SACRED HEART COLLEGE (AUTONOMOUS)

Ready for
Every Good Work

Tirupattur – 635 601, Tamil Nadu, S.India

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A Don Bosco Institution of Higher Education, Founded in 1951 * Affiliated to Thiruvalluvar University, Vellore * Autonomous since 1987

Accredited by NAAC (4th Cycle – under RAF) with CGPA of 3.31 / 4 at 'A+' Grade

PG & Research Department of Mathematics

Sacred Heart College (Autonomous),

Tirupattur, Vellore District - 635 601

Affiliated to Thiruvalluvar University, Vellore

Accredited by NAAC (4th Cycle − under RAF) with

CGPA of 3.31/4 at 'A+' Grade

PG Programme (Mathematics)

2021-22 onwards

OUTCOME-BASED EDUCATION (OBE)
LEARNING OUTCOME-BASED CURRICULUM FRAMEWORK (LOCF)

OBE is an educational theory that bases each part of an educational system around goals (outcomes). By the end of the educational experience, each student should have achieved the goal. There is no single specified style of teaching or assessment in OBE; instead, classes, opportunities and assessments should all help the students achieve the specific outcomes

Outcome Based Education, as the name suggests depends on Outcomes and not Inputs. The outcomes in OBE are expected to be measurable. In fact each Educational Institute can state its own outcomes. The ultimate goal is to ensure that there is a correlation between education and employability

Outcome –Based Education (OBE): is a student-centric teaching and learning methodology in which the course delivery, assessment are planned to achieve, stated objectives and outcomes. It focuses on measuring student performance i.e. outcomes at different levels.

Some important aspects of the Outcome Based Education

Course: is defined as a theory, practical or theory cum practical subject studied in a semester.

Course Outcomes (COs): are statements that describe significant and essential learning that learners have achieved, and can reliably demonstrate at the end of a course. Generally three or more course outcomes may be specified for each course based on its weightage.

Programme: is defined as the specialization or discipline of a Degree.

Programme Outcomes (POs): Programme outcomes are narrower statements that describe what students are expected to be able to do by the time of graduation. POs are expected to be aligned closely with Graduate Attributes.

Programme Specific Outcomes (PSOs):

PSOs are what the students should be able to do at the time of graduation with reference to a specific discipline.

Programme Educational Objectives (PEOs): The PEOs of a programme are the statements that describe the expected achievement of graduates in their career, and also in particular, what the graduates are expected to perform and achieve during the first few years after Graduation.

Programme Outcomes at SHC

Programme Outcomes at Postgraduate Level

Postgraduates will be able to:

PO1: Demonstrate intense knowledge in their discipline

PO2: Exhibit specialized skills to plan, analyze and draw conclusions related to their respective field of study in theory and in practice

PO3: Develop expertise in their field of study through projects and research activities

PO4: Prepare themselves to incorporate new technologies in their own discipline and demonstrate excellence in their area of specialization

PO5: Develop social and ethical responsibility in the transfer and management of knowledge

Programme Outcomes at Research Level

Research scholars will be able to:

PO1: Develop and demonstrate deep knowledge in the field of study to become globally competent

PO2: Manage information, undertake investigations, conduct field study, do accurate document, network with experts and mobilize resources and skills

PO3: Develop and exhibit scientific temper and adopt professional code of conduct in pursuit of research activities

Programme Specific Outcome

Mathematics Majors should:

PSO 1: Apply the knowledge of mathematical concepts in interdisciplinary fields. Understand the nature of abstract mathematics and explore the concepts in further details.

PSO 2: Identify challenging problems in mathematics and find appropriate solutions.

PSO 3: Pursue research in challenging areas of pure/applied mathematics. Employ confidently the knowledge of mathematical software and tools for treating the complex mathematical problems and scientific investigations.

PSO 4: Comprehend and write effective reports and design documentation related to mathematical research and literature, make effective presentations. Qualify national level tests like NET/GATE etc.

PSO5: Effectively communicate and explore ideas of mathematics for propagation of knowledge and popularization of mathematics in society.

PG and Research Department of Mathematics

Proposed Internal Components
For the Batch 2021 – 22

Post Graduate Programme		
Components		**Marks**
I CA		15
II CA		15
MCQ – 40 questions- offline/online – 60 minutes	40	10
Seminar	15	5
Problem solving Session	15	5
Total		**50**

Pattern of CA Question Paper (PG)

Section A	
Answer ALL the Questions	6 × 2 = 12 Marks
Section B	
Answer ALL Questions Either or Type	3 × 6 = 18 Marks
Section C	
Answer ANY TWO Questions Out of Three Questions	2 × 10 = 20 Marks

Pattern of Semester Question Paper (PG)

Section A	
Answer ALL the Questions	10 × 2 = 20 Marks
Section B	
Answer ALL Questions Either or Type	5 × 7 = 35 Marks
Section C	
Answer ANY THREE Questions Out of FIVE Questions	3 × 15 = 45 Marks

Total Marks for Each Course is

Continuous Internal Assessment 50 Marks + End Semester Examination 50 Marks

Total = 100 Marks

Question paper Pattern for Skill Enhancement Courses:

Continuous Internal Assessment : 60 MCQ questions -Each question carries 1 marks

(60 Marks Converted to 15 marks for CA Test Components)

End Semester Examination : 90 MCQ questions -Each question carries 1 marks (90 Marks Converted to 50 marks for End Semester Examinations)

PG & Research Department of Mathematics, Sacred Heart College (Autonomous), Tirupattur – 635 601

Sem	Course Code	Course Title	Type	Hrs/ Week	Credits	Marks		
						Int	SE	Total
I	M745	Abstract Algebra	MC	6	5	50	50	100
	M746	Real Analysis	MC	6	5	50	50	100
	M747	Ordinary Differential Equations	MC	6	5	50	50	100
	M748	Mathematical Statistics	MC	6	5	50	50	100
	M749A M749B M749C	A1. Differential Geometry -A2. Skill Enhancement Course I – Algebra A3. Coding Theory	ME	6	3	50	50	100
	Total			30	23	250	250	500
II	M848	Advanced Linear Algebra	MC	6	5	50	50	100
	M849	Partial Differential Equations	MC	6	5	50	50	100
	M850	Advanced Graph Theory	MC	6	5	50	50	100
	M851	Classical Dynamics	MC	6	5	50	50	100
	M852A M852B M852C	B1. Mathematical Models in Biology B2. Skill Enhancement Course II – Linear Algebra B3. Numerical Analysis	ME	6	3	50	50	100
	Total			30	23	250	250	500
III	M953	Mathematical Analysis	MC	6	5	50	50	100
	M954	Topology	MC	6	5	50	50	100
	M955	Optimization Techniques	MC	6	5	50	50	100
	M956	Fluid Dynamics	MC	6	5	50	50	100
	M957A M957B M957C	C1. Nonlinear Dynamical Systems C2. Skill Enhancement Course III – Real Analysis C3. Mathematical Physics	ME	6	3	50	50	100
	Total			30	23	250	250	500
IV	M1049	Complex Function Theory	MC	6	5	50	50	100
	M1050	Functional Analysis	MC	6	5	50	50	100
	M1051	Difference Equations	MC	5	4	50	50	100
	M1052A M1052B M1052C	D1. Stochastic Processes D2. Skill Enhancement Course IV – Complex Analysis D3. Theory of Transforms	ME	5	3	50	50	100
	VE10XX	Human Rights		2	1	50	50	100
	M1053J	Project	MC	6	3	20	80	100
	Total			30	21	270	330	600

	Grand Total		**120**	**90 +10***	**1020**	**1080**	**2100**

Programme structure for M.Sc., Mathematics under new CBCS with effect from 2021– 2022

Semester	**II**	**III**	**IV**	**Credits**
Title of the Certificate Course	M8XXX - R Language for Statistics	M9XXX - LaTeX for Mathematics	M10XXX - Comprehensive Algebra	**$2^{*}+2^{*}+2^{*}$**
Title of Self Study Course	M8XXX - Formal Languages and Automata	-	-	**2^{*}**
MOOC Courses	MOOC Courses are approved by the Department of Mathematics			Number of Credits awarded as per the recommendation of NPTEL
One Research Article Publication	Approved by UGC/Thiruvalluvar University/Scopus/WOS /Anna University Annexure Journals			**2^{*}**

**Subject to the maximum of additional 10 credits

Additional Credits for various other Post graduate programmes

M9XXX - Mathematics for Competitive Examinations – I (**IDC**) : 2^{*} Credits

M10XXX - Mathematics for Competitive Examinations – II (**IDC**) : 2^{*} Credit.

Knowledge levels for assessment of Outcomes based on Blooms Taxonomy

S.No.	Level	Parameter	Description
1.	K1	Knowledge/Remembering	It is the ability to remember the previously learned.
2.	K2	Comprehension/Understanding	The learner explains ideas or concepts.
3.	K3	Application/Applying	The learner uses information in a new way.
4.	K4	Analysis/Analysing	The learner distinguishes among different
5.	K5	Evaluation/Evaluating	The learner justifies a stand or decision
6.	K6	Synthesis/Creating	The learner creates a new product or point of view.

Semester – I **Hours/Week: 6**
Code: M745 **Credits: 5**

ABSTRACT ALGEBRA

Objectives: To study the transformations, Extension Fields and algebraic extensions, Finite Fields and Sylow's theorems, Finite Simple groups, Symmetry groups and Cayley digraphs of groups and Galois Theory in Vector Space.

Unit – I: Extension Fields and Algebraic Extensions
The Fundamental Theorem of Field Theory - Splitting Fields - Zeros of an Irreducible Polynomial - Characterization of Extensions – Finite Extensions - Properties of Algebraic Extensions.
(Chapters 20, 21)

Unit – II: Finite Fields and Class Equation
Classification of Finite Fields - Structure of Finite Fields - Subfields of a Finite Field - Conjugacy Classes - The Class Equation - The Probability That Two Elements Commute.
(Chapter 22, Chapter 24 (pages 395-397 only))

Unit – III: Sylow's Theorems and Finite Simple Groups
The Sylow's Theorems - Applications of Sylow's Theorems - Historical Background - Non-Simplicity Tests - The Simplicity of A_5.
(Chapter 24 (pages 398-407 only), Chapter 25)

Unit – IV: Generators and Relations and Cayley Digraphs of Groups
Definitions and Notation – Free Group - Generators and Relations - The Cayley Digraph of a Group - Hamiltonian Circuits and Paths - Some Applications.
(Chapter 26 (pages 434- 441 only), Chapter 30).

Unit – V: Galois Theory
Fundamental Theorem of Galois Theory - Solvability of Polynomials by Radicals - Insolvability of a Quintic.
(Chapter 32)

Book for Study

1. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa, 1999.

Books for Reference

1. George E Andrews, *Number Theory*, Hindustan Publishing Corporation, 1984.
2. I. N. Herstein, *Topics in Algebra*, John Wiley and sons, 2-e, New Delhi, 2006.
3. John B. Fraleigh, *A First Course in Abstract Algebra*, 7-e, Pearson Education Publication, New Delhi 2003.
4. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
5. S. Arumugam and A. Thandapani, *Modern Algebra*, SciTech Publications Pvt. Ltd.
6. Saunders Maclane and Garrett Birkoff, *Algebra*, 2-e, Macmillan Publishing Co.inc, New York, 1979.
7. Serge Lang, *Algebra*, Addition Wesley Publishing Company, London 1965.
8. Surjeeth Singh and QuaziZameeruddin, *Modern Algebra*, 2-e, Vikas Publishing House Pvt. Ltd., New Delhi, 1975.

Course Learning Outcomes

This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	prove theorems applying algebraic ways of thinking.	K3, K5
CO2	connect groups with graphs and understanding about Hamiltonian graphs.	K4
CO3	compose clear and accurate proofs using the concepts of Galois Theory.	K6
CO4	bringout insight into Abstract Algebra with focus on axiomatic theories.	K1
CO5	demonstrate knowledge and understanding of fundamental concepts including extension fields, Algebraic extension, Finite fields, Class equations and Sylow's theorem.	K2

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	2	3	2	3	3	2	3	2	2.6
2	3	3	2	2	3	3	3	3	2	2	2.6
3	3	3	3	3	2	3	3	2	3	2	2.7
4	3	3	3	3	2	3	3	3	2	1	2.6
5	3	3	3	2	2	3	3	3	3	2	2.7
Mean Overall Score											2.64
Result											High

E-Learning source: https://cosmolearning.org/courses/abstract-algebra/

Semester – I **Hours/Week : 6**
Code: M746 **Credits : 5**

REAL ANALYSIS

Objective: To study the real number system, Functions of Bounded Variation and Rectifiable, Riemann–Stieltjes integral, Lebesgue Integral and Square Space.

