CURRICULUM & SYLLABUS

CHOICE BASED CREDIT SYSTEM (CBCS)

Doctor of Philosophy (Ph.D.)

IN

MATHEMATICS

[w. e. f 2025-26]

FACULTY OF SCIENCE & HUMANITIES

SRM UNIVERSITY DELHI-NCR, SONEPAT

39, Rajiv Gandhi Education City, P.S. Rai, Sonepat

Haryana-131029

SRM UNIVERSITY DELHI-NCR, SONEPAT (HARYANA)

VISION

SRM University Delhi – NCR, Sonepat, Haryana aims to emerge as a leading world - class university that creates and disseminates knowledge upholding the highest standards of instruction in Medicines & Health Sciences, Engineering & Technology, Management, Law, Science and Humanities. Along with academic excellence and skills, our curriculum imparts integrity and social sensitivity to mould our graduates who may be best suited to serve the nation and the world.

MISSION

- To create a diverse community campus that inspires freedom and innovation.
- Promote excellence in educational & skill development processes.
- Continue to build productive international alliances.
- Explore optimal development opportunities available to students and faculty.
- Cultivate an exciting and rigorous research environment.

DEPARTMENT OF MATHEMATICS

VISION

The broad vision of the Department is to carry out high quality research in the different areas of Mathematics, Statistics and Computing so that we can produce proficient graduates, engineers and scientists to contribute significantly in the development of the society. Excellence, integrity, innovation, entrepreneurship and leadership are priorities of the Department. The vision is to become a leading department of global excellence in research and education in all discipline of Mathematics.

MISSION

The Department supports the University's mission by empowering students to:

- Provide excellent knowledge of Mathematical Sciences as well as Statistics for suitable career and groom them for institutional, state, national and international recognition.
- Discover, mentor, and nurture mathematically inclined students, and provide them a supportive environment that fosters intellectual growth.
- Train the students for interdisciplinary applications and research.
- Train the students with Mathematical and Statistical tools for industries as well as research organizations.
- Provide professional services based on our diverse mathematical and statistical expertise.
- The scientific, technical, and educational community.
- Achieve excellence in the subject as well as overall development of the student to strive in a competitive society.

Ph.D. COURSE WORK

Code	Category	Course	L	T	P	C
RES– 701	Core	Research Methodology	4	0	0	4
[x]CPE-RPE101	Core	Research and Publication Ethics	2	0	0	2
	DSE	Department Specific Elective - I	4	0	0	4
	DSE	Department Specific Elective - II	4	0	0	4

[x]Amended w.e.f. January 01, 2020, as per UGC D.O. No. F-1-1/2018(Journal/CARE)

SUMMARY OF CREDITS

Category	I Sem	Total	%
Core Courses	10	10	71.43
DSE	4	4	28.57
Total	14	14	100

PROGRAM EDUCATIONAL OBJECTIVE (PEOs)

The Ph.D. Programme in Mathematics aims to provide research options both in pure and applied mathematics whichprepare PhDs to acquire the skills necessary for carrying out research in the different branches of mathematics. Somespecific objectives of this program are:

- Identifying unsolved yet relevant problem in a specific field.
- Articulating ideas and strategies for addressing a research problem.
- Undertaken original research on a particular topic.
- Effectively communicating research, through journal publications and conference presentations, to themathematics community.
- Disseminating research to a broader audience.

PROGRAM LEARNING OUTCOME (PLOs)

The main skills and competences to be developed by research scholars throughout this program are:

- Produce publications in reputed mathematical journals.
- Develop the skills to express his/her ideas through various seminars and conferences both at nationallevel as well as international level.
- Provide scope for interaction with international researchers and developing collaborations
- Demonstrate the highest standard of ethics in research.
- Offer opportunities to research students for communication (and discussion) of advanced mathematicaltopics to undergraduate and graduate students.

MAPPING BETWEEN PROGRAM EDUCATIONAL OBJECTIVE (PEOs) AND PROGRAM LEARNING OUTCOME (PLOs)

PLO / PEO	PLO 1	PLO 2	PLO 3	PLO 4	PLO5
PEO 1	✓				
PEO 2		✓			
PEO 3			✓		
PEO 4				✓	
PEO 5					✓

LIST OF DISCIPLINE SPECIFIC ELECTIVES (DSE)

Code	Category	Course	L	T	P	C
Departmental Elective – I						
25MA711	DSE	Functional Analysis	4	0	0	4
25MA712	DSE	Optimization Techniques	4	0	0	4
25MA713	DSE	Advanced Special Functions	4	0	0	4
25MA714	DSE	Elements of Sampling Theory	4	0	0	4
Departmental Elective – II						
MA-702	DSE	Advanced Functional Analysis	4	0	0	4
MA-703	DSE	Fixed Point Theory	4	0	0	4
MA-704	DSE	Fuzzy Set Theory	4	0	0	4
MA-705	DSE	Algebraic Number Theory	4	0	0	4
20 MA-706	DSE	Operational Research	4	0	0	4
MA-707	DSE	Advanced Sampling theory	4	0	0	4
20 MA – 708	DSE	Water Wave Theory	4	0	0	4
20 MA - 709	DSE	Linear programming Problem with application of DEA	4	0	0	4
21 MA - 710	DSE	Tensor Analysis and Basic Thermo elasticity	4	0	0	4

RESEARCH METHODOLOGY	
Course Code: RES-701	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- To develop a research interest in students
- To know about different types of data
- To study about descriptive statistics
- To know about computer fundamentals and creating and editing documents
- To know about how to write research reports

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- understand some basic concepts of research and its methodologies
- select and define appropriate research problem and parameters
- prepare a project proposal (to undertake a project)
- organize and conduct research (advanced project) in a more appropriate manner
- write a research report and thesis

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit – I

Introduction, Philosophical Underpinnings, Meaning of Research, Objectives of Research, Motivations in Research, Types of Research, Research Approaches, Significance of Research, Scope of Research, Literature Review, Research Methods vs. Research Methodology, Research Process, Research and Scientific Methods, Criteria of Good Research, Research Questions, Research problem, Selecting the

Problem, Necessity and Techniques of Research Problem, Qualitative & Quantitative Research, Research Proposal, Synopsis, Transdisciplinary, Multidisciplinary & Interdisciplinary in Research.

