REGULATIONS 2019-20 for Post Graduate Programme

(Outcome Based Education model with Choice Based Credit System)

M.Sc. Mathematics Degree

(For the students admitted during the academic year 2019-20 and onwards)

Dr. N.G.P.ARTS AND SCIENCE COLLEGE (Autonomous)

Programme: M.Sc. MATHEMATICS

Eligibility:

A candidate who has passed the Degree Examination in B.Sc. (Mathematics) or B.Sc (Mathematics with Computer Applications) of Bharathiar University and as per the norms set by the Government of Tamil Nadu or an Examination accepted as equivalent thereto by the Academic Council, subject to such conditions as may be prescribed thereto are permitted to appear and qualify for the **Master of Science-Mathematics Degree Examination** of this College after a course of study of two academic years.

Programme Objectives:

- To meet the demand for well trained Post Graduates in Mathematics with academic Excellence.
- To demonstrate an understanding of the theoretical concepts and axiomatic underpinnings of Mathematics and an ability to construct proofs at the appropriate level.
- To demonstrate competency in Mathematical modeling of complex phenomena, problem solving and decision making.
- To demonstrate a level of proficiency in quantitative and computing skills sufficient to meet the growing demands of society upon modern education.

PROGRAMME OUTCOMES:

On the successful completion of the programme, the following expected outcomes

PO Number	PO Statement
PO1	Students will have knowledge, understanding and Mathematical thinking of the basic and advanced concepts, techniques from different topics
PO2	They have a fundamental and advanced understanding of at least one Mathematical topic of their choice and able to solve problem related to the topic
PO3	They can be able to communicate clearly in writing and orallying the detailed technical arguments of complex Mathematical concepts
PO4	The students develop problem solving skill and apply them independently to problems in pure and applied Mathematics
PO5	They can develop the knowledge of formulating, analyzing and problem solving in core areas of the Mathematics including Analysis, Algebra and Statistics

CURRICULUM

M.Sc. MATHEMATICS PROGRAMME

Course Code	Course Category	Course Name	L	T	P	Exam (h)	Max Marks			Credits
							CIA	ESE	Total	
First Semester										
192MT2A1CA	CORE	Advanced Analysis	4	2	-	3	25	75	100	4
192MT2A1CB	CORE	Algebra	4	1	-	3	25	75	100	4
192MT2A1CC	CORE	Measure Theory	4	1	-	3	25	75	100	4
192MT2A1CD	CORE	Ordinary Differential Equations	4	1	-	3	25	75	100	4
192MT2A1CE	CORE	Fuzzy Sets and Fuzzy Logic	3	2	-	3	25	75	100	3
192MT2A1DA / 192MT2A1DB/ 192MT2A1DC	Elective	Advanced Numerical Analysis/ Differential Geometry/ Advanced Operations Research	4	-	-	3	25	75	100	4
		Total	**23**	**7**					**600**	**23**
		Second Semester								
192MT2A2CA	CORE	Complex Analysis	4	1	-	3	25	75	100	4
192MT2A2CB	CORE	Partial Differential Equations	4	1	-	3	25	75	100	4
192MT2A2CC	CORE	Topology	4	1	-	3	25	75	100	4
192MT2A2CE	CORE	Mathematical Softwares	3	-	-	3	25	75	100	3
192MT2A2CP	CORE - PRACTICAL	Mathematical Softwares	-	-	4	3	40	60	100	2
194DA2A2IA	EDC	Foundations of Data Analytics	3	1	-	3	25	75	100	3
192MT2A2DA / 192MT2A2DB/ 192MT2A2DC	Elective	Mathematical Finance/ Mathematical Biology/ Advanced Statistics	4	-		3	25	75	100	4
		Total	**22**	**4**	**4**				**700**	**24**

BoS Chairman/HoD
Department of Mathematics
Dr. N. G. P. Arts and Science College

Academic Council
Dr.V. Rajendran
CHAIRMAN
Dr. N.G.P. Arts and Science College

		Third semester								
192MT2A3CA	CORE	Functional Analysis	4	2	-	3	25	75	100	4
192MT2A3CB	CORE	Industrial Mathematics	3	2	-	3	25	75	100	3
192MT2A3CC	CORE	Mathematical Methods	4	1	-	3	25	75	100	4
192MT2A3CD	CORE	Stochastic Differential Equations	4	2	-	3	25	75	100	4
192MT2A3CE	CORE	Research Methodology	4	-	-	3	25	75	100	4
192MT2A3DA / 192MT2A3DB/ 192MT2A3DC	Elective	Mathematical Modeling/ Control Theory/ Wavelet Analysis	4	-	-	3	25	75	100	4
		Total	**23**	**7**					**600**	**23**
		Fourth Semester								
192MT2A4CA	CORE	Finite Element Theory and Applications	4	1	-	3	25	75	100	4
192MT2A4CB	CORE	Mechanics	4	1	-	3	25	75	100	4
192MT2A4DA / 192MT2A4DB/ 192MT2A4DC	Elective	Actuarial Mathematics/ Nonlinear Ordinary Differential Equations/ Fluid Dynamics	4	-	-	3	25	75	100	4
192MT2A4CV	Project	Project	16	-	-	3	80	120	200	8
		Total	**28**	**2**	**-**				**500**	**20**
								Total	**2400**	**90**

DISCIPLINE SPECIFIC ELECTIVE

Students shall select the desired course of their choice in the listed elective course during Semesters I & IV

Semester I (Elective I)
List of Elective Courses

S. No	Course Code	Name of the Course
1.	192MT2A1DA	Advanced Numerical Analysis
2.	192MT2A1DB	Differential Geometry
3.	192MT2A1DC	Advanced Operations Research

Semester II (Elective II)
List of Elective Courses

S. No	Course Code	Name of the Course
1.	192MT2A2DA	Mathematical Finance
2.	192MT2A2DB	Mathematical Biology
3.	192MT2A2DC	Advanced Statistics

Semester III (Elective III)
List of Elective Courses

S. No	Course Code	Name of the Course
1.	192MT2A3DA	Mathematical Modeling
2.	192MT2A3DB	Control Theory
3.	192MT2A3DC	Wavelet Analysis

Semester IV (Elective IV)
List of Elective Courses

S. No	Course Code	Name of the Course
1.	192MT2A4DA	Actuarial Mathematics
2.	192MT2A4DB	Nonlinear Ordinary Differential Equations
3.	192MT2A4DC	Fluid Dynamics

Self study paper offered by the Mathematics Department

S. No.	Course Code	Course Title
1.	192MT2ASSA	Innovation, IPR and Entrepreneurship
2.	192MT2ASSB	Mathematics of Bioinformatics

Regulation
(2019-2020)

PG Programme

Effective from the academic year 2019-20 and applicable to the students admitted to the Degree of Master of Arts/Commerce/Management/Science.

1. NOMENCLATURE

1.1 Faculty: Refers to a group of programmes concerned with a major division of knowledge. Eg. Faculty of Computer Science consists of Programmes like Computer Science, Information Technology, Computer Technology, Computer Applications etc.

1.2 Programme: Refers to the Master of Arts/Management/Commerce/Science Stream that a student has chosen for study.

1.3 Batch: Refers to the starting and completion year of a programme of study. Eg. Batch of 2015–2017 refers to students belonging to a 2-year Degree programme admitted in 2015 and completing in 2017.

1.4 Course: Refers to a component (a paper) of a programme. A course may be designed to involve lectures / tutorials / laboratory work / seminar / project work/ practical training / report writing / Viva voce, etc or a combination of these, to effectively meet the teaching and learning needs and the credits may be assigned suitably.

a) **Core Courses**

A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

b) **Extra Departmental Course (EDC)**

A course chosen generally from a related discipline/subject, with an intention to seek exposure in the discipline relating to the core domain of the student.

c) **Discipline Specific Elective Course (DSE)**: DSE courses are the courses offered by the respective disciplinary/ interdisciplinary programme.

d) Project Work:

It is considered as a special course involving application of knowledge in problem solving/analyzing/exploring a real-life situation. The Project work will be given in lieu of a Core paper.

e) Extra credits

Extra credits will be awarded to a student for achievements in co-curricular activities carried out outside the regular class hours. The guidelines for the award of extra credits are given in section two, these credits are not mandatory for completing the programme.

e) Advanced Learner Course (ALC):

ALC is doing work of a higher standard than usual for students at that stage in their education. Research work carried out in University/ Research Institutions/ Industries of repute in India or abroad for a period of 15 to 30 days.

2. EXTRA CREDITS

- Earning extra credit is mandatory. However, it is not essential for programme completion.
- Extra Credits will be awarded to a student for achievement in co-curricular/ extracurricular activities carried other than the regular class-hours.
- A student is permitted to earn a maximum of 10 extra Credits during the programme duration of PG from I to IV Semester.
- Candidate can claim a maximum of 1 credit under each category listed.

The following are the guidelines for the award of Extra credits:

2.1 Proficiency in Foreign Language

Qualification	Credit
A pass in any foreign language in the examination conducted by an authorized agency	1

2.2 Proficiency in Hindi

Qualification	Credit
A pass in the Hindi examination conducted by Dakshin Bharat Hindi Prachar Sabha	1

Examination passed during the programme period only will be considered for extra credit

2.3 Self-study Course

Qualification	Credit
A pass in the self-study courses offered by the department	1

The candidate should register in the self-study course offered by the department only in the III semester

2.4 Typewriting/Short hand

A Pass in shorthand /typewriting examination conducted by Tamil Nadu Department of Technical Education (TNDTE) and the credit will be awarded.

Qualification	Credit
A pass in the type writing / short hand examination offered by TNDTE	1

2.5 Diploma / Certificate

Courses offered by any recognized University / NCVRT

Qualification	Credit
A pass in any Certificate /Diploma/PG Diploma Course	1

2.6 CA /ICSI/ CMA

Qualification	Credit
Qualifying foundation/Inter level/Final in CA/ICSI/CMA etc.	1

2.7 Sports and Games

The Student can earn extra credit based on their achievement in sports as given below:

Qualification	Credits
Achievement in University/State /National/ International	1

2.8 Online Courses

Pass in any one of the online courses

Qualification	Credit
SWAYAM/NPTEL/Spoken Tutorial etc.,	1

2.9 Publications / Conference Presentations (Oral/ Poster) /Awards

Qualification	Credit
Research Publications in Journals/oral/poster presentation in Conference	1

2.10 Innovation / Incubation / Patent / Sponsored Projects / Consultancy

Qualification	Credit
Development of model/ Products/ Prototype/ Process/App/Registration of Patents/ Copyrights/ Trademarks/Sponsored Projects/Consultancy	1

2.11 Representation

Qualification	Credit
Participation in State / National level celebrations such as Independence day, Republic day Parade, National Integration camp etc.,	1

3. EXAMINATIONS

The following are the distribution of marks for External and Internal i.e., Comprehensive examination and Continuous Internal Assessment and passing minimum marks for theory papers of PG programmes.

TOTAL MARKS	EXTERNAL		Internal Max. marks	Overall Passing Minimum for total marks (Internal + External)
	Max. marks	Passing Minimum for External alone		
100	75	38	25	50
50	50	25	----	25

The following are the Distribution of marks for the Continuous Internal Assessment in the theory papers of PG programmes.

S. No.	For Theory– PG courses	Distribution of Marks
1	TESTS I (2 hours)	5
2	TESTS II / End semester Model test (3 hours)	10
3	OBE- Rubrics	10
	TOTAL MARKS	**25**

The following are the distribution of marks for the External Assessment in PG Theory courses

S. No.	For Theory– PG courses	Distribution of Marks	
1	Comprehensive (Written) Examination	65	50
2	Online MCQ Examination	10	--
	TOTAL MARKS	**75**	**50**

The following are the distribution of marks for External examinations (CE) and Continuous Internal Assessment (CIA) and passing minimum marks for the practical courses of PG programmes.

TOTAL MARKS	EXTERNAL		Internal Max. marks	Overall Passing Minimum for total marks (Internal + External)
	Max. marks	Passing Minimum for External alone		
100	60	30	40	50
200	120	60	80	100

The following are the distribution of marks for the Continuous Internal Assessment (CIA) in PG practical courses

S. No.	For Theory – PG Practical courses	Distribution of Marks	
1	Tests: Two tests out of which one shall be during the mid semester and the other to be conducted as model test at the end of the semester.)	24	48
2	OBE- Rubrics	16	32
	TOTAL MARKS	**40**	**80**

The following are the distribution of marks for the External Assessment in PG practical courses

S. No.	For Theory – PG Practical courses	Distribution of Marks	
1	Experiment-I	25	50
2	Experiment-II	25	50
3	Record & Viva-Voce	10	20
	TOTAL MARKS	**60**	**120**

The following are the distribution of marks for Project and Viva voce examinations/Industrial Training and Continuous Internal Assessments and passing minimum marks for the project courses/Industrial Training of PG programmes

TOTAL MARKS	**EXTERNAL**		**Internal Max. marks**	**Overall Passing Minimum for total marks (Internal + External)**
	Max. marks	**Passing Minimum for External alone**		
100	60	30	40	50
200	120	60	80	100

The following are the distribution of marks for the Continuous Internal Assessment in PG Project/ Industrial Training courses.

