Course Objectives

1. Provide the brief knowledge of Complex Function and analytic function.
2. To understand and find the integral of the Complex function.
3. Solve the problems related to the pole, zeros and residues.
4. Recognize the series, bilinear transformation and apply their properties to solve real file problems.
5. Apply conformal mapping appearing in social sciences, physical sciences, life sciences and a host of other disciplines.

### Course Outcomes

On completion of this course, the students will be able to

- CO.1 Applied analytic function and its properties to solve different type of problems.  
CO2. Recognize the higher order derivative and apply the Cauchy integral formula to solve different type of the problems.  
CO3. Determine and solve the problems related to the pole, zeros and residues.  
CO4. Recognize the bilinear transformation and apply their properties to solve real file problems.  
CO5: Determine the concept of conformal mapping to solve complex and critical problems.

### Catalog Description

Complex analysis is indeed a beautiful and useful branch of mathematics. It is one of the classical subjects with most of the main results extending back into the nineteenth century and earlier. Yet, the subject is far from dormant. It is a launching point for many areas of research and it continues to find new areas of applicability, from pure mathematics to applied physics. Many of the giants of mathematics have contributed to the development of complex analysis. Important objectives of the Complex analysis is to develop and strengthen the students' problem-solving skills and to teach them to read, write, speak, and think in the language of mathematics. In particular, students learn how to apply the tools of calculus to a variety of problem situations.

## Course Content

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### **Unit I:** **16 lecture hours**

**Complex Variable:** Function of a complex variable, continuity, differentiability. Analytic functions and their properties, Cauchy-Riemann equations in Cartesian and polar coordinates, Power series, Radius of convergence, Differentiability of sum function of a power series.

Path in a region, smooth path, p.w. smooth path, contour, simply connected region, multiply connected region, bounded variation, total variation, complex integration, Cauchy-Goursat theorem, Cauchy theorem for simply and multiply connected domains.

### **Unit II:** **16 lecture hours**

**Complex Integration:** Cauchy integral formula. Extension of Cauchy integral formula for multiple connected domain. Higher order derivative of Cauchy integral formula. Gauss mean value theorem Morera's theorem. Cauchy's inequality. Zeros of an analytic function, entire function, radius of convergence of an entire function, Liouville's theorem, Fundamental theorem of algebra, Taylor's theorem.

### **Unit III:** **14 lecture hours**

**Complex Series and Residue:** Maximum modulus principle, Minimum modulus principle. Schwarz Lemma. Singularity, their classification, pole of a function and its order. Laurent series, Cassorati – Weiertrass theorem Meromorphic functions, Poles and zeros of Meromorphic functions. The argument principle, Rouche's theorem, inverse function theorem Residue at a singularity, residue at a simple pole, residue at infinity. Cauchy residue theorem and its use to calculate certain integrals.

### **Unit IV:** **14 lecture hours**

**Complex transformation and mapping:** Bilinear transformation, their properties and classification, cross ratio, preservice of cross ratio under bilinear transformation, preservice of circle and straight line under bilinear transformation, fixed point bilinear transformation, normal form of a bilinear transformation. Definition and examples of conformal mapping, critical points.

### **Textbooks**

1. (AR) A.R. Vashisth, Complex Analysis, krishana prakashan Media, Meerut, 1942.i.

### **Reference Books/Materials**

1. J. B. Conway, Functions of One Complex Variable, 2nd ed., Narosa, New Delhi.
2. T.W. Gamelin, Complex Analysis, Springer International Edition.
3. R. Remmert, Theory of Complex Functions, Springer Verlag.
4. A.R. Shastri, An Introduction to Complex Analysis, Macmilan India, New Delhi.
5. Shanti Narayan; Theory of Functions of a complex variable, S. Chand & Co.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination Examination Scheme:**

<b>Components</b>	<b>Quiz</b>	<b>Attendance</b>	<b>Mid Term Exam</b>	<b>Presentation/ Assignment/ etc.</b>	<b>End Term Exam</b>
<b>Weightage (%)</b>	<b>10</b>	<b>10</b>	<b>20</b>	<b>10</b>	<b>50</b>

**Relationship between the Course Outcomes (COs) and Program Outcomes (POs)**

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Applied analytic function and its properties to solve different type of problems.	<b>PO1</b>
<b>CO2</b>	Recognize the higher order derivate and apply the Cauchy integral formula to solve different type of the problems.	<b>PO8</b>
<b>CO3</b>	Determine and solve the problems related to the pole, zeros and residues.	<b>PO2</b>
<b>CO4</b>	Recognize the series, bilinear transformation and apply their properties to solve real file problems.	<b>PO4</b>
<b>CO5</b>	Determine the concept of conformal mapping to solve complex and critical problems.	<b>PO3</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 706A	Complex Analysis	2	3	3	2				2			3		3	2	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work.	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped  
 2= moderately mapped  
 3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>C01</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C02</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C03</b>					<b>3</b>						<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C04</b>		<b>2</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C05</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C06</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
			1=lightly mapped			2= moderately mapped			3=strongly mapped						

<b>BSMA708A</b>	<b>ADVANCED ORDINARY DIFFERENTIAL EQUATIONS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>	<b>Ordinary Differential Equations</b>				
<b>Co-requisites</b>	<b>--</b>				

### Course Objectives

- 1 To identify classes of non-linear ordinary differential equations.
- 2 To apply an appropriate method for the solution of ordinary differential equations
- 3 To analyze qualitative properties of systems of ordinary differential equations.
- 4 To develop ability to solve method of describing limiting behavior and asymptotic analysis to build numerical methods to approximate equation solutions.

### Course Outcomes

On completion of this course, the students will be able to know

- CO1 Solution methods for first order as well as second order equations
- CO2 Existence and Uniqueness of Initial Value Problems
- CO3 Higher Order Linear Equations and linear Systems
- CO4 Two Dimensional Autonomous Systems and Phase Space Analysis
- CO5 Asymptotic Behavior
- CO6 Boundary Value Problems for Second Order Equations

### Catalog Description

The course prepares students to do independent work at the frontiers of linear and non-linear systems and determine the location, type, and stability of all critical points by finding the eigenvalues of the linearized system graphically and analytically. The course builds further on qualitative behaviour of the solution vis-a-vis orbits and phase plane portraits. Students learn to formulate and find solutions to more complex mathematical problems encountered in the applied sciences and engineering involving differential equations and appreciate fundamental limitations in control systems.

## Course Content

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### Unit I

14 lecture hours

#### Power Series Methods

Review of solution methods for first order as well as second order equations, Power Series methods with properties of Bessel functions and Legendre polynomials.

### Unit II

14 lecture hours

#### Existence and Uniqueness of IVP

Existence and Uniqueness of Initial Value Problems: Picard's and Peano's Theorems, Gronwall's inequality, continuation of solutions and maximal interval of existence, continuous dependence.

Higher Order Linear Equations and linear Systems: fundamental solutions, Wronskian, variation of constants, matrix exponential solution, behaviour of solutions.

### Unit III

14 lecture hours

#### Two Dimensional Autonomous Systems

Two Dimensional Autonomous Systems and Phase Space Analysis: critical points, proper and improper nodes, spiral points and saddle points.

Asymptotic Behavior: stability (linearized stability and Lyapunov methods).

### Unit IV

14 lecture hours

#### BVP of Second Order

Boundary Value Problems for Second Order Equations: Green's function, Sturm comparison theorems and oscillations, eigenvalue problems.

### Reference Books/Materials

1. M. Hirsch, S. Smale and R. Devaney; *Differential Equations, Dynamical Systems and Introduction to Chaos*, Academic Press.
2. L. Perko; *Differential Equations and Dynamical Systems, Texts in Applied Mathematics*, Vol. 7, 2<sup>nd</sup> ed., Springer Verlag, New York.
3. M. Rama Mohana Rao; *Ordinary Differential Equations: Theory and Applications*, Affiliated East-West Press Pvt. Ltd., New Delhi.
4. D. A. Sanchez; *Ordinary Differential Equations and Stability Theory: An Introduction*, Dover Publ. Inc., New York, 1968.



**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

**Examination Scheme:**

<b>Components</b>	<b>Quiz</b>	<b>Attendance</b>	<b>Mid Term Exam</b>	<b>Presentation/ Assignment/ etc.</b>	<b>End Term Exam</b>
<b>Weightage (%)</b>	<b>10</b>	<b>10</b>	<b>20</b>	<b>10</b>	<b>50</b>

**Relationship between the Course Outcomes (COs) and Program Outcomes (POs)**

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Solution methods for first order as well as second order equations	<b>PO1</b>
<b>CO2</b>	Existence and Uniqueness of Initial Value Problems	<b>PO6</b>
<b>CO3</b>	Higher Order Linear Equations and linear Systems	<b>PO7</b>
<b>CO4</b>	Two Dimensional Autonomous Systems and Phase Space Analysis	<b>PO9</b>
<b>CO5</b>	Asymptotic Behaviour	<b>PO2</b>
<b>CO6</b>	Boundary Value Problems for Second Order Equations	<b>PO3</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 708A	Advanced Ordinary Differential Equations	3	2	2			2	3		3			3	2		2
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

**Programme and Course Mapping**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO11	PSO1	PSO2	PSO3	PSO4	PSO5
C01	2										3	2	1	1	2
C02								2			3	2	1	1	2
C03		3									3	2	1	1	2
C04				2							3	2	1	1	2
C05			3								3	2	1	1	2
C06	3										3	2	1	1	2
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA712A</b>	<b>NUMERICAL ANALYSIS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### Course Objectives

1. Derive appropriate numerical methods to solve algebraic and transcendental equations
2. Approximate a function using various interpolation techniques.
3. To find the numerical solution of initial value problems and boundary value problems
4. Familiar with numerical integration and differentiation, numerical solution of ordinary differential equations and Partial differential equations

### Course Outcomes

This course will enable the students to:

- CO1. Approximate a function using an appropriate numerical method in various research problems
- CO2. Solve algebraic and transcendental equation using an appropriate numerical method
- CO3. Learn about various interpolating and extrapolating methods.
- CO4. Evaluate derivative at a value using an appropriate numerical method in various research problems.
- CO5. Solve differential equation numerically.

### Catalog Description

This course will emphasize the development of numerical algorithms to provide solutions to common problems formulated in science and engineering. The primary objective of the course is to develop the basic understanding of the construction of numerical algorithms, and perhaps more importantly, the applicability and limits of their appropriate use. Acquire the ability to calculate and reason to design complex and critical financial models for any organization and after completing this course students apply the mathematical modeling and reasoning to solve basic problems. To develop the mathematical skills of the students in the areas of numerical methods

## Course Content

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### **Unit I:** **14 lecture hours**

#### **Solution of Algebraic and Transcendental Equations**

Iterative Methods, Bisection Method, Method of false position, Secant Method, Newton-Raphson Method, Muller's Method, Horner's Method, Lin-Bairstow's Method and Graeffe's Root squaring Method. Solution of Simultaneous Algebraic Equations: Direction methods, Matrix inversion method, Gauss elimination, Gauss-Jordan method, Factorization method; Iterative method- Jacobi and Seidal Methods, Relaxation Method.

### **Unit II:** **16 lecture hours**

#### **Interpolation**

Newton's Interpolation, Gauss's interpolation, Stirling's formula, Bessel's formula, Everett's formula, Lagranges's interpolation, Divided Differences and Newton's divided difference formula, Hermite's interpolation, Spline interpolation, Double interpolation, Inverse interpolation.

### **Unit III:** **16 lecture hours**

#### **Numerical Differentiation and Integration**

Formulae for derivatives, Maxima and Minima of a tabulated function, Newton-Cote's Quadrature Formula, Romberg's Method, Euler-Maclaurin formula, Gaussian integration, Numerical double integration. Numerical Solution of Ordinary Differential Equations: Picard's Method, Taylor's series method, Euler's Method, Modified Euler's Method, Runge-Kutta Method, Milne's Predictor-Corrector Method, Adams-Bashforth method, Solving simultaneous first order differential equations and second order differential equations. Error analysis, Stability analysis, Boundary-value problems, Finite-difference method, Shooting method.

### **Unit IV:** **14 lecture hours**

#### **Numerical Solution of Partial Differential Equations**

Finite – difference approximations to partial derivatives, Solutions of Laplace equation, Poisson's equation, Five point formulae for Laplacian, Concept of compatibility, convergence and stability, explicit, full implicit, Crank-Nicholson, du-Fort and Frankel scheme, ADI methods to solve two-dimensional equations with error analysis.

#### **Textbooks**

1. M. K. Jain, S. R. K. Iyengar and R. K. Jain; *Numerical Methods for Scientific and Engineering Computation*, New age International Publisher, India.
2. Kresyzig; *Advanced Engineering Mathematics*, John Wiley and Sons.
3. Veerarajan and Ramachandran, *Numerical Methods: With Programs In C*, Tata McGraw-Hill Education.

### Reference Books/Materials

1.B. S. Grewal, *Numerical Methods in Engineering and Science*, Khanna Publishers.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
CO1	Approximate a function using an appropriate numerical method in various research problems	PO4
CO2	Solve algebraic and transcendental equation using an appropriate numerical method	PO5
CO3	Learn about various interpolating and extrapolating methods	PO3
CO4	Evaluate derivative at a value using an appropriate numerical method in various research problems	PO9
CO5	Solve differential equation numerically.	PO10

		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 712A	Numerical Analysis			2	2	3				2	3		2			3

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>CO1</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO2</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO3</b>					<b>3</b>						<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO4</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO5</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO6</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															



<b>BSMA772A</b>	<b>NUMERICAL ANALYSIS LAB</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>
<b>Total Contact Hours</b>	<b>15</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	<b>MATLAB SOFTWARE</b>				

### **Course Objectives**

This course is an introduction to a broad range of numerical methods for solving mathematical problems that arise in Science and Engineering. The goal is to provide a basic understanding of the derivation, analysis, and use of these numerical methods, along with a rudimentary understanding of finite precision arithmetic and the conditioning and stability of the various problems and methods. This will help you choose, develop and apply the appropriate numerical techniques for your problem, interpret the results, and assess accuracy. The purpose of these labs is to develop the mathematical skills of the students in the areas of numerical methods, The explaining and understanding of the several available methods to Solve the simultaneous equations, Perform statistical data analysis, data interpolation by MATLAB and to calculate the numerical integration and differentiation, numerical solution of differential equation with MATLAB

### **Course Outcomes**

On completion of this course, the students will be able to

- CO1. To develop the mathematical skills of the students in the areas of numerical methods
- CO2. The explaining and understanding of the several available methods to Solve the simultaneous equations
- CO3. Perform statistical data analysis, data interpolation by MATLAB
- CO4. To calculate the numerical integration and differentiation, numerical solution of differentiation equation with MATLAB

### **Catalog Description**

This Lab Course takes up the problems of practical that arise in various area of mathematics such as solving algebraic or differential equation. Lab experiments will be set in consonance with materials covered in the theory. Implementation of numerical techniques using MATLAB.