Unit- II

Collection of Primary Data/Sources, Secondary Data/Sources, Observation Method, Interview, Libraries, Archives & Repositories, Questionnaire, Schedules, Case Study and other Innovative Methods, Research Procedure. Sampling, Steps and Criteria for selecting a Sample procedure, Characteristics of Good Sampling, Types of Sample Design, Selecting Random Samples, Complex Random Sampling Design.

Unit- III

Measures of Central Tendency, Dispersion, Correlation & Regression, Chi-Square Test: applications, Steps, Characteristics, Limitations, Analysis of Variance & Co-variance. Hypothesis: Meaning, Basic Concepts, Flow Diagram, Testing, of Means, Testing of Hypothesis testing of Correlation coefficients, Limitations of Tests of Hypothesis Theory& Empirical approaches, Ethnographic, Comparative and Interpretative Research.

Unit- IV

Computer Fundamentals, Basics, Data Representation, Word Processing Package, Creating & Editing a Word Document. Ethical issues related to Publishing & Plagiarism, LaTex tool for Detection and Elimination of Plagiarism, Intellectual Property Rights, Copy Rights & Patent Laws.

Unit- V

Structure& Components of Research Report, Types of Report, Layout of Research Report, Mechanism of Writing a Research Report. Presentation: Tailoring the presentation to the target audience, Oral Presentation, Poster Presentation, Submission of Research Article, Thesis Writing, and Visual & Delivery.

TEXT BOOKS

1. Kothari, C. R. Research Methodology: Methods and Techniques, New Age Publishers, Delhi, 2018.
2. Rand R. Wilcox, Fundamentals of Modern Statistical Research, Springer, New York, 2010.
3. Ross, Timothy J. Fuzzy Logic with Engineering Applications, 2ndEdn. Wiley Publications, 2005.

REFERENCE BOOKS

1. Adam Pzreworsky and Frank Solomon. On the Art of Writing Proposals, rev. edn, New York, 1995.
2. Blaxter Loraine, Hughes Christina and Tight Malcolm. How to Research, Open University Press, 2006.
3. Gerard Guthrie. Basic Research Methods, Sage, London, 2010.

RESEARCH AND PUBLICATION ETHICS	
Course Code: CPE-RPE101	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE OBJECTIVES

This course has total 6 units focusing on basics of philosophy of science and ethics, research integrity, publication ethics. Hands-on-sessions are designed to identify research misconduct and predatory publications. Indexing and citation databases, open access publications, research metrics (citations, h-index, Impact Factor, etc.) and plagiarism tools will be introduced in this course.

COURSE CONTENTS

1. Pedagogy: Classroom teaching, guest lectures, group discussions, and practical sessions.
2. Evaluation: Continuous assessment will be done through tutorials, assignments, quizzes, and group discussions. Weight age will be given for active participation. Final written examination will be conducted at the end of the course.
3. Course structure: The course comprises of six modules listed in table below. Each module has 4-5 units.

MODULES	UNIT TITLE	TEACHING HOURS
Theory		
RPE 01	Philosophy and Ethics	4
RPE 02	Scientific Conduct	4
RPE 03	Publication Ethics	7
Practice		
RPE 04	Open Access Publishing	4
RPE 05	Publication Misconduct	4
RPE 06	Databases and Research Metrics	7
	Total	30

SYLLABUS IN DETAIL

THEORY

- **RPE 01: PHILOSOPHY AND ETHICS (3 hrs.)**

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgments and reactions

- **RPE 02: SCIENTIFICCONDUCT (5 hrs.)**

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing

5. Selective reporting and misrepresentation of data

- **RPE 03: PUBLICATION ETHICS (7 hrs.)**

1. Publication ethics: definition, introduction and importance
2. Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behavior and viceversa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

PRACTICE

- **RPE 04: OPEN ACCESS PUBLISHING (4 hrs.)**

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggested, etc.

- **RPE 05: PUBLICATION MISCONDUCT (4hrs.)**

(A) Group Discussions (2 hrs.)

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

(B) Software tools (2 hrs.): Use of plagiarism software like Tumitin, Urkund and other open-source software tools

- **RPE 06: DATABASES AND RESEARCH METRICS (7hrs.)**

(A) Databases (4 hrs.)

1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

(B) Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SIR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics.

FUNCTIONAL ANALYSIS	
Course Code: 25MA711	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- To acquire basic knowledge of functional analysis.
- To provide a deeper knowledge of Banach algebra.
- To construct and apply the concepts of metric spaces.
- To develop the concept of Measure theory.
- To provide a deeper knowledge of Lp spaces and their inequalities.

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe fundamental properties of functional analysis.
- Demonstrate an understanding of Banach algebra.
- Develop rigorous mathematical proofs in metric spaces.
- Describe the concept of measure theory.
- Implement Lp spaces and their inequalities.

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit – I

Arzela-Ascoli theorem, Hahn Banach Theorems, Open mapping and closed graph theorem, Uniform boundedness principle. Hilbert spaces, existence of orthonormal basis, Riesz theorem for linear functionals Vector valued Holomorphic functions.

Unit- II

Banach algebras, Complex Homomorphisms, Multiplicative linear functionals, Spectrum of a Banach algebra, Gelfand-Mazur Theorem, Symbolic calculus, Integration of Banach algebra valued functions, Holomorphic Banach algebra valued functions and Cauchy's theorem, Banach algebra of bounded operators on a Banach space X, Group of invertible elements. Commutative Banach algebras, Gelfand transform, Gelfand -Naimark Theorem, Compact Operators, Fredholm Theory.