S. No.	**For- PG Project courses/ Industrial Training**	**Distribution of Marks**	
1	Review-I	8	16
2	Review-II	8	16
3	Review-III	8	16
4	OBE- Rubrics	16	32
	TOTAL MARKS	**40**	**80**

The following are the distribution of marks for the External Examination (CE) in PG Project / /Industrial Training courses

S. No.	**For- PG Project courses/ Industrial Training Courses**	**Distribution of Marks**	
1	Record Work and Presentation	40	80
2	Viva-Voce	20	40
	TOTAL MARKS	**60**	**120**

- The end semester examinations shall normally be conducted after completing 90 working days for each semester.

- The maximum marks for each theory and practical course (including the project work and Viva-Voce examination in the final Semester) shall be 100 with the following breakup.

  (i) **Theory Courses**

  Continuous Internal Assessment (CIA) : 25 Marks

  End Semester Exams (ESE) : 75 Marks

  (Online Exam: 10 Marks &Written Exam: 65 Marks)

  (ii) **For Practical Courses**

  Continuous Internal Assessment (CIA) : 40 Marks

  End Semester Exams (ESE) : 60 Marks

Continuous Assessment OBE Rubrics Score Sheet

Degree: __________ Branch: _____________ Semester: __________

Course Code: _________ Course: _____________________________

Max. Marks: Internal:_____ External: ________ Total: _______

S. No.	REG. NO.	THEORY / PRACTICAL & LIBRARY CLASS PARTICIPATION (15) (Compulsory)				RUBRICS ASSESSMENT (SELECT ANY ONE)									Total Marks out of : 30	Total Marks out of : 16 / 10 / 08 / 04
						PAPERS / REPORTS (15)			ASSIGNMENTS (15)			CLASS PRESENTATION (15)				
		Library	Integration of Knowledge	Interaction & Participation	Demonstration of Knowledge	Organization & Knowledge	Format & Spelling	Reference / Experiments	Demonstration of Knowledge	Format & Spelling	Reference	Content & Coherence	Creativity and Speaking Skills	Duration of Presentation		
		6	3	3	3	5	5	5	5	5	5	5	5	5		
1																

a) Utilization of Library

Marks will be awarded to the student based on the hours spent in the library after the working hours and submission of report by the student.

Hours spent in Library	Marks	Type of Document submitted
2	1	Report/ Assignment/ Class presentation
4	2	
6	3	
8	4	
10	5	
12	6	

- During the Library hour, the student must spend time in reading the articles, books, journals of their subject of interest
- Each student should borrow minimum three books during the semester

b) Class Participation

Active participation in classroom discussion by the student will be evaluated based on Integration of knowledge, Interaction and Participation and demonstration of knowledge.

c) Papers / Reports/ Assignments/ Class Presentation

The student will be evaluated based on his ability to do analysis of application of theory to real world problems or creative extension of class room learning and his/her ability to communicate the given topic effectively and clearly. The following are the distribution of marks for the continuous internal assessment in PG practical courses

4. FOR PROGRAMME COMPLETION

Programme Completion (for students admitted during the A.Y.2019-20 and Onwards)

Student has to complete the following:

i) Core, EDC, DSE, Project as mentioned in the scheme
ii) Internship / Industrial/ Institutional training as mentioned in the scheme

Students must undertake industrial / institutional training for a minimum of 15 days and not exceeding 30 days during the II semester summer vacation. The students will submit the report for evaluation during III semester.

Based on the performance Grade will be awarded as follows:

Marks Scored	**Grade to be awarded**
75 and above	A
60-74	B
50-59	C
< 50	Re-Appearance

Course Code	Course Name	Category	L	T	P	Credit
192MT2A1CA	ADVANCED ANALYSIS	CORE	4	2	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The concept of Riemann Stieltjes integral
- The functions of several variables
- The inverse and Implicit function theorems

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Understand the concept of Riemann Stieltjes integral of a bounded function	K2
CO2	Relate the concept of convergence and continuity	K2
CO3	Apply the concept of inverse and implicit theorems	K3
CO4	Analyze the concept of functions of Several Variables.	K4
CO5	Explain the method of integration of function of several variables using the Rank theorem.	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	M	M	M	L
CO2	S	M	M	M	L
CO3	S	S	S	S	M
CO4	S	S	S	S	S
CO5	S	S	S	S	S

S Strong M Medium L Low

192MT2A1CA	CORE: ADVANCED ANALYSIS	SEMESTER I

Total Credits: 4
Total Instructions Hours: 72 **H**

Syllabus

Unit I The Riemann Stieltjes Integral **14 H**

Definition and Existence of the Integral – Properties of the integral – Integration and Differentiation – Integration of Vector-valued Function

Unit II Sequence and Series of a Function **14 H**

Discussion of main Problem - Uniform Convergence - Uniform Convergence and Continuity – Uniform Convergence and Integration – Uniform Convergence and Differentiation – Equicontinuous Families of Functions – The Stone-Weierstrass Theorem

Unit III Some Special Functions **14 H**

Power Series - The Exponential and Logarithmic functions - The Trigonometry functions - The Algebraic completeness of the Complex Field - The Gamma functions

Unit IV Functions of Several Variables **15 H**

Linear Transformations – Differentiation-The Contraction Principle – The Inverse Function Theorem – The Implicit Function Theorem

Unit V Functions of Several Variables **15 H**

The Rank theorem - Determinants - Derivatives of higher Order - Differentiation of integrals.

Text Books

1 Walter Rudin. 1976. Principles of Mathematical Analysis, 3rd Edition. McGraw-Hill Book Company, New York.

2 H.L. Royden. 2005. Real Analysis. 3rd Edition. Prentice-Hall of India Private Limited, New Delhi.

References

1 R.G. Bartle. 2005. Introduction to Real Analysis. 3rd Edition. John Wiley and Sons Inc, New York.

2 Walter Rudin. 1987. Real and Complex Analysis. 3rd Edition. McGraw – Hill, New York.

3 Terence Tao. 2016. Analysis I: 3rd Edition. Hindustan Book Agency

4 https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxtYXRoc29sdXRpb25ndWlkZXN8Z3g6MzIxZGJmOTAzNzQzZTAyYw

Course Code	Course Name	Category	L	T	P	Credit
192MT2A1CB	ALGEBRA	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- Use the results from elementary group theory to solve contemporary problems
- Explain from elementary principles why certain algebraic facts are true
- Use Sylow's theorems to describe the structure of certain finite groups

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Understand the Orbits and P-groups	K2
CO2	Apply Sylow theory in the factorization of polynomials	K3
CO3	Analyze the structure of finite fields	K4
CO4	Relate the concepts Automorphisms and Isomorphism	K5
CO5	Explain the applications of Galois theory	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	S	M	M	L
CO2	S	S	S	S	M
CO3	S	S	S	S	S
CO4	S	S	S	S	S
CO5	S	S	S	S	S

S Strong M Medium L Low

192MT2A1CB	CORE: ALGEBRA	SEMESTER I

Total Credits: **4**
Total Instructions Hours: 60 **H**

Syllabus

Unit I Direct Products **12 H**

External Direct Products - Internal Direct Products. Group Action on a Set: The Notion of a Group Action - Fixed Sets and Isotropy Subgroups – Orbits. Application on G-Sets to Counting: Sylow Theorems: p-Groups - The Sylow Theorems

Unit II Applications of the Sylow Theory **12 H**

Applications to p-Groups and the Class Equation - Further Applications. Rings of Polynomials: Polynomials in an Indeterminate - The Evaluation Homomorphisms. The New Approach. Factorization of Polynomials over a Field: The Division Algorithm in $F[x]$ - Irreducible Polynomials – Ideal Structure in $F[x]$ - Uniqueness of Factorization in $F[x]$.

Unit III Introduction to Extension Fields **13 H**

Extension Fields - Algebraic and Transcendental Elements - Irreducible Polynomial for α over F - Simple Extensions. Algebraic Extensions: Finite extensions – The Structure of a Finite Fields.

Unit IV Automorphisms of Fields **11 H**

Basic Isomorphism of Algebraic Field Theory - Automorphisms and Fixed Fields - The Frobenius Automorphism. Isomorphishm Extension Theorem: The Extension Theorem - Splitting Fields

Unit V Separable Extensions-Galois Theory **12 H**

Normal Extensions - The Main Theorem. Illustrations of Galois Theory: Symmetric Functions

Text Books

1. John B. Fraleigh. 2003. A First Course in Abstract Algebra. 3rd Edition, Narosa Publishing House
2. Marlow Anderson and Todd Feil. 2014. A First Course in Abstract Algebra Rings, Groups, and Fields. 3rd Edition. Chapman and Hall/CRC.

References

1. I.N. Herstein. 2007. Topics in Algebra. 2rd Edition. Narosa Publishing House, New Delhi.
2. M. Artin. 1991. Algebra. Prentice-Hall of India, New Delhi.
3. Hall and Knight. 2016. Higher Algebra. 6th Edition, Arihant Publications.
4. Ben Hekster. Solutions to A First Course in Abstract Algebra, John B. Fraleigh 6th edition (http://www.hekster.org/Academic/Mathematics/)

Course Code	Course Name	Category	L	T	P	Credit
192MT2A1CC	MEASURE THEORY	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The basic concepts from measure theory, including sets of measure zero, measurable functions
- The Lebesgue integral and Lebesgue spaces
- The results of the theory of Lebesgue integration, including convergence theorems and Fubini's theorem.

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Understand the concept of Lebesgue integral and solve it	K2
CO2	Utilize the concepts Lebesgue integral and Lebesgue spaces	K3
CO3	Apply integration theory in one or several variables to formulate	K3
CO4	Examine the convergence of measures	K4
CO5	Explain the relation between integrals and derivatives	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	M	M	M	L
CO2	S	S	S	S	M
CO3	S	S	S	S	M
CO4	S	S	S	S	S
CO5	S	S	S	S	S

S Strong M Medium L Low

192MT2A1CC	CORE: MEASURE THEORY	SEMESTER I

Total Credits: 4

Total Instructions Hours: 60 H

Syllabus

Unit I Constructions and Extensions of Measures **12 H**

Measurement of length: Introductory remarks - Algebras and σ-algebras - Additivity and countable additivity of measures - Compact classes and countable additivity -Outer measure and the Lebesgue extension of measures - Infinite and σ-finite measures - Lebesgue measure - Lebesgue–Stieltjes measures.

Unit II The Lebesgue integral **12 H**

Measurable functions - Convergence in measure and almost everywhere - The integral for simple functions - The general definition of the Lebesgue integral - Basic properties of the integral - Integration with respect to infinite measures - The completeness of the space L^1 - Convergence theorems - Criteria of integrability - Connections with the Riemann integral - The Holder and Minkowski inequalities

Unit III Operations on measures and functions **12 H**

Decomposition of signed measures- The Radon–Nikodym theorem- Products of measure spaces- Fubini's theorem- Infinite products of measures- Images of measures under mappings- Change of variables in R^n- The Fourier transform- Convolution.

Unit IV The spaces L^p and spaces of measures **12 H**

The spaces L^p - Approximations in L^p - Duality of the spaces L^p - Uniform integrability - Convergence of measures.

Unit V Connections between the integral and derivative **12 H**

Differentiability of functions on the real line - Functions of bounded variation - Absolutely continuous functions - The Newton–Leibniz formula - Covering theorems - The maximal function - The Henstock–Kurzweil integral.

Text Books

1	Vladimir I. Bogachev. 2007. Measure Theory Volume I. Springer-Verlag Berlin Heidelberg.
2	Richard F. Bass. 2013. Real analysis for graduate Students. 2rd Edition. Create Space Independent Publishing Platform.

References

1	Hari Bercovici, Arlen Brown and Carl Pearcy. 2016. Measure and Integration. Springer.
2	J. Yeh. 2006. Real Analysis: Theory of Measure and Integration. 3rd Edition. World Scientific Publishing Co Pte Ltd
3	D.H. Fremlin. 2008. Measure Theory Volume 1, The Irreducible Minimum. Torres Fremlin. England(http://www.lulu.com/buy).
4	Terrence Tao, 2011, An Introduction to Measure Theory, American Mathematical Society; New ed. Edition.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A1CD	ORDINARY DIFFERENTIAL EQUATIONS	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- First order and second order ordinary differential equations.
- Power series method
- Homogenous and non-homogeneous order ordinary differential equations.

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Solve Legendre and Bessel equations	K2
CO2	Understand the concept of fundamental matrix of system	K2
CO3	Apply Lipschitz condition in mathematical problems	K3
CO4	Inspect the existence and uniqueness solutions	K4
CO5	Prove some oscillatory theorems	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	M	M	M	L
CO2	S	M	M	M	L
CO3	S	S	S	S	M
CO4	S	S	S	S	S
CO5	S	S	S	S	S

S Strong M Medium L Low

192MT2A1CD	CORE: ORDINARY DIFFERENTIAL EQUATIONS	SEMESTER I

Total Credits: 4

Total Instructions Hours: 60 H

Syllabus

Unit I Solutions in Power Series **12 H**

Introduction-Second order linear equations with ordinary points – Legendre equation and Legendre polynomials – Second order equation with regular singular point – Properties of Bessel functions.

Unit II System of Linear Differential Equations **12 H**

System of first order Equations – Model for ARMS competition between two nationals – Existence and uniqueness theorem – Fundamental matrix.

