COURSE CODE	COURSE TITLE	L	T	P	C
60192MA101	THEORY OF PROBABILITY	3	0	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble:

The aim of this course is to introduce the fundamentals of Probability Theory. Emphasis will be laid on laws of large numbers.

b. Prerequisite Courses:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Measure and Integration, Combinatorics

d. Course Educational Objectives:

The purpose of this course is to train the students in various probability distributions.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Understand the random variables, axioms of probability and distribution functions	K3
CO2	Familiarize with the parameters of the distribution	K3
CO3	Appreciate the properties of characteristic function	K3
CO4	Know certain special probability distributions	K3
CO5	Learn the law of large numbers	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**H**	**M**		**M**	**H**				**M**	**M**
CO2	**H**	**H**	**H**	**M**		**M**	**M**				**M**	**M**
CO3	**H**	**H**	**M**	**H**		**H**	**M**				**M**	**M**
CO4	**H**	**H**	**M**	**H**		**M**	**M**				**M**	**M**
CO5	**H**	**H**	**H**	**M**		**H**	**M**				**M**	**M**

H – High; M – Medium; L - Lo

g. Course Content

UNIT I Probability

Random experiment – Definition of various terms – Mathematical Definition of probability – Statistical definition of probability – Axioms on probability – Addition theorem – Multiplication theorem – Boole's Inequality – Bayes theorem – Problems.

UNIT II Random Variables and Distribution Function

Random variable – Distribution function: Discrete random variable – Probability mass function – Probability Distribution – Distribution function – Mathematical Expectation – Expectation of a sum of random variables – Expectation of a product of independent random variable – Correlation coefficient – Problems.

UNIT III Mathematical Expectation and Generating Function

Moment Generating function – Characteristic function – properties – Characteristic function and moments – Uniqueness Theorem – Inversion theorem – Probability Generating function – Chebyshev Inequality – Weak law of Large numbers – Central limit theorem's: De moivre's Laplace theorem – Lindeberg Levy theorem – Markoff's theorem – Khintchin's theorem – Borel-Cintelli lemma.

UNIT IV Discrete Distribution

Discrete Distribution: Uniform distribution – Bernoulli and Binomial distribution – Hypergeometric distribution – Poisson distribution – Geometric and Negative Binomial distribution.

UNIT V Continuous Distribution

Continuous Distribution: Uniform distribution – Normal distribution – Exponential distribution – Gamma and Beta distribution – Weibull distribution.

Learning Resources

i. Text book:

1. Peyton J. Peebles, Probability, Random Variables and Random Signal Principles, 3rd Edition, John Wiley, 1984.
2. V. Sundarapandian, Probability, Statistics and Queuing Theory, PHI Learning, 2009.

ii. Reference Books

1. R.B. Ash, Real Analysis and Probability, Academic Press, New York, **1972**
2. B.R.Bhat , Modern Probability Theory, 3rd Edition, New Age International (P) Ltd, New Delhi, **1999**
3. P. Billingsley, Probability and Measure, John Wiley, **1985**.
4. K.L.Chung, A Course in Probability, Academic Press, New York, **1974**.
5. R.Durrett, Probability Theory and Examples, 2nd Edition, Duxbury Press, New York, **1996**.
6. J. Jacod and P. Protter, Probability Essentials, Universitext, Springer-Verlag, **2003**.
7. K.R. Parthasarathy, Introduction to Probability and measure, Texts and Readings in Mathematics 22, Hindustan Book Agency, **2002**.
8. V.K.Rohatgi, An Introduction to Probability Theory and Mathematical Statistics, 3rd Print, Wiley Eastern Ltd., New Delhi, **1988.**
9. J.P. Romano and A.F. Siegel, Counter Examples in Probability and Statistics, Wadsworth and Brooks / Cole Advanced Books and Software, California, **1968**.

iii. **Online Resources**:

1. https://www.stat.pitt.edu/stoffer/tsa3/intro_prob.pdf
2. http://wwwf.imperial.ac.uk/~ayoung/m2s1/M2S12011.PDF
3. http://www.iitg.ac.in/budhaditya.hazra/CE-513-2017/Fundamentals_of_probability.pdf
4. https://warwick.ac.uk/fac/sci/mathsys/courses/msc/ma930/resources/adam_johansen_lecture_notes.pdf
5. http://www.stat.umn.edu/geyer/f11/5101/notes/n1.pdf
6. https://inis.iaea.org/collection/NCLCollectionStore/_Public/16/062/16062019.pdf?r=1&r=1
7. http://people.missouristate.edu/songfengzheng/Teaching/MTH541/Lecture%20notes/MLE.pdf
8. https://ocw.mit.edu/courses/mathematics/18-05-introduction-to-probability-and-statistics-spring-2014/readings/MIT18_05S14_Reading10b.pdf
9. https://www2.stat.duke.edu/courses/Spring02/sta103/lec/ch9_4.pdf
10. https://web.stanford.edu/class/cs109/lectureNotes/21%20-%20MLE.pdf
11. https://ocw.mit.edu/courses/mathematics/18-443-statistics-for-applications-fall-2006/lecture-notes/lecture2.pdf
12. http://www.cs.cornell.edu/courses/cs321/2005fa/HW%20Solutions/solutions6.pdf
13. http://statweb.stanford.edu/~susan/courses/s200/lectures/lect11.pdf
14. https://newonlinecourses.science.psu.edu/stat414/node/191/
15. https://www.stat.washington.edu/thompson/S341_10/Notes/week6.pdf

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA102	CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble:

The aim of this course is to introduce the fundamentals of Calculus of Variations and Integral Equations. Emphasis will be on optimization, Green's function and Fredholm equations

b. Prerequisite Courses:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Topology

d. Course Educational Objectives:

This subject is to develop the mathematical methods of applied mathematics and mathematical physics with an emphasis on calculus of variations and integral transforms.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Determine the maxima and minima of functions using calculus of variations	K3
CO2	Deal with constraints by employing Lagrange multiplier	K3
CO3	Familiarize with integral equations	K3
CO4	Understand Fredholm equations	K3
CO5	Know Hilbert – Schmidt theory	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO2	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO3	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO4	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO5	**H**	**H**	**M**	**M**		**M**	**M**					**M**

H – High; M – Medium; L - Low

g. Course Content

Unit I Calculus of variations: Concepts, Problems and Examples

Functionals, Euler's equation – Different forms of Euler's equations, Solutions of Euler's equation – Geometrical problems. Calculus of Variations and Applications: Maxima and Minima - The Simplest case - Illustrative examples-Natural boundary conditions and transition conditions – The variational notation.

Unit II Methods of solving problems

Constraints and Lagrange multipliers, Isoperimetric problems -Variable end points - Sturm-Liouville problems -Hamilton's principle-Lagrange's equations, Approximate solution of boundary value problems –Rayleigh-Ritz method, Galerkin method.

Integral Equations

Unit III Integral Equations: Concepts

Integral Equations: Introduction – Relations between differential and integral equations – The Green's function.

Unit IV Linear equations

Linear equation in cause and effect: The influence function – Fredholm equations with separable kernels – Illustrative example.

Unit V Theories of integral equations

Hilbert – Schmidt theory – Iterative methods for solving equations of the second kind – Fredholm theory.

h. Learning Resources:

i. Text Book:

1. F.B. Hildebrand, Methods of Applied Mathematics, 2nd Edition, Prentice Hall of India Private Limited, New Delhi, **1972.**

ii. Reference Books

1. L. Elsgolts, Differential Equations and the Calculus of Variations, Mir Publishers, Moscow, **1970.**
2. I.M. Gelfand and S.V.Fomin, Calculus of Variations, Dover Publications, **2000**.
3. A.S. Gupta, Calculus of Variations with Applications, Prentice-Hall of India, **2008.**
4. R. P.Kanwal, Linear Integral Equations Theory and Practice, Academic Press, **1971**.
5. M.L.Krasnov, G.I.Makarenko and A.I. Kiselev, Problems and Exercises in the Calculus of Variations, MIR Publishers, Moscow, **1975**
6. Dr. M. K. Venkataraman, Higher Engineering Mathematics, National Publishing Company,**2012**.
7. W.V.Lovitt, Linear Integral Equations, Dover Publications, New York, **1950**.
8. S.J. Mikhlin, Linear Integral Equations (Translated from Russian), Hindustan Book Agency, **1960.**
9. B.L.Moiseiwitsch, Integral Equations, Longman, **1977**
10. W.Pogovzelski, Integral Equations and their Applications, Vol - I; Pergamon Press, Oxford, **1966.**
11. Porter and Stirling, Integral Equations, A Practical Treatment from Spectral Theory to Applications, Cambridge University Press, Cambridge, **1996**.
12. M.Rahman, Integral Equations and Their Applications, WIT Press, Southampton, UK, **2007**
13. I.N. Snedden, Mixed Boundary Value Problems in Potential Theory, North Holland, **1966**.
14. F.G.Tricomi, Integral Equations; Wiley, New York, **1957**.

iii. **Online Resources:**

1. http://www.math.uni-leipzig.de/~miersemann/variabook.pdf
2. https://www.iith.ac.in/~ashok/Maths_Lectures/TutorialB/Maths_Book.pdf
3. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.393.143&rep=rep1&type=pdf
4. https://nptel.ac.in/courses/111107103/6
   http://www.umiacs.umd.edu/~stewart/FHS.pdf

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA103	FLUID MECHANICS	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble

The aim of this course is to introduce a branch of mechanics called Fluid Mechanics dealing with the analysis of the kinematics and the mechanical behaviour of fluids.

b. Prerequisite Courses:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Real Analysis
Complex Analysis
Ordinary Differential Equations
Partial Differential Equations

d. Course Educational Objectives:

This course seeks to introduce to the students certain topics in fluid mechanics for applications in practical problems. The students will be equipped with knowledge of the fundamental concepts of fluid mechanics, with emphasis on areas of applications. .

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Understand the basic principles of fluid mechanics	K3
CO2	Use Euler and Bernoulli's equations for motion of a fluid	K3
CO3	Learn the Stream function and complex potential for two-dimensional flows and irrotational, incompressible flows	K3
CO4	Know hydrodynamical aspects of conformal mapping	K3
CO5	Appreciate Navier-Stokes equations of motion	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO2	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO3	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO4	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO5	**H**	**H**	**M**	**M**		**M**	**M**					**M**

H – High; M – Medium; L - Low

g. Course Content

Unit-I Kinematics of fluids in motion

Real and Ideal fluids – Velocity - Acceleration – Streamlines – Pathlines – Steady & unsteady flows – Velocity potential – Vorticity vector – Local and particle rates of change – Equation of continuity – Conditions at a rigid boundary.