## Course Content

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### List of practical

1. Bisection Method.
2. Newton Raphson Method.
3. Secant Method.
4. Regulai Falsi Method.
5. LU decomposition Method.
6. Gauss-Jacobi Method.
7. SOR Method or Gauss-Siedel Method.
8. Lagrange Interpolation.
9. Newton Interpolation.
10. Trapezoidal rule.
11. Simpson's rule.
12. Modified Euler's Method.
13. Runge-Kutta Method.
14. Milne's Predictor-Corrector Method.
15. Poisson's equation
16. First-order quasi-linear PDEs.
17. 3-D Heat Equation
18. Laplace equation of heat equilibrium problem

### Textbooks

1. B. S. Grewal, *Numerical Methods in Engineering and Science*, Khanna Publishers.
2. M. K. Jain, S. R. K. Iyengar and R. K. Jain; *Numerical Methods for Scientific and Engineering Computation*, New age International Publisher, India

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**  
**Examination Scheme:**

Components	Conduct of Experiment	Attendance	Lab Record/ Quiz/ Viva-Voce	End Term Practical Exam
Weightage (%)	20	10	20	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	To develop the mathematical skills of the students in the areas of numerical methods	<b>PO9</b>
<b>CO2</b>	The explaining and understanding of the several available methods to Solve the simultaneous equations.	<b>PO10</b>
<b>CO3</b>	Perform statistical data analysis, data interpolation by MATLAB.	<b>PO9</b>
<b>CO4</b>	To calculate the numerical integration and differentiation, numerical solution of differentiation equation with MATLAB	<b>PO9</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 772A	Numerical Analysis lab									3	3	3	3	2		2
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>CO1</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO2</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO3</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO4</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO5</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO6</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA776A</b>	<b>LaTeX LAB</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>
<b>Total Contact Hours</b>	<b>15</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### Course Objectives

The objective of the course is

1. To learn about a document preparation system for high-quality typesetting
2. To learn typesetting of complex mathematical formulas

### Course Outcomes

On completion of this course, the students will be able to

- CO1. Typesetting journal articles, technical reports, books, and slide presentations.
- CO2. Control over large documents containing sectioning, cross-references
- CO3. Automatic generation of bibliographies and indexes

### Catalog Description

The course aims to introduce students to LaTeX - a high quality open-source typesetting software. LaTeX is most commonly used for medium to large technical or scientific documents but can be used for almost any type of publication. The course will, therefore, enable students to type a report, article, or mathematical document.

### Course Content

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Introduction to TeX and LaTeX, Benefits and comparison with word processor, Installing LaTeX, Formatting lines and paragraph, Typesetting a simple document, Text alignment, installing packages

Creating Lists, Typing Math Formulas, Environments – equations, arrays, matrices, Footnotes, Fonts, Title and Headers, Sectioning, Listing content and references, Cross- referencing, Math styles – cases, braces, minipages, math symbols, Theroem-like environments

Inserting Tables and Figures, Graphics in LaTeX, Creating pictures using PSTricks, Plotting of functions, introduction to TikZ package, Sample article and report, Preparing a large document, Beamer presentation, Sample presentation, Using online resources

### Textbooks

1. David F. Griffiths, Desmond J. Higham, Learning LaTeX, Society for Industrial and Applied Mathematics(SIAM), 2016.
2. Stefan Kottwitz , LaTeX Beginner's Guide. Packt Publishing, Birmingham, UK, 2011.
3. Lamport, Leslie, LaTeX: A Document Preparation System, User's Guide and Reference Manual (2nd ed.). Addison-Wesley, 1994.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination Examination Scheme:**

<b>Components</b>	<b>Conduct of Experiment</b>	<b>Attendance</b>	<b>Lab Record/ Quiz/ Viva-Voce</b>	<b>End Term Practical Exam</b>
<b>Weightage (%)</b>	<b>20</b>	<b>10</b>	<b>20</b>	<b>50</b>

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Typesetting journal articles, technical reports, books, and slide presentations.	<b>PO9, PO10</b>
<b>CO2</b>	Control over large documents containing sectioning, cross-references	<b>PO7</b>
<b>CO3</b>	Automatic generation of bibliographies and indexes	<b>PO9, PO10</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 776A	LaTeX Lab	Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.
								3		3	2			3		



1=weakly mapped

2= moderately mapped

3=strongly mapped

**Programme and Course Mapping**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2										3	2	1	1	2
CO2								2			3	2	1	1	2
CO3		3									3	2	1	1	2
CO4				2							3	2	1	1	2
CO5			3								3	2	1	1	2
CO6										3	3	2	1	1	2
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

### Semester III

<b>BSMA801A</b>	<b>ABSTRACT ALGEBRA - II</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>	<b>Modern Algebra course at undergraduate level</b>				
<b>Co-requisites</b>	<b>--</b>				

#### **Course Objectives**

1. To develop ability to deal with module theory which is used in topology and operator theory
2. To apply insights from linear algebra to other some other concept in algebra

#### **Course Outcomes**

On completion of this course, the students will be able to

- CO1. Apply theory of modules similar to linear spaces over rings
- CO2. Apply module theory over different ideals and its applications in canonical forms
- CO3. Handle complicated linear systems by decomposing them in Jordan and Ration forms
- CO4. Build foundations for various research areas in pure mathematics

#### **Catalog Description**

The course aims to describe the structure of modules over Euclidean domains. This module theory is then applied to obtain the structure of abelian groups and the rational canonical and Jordan normal forms of matrices. Some fundamental concepts about modules and rings are supposed to be discussed in detail, so that some further topics like representations of groups can be easily understood.

#### **Course Content**

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**Unit I:** **14 lecture hours**

##### **Module Theory**

Modules, General properties of modules, sub modules, Quotient modules, Homomorphism of modules, simple and semi- simple modules, free modules, Cyclic modules, Schur's lemma, Free modules, Fundamental structure theorem of finitely generated modules over principal ideal domain and its applications to finitely generated abelian groups.

**Unit II:****14 lecture hours****Neotherian and Artinian rings**

Neotherian and Artinian modules and rings with simple properties and examples, Nil and Nilpotent ideals in Neotherian and Artinian rings, Hilbert Basis theorem.

**Unit III:****16 lecture hours****Uniform Modules**

$\text{Hom}_R(R,R)$ , Opposite rings, Wedderburn – Artin theorem, Maschk’s theorem, Equivalent statement for left Artinian rings having non-zero nilpotent ideals, Uniform modules, Primary modules and Neother- Lasker theorem.

**Unit IV:****16 lecture hours****Primary Decomposition Theorem**

Canonical forms: Similarity of linear transformations, Invariant subspaces, Reduction to triangular form, Nilpotent transformations, Index of nilpotency, Invariants of nilpotent transformations, The primary decomposition theorem, Rational canonical forms, Jordan blocks and Jordan forms.

**Text Books**

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul; Basic Abstract Algebra, Cambridge University Press, Indian Edition.
2. M. Artin; Algebra, Prentice-Hall of India.

**Reference Books/Materials**

1. P.M. Cohn; Algebra, Vols. I, II & III, John Wiley & Sons.
2. I.S. Luther and I. B. S. Passi; Algebra, Vol. I-Groups, Vol. II-Rings, Narosa Publishing House.
3. K.B. Datta; Matrix and Linear Algebra, Prentice Hall of India Pvt., New Delhi.
4. Vivek Sahai and VikasBist; Algebra, Narosa Publishing House.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

**Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Apply theory of modules similar to linear spaces over rings	<b>PO2</b>
<b>CO2</b>	Apply module theory over different ideals and its applications in canonical forms	<b>PO5</b>
<b>CO3</b>	Handle complicated linear systems by decomposing them in Jordan and Ration forms	<b>PO10</b>
<b>CO4</b>	Build foundations for various research areas in pure mathematics	<b>PO3</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 801A	Abstract Algebra - II			2	3			3	3				3		2	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>CO1</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO2</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO3</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO4</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO5</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO6</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA803A</b>	<b>MEASURE AND INTEGRATION</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 2.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>	<b>Real Analysis course at undergraduate level</b>				
<b>Co-requisites</b>	<b>--</b>				

### Course Objectives

1. To understand scope and limitations of Riemann integration
2. To learn of the construction of measures and integrals
3. To learn key concepts on measurable functions and their properties

### Course Outcomes

On completion of this course, the students will be able to

- CO1. Construct Borel sets, measurable and non-measurable sets and different type of measure
- CO2. Understand concept of integral, integrable functions, monotone and the dominated convergence theorem.
- CO3. Apply some fundamental concepts that are particularly related to probability theory
- CO4. Use measure theory in mathematics and some other fields.

### Catalog Description

This course particularly attempts to give an introduction to measure and integration, and shall lay a foundation for a more advanced course on measure theory. The course begins with a review, scope and limitations of Riemann integration and moves forward with definitions and examples of Borel set, outer measure, Lebesgue measure and probability space. Measurable functions and their properties are the key concepts in this learning programme. Moreover, the concept of integral, integrable functions, monotone and the dominated convergence theorem and their applications are also considered in the plan of action.

### Course Content

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#### Unit I:

**14 lecture hours**

#### Introduction to semi-algebras

Semi-algebras, algebras, monotone class, sigma-algebras, measure and outer measure

**Unit II:** **16 lecture hours**  
**Lebesgue Measure**

Borel sets, Lebesgue outer measure and Lebesgue measure on  $\mathbb{R}$ , translation invariance of Lebesgue measure, existence of a non-measurable set, characterizations of Lebesgue measurable sets

**Unit III:** **16 lecture hours**  
**Measurable Functions**

Measurable functions on a measure space and their properties. Lebesgue integral and its properties, Comparison between Lebesgue and Riemann integral.

**Unit IV:** **14 lecture hours**  
**Convergence of Measurable Functions**

Theorems on convergence of sequences of measurable functions, Bounded convergence theorem, Fatou's lemma, Lebesgue monotone convergence theorem, Lebesgue dominated convergence theorem. F-Riesz and D.F.Egorff theorem.

**Text Books**

1. H. L. Royden and P. M. Fitzpatrick, Real Analysis, (Fourth edition), P.H.I. New Delhi.

**Reference Books/Materials**

1. P. R. Halmos; Measure Theory, Graduate Texts in Mathematics, Springer-Verlag New York, 1950.
2. I. K. Rana; An Introduction to Measure and Integration, Narosa Publishing House, New Delhi.
3. E. Hewit and K. Stromberg; Real and Abstract Analysis, Springer-Verlag Berlin Heidelberg, 1965.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**  
**Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50



### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Construct Borel sets, measurable and non-measurable sets and different type of measure	<b>PO2</b>
<b>CO2</b>	Understand concept of integral, integrable functions, monotone and the dominated convergence theorem.	<b>PO3</b>
<b>CO3</b>	Apply some fundamental concepts that are particularly related to probability theory	<b>PO7</b>
<b>CO4</b>	Use measure theory in mathematics and some other fields.	<b>P10</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 803A	Measure and Integration		3	3				3	2				3		2	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

Programme and Course Mapping															
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
C01	2										3	2	1	1	2
C02								2			3	2	1	1	2
C03		3									3	2	1	1	2
C04				2							3	2	1	1	2
C05			3								3	2	1	1	2
C06	3										3	2	1	1	2
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA805A</b>	<b>ADVANCED PARTIAL DIFFERENTIAL EQUATIONS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### Course Objectives

1. Determine the method of characteristics to solve first order partial differential equations.
2. Classify a second order PDE as elliptic, parabolic or hyperbolic.
3. Use the method of Lagrange-Green's identity and uniqueness by energy methods.
4. Determined the representation formulas for the solutions of Laplace equation, heat equation and wave equation.
5. Understand the existence of weak solutions and shocks also similarity solutions and their applications in social sciences, physical sciences, life sciences and a host of other disciplines.

### Course Outcomes

On completion of this course, the students will be able to

1. Applied the knowledge and understanding partial differential equations and how they relate to different modelling situations.
2. Applied the concept of the symbol of a PDEs and the resulting classification of PDEs.
3. Appreciate a brief knowledge of linear ODEs and PDEs with the use of the Green's function method.
4. Recognize and determined Apply the existence of weak solutions and shocks by applying mathematical modelling and reasoning to solve basic problems.
5. Determine the concept of advanced PDEs to design complex and critical financial models for any organization.
6. Apply the methods of classification of PDEs to compose the relationship of basic mathematics in real life.

### Catalog Description

The focus of the course is the concepts and techniques for solving the partial differential equations (PDE) that permeate various scientific disciplines. The emphasis is on nonlinear PDE. Applications include problems from fluid dynamics, electrical and mechanical engineering, materials science, quantum mechanics, etc. Important objectives of the advanced partial differential equations are to develop and strengthen the students' problem-solving skills and to

teach them to read, write, speak, and think in the language of mathematics. In particular, students learn how to apply the tools of calculus to a variety of problem situations.

## Course Content

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**Unit I:** **14 lecture hours**

**Classifications of PDE:** Cauchy Problems for First Order Hyperbolic Equations: method of characteristics, Monge cone. Classification of Second Order Partial Differential Equations: normal forms and characteristics.

**Unit II:** **16 lecture hours**

**Initial and Boundary Value Problems:** Lagrange-Green's identity and uniqueness by energy methods. Stability theory, energy conservation and dispersion.

**Unit III:** **16 lecture hours**

**Laplace equation:** mean value property, weak and strong maximum principle, Green's function, Poisson's formula, Dirichlet's principle, existence of solution using Perron's method (without proof). Heat equation: initial value problem, fundamental solution, weak and strong maximum principle and uniqueness results.

**Unit IV:** **14 lecture hours**

**Wave equation:** uniqueness, D'Alembert's method, method of spherical means and Duhamel's principle. Methods of separation of variables for heat, Laplace and wave equations.

### Textbooks

1. E. Di Benedetto; Partial Differential Equations, Birkhauser, Boston.
2. L.C. Evans; Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, Providence.

### Reference Books/Materials

1. F. John; Partial Differential Equations, 3rd ed., Narosa Publ. Co., New Delhi.
2. E. Zauderer; Partial Differential Equations of Applied Mathematics, 2nd ed., John Wiley and Sons, New York.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

**Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Applied the knowledge and understanding partial differential equations and how they relate to different modelling situations.	<b>PO1</b>
<b>CO2</b>	Applied the concept of the symbol of a PDEs and the resulting classification of PDEs.	<b>PO8</b>
<b>CO3</b>	Appreciate a brief knowledge of linear ODEs and PDEs with the use of the Green's function method.	<b>PO2</b>
<b>CO4</b>	Recognize and determined Apply the existence of weak solutions and shocks by applying mathematical modelling and reasoning to solve basic problems.	<b>PO4</b>
<b>CO5</b>	Determine the concept of advanced PDEs to design complex and critical financial models for any organization.	<b>PO3</b>
<b>CO6</b>	Apply the methods of classification of PDEs to compose the relationship of basic mathematics in real life.	<b>PO1</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 805A	Advanced Partial Differential Equations	2	3	3	2				2			3		3	2	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work.	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>CO1</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO2</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO3</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO4</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO5</b>						<b>3</b>					<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO6</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
			1=lightly mapped				2= moderately mapped				3=strongly mapped				



## Course Objectives

- 1 To demonstrate the ability to create mathematical models of empirical or theoretical phenomena in domains such as the physical, natural, or social science.
- 2 To create variables and other abstractions to solve mathematical problems in conjunction with previously learned fundamental mathematical skills.
- 3 To draw inferences from models using mathematical techniques including problem solving, quantitative reasoning, and exploration using multiple representations such as equations, tables, and graphs.
- 4 To make predictions of the behaviour of this system based on the analysis of its mathematical model and take an analytical approach to problems in their future endeavours.

## Course Outcomes

On completion of this course, the students will be able to

- CO1 understand powerful mathematical tools such as calculus of several variables, differential equations and elementary dynamical systems theory.
- CO2 apply these tools to mathematically analyze and solve contemporary problems of both theoretical and practical importance.
- CO3 assemble a mathematical model for a range of physical situations and able to identify, formulate, and solve engineering problems.
- CO4 critically analyse the effectiveness of any differential equation in modelling specified situations recognising that useful qualitative information in the behaviour of a system can often be gleaned from suitably "crude" models.
- CO5 recognition of the need for, and an ability to engage in life-long learning.
- CO6 understand the balance between the complexity / accuracy of the mathematical / statistical models used and the timeliness of the delivery of the solution.