Unit III Non homogeneous linear Systems **11 H**

Non - homogeneous linear systems – Linear systems with constant coefficients - Linear systems with periodic coefficients.

Unit IV Existence and Uniqueness of Solutions **13 H**

Preliminaries - Successive approximations – Picard's theorem – Some examples. Continuation and dependence on initial conditions-Existence of solutions in the large

Unit V Oscillations of Second Order Equations **12 H**

Fundamental results - Sturm's comparison theorem – Elementary linear oscillations. Comparison theorem of Hille - Winter – Oscillations of x'' + a(t) x = 0.

Text Books

1. S.G. Deo, V. Lakshmikandham and V. Raghavendra. 2007. Text book of Ordinary Differential Equations. 2rd ond Edition. McGraw-Hill Education (India), New Delhi.
2. Earl. A. Coodington. 2006. An Introduction to Ordinary Differential Equations. Prentice Hall of India Private Limited, Newdelhi.

References

1. W.T. Reid. 1971. Ordinary Differential Equations. John Wiley & Sons, New York.
2. E.A. Coddington and N. Levinson. 1955. Theory of Ordinary Differential Equations. McGraw-Hill Publishing Company, New York.
3. Gerald Teschl. 2012. Ordinary Differential Equations and Dynamical Systems. American Mathematical Society.
4. David G. Schaeffer and John W. Cain. 2016. Ordinary Differential Equations: Basics and Beyond. Springer.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A1CE	FUZZY SETS AND FUZZY LOGIC	CORE	3	2	-	3

PREAMBLE

This course has been designed for students to learn and understand

- The notion and concepts of fuzzy sets
- The operations of fuzzy
- The fuzzy arithmetic and possibility theory

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Understand about the crisp and fuzzy sets	K1
CO2	Know the fuzzy operations	K3
CO3	Develop fuzzy arithmetic properties	K2
CO4	Model the uncertainty and probability theory	K1
CO5	Analyze the fuzzy sets	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	M	M	S	L
CO2	S	M	M	S	L
CO3	S	S	S	S	M
CO4	S	S	S	S	M
CO5	S	S	S	S	S

S Strong M Medium L Low

192MT2A1CE	CORE: FUZZY SETS AND FUZZY LOGIC	SEMESTER I

Total Credits: 3
Total Instructions Hours: 60 **H**

Syllabus

Unit I From Classical (crisp) Sets to Fuzzy Sets **12 H**

A Grand Paradigm Shift: Introduction - Crisp Sets: An Overview - Fuzzy Sets: Basic Types - Fuzzy Sets: Basic Concepts - Characteristics and Significance of the Paradigm Shift. Fuzzy Sets Versus Crisp Sets: Additional Properties of $\alpha -$cuts - Representations of Fuzzy Sets - Extension Principle for Fuzzy Sets.

Unit II Operations on Fuzzy Sets **12 H**

Types of Operations - Fuzzy Complements - Fuzzy Intersections: t-Norms - Fuzzy Unions: t-Conorms - Combinations of Operations - Aggregation Operations.

Unit III Fuzzy Arithmetic **11 H**

Fuzzy Numbers - Linguistic Variables - Arithmetic Operations on Intervals - Arithmetic Operations on Fuzzy Numbers – Lattice of Fuzzy Numbers - Fuzzy Equations.

Unit IV Possibility Theory **11 H**

Fuzzy Measures - Evidence Theory - Possibility Theory - Fuzzy Sets and Possibility Theory - Possibility Theory versus Probability Theory.

Unit V Uncertainty-Based Information 14 **H**

Information and Uncertainty - Nonspecificity of Crisp Sets - Nonspecificity of Fuzzy Sets - Fuzziness of Fuzzy Sets - Uncertainty in Evidence Theory - Summary of Uncertainty Measures - Principles of Uncertainty.

Text Books

1	George J. Klir and Bo Yuan. 2006. Fuzzy Sets and Fuzzy Logic Theory and Applications. Prentice-Hall of India Private Limited, New Delhi.
2	George J. Klir and Tina and A. Folger. 1995. Fuzzy Sets Uncertainty and Information.4th Edition. Printing Prentice-Hall of India Private Limited.

References

1	Guanrong Chen and Trung Tat Pham. 2000. Introduction to Fuzzy Sets, Fuzzy Logic, and Fuzzy Control Systems. CRC Press, New York.
2	C. Mohan. 2009. An Introduction to Fuzzy Set Theory and Fuzzy Logic. Viva Publishers.
3	Bhargava A.K. 2013. Fuzzy Set Theory Fuzzy Logic and their Applications. S Chand.
4	Lotfi A Zadeh and Rafik A Aliev. 2018. Fuzzy Logic Theory and Applications: Part I and Part II. World Scientific Publishing Company.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A1DA	ADVANCED NUMERICAL ANALYSIS	ELECTIVE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The system of nonlinear equations using various numerical methods
- To solve the Ordinary Differential Equations
- To solve the Partial Differential Equations

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Find the numerical solution of nonlinear equations	K1
CO2	classify the set of equations	K2
CO3	Know the concept of numerical differentiation and integration	K2
CO4	Apply the Taylor's method to Ordinary and Partial Differential Equations	K3
CO5	Analyze the nature of solution of one and two dimensional problems	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	M	L	L	L	L
CO2	S	M	M	M	L
CO3	S	M	M	M	L
CO4	S	S	S	S	S
CO5	S	S	S	S	S

S Strong M Medium L Low

192MT2A1DA	ELECTIVE: ADVANCED NUMERICAL ANALYSIS	SEMESTER I

Total Credits: **4**
Total Instructions Hours: 48 **H**

Syllabus

Unit I Solving Nonlinear Equations 10 **H**

Interval Halving (Bisection) Revisited - Linear Interpolation Methods - Newton's Method - Fixed - Point Iteration: $x = g(x)$ Method - Newton's Method for Polynomials - Bairstow's Method for Quadratic Factors.

Unit II Solving Algebraic Equations 10 **H**

Applications of Sets of Equations - Matrix Notation - The Elimination Method - The Gaussian Elimination and Gauss - Jordan Methods - Other Direct Methods - Iterative Methods - The Relaxation Method.

Unit III Numerical Differentiation and Numerical Integration 9 **H**

Extrapolation Techniques - Newton - Cotes Integration Formulas - The Trapezoidal Rule-A Composite Formula - Simpson's Rules - Gaussian Quadrature.

Unit IV Numerical Solution of Ordinary Differential Equations 9 **H**

The Spring-Mass Problem-A Variation - The Taylor-Series method - Euler and Modified Euler Methods - Runge-Kutta methods - Milne's method - The Adams-Moulton Method - Convergence Criteria.

Unit V Parabolic and Hyperbolic Partial-Differential Equations 10 **H**

Types of Partial Differential equations - The Heat Equation and the Wave Equation - Solution Techniques for the Heat Equation in one Dimension - Solving the Vibrating String Problem - Parabolic Equations in Two or Three Dimensions.

Text Books

1 Curtis F.Gerald and Patrick O.Wheatley. 1999. Applied Numerical Analysis. 6th Edition. Pearson Education Asia, New Delhi.

2 D. Samuel Conte and Carl. De Boor. 1983. Elementary Numerical Analysis. McGraw- Hill International Edition.

References

1 Gordon D Smith. 1985. Numerical Solution of Partial Differential Equations – Finite Difference Methods. Oxford University Press.

2 M.K. Jain, S.R.K. Iyengar and R.K. Jain. 1993. Numerical Methods for Scientific and Engineering Computation. 3rd Edition, Wiley Eastern Ltd.

3 Dan B. Marghitu and Mihai Dupac. 2012. Advanced Dynamics: Analytical and Numerical Calculations with MATLAB. Springer.

4 Peter Linz. 2019. Theoretical Numerical Analysis: An Introduction to Advanced Techniques. Dover Publications.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A1DB	ELECTIVE:DIFFERENTIAL GEOMETRY	ELECTIVE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The curves and arcs
- The Geodesics
- The concept of elementary theory of surface

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Learn about the curves and curvature	K2
CO2	Develop the solution of natural equation, Evolutes and Involutes.	K3
CO3	Understand the concept of Elementary Theory of surfaces	K2
CO4	Apply in higher dimensional objects	K3
CO5	Apply in the hyper surface	K3

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	M	M	M	L
CO2	S	S	S	S	M
CO3	S	M	M	M	L
CO4	S	S	S	S	M
CO5	S	S	S	S	M

S Strong M Medium L Low

192MT2A1DB	DIFFERENTIAL GEOMETRY	SEMESTER I

Total Credits: 4

Total Instructions Hours: 48 H

Syllabus

Unit I Helicoids **10 H**

Helicoids - Metric on a surface - Direction coefficients on a surface - Orthogonal Trajectories - Isometric correspondence.

Unit II Geodesics on a Surface 9 **H**

Introduction - Geodesics and their Differential equations - Canonical Geodesics equations - Geodesics on surfaces of revolution - Normal property of Geodesics - Differential equations using normal property.

Unit III Geodesics on a Surface **10 H**

Geodesics parallels - Geodesics polar coordinates - Geodesics curvature - Gauss–Bonnet theorem - Gaussian Curvature - Surfaces of constant curvature.

Unit IV The Second Fundamental theorem 10 **H**

Introduction - The Second Fundamental form - Classification of points on a surface - Principle curvatures - Lines of curvature

Unit V Developable Surfaces 9 **H**

Developable Surfaces - Developable associated with space curves and curves on surfaces - Minimal surfaces - Ruled surfaces

Text Books

1	D. Somasundaram. 2005. Differential Geometry A first course. Narosa Publishing House, New Delhi.
2	E. Kreyszig. 1991. Differential Geometry. Dover Publications.

References

1	S.G. Venkatachalam. 2012. Differential Geometry. Margham publications
2	Dirk. J. Struik. 1961. Lectures on Classical Differential Geometry. Addison Wesley Publishing Company
3	Michael Spivak. 1999. A Comprehensive Introduction to Differential Geometry. 3rd Edition. Perish
4	Barrett O'Neill. 2006. Elementary Differential Geometry.Revised 2nd Edition. Academic Press.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A1DC	ELECTIVE: ADVANCED OPERATIONS RESEARCH	ELECTIVE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The Dynamic, Integer programming and Decision Analysis
- Concept of Queuing and Simulation
- How to solve the queuing models

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Understand characteristics of dynamic programming problem	K3
CO2	Deterministic dynamic programming-probabilistic dynamic programming	K2
CO3	Learn A prototype Example for Dynamic Programming	K2
CO4	Apply to Binary Integer Programming	K3
CO5	Analyze decision making with experiment	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	M	M	M	L
CO2	S	M	M	M	L
CO3	S	M	M	M	L
CO4	S	S	S	S	M
CO5	S	S	M	S	S

S Strong M Medium L Low

192MT2A1DC	ADVANCED OPERATIONS RESEARCH	SEMESTER I

Total Credits: 4

Total Instructions Hours: 48 H

Syllabus

Unit I Dynamic Programming **10 H**

A prototype Example for Dynamic Programming- Characteristics of Dynamic Programming problem - Deterministic Dynamic Programming.

Unit II Integer Programming 9 **H**

Prototype Example - Some BIP Applications-Innovative uses of Binary Variables in Model Formulation - Some Formulation Examples-Some Perspectives on solving Integer Programming Problem.

Unit III Decision Analysis **11 H**

A Prototype Example-Decision making without experiment - Decision making with experiment-Decision trees.Markov Chains: Stochastic Processes - Markov Chains.

Unit IV Queueing Theory 9 **H**

Prototype Example-Basic structure of Queueing Models - Examples of Real Queueing System - The Role of Exponential Distribution – The Birth andDeath Process - Queueing Models Based on Birth and Death Process.

Unit V Simulation 9 **H**

The Essence of Simulation - Some common types of applications of simulation -Generation of random number - Generation of random observation from a probability distribution.

Text Books

1. Frederick S. Hillier, Gerald and J. Lieberman. 2010. Operations Research: Concepts and Cases. 13th Edition. The McGraw-Hill Companies, New York.
2. Frederick S Hillier. 2014. Introduction to Operations Research. McGraw-Hill; Revised ed. Edition.

References

1. H.A. Taha. 2006. Operations Research: An Introduction. 8th Edition. Prentice-Hall of India Private Limited, New Delhi.
2. Kandiswarup, P.K. Gupta and Man Mohan. 1998. Operations Research. S. Chand & Sons Education Publications, New Delhi.
3. Wayne L. Winston. 1994. Operations Research: Applications and Algorithms. 3rd Revised & enlarged edition , Duxbury Press.
4. Lieberman, Nag and Basu Hillier. 2017. Introduction To Operations Research. 10th Edition. Mc Graw Hill India.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A2CA	**CORE :** COMPLEX ANALYSIS	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- Concept of analytic function and its applications.
- The methods of integration with complex function.
- The existence and applications of conformal mapping.