Unit-II Equations of motion of a fluid

Pressure at a point in a fluid – Boundary conditions of two inviscid immiscible fluids – Euler's equations of motion – Bernoulli's equation – Some potential theorems – Flows involving axial symmetry.

Unit-III Two dimensional flows

Two-Dimensional flows – Use of cylindrical polar co-ordinates – Stream function, complex potential for two-dimensional flows, irrotational, incompressible flow – Complex potential for standard two-dimensional flows –Two dimensional image systems – Milne-Thomson circle theorem – Theorem of Blasius.

Unit-IV Conformal transformation and its applications

Applications of conformal transformations – Hydrodynamical aspects of conformal mapping - Schwarz Christoffel transformation – Vortex rows.

Unit-V Viscous flows

Stress – Rate of strain – Stress analysis – Relation between stress and rate of strain – Coefficient of viscosity – Laminar flow – Navier-Stokes equations of motion – Some problems in viscous flow.

h. Learning Resources:

i. **Text book**:

Treatment and Content as in:

1. F.Chorlton, Textbook of Fluid Dynamics, CBS Publishers, New Delhi, **1985**.

Sections: 2.1 - 2.10, 3.1 – 3.9, 5.1 – 5.12, 8.1 – 8.10, 8.15

ii. Reference books:

1. T. Allen and I. L. Ditsworth, Fluid Mechanics, McGraw Hill, New York, **1972**
2. G.K.Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press, Cambridge, **1993**.
3. I. G. Currie, Fundamentals of Mechanics of Fluids, CRC Press, **2002**
4. R. W. Fox, A. T. McDonald and P. J. Pritchard, Introduction to Fluid Mechanics, John Wiley and Sons Private. Ltd., **2003**
5. E.Krause, Fluid Mechanics with Problems and Solutions, Springer Verlag, New York, **2005**.
6. B.S.Massey, J.W.Smith and A.J.W.Smith, Mechanics of Fluids, Taylor and Francis, New York, **2005**
7. P.Orlandi, Fluid Flow Phenomena, Kluwer, New York, **2002**.
8. T.Petrila, Basics of Fluid Mechanics and Introduction to Computational Fluid Dynamics, Springer, Berlin, **2004.**
9. L.M.M.Thomson, Theoretical Hydrodynamics, Macmillan, **1967**.
10. Chia-Shun Yeh, Fluid Mechanics: An Introduction to the Theory, McGraw Hill, **1974**
11. S. W. Yuan, Foundations of Fluid Mechanics, Prentice-Hall of India, 1988.
12. F.M.White, Viscous Fluid Flow, Mc Graw-Hill, New York, **1991**.
13. F.M.White, Fluid Mechanics, Mc Graw-Hill, New York, **2000**.

iii. **Online Resources:**

1. https://user.engineering.uiowa.edu/~fluids/Posting/Lecture_Notes/Chapter4.pdf
2. http://fluid.itcmp.pwr.wroc.pl/~znmp/dydaktyka/fundam_FM/Lecture9_10.pdf
3. https://www.youtube.com/watch?v=-Eas42UZ32s
4. http://www.iaeng.org/publication/WCE2012/WCE2012_pp204-209.pdf
   https://courses.maths.ox.ac.uk/node/view_material/36405

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA104	GRAPH THEORY	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble

The aim of this course is to introduce the fundamentals of graph theory. Emphasis will be laid on trees, cut sets and planar graphs.

b. Prerequisite Courses:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Discrete Mathematics
Number Theory
Combinatorics

d. Course Educational Objectives:

The students would be able to understand the structural complexity of various graph structures and related research problems as well as their applications in real world problems. The students will also be able to understand the algorithmic aspects of the graph structures and graph parameters.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Understand the basic concepts of Graph Theory	K3
CO2	Familiarize with Trees and their properties	K3
CO3	Learn connectivity and separability in graphs	K3
CO4	Know Planar graphs	K3
CO5	Apply matrices in Graph Theory	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**			**M**						**M**
CO2	**H**	**H**	**M**			**M**						**M**
CO3	**H**	**H**	**M**			**M**						**M**
CO4	**H**	**H**	**M**			**M**						**M**
CO5	**H**	**H**	**M**			**M**						**M**

H – High; M – Medium; L - Low

g. Course Content

Unit-I Basic concepts in graph theory

Graphs – degrees – Isomorphism – sub-graphs – Walks, paths, Circuits - connected graphs – components – Euler graphs – Operations on graphs – Hamiltonian paths and circuits – Traveling Salesman Problem

Unit-II Trees

Trees – some properties of trees – pendant vertices in a tree – distance and centers in a tree – Rooted and binary trees – On counting trees – Spanning trees – Fundamental circuits – finding all spanning trees of graph – spanning trees in a weighted graph - Prims and Kruskal's algorithm.

Unit-III Cut sets and connectivity

Cut sets – some properties of a cutest – All cut sets in a graph – Fundamental circuits and cut sets – connectivity and separability – Network flows – Isomorphism.

Unit – IV Planar graphs

Planar graphs – Kuratowski's two graphs – Different representations of a planar graph – Detection of planarity

Unit-V Matrices in graph theory

Incidence matrix – Sub matrices - Circuit matrix – Fundamental Circuit matrix and rank – An application to a switching network – Cut set matrix – Relationships – path matrix .

h. Learning Resources

h. Text book:

1. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall of India Private Limited, New Delhi, **2004**

Unit – I – Chapters 1 and 2 in which Sections (1.2),(1.6) and (2.3) are omitted
Unit – II - Chapter 3
Unit – III - Chapter 4
Unit – IV - Chapter 5 Sections 5.2 – 5.5
Unit – V - Chapter 7.

ii. Reference books:

1. Balakrishnan R. and Ranganathan K, A Text Book of Graph Theory, Springer- Verlag, **2012.**
2. J. A. Bondy and U. S. R. Murty ,GRAPH THEORY WITH APPLICATIONS, Elsevier Science Publishing Co.., Inc, 1982.
3. S. Arumugam , Invitation to Graph Theory, Scitech Publications (India) Pvt Ltd, 2006.
4. F. Harary, Graph Theory, Addison Wesley, **1969**
5. C.L.Liu, Elements of Discrete Mathematics, McGraw Hill Book Company, 2nd Edition, **1986**
6. R. Johnson baurgh, Discrete Mathematics, **1989**
7. L.R. Foulds, Graph Theory Applications, Narosa Publishing House, New Delhi

iii. Online Resources:

1. https://en.wikipedia.org › wiki › Seven_Bridges_of_Königsberg
2. https://www.gatevidyalay.com › konigsberg-bridge-problem
3. https://www.britannica.com › science › Konigsberg-bridge-problem5.
4. https://en.wikipedia.org › wiki › Graph_theory
5. https://www.geeksforgeeks.org › mathematics-graph-theory-basics-set-1
6. .https://www.geeksforgeeks.org › mathematics-graph-theory-basics
7. https://medium.com › basecs › a-gentle-introduction-to-graph-theory-7796.
8. https://brilliant.org › wiki › graph-theory
9. https://www.britannica.com › topic › graph-theory
10. https://www.tutorialspoint.com › graph_theory
11. https://www.tutorialspoint.com › graph_theory › types_of_graphs
12. https://towardsdatascience.com › graph-theory-132122ac38f2
13. https://www.hackerearth.com › practice › notes › graph-theory-part-i
14. https://primes.utm.edu › graph › glossary
15. https://whatis.techtarget.com › definition › graph-theory

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA105	FUZZY SET THEORY	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble

The aim of this course is to provide the fundamentals of fuzzy logic. The students will learn the uncertainty environment through the fuzzy sets that incorporate imprecision and subjectivity into the model formulation and solution process. Emphasis will be laid on operations on fuzzy sets, fuzzy arithmetic and fuzzy relations.

b. **Prerequisite Courses**:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Topology, Discrete mathematics

d. Course Educational Objectives:

To train the students in the usage of fuzzy logic based methodology in problems of decision making.

e. **Course Outcomes:**

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Distinguish between crisp sets and Fuzzy sets	K3
CO2	Understand the operations on fuzzy numbers	K3
CO3	Learn fuzzy arithmetic and operations on intervals	K3
CO4	Know crisp and fuzzy relations	K3
CO5	Solve equations involving fuzzy relations	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**			**M**							**M**
CO2	**H**	**H**			**M**							**M**
CO3	**H**	**H**			**M**							**M**
CO4	**H**	**H**			**M**							**M**
CO5	**H**	**H**			**M**							**M**

H – High; M – Medium; L – Low

g. Course Content

Unit - I Fuzzy sets vs Crisp sets

Fuzzy sets-Basic types - Basic concepts of Fuzzy sets - Additional properties of α-cuts - Representations of fuzzy sets - Extension principle for fuzzy sets.

Unit - II Operations on Fuzzy sets

Types of operations - Fuzzy complements - Fuzzy intersections - t-norms - Fuzzy unions - t- co-norms - Combinations of operations.

Unit - III Fuzzy Arithmetic

Fuzzy numbers - Linguistic variables - Arithmetic operations on Intervals - Arithmetic operations on fuzzy numbers.

Unit - IV Fuzzy Relations

Crisp and fuzzy relations - Projections and cylindric extensions - Binary fuzzy relations - Binary relations on a single set - Fuzzy equivalence relations - Fuzzy compatibility relations - Fuzzy ordering relations - Sup-i composition and inf-w_i composition of Fuzzy relations.