## Catalog Description

The course also provides introduction to state-of-the-art mathematical resources for mathematical modelling, optimization, numerical simulation, graph theory and forecasting techniques. Case studies will form a large part of the course. In addition to learning the mathematics behind the modelling tools, the course aims to equip students with the modelling skills and presentation skills for dealing with real world problems.

## Course Content

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### UNIT-I

14 lecture hours

#### Modelling through ODE of First order

Need, Techniques, Classifications, Characteristic and Limitations of Mathematical Models. Modelling through Ordinary Differential Equation of First Order and systems of Ordinary Differential Equation of First Order: Linear and Non – Linear Growth and Decay Models, Compartment Models.

### UNIT-II

16 lecture hours

#### Modelling through Difference Equation

Modelling through Ordinary Differential Equation of Second Order: Planetary Motion, Motion of Satellites, Electrical Circuits.

Modelling through Difference Equations: Basic Theory of Linear Difference equations with constant coefficient, Models used in Economics and Finance, Population dynamics and genetics.

### UNIT-III

16 lecture hours

#### Modelling through Graphs

Modelling through Graphs: Directed and Signed graphs, Weighted Di-graphs, Eulerian and Hamiltonian graphs, Applications to route problems, network flow and scheduling problems.

### UNIT-IV

14 lecture hours

#### Simulation Modelling

Monte Carlo Simulation Modelling: simulating deterministic behaviour (area under a curve, volume under a surface). Forecasting: Time Series, Linear and Nonlinear Trend, seasonal Variations and Irregular Variations and their Measurements, Moving Averages, Single and Double exponential smoothing.

#### Reference Books/Materials

1. Reinhard Illner; *Mathematical Modelling, A Case Studies Approach*, Indian Editions of AMS (American Mathematical Society).
2. Rutherford Aris; *Mathematical Modelling Techniques*, Dover Publications Inc.
3. Frank R. Giordano , William P. Fox , Steven B. Horton; *A First Course in Mathematical Modeling*, Brooks Pub Co.
4. Edward A. Bender; *An Introduction to Mathematical Modeling*, John Wiley & Sons.
5. Mark M. Meerschaert; *Mathematical Modeling*, Academic Press Inc.
6. J. Caldwell and Y. M. Ram; *Mathematical Modelling; Concepts and Case Studies*, Springer.
7. S.C. Gupta and V.K. Kapoor, *Fundamentals of Applied Statistics*, Sultan Chand & Sons.
8. J. N. Kapur; *Mathematical Modelling*, New Age International Publishers.
9. John E. Hanke, Dean Wichern and Arthur G. Reitch, *Business Forecasting*, 7th Ed., Pearson.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination  
Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

**Relationship between the Course Outcomes (COs) and Program Outcomes (POs)**

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
<b>CO1</b>	Understand powerful mathematical tools such as calculus of several variables, differential equations and elementary dynamical systems theory.	<b>PO5</b>
<b>CO2</b>	Apply these tools to mathematically analyze and solve contemporary problems of both theoretical and practical importance.	<b>PO2</b>
<b>CO3</b>	Assemble a mathematical model for a range of physical situations and able to identify, formulate, and solve engineering problems.	<b>PO8</b>
<b>CO4</b>	Critically analyse the effectiveness of any differential equation in modelling specified situations recognising that useful qualitative information in the behaviour of a system can often be gleaned from suitably "crude" models.	<b>PO1</b>
<b>CO5</b>	Recognition of the need for, and an ability to engage in life-long learning.	<b>PO4</b>
<b>CO6</b>	Understand the balance between the complexity / accuracy of the mathematical / statistical models used and the timeliness of the delivery of the solution.	<b>PO6</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 821A	Mathematical Modelling	3	3		2	2	3		2				3	3	3	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>C01</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C02</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C03</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C04</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C05</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C06</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
			1=lightly mapped			2= moderately mapped			3=strongly mapped						

<b>BSMA871A</b>	<b>MATHEMATICAL MODELLING LAB</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>
<b>Total Contact Hours</b>	<b>15</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	<b>MATLAB / MATHEMATICA / MAPLE SOFTWARE</b>				

### Course Objectives

- 1 To introduce students to the elements of the mathematical modelling process.
- 2 To present application-driven mathematics motivated by problems from within and outside mathematics.
- 3 To exemplify the value of mathematics in problem solving.
- 4 To demonstrate connections among different mathematical topics.

### Course Outcomes

On completion of this course, the students will be able to know

- CO1 Able to design and conduct experiments, as well as to analyze and interpret data.
- CO2 Recognize the power of mathematical modelling and analysis and be able to apply their understanding to their further studies.
- CO3 Apply analytical techniques to solve a mathematical model, i.e. perform the calculations needed to obtain a solution or a suitable approximation.
- CO4 An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- CO5 Suggest modifications that may improve the theoretical "fit" to the actual application being modelled being mindful of any added complexity to the efficacy of then being able to generate a feasible solution.
- CO6 Bring together and flexibly apply knowledge to characterize, analyze and solve a wide range of problems.

### Catalog Description

This course presents mathematical techniques for constructing quantitative mathematical models to describe different systems and predict future events. The course covers the fundamentals of deterministic models in both discrete and continuous time domain. The emphasis is on developing linear and non-linear models with sufficient amount of theoretical framework. The relevant concepts and solution methods of various difference and differential equations are discussed with graphical solution for clear analysis of nature of models.

Students who successfully complete a course in mathematical modeling should be able to: translate everyday situations into mathematical statements (models) which can be solved/analyzed, validated, and interpreted in context; identify assumptions which are consistent with the context of the problem and which in turn shape and define the mathematical characterization of the problem; revise and improve mathematical models so that they will better correspond to empirical information and/or will support more realistic assumptions; assess the validity and accuracy of their approach relative to what the problem requires; work as members of a team toward a common goal, and communicate mathematics in both oral and written form to a broad mathematical and lay audience, including the “end users” of a modeling problem, who may be utterly unfamiliar with the mathematics used.

## **Course Content**

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Modeling of the following problems using Matlab / Mathematica / Maple etc.

### **List of Practicals**

1. Plotting of second & third order solution family of differential equations.
2. Growth & Decay model (exponential case only).
3. Lake pollution model (with constant/seasonal flow and pollution concentration)
4. Case of single cold pill and a course of cold pills.
5. Limited growth of population (with and without harvesting).
6. Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
7. Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers).
8. Battle model (basic battle model, jungle warfare, long range weapons).
9. Sketching the Phase Plane for the system
10. Coupled Mass-Spring Systems
11. Second Order RLC electrical circuits
12. Shortest Path Graph Algorithms (Dijkstra's/ Floyd Warshall's/ Bellman Ford's).
13. Minimum Spanning Tree Algorithms (Kruskal's/Prim's).
14. Traffic Flow Analysis Model.
15. Fitting of trend by Moving Average Method
16. Forecasting by exponential smoothing

**Reference Books/Materials**

1. J. Sinha Roy and S Padhy: A course of Ordinary and Partial differential equation Kalyani Publishers, New Delhi.
2. Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed., Taylor and Francis group, London and New York, 2009.
3. Simmons G F, Differential equation, Tata Mc Graw Hill, 1991.
4. Martin Braun, Differential Equations and their Applications, Springer International, Student Ed.
5. S. L. Ross, Differential Equations, 3rd Edition, John Wiley and Sons, India. 4. C.Y. Lin, Theory and Examples of Ordinary Differential Equations, World Scientific, 2011.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination Examination Scheme:**

<b>Components</b>	<b>Conduct of Experiment</b>	<b>Attendance</b>	<b>Lab Record/ Quiz/ Viva-Voce</b>	<b>End Term Practical Exam</b>
<b>Weightage (%)</b>	<b>20</b>	<b>10</b>	<b>20</b>	<b>50</b>



### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Able to design and conduct experiments, as well as to analyze and interpret data.	<b>PO4</b>
<b>CO2</b>	Recognize the power of mathematical modelling and analysis and be able to apply their understanding to their further studies.	<b>PO7</b>
<b>CO3</b>	Apply analytical techniques to solve a mathematical model, i.e. perform the calculations needed to obtain a solution or a suitable approximation.	<b>PO9</b>
<b>CO4</b>	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	<b>PO3</b>
<b>CO5</b>	Suggest modifications that may improve the theoretical "fit" to the actual application being modelled being mindful of any added complexity to the efficacy of then being able to generate a feasible solution.	<b>PO8</b>
<b>CO6</b>	Bring together and flexibly apply knowledge to characterize, analyze and solve a wide range of problems.	<b>PO10</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 871A	Mathematical Modelling Lab			3	2			2	2	3	3		3	3	3	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

**Programme and Course Mapping**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2										3	2	1	1	2
CO2								2			3	2	1	1	2
CO3		3									3	2	1	1	2
CO4				2							3	2	1	1	2
CO5			3								3	2	1	1	2
CO6	3										3	2	1	1	2
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA823A</b>	<b>OPERATIONAL RESEARCH</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### Course Objectives

1. Describe the linear programming duality. and the simplex and revised simplex algorithms
2. Describe the linear programming applications and formulations
3. Describe the transportation problem and its application
4. Describe the Assignment problem and its application
5. To acquaint the students with the use of quantitative models in decision making and game theory

### Course Outcomes

On completion of this course, the students will be able to

CO1- Understand the origin and development of Operations Research

CO2- Analyze the real life systems with limited constraints

CO3-Identify a problem in your locality, formulate it as an LPP and solve

CO4- Maximize the profit, minimize the cost, minimize the time in transportation problem

CO5- Travelling salesman problem, Assignment problem

CO6 The students will be able to recognize strategic environments and to use Game Theory.

### Catalog Description

This course covers some core areas of Operational Research, namely Linear programming,, Transportation problem, Assignment problem and Game Theory. Emphasis will be placed both on the mathematical techniques and on problem formulation through examples from applications.

### Course Content

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#### Unit I:

**14 lecture hours**

#### Linear Programming Problems

Operations Research: Origin, definition, methodology and scope. Linear Programming: Formulation and solution of linear programming problems by graphical and simplex methods, Big - M and two phase methods, Degeneracy, Duality in linear programming

**Unit II:****16 lecture hours****Transportation Problems**

Transportation Problems: Basic feasible solutions, optimum solution by stepping stone and modified distribution methods, unbalanced and degenerate problems, transshipment problem. Assignment problems: Solution by Hungarian method, unbalanced problem, case of maximization, travelling salesman and crew assignment problems.

**Unit III:****16 lecture hours****Game Theory**

Game Theory : Two person zero sum game, Game with saddle points, the rule of dominance; Algebraic, graphical and linear programming methods for solving mixed strategy games

**Unit IV:****14 lecture hours****Sequencing Problems**

Sequencing problems: Processing of n jobs through 2 machines, n jobs through 3 machines, 2 jobs through m machines, n jobs through m machines.

**Text Books**

Kanti Swarup, P.K. Gupta and Manmohan, Operations Research, Sultan Chand & Sonsv

**Reference Books/Materials**

1. H.A. Taha, Operation Research-An introducton, Printice Hall of India.
2. P.K. Gupta and D.S. Hira, Operations Research, S. Chand & Co.
3. S.D. Sharma, Operation Research, Kedar Nath Ram Nath Publicationsv

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

**Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Understand the origin and development of Operations Research	<b>PO7</b>
<b>CO2</b>	Analyze the real-life systems with limited constraints	<b>PO2</b>
<b>CO3</b>	Identify a problem in your locality, formulate it as an LPP and solve	<b>PO3</b>
<b>CO4</b>	Maximize the profit, minimize the cost, minimize the time in transportation problem	<b>PO3</b>
<b>CO5</b>	Travelling salesman problem, Assignment problem to solve real life problem	<b>PO6</b>
<b>CO6</b>	The students will be able to recognize strategic environments and to use Game Theory	<b>PO5</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 823A	Operational Research		2	3		3	3	3				2	3		3	3
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics	Understand demands of the growing field of Mathematics by lifelong learning	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

Programme and Course Mapping															
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2										3	2	1	1	2
CO2								2			3	2	1	1	2
CO3		3									3	2	1	1	2
CO4				2							3	2	1	1	2
CO5			3								3	2	1	1	2
CO6	3										3	2	1	1	2
			1=lightly mapped				2= moderately mapped				3=strongly mapped				



<b>BSMA873A</b>	<b>OPERATIONAL RESEARCH LAB</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	<b>MATLAB</b>				

### Course Objectives

1. Understand how to find the solution of LPP having more than three variables.
2. Learn how to find IBFS of transportation problem by MATLAB.
3. Understand how to solve Assignment problem by MATLAB.

### Course Outcomes

On completion of this course, the students will be able to

- CO1. Solve Linear Programming Problems and its dual by MATLAB
- CO2. Find Initial basic feasible solution by NWCR, LCM and VAM methods and its optimal solution by MATLAB
- CO3. To understand the solution of unbalanced transportation problem and their maximisation problem by MATLAB.
- CO4. Students learn how to solve Assignment problem by using MATLAB
- CO5. To solve the game and optimal strategy game by MATLAB

### Catalog Description

The purpose of these labs is to help students talk and write in meaningful ways the linear programming duality and the simplex and revised simplex algorithms, transportation problem, Assignment problem, game theory. Specifically, to describe LPP clearly in terms are related to transportation and assignment problem, and to make connections between these two.

### Course Content

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#### List of practical

- Find the Solution the LPP problem with equality constraint and mixed constraint
- To Solve the LPP problem by Big M method

- Find the Solution of the dual of LPP problem
- Solve the transportation problem by North west corner rule, LCEM and vogels method
- Check Optimality test for transportation problem by Modi method
- To obtain the solution of assignment Problem. i.e., balanced and unbalanced
- Find the saddle point and value of game

### Reference Books/Materials

1. Lisa Oberbroeckling, Programming Mathematics Using MATLAB, Academic Press
2. Kanti Swarup, P.K. Gupta and Manmohan, Operations Research, Sultan Chand & Sonsv

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination Examination Scheme:**

Components	Conduct of Experiment	Attendance	Lab Record/ Quiz/ Viva-Voce	End Term Practical Exam
Weightage (%)	20	10	20	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
<b>CO1</b>	Solve Linear Programming Problems and its dual by MATLAB	<b>PO6, PO10</b>
<b>CO2</b>	Find Initial basic feasible solution by NWCR,LCM and VAM methods and its optimal solution by MATLAB	<b>PO2. PO9</b>
<b>CO3</b>	To understand the solution of unbalanced transportation problem and their maximisation problem by MATLAB.	<b>PO3, PO9</b>
<b>CO4</b>	Students learn how to solve Assignment problem by using MATLAB	<b>PO10</b>
<b>CO5</b>	To solve the game and optimal strategy game by MATLAB	<b>PO6, PO9</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 873A	Operational Research Lab		2	2			2			3	3		3	2		
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics	Understand demands of the growing field of Mathematics by lifelong learning	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

**Programme and Course Mapping**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2										3	2	1	1	2
CO2								2			3	2	1	1	2
CO3		3									3	2	1	1	2
CO4				2							3	2	1	1	2
CO5			3								3	2	1	1	2
CO6	3										3	2	1	1	2
1=lightly mapped			2= moderately mapped			3=strongly mapped									

<b>BSMA825A</b>	<b>BASICS OF STATISTICAL INFERENCE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>	<b>Probability</b>				
<b>Co-requisites</b>	<b>--</b>				

### Course Objectives

- 1 To understand the concept of small sample and large sample tests.
- 2 To understand the concept of Testing of hypothesis and estimation theory.
- 3 To analyse and interpret the data vis-à-vis statistical inference.
- 4 To work on several standard examples to help them understand the various inherent concepts

### Course Outcomes

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On completion of this course, the students will be able to

- CO1 understand of Parametric models for developing relevant inferences on associated parameters
- CO2 use different nonparametric/distribution-free tests when data don't meet the assumptions of parametric test,
- CO3 know advanced level topics in statistical inference on testing of statistical hypotheses for both randomized and non-randomized tests
- CO4 knowledge of point and interval estimation procedures and different methods of point estimation
- CO5 use appropriate experimental designs to analyze the experimental data
- CO6 real lifetime data implementation of various concepts as outlined above through practical assignments.