Unit – I: Functions of Bounded Variation and Rectifiable Curves

Properties of monotonic functions – Functions of bounded variation – Total variation – Additive property of total variation – Total variation on [a,b] as a function of x – Functions of bounded variation expressed as the difference of increasing functions – Continuous functions of bounded variation – Curves and paths – Rectifiable paths and arc length – Additive and continuity properties of arc length – Equivalence of paths. Change of parameter. (Chapter: 6 Sec 6.2 to 6.12)

Unit – II: Riemann–Stieltjes integral

The definition of the Riemann-Stieltjes integral – Linear properties – Integration by parts – Change of variable in a Riemann–Stieltjes integral – Reduction to a Riemann integral – Step functions as integrators – Reduction of a Riemann-Stieltjes integral to a finite sum – Euler's summation formula – Monotonically increasing integrators – Upper and lower integrals – Additive and linearity properties of upper and lower integrals – Riemann's condition – Comparison theorems.
(Chapter 7: Sec 7.3 to 7.14)

Unit – III: Riemann–Stieltjes integral (contd.)

Integrators of bounded variation – Sufficient conditions for existence of Riemann-Stieltjes integrals – Necessary conditions for existence of Riemann-Stieltjes integrals – Mean Value Theorems for Riemann–Stieltjes integrals – The integral as a function of the interval – Second fundamental theorem of integral calculus – Change of variable in a Riemann integral – Second Mean–Value Theorem for Riemann integrals – Riemann-Stieltjes integrals depending on a parameter – Differentiation under the integral sign – Interchanging the order of integration. (Chapter: 7 Sec 7.15 to 7.25)

Unit – IV: Lebesgue Integral

The integral of a step function – Monotonic sequences of step functions – Upper functions and their integrals – Riemann-Integrable functions as examples of upper functions – The class of Lebesgue–Integrable functions on a general interval – Basic properties of the Lebesgue integral – Lebesgue integration and sets of measure zero – The Levi monotone convergence theorems. (Chapter: 10 Sec 10.2 to 10.9)

Unit – V: Lebesgue Square Space

Lebesgue integrals on unbounded intervals as limits of integrals on bounded intervals – Improper Riemann integrals – Measurable functions – Continuity of functions defined by Lebesgue integrals – Differentiation under the integral sign – Inner products and norms – The set $L^2(I)$ of square–integrable functions – The set $L^2(I)$ as a semi-metric space – A convergence theorem for series of functions in $L^2(I)$ – The Riesz-Fischer theorem.
(Chapter 10: Sec 10.12 to 10.16, 10.21 to 10.25)

Book for Study

1. Tom M. Apostol, *Mathematical Analysis*, Indian student second edition, Narosa Publishing House, Chennai, 20th reprint, 2002.

Books for Reference

1. E. Fischer, *Intermediate Real Analysis*, Springer Verlag, 1983.
2. P.N. Arora and Ranjit Singh, *First course in Real Analysis*, Third edition, Sultan Chand and Sons Publishers, New Delhi, 1981.
3. Richard R. Goldberg, *Methods of Real Analysis*, Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi, 1970.
4. Robert G. Bartle and Donald R. Sherbert, *Introduction to Real Analysis*, by 2-e John Wiley and Sons, 2000.
5. S. Arumugam, *Modern Analysis*, New Gamma Publishers, Palayamkottai, 1993.

Course Learning Outcomes

This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	analyze and evaluate functions of bounded variation and Rectifiable Curves.	K4, K5
CO2	describe the concept of Riemann–Stieltjes integral and its properties.	K1
CO3	demonstrate the concept of step function, upper function, Lebesgue function and their integrals.	K2
CO4	construct various mathematical proofs using the properties of Lebesgue integrals and establish the Levi monotone convergence theorem.	K3
CO5	formulate the concept and properties of inner products, norms and measurable functions.	K6

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	2	3	2	1	0	1	2	3	2	1	1.7
2	1	2	1	3	0	3	1	2	3	2	1.8
3	3	3	3	2	1	2	2	3	1	2	2.2
4	2	3	3	3	1	1	3	3	2	2	2.3
5	1	2	2	2	3	3	1	2	3	3	2.2
										Mean Overall Score	2.04
										Result	High

E-Learning source: https://ocw.mit.edu/courses/mathematics/18-100a-introduction-to-analysis-fall-2012/

Semester – I **Hours/Week: 6**
Code: M747 **Credits: 5**

ORDINARY DIFFERENTIAL EQUATIONS

Objective: To study the Differential equation of higher order, to find the power series solution of special type of Differential equations, to solve the system of linear Differential equations, to study existence and uniqueness of the solutions, boundary value problems.

Unit– I: Linear Differential Equations of Higher order
Linear Dependence and Wronskian– Basic Theory for Linear Equations – Method of Variation of Parameters – Two Useful Formulae– Homogeneous Linear Equations with Constant Co-efficients.
(Chapter 2, Sections: 2.2 to 2.6)

Unit – II: Solutions in Power Series
Introduction – Second Order Linear Equations with Ordinary Points – Legendre Equation and Legendre Polynomials – Second Order Equations with Regular Singular Points [up to example 3.9, Bessel function of first kind] – Bessel Equation.
(Chapter 3, Sections: 3.1 to 3.5)

Unit– III: Systems of Linear Differential Equations
Introduction – Systems of First Order Equations – Existence and Uniqueness Theorem – Fundamental Matrix – Non-homogeneous Linear Systems – Linear Systems with Constant Coefficients.
(Chapter4, Sections: 4.1 to 4.6)

Unit– IV: Existence and Uniqueness of Solutions
Preliminaries – Successive Approximations – Picard's theorem – Non-uniqueness of Solutions – Continuation and Dependence on Initial Conditions.
(Chapter5, Sections: 5.2 to 5.6)

Unit–V: Boundary Value Problems
Introduction – Sturm– Liouville Problem – Green's Functions.
(Chapter 7, Sections: 7.1 to 7.3)

Book for Study

1. S.G.Deoand V. Raghavendra, *Ordinary Differential Equations and Stability theory*, Tata McGraw Hill Publishing Company, New Delhi, 1980, Seventh Reprint 1993.

Books for Reference

1. D. Raj, D. P. Choudary and H. I. Freedan, *A Course in Ordinary Differential Equations*, Narosa Publishing House, Chennai, 2004.
2. D. Somasundaram, *Ordinary Differential Equations*, Narosa Publishing House, Chennai, 2002.
3. Ean A. Coddington, *An Introduction to ODE*, Prentice Hall of India Pvt., Ltd, New
4. Delhi.1992
5. G. F. Simmons, *Differential Equations*, S. Chand and Company Ltd, New Delhi, 1974
6. M. D. Rasingania, *Advanced Differential Equations*, 4-e, Tata McGraw Hill Publishing Company, New Delhi, 1995.

7. M. Rana Mohan Rao, *Ordinary Differential Equations Theory and Applications*, Affiliate East – West Press Private Ltd, Chennai, 1935.

Course Learning Outcomes

This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	establish the qualitative behavior of solutions of systems of differential equations.	K3
CO2	recognize the physical phenomena modeled by differential equations and dynamical systems.	K1
CO3	analyze solutions using appropriate methods and give examples.	K2, K4
CO4	formulate Green's function for boundary value problems.	K6
CO5	Understand and use various theoretical ideas and results that underlie the mathematics in this course.	K5

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	3	2	2	3	3	3	2	2	2.6
2	2	3	2	2	2	2	3	3	1	2	2.2
3	2	3	3	1	2	3	3	3	2	3	2.5
4	1	2	2	3	1	2	2	3	3	2	2.1
5	3	2	2	2	2	3	2	2	2	3	2.3
Mean Overall Score											**2.34**
Result											**High**

E–Learning source: http://nptel.ac.in/courses/111104031/
https://ocw.mit.edu/courses/mathematics/18-03-differential-equations-spring-2010/

Semester – I **Hours/week: 6**
Code: M748 **Credits: 5**

MATHEMATICAL STATISTICS

Objective: To study and apply sampling theory, significance tests, estimation, testing of hypothesis and design of experiments.

Unit– I: Sampling and Sampling Distributions
Sampling – Sample mean – Sampling from the normal distributions.
(Book 1: Chapter 6, Sections: 6.2 to 6.4)

Unit– II: Parametric Point Estimation
Methods of finding Estimators – Properties of Point Estimators – Sufficiency – Unbiased estimation.
(Book 1: Chapter 7, Sections: 7.2 to 7.5)

Unit– III: Parametric Point and Interval Estimation
Baye's estimators – Confidence intervals – Sampling from the normal distribution – Methods of finding confidence intervals–Large sample confidence intervals – Bayesian Interval Estimates.
(Book 1: Chapter 7, Section: 7.7; Chapter8, Sections: 8.2 to 8.6)

Unit–IV: Tests of Hypotheses
Test of hypotheses – Sampling from the normal distribution – Chi-square Tests –Test of Hypotheses and Confidence Intervals.
(Book 1: Chapter 9,Sections: 9.4 to 9.6)

Unit– V: Design of Experiments
Aim of the Design of experiments - Basic Principles of Experimental Design - Some Basic Designs of Experiments - Analysis of variance - Comparison of RBD and LSD - Examples. (Book 2: Chapter 10: pages 10.1 to 10.25)

Books for Study

1. Alexander M. Mood, Franklin, A. Graybilland Duane C. Boes, *Introduction to the Theory of Statistics*, John Wiley and Sons, 3-e, 1974.
2. Veerarajan T, Probability, Statistics and Random Processes, 3rd Edition – Tata McGraw-Hill, 2012.

Books for Reference

1. Ruma Falk, *Understanding Probability and Statistics: A Book of Problems*, A K Peters/CRC Press, 1997.
2. Marek Fisz, *Probability and Mathematical statistics*, Krieger Publishing Company; 3 edition, 1980.
3. Paul G. Hoel, *Introduction to Mathematical Statistics*, 5-e, Wiley, 1984.
4. Simmons and Schuster, *Probability Statistics and Random Process*, 1971.
5. S. P. Gupta & M. P. Gupta, *Business Statistics*, 14th enlarged edition, Sultan Chand and sons, educational publishers, New Delhi, reprint 2007.
6. S. S. Wilks, *Mathematical Statistics*, John Wiley and Sons, 1967.

7. Vijay K. Rohatgi, *An Introduction to Probability Theory and Mathematical Statistics* (Wiley Series in Probability and Statistics), Wiley-Blackwell, 1976.

Course Learning Outcomes

This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	understand Sampling and Sampling distributions.	K2
CO2	illustrate the methods of finding Estimators	K2
CO3	determine Parametric point and Interval Estimation.	K3
CO4	perform hypothesis testing , justify hypothesis testing to Sampling problems and to determine confidence Intervals.	K3, K4, K6
CO5	define the basic terms used in design of experiments and use appropriate experimental designs to analyze the experimental data.	K1, K5

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	3	2	2	3	3	3	3	2	2.7
2	3	3	3	3	1	3	3	3	3	2	2.7
3	3	3	3	3	2	3	3	3	3	1	2.7
4	3	3	3	3	2	3	3	3	3	1	2.7
5	3	3	3	3	1	3	3	3	2	2	2.6
										Mean Overall Score	**2.68**
										Result	**High**

E–Learning source: https://ocw.mit.edu/courses/mathematics/18-655-mathematical-statistics-spring-2016/index.htm
http://www.math.uah.edu/stat/

Semester – I **Hours/Week: 6**
Code: M749A (Elective) **Credits : 3**

DIFFERENTIAL GEOMETRY

Objective: This course introduces space curves and their intrinsic properties of a surface and geodesics. Further the non – intrinsic properties of surfaces are explored.

Unit – I: Space curves
Introductory remarks about Space Curves, Definitions – Arc Length – tangent –normal and binormal – curvature and torsion of a curve given as the intersection of two surfaces – contact between curves and surfaces – tangent surface, involutes and Evolutes - Intrinsic equations – fundamental Existence Theorem for space curves- Helices.
(Chapter I, Sections: 1 to 9)

Unit – II: The metric: Local Intrinsic Properties of a Surface
Definition of a surface – curves on a surface– Surface of revolution – Helicoids – Metric – Direction coefficients – Families of curves – Isometric correspondence – Intrinsic Properties. (Chapter II, Sections: 1 to 9)

Unit – III: Geodesics
Geodesics – Canonical geodesic equations – Normal Property of geodesics – Existence Theorems – Geodesic parallels.
(Chapter II, Sections: 10 to 14)

Unit – IV: Geodesics (contd.)
Geodesics curvature – Gauss – Bonnet Theorem – Gaussian curvature – surface of constant curvature.
(Chapter II, Sections: 15 to 18)

Unit – V: The Second Fundamental form: Local non-intrinsic Properties of a Surface
The Second fundamental form – Principal Curvature – Lines of Curvature – Developables- Developables associated with space curves and with curves on surfaces – Minimal surfaces- Ruled surfaces.
(Chapter III, Sections: 1 to 8)

Book for Study

1. T.J. Wilmore, *An introduction to Differential Geometry*, Oxford University Press, (17th Impression) New Delhi 2002. (Indian Print).