Unit- III

Metric spaces: definition and examples. Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces. Open and closed balls, neighbourhood, open set, interior of a set, Limit point of a set, closed set, diameter of a set, Cantor's Theorem, Subspaces, dense sets, separable spaces.Continuous mappings, sequential criterion and other characterizations of continuity, Uniform continuity, Homeomorphism, Contraction mappings, Banach Fixed point Theorem.

Unit- IV

Length of an open set, concept of measure, Lebesgue outer measure and measurable sets, example of non-measurable set, sigma algebra, Borel sets, $G\delta$ and $F\sigma$ –sets, outer and inner regularity of Lebesgue measure Set function, abstract measure spaces, properties of measures, some examples of measures, measurable spaces, measurable functions, combinations of measurable functions, limits of measurable functions.

Unit- V

Lp spaces, basic inequalities including Holder's, Chebyshev, and Minkowski, inequalities for integrals, weak Lp spaces, the Riesz-Thorin and Marcinkiewicz Interpolation Theorems Convolution, Young's inequality, the generalized inequality of Young, approximations to the identity.

TEXT BOOKS

1. S. C. Malik and Savita Arora, Mathematical Analysis, New Age International Publishers, 2017.
2. W. Rudin, Principles of Mathematical Analysis McGraw-Hill, 4th edition, 2017.
3. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration, Published by Anshan Ltd, 2nd Edition, 2012.

REFERENCE BOOKS

4. G. B. Folland, Real analysis; Modern techniques and their applications, Second edition, Pure and Applied Mathematics: A Wiley Series of Texts, Monographs and Tracts.
5. F. Treves, Topological Vector Spaces, Distributions and Kernels, Dover Publications Inc.; Illustrated edition (26 January 2007), ISBN-13 : 978-0486453521.
6. E.M. Stein and R. Shakarchi, Functional Analysis: Introduction to Further Topics in Analysis, Princeton University Press (11 September 2011), ISBN-13 : 978-0691113876.
7. V.S. Sunder, Functional Analysis: Spectral Theory, Hindustan Book Agency (10 January 1996), ISBN-13 : 978-8185931142.

OPTIMIZATION TECHNIQUES	
Course Code: 25MA712	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- To develop an understanding of supply chain structures, decision-making strategies, and performance evaluation metrics.
- To equip students with quantitative techniques for inventory optimization under various demand and cost conditions.
- To provide knowledge of network optimization techniques for solving flow and transportation problems.
- To introduce stochastic modeling and queuing theory for performance analysis in uncertain environments.
- To explore advanced optimization concepts and their applications in operations research.

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Analyze different supply chain strategies and evaluate their impact on supply chain performance, including the bullwhip effect and sustainability considerations.
- Formulate and solve deterministic inventory models, including deteriorating items, stock-dependent demand, and trade credit policies, to optimize replenishment decisions.
- Apply network optimization methods (minimum cost flow, maximum flow, network simplex) to solve real-world logistics and distribution problems.
- Model and analyze Markov chains and queuing systems using Little's formula and evaluate transient and steady-state behaviors.
- Solve linear complementarity problems (LCP) using pivot algorithms and apply invexity conditions to analyze optimality and duality in nonlinear programming.

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit – I

Introduction to supply chain network, Supply chain evaluation, Supply chain decisions- strategic, Supply chain strategies- push, Pull and push-pull, Bullwhip effect supply chain evaluation and performance measures. Inventory distribution, Coordination, and procurement distribution coordination, Reverse, and closed loop supply chain, green supply chain and Sustainability in supply chain

Unit- II

Deterministic Inventory Lot-Size Models with Time proportional demand, Deterministic Joint replenishment policy, Inventory Control of deteriorating Items (discrete and continuous), Inventory Control under Inflationary Conditions, Inventory models with stock dependent demand, Interaction of Inventory and trade credit policies, Impact of marketing policies on Inventory decisions, Joint buyer-seller inventory model

Unit- III

Constrained Network Problems, Minimum Cost Flows- Optimality and Duality, Maximum Flow Problem, Network Simplex Method, Relaxation Methods for Network Flow Problems, Multi Commodity Network Flow, Minimum Concave Cost Network Flow Problems.

Unit- IV

Stochastic processes and Markov chains (Discrete Time Markov Chains and Continuous Time Markov Chains), Characteristics of queueing systems; Little's formula, Markovian and non Markovian queueing systems, Transient

Unit- V

Generalized Convexity: Invexity and its Generalization, Optimality and Duality under invexity. Complementarity Problem: Linear Complementarity Problem (LCP), Applications of LCP, Complementary Pivot Algorithm and Its variants.

TEXT BOOKS

1. S. K. Mishra and G. Giorgi (2008), "Invexity and Optimization", Nonconvex Optimization and Its Applications, Vol. 88, Springer-Verlag
2. D. Gross and C. Harris, Fundamentals of Queueing Theory, 3rd Edition, Wiley
3. S. Chopra and P. Meindl, Supply Chain Management, Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.
4. R. K. Ahuja, T. L. Magnanti and J. B. Orlin (1993), "Network Flows: Theory, Algorithms, and Applications", Prentice Hall, Inc.

REFERENCE BOOKS

1. D. Jungnickel (2013), "Graphs, Networks and Algorithms", Fourth Edition, Algorithms and Computation in Mathematics, Springer Heidelberg.

2. J. Lee (2004), "A First Course in Combinatorial Optimization", Cambridge Texts in Applied Mathematics Cambridge University Press.

3. C. H. Papadimitriou and K. Steiglitz (1998), "Combinatorial Optimization: Algorithms and Complexity", Dover Publications Inc., N.Y. 5. Relevant Research Papers on the Selected Topics.

ADVANCED SPECIAL FUNCATIONS	
Course Code: 25MA713	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- To introduce foundational and advanced special functions used in pure and applied mathematics.
- To understand the differential and integral representations of special functions.
- To explore generalized functions such as the Meijer G-function, H-function, and I-function.
- To understand the types of incomplete special functions.
- To develop computational skills for evaluating and visualizing special functions using mathematical software.