### Catalog Description

At the end of the course, students shall be able to analyze data using various parametric and non-parametric tests. Also, the students will be in a position to visualize the scope of experimental designs in getting valid and efficient results. As a result, they will decide to select an appropriate experimental design and analyze the same to interpret the results so obtained.

## Course Content

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### UNIT-I

16 lecture hours

#### Hypothesis Tests

Estimation of population mean, confidence intervals for the parameters of a normal distribution (one sample and two sample problems). The basic idea of significance test. Null and alternative hypothesis. Type I & Type II errors, level of significance, concept of p-value. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).

### UNIT-II

14 lectures hours

#### Goodness-Fit Tests

Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square test, Yates' correction.

### UNIT-III

16 lecture hours

#### Sign Test for Symmetry

Tests for the significance of correlation coefficient. Sign test for median, Sign test for symmetry, Wilcoxon two-sample test.

### UNIT-IV

14 lecture hours

#### Designs of Experiments

Analysis of variance, one-way and two-way classification. Brief exposure of three basic principles of design of experiments, treatment, plot and block. Analysis of completely randomized design, randomized complete block design. Bioassay.

### Reference Books/Materials

1. Daniel, Wayne W., Bio-statistics: A Foundation for Analysis in the Health Sciences. John Wiley.
2. Goon, A.M., Gupta M.K. & Das Gupta, Fundamentals of statistics, Vol.-I & II.
3. Dass, M. N. &Giri, N. C.: Design and analysis of experiments. John Wiley.
4. Dunn, O.J Basic Statistics: A primer for the Biomedical Sciences by John Wiley.
5. Bancroft, Holdon Introduction to Bio-Statistics , P.B. Hoebar New York.
6. Goldstein, A Biostatistics-An introductory text, The Macmillan New York.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination  
Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

**Relationship between the Course Outcomes (COs) and Program Outcomes (POs)**

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
<b>CO1</b>	understand of Parametric models for developing relevant inferences on associated parameters	<b>PO7</b>
<b>CO2</b>	use different nonparametric/distribution-free tests when data don't meet the assumptions of parametric test,	<b>PO1</b>
<b>CO3</b>	know advanced level topics in statistical inference on testing of statistical hypotheses for both randomized and non-randomized tests	<b>PO2</b>
<b>CO4</b>	knowledge of point and interval estimation procedures and different methods of point estimation	<b>PO5</b>
<b>CO5</b>	use appropriate experimental designs to analyze the experimental data	<b>PO3</b>
<b>CO6</b>	real lifetime data implementation of various concepts as outlined above through practical assignments.	<b>PO4</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 825A	Basics of Statistical Inference	2	3	3	3	2		2					2	3	3	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.



1=weakly mapped

2= moderately mapped

3=strongly mapped

**Programme and Course Mapping**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2										3	2	1	1	2
CO2								2			3	2	1	1	2
CO3		3									3	2	1	1	2
CO4				2							3	2	1	1	2
CO5			3								3	2	1	1	2
CO6	3										3	2	1	1	2
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA875A</b>	<b>BASICS OF STATISTICAL INFERENCE LAB</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>
<b>Total Contact Hours</b>	<b>15</b>				
<b>Pre-requisites/Exposure</b>	<b>--</b>				
<b>Co-requisites</b>	<b>MINITAB /MATLAB/R/ SAS/ SPSS/ STATISTIKA</b>				

### Course Objectives

- 1 Knowledge of Statistics and its scope and importance in various areas such as Medical, Engineering, Agricultural and Social Sciences etc.
- 2 Knowledge of other types of data reflecting quality characteristics including concepts of independence and association between two attributes
- 3 Real illustrations for the concepts mentioned above through laboratory assignments

### Course Outcomes

On completion of this course, the students will be able to know

- CO1 with knowledge of two dimensional discrete and continuous random variables, their associated distributions and characteristics
- CO2 with inferential knowledge regarding the parameters of Bivariate and Multivariate Normal distributions
- CO3 confidence interval estimation and their relationships with testing
- CO4 knowledge about important inferential aspects such as point estimation, test of hypotheses and associated concepts
- CO5 order statistics and their distributions
- CO6 give statistical interpretation of the experimental results obtained

### Catalog Description

This course is based on BSMA 825A and will provide practical knowledge to the students on various concepts elaborated in the course. R programming is introduced in this practical. All standard statistical software packages, namely, MINITAB, MATLAB, R, MATHEMATICA, SAS, S-SPLUS, STATISTIKA, etc. are introduced and also used in the subsequent practical courses and projects.

## Course Content

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### List of Practicals

1. Estimators of population mean.
2. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).
3. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).
4. Chi-square test of proportions.
5. Chi-square tests of association.
6. Chi-square test of goodness-of-fit.
7. Test for correlation coefficient.
8. Sign test for median.
9. Sign test for symmetry.
10. Wilcoxon two-sample test.
11. Analysis of Variance of a one way classified data
12. Analysis of Variance of a two way classified data.
13. Analysis of a CRD.
14. Analysis of an RBD.

### Reference Books/Materials

1. Daniel, Wayne W., Bio-statistics: A Foundation for Analysis in the Health Sciences. John Wiley.
2. Goon, A.M., Gupta M.K. & Das Gupta, Fundamentals of statistics, Vol.-I & II.
3. Dass, M. N. &Giri, N. C.: Design and analysis of experiments. John Wiley.
4. Dunn, O.J Basic Statistics: A primer for the Biomedical Sciences by John Wiley.
5. Bancroft, Holdon Introduction to Bio-Statistics , P.B. Hoebar New York.
6. Goldstein, A Biostatistics-An introductory text, The Macmillan New York.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination Examination Scheme:**

Components	Conduct of Experiment	Attendance	Lab Record/ Quiz/ Viva-Voce	End Term Practical Exam
Weightage (%)	20	10	20	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	with knowledge of two dimensional discrete and continuous random variables, their associated distributions and characteristics	<b>PO9</b>
<b>CO2</b>	with inferential knowledge regarding the parameters of Bivariate and Multivariate Normal distributions	<b>PO2</b>
<b>CO3</b>	confidence interval estimation and their relationships with testing	<b>PO3</b>
<b>CO4</b>	knowledge about important inferential aspects such as point estimation, test of hypotheses and associated concepts	<b>PO8</b>
<b>CO5</b>	order statistics and their distributions	<b>PO5</b>
<b>CO6</b>	give statistical interpretation of the experimental results obtained	<b>PO10</b>

			Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	
BSMA 875A	Basics of Statistical Inference Lab		3	3		2			2	3	3		2	3	3		

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO 10</b>	<b>PSO 1</b>	<b>PSO 2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>CO1</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO2</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO3</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO4</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO5</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO6</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA827A</b>	<b>STOCHASTIC PROCESSES AND QUEUING THEORY</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### Course Objectives

1. To understand the basic notions of probability theory, give a definition of a stochastic process; plot a trajectory and find finite-dimensional distributions for simple stochastic processes.
2. To describe and explain the theory of Markov Chains
3. To understand the definitions and main properties of Poisson processes of different types and apply these processes to various real-life tasks,
4. To describe and analyze basic Markov queuing models and situations to which they may be applied
5. To describe networks of queuing systems

### Course Outcomes

On completion of this course, the students will be able to

CO1- Understand the basic of Probability Distributions

CO2- To construct models in discrete and continuous time based on Markov Chains and explain the theory of Markov Chains

CO3- To analyze basic Markov queuing models which applied to describe networks of queuing systems

CO4- Determine the stationary distributions of a Markov chain

CO5- Understand strengths and weaknesses of Queuing Models

CO6 -To develop the modeling and mathematical skills to analytically determine computer systems

### Catalog Description

Basic mathematical modeling is at the heart of engineering. In both electrical and computer engineering, many complex systems are modeled using stochastic processes. This course will introduce students to basic stochastic processes and queuing theory tools that can be utilized for performance analysis.

## Course Content

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**Unit I:** **14 lecture hours**

### Stochastic Process

Probability Distributions: Generating functions, Bivariate probability generating function.  
Stochastic Process: Introduction, Stationary Process.

**Unit II:** **16 lecture hours**

### Markov Chains

Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markovchain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains, stability of Markov system, graph theoretic approach.

**Unit III:** **16 lecture hours**

### Poisson Process

Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process, pure death process.

**Unit IV:** **14 lecture hours**

### Queuing Models

Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof). Gambler's Ruin Problem: Classical ruin problem, expected duration of the game.

### Reference Books/Materials

1. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
2. Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.
3. Bhat, B.R. (2000): Stochastic Models: Analysis and Applications, New Age International Publishers.
4. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.
5. Feller, William (1968): Introduction to probability Theory and Its Applications, Wiley International.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

**Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50



### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Understand the basic of Probability Distributions determine computer systems	<b>PO7</b>
<b>CO2</b>	To construct models in discrete and continuous time based on Markov Chains and explain the theory of Markov Chains	<b>PO2</b>
<b>CO3</b>	To analyze basic Markov queuing models which applied to describe networks of queuing systems	<b>PO3</b>
<b>CO5</b>	Understand strengths and weaknesses of Queuing Models	<b>PO6</b>
<b>CO6</b>	To develop the modeling and mathematical skills to analytically	<b>PO5</b>

			Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings and drawing logical conclusions	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics	Understand demands of the growing field of Mathematics by lifelong learning	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	
BSMA 827A	Stochastic Processes and Queuing Theory		2	3		3	3	3				2	2			3	

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>	<b>PO 6</b>	<b>PO 7</b>	<b>PO 8</b>	<b>PO 9</b>	<b>P O 10</b>	<b>PS O 1</b>	<b>PS O 2</b>	<b>PSO 3</b>	<b>PSO 4</b>	<b>PSO 5</b>
<b>CO 1</b>	2										3	2	1	1	2
<b>CO 2</b>								2			3	2	1	1	2
<b>CO 3</b>		3									3	2	1	1	2
<b>CO 4</b>				2							3	2	1	1	2
<b>CO 5</b>			3								3	2	1	1	2
<b>CO 6</b>	3										3	2	1	1	2
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA877A</b>	<b>STOCHASTIC PROCESSES AND QUEUING THEORY LAB</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>
<b>Total Contact Hours</b>	<b>15</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	<b>MATLAB</b>				

### Course Objectives

The purpose of these labs is to help students talk and write in meaningful ways The Poisson process, Discrete time and continuous time Markov Chains. Markov queuing systems: one server, several servers, finite and infinite carrying capacity, Markovian queuing systems, networks of queuing systems, M/M/, M/M/m, M/G/1 systems, Theory and methods applied to applications in communication, traffic and transport systems.

### Course Outcomes

On completion of this course, the students will be able to

- CO1. Calculation of transition probability matrix and Identification of characteristics of reducible and irreducible chains.
- CO2. Identification of types of classes and ergodic transition probability matrix
- CO3. Stationary of Markov chain and graphical representation of Markov chain and Computation of probabilities in case of generalizations of independent Bernoulli trials
- CO4 Calculation of probabilities for given birth and death rates and compute the inter-arrival time for a Poisson process.
- CO5 Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as N tends to infinity and compute the probabilities and expected duration between players.

### Catalog Description

The aim of this course is to provide students with basic knowledge of stochastic models with a special focus on queueing models, that may apply to telecommunications topics, such as traffic modelling, performance evaluation, resource provisioning and traffic management.

### List of Practicals

1. Calculation of transition probability matrix
2. Identification of characteristics of reducible and irreducible chains.
3. Identification of types of classes
4. Identification of ergodic transition probability matrix
5. Stationarity of Markov chain and graphical representation of Markov chain

6. Computation of probabilities in case of generalizations of independent Bernoulli trials
7. Calculation of probabilities for given birth and death rates and vice versa
8. Computation of inter-arrival time for a Poisson process.
9. Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as N tends to infinity.
10. Calculation of generating function and expected duration for different amounts of stake.
11. Computation of probabilities and expected duration between players.

#### Reference Books/Materials

1. Nelson, Randolph , **Probability, Stochastic Processes, and Queueing Theory, Springer**
2. Andrey Sarantsev, **Introduction To Probability Theory And Stochastic Processes(Online)**  
**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

#### Examination Scheme:

Components	Conduct of Experiment	Attendance	Lab Record/ Quiz/ Viva-Voce	End Term Practical Exam
Weightage (%)	20	10	20	50

#### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
CO1	Calculation of transition probability matrix and Identification of characteristics of reducible and irreducible chains.	PO2,PO9
CO2	Identification of types of classes and ergodic transition probability matrix	PO7
CO3	Stationary of Markov chain and graphical representation of Markov chain and Computation of probabilities in case of generalizations of independent Bernoulli trials	PO3, PO10
CO4	Calculation of probabilities for given birth and death rates and compute the inter-arrival time for a Poisson process.	PO5, PO10
CO5	Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as N tends to infinity and compute the probabilities and expected duration between players.	PO2, PO9

			Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics	Understand demands of the growing field of Mathematics by lifelong learning	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	
BSMA 877A	Stochastic Processes and Queuing Theory Lab		3	3		2		2		3	3		3	2	3		

1=weakly mapped

2= moderately mapped

3=strongly mapped

Programme and Course Mapping															
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2										3	2	1	1	2
CO2								2			3	2	1	1	2
CO3		3									3	2	1	1	2
CO4				2							3	2	1	1	2
CO5			3								3	2	1	1	2
CO6	3										3	2	1	1	2
1=lightly mapped			2= moderately mapped				3=strongly mapped								

<b>BSCA330A</b>	<b>NETWORK SECURITY AND CRYPTOGRAPHY</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 2.0</b>		<b>3</b>	<b>1</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### **Course Objectives**

1. Understand the difference between classical and modern cryptography.
2. Learn the fundamentals of cryptography, including Data and Advanced Encryption Standards (DES & AES) and RSA.
3. Encrypt and decrypt messages using block ciphers, sign and verify messages using well-known signature generation and verification algorithms.
4. Know about the aspects of number theory which are relevant to cryptography.

### **Course Outcomes**

On completion of this course, the students will be able to

- CO1. Describe network security services and mechanisms.
- CO2. Differentiate between Symmetrical and Asymmetrical cryptography.
- CO3. Analyze Data integrity, Authentication, Digital Signatures
- CO4. Understand various network security applications, IPSec, Firewall, IDS, Web security, Email security, and malicious software etc.

### **Catalog Description**

Network Security and Cryptography is an indispensable tool for protecting information in computer systems. In this course students will learn the inner workings of cryptographic systems and how to correctly use them in real-world applications. The course begins with a detailed discussion of how two parties who have a shared secret key can communicate securely when a powerful adversary eavesdrops and tampers with traffic. Students will examine many deployed protocols and analyze mistakes in existing systems. The second half of the course discusses public-key techniques that let two parties generate a shared secret key. Throughout the course participants will be exposed to many exciting open problems in the field and work on fun (optional) programming projects. In a second course (Crypto II) we will cover more advanced cryptographic tasks such as zero-knowledge, privacy mechanisms, and other forms of encryption.



