SYLLABUS STRUCTURE

FOR

POST-GRADUATE PROGRAMME

IN

MATHEMATICS

(M.A./M.Sc. in Mathematics)

(2019-20)

SCHOOL OF MATHEMATICS

GANGADHAR MEHER UNIVERSITY, AMRUTA VIHAR

SAMBALPUR, ODISHA-768004, INDIA

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VISION

To foster in mathematical education and research, technical excellence, well poised between abstraction and application.

MISSION

M-1-To offer globally-relevant, research-focused, technology-enabled education at the graduate, Post-graduate and research levels in various areas of Mathematical sciences.

M-2-To contribute to the development of students as mathematical thinkers, enabling them to become lifelong learners, to continue to grow in their chosen professions, and to function as productive citizens.

M-3-To develop and conduct continuing education programs with a view to update their fundamental knowledge base and problem-solving capabilities in the various areas of core specialization of the University.

M-4-To develop comprehensive linkages with premier academic and research institutions within the country and abroad for mutual benefit.

PROGRAMME OUTCOMES
(Chosen from the allowed list as set by UGC)

The programme outcomes and attributes are attained by the postgraduate students of Gangadhar Meher University through learning acquired on completion of a programme of study. Individual programmes of study have a defined programme specific learning outcomes which needs to be attained for the award of a specific degree. The programme learning outcomes of Gangadhar Meher University focus on various aspects of knowledge and skills that prepare students for further study, employment, and citizenship. Therefore, the PG programme of this University has been designed with the objective to develop in-depth knowledge of students in frontier areas of concerned subject and seeks to achieve the following:

PO-1: Knowledge and Understanding:
Capable of demonstrating comprehensive knowledge and understanding of one or more disciplines that form a part of a post-graduate programme of study.

PO-2: General, Technical and Professional Skills:
Enable students to enhance mathematical skills and understand the fundamental concepts of pure and applied mathematics.

PO-3: Application of Knowledge and Skills:
Capability to apply analytic thought to a body of knowledge; analyze and evaluate evidence, arguments, claims, beliefs on the basis of empirical evidence; identify relevant assumptions or implications; formulate coherent arguments; critically evaluate practices, policies and theories by following scientific approach to knowledge development.

PO-4: Research Skills:
A sense of inquiry and capability for asking relevant/appropriate questions, problematizing, synthesizing and articulating; Ability to recognize cause-and-effect relationships, define problems, formulate hypotheses, test hypotheses, analyze, interpret and draw conclusions from data, establish hypotheses, predict cause-and-effect relationships; ability to plan, execute and report the results of an experiment or investigation.

PO-5: Generic Learning Outcomes:
Capable of strengthening knowledge and understanding in deeper stage and developing the art of skills. Along with this, constructing a good moral and ethics in the students.

PO-6: Constitutional, Humanistic, Ethical and moral values
Ability to embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work. Capable of demonstrating the ability to identify ethical issues related to one's work, avoid unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights; appreciating environmental and sustainability issues; and adopting objective, unbiased and truthful actions in all aspects of work.

PO-7: Employability and Job skills, Entrepreneur skills
Postgraduate study boosts the career progress and chart out the career paths. It demonstrates the ability to tackle complex and challenging assessment tasks.

PROGRAMME SPECIFIC LEARNING OUTCOME (PSO)

(Set by School of Mathematics)

PSO-1: Will have a strong foundation in both pure and applied mathematics.

PSO-2: Will be able to apply mathematical skills for solving problems and for preparing various competitive exams.

PSO-3: Will be able to communicate mathematical knowledge effectively, in writing as well as orally.

PSO-4: Will identify applications of mathematics in other disciplines, leading to enhancement of career prospects in different fields and research areas.

PSO-5: Will have basic knowledge of programming and computational techniques as required for employment.

PSO-6: Should have the knowledge of the fundamental axioms in mathematics and capability of developing ideas based on them and inculcate mathematical reasoning.

PSO-7: Will be able to locate and analyze the different mathematical texts with appropriate theoretical framework.

PSO-8: Have the knowledge of a wide range of mathematical techniques and application of mathematical methods/tools in science, social science, engineering and technology.