Unit - V Fuzzy Relation Equations

Partition - Solution method - Fuzzy relation equations based on sup-i compositions and inf-w_i compositions.

h. Learning Resources:

i. Text book:

J.K.George and B.Yuan, Fuzzy Sets and Fuzzy Logic, Theory and Applications, Prentice Hall of India Pvt. Ltd., New Delhi, **2010**.

ii. Reference books:

1. D.Dubois and H.Prade, Fuzzy Sets and Systems, Theory and Applications, Academic Press, New York,**1980**.
2. A.Kaufmann, Introduction to the Theory of Fuzzy Subsets, Vol. I, Fundamental Theoretical Elements, Academic Press, New York,**1975**.
3. M.Ganesh, Introduction to Fuzzy Sets and Fuzzy Logic, Prentice Hall of India Pvt. Ltd., New Delhi, **2009.**

iii**. Online Resources:**

1. https://en.wikipedia.org › wiki › Fuzzy_logic
2. https://www.geeksforgeeks.org › fuzzy-logic-introduction
3. https://searchenterpriseai.techtarget.com › definition › fuzzy-logic
4. https://www.guru99.com › what-is-fuzzy-logic
5. https://www.mathworks.com › ... › Fuzzy Inference System Modeling
6. https://www.sciencedirect.com › topics › computer-science › fuzzy-logic
7. https://www.investopedia.com › terms › fuzzy-logic
8. www.scholarpedia.org › article › Fuzzy_sets
9. https://en.wikipedia.org › wiki › Fuzzy_set
10. https://www.geeksforgeeks.org › fuzzy-logic-set-2-classical-fuzzy-sets
11. https://www.tutorialspoint.com › fuzzy_logic › fuzzy_logic_set_theory
12. www.sjsu.edu › faculty › watkins › fuzzysets
13. https://www.sciencedirect.com › topics › engineering › fuzzy-set-theory
14. https://www.tutorialspoint.com › fuzzy_logic › fuzzy_logic_membership_f.
15. https://www.tutorialspoint.com › fuzzy_logic › fuzzy_logic_set_theory

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA106	DISCRETE MATHEMATICS	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble

The aim of this course is to provide logical and analytical ability to the students to deal with the generality and abstraction of mathematical principles. Emphasis will be laid on the fundamentals of counting and combinatorial methods and Boolean Algebra.

b. **Prerequisite Courses**:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Fuzzy Set Theory
Graph Theory
Number Theory
Combinatorics

d. Course Educational Objectives:

The students would be able to validate the logical arguments and understand the generalization and abstract of Mathematical concepts would be able to apply and the combinatorial methods, Boolean optimization methods to solve mathematical as well as computer science problems.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Validate the logical arguments	K3
CO2	Implement algorithms of integers	K3
CO3	Apply the counting principle	K3
CO4	Solve the problems involving recurrence relations	K3
CO5	Use Boolean algebra to solve the minimization problem of circuits.	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**										**M**
CO2	**H**	**H**										**M**
CO3	**H**	**H**										**M**
CO4	**H**	**H**										**M**
CO5	**H**	**H**										**M**

H – High; M – Medium; L - Low

g. Course Content

UNIT - I Logic

Propositions - Implications - Equivalence - Normal Forms - Predicates and Quantifiers - Nested Quantifiers - Methods of Proof - Mathematical Induction.

UNIT - II Algorithms for Integers

The Integers and Division - Integers and Algorithms - Applications of Number Theory.

UNIT - III Counting Principle

The Basis of Counting - The Pigeonhole Principle - Permutations and Combinations - Binomial Coefficients - Generalized Permutations and Combinations - Generating Permutations and Combinations - Inclusion - Exclusion - Applications of Inclusion - Exclusion.

UNIT - IV Recurrence Relations

Solving Recurrence Relations - Divide-and-Conquer Algorithms and Recurrence Relations Generating Functions.

UNIT - V Boolean Algebra

Boolean Functions - Representing Boolean Functions - Logic Gates - Minimization of Circuits.

h. Learning Resources:

i. Text Book:

1. Rosen K.H., Discrete Mathematics and its Applications, 7th Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, **2011.**

ii. Reference books:

1. R.P.Grimaldi, Discrete and Combinatorial Mathematics: An Applied Introduction, Pearson Education Asia, Delhi, **2002.**
2. Jean-Paul Tremblay and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, Tata McGraw-Hill Education, 2008.
3. B.Kolman, R.C.Busby, and S.C.Ross, Discrete Mathematical Structures, Pearson Education Pvt. Ltd, New Delhi, **2003**
4. C.L.Liu, Elements of Discrete Mathematics, Mc Graw Hill Book Company, New York, **1985.**
5. Scheincreman E.R., Mathematics – A Discrete Introduction, Brooks/Cole: Thomson Asia Pvt. Ltd., Singapore, **2013.**
6. Wiitala, Discrete Mathematics: A unified Approach, Mc Graw Hill Book Company. New York.

iii. Online Resources:

1. https://www.javatpoint.com/discrete-mathematics-tutorial
2. http://www.cs.columbia.edu/~abishek/files/DM-Ch3.pdf
3. https://www.varsitytutors.com/hotmath/hotmath_help/topics/fundamental-counting-principle
4. https://www.toppr.com/bytes/boolean-algebra/
5. www.tutorialspoint.com › discrete_mathematics › boolean_expression
6. www.wisdomjobs.com › ... › Discrete Mathematics
7. www.javatpoint.com › discrete-mathematics-boolean-algebra

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA107	NUMBER THEORY	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble

The aim of this course is to introduce the properties of natural numbers. Emphasis will be laid on the Quadratic characters of natural numbers, Arithmetic functions and Diophantine equations.

b. Prerequisite Courses:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Graph Theory
Discrete Mathematics
Combinatorics
Cryptography

d. Course Educational Objectives:

The students will be introduced to Quadratic Residues and reciprocity.
The students will be able to solve some Diophantine equations and some special cases of Fermat's Last theorem.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Apply the algorithms of divisibility of integers	K3
CO2	Employ congruence relation to solve problems	K3
CO3	Identify the quadratic character of natural numbers	K3
CO4	Evaluate different arithmetic functions	K3
CO5	Understand the methods of solving different Diophantine equations	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**									**M**
CO2	**H**	**H**	**M**									**M**
CO3	**H**	**H**	**M**									**M**
CO4	**H**	**H**	**M**									**M**
CO5	**H**	**H**	**M**									**M**

H – High; M – Medium; L - Low

g. Course Content

Unit-I Divisibility

Divisibility: Introduction - Divisibility - Primes.

Unit-II Congruences

Congruences - Solution of Congruences - Congruences of higher degree - Prime power moduli - Prime Modulus - Congruences of degree two, prime modulus - Power residues - Number theory from an algebraic view point Multiplicative groups, rings and fields.

Unit-III Quadratic Reciprocity

Quadratic Reciprocity: Quadratic Residues - Quadratic Reciprocity - The Jacobi Symbol.

Unit-IV Arithmetic Functions

Some functions of Number Theory: Greatest Integer function - Arithmetic function s - The Moebius Inversion Formula - Multiplication of arithmetic functions – Recurrence functions.

Unit-V Diophantine Equations

Some Diophantine Equations: The equation $ax+by = c$ - Positive Solutions - Other linear equations - The equation $x^2 + y^2 = z^2$ - The Equation $x^4 + y^4 = z^2$ - Sum of fourth powers - Sum of two squares - The equation $4x^2 + y^2 = n$.

h. Learning Resources

i. **Text book**:

Treatment and Content as in:

1. I.Niven and S.Zuckerman, An Introduction to the Theory of Numbers, John Wiley, New York, **2000**

Chapter 1: Sections 1.1 – 1.3
Chapter 2: Sections 2.1 - 2.11
Chapter 3: Sections 3.1 – 3.3
Chapter 4: Sections 4.1 – 4.5
Chapter 5: Sections 5.1 - 5.6, 5.10 and 5.11

ii. Reference Books:

1. T.M.Apostol, An Introduction to Analytic Number Theory, Narosa Publishing House, New Delhi, **1998**
2. D.M.Burton, Elementary Number Theory, Brown Publishers, Iowa,**1989**
3. G.H.Hardy and E.M Wright, An Introduction to the Theory of Numbers, The English Language Book Society and Oxford University Press
4. K.Ireland and M.Rosen, A Classical Introduction to Modern Number Theory, Springer Verlag, **1972**
5. K.H. Rosen; Elementary Number Theory & Its Applications, 3rd Edition, AT&T Bell Laboratories, Addition Wesley Publishing Company.
6. S. G. Telang, Number Theory, Tata Mac Graw Hill
7. S.Y.Yan, Number Theory for Computing, Springer, 2nd Edition, **2000**

iii. **Online Resources**:

1. webmaster@numbertheory.org
2. mathforum.org/library/drmath/sets/college_number_theory.html
3. https://www.toppr.com/guides/maths/...numbers/properties-of-whole-natural-numbers/
4. https://www.factmonster.com/.../prime-numbers-facts-examples-table-of-all-up-to-1000
5. https://www.khanacademy.org › ... › Journey into cryptography › Modular arithmetic
6. https://crypto.stanford.edu/pbc/notes/numbertheory/quadrecip.html
7. https:/crypto.stanford.edu/pbc/notes/numbertheory/qr.html
8. https://ww.bookdepository.com/Quadratic-Residues-Non-Residues.../978331945954...
9. https://www.sringer.com/in/book/9783319459547
10. https://www.encyclopediaofmath.org/index.php/Arithmetic_function
11. https://primes.utm.edu/lossary/page.php?sort=EulersPhi
12. https://www.encyclopediaofmath.org/index.php/Möbius_function
13. https://artofproblemsolving.com/wiki/index.php/Diophantine_equation
14. https://artofproblemsolving.com/wiki/index.php/Pythagorean_triple
15. primes.utm.edu/glossary/xpage/PrmPythagTriples.html

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA108	COMBINATORICS	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble

Combinatorics deals with the existence of certain configurations in a structure and when it exists, it counts the number of such configurations. In this course, the students will be introduced to the basic concepts such as Permutations and Combinations, Generating Functions, Recurrence Relations, The Principle of Inclusion and Exclusion, Ramsey theory, etc.

b. Prerequisite Courses:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Graph Theory
Discrete Mathematics
Number Theory

d. Course Educational Objectives:

The objective of this course is to improve the mathematical proof writing skills and the problem-solving skills of the students through different combinatorial techniques.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Learn the technique of generating Permutations and Combinations	K3
CO2	Understand generating function models	K3
CO3	Identify solutions by the technique of Generating Functions and Recurrence Relations	K3
CO4	Know the inclusion-exclusion principle	K3
CO5	Appreciate Ramsey theory and its applications	K3

a. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**									**M**
CO2	**H**	**H**	**M**									**M**
CO3	**H**	**H**	**M**									**M**
CO4	**H**	**H**	**M**									**M**
CO5	**H**	**H**	**M**									**M**

H – High; M – Medium; L - Low

g. Course Content

Unit-I Counting principle

Counting Methods for selections arrangements: Basic counting principles, simple arrangements and selections, arrangements and selection with repetition, distributions, binomial, generating permutations and combinations and programming projects.