## Course Content

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**Unit I:** **14 lecture hours**

**Introduction:** Plain text and cipher text, substitution techniques, transposition techniques, encryption and decryption, symmetric and asymmetric key cryptography.

**Unit II:** **16 lecture hours**

**Symmetric and Asymmetric key algorithms:** Introduction, algorithm types and modes, DES, AES. Introduction, history of asymmetric key cryptography, RSA symmetric and asymmetric key cryptography together, Digital signature.

**Unit III:** **16 lecture hours**

**Internet security protocols:** basic concepts, Secure Socket Layer (SSL), Transport Layer Security (TLS), Secure HyperText Transfer protocol (SHTTP), Time Stamping Protocol (TSP), Secure Electronic Transaction (SET), SSL versus SET, Electronic Money, Email Security.

**Unit IV:** **14 lecture hours**

**User Authentication and Kerberos:** Introduction, Authentication basics, Passwords, authentication tokens, certificate based authentication, biometric based authentication, Kerberos, key distribution center (KDC), Security handshake pitfalls, single sign on(SSO) approach.

### Textbooks

1. Atul Kahate, "Cryptography and Network Security", TMH
2. Mani Subramaniam , "Network Management Principles & Practices" AWL

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

**Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Describe network security services and mechanisms.	<b>PO1,PO7</b>
<b>CO2</b>	Differentiate between Symmetrical and Asymmetrical cryptography.	<b>PO5,PO7</b>
<b>CO3</b>	Analyze Data integrity, Authentication, Digital Signatures	<b>PO8,PO7</b>
<b>CO4</b>	Understand various network security applications, IPSec, Firewall, IDS, Web security, Email security, and malicious software etc.	<b>PO4,PO7</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSCA330A	Network Security and Cryptography	3			3	3		3	3			2		3	3	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>CO1</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO2</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO3</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO4</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO5</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO6</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSCA372A</b>	<b>NETWORK SECURITY AND CRYPTOGRAPHY LAB</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>
<b>Total Contact Hours</b>	<b>15</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### Course Objectives

1. Understand the difference between classical and modern cryptography.
2. Learn the fundamentals of cryptography, including Data and Advanced Encryption Standards (DES & AES) and RSA.
3. Encrypt and decrypt messages using block ciphers, sign and verify messages using well-known signature generation and verification algorithms.
4. Know about the aspects of number theory which are relevant to cryptography.

### Course Outcomes

On completion of this course, the students will be able to

- CO1. Describe network security services and mechanisms.
- CO2. Differentiate between Symmetrical and Asymmetrical cryptography.
- CO3. Analyze Data integrity, Authentication, Digital Signatures
- CO4. Understand various network security applications, IPSec, Firewall, IDS, Web security, Email security, and malicious software etc.

### Catalog Description

Network Security and Cryptography is an indispensable tool for protecting information in computer systems. In this course students will learn the inner workings of cryptographic systems and how to correctly use them in real-world applications. The course begins with a detailed discussion of how two parties who have a shared secret key can communicate securely when a powerful adversary eavesdrops and tampers with traffic. Students will examine many deployed protocols and analyze mistakes in existing systems. The second half of the course discusses public-key techniques that let two parties generate a shared secret key. Throughout the course participants will be exposed to many exciting open problems in the field and work on fun (optional) programming projects. In a second course (Crypto II) we will cover more advanced cryptographic tasks such as zero-knowledge, privacy mechanisms, and other forms of encryption.

## Course Content

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### List of Experiments

1. Understanding types of Network Attacks:
2. Case study of different types of passive and active attacks (2 each).
3. To study Symmetric key encryption principles.
4. Write a program to implement DES algorithm or use existing library programs to test it.
5. Examine different techniques for authentication. Study examples of each type.
6. Examine how PGP works.
7. Use the tools available at gnupg.org, study the commands and use it.
8. To study MD5 algorithm. Use existing implementations in your own code to generate and verify MD5 hashes for files.
9. To study RSA algorithm.
10. Study of Secure Socket Layer (SSL).
11. To study security requirements for websites
12. To study Wireless Network security.
13. Examine how firewalls work.

### Textbooks

1. Jeffrey Hoffstein, Jill Pipher & Joseph H. Silverman (2014). An Introduction to Mathematical Cryptography (2<sup>nd</sup> edition). Springer.
2. Neal Koblitz (1994). A Course in Number Theory and Cryptography (2<sup>nd</sup> edition). Springer-Verlag.
3. Christof Paar & Jan Pelzl (2014). Understanding Cryptography. Springer.
4. Simon Rubinfeld-Salzedo (2018). Cryptography. Springer.
5. Douglas R. Stinson & Maura B. Paterson (2019). Cryptography Theory and Practice

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination Examination Scheme:**

Components	Conduct of Experiment	Attendance	Lab Record /Quiz/Viva-Voce	End Term Practical Exam
Weightage (%)	20	10	20	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Describe network security services and mechanisms.	<b>PO2,PO7</b>
<b>CO2</b>	Differentiate between Symmetrical and Asymmetrical cryptography.	<b>PO5,PO7</b>
<b>CO3</b>	Analyze Data integrity, Authentication, Digital Signatures	<b>PO8,PO7,PO10</b>
<b>CO4</b>	Understand various network security applications, IPsec, Firewall, IDS, Web security, Email security, and malicious software etc.	<b>PO4,PO7,PO10</b>

			Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.													
			Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.													
			Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.													
			Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.													
			Enhance knowledge mobilization through increased application of mathematics.													
			Able to use the advance knowledge in consultancy to solve real life problems.													
			Learn the subject with curiosity to understand new scientific developments.													
			Understand international perspective about mathematics.													
			Capability to use appropriate software's to solve mathematical equations.													
			Develop the protocols as per laboratory standards to accomplish the objectives.													
			Develop aptitude to formulate concepts based on fundamental axioms of mathematics.													
			Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.													
			Understand demands of the growing field of Mathematics by lifelong learning.													
			Develop problem-solving skills, critical thinking, and interest through assignments and project work													
			Prepare students for competitive examinations such as NET, GATE, and many others.													
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSCA330A	Network Security and Cryptography		2		2	2		3	3		3		3	3	3	



1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>C01</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C02</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C03</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C04</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C05</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C06</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
			1=lightly mapped			2= moderately mapped			3=strongly mapped						

<b>BSCS401A</b>	<b>ARTIFICIAL INTELLIGENCE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>	<b>Logical and Analytical skill</b>				
<b>Co-requisites</b>	<b>--</b>				

### **Course Objectives**

- 1 Become familiar with basic principles of AI toward problem solving, inference, perception, knowledge representation, and learning.
- 2 To understand how machines act accordingly to situations as a human brain
- 3 To understand different search algorithms and their implementation at realistic models.
- 4 Investigate applications of AI techniques in intelligent agents, expert systems, and other machine learning models

### **Course Outcomes**

On completion of this course, the students will be able to know.

- CO1 Demonstrate fundamental understanding of the history of artificial intelligence (AI) and its foundations.
- CO2 Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning.
- CO3 Demonstrate awareness and a fundamental understanding of various applications of AI techniques in intelligent agents, expert systems, and other machine learning models.
- CO4 Understanding of rule based and knowledge-based approaches in real life scenarios.
- CO5 Demonstrate proficiency in applying scientific method to models of machine learning.

### **Catalog Description**

In this course, An introduction to the basic principles, techniques, and applications of Artificial Intelligence. Coverage includes knowledge representation, handling uncertainties, logic inference, problem solving, search algorithms, natural language processing, perception, learning, planning, and agent design. In addition, how artificial intelligence is used in real-world situations.

## Course Content

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### UNIT-I

14 lecture hours

**Scope of AI:** Games, theorem proving, natural language processing, vision and speech processing, robotics, expert systems, AI techniques-search knowledge, abstraction. State space search; production systems, search space control; depth-first, breadth-first search.

Heuristic search, Hill climbing, best-first search, A\* Algorithm, Problem Reduction, Constraint Satisfaction

### UNIT-II

16 lecture hours

**Knowledge Representation:** Predicate Logic: Unification, Modus Ponens, Modus Tokens, Resolution in Predicate Logic, Conflict Resolution Forward Chaining, Backward Chaining, Declarative and Procedural Representation, Rule based Systems. Semantic Nets: Slots, exceptions and default frames, conceptual dependency.

### UNIT-III

14 lecture hours

**Handling Uncertainty:** Non-Monotonic Reasoning, Probabilistic reasoning: Bayesian Inference, use of uncertainty factors. Introduction to Natural Language Processing, Syntactic Processing, Semantic Processing, Pragmatic Processing.

### UNIT-IV

16 lecture hours

**Learning and Expert Systems:** Concept of learning, learning automation, genetic algorithm, learning by inductions, neural nets. Need and justification for expert systems, knowledge acquisition, Case Studies: MYCIN, RI.

### Textbooks

1. Artificial Intelligence, E. Rich and K. Knight, TMH.

### Reference Books/Materials

1. Artificial Intelligence, P. H. Winston, Pearson Education.
2. Introduction to AI and Expert Systems, D. W. Patterson, PHI.
3. Principles of AI, N. J. Nilsson, Narosa Publishing House.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination  
Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

**Relationship between the Course Outcomes (COs) and Program Outcomes (POs)**

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
<b>CO1</b>	Demonstrate fundamental understanding of the history of artificial intelligence (AI) and its foundations.	<b>PO7, PO8</b>
<b>CO2</b>	Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning.	<b>PSO4</b>
<b>CO3</b>	Demonstrate awareness and a fundamental understanding of various applications of AI techniques in intelligent agents, expert systems, and other machine learning models.	<b>PO4, PSO1</b>
<b>CO4</b>	Understanding of rule based and knowledge-based approaches in real life scenarios.	<b>PO6</b>
<b>CO5</b>	Demonstrate proficiency in applying scientific method to models of machine learning.	<b>PSO3</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSCS401A	Artificial Intelligence				2		2	3	3			2		2	3	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>CO1</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO2</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO3</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO4</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO5</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO6</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSCS451A</b>	<b>ARTIFICIAL INTELLIGENCE LAB</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>
<b>Total Contact Hours</b>	<b>15</b>				
<b>Pre-requisites/Exposure</b>	<b>Basics of Programming</b>				
<b>Co-requisites</b>	<b>--</b>				

### **Course Objectives**

1. The basic objective of AI (also called heuristic programming, machine intelligence) is to enable computers to perform such intellectual tasks as decision making, problem solving, perception, understanding human communication (in any language, and translate among them).
2. To understand main aim of Artificial intelligence how to automate the things as far as it can and reduce the need for manpower.

### **Course Outcomes**

On completion of this course, the students will be able to know.

- CO1 Understand how to set up an environment for working with AI problems. What are the other options/software that can be used for AI problems
- CO2 How prolog can be used for inference, perception, knowledge representation, and learning processes.
- CO3 How to apply rule based and knowledge-based approaches in real life scenarios by checking the working of different algorithms on prolog
- CO4 Using knowledge of reasoning in the presence of incomplete and/or uncertain information

### **Catalog Description**

While AI applications can be developed in any number of different languages, certain language features make programming AI applications straightforward. Prolog is structured in such a way that AI program development is supported by Prolog language features. Other languages, such as Java, support AI programming through code libraries. This course will provide students with an introduction to AI via programming features that support basic AI applications. It enables them to write algorithms for solving problems with the help of fundamental of artificial intelligence.

### List of Experiments (Indicative)

<b>1</b>	Write a program to solve 8-queens problem.	<b>4 lab hours</b>
<b>2</b>	Solve any problem using depth first search.	<b>2 lab hours</b>
<b>3</b>	Solve any problem using best first search.	<b>2 lab hours</b>
<b>4</b>	Solve 8-puzzle problem using best first search.	<b>3 lab hours</b>
<b>5</b>	Solve Robot (traversal) problem using means End Analysis.	<b>2 lab hours</b>
<b>6</b>	Solve traveling salesman problem.	<b>2 lab hours</b>

**Modes of Evaluation: Quiz/Oral practical oral exam/presentation/projects/Practical Examination**

#### Examination Scheme:

<b>Components</b>	<b>Conduct of Experiment</b>	<b>Attendance</b>	<b>Lab Record/ Quiz/ Viva-Voce</b>	<b>End Term Practical Exam</b>
<b>Weightage (%)</b>	<b>20</b>	<b>10</b>	<b>20</b>	<b>50</b>

#### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Understand how to set up an environment for working with AI problems. What are the other options/software that can be used for AI problems	<b>PO1, PO5</b>
<b>CO2</b>	How prolog can be used for inference, perception, knowledge representation, and learning processes.	<b>PO2, PO8, PSO4</b>
<b>CO3</b>	How to apply rule based and knowledge-based approaches in real life scenarios by checking the working of different algorithms on prolog	<b>PO6, PSO3</b>
<b>CO4</b>	Using knowledge of reasoning in the presence of incomplete and/or uncertain information	<b>PSO1, PO4</b>



		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSCS 451A	Artificial Intelligence Lab	2	2		3	2	2		3			2		2	3	

1=weakly mapped  
 2= moderately mapped  
 3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>C01</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C02</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C03</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C04</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C05</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C06</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
1=lightly mapped			2= moderately mapped					3=strongly mapped							

### Semester IV

<b>BSMA802A</b>	<b>FUNCTIONAL ANALYSIS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 2.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>	<b>Linear Algebra and Real Analysis</b>				
<b>Co-requisites</b>	<b>--</b>				

#### **Course Objectives:**

The course will enable the students to:

1. Understand the a more advanced concepts such as normed spaces and Banach spaces
2. Describe Inner product with its applications.
3. Know concepts about some fundamental operators

#### **Course Outcomes:**

On completion of this course, the students will be able to

- CO1. Understand the concept of bounded linear operators
- CO2. Connect Hilbert spaces with simple applications
- CO3. Apply the notions Adjoint and self-adjoint operators.
- CO4. Learn in detail about Hahn Banach theorem and open mapping theorem

#### **Catalog Description:**

This course aims to deal with some more advanced concepts in analysis, and it is laid on a preliminary course in linear algebra and real analysis. The course begins with a review of metric spaces with definitions and examples of it. Self-adjoint, unitary and normal operators, Hilbert - adjoint operator are the key concepts in this learning programme. Moreover, some fundamental results such as Hahn Banach theorem, uniform boundedness theorem and open mapping theorem are also considered in the plan of action.

#### **Course Content**

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##### **Unit I:**

**14 lecture hours**

##### **Introduction to Normed Spaces**

Review of metric spaces, normed spaces, Banach spaces, bounded linear operators and functionals, convergence.

**Unit II: 16 lecture hours**  
**Hilbert Spaces**

Inner product spaces, Hilbert spaces with example, projection theorem, orthonormal sets and sequences.

**Unit III: 14 lecture hours**

**Riesz representation theorem**

Riesz representation theorem, self-adjoint, unitary and normal operators, Hilbert - adjoint operator

**Unit IV: 16 lecture hours**

**Hahn Banach Theorem**

Hahn Banach theorem, uniform boundedness theorem (Banach-Steinhaus theorem), open mapping theorem and closed graph theorem

**Textbooks**

1. G. F. Simmons; Introduction to Topology and Modern Analysis, McGraw-Hill.
2. Kreyszig; Introductory Functional analysis with Applications, Wiley India publication.