Matching

Matching Percentage	Level Indicator
> 70%	3
= 60 %	2
< 50%	1

MISSION TO PO MAPPING

	PO-1	PO-2	PO-3	PO-4	PO-5	PO6	PO7
M1	3	3	3	3	3	3	3
M2	3	2	3	3	3	2	3
M3	3	2	2	3	2	2	2
M4	1	2	1	3	1	1	2

PSO TO PO MAPPING

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
PSO1	3	3	2	3	3	3	3
PSO2	1	3	3	2	3	3	3
PSO3	3	2	2	2	2	3	2
PSO4	1	2	3	3	3	2	2
PSO5	2	3	3	2	3	2	2
PSO6	1	2	2	3	1	1	3
PSO7	2	3	2	3	1	3	2
PSO8	1	2	3	3	3	2	3

Brief Overview of Syllabus

Paper	Subject	Mark	Credit
SEMESTER - I			
Paper – 101	**Algebra**	20+80	4
Paper - 102	Partial Differential Equation	20+80	4
Paper - 103	Graph Theory-I	20+80	4
Paper - 104	Programming in C	20+80	4
Paper - 105	Practical	100	4
	Total	**500**	**20**
SEMESTER - II			
Paper - 201	Real Analysis	20+80	4
Paper – 202	Topology	20+80	4
Paper – 203	Graph Theory - II	20+80	4
Paper - 204	Programming with C++ - I	20+80	4
Paper - 205	Practical	100	4
DSE PAPER (Any One)			
Paper - 206 A	Mathematical Method	20+80	4
Paper - 206 B	Differential Geometry	20+80	4
Paper - 206 C	Advance Calculus	20+80	4
	Total	**600**	**24**
SEMESTER - III			
Paper - 301	Operation Research - I	20+80	4
Paper- 302	Functional Analysis - I	20+80	4
Paper - 303	Complex Analysis	20+80	4
Paper - 304	Programming with C++ - II	20+80	4
Paper - 305	Practical	100	4
IDSE Papers(Any One)**			
Paper - 306 A	Operation Research	20+80	4
Paper - 306 B	Elements of Number Theory	20+80	4
Paper - 306 C	Elements of Computer Programming	20+80	4
	Total	**600**	**24**
SEMESTER - IV			
Paper - 401	Operation Research - II	20+80	4
Paper - 402	Functional Analysis - II	20+80	4
Paper - 403	Operation Theory	20+80	4
Paper - 404	Number Theory	20+80	4
Paper - 405	Practical/Project	100	4
	Total	**500**	**20**
	Grand Total	**2200**	**88**

Red-Employability **Green-Skill Development** **Blue-Entrepreneurship**

SEMESTER – I

Paper - 101: ALGEBRA
Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:
Basic familiarity with the concepts of sets, functions, binary operation, group theory and linear algebra.

Objective:
This course is designed to give students a foundation for all future mathematics courses. The fundamentals of algebraic problem-solving are explained. Students will explore: foundations of Algebraic structures, Groups, Rings, Ideals, Fields, Homomorphisms etc. The course also fulfills the objective to make students aware of the applicability of abstract mathematics in real world problems

Syllabus-:

Unit-I: **(12 Hours)**
Ideals and Quotient rings, The Field of Quotients of an Integral Domain, Euclidean rings.

Unit – II: **(12 Hours)**
Polynomial Rings, Roots of Polynomials over the Rational Field, Polynomial Rings, Over Commutative Rings.

Unit – III: **(12 Hours)**
Fields, Extension Fields. Roots of Polynomials, More about Roots.

Unit- IV: **(12 Hours)**
The Elements of Galois Theory. Solvability by Radicals.

Book Prescribed:
Topics in Algebra: I. N. Herstein, Chapter- 3 (Sec. 4 to 11), 5 (5.1, 5.3, 5.5, 5.6 and 5.7 only).