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand the core definitions and integral forms of Gamma and Beta functions.
- Define and identify hypergeometric functions and their domains.
- Define, analyze, and apply classical and generalized special functions in theoretical and applied contexts.
- Understand incomplete and generalized forms of special functions and their applications.
- Use software tools like MATLAB/Mathematica/Maple to visualize and compute special functions.

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit – I

Gamma and Beta Functions: Definitions and elementary properties; Euler's integral representations; Legendre's duplication formula; Stirling's approximation; Recurrence relations; Mittag-Leffler function and its properties

Unit- II

Hypergeometric Functions: Generalized hypergeometric series and Gauss's hypergeometric function; Confluent hypergeometric function and its differential equation; Transformation and integral representations; Kummer's transformations; Contiguous relations

Unit- III

Generalized Special Functions: Wright function: asymptotic properties and applications; Meijer G-function and Fox H-function: definitions, properties, integral forms; Saxena's and Rathie's I-functions: motivation and comparison; Aleph-function: motivation, properties, and its properties; Yang-Yu-W and Y-function: structure and its properties

Unit- IV

Incomplete Special Functions: Incomplete Gamma, Beta, and Mittag-Leffler functions; Incomplete G, H, and I-functions; Incomplete Aleph-function; -Functions: definitions and their properties

Unit- V

Special Functions in Fractional Calculus and Applications: Role of Mittag-Leffler-type functions in fractional differential equations; Integral transforms involving special functions; Definition, properties, and applications of Srivastava Polynomials; Introduction to M-series and Generalized M- series: definitions, generating functions, and their properties; Numerical evaluation and plotting of special functions using MATLAB/Mathematica/Maple

TEXT BOOKS

1. Rainville, E. D. Special Functions. Macmillan, 1960.
2. Andrews, G. E., Askey, R., & Roy, R. Special Functions. Cambridge University Press, 1999.
3. Mathai, A. M., Saxena, R. K., & Haubold, H. J. The H-Function: Theory and applications. Springer, 2009.

REFERENCE BOOKS

1. Prudnikov, A. P., Brychkov, Y. A., & Marichev, O. I. Integrals and Series, Volume 3: More Special Functions. Gordon and Breach Science Publishers, 1990.
2. Srivastava, H. M., & Manocha, H. L. A Treatise on Generating Functions. Ellis Horwood Ltd., 1984.
3. Podlubny, I. Fractional Differential Equations: An Introduction to Fractional Derivatives, Fractional Differential Equations, to Methods of Their Solution and Some of Their Applications. Academic Press, 1998.
4. Gorenflo, R., Kilbas, A. A., Mainardi, F., & Rogosin, S. V. Mittag-Leffler Functions, Related Topics and Applications. Springer Monographs in Mathematics, 2014.

ELEMENTS OF SAMPLING THEORY	
Course Code: 25MA714	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- Understand the fundamental principles of sampling and the planning of large-scale surveys.
- Analyze the properties of estimators and identify different types of errors in survey sampling.
- Apply different sampling techniques and utilize auxiliary information for improved estimation
- Implement probability proportional to size (pps) sampling and analyze IPPS schemes.
- Utilize advanced sampling methods like two-phase sampling and resampling techniques.

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Explain the concept of design effect and evaluate its impact on survey efficiency.
- Compare unbiasedness, consistency, and efficiency of estimators and assess non-sampling errors.
- Construct ratio, regression, and product estimators using auxiliary variables in stratified and systematic sampling.
- Compute the Horvitz-Thompson estimator and its variance under different IPPS sampling designs.
- Apply jackknife and bootstrap techniques for variance estimation in complex survey designs.

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit – I

Basic Concepts in Sampling: Basic concepts of sampling, planning of large-scale sample surveys. Acquaintance with the working (questionnaire, sampling design, methods followed in field investigation, principal findings, etc.). Concept of design effect.

Unit- II

Properties of a best estimator, Unbiasedness, Bias, Consistency, Sufficiency, Efficiency, Variance, Mean square error, Relative efficiency, and Relative bias. Sample survey design, Errors in the estimators, Sampling errors, non-sampling errors: non-response errors, Measurement errors, Tabulation errors and Computational errors. Auxiliary information

Unit- III

Simple Random Sampling, Stratified Random Sampling, Systematics Random Sampling, Cluster Sampling. Use of Auxiliary Information: Ratio estimator, Product estimator, Regression estimator and Power transformation estimator. A dual of ratio estimator and General class of estimators.

Unit- IV

πps and pps sampling; Horvitz – Thompson's estimator (THE); variance of THE, its estimation and related issues; IPPS schemes of sampling due to Midzuno – Sen, Brewer, Durbin and JNK Rao (sample size 2 only).

Unit- V

Rao-Hartley-Cochran sampling scheme for sample size n with random grouping. Two – stage sampling with unequal number of second stage units. Two – phase sampling for ratio, regression, pps estimation and for stratification. Certain important classes of estimators with and without auxiliary information. Jackknife technique; bootstrap technique

TEXT BOOKS

1. W. G. Cochran, 1977, Sampling Techniques, 3rd ed.. Wiley Eastern.
2. M. N. Murthy, 1977, Sampling Theory and Methods, 2nd ed. Stat. Pub. Soc.
3. L. Kish, 1965, Survey Sampling. Wiley
4. P. Mukhopadhyay, 2000, Theory and Methods of Survey Sampling. Prentice Hall of India.
5. C. E. Sarndal, B. Swensson, J. Wretman, 1992, Model Assisted Survey Sampling. Springer – Verlag.

REFERENCE BOOKS

1. P. V. Sukhatme, B. V. Sukhatme, S. Sukhatme, C. Asok, 1984, Sampling Theory of Surveys with Applications. Iowa State University Press, Iowa.
2. Des Raj, P. Chandhok, 1999, Sample Survey Theory. Narosa Publishing House.
3. A. Chaudhari, J. W. E. Vos, 1988, Unified Theory and Strategies of Sampling. North Holland, Amsterdam.
4. S. Singh, 2003, Advanced Sampling Theory with Applications: How Michael ―Selected‖ Amy. Kluwer Academic Publishers, The Netherlands.
5. C, Wu, M.E. Thompson, 2020, Sampling theory and practice. Springer.