**Reference Books/Materials**

3. A. E. Taylor; Introduction to Functional Analysis, John Wiley.
4. N. Dunford and J. T. Schwartz; Linear Operators, Part-I, Interscience.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination/ Examination Scheme:**

<b>Components</b>	<b>Quiz</b>	<b>Attendance</b>	<b>Mid Term Exam</b>	<b>Presentation/ Assignment/ etc.</b>	<b>End Term Exam</b>
<b>Weightage (%)</b>	<b>10</b>	<b>10</b>	<b>20</b>	<b>10</b>	<b>50</b>

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Understand the concept of bounded linear operators	<b>PO3</b>
<b>CO2</b>	Connect Hilbert spaces with simple applications	<b>PO5</b>
<b>CO3</b>	Apply the notions Adjoint and self-adjoint operators	<b>PO8</b>
<b>CO4</b>	Learn in detail about Hahn Banach theorem and open mapping theorem	<b>PO10</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA802A	Functional Analysis		3				3	3		2		3		2		
		<p>Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.</p> <p>Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.</p> <p>Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.</p> <p>Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.</p> <p>Enhance knowledge mobilization through increased application of mathematics.</p> <p>Able to use the advance knowledge in consultancy to solve real life problems.</p> <p>Learn the subject with curiosity to understand new scientific developments.</p> <p>Understand international perspective about mathematics.</p> <p>Capability to use appropriate software's to solve mathematical equations.</p> <p>Develop the protocols as per laboratory standards to accomplish the objectives.</p> <p>Develop aptitude to formulate concepts based on fundamental axioms of mathematics.</p> <p>Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.</p> <p>Understand demands of the growing field of Mathematics by lifelong learning.</p> <p>Develop problem-solving skills, critical thinking, and interest through assignments and project work</p> <p>Prepare students for competitive examinations such as NET, GATE, and many others.</p>														

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>CO1</b>	2										3	2	1	1	2
<b>CO2</b>								2			3	2	1	1	2
<b>CO3</b>		3									3	2	1	1	2
<b>CO4</b>				2							3	2	1	1	2
<b>CO5</b>			3								3	2	1	1	2
<b>CO6</b>	3										3	2	1	1	2
1=lightly mapped			2= moderately mapped				3=strongly mapped								

<b>BSMA804A</b>	<b>MATHEMATICAL PROGRAMMING</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 2.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### Course Objectives

1. Assess critically the utility of a number of mathematical programming techniques.
2. Describe mathematical programming solution strategies and techniques.
3. Use mathematical programming methods to address management decision problems.

### Course Outcomes

On completion of this course, the students will be able to

- CO1. To formulate a real-world problem as a mathematical programming model
- CO2. To apply the appropriate method in order to find an optimal solution
- CO3. Understand the problems of mathematical programming and related theorems
- CO4. Understands the basics concepts of integer programming (IP) and nonlinear programming (NLP) problems
- CO5. Emphasizing the underlying mathematical structures, geometrical ideas, algorithms solutions of relevant practical problem
- CO6. Learn about solution of nonlinear programming problems by using Lagrange multiplier and KuhnTucker conditions

### Catalog Description

Optimisation problems are concerned with optimising an objective function subject to a set of constraints. When deterministic optimisation problems are translated in algebraic form, we refer to them as mathematical programs. Mathematical programming, as an area within Operational Research (OR), Management Science (MS) and Business Analytics (BA), is concerned with model building and strategies and methods for solving mathematical programs. In this course, we address model building in OR/MS/BA, present a variety of typical OR/MS/BA problems and their mathematical programming formulations, provide general tips on how to model managerial situations, and discuss solution strategies and present solution methods for linear programs, non-linear programs and integer programs.



## Course Content

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**Unit I:** **14 lecture hours**

**Unconstrained Optimization Problems**

Existence theorems, First order optimality conditions and second order optimality conditions for unconstrained optimization problems

**Unit II:** **16 lecture hours**

**Convex Functions**

Convex functions, Differentiable convex functions, Optimization on convex sets, Karush Kuhn Tucker conditions in nonlinear programming, Second order conditions in nonlinear programming

**Unit III:** **16 lecture hours**

**Quadratic Programming**

Quadratic programming, Wolfe's method as application of Karush Kuhn Tucker conditions, convex simplex method, Penalty function methods.

**Unit IV:** **14 lecture hours**

**Integer Linear Programming**

Integer Linear Programming, Modelling using pure and mixed integer programming, Branch and Bound Technique, Gomory's Cutting Plane Algorithm

**Reference Books/Materials**

1. Jan Brinkhuis and Vladimir Tikhomirov; Optimization : Insights and Applications, Princeton University Press.
2. Kenneth Lange; Optimization, Springer.
3. Osman Gler; Foundations of Optimization, Springer.
4. David G. Luenberger and Yinyu Ye; Linear and Nonlinear Programming, Springer.
5. Mokhtar S. Bazaraa, Hanif D. Sherali and C.M. Shetty; Nonlinear Programming: Theory and Algorithms, John Wiley & Sons, 2006.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

**Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	To formulate a real-world problem as a mathematical programming model	<b>PO2</b>
<b>CO2</b>	To apply the appropriate method in order to find an optimal solution	<b>PO4</b>
<b>CO3</b>	Understand the problems of mathematical programming and related theorems	<b>PO3</b>
<b>CO4</b>	Understands the basics concepts of integer programming (IP) and nonlinear programming (NLP) problems	<b>PO1</b>
<b>CO5</b>	Emphasizing the underlying mathematical structures, geometrical ideas, algorithms solutions of relevant practical problem	<b>PO6</b>
<b>CO6</b>	Learn about solution of nonlinear programming problems by using Lagrange multiplier and KuhnTucker conditions	<b>PO5, PO7</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 804A	Mathematical Programming	2	3	3		2	3	3				3	2	2	2	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics	Understand demands of the growing field of Mathematics by lifelong learning	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>CO1</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO2</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO3</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO4</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO5</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO6</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA806A</b>	<b>FUZZY SET AND APPLCATIONS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### **Course Objectives**

1. Provide a brief knowledge of Fuzzy sets.
2. Invention the Decomposition of fuzzy sets and power of the fuzzy sets.
3. Determined the Transitivity, involution, Demorgans laws by using the fuzzy sets.
4. Understand the identity the arbitrary collection of fuzzy sets and their applications in social sciences, physical sciences, life sciences and a host of other disciplines.

### **Course Outcomes**

On completion of this course, the students will be able to

1. Applied distinguish between the crisp set and fuzzy set concepts through the learned differences between the crisp set characteristic function and the fuzzy set membership function.
2. Construct the appropriate fuzzy numbers corresponding to uncertain and imprecise collected data.
3. Recognize the fuzzy inference systems in the design of intelligent or humanistic systems.
4. Determine the concept of fuzzy applications to design complex and critical financial models for any organization.
5. Apply the fuzzy application to solve real life problems in different field.

### **Catalog Description**

The focus of the course is the concepts and techniques for solving the fuzzy sets that permeate various scientific disciplines. Applications include problems from electrical and mechanical engineering, materials science, quantum mechanics, etc. Important objectives of the fuzzy sets and application are to develop and strengthen the students' problem-solving skills and to teach them to read, write, speak, and think in the language of mathematics. In particular, students learn how to apply the tools of calculus to a variety of problem situations.

## Course Content

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### Unit I:

14 lecture hours

**Fuzzy concepts:** Definition of a fuzzy set and membership function, representation of membership function, General definitions and properties of fuzzy sets, Support, height, equality of two fuzzy sets.

### Unit II:

16 lecture hours

**Fuzzy union and intersection:** Union and Intersection of fuzzy sets, Complement of a fuzzy set, normal fuzzy set,  $\alpha$ - cut set, strong  $\alpha$ -cut, convex fuzzy set, Necessary and Sufficient condition for convexity of a fuzzy set, Decomposition of fuzzy sets, Level set of a fuzzy set, Cardinality, fuzzy cardinality, Product of fuzzy sets, Product of a fuzzy set with a crisp number, Power of a fuzzy set, Difference of fuzzy sets, Disjunctive sum of fuzzy sets.

### Unit III:

16 lecture hours

**Properties of fuzzy sets:** General properties of operations on fuzzy sets, Commutativity, associativity, distributivity, Idempotent law, identities for operations, Transitivity, involution, Demorgans laws, proofs and examples, Some important theorems on fuzzy sets, set inclusion of fuzzy sets and corresponding  $\alpha$ -cuts and strong  $\alpha$ -cuts.

### Unit IV:

14 lecture hours

**Applications of fuzzy sets:** Comparison of  $\alpha$ -cut and strong  $\alpha$ -cut, Order relation of scalars  $\alpha$  is inversely preserved by set inclusion of corresponding  $\alpha$ -cuts and strong  $\alpha$ -cuts,  $\alpha$ -cut of union and intersection of two fuzzy sets,  $\alpha$ -cut of complement of a fuzzy set,  $\alpha$ -cuts and strong  $\alpha$ -cuts of union and intersection of arbitrary collection of fuzzy sets.

### Textbooks

1. Pundir and Pundir; *Fuzzy Sets and their Applications*, Pragati Prakashan.

### Reference Books/Materials

1. G.J. Klir, B.Yuan; *Fuzzy Sets and Fuzzy Logic: Theory and Applications*, Prentice Hall.
2. Hao Ying; *Fuzzy Control and Modeling: Analytical Foundations and Applications*, IEEE Press.
3. T.J. Ross; *Fuzzy Logic with Engineering Applications*, John Wiley & Sons.
4. H.J. Zimmermann; *Fuzzy set theory and its Applications*, Allied Publishers Ltd, New Delhi.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination  
Examination Scheme:**

<b>Components</b>	<b>Quiz</b>	<b>Attendance</b>	<b>Mid Term Exam</b>	<b>Presentation/ Assignment/ etc.</b>	<b>End Term Exam</b>
<b>Weightage (%)</b>	<b>10</b>	<b>10</b>	<b>20</b>	<b>10</b>	<b>50</b>

**Relationship between the Course Outcomes (COs) and Program Outcomes (POs)**

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Applied distinguish between the crisp set and fuzzy set concepts through the learned differences between the crisp set characteristic function and the fuzzy set membership function.	<b>PO1</b>
<b>CO2</b>	Construct the appropriate fuzzy numbers corresponding to uncertain and imprecise collected data.	<b>PO8</b>
<b>CO3</b>	Recognize the fuzzy inference systems in the design of intelligent or humanistic systems.	<b>PO2</b>
<b>CO4</b>	Determine the concept of fuzzy applications to design complex and critical financial models for any organization.	<b>PO4</b>
<b>CO5</b>	Apply the fuzzy application to solve real life problems in different field.	<b>PO3</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 806A	Fuzzy sets and applications	2	3	3	2				2			3		3	2	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work.	Prepare students for competitive examinations such as NET, GATE, and many others.



1=weakly mapped

2= moderately mapped

3=strongly mapped

**Programme and Course Mapping**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
C01	2										3	2	1	1	2
C02								2			3	2	1	1	2
C03		3									3	2	1	1	2
C04				2							3	2	1	1	2
C05			3								3	2	1	1	2
C06	3										3	2	1	1	2
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA809A</b>	<b>FLUID DYNAMICS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 2.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### Course Objectives

The objective of this course is to introduce fundamental aspects of fluid flow behaviour and to develop steady state mechanical energy balance equation for fluid flow systems, estimate pressure drop in fluid flow systems and determine performance characteristics of fluid machinery.

### Course Outcomes

This course will enable the students to:

- CO1. Develop appreciation properties of fluids
- CO2. Derived Euler's equation, Bernoulli's equation and Discuss the case of steady motions under conservative body forces.
- CO3. Apply concepts of mass, momentum and energy conservation to flows,
- CO4. Prove Milne- Thomson Circle theorem and derived some application.
- CO5. Understand the concept of elements of thermodynamics and explain Entropy-Maxwell's Thermodynamics relation

### Catalog Description

After completing this course the student able to: study of Fluid motion, Lagrangian and Eulerian methods , Euler's and Lagrange's Equation of continuity and equation of motion , Newton's law of viscosity Navier-Stokes equations of motion, Steady viscous flow between parallel planes.

### Course Content

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#### Unit I:

**14 lecture hours**

#### Introduction to Fluid Flows

Classification of fluid flows - viscous flow, compressible flow, steady flow, uniform flow, laminar flow, turbulent flow, Properties of fluids.

**Unit II:** **16 lecture hours**

**Fluid Kinematics**

Fluid kinematics - Lagrangian and Eulerian Descriptions, Flow Patterns - streamlines and streamtubes, pathlines, streaklines, timelines, Vorticity and rotationality, The Reynolds Transport Theorem

**Unit III:** **14 lecture hours**

**Law of Conservation of Mass**

Conservation of mass, Conservation of energy, Mass and volume flow rates, The Linear Momentum Equation, Bernoulli Equation, General Energy Equation

**Unit IV:** **16 lecture hours**

**Navier-Stokes Equations**

Laminar flow in pipes, Turbulent flow in pipes, Newtonian versus Non-Newtonian fluids, The Navier–Stokes Equation, Continuity and Navier–Stokes equations

**Textbooks**

1. W. H. Besant and A.S. Ramsey; *A Treatise on Hydromechanics*, Part-II, CBS Publishers.
2. F. Chorlton; *Text-book of Fluid Dynamics*, C. B. S. Publishers, Delhi.
3. Michael E.O. Neill and F. Chorlton; *Ideal and Incompressible Fluid Dynamics*, John Wiley & Sons.
4. R.K. Rathy. *An Introduction to Fluid Dynamics*, Oxford and IBH Publishing Company.
5. A.J. Chorin and A. Marsden, *A Mathematical Introduction to Fluid Dynamics* Springer-Verlag, New York.
6. L.D. Landau and E.M. Lipschitz, *Fluid Mechanics*, Pergamon Press, London.
7. G. K. Batchelor; *An Introducton to Fluid Mechanics*, Foundation Books, New Delhi.

**Reference Books/Materials**

1. J.F. Wendt, J.D. Anderson, G.Degrez and E. Dick, *Computational Fluid Dynamics : An Introduction*, Springer-Verlag, 1996.
2. J.D. Anderson, *Computational Fluid Dynamics, The Basics with Applications*, McGraw Hill, 1995.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

**Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Develop appreciation properties of fluids	<b>PO1</b>
<b>CO2</b>	Derived Euler's equation, Bernoulli's equation and Discuss the case of steady motions under conservative body forces.	<b>PO3</b>
<b>CO3</b>	Apply concepts of mass, momentum and energy conservation to flows	<b>PO5</b>
<b>CO4</b>	Prove Milne- Thomson Circle theorem and derived some application.	<b>PO9</b>
<b>CO5</b>	Understand the concept of elements of thermodynamics and explain Entropy-Maxwell's Thermodynamics relation	<b>PO8</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 809A	Fluid Dynamics	2		2		3			2	2						
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>C01</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C02</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C03</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C04</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C05</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C06</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
			1=lightly mapped			2= moderately mapped			3=strongly mapped						

<b>BSMA812A</b>	<b>MATHEMATICAL BIOLOGY</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 2.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### Course Objectives

1. Finding the equilibria of a single-population model and their stability
2. Analysis of equilibria and stability of a delay-differential equation
3. Ability to analyse nonlinear PDE for travelling wave solution
4. Analysis and stability of equilibria of planar nonlinear system
5. Analysis and stability of equilibria of nonlinear systems in more than two variables.
6. Familiarity with biological applications as stated in the syllabus

### Course Outcomes

On completion of this course, the students will be able to

CO1- To enhanced knowledge and understanding of mathematical modeling and statistical methods in the analysis of biological

CO2- Choose and apply computational tools to perform parameter estimation and to solve discrete and differential equation models.

CO3- Be better able to assess biological inferences that rest on mathematical and statistical arguments;

CO4: To analyses data from experiments and draw sound conclusions about the underlying processes using their understanding of mathematics and statistics;

CO5 To use of computers to assist them in studying mathematical functions and carrying out statistical tests.