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Explain the Taylor's series and Laurent's series.	K2
CO2	Apply the concept of Analytic function and linear transformations.	K3
CO3	Illustrate complex Integration through Cauchy's integral formula.	K3
CO4	Analyze the calculus of residues and evaluating complex integrals.	K4
CO5	Assess the boundary behavior at an angle through reflection principle.	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	S	S	S	S
CO2	S	S	S	S	S
CO3	S	S	S	S	S
CO4	M	M	S	S	S
CO5	L	L	M	S	S

S **Strong** **M** **Medium** **L** **Low**

192MT2A2CA	CORE : COMPLEX ANALYSIS	**SEMESTER II**

Total Credits: 4
Total Instruction Hours: 60 h

Syllabus

Unit I Analytic function and conformality 14 h

Limits and continuity – Analytic functions – Polynomials – Rational functions. Arcs and closed curves – Analytic functions in regions – Conformal mapping – Length and area.

Unit II Complex integration 14 h

Line integrals - Rectifiable arcs – Line integrals as functions of arcs – Cauchy's theorem for a rectangle - Cauchy's theorem in a disk - Cauchy's integral formula – Higher derivatives. Removable singularities - Taylor's theorem – Zeros and poles – Local mapping – Maximum principle.

Unit III Calculus of residues 12 h

Residue theorem – Argument principle – Evaluation of definite integrals. Mean-value property – Poisson's formula.

Unit IV Series and product developments 10 h

Weierstrass's theorem – Taylor series – Laurent series. Partial fractions – Infinite products – Canonical products.

Unit V Riemann mapping theorem and applications 10 h

Riemann mapping theorem – Statement and proof – Boundary behavior – Use of the reflection principle – Analytic arcs - behavior at an angle –Schwarz-Christoffel formula – Mapping on a rectangle.

Text Books

1 Ahlfors, L.V. (1979). Complex Analysis. (3rd Edn.) New York: Mc Graw-Hill.

References

1 James Ward Brown and Churchill,R.V, (2013). Complex Variables and Applications. (9th Edn.) New Delhi: Tata McGraw Hill.

2 Joseph Bak and Newman,Donald , (2010). Complex Analysis. (3rd Edn.) New York: Springer.

3 Kasana, H.S. (2005). Complex Variables: Theory and Applications. (2nd Edn.) New Delhi: PHI Learning.

4 Conway, J.B (2000). Functions of one Complex Variables. (2nd Edn.) New Delhi: Narosa Publication.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A2CB	**CORE :** PARTIAL DIFFERENTIAL EQUATIONS	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The basic forms of partial differential equations and methods to solve it.
- Analytical techniques used to solve parabolic and hyperbolic equations.
- The various forms of solutions that exists for partial differential equations.

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Classify the type of partial differential equations and identify the method to solve them.	K2
CO2	Determine the characteristic curve for a second order partial differential equations.	K3
CO3	Analyze the characteristics of Laplace's equation.	K4
CO4	Analyze the solvability of wave equations.	K4
CO5	Evaluating diffusion equations by using integral transforms method.	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	M	S	S	M	S
CO2	M	S	S	S	S
CO3	S	S	S	S	M
CO4	S	S	M	S	M
CO5	S	M	M	S	M

S Strong M Medium L Low

192MT2A2CB	CORE : PARTIAL DIFFERENTIAL EQUATIONS	**SEMESTER II**

Total Credits: 4
Total Instruction Hours: 60 h

Syllabus

Unit I Partial differential equations of first order 14 h

Nonlinear partial differential equations of the first order - Cauchy's method of characteristics - Compatible systems – Charpit's method - Special types – Solutions satisfying given conditions - Jacobi's method.

Unit II Partial differential equations of second order 12 h

Origin – Second order equations in Physics - Higher order equations in Physics - Linear partial differential equations with constant coefficients – Equations with variable coefficients – Characteristic curves of second – order equations- Characteristics of equations in three variables.

Unit III Laplace equation 10 h

Occurrence - Elementary solutions of Laplace's equation – Families of equipotential surfaces - Boundary value problems - Separation of variables - Problems with axial symmetry.

Unit IV Wave equation 12 h

Occurrence – Elementary solutions of the one - dimensional wave equation – The Riemann-Volterra solution - Vibrating membranes - Applications of the calculus of variations – Three dimensional problems.

Unit V The diffusion equation 12 h

Occurrence – The resolution of boundary value problems - Elementary solutions of the diffusion equation – Separation variables - The use of integral transforms.

Text Books

1 Sneddon I.N ,, (1957). Elements of Partial Differential Equations. Singapore: McGraw-Hill.

References

1 Tyn Myint-U and Lokenath Debnath, (2007). Linear Partial Differential Equations for Scientists and Engineers. (4 Edn.) Boston: Birkhauser.

2 Aslak Tveito and Ragnar Winther, (1998). Introduction to Partial Differential Equations: A Computational Approach.New York: Springer-Verlag.

3 Hillen T, Leonard E.I and Van Roessel H, (2012). Partial Differential Equations: Theory And Completely Solved Problems. New Jersey: Wiley & Sons.

4 O'Neil, V. (2008). Beginning Partial Differential Equations. (2 Edn.) New Jersey: Wiley& Sons.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A2CC	**CORE :** TOPOLOGY	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The concept of Spaces and Maps.
- Fixed point theorems and its applications.
- The influence of metric space in topology.

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	explain the concepts behind topological spaces.	K2
CO2	constructing various spaces through the axioms of spaces.	K3
CO3	applying fixed point theorems to study the properties of spaces.	K3
CO4	examine the properties of metric spaces.	K4
CO5	Analyzing the Topological properties.	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	S	S	M	M
CO2	S	S	S	M	M
CO3	S	M	S	S	S
CO4	M	S	S	S	S
CO5	S	M	S	M	S

S **Strong** **M** **Medium** **L** **Low**

192MT2A2CC	CORE: TOPOLOGY	**SEMESTER II**

Total Credits: 4
Total Instruction Hours: 60 h

Syllabus

Unit I Spaces and Maps 13 h

Sets – Functions – Cartesian products. Topological spaces – Sets in space – Maps – Subspaces – Sum and product of spaces.

Unit II Properties of Spaces and Maps 12 h

Separation of axioms – Hausdorff space - Frechet space - Completely regular space - Tychonoff space - Normal space - Urysohn's lemma - Compactness - Locally compactness-paracompactness.

Unit III Connectedness 13 h

Connectedness – Homotopic maps - Fixed point theorems - Locally connectedness - Pathwise connectedness – Locally pathwise connectedness - Imbedding theorems – Extension theorems.

Unit IV Compactification and Metric spaces 12 h

Compactification- Stone-Cech compactification - Hausdorff compactification - Distance function – Metric spaces - Meterizability - Urysohn Metrization theorem.

Unit V Covering 10 h

Topological properties - Completely Normal space - Michael's lemma - Compact subsets – Lebesgue's covering lemma - Completeness.

Text Books

1	Sze-Tsen Hu, (1966). Introduction to General Topology. San Francisco: Holden-Day, INC.

References

1	Nainpally, S. Peters, J (2013). Topology with Applications:Topological Spaces via Near and Far. Singapore: World Scientific.
2	Munkres, J.R. (2007). Topology. (2 Edn.) New Delhi: Prentice-Hall of India Private Limited.
3	Adams and Franzosa. (). Introduction to Topology: Pure and Applied. New Delhi: Pearson-Prentice Hall.
4	Simmons, G.F. (2004). Introduction to Topology and Modern Analysis. New Delhi: Tata McGraw Hill.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A2CE	**CORE :** MATHEMATICAL SOFTWARES	CORE	3	-	-	3

PREAMBLE

This course has been designed for students to learn and understand

- The procedure of document preparation using LATEX.
- The basic structure of various built-in functions both Latex and MATLAB.
- The application of MATLAB in various branches of Mathematics.

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Express the mathematical documentation through LATEX.	K2
CO2	Learn how to employ LATEX for various diagrammatic representations.	K3
CO3	Discuss the basic operations through MATLAB	K2
CO4	Illustrate the application of MATLAB to solve various forms of Mathematical problems	K4
CO5	Plots and export figures and test the efficiency of a method by computing errors	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	M	M	S	M	M
CO2	S	S	S	M	S
CO3	M	M	S	S	M
CO4	S	S	S	S	S
CO5	S	S	S	S	S

S **Strong** **M** **Medium** **L** **Low**

192MT2A2CE	CORE: MATHEMATICAL SOFTWARES	**SEMESTER II**

Total Credits: 3
Total Instruction Hours: 36 h

Syllabus

Unit I LATEX: Introduction and Typesetting 6 h

Pros and Cons – Basics - Document hierarchy - Document management - Labels and cross-references - Controlling the style of references - Bibliography - Table of contents and lists of things - Class files – Packages - Useful classes and packages - Errors and troubleshooting. Special characters – Diacritics – Ligatures - Quotation marks – Dashes - Full stops – Ellipsis – Emphasis - Borderline punctuation - Footnotes and Marginal notes - Displayed quotations and verses - Line breaks - Controlling the size - Seriffed and Sans Serif Typefaces - Small caps letters - Controlling the type style – Abbreviations - Phantom text – Alignment.

Unit II Tables, Diagrams, and Data Plots 6 h

The figure environment - Special packages - External picture files - The graphicx package - Setting default key values - Setting a search path - Graphics extensions - Why Specify your Diagrams? - The tikzpicture environment - The \tikz command - Grids - Paths - Coordinate labels - Extending paths - Actions on paths - Nodes and node labels - The spy library - Trees.

Unit III MATLAB: Introduction and Interactive Computation 6 h

On-line help - Input-output - File types - Platform dependence - General commands should remember - Matrices and Vectors - Input - Indexing - Matrix manipulation - Creating Vectors – Matrix and Array operations: Arithmetic operations - Relational operations - Logical operations - Elementary math functions - Matrix functions - Character strings – Command line Functions: Inline functions - Anonymous functions – Saving and Loading data - Saving into and loading from the binary Mat-files - Importing data files - Recording a session with diary – Plotting Simple Graphs.

Unit IV Applications 9 h

Solving a linear system - Gaussian elimination - Finding eigenvalues and eigenvectors - Matrix factorization - Advanced topics – Polynomial curve fitting on the fly - Curve fitting with polynomial functions - Least squares curve fitting - General nonlinear fits - Interpolation – Data Analysis and Statistics – Numerical integration - Double integration – Ordinary differential equations - First-order linear ODE - Second-order nonlinear ODE - ode23 versus ode45 - Specifying tolerance - The ODE suite - Event location – Nonlinear Algebraic equations: Roots of polynomials – Advanced topics.

Unit V Graphics and Errors 9 h

Basic 2-D Plots - Style options - Labels, title, legend and other text objects - Axis control, zoom in and zoom out - Modifying plots with the plot editor - Overlay plots - Specialized 2-D plots – Using subplot for Multiple Graphs - 3-D Plots: View - Rotate view- Mesh and surface plots – Vector field and volumetric plots - Interpolated surface plots - Object hierarchy - Object handles - Object properties - Modifying an existing plot - Complete control over the graphics layout – Saving graphs to reusable files – Animation - Errors.

Text Books

1 Van Dongen M.R.C. (2012). LATEX and Friends. Berlin: Springer-Verlag.

2 Rudra Pratap, (2006). Getting started with MATLAB 7 A Quick Introduction for Scientists and Engineers. Noida: Oxford University Press.

References

1 Stefan Kottwitz, (2011). LATEX Beginner’s Guide. UK: Packt Publishing Limited.

2 Kopka,H. and Daly,P.W.,. (1999). A Guide to LATEX. (3rd Edn.) London: Addison Wesley.

3 Nambudiripad, K.B.M. (2014). LATEX for Beginners. Delhi: Narosa Publishing House Private Limited.

4 Kirani Singh,Y. and Chaudhuri,B.B., (2007). MATLAB Programming. (1st Edn.) New Delhi: PHI Learning.

192MT2A2CP	CORE PRACTICAL: MATHEMATICAL SOFTWARES	**SEMESTER II**

Total Credits: 2
Total Instructions Hours: 48 h

S.No	**Contents**
1	Creating a document with paragraph alignment.
2	Creating a document with tables.
3	Inserting a graph or picture in a document.
4	Creating a document with mathematical formulas.
5	Creating a PPT using Latex.
6	Creating a simple project using Latex.
7	Insert a graph and table from excel using Latex.
8	Creating a question paper model.
9	Generating Fibonacci numbers.
10	Solving a first order differential equation using Euler's method.
11	Finding the factorial value of a given number.
12	Solve a simple equation using Newton Raphson Method.
13	Solving a first order differential equation using Runge-Kutta fourth order method.
14	Designing a Simple Plot.
15	Design a simple Bar chart and Pie Chart.
16	Solving a quadratic equation.
17	Solving a system of equations using Gauss elimination method.
18]	Solving a system of equations using Gauss Seidal method.
19]	Solve the integral using Trapezoidal method.
20	Solve 2D diffusion equation.
21	Solve 2D wave equation.
22	Solve 2D heat equation.

Note A minimum of Seventeen programs are to be completed.

Course Code	Course Name	Category	L	T	P	Credit
194DA2A2IA	EDC:FOUNDATIONS OF DATA ANALYTICS	EDC	3	1	-	3

PREAMBLE

This course has been designed for students to learn and understand

- Exciting growing field of data analytics.
- Fundamental techniques and principles in achieving data analytics with scalability and streaming capability.
- To solve complex real-world problems in decision support.