Books for Reference

1. D. Somasundaram, *Differential Geometry*, Narosa Publication House, Chennai, 2005.
2. J. A. Thorpe, *Elementary topics in Differential Geometry*, Under–Graduate Texts in Mathematics, Springer Verlag 1979.
3. Kobayashi. S. and Nomizu. K., *Foundations of Differential Geometry*, Interscience Publishers, 1963.
4. K. P. Gupta, G. S. Malik, *Differential Geometry*, 3-e, Pragati Prakasam, Meerut, India, 2005.
5. Struik, D. T., *Lectures on Classical Differential Geometry*, Addison – Wesley, Mass.1950.
6. Wilhelm Klingenberg, *A course in Differential Geometry*, Graduate Texts in Mathematics, Springer Verlag 1978.

Course Learning Outcomes

This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	explain space curves, Curves between surfaces, metrics on a surface, fundamental form of a surface and Geodesics.	K2
CO2	evaluate these concepts with related examples.	K5
CO3	compose problems on geodesics	K6
CO4	recognize applicability of developables	K1
CO5	construct and analyze the problems on curvature and minimal surfaces	K3,K4

Mapping of CO with PO and PSO

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CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	3	2	1	3	3	2	2	2	2.4
2	3	3	3	3	1	3	3	2	2	3	2.6
3	3	3	3	3	1	3	3	3	2	2	2.6
4	3	3	3	3	2	3	3	3	2	2	2.6
5	3	3	3	3	1	3	3	3	3	2	2.7
										Mean Overall Score	**2.58**
										Result	**High**

E–Learning source: http://www.math.ku.dk/noter/filer/geom1.pdf

Semester – I **Hours/Week : 6**
Code: M749B (Elective) **Credits : 3**

SKILL ENHANCEMENT COURSE I – ALGEBRA

Objectives:

1. To develop broad and balanced knowledge and understanding of definitions, concepts, theorems and principles.
2. To enhance the ability of learners to apply the knowledge and skills acquired by them during the programme to solve specific theoretical and applied problem in Mathematics.
3. To empower students to crack competitive examinations such as NET, SET and TRB and to complement the theoretical content of the subject with exercise problems.

Unit-I: Finite Group
Introduction to groups – Groups - finite groups – subgroups.
(Chapters 1 to 3 – examples and exercise)

Unit-II: Cyclic and Permutation groups and Isomorphism
Cyclic groups - permutation groups – isomorphism.
(Chapters 4 to 6 – examples and exercise)

Unit-III: Cosets and Direct Products
Cosets and Lagrange's theorem – external direct products - normal subgroups and factor groups.
(Chapters 7 to 9 – examples and exercise)

Unit-IV: Rings and Ideals
Introduction to rings – integral domains – ideals and factor rings.
(Chapters 12 to 14 – examples and exercise)

Unit-V: Ring Homomorphism and Factorization
Ring homomorphism - polynomial rings – factorization of polynomials.
(Chapters 15 to 17 – examples and exercise)

Book for Study

1. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa, 1999.

Books for Reference

1. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
2. S. Arumugam and A. Thandapani, *Modern Algebra*, SciTech Publications Pvt. Ltd.
3. George E Andrews, *Number Theory*, Hindustan Publishing Corporation, 1984.
4. I.N. Herstein, *Topics in Algebra*, John Wiley and Sons, 2-e, New Delhi, 2006.
5. John B. Fraleigh, *A First Course in Abstract Algebra*, 7-e, Pearson Education Publication, New Delhi 2003.
6. Saunders Maclane and Garrett Birkoff, *Algebra*, 2-e, Macmillan Publishing Co.inc, New York, 1979.
7. Serge Lang, *Algebra*, Addition Wesley Publishing Company, London, 1965.
8. Surjeeth Singh and Quazi Zameeruddin, *Modern Algebra,* 2-e, Vikas Publishing House Pvt. Ltd., New Delhi, 1975.

Course Learning Outcomes

This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	disseminate new and innovative knowledge that will make them fit for any competitions in job opportunities.	K5
CO2	apply new tangents or to exercise their knowledge and skill in other disciplines.	K3
CO3	develop, prioritize, demonstrate display, and disseminate newer versions and to interpret in novel ways.	K4, K6
CO4	bringout the flair for new and continuous learning process.	K1
CO5	build the dexterity.	K3

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	2	3	3	3	2	3	3	2	3	3	2.7
2	2	3	3	3	2	3	3	2	3	3	2.7
3	2	3	3	3	2	3	3	2	3	2	2.6
4	2	3	3	3	2	3	3	2	3	2	2.6
5	2	3	3	3	2	3	3	2	3	3	2.7
Mean Overall Score											**2.66**
Result											**High**

E –Learning source: https://ocw.mit.edu/courses/mathematics/18-702-algebra-ii-spring-2011

Semester – I **Hours/Week: 6**
Code: M749C (Elective) **Credits: 3**

Coding Theory

Objectives: To provide students with elementary knowledge of theory of error correcting codes and readable introduction to mathematical aspect of coding.

Unit 1:
Introduction to linear codes and error correcting codes. Encoding and decoding of a linear coe.

Unit 2:
Dual codes. Hamming codes and perfect codes.

Unit 3:
Cyclic codes. Codes with Latin Squares, Introduction to BCH codes.

Unit 4:
Weight enumerators and MDS codes.

Unit 5:
Linear coding theory problems and conclusions.

Books for Study

1. Raymond Hill, *A first course in Coding Theory*, Clarandon Press, Oxford (1986).
2. J.H. Van Lint, *Introduction to Coding Theory*, Springer (1998).

Books for Reference

1. W. Cary Huffman and Versa Pless, *Fundamentals of Error Correcting Codes*, Cambridge University Press (2003).
2. W.W. Peterson, *Error Correcting Codes*, Cambridge, MA MIT Press (1961).
3. V. Pless, W.C. Huffman and R.A. Brualdi, *An Introduction to Algebraic Codes*, in Hand book of coding theory, Eds. Amsterdam Elsevier (1998)

Course Learning Outcomes
This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	describe and justify the concept of linear codes and error correcting codes.	K1, K4
CO2	perform encoding and decoding using linear codes.	K6
CO3	construct and decode BCH code.	K3
CO4	summarize different types of codes.	K2
CO5	solve linear coding theory problems	K3

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	3	3	1	3	3	3	1	2	2.5
2	3	3	3	3	1	3	3	3	1	1	2.4
3	3	3	3	3	1	3	3	3	1	2	2.4
4	3	3	3	2	1	3	3	3	1	2	2.4
5	3	3	3	3	2	3	3	3	1	2	2.3
Mean Overall Score											**2.4**
Result											**High**

E-Learning Sources: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-895-essential-coding-theory-fall-2004/

Semester – II **Hours/Week: 6**
Code: M848 **Credits: 5**

ADVANCED LINEAR ALGEBRA

Objective: To give the students a thorough knowledge of the various aspects of Linear Algebra. To train the students in problem-solving as a preparatory for competitive exam.

Unit – I: Linear transformations
The algebra of linear transformations- Isomorphism – Representations of Transformations by Matrices – Linear Functionals.
(Book – 1, Chapter 3, Sections: 3.2 to 3.5)

Unit – II: Algebras of Polynomials
Algebras - The algebra of polynomials – Lagrange-Interpolation – Polynomial Ideals – The Prime factorization of a polynomial.
(Book – 1, Chapter 4, Sections: 4.1 to 4.5)

Unit – III: Inner Product Spaces
Inner Products and Norms – The Gram – Schmidt Orthogonalization Process and Orthogonal Complements – The Adjoint of a Linear Operator – Normal and Self – Adjoint Operators.
(Book – 2, Chapter 6, Sections: 6.1 to 6.4)

Unit – IV: Orthogonal System
Unitary and Orthogonal Operators and their Matrices - Orthogonal Projections and the Spectral Theorem – Bilinear and quadratic forms.
(Book – 2, Chapter 6, Sections: 6.5, 6.6, 6.8)

Unit – V: Canonical Forms
Jordan Canonical form I – Jordan Canonical form II-The minimal polynomial.
(Book – 2, Chapter 7, Sections: 7.1 to 7.3)

Books for Study

1. Kenneth Hoffman and Ray Alden Kunze, *Linear Algebra*, Second Edition, Prentice Hall of India Private Limited, New Delhi, 2010.
2. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra*, Fourth Edition, Prentice Hall of India Private Limited, New Delhi, 2007.

Books for Reference

1. A. R. Rao, P. Bhimashankaram, *Linear Algebra*, Second Edition, Tata McGraw Hill, 2000.
2. Edgar G. Goodaire, *Linear Algebra-Pure & Applied World Scientific*, Cambridge University Press India Ltd, 2014.
3. I. N. Herstein, *Topics in Algebra*, 2-e, Vikas Publishing House Pvt., Ltd,Chennai-6, 2006.
4. P. P Gupta, S. K. Sharma, *Linear Algebra*, S.Chand and Company Ltd, New Delhi,1982.
5. S. Kumaresan, *Linear Algebra: A Geometric Approach*, Prentice – Hall of India Ltd, 2004.
6. V. Krishnamurthy, V. P. Mainra, J. L. Arora, *Introduction to Linear Algebra*, East West Press Ltd, 1985.

Course Learning Outcomes

This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	understand linear transformations and represent in matrix form.	K2
CO2	compute minimal polynomial and characteristic polynomial of linear transformation.	K3
CO3	find applicability of the inner product spaces.	K5
CO4	outline and formulate the theory of the course to solve variety of problems at an appropriate level of difficulty	K4, K6
CO5	examine bi-linear and Jordan canonical forms.	K1

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	2	3	2	2	2	3	2	2	2.4
2	3	3	2	3	2	1	3	3	2	2	2.4
3	1	1	2	2	1	2	2	3	1	2	1.7
4	2	2	1	2	1	2	2	3	2	2	1.9
5	2	2	1	2	1	2	2	3	2	2	1.9
										Mean Overall Score	**2.06**
										Result	**High**

E –Learning Source: http://nptel.ac.in/courses/111106051/

Semester – II **Hours/week : 6**
Code: M849 **Credits : 5**

PARTIAL DIFFERENTIAL EQUATIONS

Objective: To develop skills in solving partial differential equations.

Unit – I: Partial Differential Equations of First Order
Introduction – Formation of Partial Differential Equation – Solution of Partial Differential Equations of First Order – Charpit's Method.
(Chapter 0, Sections: 0.1, 0.4, 0.5, 0.11)

Unit – II: Fundamental Concepts
Introduction – Classification of second Order PDE – Canonical Forms
(Chapter 1, Sections: 1.1 to 1.3)

Unit – III: Elliptic Differential Equations
Occurrence of the Laplace and Poisson Equations – Boundary Value Problems – Separation of Variables – Dirichlet Problem for a Rectangle – The Neumann Problem for a Rectangle – Interior Dirichlet Problem for a Circle – Exterior Dirichlet Problem for a Circle – Interior Neumann Problem for a Circle.
(Chapter 2,Sections: 2.1, 2.2, 2.5 to 2.10)

Unit – IV: Parabolic Differential Equations
Occurrence of the Diffusion Equation – Boundary Conditions – Elementary Solutions of the Diffusion Equation – Dirac Delta Function – Separation of Variables Method.
(Chapter 3, Sections: 3.1 to 3.5, Omit Examples 3.2 and 3.3)

Unit – V: Hyperbolic Differential Equations
Occurrence of the Wave Equation – Derivation of One – dimensional Wave Equation – Solution of One – dimensional Wave equation by Canonical Reduction – The initial Value Problem; D'Alembert's Solution – Vibrating string – Variables Separable Solution – Forced Vibrations – Solution of Non-homogeneous Equation.
(Chapter 4, Sections: 4.1 to 4.6).

Book for Study

1. K. Sankara Rao, *Introduction to Partial Differential Equations*, 2-e, New Delhi, 2006.

Books for Reference

1. Amarnath. T, *An Elementary Course in Partial Equations*, Narosa Publishing House, 1997.
2. M. D. Raisingania, *Advanced Differential Equations*, 4-e, Tata McGraw Hill Publishing Company, New Delhi, 2001.
3. L.C.Evans, *Partial Differential Equations*, Graduate Studies in Mathematics, Vol.19, AMS, 1998.
4. Erich Miersemann, *Partial Differential Equations*, Lecture Notes, Leipzig University Version October, 2012.
5. Snedon. I. N, *Elements of Partial Differential Equations*, Tata McGraw Hill, New Delhi, 1991.
6. P. Prasad and R. Ravindran, *Partial differential equations*, Wiley Eastern, 1985.

Course Learning Outcomes

This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	recognize the major classification of PDEs and the qualitative differences between the classes of equations.	K1
CO2	demonstrate modeling assumptions and derivations that lead to PDEs.	K2
CO3	be crtically competent in solving linear PDEs using classical solution methods.	K4
CO4	Use knowledge of partial differential equations for modelling the general structure of solutions and using analytic methods for solutions.	K6
CO5	investigate and solve boundary values problems and point out its significance	K3, K5

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	3	1	1	3	1	3	1	1	2
2	3	3	3	2	1	3	3	2	2	1	2.3
3	3	3	3	2	1	3	2	2	2	1	2.2
4	3	3	3	2	1	3	2	2	2	1	2.2
5	1	2	2	1	1	3	3	2	3	1	1.9
Mean Overall Score											2.12
Result											High

E–Learning source: https://ocw.mit.edu/courses/mathematics/18-156-differential-analysis-ii-partial-differential-equations-and-fourier-analysis spring2016/index.htm?utm_source=OCWDept&utm_medium=CarouselSm&utm_campaign=FeaturedCourse

Semester – II **Hours/Week : 6**
Code: M850 **Credits : 5**

ADVANCED GRAPH THEORY

Objective: To understand the concept of graphs, sub graphs, trees, connectivity, Euler tour, Hamilton cycle, matching, colouring of graphs, independent set, cliques, vertex colouring and planar graphs.