Unit-II Generating functions

Generating function: Generating function models, calculating of generating functions, partitions exponential generating functions, a summation method.

Unit-III Recurrence Relations

Recurrence Relations: Recurrence relation model, divide and conquer relations, solution of inhomogeneous recurrence relation, solution with generating functions.

Unit-IV Inclusion-exclusion

Inclusion-exclusion: Counting with Venn diagrams - inclusion formula, restricted positions and rook polynomials.

Unit-V Ramsey Theory

Ramsey Theory - Ramsey theorem - Applications to geometrical problems.

h. **Learning Resources**

i. Text books:

1. A.Tucker, Applied Combinatorics, 3rd Edition, John Wiley & Sons, New York, **1995.**
2. V. Krishnamurthy, Combinatorial Theory and Applications, East West Press, New Delhi, **1989**.

ii. Reference Books:

1. M. Aigner, A course in Enumeration, Springer.
2. C.Berge, Principles of Combinatorics**,** Academic Press**,** New York**, 1972.**
3. C.L.Liu, Introduction to Combinatorial Mathematics, Mc Graw – Hill, New York, **1968**.
4. F. Roberts and B. Tesman: Applied Combinatorics. Pearson Education, **2005.**
5. R.P.Stanley, Enumerative Combinatorics, Vol. 1, Wadsworth and Brooks/Cole, **1986**

iii. **Online Resources:**

1. www.cetking.com › Cetking-Permutation-Combination-Basic-handout
2. https://www.stat.auckland.ac.nz › ~fewster › notes
3. www.maths.surrey.ac.uk › hosted-sites › R.Knott › Fibonacci › LRGF
4. https://wikivisually.com › wiki › Inclusion–exclusion_principle
5. https://www.whitman.edu › Documents › Academics › Mathematics › Barton

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
60192MA109	**REPRESENTATION THEORY OF FINITE GROUPS**	**2**	**2**	**0**	**3**

Course Category: PROGRAMME ELECTIVE

a. Preamble

The aim of this course is to introduce the fundamentals of representations of finite groups. Emphasis will be laid on the Wedderburn structure theorems, the generalized Burnside theorem and the theory of characters.

b. Prerequisite Courses:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Number Theory

c. Course Educational Objectives:

Representation is an important approach in mathematics. The course seeks to introduce to the students the basic ideas of representation theory of finite groups and equip them with the modern tools such as group characters, radical of a ring, the group algebra, etc.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Learn the fundamental concepts of representation theory of finite groups	K3
CO2	Know the principle of indecomposable representations	K3
CO3	Appreciate the generalized Burnside theorem	K3
CO4	Understand the module of characters over the integers	K3
CO5	Learn the applications of the theory of characters	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**										**M**
CO2	**H**	**H**										**M**
CO3	**H**	**H**										**M**
CO4	**H**	**H**										**M**
CO5	**H**	**H**										**M**

H – High; M – Medium; L - Low

g. Course Content

Unit I Group characters

Foundations - Introduction – Group characters – Representation modules – Regular representation. Representation theory of rings with identity: Some fundamental lemmas.

Unit II Semi-simple rings

The principle of indecomposable representations – The radical of a ring – Semi-simple rings – The Wedderburn structure theorems for semi-simple rings – Interwining numbers.

Unit III Group algebra

Multiplicities of the indecomposable representation – The generalized Burnside theorem - The representation theory of finite groups: The group algebra – The regular representation of a group- Semi-simplicity of the group algebra- The centre of the group algebra.

Unit IV Irreducible representations

The number of in-equivalent irreducible representations – relations on the irreducible characters – The module of characters over the integers – The Kronecker product of two presentations – Linear characters – Induced representations and induced characters.

Unit V The theory of characters

Applications of the theory of characters: Algebraic numbers – Some results from the theory of characters – Normal subgroups and the character table – Some classical groups.

h. Learning Resources

i. Text book

1. M. Burrow, Representation Theory of Finite Groups, Academic Press, New York, 1965.

Chapters 1 (except Section 4), 2, 3, and 4.

ii. Reference Books

1. J.l.Alperin, and R.B.Bell,, Groups and Representations, Graduate Texts in Mathematics, 162, Springer-Verlag, New York, 1995.
2. M. Burrow, Representation Theory of Finite Groups, Academic Press, 1965
3. C.W.Curtis and I.Reiner I., Representation Theory of Finite Groups and Associative Algebras, Pure and Applied Mathematics, Vol. XI Interscience Publishers, a division of John Wiley and Sons, New York and London, 1962.
4. D.S.Dummit and R.M.Foote, Abstract algebra, 3rd Edition, John Wiley and Sons, Hoboken, New Jersey,2004.
5. W. Fulton and J. Harris, Representation Theory: A first course, Graduate Texts in Mathematics. Readings in Mathematics 129. Springer Verlag, International Edition, 1991
6. J.Gordon and Martin, Representations and Characters of Groups, 2nd Edition, Cambridge University Press, New York, 2001.
7. F.Harris, Representation Theory: A First Course, Graduate Texts in Mathematics, 129, Readings in Mathematics, Springer-Verlag, New York, 1991.
8. G. James, M. Liebeck, Representations and Characters of Groups, Cambridge University Press, 2010.
9. J.P.Serre, Linear Representations of Finite Groups, Springer- Verlag, New York, 1977,
10. B. Simon, Representations of Finite and Compact Groups. Graduate Studies in Mathematics American Mathematical Society, 2009.
11. B. Steinberg, Representation Theory of finite groups, Springer, 2012.
12. E. B. Vinberg: Linear Representations of Groups, Birkhäuser, 1988.

iii. Online Resources:

1. https://www.sciencedirect.com/book/9780121463564/representation-theory-of-finite-groups
2. https://link.springer.com/book/10.1007/978-1-4614-0776-8
3. https://web.math.princeton.edu/~smorel/rep_theory_notes.pdf
4. http://pwrwroc.academia.edu/Departments/Faculty_of_Pure_and_Applied_Mathematics/Documents
5. https://www.youtube.com/watch?v=HB9KK3Qfvx8
6. http://mathworld.wolfram.com/InducedRepresentation.html
7. https://brilliant.org/wiki/normal-subgroup/

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
60192MA110	**ADVANCED MATRIX THEORY**	**2**	**3**	**0**	**3**

Course Category: PROGRAMME ELECTIVE

a. Preamble:

Matrix computation is fundamental for applications in different branches of Mathematics. In this course, students will learn some important concepts and techniques concerning matrix computation.

b. **Prerequisite Courses**:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. **Related Courses**:
MATLAB

d. **Course Educational Objectives**:
The purpose of this course is to introduce to the students certain techniques of computations with matrices which have several practical applications.

e. **Course Outcomes:**
After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Know the Cholesky Decomposition of a matrix	K3
CO2	Determine the sensitivity of a system of linear equations	K3
CO3	Understand the Least Squares Problem and the method of solution	K3
CO4	Grasp the idea of Singular Value Decomposition	K3
CO5	Learn the power method for eigenvalues	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**										**M**
CO2	**H**	**H**										**M**
CO3	**H**	**H**										**M**
CO4	**H**	**H**										**M**
CO5	**H**	**H**										**M**

H – High; M – Medium; L – Low

g. Course Content:

Unit - I System of Linear Equations

System of Linear Equations - Triangular Systems – Lower Triangular Systems – Upper Triangular Systems - Positive Definite Systems - Cholesky Decomposition – Outer-period form of Cholesky's method.

Unit - II Sensitivity of Linear Systems

Vector and Matrix Norms - Condition Numbers – Geometric Interpretation of the Condition Number – Ill Conditioning Caused by Poor Scaling – Estimating the Condition Number - Perturbing the Coefficient Matrix.

Unit - III The Least Squares Problem

The Discrete Least Squares Problem - Orthogonal Matrices, Rotators, and Reflectors – QR Decomposition - Givens rotators - Householder transformations, - QR Decomposition by Reflectors - Solution of the Least Squares Problem.

Unit - IV The Singular Value Decomposition

SVD Theorem - Some Basic Applications of Singular Values – Orthogonal Decompositions - The SVD and the Least Squares Problem – The pseudo inverse.

Unit - V Eigenvalues and Eigenvectors

The Power Method and Some Simple Extensions - The dominant eigenvalue and its eigen vectors - Dominant eigenvector - Power Method and Inverse Power Method – Convergence Ratio - Similarity Transforms - Schur Decomposition.

h. Learning Resources:

i. **Text book**:

Watkins, D. S. Fundamentals of Matrix Computation, Wiley, **1991**

ii. Reference books:

1. K./B.Datta, Matrix and Linear Algebra, Prentice Hall of India, **1991**.
2. G.H.Golub, G. H. and C.F.van Loan, Matrix Computation, John Hopkin University Press, Baltimore, **1996**.
3. M.T.Heath, Scientific Computing: An Introductory Survey, Mc Graw Hill, International Edition, **2002**.
4. L. Hogben, Handbook of Linear Algebra, Chapman and Hall, CRC Press, **2006**.
5. G.W.Stewart, Introduction to Matrix Computations, Academic Press, **1973**.
6. A.Stuart and J.Voss, Matrix Analysis and Algorithms, **2009.**
7. V. Sundarapandian, Numerical Linear Algebra, PHI Learning Pvt. Ltd, **2008**.

iii. Online Resources:

1. https://www.youtube.com/watch?v=aglyKBEg_7M
2. https://www2.math.uconn.edu/~leykekhman/courses/MATH3795/Lectures/Lecture_6_Linear_system_error.pdf
3. http://www4.ncsu.edu/~mtchu/Teaching/Lectures/MA529/chapter4.pdf(Least
4. https://www.youtube.com/watch?v=P5mlg91as1c
5. http://web.math.ucsb.edu/~padraic/ucsb_2013_14/math108b_w2014/math108b_w2014_lecture5.pdf

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA111	APPROXIMATION THEORY	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble

The course aims to introduce the basic concepts of approximation theory and its applications.

b. Prerequisite Courses:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Numerical Methods

d. **Course Educational Objectives**:

The course seeks to enable the students to gain better knowledge on topics like interpolation, best approximation, projection, etc.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Learn the characterization of best uniform approximations	K3
CO2	Know the role of Chebyshev polynomials in Approximation Theory	K3
CO3	Appreciate the algebraic formulation of finite interpolation	K3
CO4	Understand the best approximation in normed linear spaces	K3
CO5	Use projections in approximations of functions	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**										**M**
CO2	**H**	**H**										**M**
CO3	**H**	**H**										**M**
CO4	**H**	**H**										**M**
CO5	**H**	**H**										**M**

H – High; M – Medium; L - Low

g. Course Content

Unit-I Approximation in normed linear spaces

Existence- Uniqueness – convexity – Characterization of best uniform approximations – Uniqueness results – Haar subspaces – Approximation of real valued functions on an interval.