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Understand the key issues in data management and its applications in business and scientific computing.	K3
CO2	Acquire fundamental enabling techniques and scalable algorithms.	K3
CO3	Interpret business models and scientific computing paradigms.	K4
CO4	Apply software tools for data analytics.	K4
CO5	Achieve perspectives of data analytics in real applications like recommender systems, social media applications.	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	S	M	M	S
CO2	S	S	S	S	M
CO3	M	M	S	S	S
CO4	M	S	S	S	S
CO5	S	S	S	M	S

S **Strong** **M** **Medium** **L** **Low**

194DA2A2IA	EDC: FOUNDATIONS OF DATA ANALYTICS	**SEMESTER II**

Total Credits: 3
Total Instruction Hours: 48 h

Syllabus

Unit I Introduction to Data 10 h

Understanding Data: Introduction-Types of Data: Numeric - Categorical – Graphical - High Dimensional Data - Sources of Data: Time Series - Transactional Data - Biological Data - Spatial Data - Social Network Data- Data Science Components: Statistics - Mathematics - Programming Languages - Database - Machine Learning - Big data technology.

Unit II Data Quality and Preprocessing 9 h

Data Preprocessing: Data Quality - Data Cleaning: Missing values -Redundant Data- Inconsistency - Noisy data - Outliers - Data Conversion: Nominal to Relative - Ordinal to Relative - Data Transformation- Dimensionality Reduction - Attribute Aggregation - Principal Component Analysis - Independent Component Analysis - Multidimensional Scaling - Attribute Selection.

Unit III Clustering 9 h

Clustering: Distance Measures- Distance Measures for Objects with Quantitative Attributes - Distance Measures for Non-conventional Attributes - Clustering Validation -Clustering Techniques: K Means - DBSCAN- Hierarchical Clustering Technique.

Unit IV Frequent Pattern mining 10 h

Frequent Itemsets: Introduction - Setting the min_sup Threshold - Apriori - FP-Growth- Maximal Frequent Itemsets - Closed Frequent Itemsets - Association Rule Mining - Lift - Sequential patterns - Frequent Sequence Mining- Closed and Maximal Sequences.

Unit V Regression and Classification 10 h

Regression - Predictive Performance Estimation - Finding the Parameters of the Model: Linear Regression - Bias-variance Trade-off - Shrinkage Methods - Classification: Binary Classification - Predictive Performance Measures for Classification - Distance-based Algorithms - Probability-based algorithms.

Text Book

1 Moreira, J.M., Andre Carvalho, Horvath T., (2019). A General Introduction to Data Analytics. USA: John Wiley and Sons.

References

1 Woz, R.J. (2017). Data Analytics for Beginners. California: CreateSpace Independent Publishing Platform.

2 Ahmad, M. and Pathan, A.K., (2019). Data Analytics Concepts, Techniques and Applications. New York: CRC Press.

3 Jain,V.K. (2018). Data Science and Analytics. New Delhi: Data Science and Analytics.

4 Anil Maheshwari, (2017). Data Analytics. New York:McGraw Hill Publishers.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A2DA	ELECTIVE: MATHEMATICAL FINANACE	ELECTIVE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- To lay theoretical foundation with potential applications to financial problems.
- To provide efficient introduction to theoretical skills that are genuinely used in financial institutions.
- To provide Analytic Approach to Black-Scholes.

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Learn about financial model and its representation through Binomial trees.	K2
CO2	Develop the stock and option trees using Spreadsheets.	K3
CO3	Analyze continuous models.	K4
CO4	Learn about Black-Scholes model for various options.	K2
CO5	Evaluate parameters corresponding to Financial model.	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	S	M	L	L
CO2	S	S	M	L	L
CO3	S	S	M	L	L
CO4	S	S	S	M	L
CO5	S	S	S	S	M

S **Strong** **M** **Medium** **L** **Low**

192MT2A2DA	ELECTIVE: MATHEMATICAL FINANACE	**SEMESTER II**

Total Credits: 4
Total Instruction Hours: 60 h

Syllabus

Unit I	Financial Markets and Binomial Trees, Replicating Portfoilos and Arbitrage	11 h

Financial Markets: Markets and Math - Stocks and their Derivatives - Pricing Futures Contracts - Bond Markets - Interest Rate Futures - Foreign Exchange. Binomial Trees, Replicating Portfoilos and Arbitrage: Three Ways to Price a Derivative - The Game Theory method - Replicating Portfolios - The Probabilistic approach - Risk - Repeated Binomial Trees and Arbitrage.

Unit II	Tree Models for Stocks and Options& Using Spreadsheets to Compute Stock and Option Trees	11 h

Tree Models for Stocks and Options: A Stock Model - Pricing a call Option With the Tree Model - Pricing an American Option - Pricing an Exotic Option - Knockout Options - Pricing an Exotic Option - Lookback Options - Adjusting the Binomial Tree Model to Real - World Data - Hedging and Pricing the N - Period Binomial Model. Using Spreadsheets to Compute Stock and Option Trees: Some Spreadsheets Basics –Computing European Trees - Computing American Option trees - Computing a Barrier Option Tree - Computing N - Step Trees.

Unit III	Continuous Models and the Black - Scholes Formula	12 h

Continuous Models and the Black - Scholes Formula: A continuous –Time Stock Model - The Discrete Model - An Analysis of The Continuous Model - The Black - Scholes Formula - Derivation of the The Black - Scholes Formula - Put - Call Parity - Trees and Continuous Models - The GBM Stock Price Model - A Cautionary Tale.

Unit IV	The Analytic Approach to Black-Scholes	13 h

The Analytic Approach to Black-Scholes: Strategy for Obtaining the Differential Equation - Expanding V(S,t) - Expanding and Simplifying $V(S_t, t)$ - Finding a Portfolio - Solving the Black - Scholes Differential Equation - Options on Futures - Appendix: Portfolio Differentials.

Unit V	Hedging	13 h

Hedging: Delta Hedging - Methods of Hedging a Stock or Portfolio - Implied Volatility - The Parameters Δ, Γ and Θ - Derivation of the Delta Hedging Rule - Delta Hedging a Stock Purchase

Text Books

1 Joseph Stampfli and Victor Goodman, (2002). The Mathematics of Finance: Modeling and Hedging. Singapore: Thomson Asia Private Limited.

References

1 Chandra, S. Dharmaraja, S. Paraná Mehra and Khemchandani, R (2014). Financial Mathematics – An introduction. New Delhi: Narosa Publications.

2 Hull, J.C. and Sankarshan Basu,. (2009). Options futures and other derivatives. (7 Edn.) New Delh: Pearson Education.

3 Marek Capiński and Tomasz Zastawniak, (2011). Mathematics for Finance: An Introduction to Financial Engineering. (2 Edn.) New York: Springer.

4 Kevin J.Hastings, (2015). Introduction to Financial Mathematics (Advances in Applied Mathematics). (1 Edn.) New York: Chapman and Hall/CRC.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A2DB	ELECTIVE: MATHEMATICAL BIOLOGY	ELECTIVE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- To introduce Mathematics as a tool in the study of Biology.
- To understand the structures of various mathematical methods that are used in Biological modeling.
- How to Model the Dynamics of Marital Interaction.

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Know the continuous population models for single species.	K2
CO2	Understand the discrete population models for a single species.	K2
CO3	Understand the concept of Mathematical models.	K2
CO4	Apply mathematical model for human beings.	K3
CO5	Analyze the marital relationship between man and women.	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	M	M	S	S
CO2	S	M	S	S	S
CO3	S	M	S	S	M
CO4	S	S	M	S	M
CO5	S	S	S	M	M

S **Strong** **M** **Medium** **L** **Low**

192MT2A2DB	ELECTIVE: MATHEMATICAL BIOLOGY	**SEMESTER II**

Total Credits: 4
Total Instruction Hours: 48 h

Syllabus

Unit I Continuous Population Models for Single Species 12 h

Continuous Population Models for Single Species: Continuous Growth Models – Insect Outbreak Model: Spruce Budworm – Delay Models - Linear Analysis of Delay Population Models: Periodic Solutions - Delay Models in Physiology: Periodic Dynamic Diseases.

Unit II Discrete Population Models for a Single Species 10 h

Discrete Population Models for a Single Species: Introduction: Simple Models - Cobwebbing: A Graphical Procedure of Solution – Discrete Logistic - Type Model: Chaos - Stability, Periodic Solutions and Bifurcations – Discrete Delay Models – Fishery Management Model.

Unit III Models for Interacting Populations 08 h

Models for Interacting Populations: Predator–Prey Models: Lotka–Volterra Systems - Complexity and Stability – Realistic Predator–Prey Models - Analysis of a Predator–Prey Model with Limit Cycle Periodic Behaviour: Parameter Domains of Stability - Competition Models: Principle of Competitive Exclusion – Mutualism or Symbiosis – General Models and Some General and Cautionary Remarks.

Unit IV Temperature - Dependent Sex Determination (TSD) 09 h

Temperature - Dependent Sex Determination (TSD): Crocodilian Survivorship: Biological Introduction and Historical Asides on the Crocodilia - Basic Nesting Assumptions and Simple Population Model - Age - Structured Population Model for Crocodilia - Density - Dependent Age.

Unit V Modelling the Dynamics of Marital Interaction 09 h

Modelling the Dynamics of Marital Interaction: Divorce Prediction and Marriage Repair: Psychological Background and Data: Gottman and Levenson Methodology - Marital Typology and Modelling Motivation - Modelling Strategy and the Model Equations - Steady States and Stability – Practical Results from the Model - Benefits, Implications and Marriage Repair Scenarios.

Text Books

1	Murray, J.D. (2002). Mathematical Biology I. An Introduction. (3rd Edn.) New York: Springer.

References

1	Nicholas F. Britton, (2003). Essential Mathematical Biology. (2nd Edn.) London: Springer-Verlag.
2	Rubinow,.S.I. (2003). Introduction to Mathematical Biology. New York: Dover Publications.
3	Chou, Ching Shan and Friedman Avner, (2016). Introduction to Mathematical Biology:Modeling, Analysis, and Simulations. (1st Edn.) Switzerland: Springer International Publishing.
4	Linda J.S. Allen, (2006). An Introduction to Mathematical Biology). New York: Pearson Education.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A2DC	ELECTIVE: ADVANCED STATISTICS	ELECTIVE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- The concepts of confidence intervals in various distributions
- The application of maximum likelihood estimation.
- The concept of Nonparametric tests

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Identity the confidence intervals.	K2
CO2	Explain the method solving non-parametric test.	K2
CO3	Compute one maximum likelihood estimator.	K3
CO4	Analyze the sufficiency in estimation.	K4
CO5	Choose the optimal tests for hypothesis.	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	M	S	S	S	S
CO2	S	S	M	S	S
CO3	S	S	S	S	S
CO4	S	M	S	S	M
CO5	S	M	S	M	S

S **Strong** **M** **Medium** **L** **Low**

192MT2A2DC	ELECTIVE: ADVANCED STATISTICS	SEMESTER **II**

Total Credits: 4
Total Instruction Hours: 48 h

Syllabus

Unit I Statistical Inferences 11 h

Sampling and Statistics - order statistics - Tolerance limits for distributions - more on confidence intervals - Introduction to hypothesis testing - Additional comments about Statistical tests-Chi-Square tests - Method of Monte Carlo.

Unit II Maximum Likelihood estimation 10 h

Maximum likelihood estimation - Rao-Cramer Lower Bound and efficiency - Maximum likelihood tests - Estimation - Multiparameter Case: Testing.

Unit III Sufficiency 09 h

Measures of quality of estimators - Sufficient statistic for a Parameter - Properties - Completeness and uniqueness - Exponential Class of distributions - Functions of a Parameter - Case of several parameters - Minimal sufficiency and ancillary statistics –Sufficiency, completeness and independence.

Unit IV Optimal tests of hypotheses 09 h

Most powerful tests - Uniformly most powerful tests - Likelihood ratio tests - sequential Probability Ratio Test - Minimax and classification procedures.

Unit V Nonparametric Statistics 09 h

Location models - sample median and sign test - Signed-Rank Wilcoxon - Mann-Whitney-Wilcoxon procedures.

Text Books

1 Hogg, R.V, McKean, J.W and Craig, A.T (2006). Introduction to Mathematical Statistics. (6th Edn.) New Delhi: PearsonEducation Inc.

References

1 Hoel, P.G. (1984). Introduction to Mathematical Statistics. (5th Edn.) New Delhi: Wiley India.

2 Larsen R.J and Marx, M.L. (2011). An Introductionto Mathematical Statistics and its Applications. (3rd Edn.) New Delhi: Pearson Education Inc.