ADVANCED FUNCTIONAL ANALYSIS	
Course Code: MA-702	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- To familiarize with the basic tools of Advanced Functional Analysis
- To impart knowledge of Weierstrass's Approximation Theorem and its application
- To understand Contraction mapping theorem, normed and Banach algebras with identity
- To know Gelfand representation for algebras with identity
- To get the knowledge that illustrate Hilbert space and its properties

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Solve problems by using Contraction Mapping and Arzela-Ascoli theorems.
- Understand the concept of normed and Banach algebras with identity, spectrum, Resolvent function and its analyticity.
- Be familiar with Gelfand's theorem, spectral radius, and spectral mapping theorem and Gelfand representation for algebras with identity.
- Choose operator algebras as their speciality.
- Explain the concept of Bilinear Mappings, sesquilinear mappings and their properties.

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit - I

Normed spaces: Norms bounded linear operators, completeness, Contraction mapping theorem and its applications to differential equation, integral equation and system of linear equations, Equicontinuity, Arzla-Ascoli theorem and its application to differential equations.

Unit- II

Weierstrass's Approximation Theorem, Stone- Weierstrass's Approximation Theorem, Semi-Continuity and its applications to Arc length.

Unit- III

Definition of normed and Banach algebras with identity, Haar measure, Regular points and spectrum, Compactness of spectrum,Resolvent function and its analyticity in the set of regular points.

Unit- IV

Gelfand's theorem about isomorphism between Banach algebras and complex numbers, Spectral radius and the spectral mapping theorem for polynomial Ideals and Maximal ideals in commutative Banach algebras with identity, The set C(M) of complex functions on the set M of maximal ideals in a Banachalgebra,Gelfand representation for algebras with identity.

Unit- V

Hilbert space: Cauchy's inequality, Bessel's inequality, orthonormal bases, Convex sets, minimization, Riesz' theorem, adjoints, Compact sets, weak convergence, Baire's theorem, uniform boundedness Bilinear Mappings, Bounded bilinear mappings, sesquilinear mappings, Hermitian form, bounded sesquilinear mappings, bounded sesquilinear forms in Hilbert space.

TEXT BOOKS

1. Siddiqi, AbulHasan,Functional Analysis and Applications, Springer, 2018.
2. Bachman, G. and LawrerieNarici, Functional Analysis, Dover Publication, Inc., New York,2000.
3. Goffman, C. and G. Pedrick, First Course in Functional Analysis, Publication of AMS, 2017.

REFERENCE BOOKS

1. Babu Ram, Metric Spaces, Narendra Publishing House, 2005.
2.EberhardMalkowsky, Vladimir Rakočević, Advanced Functional Analysis, Taylor & Francis Group, Boca Raton, 2019.
3. G.F. Simmons, Introduction to topology and modern analysis, McGraw Hill, 1st edition, 2004.
4. Erwin Kreyszig, Introductory functional analysis, Wiley, 1st edition, 1989.

FIXED POINT THEORY	
Course Code: MA-703	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- To get the knowledge that illustrates distance functions and control functions in various spaces
- To introduce Iterative Methods for Fixed Points
- To familiarize with non-expansive mappings and its properties
- To Understand Fixed point theorem and their applications
- To develop new notions in the field as well as highlight the importance of iterative schemes in interrelated courses such as computer sciences etc

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Develop sequences of points of self-mappings in various spaces and find out fixed points of locally contractive, ε-Contractive and Contractive mappings.
- Describe iterative methods for fixed points.
- Understand the concept of non-expansive mappings, their general properties and approximation of Fixed Points.
- Use the concept of Fixed-point Theorems and Contraction mappings in PM spaces.
- Apply Brouwer's Fixed Point Theorem and Schauder's Theorem to various algebras.

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit - I

Banach contraction theorem and its extensions, namely, Computation of fixed points of locally Contractive, € -Contractive and Contractive mappings as defined by Boyd and Wong theorem, Caristi's fixed point theorem, A converse of contraction Principle, Retraction mappings.

Unit- II

Iterative Methods for Fixed Points: Demi Closed Principle, Picard iterative method, Mann iterative methods, Ishikawa iterative method, Helpern iterative method, Browder iterative method.

Unit- III

Non expansive mappings, some general properties of non-expansive mappings, Approximation of Fixed Points of non-expansive and generalized non-expansive mappings, Normal Structure, Some general properties of non-expansive mappings in Hilbert and Banach spaces, Fixed points of Pseudo Contractive, Quasi non-expansive and asymptotically non-expansive mappings.

Unit- IV

Fixed point Theorems for mappings on PM spaces, Contraction mappings in PM spaces, (€, λ) Chainable mappings Probabilistic Measure of Non-Compactness, sequence of mappings and fixed points

Unit- V

Fixed point Property, Brouwer's Fixed point Theorems and applications, Schauder's Fixed point Theorem and Consequences of Schauder'sTheorem, Schauder Tychonoff and Krsnoselkii's fixed point

TEXT BOOKS

1. Agarwal, Praveen, Jleli, Mohamed, Samet, Bessem,Fixed Point Theory in Metric Spaces Springer Singapore, 2018.
2. V.I. Istratescu, Fixed Point Theory,Vol. 7, Springer Netherlands, 1981.
3. Ravi P. Agarwal, ErdalKarapınar, DonalO'Regan, Antonio Francisco Roldan-Lopez-de- Hierro, Fixed Point Theory in Metric Type Spaces, Springer International Publishing, 2015.

REFERENCE BOOKS

1. Mohamed A. Khamsi, William A. Kirk, "An Introduction to Metric Spaces and Fixed Point Theory", John Wiley & Sons, 2011.
2. S. Almezel, Q.H. Ansari and M.A. Khamsi, Topics in Fixed Point Theory, Springer, NewYork, 2014.