Unit-II Chebyshev polynomials

Properties – More on external properties of Chebyshev polynomials – Strong uniqueness and continuity of metric projection – Discretization – Discrete best approximation.

Unit-III Interpolation

Introduction – Algebraic formulation of finite interpolation – Lagrange's form – extended Haar subspaces and Hermite interpolation – Hermite – Fejer interpolation.

Unit-IV Best approximation in normed linear spaces

Introduction – Approximative properties of sets – Characterization and Duality.

Unit-V **Projection**

Continuity of metric projections – Convexity, Solarity and Cheyshevity of sets – Best simultaneous approximation.

h. **Learning Resources**

i. Text book:

H.N. Mhaskar and D. V. Pai, Fundamentals of Approximation Theory, Narosa Publishing House, New Delhi, **2000**.
Chapter II (Except 2.6), IV (except 4.5, 4.6 and 4.7) and VIII (except 8.6 and 8.7).

ii. Reference books:

1. E.W. Cheney and Light, A Course in Approximation Theory, Brooks / Cole Publishing Company, New York, **2000**.
2. E.W.Cheney, Introduction to Approximation Theory, McGraw Hill, New York, **1966.**
3. I.Singer I, Best Approximation in Normed Linear Spaces by Element of Linear Subspaces, Springer-Verlag, Berlin, **1970.**

iii. Online Resources:

1. www.personal.acfr.usyd.edu.au › spns › cdm › resources › Kreyszig - Intr...
2. mathfaculty.fullerton.edu › mathews › ChebyshevPolyMod
3. math.iit.edu › ~fass
4. https://scialert.net › fulltext
5. www.pef.uni-lj.si › repovs › knjige › book › metric_projections

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA112	FIXED POINT THEORY	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble

This course aims to introduce fixed point theory and to identify the self maps which have at least one fixed point. Emphasis will be laid on standard theorems in fixed point theory.

b. Prerequisite Courses:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Measure Theory and Integration
Complex Analysis
Functional Analysis

d. Course Educational Objectives:

The students will be enabled to apply fixed point theory in various branches of applied mathematics.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Appreciate the significance of Banach fixed point theorem	K3
CO2	Know the Brouwer fixed point theorem	K3
CO3	Determine the fixed points of multivalued maps	K3
CO4	Understand the fixed point theorems of Gohde and Kirk	K3
CO5	Learn the concept of condensing maps and Sadovskii's fixed point theorem for these maps	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**										**M**
CO2	**H**	**H**										**M**
CO3	**H**	**H**										**M**
CO4	**H**	**H**										**M**
CO5	**H**	**H**										**M**

H – High; M – Medium; L – Low

g. Course Content

Unit-I The Banach fixed point theorem and iterative methods

The Banach fixed point theorem – The significance of Banach fixed point theorem – Applications to nonlinear equations – The Picard – Lindelof theorem – The Main theorem for iterative methods for linear operator equation – Applications to systems of linear equations and to linear integral equations.

Unit-II The Schauder fixed point theorem and compactness

Extension theorem – Retracts – The Brouwer fixed point theorem – Existence principle for systems of equations – Compact operators – Schauder fixed – point theorem – Peano's theorem – Systems of Integral equations and semi linear differential equations.

Unit-III Fixed points of multivalued maps

Generalized Banach fixed point theorem – Upper and lower semi continuity of multivalued maps – Generalized Schauder fixed point theorem – Variational inequalities and Brouwer fixed point theorem.

Unit-IV Nonexpansive operators and iterative methods

Uniformly convex Banach spaces – Demi-closed operators – The fixed point theorem of Brouwer, Gohde and Kirk – Demi-compact operators – Convergence principles in Banach spaces – Modified successive approximations – Applications to periodic solutions.

Unit-V Condensing maps

A non-compactness measure – Condensing maps – Operators with closed range and an approximation technique for constructing fixed points – Sadovskii's fixed point theorem for condensing maps – Fixed point theorem for perturbed operators – Application to differential equations in Banach spaces.

h. Learning Resources

Treatment and Content as in:

i. Text book:

E.Zeidler, Nonlinear Functional Analysis and its Applications, Vol. 1, Springer Verlag, New York, **1986**. Chapters 1, 2, 9, 10 and 11

ii. Reference books:

1. K.Deimling, Nonlinear Functional Analysis, Springer-Verlag, New York, **1985**.
2. D.R.Smart, Fixed Point Theory, Cambridge University Press, **1974**.
3. V.L.Istratescu, Fixed Point Theory, D. Reidel Publishing Company, Boston, **1979**.

iii. Online Resources:

1. dmuw.zum.de › images › Banach2
2. www.math.ac.vn › publications › vjm › vjm_27 › 187-222_Park
3. https://www.sciencedirect.com › science › article › pii
4. shodhganga.inflibnet.ac.in › bitstream
5. www.math.ubbcluj.ro › ~nodeacj › download › f=052appell

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
60192MA113	**ALGEBRAIC TOPOLOGY**	**2**	**2**	**0**	**3**

Course Category: PROGRAMME ELECTIVE

a. Preamble

The aim of this course is to introduce the notion of homotopy and covering spaces. Emphasis will be laid on simplicial and singular homology.

b. Prerequisite Courses:
Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:
Group Theory
Fixed Point Theory

d. Course Educational Objectives:

The course seeks to introduce to the students the basic concepts of Algebraic Topology, a subject full of rigor and inspiration.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Understand the homotopy of paths	K3
CO2	Appreciate the fundamental group	K3
CO3	Know the covering space and lifting theorem	K3
CO4	Familiarize with simplicial and singular homology	K3
CO5	Apply Brouwer's fixed point theorem	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**										**M**
CO2	**H**	**H**										**M**
CO3	**H**	**H**										**M**
CO4	**H**	**H**										**M**
CO5	**H**	**H**										**M**

H – High; M – Medium; L – Low

g. Course Content

UNIT I Homotopy and fundamental group

Homotopy of paths, fundamental group of a topological space, fundamental group functor, homotopy of maps of topological spaces; homotopy equivalence; contractible and simply connected spaces; fundamental group of 1 , 1 x 1 etc.; degree of maps of 1 . 26

UNIT II Fundamental group of a topological group

Calculation of fundamental groups of n (n > 1) using Van Kampen's theorem (special case); fundamental group of a topological group; Brouwer's fixed point theorem; fundamental theorem of algebra; vector fields, Frobenius theorem on eigenvalues of 3 x 3 matrices.

UNIT III Covering spaces

Covering spaces, unique lifting theorem, path-lifting theorem, covering homotopy theorem, applications; criterion of lifting of maps in terms of fundamental groups; universal coverings and its existence; special cases of manifolds and topological groups.

UNIT IV Simplicial and singular homology

Simplicial and singular homology, reduced homology, Eilenberg-Steenrod axioms, relation between Π1 and H1; relative homology.

UNIT V Brouwer's fixed point theorem

Calculations of homology of n - Brouwer's fixed point theorem for f : n → n (n > 2) and its applications to spheres and vector fields; Meyer-Vietoris sequence and its application.

h. Learning Resources

i. **Text books:**

1. J. R. Munkres, Topology, A First Course, Prentice-Hall of India Ltd., New Delhi, **2000.**
2. M. J. Greenberg and J. R. Harper, Algebraic Topology, A First Course, 2nd Edition, Addison Wesley Publishing Co., **1997.**
3. A.Hatcher, Algebraic Topology, Cambridge University Press, **2002.**

ii. Reference books:

1. G.E.Bredon, Toplogy and Geometry, Graduate Texts in Mathematics Vol. 139,
2. Springer Verlag, New York, 1993.
3. F.H. Croom, Basic Concepts of Algebraic Topology, Springer Verlag.
4. S. Eilenberg and N. E. Steenrod, Foundations of Algebraic Topology, 2nd Edition, Princeton University Press, 1995.
5. W. Fulton, Algebraic Topology, A First Course, 2nd Edition, Graduate Texts in Mathematics, No. 153, Springer Verlag, New York, 1995.
6. Hatcher, Algebraic Topology, Cambridge University Press, 2009.
7. C, Kosniowski, A First Course in Algebraic Topology, Cambridge University Press.
8. W.Massey, A Basic Course in Algebraic Topology, Springer Verlag, Berlin, 1991.
9. P.May, A Concise Course in Algebraic Topology, Chicago Lectures in Mathematics, University of Chicago Press, Chicago, 1999.
10. J. J. Rotman, An Introduction to Algebraic Topology, Graduate Text in Mathematics, No. 10, Springer (India), 2004.
11. Singer, I.M., Thorpe, J.A, Lecture Notes on Elementary Topology and Geometry, Springer Verlag
12. E. H. Spanier, Algebraic Topology, 2nd edition, Springer-Verlag, New York, 2000.
13. J.W.Viek, Homology Theory: An Introduction to Algebraic Topology, 2nd Edition, Springer Verlag, New York, 1994.

iii. Online Resources

1. https://nptel.ac.in/courses/111101002
2. https://nptel.ac.in/courses/111101002/downloads/lecture7.pdf
3. http://www.math.harvard.edu/~knill/teaching/math19b_2011/handouts/lecture34.pdf
4. https://math.arizona.edu/~glickenstein/math534_1011/coveringspaces.pdf
5. https://www.youtube.com/watch?v=Uq4dTjHfLpI
6. https://perso.esiee.fr/~mustafan/TechnicalWritings/math-lec4.pd

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA114	OPERATOR THEORY	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble:
This course seeks to introduce to the students the basic concepts of Operator Theory

b. Prerequisite Courses:
Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:
Functional Analysis

d. Course Educational Objectives:
The purpose of this paper is to familiarize the students with the techniques of Operator Theory, with emphasis on Spectral theorem.

e. Course Outcomes:
After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Learn the concept and examples of Banach Algebras	K3
CO2	Understand Gelfand - Naimark theory for commutative Banach algebras	K3
CO3	Know the Representations of C*- Algebras	K3
CO4	Grasp the spectral theorem for normal operators and unitary operators.	K3
CO5	Familiarize with the properties of compact operators	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**										**M**
CO2	**H**	**H**										**M**
CO3	**H**	**H**										**M**
CO4	**H**	**H**										**M**
CO5	**H**	**H**										**M**

H – High; M – Medium; L – Low

g. Course Content:

UNIT - I Banach algebras and spectral mapping theorem

Banach algebras – Involutive Banach algebras – Various examples including Group algebras – Spectrum – Spectral mapping theorem.