Unit – I: Graphs and Sub graphs

Graphs and simple graphs – Graph isomorphism – The Incidence and Adjacency matrices – Sub graphs – Vertex degrees – Paths and connection – Cycles – The shortest path problem. (Chapter 1, Sections: 1.1 to 1.8)

Unit – II: Trees and Connectivity

Trees – Cut edges and Bonds – Cut vertices – Cayley's formula – The connector problem – Connectivity – Blocks.
(Chapter 2,Sections: 2.1 to 2.5 and Chapter 3, Sections: 3.1 to 3.2).

Unit – III: Euler Tours and Hamilton Cycles

Euler tour – Hamilton cycles – The Chinese postman problem – The traveling salesman problem. (Chapter 4, Sections: 4.1 to 4.4)

Unit – IV: Matching, Independent Sets and Cliques

Matchings – Matchings and coverings in bipartite graphs – Perfect matchings – The personal assignment problem – The optimal assignment problem – Independent sets.
(Chapter 5, Sections: 5.1 to 5.5 and Chapter 7, Section: 7.1)

Unit – V: Vertex Colouring and Planar Graphs

Chromatic number – Brook's theorem – Chromatic polynomials – Plane and planar graphs – Dual graphs – Euler's formula – The five colour theorem and the four colour conjecture. (Chapter 8, Sections: 8.1, 8.2, 8.4 and Chapter 9, Sections: 9.1 to 9.3, 9.6)

Book for Study

1. J.A. Bondy & U.S.R. Murty, *Graph theory with application*, Macmillan press, 2011.

Books for Reference

1. K. R. Parthasarthy, *Basic graph theory*, Tata McGraw Hill Company, New Delhi, 1994.
2. P. Harray, *Graph theory*, Narosa Publishing House, New Delhi, 1998.
3. S. Arumugam & S. Ramachandran, *Invitation to graph theory*, SciTech publishing company, 2004.
4. V. K. Balakrishnan, *Graph theory*, Tata McGraw Hill Company, New Delhi, 2004.

Course Learning Outcomes

This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	understand basic concepts in Graph theory .	K2
CO2	apply the understanding and use it to model real life situations.	K3
CO3	apply the concepts of connectivity, Euler and Hamilton cycles in the real life situations.	K4
CO4	identify and develop the applications of planarity and colourability.	K1,K6
CO5	create graph models in network and computing	K5

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	2	2	2	3	2	2	0	1	2
2	3	3	2	2	2	3	3	2	0	1	2.1
3	2	3	2	2	2	3	3	3	0	1	2.1
4	3	3	2	2	2	3	3	3	1	1	2.3
5	3	3	2	2	2	3	3	2	1	1	2.2
Mean Overall Score											2.14
Result											High

E – Learning source: http://cs.bme.hu/fcs/graphtheory.pdf

Semester – II **Hours/Week : 6**
Code: M851 **Credits : 5**

CLASSICAL DYNAMICS

Objective: To study mechanical systems under generalized coordinate, virtual work, energy and momentum, also to study the mechanics developed by Newton, Lagrange, Hamilton and Jacobi.

Unit – I: Mechanical Systems
The mechanical system – Generalized co-ordinates – Configuration space – Constraints – Virtual work – Principle of virtual work – D'Alembert's Principle – Generalized force – Energy – Momentum.
(Chapter 1, Sections: 1.1 to 1.5)

Unit – II: Lagrange's Equations
Derivation of Lagrange's equations – Examples – Integrals of the motion – Ignorable co-ordinates – The Routhian function – Conservative systems – Natural systems.
(Chapter 2, Sections: 2.1 to 2.3)

Unit – III: Hamilton's Equation
Hamilton's principle – Derivation of Hamilton's equations – The Legendre transformation– Modified Hamilton's principle – Principle of least action.
(Chapter 4, Sections: 4.1 to 4.3)

Unit – IV: Hamilton Jacobi Theory
Hamilton's principal function – Pfaffian differential forms – The Hamilton-Jacobi equation – Jacobi's theorem – Separability.
(Chapter 5, Sections: 5.1 to 5.3)

Unit – V: Canonical Transformation
Differential forms and generating functions - Special Transformations - Lagrange and Poisson brackets.
(Chapter 6, Sections: 6.1 to 6.3)

Book for Study

1. Donald T. Greenwood, *Classical Dynamics*, Prentice Hall of India Pvt. Ltd., New Delhi, 1985.

Books for Reference

1. D. E. Rutherford, *Classical Mechanics*, Oliver Boyd, New York, 2000.
2. H. Goldstein, *Classical Mechanics*, Second edition, Narosa Publishing House, New Delhi, 1994.
3. J. L. Synge and B. A Grifth, *Principles of Mechanics*, 3e, McGraw Hill Book Company, New York, 1959.
4. J. L. Synge and P. S. C. Joag, *Classical Mechanics*, Tata McGraw Hill, New Delhi, 1991.
5. P. G. Bergmann, *Introduction to Theory of Relativity*, Prentice Hall of India, Eddington, New Delhi, 1969.

Course Learning Outcomes

This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	demonstrate the knowledge of core principles in mechanics	K2
CO2	interpret and consider complex problems of classical dynamics in a systematic way	K3, K5
CO3	apply the variation principle for real physical situations	K4
CO4	explore different applications of these concepts in the mechanical and electromagnetic fields.	K6
CO5	describe and apply the concept of Angular momentum, Kinetic energy and Moment of inertia of a particle.	K1

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	2	2	2	1	3	3	3	2	1	2.2
2	3	2	2	2	1	3	3	3	2	1	2.2
3	3	3	3	2	1	2	2	3	2	1	2.2
4	3	3	2	2	1	3	3	3	2	1	2.3
5	3	3	2	2	1	3	3	2	2	1	2.2
										Mean Overall Score	2.22
										Result	High

E-Learningsource: https://ocw.mit.edu/courses/physics/8-09-classical-mechanics-iii-fall-2014/

Semester - II **Hours/Week: 6**
Code: M852A (Elective) **Credits: 3**

MATHEMATICAL MODELS IN BIOLOGY

Objective: This Course aims to explore the potential of Mathematical Modeling among the Students and in emphasizing the role of Mathematical Models in Biology and Medicine.

Unit – I: Microbial Population Models
Importance of Microbial Kinetics – Microbial Growth in a Chemostat – Stability of Steady States for Chemostat – Growth of Microbial Populations – Product formation due to Microbial Action.
(Chapter 2, Sections: 2.1- 2.5)

Unit – II: Single-Species Non-Age Structured Population Models
Simple Logistic Models: The Logistic Equation – Physical Basis of Logistic Model – Smith's Model – Generalized Logistic Models – Difference Equation for Logistic Model – Logistic Model for a Non- isolated Population – Logistic Models with Time-Delay Effects: Derivation of the Logistic Equation with Time Delay – Biological Mechanisms Responsible for Time Lags – Solution of the Basic Equation in Two Special Cases.
(Chapter 3, Sections: 3.1, 3.2 (3.2.1 – 3.2.3))

Unit – III: Two-Species Population Models
A Simple Prey-predator Model: Basic Equations for a Simple Prey-Predator Model – The Trajectories – Stability of Equilibrium Positions – Time Averages over a Period – Numerical Illustrations – Some Other Prey-Predator Models: Secular Equation for Determining Stability – A General Prey-predator Model – Predator Not-dependent-on-prey-alone Model.
(Chapter 5, Sections: 5.1, 5.2 (5.2.1 – 5.2.3))

Unit – IV: Multi-Species Population Models
Volterra's Model for n Interacting Species: The Basic System of Equations – Existence of Constant of Motion – Stability of Equilibrium Position – Long-time Averages of Powers and Products of Species Populations – Particular Case of Two Species – Statistical Mechanical Treatment of Voterra's Equations: Liouville's Theorem – Time Averages and Ensemble Averages – Ensemble Averages of Population Sizes of Different Species.
(Chapter 6, Sections: 6.1 (6.1.1 – 6.1.5), 6.2 (6.2.1 – 6.2.3))

Unit – V: Mathematical Models in Pharmacokinetics
Basic Equations and Their Solutions: Compartments – Basic Equations for an n-Compartment System – Solution of the System for a Given Initial Injection – Solution of the system for Repeated Medication –Solution for constant rate of Infusion – Solution for Truncated Infusion – Solutions for Special Cases: Special Case of a Single Compartment – An Example of Two Compartments: Clinical Bromsulphalein Test – A Second Example of a Two-compartment System: Repeated Pencillin Application – Compartment Model for Diabetes Mellitus.
(Chapter 10, Sections: 10.1, 10.2)

Book for Study

1. J.N. Kapur, *Mathematical Models in Biology & Medicine*, East West Press, New Delhi, Reprint 2010.

Books for Reference

1. C. Dyson, Elvery, *Principles of Mathematical Modelling*, Academic Press, New York.
2. D. J. G. James and J. J. Macdonald, *Case studies in Mathematical Modelling*, Stanly Thames, Cheltonham.
3. J. D. Murray, *Mathematical Biology*, Springer International Edition, First Indian Reprint, 2004.
4. M. Cross and A. O. Moscrcadini, *The Art of Mathematical Modelling*, Ellis Harwood and John Wiley.
5. Nicholas F. Britton, *Essential Mathematical Biology*, Springer International Edition, First Indian Reprint, 2004.
6. Pundir - Pundir, *Bio Mathematics*, A Pragati Edition, 2006.

Course Learning Outcomes

This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	describe standard modeling procedures, which involve observations of a natural system, the development of a numeric and or/analytical model.	K1
CO2	analyze the model through analytical and graphical solutions and/or statistical analysis.	K4
CO3	distinguish between two species and multi species models.	K2
CO4	formulate stochastic and deterministic models.	K6
CO5	construct and evaluate concrete examples in pharmacokinetics	K3, K5

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	2	3	3	3	2	3	2	3	1	2	2.4
2	3	3	3	2	2	3	3	3	1	2	2.5
3	3	3	3	2	1	3	3	3	1	2	2.4
4	3	3	3	2	2	3	3	3	1	1	2.4
5	3	3	3	2	1	3	3	3	1	2	2.4
										Mean Overall Score	**2.42**
										Result	**High**

E–Learning sources: www.cimpa-icpam.org/ecoles-de.../ecoles.../ https://en.wikipedia.org/wiki/Modelling_biological_systemswww.math.nthu.edu.tw/~sbhsu/Biologial%20Science.pdf

Semester – II **Hours/Week : 6**
Code: M852B (Elective) **Credits : 3**

SKILL ENHANCEMENT COURSE II – LINEAR ALGEBRA

Objectives:

1. To develop broad and balanced knowledge and understanding of definitions, concepts, theorems and principles.
2. To enhance the ability of learners to apply the knowledge and skills acquired by them during the programme to solve specific theoretical and applied problem in Mathematics.
3. Toempower students to crack competitive examinations such as NET, SET and TRB and to complement the theoretical content of the subject with exercise problems.

Unit – I: Linear Transformations and Matrices

Linear transformations – null spaces – ranges – matrix representation of a linear transformation – composition of linear transformations – matrix multiplication – invertibility – isomorphism – change of coordinate matrix – dual spaces.
(Chapter 2; Sections 2.1 to 2.6 – examples and exercise)

Unit – II: Elementary Matrix Operations and Systems of Linear Equations

Elementary matrix operations – elementary matrices – rank of a matrix – matrix inverses – system of linear equations.
(Chapter 3; Sections 3.1 to 3.4 – examples and exercise)

Unit – III: Diagonalization

Eigen values and Eigen vectors – diagonalizability – invariant subspaces and the Cayley-Hamilton Theorem.
(Chapter 5; Sections 5.1, 5.2, 5.4 – examples and exercise)

Unit – IV: Inner Product Spaces

Inner products and norms – Gram-Schmidt orthogonalization process – orthogonal complements – adjoint of a linear operator.
(Chapter 6; Sections 6.1 to 6.3 – examples and exercise)

Unit – V: Linear Operator on Inner Product Spaces

Normal, self-adjoint operators - unitary and orthogonal operators – orthogonal projections – spectral theorem.
(Chapter 6; Sections 6.4 to 6.6 – examples and exercise)

Book for Study

1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence**,** *Linear Algebra*, Fourth Edition, Prentice Hall of India, New Delhi, 2007.