FUZZY SET THEORY	
Course Code: MA-704	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- To Understand the basic concept of Fuzzy Set Theory
- To Describe Operations and Composition of Fuzzy Relations and Fuzzy matrix
- To Familiarize with Projection and Cylindrical Extension, Extension by Relation and Extension Principle.
- To Get knowledge of α- cut of Fuzzy Graph and Fuzzy Equivalence Relation
- To Learn about Operations on General Fuzzy Numbers and properties of Fuzzy Function

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Apply Fuzzy Set Theory in appropriate problems.
- Develop a fuzzy matrix and equipped with the knowledge of Fuzzy Relations.
- Use Extension Principle and understand applications of fuzzy morphism.
- Solve problems related to α- cut of Fuzzy Graph and Fuzzy Equivalence Relation.
- Well versed with the concept Operations on General Fuzzy Numbers and properties of Fuzzy Function.

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit - I

Definition of Fuzzy Set, Expanding Concepts of Fuzzy Set, Standard Operations of FuzzySet, Fuzzy Complement, Fuzzy Union, Fuzzy Intersection, Other Operations in Fuzzy Set, T- norms and T-conforms.

Unit- II

Product Set, Definition of Relation, Characteristics of Relation, Representation Methods of Relations, Operations on Relations, Path and Connectivity in Graph, Fundamental Properties, Equivalence Relation, Compatibility Relation, Pre-order Relation, Order Relation, Definition and Examples of Fuzzy Relation, Fuzzy Matrix, Operations on Fuzzy Relation, Composition of Fuzzy Relation, α - cut of Fuzzy Relation.

Unit- III

Projection and Cylindrical Extension, Extension by Relation, Extension Principle, Extension by Fuzzy Relation, Fuzzy distance between Fuzzy Sets. Graph and Fuzzy Graph, Fuzzy Graph and Fuzzy Relation, α - cut of Fuzzy Graph, Fuzzy Network, Reflexive Relation, Symmetric Relation, Transitive Relation, Transitive Closure, Fuzzy Equivalence Relation, Fuzzy Compatibility Relation, Fuzzy Pre-order Relation, Fuzzy Order Relation, Fuzzy Ordinal Relation, Dissimilitude Relation, Fuzzy Morphism, Examples of Fuzzy Morphism.

Unit- IV

Interval, Fuzzy Number, Operation of Interval, Operation of α - cut Interval, Examples of Fuzzy Number Operation, Definition of Triangular Fuzzy Number, Operation of Triangular Fuzzy Number, Operation of General Fuzzy Numbers, Approximation of Triangular Fuzzy Number, Operations of Trapezoidal Fuzzy Number, Bell Shape Fuzzy Number.

Unit- V

Function with Fuzzy Constraint, Propagation of Fuzziness by Crisp Function, Fuzzifying Function of Crisp Variable, Maximizing and Minimizing Set, Maximum Value of Crisp Function, Integration and Differentiation of Fuzzy Function.

TEXT BOOKS

1. George J. Klir / Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Theory and Applications, Pearson Education India; 1 edition, 2015.
2. Shiv Raj Singh, Fuzzy Set Theory, Krishna Prakashan, 2014.

REFERENCE BOOKS

1. Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer, International Edition, 2005.
2. H.-J. Zimmermann, Fuzzy Set Theory-and Its Applications, Springer, 4th ed. 2001, 2012.
3. John Yen, Reza Langari, Fuzzy Logic - Intelligence, Control and Information, Pearson Education, 1998.

ALGEBRAIC NUMBER THEORY	
Course Code: MA-705	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- To familiarize students with the basic concept's algebraic numbers
- To introduce algebraic number fields and related theorems
- To impart knowledge of Norm and trace of an algebraic number and Normal Extensions, Separable, Inseparable Extensions
- To provide idea about explicit construction of integral basis and discriminant of an algebraic number field
- To learn about fractional ideals and unique factorization

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand algebraic numbers and outline their interrelation.
- Understand the arithmetic of algebraic number fields.
- Prove results related to Separable and Inseparable Extensions.
- Explain the concept of explicit construction of integral basis.
- Understand ramified and unramified extensions and their related results.

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit - I

Algebraic numbers, algebraic integers, countability of sets of algebraic numbers, Liouville's theorem and generalizations, transcendental numbers.

Unit- II

Algebraic number fields, Liouville's Theorem of Primitive elements, ring of algebraic integers, Theorem of Primitive Elements, Minkowski's theorem, Four-square theorem, Minkowski's bound.

Unit- III

Norm and trace of an algebraic number, non-degeneracy of bilinear pairing, existence of an integral basis, Discriminant of an algebraic number field, Ideals in the ring of algebraic integers, Field Extensions, Automorphisms, Normal Extensions, Separable and Inseparable Extensions, the Fundamental Theorem of Galois Theory.

Unit- IV

Explicit construction of integral basis, Sign of the discriminant, cyclotomic fields, calculation for quadratic and cubic cases, Integral closure, Discriminant of an algebraic number field.

Unit- V

Noetherian ring, characterizing Dedekind domains, fractional ideals and unique factorization, g.c.d. and L.C.M. of Ideals, Chinese remainder theorem, Dedekind's theorem, ramified and unramified extensions, Different of an algebraic number field, factorization in the ring of algebraic integers.

TEXT BOOKS

1. M. Ram Murty (Author), Jody Esmonde, Problems in Algebraic Number Theory, Springer-Verlag New York Inc.; 2nd ed. 2005 edition, 2004.
2. Patrick Morandi, Field and Galois Theory, Springer, 1996.
3. Serge Lang , Algebraic Number Theory, Springer-Verlag New York Inc.; 2nd ed., 2013.

REFERENCE BOOKS

1. Harry Pollard, The Theory of Algebraic Numbers, Dover Publications Inc.; 3rd Revised edition edition, 2003.
2. Edwin Weiss, Algebraic Number Theory, Dover Publications; Unabridged edition, 2012.