Unit-II Commutative Banach algebras

Maximal ideal space for commutative Banach algebras – Gelfand - Naimark theory for commutative Banach algebras – C*- algebras, Examples.

Unit-III Representations of C*- Algebras

Representations of C*- Algebras – Von Neumann's density theorem – Double commutant theorem.

Unit-IV Spectral theorem for operators

Functional calculus – The spectral theorem for normal operators – Spectral theorem for unitary operators.

Unit-V Compact operators

Compact operators – Examples and properties – Spectral theorem for compact operators.

h. Learning Resources

i. Text book:

Sunder, V.S, Functional Analysis – Spectral Theory, TRIM Series, Hindustan Book Agency, New Delhi, **1997.**

ii. Reference Books:

1. B.Blackadar, Operator Algebras: Theory of C*- Algebras and von-Newmann Algebras
2. I.Goldberg and S.Goldberg, Basic Operator Theory,
3. G.J.Murphy, C*- Algebras and Operator Theory, Birkhauser, 1**981**.
4. Takesaki, M, Theory of Operator Algebras I, Springer Verlag, **1979.**
5. Yosida, K, Functional Analysis, Springer Verlag, **1968**
6. K.Zhu**,** An Introduction to Operator Algebras

Iii. Online Resources:

1. https://www.springer.com/gp/book/9783034806664
2. https://www.iith.ac.in/~rameshg/banachalgebras.pdf
3. https://math.dartmouth.edu/archive/m123s11/public_html/cstar.pdf
4. https://www.imsc.res.in/~sunder/stratila-zsido-lectures-on-von-neumann-algebras.pdf
5. https://nptel.ac.in/courses/111106051/52
6. https://people.maths.bris.ac.uk/~mazag/fa17/lecture5.pdf

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
60192MA115	**NON-LINEAR DIFFERENTIAL EQUATIONS**	**2**	**2**	**0**	**3**

Course Category: PROGRAMME ELECTIVE

a. Preamble:

Several phenomena occurring in nature are non-linear. This course seeks to introduce to the students certain techniques of non-linear differential equations which have wide applications in various practical situations.

b. Prerequisite Courses:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Classical Mechanics

d. Course Educational Objectives:

The purpose of this course is to familiarize the students with the properties of non-linear differential equations and the methods concerning oscillation and stability properties of the solutions.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Understand first order systems in two variables and linearization	K3
CO2	Grasp averaging methods	K3
CO3	Know amplitude equation	K3
CO4	Appreciate time varying systems	K3
CO5	Learn Poincare stability and Liapunov stability of solutions	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO2	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO3	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO4	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO5	**H**	**H**	**M**	**M**		**M**	**M**					**M**

H – High; M – Medium; L - Low

g. Course Content:

Unit – I First order systems in two variables and linearization

The general phase plane - Some population models – Linear approximation at equilibrium points – Linear systems in matrix form.

Unit – II Averaging Methods

An energy balance method for limit cycles – Amplitude and frequency estimates – Slowly varying amplitudes – Nearly periodic solutions – Periodic solutions: harmony balance – Equivalent linear equation by harmonic balance.

Unit – III Perturbation Methods

Outline of the direct method – Forced Oscillations far from resonance - Forced Oscillations near resonance with Weak excitation – Amplitude equation for undamped pendulum – Amplitude Perturbation for the pendulum equation – Lindstedt's Method.

Unit – IV Linear Systems

Time Varying Systems – Constant coefficient System – Periodic Coefficients – Floquet Theory – Wronskian.

Unit - V Stability

Poincare stability – Solutions, paths and norms – Liapunov stability – Stability of linear systems – Comparison theorem for the zero solutions of nearly – linear systems.

h. Learning Resources

i. Text books:

D.W.Jordan and P.Smith, Nonlinear Ordinary Differential Equations, Clarendon Press, Oxford, **1977**.

ii. Reference Books:

1. G.F.Simmons, Differential Equations, Tata McGraw Hill, New Delhi, **1979**.
2. D.A.Sanchez, Differential Equations and Stability Theory, Freeman, **1968**.
3. J.K.Aggarwal, Notes on Nonlinear Systems, Nostrand, **1972**.
4. Lawrence Perko, Differential Equations and Dynamical Systems, Springer Science & Business Media, 2001.
5. Roger Grimshaw, Nonlinear Ordinary Differential Equations, CRC Press, 1993.

iii. **Online Resources**:

1. https://www.youtube.com/watch?v=ZJ3MiNhrMbs
2. http://www.math.colostate.edu/~shipman/47/volume2a2010/Zhang.pdf
3. https://courses.maths.ox.ac.uk/node/view_material/433
4. https://www.youtube.com/watch?v=mGt8lTP8f7k
5. https://www.youtube.com/watch?v=4EiOmNJIR-w

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
60192MA116	**DISCRETE DYNAMICAL SYSTEMS**	**2**	**2**	**0**	**3**

Course Category: PROGRAMME ELECTIVE

a. Preamble:

The purpose of this course is to introduce to the students the fundamental concepts in a modern subject called Discrete Dynamical Systems. This course will train the students in understanding topological dynamics.

b. **Prerequisite Courses**:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. **Related Courses**:

Topology
Non-linear Differential Equations

d. **Course Educational Objectives**:

The evolution of a point in time under a map has led to major studies in Mathematics introducing Discrete Dynamical System. The concepts of Fatou Sets, Julia Sets, Cellular automata, Fractals Horseshoes, Hyperbolic dynamics, etc. have added many new results. Consequently, various new modeling techniques have emerged. . The objective of the course is to expose the students to this new discipline.

e. **Course Outcomes:**

After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Know Orbits and Phase portraits	K3
CO2	Learn Parametrized family of functions and bifurcations	K3
CO3	Grasp Devaney's definition of Chaos and Topological Conjugacy.	K3
CO4	Understand Newton's method	K3
CO5	Appreciate the dynamics of Complex functions	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**										**M**
CO2	**H**	**H**										**M**
CO3	**H**	**H**										**M**
CO4	**H**	**H**										**M**
CO5	**H**	**H**										**M**

H – High; M – Medium; L – Low

g. **Course Content**:

Unit-I Orbits

Orbits - Phase portraits- Periodic points and stable sets - Sarkovskii's theorem

Unit-II Periodic points

Attracting and repelling periodic points- Differentiability and its implications – Parametrized family of functions and bifurcations

Unit-III Symbolic dynamics

Symbolic dynamics - Devaney's definition of Chaos - Topological Conjugacy.

Unit-IV Newton's method

Newton's method-Numerical solutions of differential equations.

Unit-V Complex functions

The dynamics of Complex functions- The quadratic family and the Mandelbrot set.

h. Learning Resources

i. Text book:

R.A. Holmgren, A First Course in Discrete Dynamical Systems, Springer Verlag, **1994**.

ii. Reference Book:

1. R.L.Devaney, Introduction to Chaotic Dynamical Systems, Addison-Wesley.
2. Lawrence Perko, Differential Equations and Dynamical Systems, Springer Science & Business Media, 2001.
3. Roger Grimshaw, Nonlinear Ordinary Differential Equations, CRC Press, 1993.

iii. Online Resources:

1. http://www.kau.edu.sa/GetFile.aspx?id=134401&fn=Chapter%2013.pdf
2. http://mathworld.wolfram.com/SharkovskysTheorem.html
3. https://link.springer.com/chapter/10.1007/978-1-4419-8732-7_7
4. https://www.youtube.com/watch?v=-IqyIX2D-nw
5. https://web.math.rochester.edu/people/faculty/doug/oldcourses/215s98/lecture12.html

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA117	LIE GROUPS AND LIE ALGEBRAS	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble:
The purpose of this course is to introduce to the students the fundamental concepts in Lie groups and Lie algebras. This course will train the students in understanding representation of groups.

b. **Prerequisite Courses**:
Mathematics as subject of study in B.Sc / BE / B.Tech

c. **Related Courses**:
Topology
Functional Analysis
Representation theory of finite groups

d. **Course Educational Objectives**:
Lie Theory is a modern development in Mathematics which has applications in Physics and Engineering. The course seeks to introduce to the students the basic ideas of in Lie groups and Lie algebras. The students will be trained in representation theory of Lie groups and Lie Algebras.

e. **Course Outcomes:**
After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Learn the basic definitions of Lie groups	K3
CO2	Know Jacobi identity and Lie algebras	K3
CO3	Understand representations of Lie groups and Lie algebras	K3
CO4	Learn solvable and nilpotent Lie algebras	K3
CO5	Appreciate the properties of semi-simple Lie algebras	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**										**M**
CO2	**H**	**H**										**M**
CO3	**H**	**H**										**M**
CO4	**H**	**H**										**M**
CO5	**H**	**H**										**M**

H – High; M – Medium; L – Low

g. Course Content

Unit – I Basic Definitions of Lie groups

Lie groups, subgroups and co-sets – Lie sub-algebras and homomorphism theorem – Action of Lie groups on manifolds and representations – Orbits and homogeneous spaces.

Unit – II Lie groups and Lie algebras

Exponential map – The commutator – Jacobi identity and the definition of a Lie algebra – Sub-algebras, ideals and center.

Unit – III Representations of Lie groups and Lie algebras

Basic definitions – Operations on representations – Irreducible representations – Inter twinning operators and Schur's lemma.

Unit – IV Structure theory of Lie algebras

Universal enveloping algebra – Poincare – Birkhoff – Witt theorem – Ideals and commutant – Solvable and nilpotent Lie algebras.