Books for Reference

1. David C. Lay, *Linear Algebra and its Applications,* 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
2. S. Lang, *Introduction to Linear Algebra,* 2nd Ed., Springer, 2005.
3. Gilbert Strang, *Linear Algebra and its Applications*, Thomson, 2007.
4. I.N. Herstein, *Topics in Algebra*, John Wiley and sons, 2-e, New Delhi, 2006.
5. S. Arumugam and A.Thandapani, *Modern Algebra*, SciTech Publications Pvt. Ltd.
6. John B. Fraleigh, *A First Course in Abstract Algebra*, 7-e, Pearson Education Publication, New Delhi 2003.
7. Saunders Maclane and Garrett Birkoff, *Algebra*, 2-e, Macmillan Publishing Co.inc, New York, 1979.
8. Santiago, *Modern Algebra*, Arul Publications, Madras, 1988.
9. Serge Lang, *Algebra*, Addition Wesley Publishing Company, London 1965.

10. Surjeeth Singh and Quazi Zameeruddin, *Modern Algebra* 2-e, Vikas Publishing House Pvt. Ltd., New Delhi, 1975.

Course Learning Outcomes

This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	disseminate new and innovative knowledge that will make them fit for any competitions in job opportunities.	K5
CO2	analyze new tangents or to exercise their knowledge and skill in their own disciplines.	K4
CO3	develop, give examples, demonstrate display, and disseminate newer versions and to interpret in novel ways.	K2, K6
CO4	bringout the flair for new and continuous learning process.	K1
CO5	build the dexterity.	K3

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	2	3	3	3	1	3	3	2	3	2	2.5
2	2	3	3	2	2	3	3	3	3	2	2.6
3	2	3	2	3	2	3	3	2	3	2	2.6
4	2	3	3	2	2	3	3	2	3	2	2.5
5	2	3	3	2	2	3	3	2	3	2	2.5
										Mean Overall Score	**2.54**
										Result	**High**

E – Learning source: https://www.math.ku.edu/~lerner/LAnotes/LAnotes.pdf

Semester – II **Hours/Week: 6**
Code: M852C (Elective) **Credits: 3**

Numerical Analysis

Objective: To provide the student an understanding of the basic principles of numerical methods and to apply them in solving algebraic equations and ordinary differential equations numerically; To introduce various difference operators to enable the students to apply them in interpolation and numerical differentiation and integration.

Unit – I: Transcendental and Polynomial Equations
Introduction - Bisection method - Iteration methods based on first degree equation - Iteration methods based on second degree equation – Polynomial equations - Methods for complex roots.
(Chapter 2: Sections 2.1 – 2.4, 2.8 - 2.9)

Unit – II: System of Linear Algebraic Equations and Eigenvalue Problems
Introduction - Direct methods - Iteration methods - Eigen values and Eigen vectors – Model problems.
(Chapter 3: Sections 3.1 – 3.2, 3.4 –3.6)

Unit – III: Interpolation and Approximation
Introduction - Lagrange and Newton Interpolations - Finite difference operators - Interpolating polynomials using finite differences - Hermite interpolation - Piecewise and spline interpolation.
(Chapter 4: Sections 4.1 – 4.6)

Unit – IV: Differentiation and Integration
Introduction - Numerical Differentiation - Extrapolation methods - Partial Differentiation - Numerical integration - Methods based on interpolation - Composite integration methods - Romberg Integration.
(Chapter 5: Sections 5.1, 5.2, 5.4 - 5.7, 5.9 - 5.10)

Unit – V: Ordinary Differential Equations
Introduction - Numerical methods - Single step methods, Multi step methods.
(Chapter 6: Sections 6.1 – 6.4)

Book for Study

1. M.K.Jain, S.R.K. Iyengar and R.K.Jain, *Numerical Methods for Scientific and Engineering Computation*, New Age International Publishers 2007, Fifth Edition.

Books for Reference

1. C.F. Gerald and P.O. Wheatley, *Applied Numerical Analysis,* Addison Wesley Hill Fifth Edition, 2008.
2. Samuel D Conte and Carl de Boor , *Elementary Numerical Analysis*, Tata MacGraw Hill Pvt. Ltd Stall, New Delhi Third Edition, 1980.

Course Learning Outcomes

This course will enable the students to:

CO Number	CO Statement	Knowledge Level
CO1	Understand the need for numerical methods in real life situations.	K2
CO2	Apply the methods to solve problems and find the size errors in each method.	K3
CO3	critically analyse the accuracy of each method in solving algebraic, transcendental system of equations.	K4
CO4	identify and implement numerical methods in various physical problems and find its efficacy in real life.	K1,K5
CO5	develop and demonstrate the theoretical and practical aspects of numerical methods.	K3, K6

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	2	3	3	2	2	2	3	3	2	2	2.4
2	3	3	3	3	2	3	3	3	2	2	2.7
3	3	3	3	2	1	3	3	3	2	2	2.5
4	3	3	3	3	2	3	3	3	1	2	2.6
5	3	3	3	3	2	3	3	3	2	2	2.7
										Mean Overall Score	**2.58**
										Result	**High**

E–Learning source:
https://ocw.mit.edu/courses/mathematics/18-330-introduction-to-numerical-analysis-spring-2012/download-course-materials/

Semester – III **Hours/Week : 6**
Code: M953 **Credits : 5**

MATHEMATICAL ANALYSIS

Objective: To study and analyze the real number system, Fourier series , Fourier Integral, multivariable calculus , Cauchy Theorem and Residue Calculus.

Unit – I: Fourier series

Introduction - Orthogonal systems of functions – The theorem on best approximation – The Fourier series of a function relative to an orthonormal system – Properties of the Fourier coefficients – The Riesz-Fischer theorem – The convergence and representation problems for trigonometric series – The Riemann-Lebesgue lemma – The Dirichlet integrals – An integral representation for the partial sums of a Fourier series – Riemann's localization theorem – Sufficient conditions for convergence of a Fourier series at a particular point.
(Chapter 11, Sections: 11.1 - 11.12)

Unit – II: Fourier Integral

Cesaro summability of Fourier series – Consequences of Fejer's theorem – The Weierstrass approximation theorem – Other forms of Fourier series – The Fourier integral theorem – The exponential form of the Fourier integral theorem – Integral transforms – Convolutions – The convolution theorem for Fourier transforms – The Poisson summation formula.
(Chapter 11, Sections: 11.13 - 11.22)

Unit – III: Multivariable Differential Calculus

Introduction – The directional derivative –Directional derivatives and continuity –The total derivative - The total derivative expressed in terms of partial derivatives –An application to the complex valued functions–The matrix of a linear function –The Jacobian matrix –The chain rule – Matrix form of the chain rule –The Mean-Value theorem for differentiable functions –A sufficient condition for differentiability - A sufficient condition for equality of mixed partial derivatives – Taylor’s formula for functions from R^n to R^1.
(Chapter 12, Sections: 12.1 - 12.14)

----Unit – IV: Cauchy Theorem

Analytic functions – Paths and curves in the complex plane – Contour integrals – The integral along a circular path as a function of the radius – Cauchy's integral theorem for a circle – Homotopic curves – Invariance of contour integrals under homotopy – General form of Cauchy's integral theorem – Cauchy's integral formula – The winding number of a circuit with respect to a point – The unboundedness of the set of points with winding number zero – Analytic functions defined by contour integrals – Power-series expansions for analytic functions – Cauchy's inequalities. Liouville's theorem – Isolation of the zeros of an analytic function.
(Chapter 16, Sections: 16.1 - 16.15)

Unit – V: Residue Calculus

The identity theorem for analytic functions – The maximum and minimum modulus of an analytic function – The open mapping theorem – Laurent expansions for functions analytic in an annulus – Isolated singularities – The residue of a function at an isolated singular point – The Cauchy residue theorem – Counting zeros and poles in a region – Evaluation of real-valued integrals by means of residues – Evaluation of Gauss's sum by residue calculus – Application of the residue theorem to the inversion formula for Laplace transforms – Conformal mappings.
(Chapter 16, Sections: 16.16 - 16.27)

Book for Study

1. Tom M. Apostol**,** *Mathematical Analysis*, Indian student second edition, Narosa Publishing House, Chennai, 20th reprint 2002.

Books for Reference

1. E. Fischer, *Intermediate Real Analysis*, Springer Verlag, 1983.
2. P. N. Arora and Ranjit Singh, *First course in Real Analysis*, Third edition, Sultan Chand and Sons Publishers, New Delhi, 1981.
3. Richard R. Goldberg, *Methods of Real Analysis*, Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi, 1970.
4. Robert G. Bartle and Donald R. Sherbert, *Introduction to Real Analysis*, 2-e John Wiley and Sons, 2000.
5. S. Arumugam, *Modern Analysis*, New Gamma Publishers, Palayamkottai, 1993.

Course Learning Outcomes

CO Number	CO Statement	Knowledge Level
CO1	understand and describe the basic concepts of Fourier series and Fourier integrals with respect to orthogonal system.	K1,K2
CO2	analyze the representation and convergence problems of Fourier series.	K4
CO3	analyze and evaluate the differences between transforms of various functions	K4, K5
CO4	formulate and evaluate complex contour integrals directly and by the fundamental theorem.	K5,K6
CO5	apply the Cauchy integral theorem in its various versions to compute contour integration.	K3

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	3	3	2	3	3	3	3	2	2.8
2	3	3	3	3	2	3	3	3	3	2	2.8
3	3	3	3	3	2	3	3	3	3	1	2.7
4	3	3	3	3	1	3	3	3	3	1	2.6
5	3	3	3	3	1	3	3	2	3	1	2.5
Mean Overall Score											**2.68**
Result											**High**

E-Learning source: https://ocw.mit.edu/courses/mathematics/18-100b-analysis-i-fall-2010/

Semester – III **Hours/Week : 6**
Code: M954 **Credits : 5**

TOPOLOGY

Objective: To develop student's topological and proof writing skills which are essential in the study of advanced mathematics, understand the concepts of topological spaces, analyze and synthesize proofs, understanding the concepts of connectedness and compactness.

Unit – I: Topological Spaces

Topological Spaces –Basis for a Topology–The Order Topology–The Product Topology on X ×Y - The Subspace Topology – Closed Sets and Limit Points.
(Chapter 2,Sections: 12 - 17)

Unit – II: Continuous Functions and Metric Topology

Continuous Functions – The Product Topology – The Metric Topology.
(Chapter 2, Sections: 18 - 21)

Unit – III: Compactness

Compact Spaces – Compact Subspaces of the Real Line – Limit Point Compactness – Local Compactness.
(Chapter 3, Sections: 26 - 29)

Unit – IV:Countability and Separation Axioms

The Countability Axioms – The Separation Axioms – Normal Spaces – The Urysohn Lemma – The Urysohn Metrization Theorem – The Tietze Extension Theorem.
(Chapter 4, Sections: 30 - 35)

Unit – V: Metrization Theorems and Paracompactness

Local Finiteness – The Nagata-Smirnov Metrization Theorem – Paracompactness - The Smirnov Metrization Theorem.
(Chapter 6: Sections 39 - 42)

Book for Study

1. James R. Munkres, *Topology*, 2-e, Prentice Hall of India Private Limited, New Delhi, 2003.

Books for Reference

1. J. Dugundji, (1975), *Topology*, Prentice Hall of India , New Delhi.
2. George F. Simmons, (1963), *Introductions to Topology and Modern Analysis*, McGraw Hill.
3. J.L. Kelly, *General Topology*, Van Nostrand, Reinhold Co, New York.
4. L. Sten and J. Subash, Holt, Rinehart and Winston, *Counter Examples in Topology*.
5. S. Willard,(1970), *General Topology*, Addison Wesley Mass.

Course Learning Outcomes

CO Number	CO Statement	Knowledge Level
CO1	define and illustrate the concept of topological spaces and the basic definitions of open sets, neighbourhood, interior, exterior, closure and their axioms for defining topological space.	K1,K2
CO2	Understand continuity, compactness, connectedness, homeomorphism and topological properties.	K2
CO3	analyze and apply the topological concepts in Functional Analysis.	K3, K4
CO4	Ability to determine that a given point in a topological space is either a limit point or not for a given subset of a topological space.	K5
CO5	develop qualitative tools to characterize connectedness, compactness, second countable, Hausdorff and develop tools to identify when two are equivalent (homeomorphic).	K6

Mapping of CO with PO and PSO

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	3	3	1	3	3	3	2	1	2.5
2	3	3	3	3	2	3	3	3	2	1	2.6
3	3	3	3	3	2	3	3	3	2	2	2.7
4	3	3	3	3	1	3	3	3	2	1	2.5
5	3	3	3	3	1	3	3	3	2	1	2.5
Mean Overall Score											**2.56**
Result											**High**

E–Learning Source:https://ocw.mit.edu/courses/mathematics/18-901-introduction-to-topology-fall-2004/

Semester – III **Hours/Week : 6**
Code: M955 **Credits : 5**

OPTIMIZATION TECHNIQUES

Objective: To obtain knowledge on linear programming problems, queuing models, inventory models, dynamic programming and nonlinear programming problems.