OPERATIONAL RESEARCH	
Course Code: MA-706	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- To familiarize students with the basic concepts and applications models of operations research theory
- To provide understanding of linear programming problems and methods to solve them
- To impart knowledge of Transportation and Assignment Problems
- To introduce inventory control and its models
- To learn concept of Supply chain and related terms

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Apply principles of construction of mathematical models of conflicting situations and solve linear programming problems.
- Build and solve Transportation Models and Assignment Models and applications.
- Apply Techniques of PERT & CPM in real life.
- Get detailed knowledge of Inventory control.
- Equipped themselves with knowledge of Supply Chain.

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit - I

OR – Introduction – Background – Models in OR – Applications – Scope in OR.

Unit- II

Linear programming problem, Statement and formation of general linear programming problems,

Graphical method, Slack and surplus variables, Standard and matrix forms of linear programming problem, Basic feasible solution. Simplex method, artificial variables, Big – M method, Two phase method.

Unit- III

Transportation problems, Assignment problems, Goal Programming: Concept of goal programming, formulation and methodology for solution of goal programming.

Unit- IV

Inventory control of style goods and perishable items, Production planning for unreliable production systems, integrated production, quality and maintenance models. Production planning and inventory control in a fuzzy environment.

Unit- V

Supply chain – definition, decision phases, process view, Centralized supply network versus decentralized operation, Coordination, Bullwhip effect, multi-echelon supply chains, Simple models of supply chain management.

TEXT BOOKS

1. S D Sharma, Operations Research (Theory. Meth & App), Kadar Nath publication, 2012.
2. Bose D. Chandra, Inventory Management, Prentice Hall India Learning Private Limited, 1 edition, 2006.
3. Sunil Jain, Supply Chain Management, A.P.H. Publishing Corporation, 2010.

REFERENCE BOOKS

1. Eliezer Naddor, Inventory systems, John Wiley & Sons Inc; 99th ed. Edition, 1966.
2.Taha, Operations Research: An Introduction, Pearson Education India; 9 edition, 2014.

ADVANCED SAMPLING THEORY	
Course Code: MA-707	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- To familiarize students with the basic concepts of Non – sampling errors
- To provide understanding of non-response and their measures
- To impart the knowledge of Randomized response technique
- To learn about generalized regression estimators
- To introduce model-based inference from survey samples

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Well versed by the principles and theory of probability sampling.
- Know non response and their techniques.
- Apply sampling methods to more general problems in statistics.
- Identify appropriate use of imputation and implementation of imputation algorithms.
- Ability to analyze and interpret results of statistical sampling.

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit - I

Non – sampling errors: different kinds of non – sampling errors, Frame imperfections, Estimation in the presence of frame imperfections.

Unit- II

Non – response: sources of non – response, unit and item non – response and their measures, Dealing with non – response, call backs and follow – ups, sub-sampling of non – respondents, imputation techniques for unit and item non – response.

Unit- III

Randomized response technique: Warner's model, related and unrelated questionnaire models, use of binary responses, Measurement errors, nature of measurement errors, models of measurement errors for estimating population parameters, Interpenetrating sub-samples.

Unit- IV

Issues in small area estimation: preliminaries, background of domain estimation, basic estimation methods for domains, direct estimators, synthetic estimators, generalized regression estimators.

Unit- V

Model based inference from survey samples: super-population model approach, principles of inference based on theory of prediction, prediction under polynomial regression models, prediction under multiple regression models, balanced samples.

TEXT BOOKS

1.Mukhopadhyay, P.,Theory and Methods of Survey Sampling, Prentice Hall of India, 2000.
2.Sarndal, C. E., Swensson, B. and Wretman, J., Model Assisted Survey Sampling, Springer – Verlag, 1992.
3. Des Raj and Chandhok, P., Sample Survey Theory, Narosa Publishing House, 1999.
4. Chaudhari, A. and Mukerjee, R., Randomized Response: Theory and Techniques, Marcel Dekker Inc., New York, 1988.

REFERENCE BOOKS

1. Hedayat, A. S. and Sinha, B. K., Design and Inference in Finite Population Sampling, Wiley, 1991.
2. Mukhopadhyay, P., Inferential Problems in Survey Sampling, New Age International Pvt. Ltd, 1996.
3. Mukhopadhyay, P., Small Area Estimation in Survey Sampling, Narosa, 1998.

WATER WAVE THEORY	
Course Code: MA-708	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- To familiarize students with basic concepts about motion of fluids
- To develop understanding about equation of motion of a fluid
- To provide knowledge of theory of surface waves and wave terminology
- To get an idea about Wave reflection and diffraction
- To introduce linear and nonlinear diffraction theory

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand the concepts of Kinematics of Fluids in Motion.
- Learn about Equation of continuity, Equation of motion of a fluid and Navier-Stokes equation of motion.
- Find analytical solutions of wave problems and classify water waves.
- Understand wave reflection and diffraction.
- Analyze the mathematical formulation for Linear and Nonlinear diffraction problems.

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit - I

Kinematics of Fluids in Motion: Real Fluids and Ideal Fluids, Velocity of fluid at a point, Streamlines and Pathlines, Steady and Unsteady Flows, the Velocity Potential, Vorticity Vector.

Unit- II

The Equation of continuity. Equation of motion of a fluid: Pressure at a point in fluid at rest, Pressure

at a point in a moving fluid, Euler's equation of motion, Bernoulli's equation. Viscous and inviscid fluid, the Navier-Stokes equation of motion, rotational and irrational flows.

Unit- III

Theory of surface wave: Equation of Motion, Wave Terminology, Analytical solution of the wave problem, Dispersion relation of the wave motion, Classification of water waves, Particle motion and Pressure, Superposition of waves.

Unit- IV

Wave reflection and standing wave, Wave energy and group velocity, Wave Refraction, Wave Diffraction.

Unit- V

Finite amplitude waves: Mathematical formulation, Perturbation method of solution. Linear and Nonlinear diffraction theory.

TEXT BOOKS

1. M. Rahman, Water Waves: Relating Modern Theory to Advanced Engineering Applications, OUP, 1994.
2. G. B. Whitham, Linear and Nonlinear Waves, Wiley Interscience.
3. M. Isaacson and T. Sarpkaya, Mechanics of Wave Forces on Offshore Structures, Van Nostrand.