Unit – V Complex semi-simple Lie algebras

Properties of semi-simple Lie algebras – Relation with compact groups – Complete reducibility of representations - Semi-simple elements and toral algebras.

h. Learning Resources

i. Text book:

Treatment and content as in:

A.Krillov, An Introduction to Lie groups and Lie algebras, Cambridge University Press, New York, **2008**.

ii. Reference books:

1. D. Bump, Lie Groups, Graduate Texts in Mathematics 225, Springer, **2013**.
2. K. Erdmann, M. J. Wildon, "Introduction to Lie Algebras", Springer Undergraduate Mathematics Series, Springer-Verlag, **2006.**
3. J. Faraut, Analysis on Lie Groups, Cambridge Studies in Advanced Mathematics 110, Cambridge University Press, **2008**.
4. W. Fulton, J. Harris, Representation Theory: A first course, Springer-Verlag, **1991**.
5. N. Jacobson, Lie Algebras, Dover Publications, **1979.**
6. B. C. Hall, Lie groups, Lie Algebras and representations: An elementary introduction, Springer, Indian reprint, **2004**.
7. J. E. Humphreys, Introduction to Lie Algebras and Representation Theory, Graduate Texts in Mathematics 9, Springer-Verlag, **1978**.
8. J.S.Milne, Lie algebras, algebraic groups and Lie groups, **2012**. http://www.jmilne.org/math/
9. P.J. Olver, Applications of Lie groups to Differential Equations, Springer, Berlin. **1998**
10. J.-P. Serre, Complex Semisimple Lie Algebras, Springer Monographs in Mathematics, Springer-Verlag, **2001**.

iii. Online resources:

1. https://www.math.stonybrook.edu/~kirillov/mat552/liegroups.pdf
2. https://www.math.upenn.edu/~wziller/math650/LieGroupsReps.pdf
3. www.encyclopediaofmath.org › index.php › Lie_group
4. www.encyclopediaofmath.org › index.php › Lie_group
5. www.math.stonybrook.edu › ~kirillov › mat552 › liegroups
6. www.map.mpim-bonn.mpg.de › Lie_groups_I:_Definition_and_exa...
7. http://math.uchicago.edu/~may/REU2012/REUPapers/Bosshardt.pdf
8. www.math.rwth-aachen.de › Teaching › liealg › liea
9. www.encyclopediaofmath.org › index.php › Lie_algebra
10. www.maths.gla.ac.uk › ~gbellamy › lie
11. www.math.ucla.edu › ~vsv › liegroups2007 › 9
12. www.ime.usp.br › ~gorodski › teaching › mat5799-2013
13. www2.math.ou.edu › ~bkumar › Lie groups
14. www.mat.univie.ac.at › ~cap › files › LieGroups
15. www.physics.drexel.edu › ~bob › LieGroups

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA118	THEORY OF ELASTICITY	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble

Theory of elasticity is the branch of solid mechanics which deals with the stress and displacements in elastic solids by external forces or changes in temperature.

b. Prerequisite Courses:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Classical Mechanics

d. Course Educational Objectives:

This course is intended to provide the basic concepts of the theory of linear elasticity and its application to problems of stress. The objective is to equip the students with knowledge of fundamentals of the theory of elasticity and awareness of their applications to different practical problems.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Learn Deformation and strain tensor in rectangular Cartesian coordinates and spherical and cylindrical polar coordinates	K3
CO2	Understand the terminology related to stress tensor and stress quadric of Cauchy	K3
CO3	Know the linear theory of elasticity	K3
CO4	Understand the torsion of different objects	K3
CO5	Appreciate the applications in certain practical problems	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO2	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO3	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO4	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO5	**H**	**H**	**M**	**M**		**M**	**M**					**M**

H – High; M – Medium; L – Low

g. Course Content

Unit-I Analysis of strain

Deformation, strain tensor in rectangular Cartesian coordinates, Geometric interpretation of infinitesimal strain, rotation, compatibility of strain components, properties of strain tensor, strain in spherical and cylindrical polar coordinates.

Unit-II Analysis of stress

Stresses, laws of motion, Cauchy's formula, equations of equilibrium, transformation of coordinates, Plane state of stresses, Cauchy's stress quadric, shearing stress, Mohr's circle, stress deviation, stress tensor in general coordinates, physical components of a stress tensor in general coordinates, equation of equilibrium in curvilinear coordinates.

Unit-III Linear theory of elasticity

Generalized Hooke's law, Stress-Strain relationship for an isotropic elastic material, Basic equation of elasticity for homogeneous isotropic bodies, boundary value problems, the problem of equilibrium and the uniqueness of solution of elasticity, Saint-Venant's principle.

Unit-IV Torsion

Torsion of prismatic bars, torsion of circular, elliptic and rectangular bars, membrane analogy, torsion of rectangular section and hollow thin walled sections.

Unit-V Two and three dimensional problems in elasticity

Bending of a cantilever beam, simply supported beam with simple loadings. Semi-infinite medium subjected to simple loadings. Plane elastic waves, Rayleigh surface waves.

h. Learning Resources

i. Text books:

1. R.B.Hetnarski R.B. and J,Ignaczak, Mathematical Theory of Elasticity, Taylor and Francis, London, **2004**.
2. I.S.Sokolnikoff, Mathematical Theory of Elasticity, Tata-McGraw Hill, New Delhi, **1974.**
3. J.D.Achenbach, Wave Propagation in Elastic Solids, North-Holland Pub. Co., Amsterdam, **1973.**

ii. Reference books:

1. L.S.Srinath, Advanced Mechanics of Solids, Tata McGraw Hill, New Delhi, 3rdEdition, **2008**.
2. Y.C.Fung, Foundations of Solid Mechanics, Prentice Hall Inc., New Jersey**, 1965**.

iii. Online Resources:

1. www.ipgp.fr › ~kaminski › web_doudoud › Malvern_book
2. www.mate.tue.nl › ~piet › edu › ela › pdf
3. https://www.ntnu.no › wiki › download › attachments › IrgensChap7Elasticity
4. web.mit.edu › 6_Torsion › Torsion_files › module_6_with_solutions
5. https://core.ac.uk › download › pdf

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
60192MA119	**BOUNDARY VALUE PROBLEMS**	**2**	**2**	**0**	**3**

Course Category: PROGRAMME ELECTIVE

a. Preamble

This course aims to give a comprehensive overview of boundary value problems and their applications.

b. Prerequisite Courses:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Ordinary Differential Equations

d. Course Educational Objectives:

The purpose of this course is to equip the students with the fundamental concepts of boundary value problems. Emphasis will be laid on the important functions and equations associated with this subject.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Know the basic ideas of boundary value problems	K3
CO2	Learn the role of orthogonal functions in boundary value problems	K3
CO3	Understand Sturm-Liouville problem and its applications	K3
CO4	Familiarize with certain functions associated with boundary value problems	K3
CO5	Apply Legendre polynomials in boundary value problems	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO2	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO3	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO4	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO5	**H**	**H**	**M**	**M**		**M**	**M**					**M**

H – High; M – Medium; L – Low

g. Course Content

Unit-I Basic principles and examples

Definition of boundary Value Problems, the heat equation, wave equation, Laplace's equation, the Fourier method, Linear Operators, Principle of Superposition, series solutions, uniform convergence (Weierstrass M-test), separation of variables, non homogeneous conditions, Sturm-Liouville problems, formal solutions, the vibrating string.

Unit-II Orthogonal sets of functions

Orthogonal Legendre polynomials l sets of functions, Generalized Fourier series, Best approximation in the mean, Convergence in the mean, the orthonormal trigonometric functions, other types of orthogonality.

Unit-III Sturm-Liouville Problem

Sturm-Liouville Problem and applications, orthogonality and uniqueness of eigenfunctions, method of solutions, surface heat transfer other boundary value problems.

Unit-IV Bessel function

Bessel function J_n - recurrence relation, the zero of J_o (X) and related functions, Fourier-Bessel series, Temperatures in a long cylinder.

Unit-V Legendre polynomials

Legendre polynomials, orthogonality of Legendre polynomials, Legendre series, Dirichlet Problem in spherical regions.

h. Learning Resources

i. Text book:

R.V. Churchill and J. Brown, Fourier Series and Boundary Value Problems, 4th Edition, McGraw-Hill Book Company.

ii. Reference Books:

1. Batchelor. G.K. An introduction to Fluid Dynamics, Cambridge University Press, **1979**.
2. Yuan. S.W, Foundations of Fluid Mechanics, Prentice- Hall of India, New Delhi, **1988**.
3. D.J.Zill and M.R.Cullen, Differential Equations with Boundary Value Problems, 7th Edition, Brooks/Cole, Belmont, USA, **2009.**

iii. **Online Resources**:

1. https://pdfs.semanticscholar.org › ...
2. inis.jinr.ru › M_Mathematics › MRef_References › C0355-Ch04
3. www.math.iitb.ac.in › ~siva › ode7
4. .www.mhtlab.uwaterloo.ca › courses › web_chap4
5. web.mst.edu › ~hale › courses › 411_notes

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA120	FUDAMENTALS OF WAVELET ANALYSIS	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble

The aim of this course is to use Fourier Analysis to introduce the notions of wavelet transforms, Time frequency analysis, multi-resolution analysis and wavelets. Emphasis will be laid on compactly supported wavelets.

b. Prerequisite Courses:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. Related Courses:

Ordinary Differential Equations

d. Course Educational Objectives:

To train the students in handling "Wavelets", which is a versatile tool with rich mathematical content and has great potential for applications in engineering.

e. Course Outcomes:

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Grasp the Fourier and inverse Fourier transforms of functions	K3
CO2	Understand wavelet transforms and time-frequency analysis	K3
CO3	Learn multi resolution analysis	K3
CO4	Construct compactly supported wavelets	K3
CO5	Apply the theory in the design of filters	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO2	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO3	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO4	**H**	**H**	**M**	**M**		**M**	**M**					**M**
CO5	**H**	**H**	**M**	**M**		**M**	**M**					**M**

H – High; M – Medium; L – Low

g. Course Content

Unit-I Fourier Analysis

Fourier and inverse Fourier transforms – Continuous time convolution and the delta function – Fourier transform of square integrable functions – Poisson's summation formula.

Unit-II Wavelet transforms and time - frequency analysis

The Gabor transform – Short time Fourier transforms and the uncertainty principle – The integral wavelet transform – Diadic Wavelets and inversions – Frames.