Unit – I: Advanced Topics in Linear Programming

The Revised Simplex Method – Duality Theory and its Applications – The Dual Simplex Method.
(Chapter 4, Sections: 4.1 to 4.3)

Unit – II: Queueing Models

Introduction – An Example – General Characteristics – Performance Measures – Relations among the Performance Measures – Markovian Queueing Models – The (M/M/1) Model – Limited Queue Capacity – Multiple Servers.
(Chapter 7, Sections: 7.1 to 7.9)

Unit – III: Inventory Models

Introduction – Deterministic Models – Probabilistic Models.
(Chapter 8, Sections: 8.1 to 8.11)

Unit – IV: Dynamic Programming

Basic concepts – The development of Dynamic Programming – Illustrative Examples – Continuous State Dynamic Programming.
(Chapter 10, Sections: 10.1 to 10.12 (Omit 10.6))

Unit – V: Non Linear Programming

Basic concepts – Unconstrained Optimization – Gradient projection – Constrained Optimization Problems: Equality constraints – Constrained optimization problems: Inequality Constraints.
(Chapter 11, Sections: 11.1 to 11.2 and 11.5 to 11.9)

Book for Study

1. Ravindran, Don. T. Philips, James J. Solberg, *Operations Research Principles and Practice*, 2-e, John Wiley & sons, New York, 2006.

Books for Reference

1. Frederic S. Hillier and Gerald J. Lieberman, *Operations Research*, 2-e, CBS Publishers Distributors, Delhi, 1999.
2. Hamdy A. Taha, *Operations Research*, 5-e, Prentice Hall of India, Pvt. Ltd, New Delhi, 2008.
3. Sasieni, Arthur Yaspan, Lawrence Friedman, *Operations Research Methods and Problems*, Wiley International Edition, 1959.
4. S. D. Sharma, *Operations Research*, 15-e, Kedarnath Ram Nath & Co Publishers, 2007.

Course Learning Outcomes

CO Number	CO Statement	Knowledge Level
CO1	formulate the primal linear programming problem into standard form and use the simplex method or revised simplex method to solve it.	K6
CO2	modify a primal problem and use the fundamental insight of linear programming to identify the new solution or use dual simplex method.	K3
CO3	understand the concept of complementary slackness and its role in solving primal/dual problem pairs.	K2
CO4	examine and evaluate classical linear programming problems such as dynamic programming problem and non-linear programming problem.	K1, K5
CO5	categorize queueing models	K4

Mapping of CO with PO and PSO:

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	3	3	2	3	3	3	2	2	2.7
2	3	3	3	3	2	3	3	3	2	1	2.6
3	3	3	3	3	2	3	3	3	2	2	2.7
4	3	3	3	3	1	3	3	3	2	1	2.5
5	3	3	3	3	2	3	3	3	2	1	2.6
Mean Overall Score											**2.62**
Result											**High**

E–Learning source: http://www.pondiuni.edu.in/storage/dde/downloads/mbaii_qt.pdf

Semester – III **Hours/Week : 6**
Code: M956 **Credits : 5**

FLUID DYNAMICS

Objective: This course aims to provide basic knowledge in kinematics of fluids in motion, equations of motion of a fluid, three dimensional flows and viscous flows.

Unit – I: Kinematics of Fluids in Motion
Real fluids and Ideal fluids – Velocity of a Fluid at a Point – Streamlines and Pathlines; Steady and Unsteady flows – The Velocity Potential – The Vorticity Vector – Local and Particle Rates of Change – The Equation of Continuity – Worked Examples – Acceleration of a Fluid. (Chapter 2, Sections: 2.1 to 2.9)

Unit – II: Equations of Motion of a Fluid
Pressure at a Point in a Fluid at Rest – Pressure at a Point in a Moving Fluid – Conditions at a Boundary of Two Inviscid Immiscible Fluids – Euler's Equations of Motion – Bernoulli's Equation – Worked examples.
(Chapter 3, Sections: 3.1 to 3.6)

Unit – III: Some Three Dimensional Flows
Introduction – Sources, Sinks and Doublets – Axi-Symmetric Flows: Stokes's Stream Function. (Chapter 4, Sections: 4.1, 4.2, 4.5)

Unit – IV: Some Two Dimensional Flows
Meaning of Two-Dimensional Flow – Use of Cylindrical Polar Coordinates – The Stream Function – The Complex Potential for Two-Dimensional, Irrotational, Incompressible Flow – Complex Velocity Potentials for Standard Two-Dimensional Flows – Some Worked Examples. (Chapter 5, Sections: 5.1 to 5.6)

Unit – V: Viscous Flows
Stress Components in Real Fluid – Relations between Cartesian Components of Stress – Translation Motion of Fluid Element – The Rate of Strain Quadric and Principal Stresses – Some Further Properties of the Rate of Strain Quadric – Stress Analysis in Fluid Motion – Relations between Stress and Rate of Strain – The Coefficient of Viscosity and Laminar Flow – The Navier-Stokes Equations of Motion of a Viscous Fluid.
(Chapter 8, Sections: 8.1 to 8.9)

Book for Study

1. F. Chorlton, *Text book of Fluid Dynamics*, CBS Publishers & Distributors Pvt., Ltd., New Delhi, Reprint 2004.

Books for Reference

1. A.R.Paterson, *A First Course in Fluid Dynamics*, Cambridge University Press, New York, 1987.
2. G.K. Batchelor, *An Introduction of Fluid Mechanics*, Foundation Books, New Delhi, 1993.
3. R. K. Rathy, *An Introduction to Fluid Dynamics*, IBH Publishing Company, New Delhi, 1976.
4. R.Von Mises, O. Friedrichs, *Fluid Dynamics*, Springer International Student Edition, Narosa Publishing House, New Delhi, 1980.

Course Learning Outcomes

CO Number	CO Statement	Knowledge Level
CO1	Bring out the basic knowledge in Kinematics of fluids in motion.	K1
CO2	understand the meaning of two dimensional and three dimensional flow and related problems.	K2
CO3	analyze simple fluid flow problems (flow between parallel plates, flow through pipe etc.) with Navier-Stoke's equation of motion.	K4
CO4	construct and evaluate problems based on two and three dimensional flow.	K3, K5
CO5	interpret the real life application of the concepts.	K6

Mapping of CO with PO and PSO:

CO	**Programme Outcomes (PO)**					**Programme Specific Outcomes (PSO)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
1	3	3	3	3	1	3	3	3	2	2	2.6
2	3	3	3	3	1	3	3	3	2	1	2.5
3	3	3	3	3	2	3	3	3	2	2	2.7
4	3	3	3	3	1	3	3	3	2	2	2.6
5	3	3	3	3	1	3	3	3	2	2	2.6
Mean Overall Score											**2.6**
Result											**High**

E–Learning source: http://web.mit.edu/1.63/www/lecnote.html

Semester – III **Hours/Week: 6**
Code: M957A (Elective) **Credits: 3**

NONLINEAR DYNAMICAL SYSTEMS

Objective: To learn and apply phase plane analysis and stability techniques to problems in Science and technology.

Unit – I: Plane Autonomous Systems and Linearization
The general phase plane - Some population models - Linear approximation at equilibrium points - The general solution of linear autonomous plane systems - The phase paths of linear autonomous plane systems - Scaling in the phase diagram for a linear autonomous system - Constructing a phase diagram.
(Chapter 2, Sections: 2.1 to 2.7)

Unit – II: Periodic Solutions and Averaging methods
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.
(Chapter 4, Sections: 4.1 to 4.5)

Unit – III: Perturbation Methods
Non-autonomous systems: forced oscillations - The direct perturbation method for the undamped Duffing's equation - Forced oscillations far from resonance - Forced oscillations near resonance with weak excitation - The amplitude equation for the undamped pendulum - The amplitude equation for a damped pendulum - Soft and hard springs - Amplitude–phase perturbation for the pendulum equation - Periodic solutions of autonomous equations (Lindstedt's method) - Forced oscillation of a self-excited equation - The perturbation method and Fourier series.
(Chapter 5, Sections: 5.1 to 5.11)

Unit – IV: Stability
Poincaré stability (stability of paths) - Paths and solution curves for general systems - Stability of time solutions: Lyapunov stability - Lyapunov stability of plane autonomous linear systems - Structure of the solutions of n-dimensional linear systems.
(Chapter 8, Sections: 8.1 to 8.5)

Unit – V: Stability (Continued)
Structure of n-dimensional inhomogeneous linear systems –Stability and boundedness for linear systems - Stability of linear systems with constant coefficients - Linear approximation at equilibrium points for first-order systems in n variables – Stability of a class of non-autonomous linear systems in n dimensions - Stability of the zero solutions of nearly linear systems.
(Chapter 8, Sections: 8.6 to 8.11)

Book for Study

1. D. W. Jordan and P. Smith, *Nonlinear Ordinary Differential Equations: An introduction for Scientists and Engineers*, Fourth Edition, Oxford University Press, 2007.

Books for Reference

1. D. A. Sanchez, Freeman, *Ordinary Differential Equations and Stability Theory*, Dover Publications, Inc. New York, 1968.
2. G. F. Simmons, *Differential Equations*, Tata McGraw Hill, New Delhi, 1979.
3. J. K. Agarwal, *Notes on Nonlinear Systems*, Van Nostrand, 1972.
4. M. D. Raisinghania, *Advanced Differential Equations*, S.Chand & Company Ltd., New Delhi, 2001.

Course Learning Outcomes

CO Number	CO Statement	Knowledge Level
CO1	understand phase plane analysis and stability techniques to evaluate problems in Science and technology.	K2, K5
CO2	describe these concepts with examples.	K1
CO3	propose and solve interesting examples of Dynamical Systems	K3, K6
CO4	establish stability results	K3
CO5	point out the importance of modelling physical systems	K4

Mapping of CO with PO and PSO :

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	3	3	1	3	3	3	2	2	2.6
2	3	3	3	3	2	3	3	3	2	1	2.6
3	3	3	3	2	2	3	3	3	2	1	2.5
4	3	3	3	2	1	3	3	3	2	2	2.5
5	3	3	3	3	1	3	3	3	2	2	2.6
Mean Overall Score											**2.56**
Result											**High**

E–Learning source: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-243j-dynamics-of-nonlinear-systems-fall-2003/

Semester – III **Hours/Week : 6**
Code: M957B (Elective) **Credits : 3**

SKILL ENHANCEMENT COURSE III – REAL ANALYSIS

Objective: Empowering students to crack competitive examinations such as NET, SET and TRB. To complement the theoretical content of the subject with exercise problems.

Unit – I: Real number system and Infinite Series

Field Structures and Order Structure – Bounded and Unbounded sets: Supremum, Infimum – Completeness in the Set of Real Numbers – Absolute Value of a Real Number – Limit Points of a set – Closed Sets: Closure of a set – Countable and Uncountable Sets – Sequences - Limits Point of a Sequences – Limits Inferior and Superior – Convergent Sequences – Non-Convergent sequences – Cauchy General Principle of Convergence – Algebra of Sequences – Some Important Theorems – Monotonic Sequences – Positive Term series – Comparison tests for Positive term Series – Cauchy's Root, D'Alembert's Ratio, Raabe's, Logarithmic, Integral and Gauss Tests – Series with Arbitrary terms – Rearrangement of Terms
(Chapters 1 to 4 – Examples and exercises)

Unit – II: Functions of a Single Variable

Limits – Continuous Functions – Functions Continuous on Closed Intervals – Uniform Continuity – Derivative – Continuous Functions – Increasing and Decreasing Functions – Darboux's, Rolle's, Lagrange's Mean Value and Cauchy's Mean Value Theorems - Higher Order Derivatives.
(Chapters 5, 6 – Examples and exercises).

Unit – III: Riemann and Improper Integrals

Definitions and Existence of the Integral – Refinement of Partitions – Darboux's Theorem – Conditions of Integrability – Integrability of the sum and Difference of Integrable Functions – The Integral as a Limit of Sums – Some Integrable Functions – Integration and differentiation – The Fundamental Theorem of Calculus – Mean Value Theorems of Integral Calculus – Integration by Parts – Change of Variables in an Integral – Second Mean Value Theorem –Integration of Unbounded Functions with Finite Limits of Integration – Comparison Tests for Convergence at 'a' in $\int_a^b f(x)\,dx$ – Infinite Range of Integration – Integrand as a Product of Functions – Pointwise Convergence – Uniform Convergence on an Interval – Tests for Uniform Convergence – Properties of Uniformly Convergent Sequences and Series – The Weierstrass Approximation Theorem.
(Chapters 9, 11, 12 – Examples and exercises)

Unit – IV: Functions of Several Variables

Explicit and Implicit Functions – Continuity – Partial derivatives – Differentiability – Partial Derivatives of Higher Order – Differentials of Higher Order – Function of functions – Change of Variables – Taylor's Theorem – Extreme Values: Maxima and Minima – Functions of Several Variables – Jacobians – Stationary Values under Subsidiary Conditions.
(Chapters 15, 16 – Examples and exercises)

Unit – V: Metric Spaces and Lebesgue Integral

Metric Spaces – Measurable Sets – Sets of Measure Zero – Borel Sets – Non-Measurable Sets – Measurable Functions – Measurability of the sum, difference, product and quotient Measurable functions – Lebesgue Integral – Properties of Lebesgue Integral for Bounded Measurable Functions - Lebesgue Integral for Bounded set of finite measure and unbounded Functions – The General Integral – Some Fundamental Theorems – Lebesgue Theorem on Bounded Convergence – Integrability and Measurability – Lebesgue Integral on unbounded sets or intervals – Comparison with Riemann Integral for Unbounded Sets

(Chapters 19,20 – Examples and exercises)

Book for Study

1. S.C. Malik, Savita Arora, *Mathematical Analysis*, New age International Publishers, New Delhi, 2011.

Books for Reference

1. E. Fischer, *Intermediate Real Analysis*, Springer Verlag, 1983.
2. P.N. Arora and Ranjit Singh, *First course in Real Analysis*, Third edition, Sultan Chand and Sons Publishers, New Delhi, 1981.
3. Richard R. Goldsberg, *Methods of Real Analysis*, Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi, 1970.
4. Robert G. Bartle and Donald R. Sherbert, *Introduction to Real Analysis*, 2-e John Wiley and Sons, 2000.
5. S. Arumugam, *Modern Analysis*, New Gamma Publishers, Palayamkottai, 1993.