Course Outcomes:
Upon successful completion of this course students able to-:
CO 1: define ring, ideal, quotients ring, field, polynomial rings, extension field
CO 2: explain the fundamental concepts of algebra such as ideal, ring, polynomial ring and their role in modern mathematics and applied contexts
CO 3: describe the structure of field of quotients of an integral domain
CO 4: explain the notion of extension of a field
CO 5: use Galois theory to analyze the solvability of polynomial

CO-PO Mapping (Paper 101)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3
CO5	2	3	2	3	2	2	2

Programme articulation matrix row for Paper 101

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 101	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 101)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2
CO5	2	3	2	3	3	2	3	2

Paper - 102: PARTIAL DIFFERENTIAL EQUATION

Full Marks : 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Partial differential equation, Lagrange method, Charpit's method, Integral surface, complete integral, Monge cone, D'Alembert's solution, Dirichlet problem

Objective:

The Objective of this course is to introduce first and higher order partial differential equations and their classification. This course explains various analytic methods for computing the solutions of various partial differential equations. It also explains various applications of partial differential equations in real physical phenomenon like wave equation of string, diffusion equations and heat flow equation to students

Syllabus:

Unit – I: **(12 Hours)**

Ordinary differential equations in more than two variables.

Unit – II: **(12 Hours)**

Partial differential equations of first Order.

Unit – III: **(12 Hours)**

Partial differential equations of second order,

Unit – IV: **(12 Hours)**

Monge's method for solving Second order non-linear Partial differential Equation, Laplace's equation.

Book Recommended:

I. N. Sneddon, *Elements of Partial Differential Equations*:, Mc Graw Hill Kogakusha: I (Section - 1 to 6), II, III, IV (Section - 1 to 4).

Course Outcome:

CO 1: Use knowledge of partial differential equations (PDEs), modelling, the general structure of solutions, and analytic and numerical methods for solutions.

CO 2: Formulate physical problems as PDEs using conservation laws.

CO 3: Understand analogies between mathematical descriptions of different (wave) phenomena in physics and engineering.

CO 4: Classify PDEs, apply analytical methods, and physically interpret the solutions.

CO 5: Solve practical PDE problems with finite difference methods, implemented in code, and analyse the consistency, stability and convergence properties of such numerical methods.

CO-PO Mapping (Paper 102)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3
CO5	2	3	2	3	2	2	2

Programme articulation matrix row for Paper 102

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 102	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 102)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2
CO5	2	3	2	3	3	2	3	2

Paper - 103: GRAPH THEORY - I

Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Basic logic, set operations, elementary number theory, basic knowledge of linear algebra

Objective:

To understand and apply the fundamental concepts in graph theory To apply graph theory based tools in solving practical problems. To familiar with the major viewpoints and goals of graph theory: classification, extremality, optimization and sharpness, algorithms, and duality.

Syllabus-:

Unit - I: **(12 Hours)**

Introduction, Paths and Circuits,

Unit -II: **(12 Hours)**

Trees

Unit - III: **(12 Hours)**

Fundamental circuits, Cut sets and Cut Vertices.

Unit - IV: **(12 Hours)**

Planar and Dual graphs.

Book Prescribed:

N. Deo, *Graph Theory with applications to Engineering and Computer Science*, Prentice Hall of India Ltd., 1979**,** Chapter - I, II, III, IV, V.

Reference Books:

1. F. Harary, Graph Theory. Narosa Publishing House, 2001
2. Bondy and Murty, Graph Theory and Application, Elsevier Science Ltd, 1976.

Course Outcome

Upon successful completion of this module students able to

CO 1: Defines a graph, bipartite graph, Eulerian graph, Hamitonian graph
CO 2: Identify edges, vertices, subgraphs, matching, covers in graphs and construct examples and to distinguish examples from non-examples;
CO 3: Solve problems using basis graph theory, involving vertices and edge, connectivity, planarity, crossing numbers and edge coloring
CO 4: interpret theoretical knowledge and independent mathematical thinking in creative investigation of questions in graph theory
CO 5: explain basic results about coloring vertices, 4 color problem, planar graph notion, dual Graphs

CO-PO Mapping (Paper 103)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3
CO5	2	3	2	3	2	2	2

Programme articulation matrix row for Paper 103

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 103	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 103)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2
CO5	2	3	2	3	3	2	3	2

Paper - 104: PROGRAMMING IN C

Full Marks : 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Basic computer skills, Logic building skills

Objective:

The course is designed to provide complete knowledge of C language. Students will be able to develop logics which will help them to create programs, applications in C. Also, by learning the basic programming constructs they can easily switch over to any other language in future.