Unit-III Multi resolution analysis and wavelets

The Haar wavelet construction – Multi resolution analysis – Riesz basis to orthonormal basis – Sealing function and scaling identity – Construction of wavelet basis.

Unit-IV Compactly supported wavelets

Vanishing moments property – Meyer's wavelets – Construction of a compactly supported wavelet – Smooth wavelets.

Unit-V Applications to filters

Digital Filters – Discrete wavelet transforms and Multi resolution analysis – Filters for perfect reconstruction – Para unitary filters and orthonormal wavelets – Filter design for orthonormal wavelets – Bi-orthogonal filters.

h. Learning Resources

i. Text books:

1. C.K. Chui, An introduction to Wavelets, Academic Press, San Diego, CA, **1992**.
   Sections 2.1 - 2.3, 2.5, 3.1-3.5
2. P. Wojtaszczyk, A mathematical introduction to Wavelets, London Mathematical Society, Student Texts 37, Cambridge University Press, **1997**.
   Sections 1.1, 2.1-2.4, 3.1, 3.2, 4.1, 4.2.
3. Y.T. Chan, Wavelet Basics, Kluwer Academic Publishers, **1995**.
   Sections 3.1- 3.7

ii. Reference books

1. E.Hernandez and G.Weiss, A First Course in Wavelets, CRC Press, New York,**1996**
2. D.F.Walnut, Introduction to Wavelet Analysis, Birhauser, **2004**.
3. M.W.Frazier, An Introduction to Wavelets through Linear Algebra, Springer Verlag, Berlin, **1999.**

a. Online Resources:

1. https://people.maths.ox.ac.uk › trefethen
2. https://link.springer.com › content › pdf
3. https://arxiv.org › pdf › nucl-th
4. disp.ee.ntu.edu.tw › tutorial › WaveletTutorial
5. shodhganga.inflibnet.ac.in › bitstream

COURSE CODE	COURSE TITLE	L	T	P	C
60192MA121	TOPICS IN ELECTRODYNAMICS	2	2	0	3

Course Category: PROGRAMME ELECTIVE

a. Preamble:

The purpose of this course is to introduce to the students certain important aspects of Electrodynamics which have several practical applications.

b. **Prerequisite Courses**:

Mathematics at Higher Secondary Level

c. **Related Courses**:

Classical Mechanics

d. **Course Educational Objectives**:

The aim of this course is to familiarize the students with applications of Mathematical Techniques in Electrodynamics.

e. **Course Outcomes:**

After the successful completion of the course, students will be able to:

CO No.	Course Outcome	Level of Learning domain (Based on revised Bloom's)
CO1	Know the Maxwell Equations	K3
CO2	Understand the fundamentals of Electrostatics	K3
CO3	Apply Laplace's Equation in Potential Theory	K3
CO4	Appreciate the Poisson-Boltzmann Equation.	K3
CO5	Learn Dynamic and Quasi-static Fields	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**										**M**
CO2	**H**	**H**										**M**
CO3	**H**	**H**										**M**
CO4	**H**	**H**										**M**
CO5	**H**	**H**										**M**

H – High; M – Medium; L – Low

h. Course Content:

Unit – I The Maxwell Equations

The Maxwell equations – The Maxwell equations in vacuum – Microscopic vs Macroscopic - The Maxwell equations in matter.

Unit-II Electrostatics

Electrostatics – Coulomb's law – The scalar potential – Gauss' law and solid angle – Electrostatic Potential Energy - Electrostatic Total Energy.

Unit-III Laplace's Equation

Potential Theory – Uniqueness – Separation of Variables – Cartesian Symmetry – Azymuthal Symmetry

Unit-IV Poisson's Equation

The Key Idea: Superposition – The Method of Images – The Green Function Method – The Dirichlet Green Function – The Complex Logarithm Potential – The Poisson-Boltzmann Equation.

Unit-V Dynamic and Quasi-static Fields

The Ampere-Maxwell Law – Farady's Law – Electromagnetic Induction – Slowly Time-Varying Charge in Vacuum - Slowly Time-Varying Current in Vacuum – Quasi-static Fields in Matter.

i. Learning Resources

i. Text book:

A.Zangwill, Modern Electrodynamics, Cambridge University Press, Cambridge, **2013**.

ii. Reference Books:

1. Greiner, Classical Electrodynamics, Springer, New York, **1998.**
2. Griffiths, Introduction to Electrodynamics, 4th Edition, Pearson, **2013.**
3. J.D.Jackson, Classical Electrodynamics, 3rd Edition, John Wiley and Sons, **1999.**
4. Nunzio **Tralli,** Classical Electromagnetic Theory, McGraw-Hill, **1963**.
5. Panofsky and Phillips, Classical Electricity and Magnetism, 2nd Edition, Addison Wesley, **1962**

iii. Online Resources:

1. http://www.maxwells-equations.com/
2. https://www.youtube.com/watch?v=NXMgvrS8Gr8
3. http://www.math.tifr.res.in/~publ/ln/tifr19.pdf
4. https://nptel.ac.in/courses/122101002/downloads/lec-10.pdf
5. https://web.pa.msu.edu/courses/2014fall/PHY842/Lectures/lec1401.pdf

COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
60192MA122	**TIME SERIES ANALYSIS**	**2**	**2**	**0**	**3**

Course Category: PROGRAMME ELECTIVE

a. Preamble:

The aim of this course is to introduce to the students the techniques of time series analysis so as to enable them to forecast the future possibilities with practical applications.

b. **Prerequisite Courses**:

Mathematics as subject of study in B.Sc / BE / B.Tech

c. **Related Courses**:

Theory of Probability

d. **Course Educational Objectives**:

The aim of this course is to familiarize the students with applications of Techniques of forecasting with time series analysis.

e. **Course Outcomes:**

After the successful completion of the course, students will be able to:

CO No.	**Course Outcome**	Level of Learning domain (Based on revised Bloom's)
CO1	Understand the methods of exponential and moving average smoothing	K3
CO2	Familiarize with stationary stochastic models	K3
CO3	Learn different models of time series	K3
CO4	Appreciate Periodogram and Correlogram analysis	K3
CO5	Learn the fundamentals of seasonal ARIMA models	K3

f. Correlation of Cos with POs:

Co.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**H**	**H**										**M**
CO2	**H**	**H**										**M**
CO3	**H**	**H**										**M**
CO4	**H**	**H**										**M**
CO5	**H**	**H**										**M**

H – High; M – Medium; L – Low

g. **Course Content**:

Unit – I Exploratory Time Series Analysis

Forecasting trend and seasonality based on smoothing Methods of Exponential and moving average smoothing; Types and implications of interventions; Outliers, additive and innovational outliers, procedure for detecting outliers.

Unit-II Stationary Stochastic models

Weak and strong stationarity, Deseasonalising and detrending an observed time series, Auto-covariance, autocorrelation function (ACF), partial autocorrelation function (PACF) and their properties, Conditions for stationarity and invertibility,

Unit-III Models for Time Series

Time series data, Trend, seasonality, cycles and residuals, Stationary, White noise processes, Autoregressive (AR), Moving Average (MA), Autoregressive and Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIMA) processes, Choice of AR and MA periods

Unit-IV Spectral analysis and decomposition

Spectral analysis of weakly stationary process, Periodogram and Correlogram analysis, Spectral decomposition of weakly AR process and representation as a one-sided MA process – necessary and sufficient conditions, implication in prediction problems.

Unit-V Modeling Seasonal Time Series

Seasonal ARIMA models, estimation and forecasting, Fitting ARIMA models with Box-Jenkins procedure, Identification, Estimation, Verification, Test for white noise, Forecasting with ARMA models.

h. Learning Resources

i. Text books:

1. G.E.P. Box, G.Jenkins and G,C.M. Reinsel, Time Series Analysis–Forecasting and Control, Pearson Education, **2004**.
2. P.J. Brockwell and R.A.Davis, Introduction to Time Series and Forecasting, Springer Texts in Statistics, **2010**.
3. D.C.Montgomery and L.A.Johnson L A, Forecasting and Time Series analysis, Mc Graw Hill, **1977**.
4. T. Nicholas and Thomopoulos, Applied Forecasting Methods, Prentice Hall, **1980**

ii. Reference books:

1. C. Chatfield, The Analysis of Time Series: An Introduction, 6th edition, Chapman and Hall, **2004**.
2. J. D. Cryer and K.S. Chan, Time series analysis with applications in R, 2nd edition, Springer Veerlag, **2008**.
3. P.J.Diggle, Time Series: A Bio-statistical Introduction, Oxford University Press, **1990.**
4. J. Hamilton, Times Series Analysis, Princeton University Press, **1994**.
5. A.C.Harvey, Time Series Models, MIT Press, 1993.
6. S.M.Kendall and J.K. Ord, Time Series, Edward Arnold, **1990**.
7. R. H. Shumway and D. S. Stoffer, Time Series Analysis and its Applications with R Examples, 3rd edition, Springer Verlag, **2011**
8. R.Tsay, Analysis of Financial Time Series, Wiley Series, **2002**.

iii. Online Resources:

1. https://www.itl.nist.gov/div898/handbook/pmc/section4/pmc4.htm
2. https://www.analyticsvidhya.com/blog/2015/12/complete-tutorial-time-series-modeling/
3. https://www.sciencedirect.com/topics/medicine-and-dentistry/time-series-analysis
4. https://www.investopedia.com/terms/t/timeseries.asp
5. https://www.investopedia.com/terms/m/movingaverage.asp
6. https://www.investopedia.com/articles/active-trading/052014/how-use-moving-average-buy-stocks.asp
7. https://en.wikipedia.org/wiki/Moving_average
8. https://www.babypips.com/learn/forex/using-moving-averages
9. https://www.statisticshowto.datasciencecentral.com/moving-average/
10. 11 https://www.goodreads.com/book/show/3228917-outliers
11. https://www.amazon.com/Outliers-Story-Success-Malcolm-Gladwell/dp/0316017930
12. 13 https://towardsdatascience.com/ways-to-detect-and-remove-the-outliers-404d16608dba
13. 14. https://towardsdatascience.com/stationarity-in-time-series-analysis-90c94f27322
14. 15 https://www.investopedia.com/articles/trading/07/stationary.asp
15. https://www.statisticssolutions.com/time-series-analysis