CO6- To analysis of biological processes and data, including simple computer programming by using software

### Catalog Description

This course gives an introduction to mathematical modelling and data analysis for biological and biomedical systems. Examples include: the formation of animal coat patterns, the spread of diseases through the community, the interaction between pathogens and the immune system of the body, the growth of tumours, nerve cell signaling, population dynamics, pharmacokinetics and bacterial growth. The emphasis in this course is on the development of the governing model equations and on computer simulations of the model equations rather than on mathematical methods for solving the model equation.

## Course Content

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### UNIT – I

14 lecture hours

#### Introduction to Mathematical Biology

Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and Lotka Volterra equations,

### Unit II:

16 lecture hours

#### Population Models

Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC), Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation. Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria,

### Unit III:

16 lecture hours

#### Phase Plane Methods

Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario. Spatial Models: One species model with diffusion, Two species model with diffusion, Conditions for diffusive instability, Spreading colonies of microorganisms, Blood flow in circulatory system, Travelling wave solutions, Spread of genes in a population.

### Unit IV:

14 lecture hours

#### Discrete Models

Discrete Models: Overview of difference equations, steady state solution and linear stability analysis, Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models, Density dependent growth models with harvesting, Host-Parasitoid systems (Nicholson-Bailey model), Numerical solution of the models and its graphical representation. Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models.

### Reference Books/Materials

1. L.E. Keshet, *Mathematical Models in Biology*, SIAM, 1988.
2. J. D. Murray, *Mathematical Biology*, Springer, 1993.
3. Y.C. Fung, *Biomechanics*, Springer-Verlag, 1990.
4. F. Brauer, P.V.D. Driessche and J. Wu, *Mathematical Epidemiology*, Springer, 2008.
5. M. Kot, *Elements of Mathematical Ecology*, Cambridge University Press, 2001.



**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination  
Examination Scheme:**

<b>Components</b>	<b>Quiz</b>	<b>Attendance</b>	<b>Mid Term Exam</b>	<b>Presentation/ Assignment/ etc.</b>	<b>End Term Exam</b>
<b>Weightage (%)</b>	<b>10</b>	<b>10</b>	<b>20</b>	<b>10</b>	<b>50</b>

**Relationship between the Course Outcomes (COs) and Program Outcomes (POs)**

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	To enhanced knowledge and understanding of mathematical modeling and statistical methods in the analysis of biological	<b>PO7</b>
<b>CO2</b>	Choose and apply computational tools to perform parameter estimation and to solve discrete and differential equation models.	<b>PO2</b>
<b>CO3</b>	Be better able to assess biological inferences that rest on mathematical and statistical arguments;	<b>PO3</b>
<b>CO4</b>	To analyses data from experiments and draw sound conclusions about the underlying processes using their understanding of mathematics and statistics;	<b>PO3</b>
<b>CO5</b>	To use of computers to assist them in studying mathematical functions and carrying out statistical tests.	<b>PO6</b>
<b>CO6</b>	To analysis of biological processes and data, including simple computer programming by using software	<b>PO5</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 812A	Mathematical Biology		3	2		3	3	3				2	2		2	2
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics	Understand demands of the growing field of Mathematics by lifelong learning	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

Programme and Course Mapping															
CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O 1	PS O 2	PSO 3	PSO 4	PSO 5
CO 1	2										3	2	1	1	2
CO 2								2			3	2	1	1	2
CO 3		3									3	2	1	1	2
CO 4				2							3	2	1	1	2
CO 5			3								3	2	1	1	2
CO 6	3										3	2	1	1	2
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA818A</b>	<b>DISCRETE MATHEMATICS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>	<b>Computer Programming</b>				
<b>Co-requisites</b>	<b>--</b>				

### Course Objectives

- 1 To apply basic algorithmic techniques such as greedy algorithms, binary search, sorting and dynamic programming to solve programming challenges.
- 2 To apply graph and string algorithms to solve real-world challenges: finding shortest paths on huge maps and assembling genomes from millions of pieces.
- 3 To apply various data structures such as stack, queue, hash table, priority queue, binary search tree, graph and string to solve programming challenges.
- 4 To solve complex programming challenges using advanced techniques: maximum flow, linear programming, approximate algorithms, SAT-solvers, streaming.

### Course Outcomes

On completion of this course, the students will be able to know

- CO1 Apply counting principles to determine probabilities.
- CO2 Simplify and evaluate basic logic statements including compound statements, implications, inverses, converses, and contrapositives using truth tables and the properties of logic.
- CO3 Evaluate Boolean functions and simplify expression using the properties of Boolean algebra; apply Boolean algebra to circuits and gating networks.
- CO4 Represent a graph and apply graph theory to application problems such as computer networks.
- CO5 Demonstrate different traversal methods for trees and graphs.
- CO6 Model problems in Computer Science using graphs and trees.

### Catalog Description

Discrete mathematics forms the mathematical foundation of computer and information science. It is also a fascinating subject in itself. Discrete Math is needed to see mathematical structures in the object you work with, and understand their properties. This ability is important for software engineers, data scientists, security and financial analysts (it is not a coincidence that math puzzles are often used for interviews). We cover the basic notions and results (combinatorics, graphs, probability, number theory) that are universally needed. To deliver techniques and ideas

in discrete mathematics to the learner we extensively use interactive puzzles specially created for this specialization. To bring the learners experience closer to IT-applications we incorporate programming examples, problems and projects in our courses.

## Course Content

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### UNIT-I

14 lecture hours

**Counting and Generating Functions:** Basic counting principles, Permutations and Combinations, Binomial theorem, Multinomial theorem, Counting subsets, Set-partitions, Stirling numbers. Principle of Inclusion and Exclusion, Derangements, Inversion formulae. Algebra of formal power series, Generating function models, Calculating generating functions, Exponential generating functions.

### UNIT-II

16 lecture hours

**Boolean Algebra:** Lattices, Complete lattices, Lattices as algebraic structures, Sublattices, Products and Homomorphisms, Modular and Distributive lattices, Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, Switching circuits.

### UNIT-III

16 lectures hours

**Graph theory:** Directed graph, Euler graph, Hamiltonian graph, Matrix representation of graphs, Shortest path in a weighted graph, K- connected and K- edge connected graphs, Planar graphs, Coloring of graphs, Vizing's theorem.

### UNIT-IV

14 lecture hours

**Trees:** Rooted trees, Spanning tree and Cut set, Minimum-spanning tree, Flow network in a graph, max-flow-min cut theorem.

### Reference Books/Materials

1. C.L. Liu & Mahopatra; *Elements of Discrete mathematics*, Tata McGraw Hill.
2. N. Deo, *Graph Theory with Applications to Computer Science*, Prentice-Hall of India.
3. T.H. Cormen, C.E. Leiserson, R. L. Rivest; *Introduction to algorithms*, Prentice Hall on India.
4. M. O. Albertson and J. P. Hutchinson; *Discrete Mathematics with Algorithms*, Johnwiley Publication.
5. J. L. Hein; *Discrete Structures, Logic, and Computability*, Jones and Bartlett Publishers.
6. Kenneth H. Rosen; *Discrete Mathematics and Its Applications*, McGraw-Hill Education.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination  
Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

**Relationship between the Course Outcomes (COs) and Program Outcomes (POs)**

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
<b>CO1</b>	Apply counting principles to determine probabilities.	<b>PO1</b>
<b>CO2</b>	Simplify and evaluate basic logic statements including compound statements, implications, inverses, converses, and contrapositives using truth tables and the properties of logic.	<b>PO2</b>
<b>CO3</b>	Evaluate Boolean functions and simplify expression using the properties of Boolean algebra; apply Boolean algebra to circuits and gating networks.	<b>PO3</b>
<b>CO4</b>	Represent a graph and apply graph theory to application problems such as computer networks.	<b>PO7</b>
<b>CO5</b>	Demonstrate different traversal methods for trees and graphs.	<b>PO10</b>
<b>CO6</b>	Model problems in Computer Science using graphs and trees.	<b>PO8</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 818A	Discrete Mathematics	2	2	2				3	3		3	2		3	3	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped  
 2= moderately mapped  
 3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>C01</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C02</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C03</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C04</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C05</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>C06</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
			1=lightly mapped			2= moderately mapped			3=strongly mapped						



<b>BSMA828A</b>	<b>NUMBER THEORY</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hours</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### Course Objectives

Number theory is primarily the study of integers and their properties. To present a rigorous development of Number Theory using axioms, definitions, examples, theorems and their proofs. The course provides students an opportunity to develop an appreciation of pure mathematics while engaged in the study of basic number theoretic results. The course is also designed to provide students an opportunity to work with conjectures, proofs, and analyzing mathematics.

### Course Outcomes

This course will enable the students to:

- CO1. Define and interpret the concepts of divisibility, congruence, greatest common divisor, prime numbers and Arithmetical functions.
- CO2. Prove statements and solve problems involving divisibility, prime numbers and quadratic residues.
- CO3. Solve various types of congruence problems and use theory of congruences in applications
- CO4. Construct mathematical proofs of existence of primitive roots modulo  $m$
- CO5. Apply techniques to solve linear Diophantine equations. Apply properties of multiplicative functions such as Euler's Phi function and Mobius function.

### Catalog Description

After completing this course the student able to: Understand the properties of divisibility and prime numbers, compute the greatest common divisor and least common multiples, operations with congruences and use the Lagrange theorem, Fermat's theorem, Chinese remainder theorem.

### Course Content

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#### Unit I:

**14 lecture hours**

#### Linear Equations

The equation  $ax+by = c$ , simultaneous linear equations, Pythagorean triangles, assorted examples, ternary quadratic forms, rational points on curves.

**Unit II:**  
**Elliptic Curves**

**16 lecture hours**

Elliptic curves, Factorization using elliptic curves, curves of genus greater than 1. Farey sequences, rational approximations, Hurwitz theorem, irrational numbers, Geometry of Numbers, Blichfeldt's principle, Minkowski's Convex body theorem Lagrange's four square theorem.

**Unit III:**  
**Approximations**

**14 lecture hours**

Euclidean algorithm, infinite continued fractions, irrational numbers, approximations to irrational numbers, Best possible approximations, Periodic continued fractions, Pell's equation.

**Unit IV:**  
**Euler's formula**

**16 lecture hours**

Partitions, Ferrers Graphs, Formal power series, generating functions and Euler's identity, Euler's formula, bounds on  $P(n)$ , Jacobi's formula, a divisibility property.

**Textbooks**

1. G.H. Hardy, and E.M. Wright; *An Introduction to the Theory of Numbers*, Oxford Science Publications
2. D.M. Burton; *Elementary Number Theory*, McGraw Hill
3. N.H. McCoy; *The Theory of Number*, McMillan.
4. Ivan Niven, Herbert S. Zuckerman, Hugh L. Montgomery; *An Introduction to the Theory of Numbers*, John Wiley & Sons(Asia)Pte.Ltd.

**Reference Books/Materials**

- 1.Neville Robbins (2007). Beginning Number Theory (2nd edition). Narosa.
- 2.I.Niven (2012). An Introduction to the Theory of Numbers (5th edition). John Wiley & Sons.
- 3.Neal Koblitz (1994). A Course in Number Theory and Cryptography (2nd edition). Springer-Verlag.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**  
**Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Define and interpret the concepts of divisibility, congruence, greatest common divisor, prime numbers and Arithmetical functions.	<b>PO1</b>
<b>CO2</b>	Prove statements and solve problems involving divisibility, prime numbers and quadratic residues.	<b>PO3</b>
<b>CO3</b>	Solve various types of congruence problems and use theory of congruences in applications	<b>PO5</b>
<b>CO4</b>	Construct mathematical proofs of existence of primitive roots modulo $m$	<b>PO9</b>
<b>CO5</b>	Apply techniques to solve linear Diophantine equations. Apply properties of multiplicative functions such as Euler's Phi function and Mobius function.	<b>PO8</b>

		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.
		Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings and drawing logical conclusions.
		Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.
		Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.
		Enhance knowledge mobilization through increased application of mathematics.
		Able to use the advance knowledge in consultancy to solve real life problems.
		Learn the subject with curiosity to understand new scientific developments.
		Understand international perspective about mathematics.
		Capability to use appropriate software's to solve mathematical equations.
		Develop the protocols as per laboratory standards to accomplish the objectives.
		Develop aptitude to formulate concepts based on fundamental axioms of mathematics.
		Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.
		Understand demands of the growing field of Mathematics by lifelong learning.
		Develop problem-solving skills, critical thinking, and interest through assignments and project work.
		Prepare students for competitive examinations such as NET, GATE, and many others.
Course Code	Course Title	PO1
BSMA 828A	Number Theory	2
		PO2
		2
		PO3
		PO4
		PO5
		3
		PO6
		PO7
		PO8
		2
		PO9
		2
		PO10
		PSO1
		2
		PSO2
		2
		PSO3
		PSO4
		PSO5
		3

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>	<b>PO 6</b>	<b>PO 7</b>	<b>PO 8</b>	<b>PO 9</b>	<b>P O 10</b>	<b>PS O 1</b>	<b>PS O 2</b>	<b>PSO 3</b>	<b>PSO 4</b>	<b>PSO 5</b>
<b>CO 1</b>	2										3	2	1	1	2
<b>CO 2</b>								2			3	2	1	1	2
<b>CO 3</b>		3									3	2	1	1	2
<b>CO 4</b>				2							3	2	1	1	2
<b>CO 5</b>			3								3	2	1	1	2
<b>CO 6</b>	3										3	2	1	1	2
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA830A</b>	<b>ADVANCED MEASURE THEORY</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hour</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>					
<b>Co-requisites</b>	--				

### Course Objectives

1. To provide a concrete setting of Lebesgue measure and Lebesgue integral via the classical concepts of Jordan measure and the Riemann integration.
2. To give an expert and thorough study on abstract measures and the modern integration theory including the standard convergence theorems.
3. To introduce product measure and study the Fubini's theorem.

### Course Outcomes

This course will enable the students to:

- CO1. Discuss about the importance of monotone convergence theorem, dominated convergence theorem and Fauto's lemma.
- CO2. Discuss the concept of sigma algebra and their examples. Student will be able to understand the set of all Lebesgue measurable set is a sigma algebra.
- CO3. Prove the completeness of  $L_p$  spaces.
- CO4. Understand the proof and apply Fubini's theorem in various cases
- CO5. Comprehend the idea of Hahn and Jordan decomposition and Radon nikodym theorems.

### Catalog Description

After completing this course the student able to: To provide a concrete setting of Lebesgue measure and Lebesgue integral via the classical concepts of Jordan measure and the Riemann integration. To give an expert and thorough study on abstract measures and to introduce product measure and study the Fubini's theorem

### Course Content

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**Unit I:** **14 lecture hours**

#### Lebesgue Measure

Review of Lebesgue measure and integral, Signed measure, Complex measure Multi-dimensional Lebesgue measure

**Unit II:** **16 lecture hours**

#### Riesz Representation Theorem

Construction of the product measure, Fubini's Theorem,  $L^p$ spaces, Riesz representation theorem for bounded linear functionals on  $L^p$ spaces, Convergence in measure

**Unit III:** **14 lecture hours**

**Singular Measure**

Singular measures, Lebesgue-Stieltjes measures, Hahn decomposition theorem,

**Unit IV:** **16 lecture hours**

**Decomposition Theorems**

Jordan decomposition theorem, Radon-Nikodym theorem, Lebesgue decomposition theorem

**Textbooks**

- 1.H. L. Royden, *Real Analysis*, 3rd Edition, Prentice Hall, 1988.
- 2.P. R. Halmos, *Measure Theory*, East-West Press Pvt. Ltd., 1978.
- 3.M. E. Taylor, *Measure Theory*, American Mathematical Society, 2006.