Syllabus-:

Unit-I: **(12 Hours)**

Overview Constants, Variables, Data types, Operators and Expressions, Managing I/O operators. of C,

Unit - II: **(12 Hours)**

Decision making and Branching, Looping, Arrays, Character, Strings.

Unit - III: **(12 Hours)**

User defined Functions,

Unit- IV: **(12 Hours)**

Structure and Union, Pointers.

Book Prescribed:

E. Balagurusamy, *Programming in ANSI C*. McGraw Hill Education; 8th Edition, 2019

Reference Books:

1. Y. Kanetkar, *Let us C*, BPB Publications; 15th Edition, 2016.
2. Venugopal, *Mastering in C*, McGraw Hill Education; 1st Edition 2006.
3. V. Rajaraman, *Computer Programming in C*, Prentice Hall India Learning Private Limited 1994.

Course Outcome:

After course completion the students will have the following learning outcomes:

- **CO 1**: define and manage data structures based on problem subject domain and work with textual information, character and strings, arrays of complex objects
- **CO 2**: explain the concepts of object thinking within the framework of functional model
- **CO 3:** describe defensive programming concepts
- **CO 4**: asses to handle possible errors during program.

CO-PO Mapping (Paper 104)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	2
CO2	3	1	3	2	2	1	3
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 104

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 104	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 104)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

Paper - 105: PRACTICAL - PROGRAMMING IN C (0L-0T-4P)

Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Baic knowledge of computer, concept of Turboo C, Quadratic equation, Fibonacci series, matrices, GCD and LCM of a number, Prime number, factorial, series expansion of number

Syllabus:

Students have to practice the following programme in turbo c and verify the correct result;

1. Write a program in C to find the root of the Quadratic equation $ar^2 + br + c = 0$ for given value of a,b,c.
2. Write a program in C to enter the value of a and b, then swap the value of a and b with using the third variable.
3. Write a program in C to find the list of 'n' terms of a fibanacci series.
4. Write a program in C to test whether a no is perfect or not.
5. Write a program in C to test whether a no is palindrome or not.
6. Write a program in C to test whether a no is strong or not.
7. Write a program in C to arrange 10 given numbers in ascending order.
8. Write a program in C to arrange 10 given number in descending order.
9. Write a program in C to find the product of two matrices.
10. Write a program in C to add two given matrices.
11. Write a program in C to find the transpose of a matrix.
12. Write a program in C to find the GCD and LCM of a number.
13. Write a program in C to test whether a number is prime or not.
14. Write a program in C to find the factorial of a number.
15. Write a program in C to find series expansion of e^x for a given value of x correct up to y decimal places.

Course Outcome:

After the successful completion of all programmes, the students will be able to

CO1: write any programme of above type and apply to solve practical problem.

CO2: create similar type programming for other type of problems

CO3: apply the techniques and methods to analyses others problems

CO4: analyze the problems minutely and create their own algorithms to solve many mathematical problem

CO-PO Mapping (Paper 105)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 105

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 105	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 105)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

SEMESTER- II

Paper - 201: REAL ANALYSIS

Full Marks : 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Set Theory, Sequences and Series, Functions and Mapping

Objective:

To provide a basic course in Lebesgue Measure and Integration and a study of inequalities and the Lp –spaces.

Syllabus:

Unit - I **(12 Hours)**

Measure on the real line.

Unit – II **(12 Hours)**

Integration of functions of a real variable

Unit – III **(12 Hours)**

Differentiation.

Unit – IV **(12 Hours)**

Abstract measure space.

Text Book:

G. de. Barra, *Measure theory and Integration*, New Age International Private Limited, 1st Edition, 2013. Chapter – 1 (1.5 - 1.7), II, III, IV, V. VI.