Course Learning Outcomes

CO Number	CO Statement	Knowledge Level
CO1	apply the theoretical knowledge in solving problems.	K3
CO2	attempt competitive examinations such as NET, SET and TRB.	K1
CO3	Extend their knowledge of Lebesgue theory of integration by selecting and applying its tools for further research in this and other related areas	K2, K3
CO4	Recognize the need of concept of measure from a practical view point.	K1
CO5	Understand the nature of abstract mathematics and explore the concepts in further details.	K2

Mapping of CO with PO and PSO:

CO	**Programme Outcomes (PO)**					**Programme Specific Outcomes (PSO)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
1	3	3	3	3	2	3	3	3	2	2	2.7
2	3	3	3	3	2	3	3	3	2	1	2.6
3	3	3	3	2	1	3	3	3	2	2	2.5
4	3	3	3	2	2	3	3	3	2	2	2.6
5	3	3	3	2	2	3	3	3	2	2	2.6
										Mean Overall Score	**2.6**
										Result	**High**

E-Learning Source: https://ocw.mit.edu/courses/mathematics/18-100c-real- analysis-fall-2012/

Semester – III **Hours/Week: 6**
Code: M957C (Elective) **Credits: 3**

MATHEMATICAL PHYSICS

Objective: This course intends to introduce applications of various mathematical techniques to problems of Theoretical Physics. Examples could be chosen from all 4 traditional divisions of Modern Fundamental Theoretical Physics – Classical Mechanics, Electrodynamics, Quantum Mechanics and Statistical Physics.

Unit 1:
Vector calculus and applications in electromagnetic theory and fluid mechanics.

Unit 2:
Introduction to tensor calculus: review of basics, index notation, tensors in physics and geometry, Levi-Civita tensor, transformations of vectors, tensors and vector fields, covariance of laws of physics.

Unit 3:
Calculus of variations and extremal problems, Lagrange muItipliers to treat constraints, Introduction to the Lagrangian and Hamiltonian formulations of classical mechanics with applications.

Unit 4:
Gamma and Beta functions, Dirac delta function, Special functions, Review of Legendre, Bessel functions and spherical harmonics (with applications to Quantum mechanics), series solutions, generating functions, orthogonality and completeness,

Unit 5:
Applied linear algebra: Dirac notation, dual vectors, projection operators, symmetric hermitian, orthogonal and unitary matrices in physics, diagonalization, orthogonality and completeness of eigenvectors, spectral decomposition and representation, simultaneous diagonalization, normal matrices, applications to coupled vibrations, Schrodinger equation in matrix form.

Books for Study

1. Arften and Weber, *Mathematical Methods for Physics*, Elsevier, 6th Ed., 2005.
2. Riley, Hobson and Bence, *Mathematical Methods for Physics and Engineering*, Cup, 3rd Edition, 2010.

Books for References:

1. P. K. Chattopadhyay, *Mathematical Physics*, Wiley Eastern, New Delhi, 1992.
2. S. S. Rajput, *Mathematical Physics*, Pragati Pragasan, Meerut, 11th Edition, 1996.
3. Charlie Harper, *Introduction to Mathematical Physics***,** California State University, Hayward**.**
4. B. D. Gupta, *Mathematical Physics*, Vikas Publishing House Pvt. Ltd, New Delhi, 2004.
5. L. A. Pipes and L.R. Harvill, *Applied Mathematics for Engineers and Physicists*, McGraw Hill, London, 1970.

Course Learning Outcomes

CO Number	CO Statement	Knowledge Level
CO1	describe and employ the concepts of Gradient, Divergence, Curl and their typical applications in Physics.	K1, K3
CO2	prioritize special functions like Gamma function, Beta function, Dirac function, Delta function, Bessel function and their relations.	K4
CO3	Illustrate Lagrangian and Hamitonian approaches in classical mechanics.	K2
CO4	adapt to tensors in physics.	K6
CO5	evaluate special type of matrices that are relevant in Physics.	K5

Mapping of CO with PO and PSO:

CO	**Programme Outcomes (PO)**					**Programme Specific Outcomes (PSO)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
1	3	3	3	3	2	3	3	3	2	2	2.7
2	3	3	3	3	2	3	3	3	2	1	2.6
3	3	3	3	1	1	3	3	3	2	1	2.3
4	3	3	3	2	2	3	3	3	2	2	2.6
5	3	3	3	1	1	3	3	3	2	2	2.4
Mean Overall Score											**2.52**
Result											**High**

E-learning sources: https://nptel.ac.in/courses/115/103/115103036/#

Semester – IV **Hours/Week : 6**
Code: M1049 **Credits : 5**

Complex Function Theory

Objective: To study the Maximum Principle, Schwarz Lemma, Evaluation of Certain Integrals, Analytic Continuation, Representation of Meromorphic and Entire Functions and Mapping Theorems.

Unit – I: Maximum Principle, Schwarz' Lemma and Liouville's Theorem
Maximum Modulus Principle - Hadamard's Three Circles/Lines Theorems - Schwarz's Lemma and its Consequences - Liouville's Theorem - Doubly Periodic Entire Function - Fundamental Theorem of Algebra - Zeros of certain Polynomials
(Chapter 6, Sections: 6.1 to 6.7)

Unit – II: Evaluation of Certain Integrals
Integrals of type $\int_{\alpha}^{2\pi+\alpha} R(\cos\theta, \sin\theta)\, d\theta$ – Integrals of type $\int_{-\infty}^{\infty} f(x)dx$ – Integrals of type $\int_{-\infty}^{\infty} g(x)\cos mx\, dx$ - Singularities on the Real Axis – Exercises.
(Chapter 9, Sections: 9.1 to 9.4 and 9.7 (9.73 to 9.76))

Unit – III: Analytic Continuation
Direct Analytic Continuation - Monodromy Theorem - Poisson Integral Formula - Analytic Continuation via Reflection.
(Chapter 10, Sections: 10.1 to 10.4)

Unit – IV: Representations of Meromorphic and Entire Functions
Infinite Sums and Meromorphic Functions - Infinite Product of Complex Numbers – Infinite Product of Analytic functions - Factorization of Entire Functions - The Gamma Function - The Zeta Function.
(Chapter 11, Sections: 11.1 to 11.6)

Unit – V: Mapping Theorems
Open Mapping Theorem and Hurwitz' Theorem - Basic Results on Univalent Functions - Normal Families – The Riemann mapping theorem (without proof) - Bieberbach Conjecture - The Bloch-Landau Theorems
(Chapter 12, Sections: 12.1 to 12.6)

Book for Study

1. S. Ponnusamy, *Foundations of Complex Analysis*, Second Edition, Narosa Publishing House, New Delhi, 2005.

Books for Reference

1. Lars. V. Ahlfors, *Complex Analysis*, Third Edition, Indian Edition, McGraw Hill, Inc. in 1979.
2. Theodore W. Gamelin, *Complex Analysis*, Springer- Verlag New York, Inc. in 2001.
3. B. Choudhary, *The Elements of Complex Analysis*, 2-e, Wiley Eastern Limited, 1992.
4. Boston, *Complex Variables*, Silverman- Houghton Mifflin Company, 1975.
5. John B. Conway, *Functions of One Complex Variable*, 2-e, Springer International student Edition, 1973.

6. S. Arumugam, A. Thangapandi Isaac, A. Somasundram, *Complex Analysis*, Scitech Publications Pvt. Ltd., New Delhi, 2007.
7. Serge Lang, *Complex Analysis*, 2-e, Springer-Verlag, New York, 1993.

Course Learning Outcomes

CO Number	CO Statement	Knowledge Level
CO1	develop the maximum assistance in mastering the fundamental concepts and techniques of Complex Function Theory.	K6
CO2	establish Maximum principle, Schwarz lemma and Liouville's theorem.	K3
CO3	evaluate different Types of Integral.	K5
CO4	examine interesting results concerning certain mapping problems between domains.	K1
CO5	understand and analyze the concept of Analytic Continuation.	K2, K4

Mapping of CO with PO and PSO:

CO	**Programme Outcomes (PO)**					**Programme Specific Outcomes (PSO)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
1	3	3	3	3	1	3	3	3	2	2	2.6
2	3	3	3	3	1	3	3	3	2	1	2.5
3	3	3	3	2	1	3	3	3	2	1	2.4
4	3	3	3	3	1	3	3	3	2	1	2.5
5	3	3	3	3	1	3	3	3	2	1	2.5
Mean Overall Score											**2.5**
Result											**High**

E – Learning sources: https://ocw.mit.edu/courses/mathematics/18-04-complex-variables-with-applications-fall-2003/

Semester – IV **Hours/Week: 6**
Code: M1050 **Credits : 5**

Functional Analysis

Objective: To provide students with a strong foundation in functional analysis, focusing on spaces, operators and fundamental theorems. To develop student's skills and confidence in mathematical analysis and proof techniques.

Unit – I: Banach Spaces
Definition and Some examples – Continuous linear transformations – The Hahn-Banach theorem. (Chapter 9, Sections: 46, 47,48)

Unit – II: Banach Spaces (contd.)
The natural imbedding of $N^* \text{ in } N^{**}$ – The Open Mapping theorem – The conjugate of an operator. (Chapter 9, Sections: 49, 50, 51)

Unit – III: Hilbert Spaces
Definition and some simple Properties –Orthogonal complements – Orthonormal sets – The conjugate space H^*.
(Chapter 10,Sections: 52, 53, 54, 55)

Unit – IV: Hilbert Spaces (contd.)
The Adjoint of an operator – Self-Adjoint operators –Normal and Unitary operators – Projections.(Chapter 10, Sections: 56, 57, 58, 59)

Unit – V: Algebras of Operators
The definition and some Examples – Regular and singular elements – Topological divisors of zero – The Spectrum – The formula for the spectral radius.
(Chapter 12,Sections: 64, 65, 66, 67, 68)

Book for Study

1. Simmons G.F., *Introduction to Topology and Modern Analysis*, McGraw – Hill International Book Company, New York, 22nd reprint 2014.

Books for Reference

1. B. Choudhary, Sudarsan Nanda, *Functional Analysis with Applications*, Wiley Eastern Limited, New Delhi, 1989.
2. B. V. Limaye, *Functional Analysis*, 2-e, New Age International Ltd, Publishers, 1996.
3. Chandrasekara Rao. K, *Functional Analysis*, Narosa Publishing House, 2006.
4. E. Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley& Sons, New York, 1978.
5. Ponnusamy. S, *Foundations of Functional Analysis*, Narosa Publishing House, New Delhi, 2002.
6. Somasundaram. D, *A First Course in Functional Analysis*, Narosa Publishing House, New Delhi, 2006.

Course Learning Outcomes

CO Number	CO Statement	Knowledge Level
CO1	understand the Banach spaces and Transformations on Banach Spaces.	K2
CO2	prove Hahn Banach theorem and open mapping theorem.	K5
CO3	describe operators and fundamental theorems.	K1
CO4	validate orthogonal and orthonormal sets.	K6
CO5	Analyze and establish the regular and singular elements.	K3, K4

Mapping of CO with PO and PSO:

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	3	3	2	3	3	3	2	2	2.7
2	3	3	3	3	1	3	3	3	2	1	2.5
3	3	3	3	2	1	3	3	3	2	1	2.4
4	3	3	3	2	2	3	3	3	2	2	2.6
5	3	3	3	2	1	3	3	3	2	1	2.4
Mean Overall Score											**2.52**
Result											**High**

E–Learning source: http://www.math.ucdavis.edu/~hunter/book/ch5.pdf

Semester – IV **Hours/Week : 5**
Code: M1051 **Credits : 4**

Difference Equations

Objective: To introduce the process of discretization, discrete version of Differential Equations, oscillation and the asymptotic behaviour of solutions of certain class of difference equations. Solving difference equations using z-transforms is stressed.