REFERENCE BOOKS

1. C. C. Mei, The Applied Dynamics of Ocean Surface Waves, World Scientific.
2. G.K. Batchelor, An Introduction to Fluid Dynamics, CUP.
3.O.M. Phillips, The Dynamics of the Upper Ocean, CUP.
4. J.J. Stoker, Water Waves, Interscience.

LINEAR PROGRAMMING PROBLEM WITH APPLICATION OF DEA	
Course Code: MA-709	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- To get the knowledge that illustrate the notion of linear programming problems and its solution.
- To introduce the duality theory and sensitivity analysis
- To familiarize with basics of data envelopment analysis (DEA)
- To extend the knowledge of DEA models and its applications
- To provide deep understanding of issues in DEA and knowledge to deal with basic software related to DEA

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Solve linear programming problems by Simplex method and understand related its theory.
- Know degeneracy and alternative optimal solutions with duality theory.
- Calculate efficiencies of organizations.
- Solve problems using various DEA models with their extensions.
- Use software to solve DEA problems.

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit - I

Linear programming problems, Mathematical formulation, Slack and surplus variables, Convex sets, graphical method for both maximization model and minimization model, graphical sensitivity analysis, Simplex method, Theory of simplex method, Big M method, two phase method, special cases in simplex method, degeneracy, alternative optima, unbounded solution, infeasible solution.

Unit- II

Definition of dual problem, Primal dual relationship, Economic interpretation of duality, dual simplex method, sensitivity analysis, changes affecting feasibility, changes affecting optimality.

Unit- III

Data Envelopment Analysis-Introduction, Basic concepts of efficiency measurement, Graphical description, Mathematical programming aspects of DEA Dual DEA models, Miscellaneous DEA models and recent developments.

Unit- IV

Dual DEA models, Miscellaneous DEA models and recent developments, Selected DEA applications, Additional Discussion on DEA.

Unit- V

Incorporating value judgements in DEA Assessment, Computer based support for DEA, Internet support for DEA, Issues in DEA.

TEXT BOOKS

1. H. A. Taha, Operations Research, Pearson Education, 9th edition, 2014.
2. S. D. Sharma, Operations Research Theory Methods & Applications, KedarNath Ram Nath Publishers, 2017.
3.R. Ramathan, An Introduction to Data Envelopment Analysis: A tool for performance Measurement, Sage Publication, 2003.

REFERENCE BOOKS

1. Emmanuel Thanassoulis, Introduction to the Theory and Application of Data Envelopment Analysis, Kluwer academic publishers,2003.
2.Karou Tone, Advances in DEA Theory and Applications: With Extensions to Forecasting Models, Wiley,2017.

TENSOR ANALYSIS AND BASIC THERMOELASTICITY	
Course Code: MA-710	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Prerequisite: Nil	

COURSE EDUCTIONAL OBJECTIVES (CEOs)

- To introduce the basic principles of elasticity and thermoelasticity
- To develop students' understanding about two-dimensional classical elasticity problems
- To get the knowledge that illustrates problems on torsion
- To make students' familiar with applications of elasticity and thermoelasticity.
- To provide a foundation for mathematical modeling for problems of science and engineering.

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand basics of elasticity in terms of stress and Strain.
- Solve compatibility equations in Cartesian coordinates and equipped with understanding of Bending of Beam, bar, disc and plate.
- Demonstrate the different problems related to torsions.
- Get knowledge of thermal stress and strain relations.
- Solve and understand Dispersion equations.

MAPPING BETWEEN COURSE EDUCTIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO / CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit - I

Analysis of Stress and Strain: Definition and notation of stress, equations of equilibrium in differential form, stress components on an arbitrary plane, equality of cross shear, stress invariants, principal stresses, octahedral stress, planes of maximum shear, stress transformation, plane state of stress Displacement field, strains in term of displacement field, infinitesimal strain at a point, engineering

shear strains, strain invariants, principal strains, octahedral strains, plane state of strain, compatibility equations, strain transformation.

Unit- II

Two-Dimensional classical elasticity Problems: Cartesian coordinates- Relation between plane stress and plane strain, stress functions for plane stress and plane strain state, Airy's stress functions, Investigation of Airy's stress function for simple beams, bending of a narrow cantilever beam of rectangular cross section under edge load. Bending of a simply supported beam under UDL. General equations in polar coordinates, stress distribution symmetrical about an axis, Thick wall cylinder subjected to internal and external pressures.

Unit- III

Axisymmetric and Torsion problems: Stresses in rotating discs of uniform thickness and cylinders. Torsion of circular, elliptical and triangular bars, Prandtl's membrane analogy, torsion of thin walled thin tubes, torsion of thin walled multiple cell closed sections.

Unit- IV

Thermal stress and Elastic stability: Thermo elastic stress strain relations, equations of equilibrium, thermal stresses in thin circular discs and in long circular cylinders. Euler's column buckling load: clamped-free, clamped-hinged, clamped-clamped and pin-ended.

Unit- V

Thermo elasticity: Constitutive equations of thermos elasticity. Energy equation. Coupled parabolic heat transport equation. Displacement equation of motion. Basic equations of dynamic coupled thermoelasticity. Non-dimensional form Generalized thermoelasticity (statement only). Wave-type heat transport equation (No deduction). Basic equations. Propagation of plane waves in a thermos elastic medium (one-dimensional deformation). Dispersion equation.

TEXT BOOKS

1. I. S. Sokolnikoff, Tensor Analysis, Theory and application to geometry and mechanics of continua. John Wiley, (Second edition), 1964.
2. B. Spain, Tensor calculus, A concise course, Dover Publication, 1965.

REFERENCE BOOKS

1. W. Nowacki, Thermoelasticity, Pergamon Press, pwn-polish scietific publishers (2nd edition), 1986.
2. R. S. Dhaliwal and A. Singh, Dynamic Coupled Thermoelasticity, Hindustan Pub. Corporation, New Delhi, India, 1980.