3 Casella G and Berger, R.L. (2002). Statistical Inference. (1st Edn.)), Singpore: Duxbury Press, Thomson Learning.

4 Cox, D.R. (2006). Principles of Statistical Inference. Cambridge: Publi Cambridge University Press.

Course Code	Course Category	Course Name	L	T	P	Exam (h)	Max Marks			Credits
							CIA	ESE	Total	
Third Semester										
192MT2A3CA	CORE	Functional Analysis	4	2	-	3	25	75	100	4
192MT2A3CB	CORE	Industrial Mathematics	3	2	-	3	25	75	100	3
192MT2A3CC	CORE	Mathematical Methods	4	1	-	3	25	75	100	4
192MT2A3CD	CORE	Stochastic Differential Equations	4	2	-	3	25	75	100	4
192MT2A3CE	CORE	Fluid Dynamics	4	-	-	3	25	75	100	4
192MT2A3DA	DSC	Mathematical Modeling	4	-	-	3	25	75	100	4
192MT2A3DB		Control Theory								
192MT2A3DC		Wavelet Analysis								
		Total	**23**	**7**	**-**				**600**	**23**

EXTRA CREDIT COURSES

The following are the courses offered under self study to earn extra credits:

S. No.	Course Code	Course Name
1	192MT2ASSA	Research Methodology, IPR and Entrepreneurship
2	192MT2ASSB	Mathematics of Bioinformatics

Course Code	Course Name	Category	L	T	P	Credit
192MT2A3CA	FUNCTIONAL ANALYSIS	CORE	4	2	-	4

PREAMBLE

This course has been designed for students to learn and understand

- concept of normed linear spaces
- applications of Banach spaces
- theorems based on various spaces

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	understand the concept of normed linear spaces and its implications	K2
CO2	relate the concept of Banach space and Hilbert space	K3
CO3	apply the operators on normed linear spaces	K3
CO4	analyze the concept of orthonormal sets	K4
CO5	explain the closed graph theorem and its consequences	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	S	S	M	S
CO2	M	S	S	S	S
CO3	S	S	M	S	S
CO4	S	S	M	M	M
CO5	S	S	M	M	S

S **Strong** **M** **Medium** **L** **Low**

192MT2A3CA	FUNCTIONAL ANALYSIS	SEMESTER III

Total Credits: 4

Total Instruction Hours: 72 h

Syllabus

Unit I Normed Linear Space 14 h

Examples– seminormsand quotient spaces– measurable functions and LpSpaces – product spaceand graph norm – inner product spaces– semi-inner product and sesquilinear form

Unit II Banach Space 14 h

Incomplete and complete normed linear spaces – properties of Banachspaces – Schauderbasis and separability– Heine-Boreltheorem and Rieszlemma – best approximation theorems – projection theorem

Unit III Operators on Normed Linear Spaces 14 h

Bounded operators –basic results and examples – the space B(X,Y) –norm on B(X,Y) – Rieszrepresentation theorem – convergence of sequence of operators – completeness of B(X,Y) – convergence of quadrature formulas – closed operators

Unit IV Hahn-Banach Theorem 15 h

Orthonormal sets and orthonormal bases –Bessel's inequality –Fourier expansion and Parseval's formula –Riesz-Fischer theorem –extension theorem – consequences – on uniqueness of extension – separation theorem

Unit V Closed Graph and Open Mapping Theorem 15 h

Uniform boundednessprinciple –theorem and its consequences – applications - divergence of Lagrange interpolation- on divergence of Fourier Series- closed graph theorem – bounded inverse theorem – open mapping theorem

Text Books

1 Thamban Nair, 2014,"Functional Analysis- A first course", Prentice-Hall of India PrivateLimited, New Delhi

References

1 Simmons G.F, 2004, " Introduction to Topology and Modern Analysis", McGraw – Hill, NewDelhi

2 Somasundaram D, 2006,"A first Course in Functional Analysis",Narosa Publishing House PvtLtd., New Delhi

3 VasisthaA.R and Sharma J.N, 2014, "Functional Analysis", KrishnaPrakasham Media PvtLtd, New Delhi.

4 LimayeB.V, 1981,"Functional Analysis", Wiley Eastern, New Delhi.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A3CB	**INDUSTRIAL MATHEMATICS**	**CORE**	**3**	**2-**	**-**	**3**

PREAMBLE

This course has been designed for students to learn and understand

- Mathematical background of some prominent industrial tools
- the importance of theories and laws that leads to image reconstruction
- various forms of Monte-Carlo techniques and its applications

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	Illustrate the concept of Mathematics behind X-ray and Back projection	K2
CO2	understand the theories of filters and convolution to reconstruct the images	K3
CO3	apply Fourier transform in discrete image reconstruction	K3
CO4	analyze the applicability of various methods of optimization in Industries	K4
CO5	analyzethe Monte-Carlo theory.	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	S	S	M	S
CO2	M	M	S	S	S
CO3	S	S	S	S	S
CO4	S	S	M	M	M
CO5	S	M	S	S	S

S Strong **M** Medium **L** Low

192MT2A3CB	INDUSTRIAL MATHEMATICS	SEMESTER III

Total Credits: 3

Total Instruction Hours: 60 h

Syllabus

Unit I X-Ray and Back Projection 12 h

X-ray - Introduction - X-ray behaviour and Beer's law - Radon transform - Linearity - Phantoms - Back projection - Properties.

Unit II Filters and Convolution 10 h

Convolution - Resolution - Convolution and the Fourier transform - Rayleigh-Plancherel theorem - Convolution in two dimensional space - Low pass filters.

Unit III Discrete Image reconstruction 12 h

Sampling - Discrete Low pass filters and Radon transform - Discrete functions and convolutions - Discrete Fourier transform and Back projection -Interpolation - Image reconstruction -FFT - Fan beam geometry.

Unit IV Algorithms for Optimization 12 h

Introduction - General results - Special classes of optimization - Newton algorithm and its generalizations - Conjugate gradient method - Variable metric methods.

Unit V Monte-Carlo Method 14 h

Monte-Carlo method - Quasi Monte Carlo method - Particle methods - current study of the particle methods

Text Books

1 Timothy G. Feeman, 2010, "The Mathematics of Medical Imaging - A begineers Guide", Springer, New York

2 HelmeutNeunzurt and Abul Hasan Siddiqi, 2000, "Topics in Industrial Mathematics - Case Studies and Related Mathematical Methods", Springer, Science Media, NewYork.

References

1 Charles L. Epstein, 2008, "Introduction to the Mathematics of Medical Imaging", SIAM, Philadelphia.

2 Glenn R. Fulford and Philip Broadbridge, 2010, "Industrial Mathematics", Cambridge University Press, London.

3 Avner Friedman and Walter Littman, 1994, "Industrial Mathematics - A Course in Solving Real-World Problems", SIAM, Philadelphia.

4 Chris Guy and Dominic Ffytche, 2005, "An Introduction to the Principles of Medical Imaging", Imperial College Press, London.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A3CC	MATHEMATICAL METHODS	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- the fundamentals of integral equations and their classification.
- the variation in problems and functionals.
- the Mathematical methods collectively asasymptotic and perturbative analysis.

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	understandthe definition of the integral equations and its types.	K2
CO2	applythe method of successive approximation to find the solution of integral equations and classical Fredholm theory.	K3
CO3	Understand he method of solving variational problems.	K3
CO4	understandthe new kind of approximate calculus necessary to solve hard problems approximately.	K4
CO5	Analyze the asymptotic expansion and perturbation theory.	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	S	S	M	S
CO2	M	S	S	S	S
CO3	S	S	M	S	S
CO4	S	S	M	M	M
CO5	S	S	M	M	S

S Strong M Medium L Low

192MT2A3CC	MATHEMATICAL METHODS	SEMESTER III

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I Integral Equations 10 h

Types of integral equations - Fredholm integralequation - Volterra integral equation - singular integral equations. Specialkinds of kernels - Eigen values Eigen functions – Fredholmalternative -an approximate method

Unit II Method of Successive Approximation 12 h

Iterated kernels-Resolvent kernel- solution of Fredholmand Volterra integral equation of the second kind by successive approximations- classical Fredholm theory– Fredholm's first, second, third fundamental theorems.

Unit III Calculus of Variations 10 h

Variation and its properties – Euler's equation – functionals of the integral forms-functional dependent on higher order derivatives – functional dependent on the functions of several independent variables – variational problems in parametric form

Unit IV Asymptotic Expansion of Integrals 13 h

Introduction-elementary examples-integration by Parts-Laplace's method and Watson's lemma-method of stationary phase-asymptotic evaluation of sums

Unit V Perturbation Methods 15 h

Perturbation theory-regular and singular perturbation theory-perturbation methods for linear Eigenvalue problems-asymptotic matching -mathematical structure of perturbative Eigenvalue problems

Text Books

1 Raisinghania M.D, 2007,"Integral equations and boundary value problems",S.Chand and Company Pvt. Ltd, New Delhi(Unit I and II)

2 Elsgolts, 1970,"Differential Equations and Calculus of Variations", Moscow: Mir Publishers, Moscow(Unit III)

3 Bender C.M and Orszag S, 2010, "Advanced Mathematical Methods for Scientists and Engineers", Springer, New York (Unit IV and V).

References

1 Debnath L andBhatta P.D,2012, "Textbook of Finite Element Analysis", Prentice Hall of India Learning Private Limited, New Delhi

2 Weinstock R,1952,"Calculus of Variations, with Applications to Physics and Engineering", McGraw-Hill,New York

3 Hinch E. J, 1991, "Perturbation Methods", Cambridge University Press,New York

4 Holmes M.H,2013,"Introduction to Perturbation Methods", Springer , New York

Course Code	Course Name	Category	L	T	P	Credit
192MT2A3CD	STOCHASTIC DIFFERENTIAL EQUATIONS	CORE	4	2	-	4

PREAMBLE

This course has been designed for students to learn and understand

- the applications of the Brownian motion.
- about the method of obtaining solution for a differential equation raised in random environment.
- the stability behavior of stochastic differential equation

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	learn about the construction of Ito integral	K3
CO2	analyze and solve a stochastic differential equationsthrough Ito's formula	K4
CO3	analyze the random situations through Markov property	K4
CO4	examinethe applications of diffusion theory in various real time problems raised under uncertain situations.	K5
CO5	analyze the diffusion theory in the form of optimal stopping problems.	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	M	S	M	S	S
CO2	M	S	S	S	S
CO3	S	S	S	S	M
CO4	S	M	S	S	S
CO5	S	M	S	M	S

S **Strong** **M** **Medium** **L** **Low**

192MT2A3CD	STOCHASTIC DIFFERENTIAL EQUATIONS	SEMESTER III

Total Credits: 4

Total Instruction Hours: 72 h

Syllabus

Unit I Brownian Motion 15 h

Introduction - basic notations of probability theory - stochastic processes - Brownian motions - stochastic integrals - Itô's formula - moment inequalities - Gronwall type inequalities.

Unit II Stochastic Differential Equations 14 h

Introduction - stochastic differential equations - existence and uniqueness of solutions - L_p estimates - almost surely asymptotic estimates.

Unit III Markov Processes 15 h

Caratheodory's approximate solutions - Euler-Maruyama's approximate solutions - SDE and PDE: Feynman-Kac's formula -solutions as Markov processes.

Unit IV Linear Stochastic Differential Equations 14 h

Introduction - stochastic Liouville's formula - variation–of–constants formula - examples.

Unit V Stability of Stochastic Differential Equations 14 h

Introduction - stability in probability - almost sure exponential stability - moment exponential stability - stochastic stabilization and destabilization.

Text Books

1 Mao, X, 2007,"Stochastic Differential Equations and Applications",WP Wood Head Publishing, New Delhi.

References

1 Evans L.C, 2012,"An Introduction to Stochastic Differential Equations", American Mathematical Society, New York

2 Oksendal B, 2003,"Stochastic Differential Equations: An Introduction with Applications"6th Edition, Springer-Verlag, New York

3 Friedman A, 2006,"Stochastic Differential Equations and applications", Dover Publcations, New York

4 Douglas Henderson and Peter Plaschko, 2006, "Stochastic Differential Equatons in Science and Engineering", World Scientific Publishing Co Pvt. Ltd, Singapore

Course Code	Course Name	Category	L	T	P	Credit
192MT2A3CE	**FLUID DYNAMICS**	**CORE**	**4**	**-**	**-**	**4**

PREAMBLE

This course has been designed for students to learn and understand

- the concepts of the fluid motion.
- the flow of viscous and inviscid incompressible fluids.
- the momentum integral theorems.

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	explain about kinematics of fluids.	K2
CO2	analyzing relation between stress and strain, flow of viscous compressible fluids.	K4
CO3	analyzing flow of inviscid compressible fluids.	K4
CO4	Comparing similarity of flows.	K5
CO5	application of Momentum Integral Theorems.	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	M	M	M	L
CO2	S	M	M	M	L
CO3	S	S	S	S	M
CO4	S	S	S	S	S
CO5	S	S	S	S	S

S **Strong** **M** **Medium** **L** **Low**

192MT2A3CE	FLUID DYNAMICS	SEMESTER III

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Introduction 10 h

General description of fluid mechanics - continuum mechanics - fluid properties - regimes in the mechanics of fluids. Kinematics of Fluids: Methods of describing fluid motion - translation, rotation and rate of deformation - streamlines path lines and streak lines - the material derivative and acceleration - vorticity.

Unit II General Theory of Stress and Rate of Strain 9 h

Nature of stresses - transformation of stress-components - nature of strains - transformation of the rates of strain - relation between stress and rate of strain. Fundamental Equations of The Flow of Viscous Compressible Fluids: Equation of continuity-conservation of mass - equations of motion (Navier-Stokes equation)-conservation of momentum - energy equation-conservation of energy.