Unit – I: The Difference Calculus
The Difference Operator – Summation – Generating Functions and Approximate Summation. (Book 1: Chapter 2, Sections: 2.1 - 2.3)

Unit – II: Linear Difference Equations
First order Equations - General Results for Linear Equations – Solving Linear Equations – Applications – Equations with Variable Coefficients.
(Book 1: Chapter 3, Sections: 3.1 - 3.5)

Unit – III: The Z-transform Method
Definitions and Examples, Properties of the Z-transform - The Inverse Z-transform and Solutions of Difference Equations: The power series method, the partial fractions method and inversion integral method - Volterra Difference Equation of convolution type (The scalar case).
(Book 2: Chapter 6, Sections: 6.1 - 6.3)

Unit – IV: Oscillation Theory
Three-term difference Equations – Self-Adjoint Second Order Equations - Nonlinear Difference Equations.
(Book 2: Chapter 7, Sections: 7.1 - 7.3)

Unit – V: Asymptotic Behaviour of Difference Equations
Tools of Approximation - Poincare's Theorem - Asymptotically Diagonal Systems – High-Order Difference Equations - Second Order Difference Equations.
(Book 2: Chapter 8, Sections: 8.1 - 8.5)

Books for Study

1. Walter G. Kelley, Allan C. Peterson, *Difference Equations, An Introduction with Applications*, Second Edition, Academic Press, New York, 2001.
2. Saber N. Elaydi, *An Introduction to Difference Equations*, Third Edition, Springer Verlag, New York, 2005 (First Indian Reprint 2008).

Books for Reference

1. Ronald E. Mickens, *Difference Equations Theory, Applications and Advanced Topics*, Third Edition, CRC Press, New York, 2015.
2. R. P. Agarwal., *Difference Equations and Inequalities*, Marcel Dekker, 1999.
3. S. Goldberg, *Introduction to Difference Equations*, Dover Publications, 1986
4. V. Lakshmikantham and Trigiante, *Theory of Difference Equations Numerical Methods and Applications*, Second Edition, Academic Press, New York, 1988.

Course Learning Outcomes

CO Number	CO Statement	Knowledge Level
CO1	define the basic concepts of difference equations.	K1
CO2	calculate solutions of linear difference equations.	K3
CO3	solve difference equations using z-transforms.	K3
CO4	explain the oscillatory behaviour of difference equations.	K2
CO5	analyze and evaluate the asymptotic behaviour of solutions of certain class of difference equations.	K4, K5

Mapping of CO with PO and PSO:

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	3	3	1	3	3	3	2	2	2.6
2	3	3	3	3	1	3	3	3	2	1	2.5
3	3	3	3	2	1	3	3	3	2	2	2.5
4	3	3	3	2	2	3	3	3	2	1	2.5
5	3	3	3	2	1	3	3	3	2	1	2.4
Mean Overall Score											**2.5**
Result											**High**

E – Learning source: http://people.math.aau.dk/~matarne/11-imat/notes2011a.pdf,

http://pj.freefaculty.org/guides/stat/Math/DifferenceEquations/DifferenceEquations-guide.pdf

Semester – IV **Hours/Week : 5**
Code: M1052A (Elective) **Credits : 3**

Stochastic Processes

Objective: To introduce to the students the basic ideas of Stochastic processes, Markov chains, Markov process and Renewal process and to motivate research in these areas.

Unit – I: Stationary Process
Specification of Stochastic processes – Stationary processes – Markov chains – Definitions and Examples – Higher Transition Probabilities – Generalization of Independent Bernoulli trails – Sequence of chain dependent trials.
(Chapter 2, Sections: 2.2 - 2.3; Chapter 3,Sections:3.1 - 3.3)

Unit – II: Markov Chains
Stability of a Markov system – Graph theoretic approach–Markov chain with denumerable Number of states – Reducible chains – Statistical inference for Markov chains.
(Chapter 3, Sections: 3.6 - 3.10)

Unit – III: Markov Processes with Discrete State Space: Poisson process and its extensions
Poisson process – Poisson process and related distributions – Generalizations of Poisson process – Birth and death process – Markov process with discrete state space (Continuous time Markov chains).
(Chapter 4, Sections: 4.1 - 4.5)

Unit – IV: Markov Processes with Continuous State Space
Brownian motion–Wiener process – Differential equations for a Wiener process – Kolmogorov Equations – First Passage time distribution for Wiener process.
(Chapter 5, Sections: 5.1 - 5.5)

Unit – V: Renewal Processes and Theory
Renewal process – Renewal process in continuous time – Renewal equation – Stopping time: Wald's equation – Renewal theorems– Delayed and equilibrium renewal processes.
(Chapter 6,Sections: 6.1 - 6.6)

Book for Study

1. J.Medhi, *Stochastic Processes*, Second edition, New Age International Publication, New Delhi, 2002.

Books for Reference

1. Erhan Cinlar, *Introduction to Stochastic process*, Prentice Hall Inc., 1975
2. Samauel Karlin, *A first course in Stochastic process*, 2-e, Academic press 1968.
3. S. K. Srinivasan and A. Vijayakumar, *Stochastic Process*, Narosa Publishing House, New Delhi, 2003.
4. V. NarauyanBhat, *Elements of Applied Stochastic Processes*, John Wiley and sons, 1972.

Course Learning Outcomes

CO Number	CO Statement	Knowledge Level
CO1	demonstrate the basic concepts of Stochastic process, Markov chains.	K2
CO2	identify the type of the distribution	K1
CO3	apply the concepts in practical problems	K3
CO4	compose and evaluate simple Markovian Queueing models.	K5, K6
CO5	analyze and evaluate renewal equations	K4, K5

Mapping of CO with PO and PSO:

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	3	3	1	3	3	3	2	2	2.6
2	3	3	3	3	2	3	3	3	2	1	2.6
3	3	3	3	2	2	3	3	3	2	2	2.6
4	3	3	3	2	2	3	3	3	2	2	2.6
5	3	3	3	1	1	3	3	3	2	1	2.3
Mean Overall Score											**2.54**
Result											**High**

E–Learning source: www.expocentral.com/directory/scence/math/stochastic/process

Semester – IV **Hours/Week: 5**
Code: M1052B (Elective) **Credits : 3**

Skill Enhancement Course IV– Complex Analysis

Objective: Empowering students to crack competitive examinations such as NET, SET and TRB. To complement the theoretical content of the subject with exercise problems

Unit – I: Analytic Functions and Power Series
Differentiability and Cauchy–Riemann Equations –Harmonic Functions –Power Series as an Analytic Function – Exponential and Trigonometric Functions – Logarithmic Functions – Inverse Functions.
(Chapter 3, Sections: 3.1 - 3.6)

Unit – II: Complex Integration
Curves in the Complex Plane – Properties of Complex Line Integrals – Winding Number or Index of a Curve – Cauchy Integral Formula –Morera's Theorem– Taylor's Theorem – Zeros of Analytic Functions – Laurent Series.
(Chapter 4, Sections: 4.1, 4.2, 4.5, 4.7, 4.8, 4.10 - 4.12)

Unit – III: Conformal Mappings and Mobius Transformations
Principle of Conformal Mapping – Basic Properties of Mobius Maps – Fixed Points and Mobius Maps – Triples to Triples under Mobius Maps – The Cross-Ratio and its Invariance Property – Conformal Self-maps of Disks and Half-planes.
(Chapter 5, Sections: 5.1 - 5.6)

Unit – IV: Maximum Principle and Singularities
Maximum Modulus Principle – Liouville's Theorem –Doubly Periodic Entire Functions – Fundamental Theorem of Algebra – Zeros of certain Polynomials–Isolated and Non-isolated Singularities – Removable Singularities – Poles – Further Illustrations through Laurent's Series – Meromorphic Functions.
(Chapter 6, Sections: 6.1, 6.4 - 6.7, Chapter 7, Sections: 7.1-7.4, 7.6)

Unit – V: Calculus of Residues
Residue at a Finite Point – Residue at the Point at Infinity – Residue Theorem – Number of Zeros and Poles – Rouche's Theorem.
(Chapter 8, Sections: 8.1 - 8.5)

Book for Study

S. Ponnusamy, *Foundations of Complex Analysis*, Second Edition, Narosa Publishing House, New Delhi, 2012.

Books for Reference

1. B. Choudhary, *The Elements of Complex Analysis*, 2-e, Wiley Eastern Limited, 1992.
2. Boston, *Complex Variables*, Silverman- Houghton Mifflin Company, 1975.
3. John B. Conway, *Functions of One Complex Variable*, 2-e, Springer International student Edition, 1973.
4. S. Arumugam, A. Thangapandi Isaac, A. Somasundram, *Complex Analysis*, Scitech Publications Pvt. Ltd., New Delhi.

Course Learning Outcomes

CO Number	CO Statement	Knowledge Level
CO1	analyze and solve problems on Analytic functions, Power Series and Complex Integration.	K3, K4
CO2	Illustrate Conformal Mappings, Mobius Transformation and solve related problems.	K2, K3
CO3	identify Singularities and derive Laurent's series	K1
CO4	formulate Residue Theorem in Contour Integration.	K6
CO5	analyze and evaluate problems based on Rouche's Theorem	K4, K5

Mapping of CO with PO and PSO:

CO	Programme Outcomes (PO)					Programme Specific Outcomes (PSO)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
1	3	3	3	3	1	3	3	3	2	2	2.6
2	3	3	3	3	1	3	3	3	2	2	2.6
3	3	3	3	2	1	3	3	3	2	1	2.4
4	3	3	3	2	2	3	3	3	2	2	2.6
5	3	3	3	1	1	3	3	3	2	1	2.3
Mean Overall Score											**2.5**
Result											**High**

E - Learning Source

http://www.isibang.ac.in/~statmath/stinc/database /notes /CASolutions.pdf

http://www.unibuc.ro/prof/timofte_c/docs/res/2016febComplex-Analysis-Problems.pdf

Semester – IV **Hours/Week: 5**
Code: M1052C (Elective) **Credits : 3**

Theory of Transforms

Objective: To impart the basic knowledge of principles of Fourier series and Z-Transforms; To give different techniques to solve integral problems using Transforms.

Unit – I:
Fourier Series - Euler Formulae - Conditions for a Fourier Expansion - Functions having points of discontinuity - Change of Interval - Even and Odd Expansion - Half Range Series – Typical waveforms - Complex Form of Fourier Series - Practical Harmonic Series.
(Chapter 10: Sections 10.1 - 10.11)

Unit – II:
Integral Transforms – Fourier Integral Theorem – Fourier Transforms – Properties of Fourier Transforms – Applications to solve integral problems.
(Chapter 22: Sections 22.1 - 22.5)

Unit – III:
Convolution – Parseval's Identity for Fourier Transforms – Problems – Relation between Fourier and Laplace Transforms - Fourier Transforms of the derivative of a function – Application of Transforms to boundary Value Problems.
(Chapter 22: Sections 22.6 - 22.9, 22.11)

Unit – IV:
Z – Transform – Some standard Z – Transform – Linearity Property– Damping Rule – Some Standard Results – Shifting u_n to the right and left – Multiplication by n – Two basic theorems – Problems.
(Chapter 23: Sections 23.1 - 23.9)

Unit – V:
Some Useful Z – Transforms – Some Useful Inverse Z-transforms – Convolution Theorem – Convergence of Z-Transforms – Evaluation of Inverse Z-Transforms – Application of Difference Equations – Problems.
(Chapter 23: Sections 23.10 - 23.16)

Book for Study

1. Dr.B.S. Grewal and J.S. Grewal, *Higher Engineering Mathematics*, Khanna Publishers, 40th Edition 2007, Fifth Reprint 2008.

Books for Reference

3. Dr. Erwin Kreyszig, *Advanced Engineering Mathematics*, John Wiley & Sons, Inc, 8th Edition 1999.
4. James S. Walker, *Fourier Analysis*, Oxford University Press 1988.

Course Learning Outcomes

CO Number	CO Statement	Knowledge Level
CO1	summarize knowledge of various mathematical concepts and techniques required for successful application of mathematics in physics and related sciences	K2
CO2	examine application of Z-transform.	K1
CO3	solve differential & integral equations with initial conditions using Laplace transform.	K3
CO4	analyze and evaluate the Fourier transform of a continuous function and be familiar with its basic properties.	K4, K5
CO5	validate solution of integral equation and their application.	K6

Mapping of CO with PO and PSO:

CO	**Programme Outcomes (PO)**					**Programme Specific Outcomes (PSO)**					**Mean Scores of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
1	3	3	3	3	1	3	3	3	2	2	2.6
2	3	3	3	3	2	3	3	3	2	1	2.6
3	3	3	3	2	1	3	3	3	2	2	2.5
4	3	3	3	2	2	3	3	3	2	2	2.6
5	3	3	3	1	1	3	3	3	2	2	2.4
Mean Overall Score											**2.54**
Result											**High**

E–Learning source: https://onlinecourses.nptel.ac.in/noc20_ma41/preview