**Reference Books/Materials**

1. Theodore W. Gamelin, *Complex Analysis*, Springer Verlag, 2001.
2. Donald Sarason, *Notes on Complex Function theory*, Hindustan Book Agency, 1994.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

**Examination Scheme:**

<b>Components</b>	<b>Quiz</b>	<b>Attendance</b>	<b>Mid Term Exam</b>	<b>Presentation/ Assignment/ etc.</b>	<b>End Term Exam</b>
<b>Weightage (%)</b>	<b>10</b>	<b>10</b>	<b>20</b>	<b>10</b>	<b>50</b>

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Discuss about the importance of monotone convergence theorem, dominated convergence theorem and Fauto's lemma.	<b>PO1</b>
<b>CO2</b>	Discuss the concept of sigma algebra and their examples. Student will be able to understand the set of all Lebesque measurable set is a sigma algebra.	<b>PO3</b>
<b>CO3</b>	Prove the completeness of $L_p$ spaces.	<b>PO5</b>
<b>CO4</b>	Understand the proof and apply Fubini's theorem in various cases	<b>PO9</b>
<b>CO5</b>	Comprehend the idea of Hahn and Jordan decomposition and Radon nikodym theorems.	<b>PO8</b>



Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 830A	Advanced Measure Theory	2		2		3			2	2			2		2	3
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped  
 2= moderately mapped  
 3=strongly mapped

Programme and Course Mapping															
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
C01	2										3	2	1	1	2
C02								2			3	2	1	1	2
C03		3									3	2	1	1	2
C04				2							3	2	1	1	2
C05			3								3	2	1	1	2
C06	3										3	2	1	1	2
1=lightly mapped			2= moderately mapped						3=strongly mapped						

<b>BSMA832A</b>	<b>THEORY OF BOUNDED OPERATORS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>3</b>	<b>1</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hour</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>	<b>Introductory functional analysis course</b>				
<b>Co-requisites</b>	<b>--</b>				

### Course Objectives

1. To make students aware of some more advanced concepts they usually do not go through in their introductory functional analysis course
2. To study of operators and their properties on linear spaces

### Course Outcomes

This course will enable the students to:

- CO1. Describe spectrum of a bounded operator
- CO2. Understand different types of convergence
- CO3. Grasp properties of compact linear operators
- CO4. Apply spectral theory of self-adjoint operators

### Catalog Description

The course begins with the spectrum of a bounded operator and moves forward with weak, strong and uniform operator convergence on the space of bounded linear operators. Spectral mapping theorem for polynomials and properties of compact linear operators are the key concepts in this programme. Additionally, singular values, polar decomposition and spectral theory of self-adjoint operators are also considered in the scheme.

### Course Content

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#### Unit I:

**14 lecture hours**

#### Convergence of Operator

Spectrum of a bounded operator, uniform, strong and weak operator convergence on the space of bounded linear operators

**Unit II:** **16 lecture hours**

**Spectrum Analysis**

Approximate point spectrum and compression spectrum, spectral mapping theorem for polynomials

**Unit III:** **14 lecture hours**

**Adjoint Operator**

Compact linear operators and their properties, adjoint of compact operators, the Fredholm alternative spectral properties of self-adjoint operators, positive operators and their properties

**Unit IV:** **16 lecture hours**

**Self-adjoint Operator**

spectral representation of a self adjoint compact operator, spectral family of a self-adjoint operator and its properties, continuous functions of self-adjoint operators, polar decomposition, singular values, trace class operators, trace norm and trace, Hilbert-Schmidt operators

**Text Books**

1. J.E. Conway, A course in Operator Theory, Graduate Studies in Mathematics, Volume 21, AMS, 1999.
2. N. Dunford and J. T. Schwartz; Linear Operators, Part-I, Interscience.

**Reference Books/Materials**

1. Martin Schechter, Principles of Functional Analysis, American Mathematical Society, 2004

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**  
**Examination Scheme:**

<b>Components</b>	<b>Quiz</b>	<b>Attendance</b>	<b>Mid Term Exam</b>	<b>Presentation/ Assignment/ etc.</b>	<b>End Term Exam</b>
<b>Weightage (%)</b>	<b>10</b>	<b>10</b>	<b>20</b>	<b>10</b>	<b>50</b>

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
<b>CO1</b>	Describe spectrum of a bounded operator	<b>PO4</b>
<b>CO2</b>	Understand different types of convergence	<b>PO7</b>
<b>CO3</b>	Grasp properties of compact linear operators	<b>PO3</b>
<b>CO4</b>	Apply spectral theory of self-adjoint operators	<b>PO8</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 832A	Theory of Bounded Operators		3	3			2	3					3		2	
		<p>Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.</p> <p>Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.</p> <p>Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.</p> <p>Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.</p> <p>Enhance knowledge mobilization through increased application of mathematics.</p> <p>Able to use the advance knowledge in consultancy to solve real life problems.</p> <p>Learn the subject with curiosity to understand new scientific developments.</p> <p>Understand international perspective about mathematics.</p> <p>Capability to use appropriate software's to solve mathematical equations.</p> <p>Develop the protocols as per laboratory standards to accomplish the objectives.</p> <p>Develop aptitude to formulate concepts based on fundamental axioms of mathematics.</p> <p>Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.</p> <p>Understand demands of the growing field of Mathematics by lifelong learning.</p> <p>Develop problem-solving skills, critical thinking, and interest through assignments and project work</p> <p>Prepare students for competitive examinations such as NET, GATE, and many others.</p>														

1=weakly mapped  
 2= moderately mapped  
 3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>CO1</b>	2										3	2	1	1	2
<b>CO2</b>								2			3	2	1	1	2
<b>CO3</b>		3									3	2	1	1	2
<b>CO4</b>				2							3	2	1	1	2
<b>CO5</b>			3								3	2	1	1	2
<b>CO6</b>	3										3	2	1	1	2
			1=lightly mapped			2= moderately mapped			3=strongly mapped						

<b>BSMA834A</b>	<b>HARMONIC ANALYSIS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>
<b>Total Contact Hour</b>	<b>60</b>				
<b>Pre-requisites/Exposure</b>	<b>Graduate level knowledge of mathematical analysis</b>				
<b>Co-requisites</b>	<b>--</b>				

### Course Objectives

After successful completion of this course students will be able to

1. Continue more advanced study in this area.
2. Understand application of Fourier series and Transforms
3. Differentiate between harmonic analysis and harmonic synthesis.
4. Analyze application of harmonic analysis in physics and Electrical Engineering.

### Course Outcomes

On completion of this course, the students will be able to

- CO1. Understand application of Fourier series and Fourier Transform
- CO2. Apply concepts of Harmonic analysis on Data Science
- CO3. Analyze Haar and Plancherel measures on topological groups
- CO4. Create and solve their own problems related to signals

### Catalog Description

The goal of this course is to provide an introduction into a range of topics and techniques in harmonic analysis, covering material that is interesting not only to students of pure mathematics, but also to those interested in applications in computer science, engineering, physics, and so on. This course imparts the basic concepts Harmonic Analysis. It enables students to develop correlation between signals and Fourier series. This course helps students in variety of ways to solve the problems based upon different topological space. The course introduces the basic concepts about Haar measure on topological spaces.

### Course Content

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#### Unit I:

**16 lecture hours**

#### Basics of Fourier Series

Cassical Fourier series on the unit circle, Fourier coefficients, Cesaro means of the Fourier series, Fourier series of square summable functions.



**Unit II:** **16 lecture hours**

**Convergence of Fourier Series**

Convergence of Fourier Series- Convergence in norm, Convergence and divergence at a point, Absolutely convergent Fourier series, classic kernels – Poisson, Fejer and Dirichlet

**Unit III:** **16 lecture hours**

**Basic Properties of Topological Groups**

Basic properties of topological groups, Haar measure on topological groups with emphasis on R, Z and T, The Banach space  $L^1(G)$ , convolution with special emphasis on  $L^1(\mathbb{R})$ ,  $L^1(\mathbb{Z})$  and  $L^1(\mathbb{T})$

**Unit IV:** **12 lecture hours**

**Plancherel Theorem**

Plancherel theorem on abelian groups, Plancherel measure on R, Z and T maximal ideal space of  $L^1(G)$  (G an abelian topological group).

**Textbooks**

1. Yitzhak Katznelson, *An Introduction to Harmonic Analysis*, Cambridge University Press, 2004.
2. Henry Helson, *Harmonic Analysis*, Addition-Wesley Publishing Company, 1983.
3. Elias M. Stein & Rami Shakarchi, *Fourier Analysis: An introduction*, Princeton University Press, 2003.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

**Examination Scheme:**

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Understand application of Fourier series and Fourier Transform	<b>PO1,PO7</b>
<b>CO2</b>	Apply concepts of Harmonic analysis on Data Science	<b>PO5,PO7</b>
<b>CO3</b>	Analyze Haar and Plancherel measures on topological groups	<b>PO8,PO7</b>
<b>CO4</b>	Create and solve their own problems related to signals	<b>PO4,PO7</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 834A	Harmonic Analysis	1			2	2		3	2				3	1	3	
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.

1=weakly mapped

2= moderately mapped

3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>	<b>PSO4</b>	<b>PSO5</b>
<b>CO1</b>	<b>2</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO2</b>								<b>2</b>			<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO3</b>		<b>3</b>									<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO4</b>				<b>2</b>							<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO5</b>			<b>3</b>								<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO6</b>	<b>3</b>										<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

<b>BSMA852A</b>	<b>DISSERTATION</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Version 1.0</b>		<b>0</b>	<b>0</b>	<b>0</b>	<b>6</b>
<b>Pre-requisites/Exposure</b>	--				
<b>Co-requisites</b>	--				

### **Course Objectives**

- 1 Demonstrate advanced critical research skills in relation to career development or work-related learning studies.
- 2 Acquire the skills to publish the data in reputed journals, conference proceeding and workshops.
- 3 Demonstrate an ability to present and defend their research work to a panel of experts.

### **Course Outcomes**

On completion of this course, the students will be able to

- CO1 Know the concept, scope of research.
- CO2 Enable the students to gain knowledge on particular areas of research.
- CO3 Understand the scientific methods to study region.
- CO4 Analyse the practical knowledge of research and apply the subject matter knowledge in the field.
- CO5 Learn the art of reporting.
- CO6 Able to educate the technical skill of writing.

### **Catalog Description**

The objective of research project is to enable the student with hands-on experiences with learning to lead a research work. Research gives them experience based and active learning. It engages students with contexts, including the social and civic. The mentoring and collaboration dimensions of postgraduate research can foster ownership for commitment to high standards and accountability. While the research process in a discipline may be well-established, research always requires creativity, as well as patience and resolve in grappling with what sometimes feels ambiguous to all participants, including the faculty mentor. These features create opportunities for students to explore their own learning styles as well as develop exposure to those of others.

### **Guidelines**

1. Students will be divided among faculty members of the School for the supervision of the research work.
2. In the first week of Semester III, each faculty member will assign a suitable research topic to the students from the selected topics in the areas of mathematical sciences.
3. The student will work on the assigned research topic during semesters III and IV in regular consultation with his/her assigned faculty member.
4. The student will write a dissertation based on the research work carried out during Semesters III and IV and prepare two copies to be submitted to the office of the Dean of the School duly signed by the student and the supervisor in the sixth week of IV semester or a date decided by the Dean of the School.
5. Before preparing power point presentation and submission of dissertation, each student has to deliver a seminar talk on his/ her research project work on a date fixed by HOD, necessary suggestions have to be incorporated in the final draft of dissertation.
6. The student will make a power point presentation based on the work carried out and mentioned in the dissertation to the board of examiners appointed by the University.

**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

### **Examination Scheme:**

<b>Components</b>	<b>Internal (Interaction of Student with Supervisor)</b>	<b>External</b>			<b>Total</b>
		<b>Relevance of topic (20)</b>	<b>Presentation (20)</b>	<b>viva (10)</b>	<b>100</b>
<b>Weightage (%)</b>	<b>50</b>	<b>20</b>	<b>20</b>	<b>10</b>	

### Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

<b>Mapping between COs and POs</b>		
	<b>Course Outcomes (COs)</b>	<b>Mapped Program Outcomes</b>
<b>CO1</b>	Know the concept, scope of research.	<b>PO6</b>
<b>CO2</b>	Enable the students to gain knowledge on particular areas of research.	<b>PO1</b>
<b>CO3</b>	Understand the scientific methods to study region.	<b>PO8</b>
<b>CO4</b>	Analyse the practical knowledge of research and apply the subject matter knowledge in the field	<b>PO3</b>
<b>CO5</b>	Learn the art of reporting.	<b>PO9</b>
<b>CO6</b>	Able to educate the technical skill of writing.	<b>PO4</b>

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
BSMA 852A	Dissertation	3		3	2		3		3	3			3	3		
		Encourage critical thinking to conduct scientific investigations in a biased manner without prejudiced assumptions.	Assist students in analyzing questions, formulating hypotheses, evaluating and validating findings, and drawing logical conclusions.	Prepare students for pursuing research or careers and to design methods to conduct investigations of complex societal and environmental issues.	Continue to acquire relevant knowledge and skills to evaluate the concepts and scientific developments to take up any challenge.	Enhance knowledge mobilization through increased application of mathematics.	Able to use the advance knowledge in consultancy to solve real life problems.	Learn the subject with curiosity to understand new scientific developments.	Understand international perspective about mathematics.	Capability to use appropriate software's to solve mathematical equations.	Develop the protocols as per laboratory standards to accomplish the objectives.	Develop aptitude to formulate concepts based on fundamental axioms of mathematics.	Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.	Understand demands of the growing field of Mathematics by lifelong learning.	Develop problem-solving skills, critical thinking, and interest through assignments and project work	Prepare students for competitive examinations such as NET, GATE, and many others.



1=weakly mapped  
 2= moderately mapped  
 3=strongly mapped

<b>Programme and Course Mapping</b>															
<b>CO</b>	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>	<b>PO 6</b>	<b>PO 7</b>	<b>PO 8</b>	<b>PO 9</b>	<b>P O 10</b>	<b>PS O 1</b>	<b>PS O 2</b>	<b>PSO 3</b>	<b>PSO 4</b>	<b>PSO 5</b>
<b>CO 1</b>	2										3	2	1	1	2
<b>CO 2</b>								2			3	2	1	1	2
<b>CO 3</b>					3						3	2	1	1	2
<b>CO 4</b>		2									3	2	1	1	2
<b>CO 5</b>			3								3	2	1	1	2
<b>CO 6</b>	3										3	2	1	1	2
1=lightly mapped                      2= moderately mapped                      3=strongly mapped															

	Dissertation
Local	-
Regional	-
National	-
Global	-
Employability	Choice Based Credit System having field projects / research projects / internships ( 1.3.4) Courses on employability/ entrepreneurship/ skill development ( 1.1.3); Student centric methods, such as experiential learning, participative learning and problem-solving methodologies ( 2.3.1)
Entrepreneurship	Entrepreneurship; Team work/ Creativity by designing research problem
Skill Development	Disciplinary knowledge; Research related skills; scientific skills,
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Equal Access to TVET and Higher Education (SDG 4.3), Quality Education and skills for employability 4.4
NEP	Higher Education System through scientific temper (9.1.1) India's Higher Education System through scientific temper (9.1.1) Towards a More Holistic and Multidisciplinary Education opportunities for cross-disciplinary and interdisciplinary thinking ( 11.6); strong culture of research and knowledge creation (17.6) "
POE/4 <sup>th</sup> IR	Employability, Project, Hands on Experience, Entrepreneurship; Team work