Unit III Two- and Three-Dimensional, Inviscid Incompressible Flow: Basic Equations and Concepts of Flows 10 h

Equation of continuity - Eulerianequation of motion - circulation theorems - velocity potential-irrotational flow - integration of the equations of motion-Bernoulli's equation - the momentum theorem. Simple Flows: Laplace's equation - stream function in two-dimensional motion - the flow net - two dimensional flow examples - three-dimensional axially symmetric flow examples.

Unit IV Laminar Flow of Viscous Incompressible Fluids 9 h

Similarity of Flows: the Reynolds number - viscosity from the point of view of the kinetic theory - flow between parallel flat plates - steady flow in pipes - flow between two concentric rotating cylinders - applications of the parallel flow theory.

Unit V The Laminar Boundary Layer 10 h

Properties of Navier-Stokes equations-boundary layer concept - the boundary layer equations in two-dimensional flow - the boundary layer along a flat plate - boundary layer on a surface with pressure gradient - momentum integral theorems for the boundary layer.

Text Books

1 Yuan S.W, 1969,"Foundations of Fluid Mechanics", Prentice-Hall of India Private Limited, New Delhi

References

1 Milne Thomson, L.M. 1968,"Theoretical Hydro Dynamics", 5th Edition, McMillan Company, Noida

2 Curle N, Davies H.J, 1968,"Modern Fluid Dynamics, Volume I", D Van Nostrand Company Limited, London

3 Landau L.D,Lifshitz E.M, 1982, "Fluid Mechanics (Course of Theoretical Physics)", 1st Edition,Pergamon Press, Oxford

4 Pozrikidis C,2017, "Fluid Dynamics: Theory, Computation, and Numerical Simulation", 3rd Edition, Springer, New York

Course Code	Course Name	Category	L	T	P	Credit
192MT2A3DA	**MATHEMATICAL MODELING**	**DSE**	**4**	**-**	**-**	**4**

PREAMBLE

This course has been designed for students to learn and understand

- the deterministic states and analysis of models
- the stochastic analysis of models
- various evolution of models

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	describe the optimal power and exponential models	K2
CO2	discuss the dimensional analysis and similarity	K2
CO3	apply the concept of probability density function to define stochastic states	K3
CO4	analyze the properties of various forms of changes using modeling	K4
CO5	develop the models for situations involving evolution theory	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	M	S	S	S	S
CO2	M	M	S	S	M
CO3	S	M	S	M	S
CO4	S	M	M	M	S
CO5	S	S	S	S	S

S **Strong** **M** **Medium** **L** **Low**

192MT2A3DA	MATHEMATICAL MODELING	SEMESTER III

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Deterministic Analysis of Observations 9 h

Data transformations: Linear model –polynomial models –population modeling – global warming modeling.-model errors – optimal linear models – optimal quadratic models – optimal power and exponential models

Unit II Deterministic States 11 h

Dimensional analysis and similarity - applications of low-complexity – applications of medium complexity- time measurement - applications of high-complexity

Unit III Stochastic States 9 h

Probability density functions – models for probability density functions – data analysis – real distribution

Unit IV Deterministic Changes 10 h

Motivation - linear changes - linear changes with delays - nonlinear changes - difference and differential equations

Unit V Deterministic Evolution 9 h

Heat and Mass Transfer: Balance – Newton's laws of motion: oscillations – population ecology: growth and self-limitation – population ecology: oscillations and collapse.

Text Books

1 Stefen Heinz, 2011,"Mathematical Modeling", Springer-Verlag, New York

References

1 J.N. Kapur, 1998, "Mathematical Modeling", New Age International (P) Limited, New Delhi

2 Crossand, and Moscrcadini A.O, 1976,"The Art of Mathematical Modeling", Ellis Harwood and John Wiley, New york

3 Sarah. P.Otto and Troy Day, 2000, "A Biologist guide to Mathematical Modeling in Ecology and Evolution", Princeton University Press, Princeton

4 Frank. R.Glordance, Maurice D. Weir and William P.Fox, 2003, "A First course in Mathematical Modeling", Thomson Learning, London

Course Code	Course Name	Category	L	T	P	Credit
192MT2A3DB	CONTROL THEORY	DSE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- the controllability and observability Grammian's
- different kinds of stability
- difference between time variant and time invariant systems

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	learn about effect of fixed points in differential systems	K2
CO2	apply stability to non-linear systems	K2
CO3	apply stability to non-linear systems	K3
CO4	analyze stabilization via Linear Feedback Control	K4
CO5	evaluate nonlinear systems	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	S	S	M	S
CO2	M	S	S	S	S
CO3	S	S	M	S	S
CO4	S	S	M	M	M
CO5	S	S	M	M	S

S Strong M Medium L Low

192MT2A3DB	CONTROL THEORY	SEMESTER IV

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Introduction and Observability 10 h

Basic results of differential equations – fixed point methods - linear-systems nonlinear systems

Unit II Controllability 10 h

Linear systems –nonlinear systems – controllability with prescribed control – asymptotic null controllability

Unit III Stability 9 h

Stability – perturbed linear systems – nonlinear systems – Lyapunov stability

Unit IV Stabilizability 9 h

Stabilization via linear feedback control – the controllable subspace – stabilization with restricted feedback

Unit V Optimal Control 10 h

Linear time varying systems – linear time invariant systems – nonlinear systems

Text Books

1	Balachandran K and Dauer J.P, 2012, "Elements of Control Theory", 2rd Edition, Narosa, New Delhi

References

1	Curtain R.F and Hans Zwart, 1995, "An Introduction to Infinite dimensional Linear Systems Theory", Springer, New York.
2	Berkovitz L.D, 1974, "Optimal Control theory", Springer-Verlag, New York
3	Verma K.R, "Modern Control Theory", 2018, CBS Publishers and Distributors PVT Ltd
4	D'Andréa-Novel, Brigitte, De Lara, Michel, 2013, "Control Theory for Engineers", Springer

Course Code	Course Name	Category	L	T	P	Credit
192MT2A3DC	WAVELET ANALYSIS	DSE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- the basic concept of the Fourier transform and discrete Fourier analysis
- Haar wavelet analysis and multi resolution analysis
- the wavelet algorithm, definition of the wavelet transform, inversion formula for the wavelet transform

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	recall the Fourier transform and discrete Fourier analysis	K2
CO2	know the basic concept of Haar wavelet analysis	K3
CO3	learn multi resolution analysis	K3
CO4	understand Daubechies wavelets	K4
CO5	computational complexity and wavelet algorithm	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	S	S	M	S
CO2	M	S	S	S	S
CO3	S	S	M	S	S
CO4	S	S	M	M	M
CO5	S	S	M	M	S

S Strong **M Medium** **L Low**

192MT2A3DC	WAVELET ANALYSIS	SEMESTER IV

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I The Fourier transform and discrete Fourier analysis 9 h

Informal development of the Fourier transform, properties of the Fourier transform, the discrete Fourier transform, discrete signals

Unit II Haar wavelet analysis 9 h

Haar wavelets, the Haar scaling function, basic properties of the Haar scaling function, the Haar wavelet, Haar decomposition and reconstruction algorithms, decomposition, reconstruction, filters and diagrams.

Unit III Multi resolution analysis 12 h

The multiresolution framework, definition, the scaling relation, the associated wavelet and wavelet spaces, decomposition and reconstruction formulas: a tale of two bases, implementing decomposition and reconstruction, the decomposition algorithm, the reconstruction algorithm, processing a signal, Fourier transform criteria, the scaling function, orthogonality via the Fourier transform, the scaling equation via the Fourier transform, iterative procedure for constructing the scaling function.

Unit IV The Daubechies wavelets 9 h

Daubechies' construction, classification, moments, and smoothness, computational issues, the scaling function at dyadic points.

Unit V Other Wavelet Topics 9 h

Computational complexity, wavelet algorithm, wavelet packets, wavelets in higher dimensions, relating decomposition and reconstruction, transfer function interpretation, wavelet transform, definition of the wavelet transform, inversion formula for the wavelet transform

Text Books

1	Albert Bogges, Francis .J. Narcowich, 2009, "A first course in Wavelets with Fourier analysis", John Wiley & Sons, Inc, New Jersey

References

1	Raghuveer Rao and Ajit S.Bopardikar, 2000, "Wavelet transforms: Introduction, Theory and applications", Pearson Education Asia, Hong Kong
2	Goswami J.C and Chan A.K., 2011, "Fundamentals of Wavelets: Theory, Algorithms, and Applications", 2nd Edition, Wiley, New Jersey
3	Michel Misiti, Yves Misiti, Georges Oppenheim, Jean-Michel Poggi, 2010, "Wavelets and their Applications", John Wiley & Sons, New Jersey
4	Walker J.S, 2002, "A premier on Wavelets and their scientific applications", CRC Press, Florida

192MT2ASSA	SELF-STUDY: RESEARCH METHODOLOGY, IPR AND ENTREPRENEURSHIP	SEMESTER III

Total Credits: 1

Syllabus

Unit I Hypotheses, Theories and Laws

Hypotheses – Theories – Laws. Scientific Statements: Their Justification and Acceptance: Verification – Falsification – Acceptance – Peer Review.

Unit II Experimentation and Design of Research

Validity and Reliability in Experimentation – Design of Experiments. Scientific and their Design of Research: The Scientific Method – Research Design.

Unit III Research Ethics and Responsibilities

Basic, Applied and Evaluation Research – Multidisciplinary and Interdisciplinary Research – The Value of having Research Skills – Formulating a Research Problem – Research in Relation to Teaching and Publishing. Research Ethics – Guidelines for Ethical practices in Research.

Unit IV Intellectual Property Rights

Introduction to intellectual property - Fundamentals of patent - Copyright - Trademarks.

Unit V The practice of Entrepreneurship

Entrepreneurial Management - The Entrepreneurial Business - Entrepreneurship in the Service Institution.

Text Books

1	Pruzan P., 2016, Research Methodology The Aims, Practices and Ethics of Science, Springer, Switzerland. (Unit-I, II & III)
2	Neeraj Pandey, Khusdeep Dharni, 2014, Intellectual Property Rights, PHI learning Pvt. Ltd. New Delhi. (Unit-IV)
3	Drucker P.F., 1986, Innovation and Entrepreneurship - Practice and Principles, Harper Publishers, New York. (Unit-V)

References

1	Thomas C.G., 2015, Research Methodology and Scientific Writing, Ane Books Pvt. Ltd., New Delhi.
2	Locharoenrat, K., 2017, Research Methodologies for Beginners, Pan Stanford Publishing, Singapore.
3	Deborah E. Bouchoux, 2000, Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets, Fourth edition, Cengage learning New York.
4	Birgitte Andersen, 2006, Intellectual Property Rights: Innovation, Governance and the Institutional Environment, Edward Elgar Publishing, UK.

192MT2ASSB	SELF STUDY : MATHEMATICS OF BIOINFORMATICS	SEMESTER III

Total Credits: 1

Syllabus

Unit I Genetic Codes, Matrices and Symmetrical Techniques

Introduction – Matrix theory and Symmetry - Genetic Codes and Matrices - Genetic Matrices, Hydrogen Bonds and the Golden Section - Symmetrical patterns, Molecular Genetics and Bioinformatics.

Unit II Biological Sequences and Sequence Alignment

Mathematical Sequence - Sequence Alignment and Sequence analysis.

Unit III Structures of DNA and Knot Theory

Knot theory preliminaries – DNA knot and links.

Unit IV Protein Structures, Geometry, and Topology

Introduction – Computational Geometry and Topology Preliminaries – Protein Structures and Prediction.

Unit V Biological Networks and Graph Theory

Introduction - Graph Theory Preliminaries and Network Topology.

Text Books

1 Matthew He and Sergey Petoukhov, 2011, Mathematics of Bioinformatics:-Theory, Practice and Applications, John Wiley, New Jersey.

References

1 Krane D.E., Raymer M.L., 2003, Fundamental Concepts of Bioinformatics, Benjamin Cummings.

2 Shanmughavel P., 2005, Principle of Bioinformatics, Pointer Publishers.

3 Shanmughavel P., 2006, Trends in Bioinformatics, Pointer Publishers.

4 Gulshan Wadhwa P., Shanmughavel, Atul Kumar Singh, Jayesh R. Bellare, 2018, Current trends in Bioinformatics: An Insight, Springer, New York.

Course Code	Course Category	Course Name	L	T	P	Exam (h)	Max Marks			Credits
							CIA	ESE	Total	
Fourth Semester										
192MT2A4CA	CORE	Finite Element Theory and Applications	4	1	-	3	25	75	100	4
192MT2A4CB	CORE	Mechanics	4	1	-	3	25	75	100	4
192MT2A4DA	DSC	Actuarial Mathematics	4	-	-	3	25	75	100	4
192MT2A4DB		Nonlinear Ordinary Differential Equations								
192MT2A4DC		Computational Fluid Dynamics								
192MT2A4CV	Project	Project	16	-	-	3	80	120	200	8
		Total	**28**	**2**	**-**	**-**	**-**	**-**	**500**	**20**

Course Code	Course Name	Category	L	T	P	Credit
192MT2A4CA	FINITE ELEMENT THEORY AND APPLICATIONS	CORE	4	1	-	4

PREAMBLE

This course has been designed for students to learn and understand

- the finite element method for stationary second order elliptic problems
- how to generate the governing FE equations for systems governed by partial differential equations
- the abstract theory on finite elements and its applications

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	understand the fundamental theory of the finite element method	K2
CO2	formulate the design and heat transfer problems with application of FEM	K3
CO3	analyze linear 1D problems and 2D structural problems	K3
CO4	solve 1D, 2D and dynamic problems using finite element method	K4
CO5	develop the computer code for solving weak problems and approximate by finite elements	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	S	S	M	S
CO2	M	S	S	S	S
CO3	S	S	M	S	S
CO4	S	S	M	M	M
CO5	S	S	M	M	S

S **Strong** **M** **Medium** **L** **Low**

192MT2A4CA	FINITE ELEMENT THEORY AND APPLICATIONS	SEMESTER IV

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I Piecewise Polynomial Approximation in 1D 12 h

Piecewise Polynomial Spaces - Interpolation - L^2-Projection - Quadrature - Computer Implementation

Unit II The Finite Element Method in 1D 13 h

The Finite Element Method for a Model Problem - Mathematical Modeling - A Model Problem with Variable Coefficients - Computer Implementation - Adaptive Finite Element Methods

Unit III Piecewise Polynomial Approximation in 2D 11 h

Meshes - Piecewise Polynomial Spaces - Interpolation- L^2-Projection -Quadrature and Numerical Integration - Computer Implementation

Unit IV The Finite Element Method in 2D 13 h

Green's Formula - The Finite Element Method for Poisson's Equation - Some Useful Inequalities - Basic Analysis of the Finite Element Method - A Model Problem with Variable Coefficients - Computer Implementation

Unit V Analysis of Function Spaces 11 h

Function Spaces - Interpolation of Functions in Hilbert Spaces - The Abstract Setting - Application to Elliptic Partial Differential Equations

Text Books

1 Larson, M.G. Bengzon, F., 2013, "The Finite Element Method: Theory, Implementation, and Applications", Springer Heidelberg, New York.

References

1 Seshu, P. 2012,"Textbook of Finite Element Analysis", Prentice Hall of India Learning Private Limited, New Delhi.

2 Reddy, J.N. 2006, "An Introduction to the Finite Element Method", 3rd Edition, Mc-Graw Hill, New York.

3 Johnson, C., 1987, "Numerical solution of partial differential equations by the Finite Element Method", Cambridge University Press, New York.

4 Mazumder, S., 2016, "Numerical Methods for Partial Differential Equations: Finite Difference and Finite Volume Methods", Academic Press, UK.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A4CB	**MECHANICS**	**CORE**	**4**	**1**	**-**	**4**

PREAMBLE

This course has been designed for students to learn and understand

- the students should have understood the concepts of Lagrange's Equations
- the concepts of Hamilton's Equations
- the concept of Jacobi's theory

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	learn about the mechanical system and its basic characteristics	K2
CO2	solving the mechanical problems using Lagrange's equations	K2
CO3	understand the concept of Hamilton's equations and its applications	K3
CO4	learn about Jacobi's theory on systems and its applications	K5
CO5	applying canonical transformations for generating functions	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	M	S	S	S
CO2	S	M	S	S	S
CO3	S	S	S	S	S
CO4	S	S	S	M	S
CO5	S	S	S	S	S

S **Strong** **M** **Medium** **L** **Low**

192MT2A4CB	MECHANICS	SEMESTER IV

Total Credits: 4

Total Instruction Hours: 60 h

Syllabus

Unit I Introductory concepts 13 h

The mechanical system – generalized coordinates – constraints – virtual work – energy and momentum.

Unit II Lagrange's equations 11 h

Derivations of Lagrange's equations - examples – Integrals of the motion.

Unit III Hamilton's equations 12 h

Hamilton's principle – Hamilton's equations.

Unit IV Hamilton-Jacobi theory 11 h

Hamilton's principal function – Hamilton-Jacobi equation – separability.

Unit V Canonical transformations 13 h

Differential forms and generating functions – Lagrange and Poisson brackets.

Text Books

1 Donald T. Greenwood, 1977, "Classical Dynamics", Dover Publication, New York.

References

1 Herbert Goldstein, 2001, "Classical Mechanics", Narosa Publishing house, New Delhi.

2 Sankara Rao, 2000, "Classical Mechanics", PHI Learning Private Limited, New Delhi.

3 Mondal C.R., 2008, "Classical Mechanics", Prentice Hall of India, New Delhi.

4 Tiwari R.N, Thakur B.S., 2008, "Classical Mechanics Analytical Dynamics", Prentice Hall of India, New Delhi.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A4DA	ACTUARIAL MATHEMATICS	DSE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- the Mathematical theories applied in life insurance
- the way of constructing a life table
- the concept of multiple decrement theory and its applications

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	explain the basic terminologies in life insurance	K2
CO2	compute the premium to be payable for different forms of policies	K3
CO3	construct the approximations in life tables based on force of mortality	K4
CO4	explain the concept of multiple decrement theory in insurance and annuities	K4
CO5	estimate the premiums and annuities with the support of spreadsheets	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	M	S	M	S	S
CO2	M	S	S	S	S
CO3	S	S	S	S	S
CO4	S	S	S	S	S
CO5	S	M	S	M	S

S **Strong** **M** **Medium** **L** **Low**

192MT2A4DA	ACTUARIAL MATHEMATICS	SEMESTER IV

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Life table and Life annuities 10 h

Probabilities - constructing the life tables -Life expectancy - a simple table - annuity premium - interest and survivorship discount function - deferred annuities - spreadsheet calculations

Unit II Life Insurance and Annuity reserves 10 h

Life insurance premium - types - combined insurance - general insurance - annuity identity - spreadsheet calculation - introduction to reserves - Recursion - analysis of insurance contract - Nonforfeiture values - premium difference and paid-up-formulas - spreadsheet applications.

Unit III Fractional duration and continuous payments 10 h

Introduction - Life annuities paid monthly - Immediate annuities - approximationa and computation - Fractional period premiums and reserves - force of discount - Continous life annuities - force of mortality - insurace payable at the moment of death - premium and reserves - Differential equation for reserves - examples - approximations in the life table.

Unit IV Multiple-life contracts 09 h

The joint life status - joint life annuities and insurance - last survivor annuities and insurance - Moment of death insurance - general two-life annuity and insurance contract - contingent insurance - duration problems - application to annuity credit risk - spreadsheet application.

Unit V Multiple-decrement theory 09 h

Basic model - insurances - model from the force of decrement - analogy with joint life statuses - A machine analogy - Associated single-decrement tables.

Text Books

1 David Promislow. S, 2015, "Fundamentals of Actuarial Mathematics ", John Wiley & sons, New Delhi.

References

1 Dickson. D.C.M, Herby. M.R and Waters. H.R, 2010, “Actuarial Mathematics for Life Contingent Risks”, Cambridge University Press, New York.

2 Hossack. I.B , Polard.J.H and Zehnwirth, 1999, “Introductory Statistics with Applications in General Insurance”, Cambridge University Press, Cambridge.

3 Jozef Teugels and Bjørn Sundt, 2006, “Encyclopedia of Actuarial Science”, John Wiley & Sons, England.

4 Foundations of Actuarial Science, 2012, “Insurance Institute of India”, New Delhi.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A4DB	NONLINEAR ORDINARY DIFFERENTIAL EQUATIONS	DSE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- the foundation for topics in non - linear ordinary differential equations.
- to develop clear thinking and analyzing capacity for advanced research.
- the concept of existence of periodic solution.

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	understand the general plane and solution of a linear autonomous plane systems	K1
CO2	find the periodic solutions using averaging methods	K2
CO3	Solvenon-autonomous system with perturbation method	K3
CO4	use Liapunov stability to solve the plane autonomous linear systems	K4
CO5	demonstrate knowledge of the theory and application of Poincare and find the periodic solutions	K4

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	M	S	S	S
CO2	S	M	S	S	M
CO3	S	S	S	S	S
CO4	S	S	S	M	S
CO5	S	S	M	S	S

S Strong M Medium L Low

192MT2A4DB	NONLINEAR ORDINARY DIFFERENTIAL EQUATIONS	SEMESTER IV

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Plane autonomous systems and linearization 10 h

The general phase plane – some population models – linear approximation at equilibrium points – The general solution of a linear autonomous plane systems.

Unit II Periodic solutions; Averaging Methods 10 h

An energy-balance method for limit cycles – Amplitude and frequency estimates: polar coordinates – An averaging method for spiral phase paths - Periodic solutions: harmonic balance – The equivalent linear equation by harmonic balance.

Unit III Perturbation Methods 10 h

Non-Autonomous System: forced oscillations – The direct perturbation method for the undamped Duffing's equation – Forced oscillations far from resonance - Forced oscillations near resonance with weak excitation – Amplitude – phase perturbation for the pendulum equation – Periodic solutions of autonomous equations(Lindstedt's method) – The perturbation method and Fourier series.

Unit IV Stability 9 h

Poincare stability –Paths and solution curves for general systems – Stability of time solutions: Liapunov stability - Liapunov stability of plane autonomous linear systems - Stability and boundedness for linear systems - Stability of linear system with constant coefficients.

Unit V The existence of periodic solutions 9 h

The Poincare - Bendixson theorem and periodic solutions - A theorem on the existence of a centre - A theorem on the existence of a limit cycle - Van der Pol's equation with large parameter.

Text Books

1 Jordan D.W. and Smith P., 2007 "Nonlinear Ordinary Differential Equations", Fourth Edition, Oxford: Clarendon Press, New York.

References

1 Simmons G.F., 1979, "Differential Equations", Tata McGraw-Hill, New Delhi.

2 Sanchez D.A., 1968, "Ordinary Differential Equations and Stability Theory", Dover, New York.

3 Aggarwal J.K., 1972, "Notes on Nonlinear Systems", Van Nostrand Reinhold Co., New York.

4 Sachdev P.L., 1990, "Nonlinear Ordinary Differential Equations and Their Applications", CRC press, United States.

Course Code	Course Name	Category	L	T	P	Credit
192MT2A4DC	COMPUTATIONAL FLUID DYNAMICS	DSE	4	-	-	4

PREAMBLE

This course has been designed for students to learn and understand

- the basics concepts of computational fluid dynamics.
- the modeling of turbulent flows and its governing equations.
- to solve diffusion equations by finite volume method.

COURSE OUTCOMES

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

CO Number	CO Statement	Knowledge Level
CO1	learn the basic concepts of computational fluid dynamics	K1
CO2	solve the governing equations of fluid flow	K2
CO3	know the effect of laminar and turbulence flow in the system	K3
CO4	understand the concept of finite volume method	K4
CO5	solve the convection - diffusion problems by various scheme	K5

MAPPING WITH PROGRAMME OUTCOMES

COs/POs	PO1	PO2	PO3	PO4	PO5
CO1	S	S	S	S	S
CO2	S	S	S	S	S
CO3	S	S	S	S	S
CO4	S	S	S	S	S
CO5	S	S	S	S	S

S Strong M Medium L Low

192MT2A4DC	COMPUTATIONAL FLUID DYNAMICS	SEMESTER IV

Total Credits: 4

Total Instruction Hours: 48 h

Syllabus

Unit I Introduction to CFD 9 h

CFD– Workingof CFD code– Problem solving with CFD. Conservation laws of fluid motion and boundary conditions: Governing equations of fluid flow and heat transfer – Equations of state – Navier-Stokes equations for a Newtonian fluid.

Unit II Conservation laws of Fluid Motion and Boundary Conditions 9 h

Conservation form of the governing equations of fluid flow – Differential and integral forms of the general transport equations – Classification of physical behaviours- The role of characteristics hyperbolic equations – Classification method for simple PDE's – Classification of fluid flow equations – Problems in transonic and supersonic compressible flows.

Unit III Turbulence and its Modeling 10 h

Definition of turbulence – Transition from laminar to turbulent flow – Descriptors of turbulent flow – Characteristics of simple turbulent flows – The effect of turbulent fluctuations on properties of the mean flow – Turbulent flow calculations – Reynolds-averaged Navier-Stokes equations and classical turbulence models.

Unit IV Finite Volume Method 10 h

Introduction – Finite volume method for one-dimensional steady state diffusion – Worked examples: one-dimensional steady state diffusion – Finite volume method for two-dimensional diffusion problems – Finite volume method for three-dimensional diffusion problems.

Unit V Finite Volume Method for Convection-Diffusion Problems 10 h

Introduction – Steady one-dimensional convection and diffusion – The central differencing schemes – Properties of discretisation schemes – Assessment of the central differencing scheme for convection-diffusion problems – The upwind difference scheme – The hybrid differencing scheme – The power-law scheme.

Text Books

1 Versteeg H.K. and MalalasekaraW., 2007, "An Introduction to Computational Fluid Dynamics", Second Edition, Pearson India Educational Service Private Limited, India.

References

1 Atul Sharma, 2016, "Introduction to Computational Fluid Dynamics: Development, Application and Analysis", John Wiley & Sons Ltd., United Kingdom.

2 John Anderson, 1995, "Computational fluid dynamics: the basics with applications", McGraw-Hill, New Delhi.

3 Chung T.J., 2010, "Computational Fluid Dynamics", 2nd Edition. Cambridge University Press, England

4 Jiyuan Tu, Guan-Heng Yeoh, Chaoqun Liu., 2018, "Computational Fluid Dynamics: A Practical Approach", Butterworth-Heinemann, United States.

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