Reference Books:

1. E. Hewitt and K. Stromberg, Real and Abstract Analysis, Springer; 1975
2. W. Rudin, Real and Complex Analysis, Tata Mc Graw Hill, 2017.

Course Outcomes:

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

CO1: Demonstrate understanding of the basic concepts underlying the definition of the general Lebesgue measure in real line and properties.

CO2: Demonstrate understanding of the statements of the main results on integration on Real line and an ability to apply these in examples.

CO3: Apply the theory of the concept of differentiation to solve a variety of problems at an Appropriate level of difficulty.

CO4: Demonstrate skills in communicating mathematics orally and in writing of abstract measure

CO-PO Mapping (Paper 201)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 201

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 201	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 201)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

Paper - 202: TOPOLOGY

Full Marks : 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Knowledge of Sets, partially ordered Sets, Totally Ordered Sets, Calculus, Real line, Sequences, Convergence of sequences.

Objective:

The objective of the course on Topology is to provide the knowledge of Topological Spaces and their importance. To acquaint students with the concept of Homeomorphism and the topological properties and important mathematical concepts which can be generalized in topological spaces, so that students may learn and appreciate the nature of abstract Mathematics

Syllabus:

Unit – I **(12 Hours)**

Topological Spaces and Continuous Functions.

Unit – II **(12 Hours)**

Connectedness and Compactness.

Unit – III **(12 Hours)**

Countability and Separation Axioms,

Unit – IV **(12 Hours)**

The Tychonoff Theorem, Complete Metric Space, Compactness on Metric Spaces.

Books Prescribed:

J.R. Munkres, *Topology - A First Course in Topology*, Pearson, 2nd Edition, 2000.

Books for Reference:

1. M. A. Armstrong, *Basic Topology*, Springer-Verlag New York Inc, 1st Edition.1983.
2. TW Gamelin and RE Greene. *Introduction to Topology*. 2nd Edition, Dover Publications, 1999.
3. Stephen Willard, *General Topology*, Dover Publication, 2004.

Course Outcomes:

After completing this course successfully, the student will be able to:

CO1: Understand basic problems in the Topology of R, Topology of Metric Spaces and Hausdorff spaces.

CO2: Apply the concepts of metric spaces and topological spaces, and their role in mathematics. Demonstrate familiarity with a range of examples of these structures.

CO3: Understand separability, completeness, connectedness, compactness.

CO4: Express regularity and normality separation axioms and use them to prove various properties.

CO-PO Mapping (Paper 202)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 202

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 202	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 202)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

Paper - 203: GRAPH THEORY - II

Full Marks : 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Basic logic, set operations, elementary number theory, basic knowledge of linear algebra

Objective:

To understand and apply the fundamental concepts in graph theory To apply graph theory based tools in solving practical problems. To familiar with the major viewpoints and goals of graph theory: classification, extremality, optimization and sharpness, algorithms, and duality.

Syllabus

Unit - I: **(12 Hours)**

Vector spaces of graph.

Unit - II: **(12 Hours)**

Matrix representation of graphs, Coloring

Unit - III: **(12 Hours)**

Covering and partioning,

Unit - IV: **(12 Hours)**

Directed graphs

Book Prescribed:

Graph Theory with applications to Engineering and Computer Science: N. Deo, (Prentice Hall of India Ltd.), Chapter - VI, VII, VIII, IX.

Reference Books:

1. Graph Theory: F. Harary.
2. Graph Theory and Application: Bondy and Murty (Mac Milian).

Course Outcome

Upon successful completion of this module students able to

CO 1: Defines a graph, bipartite graph, Eulerian graph, Hamitonian graph

CO 2: Identify edges, vertices, subgraphs, matching, covers in graphs and construct examples and to distinguish examples from non-examples;

CO 3: Solve problems using basis graph theory, involving vertices and edge, connectivity, planarity, crossing numbers and edge coloring

CO 4: interpret theoretical knowledge and independent mathematical thinking in creative investigation of questions in graph theory

CO 5: explain basic results about coloring vertices, 4 color problem, planar graph notion, dual Graphs

CO-PO Mapping (Paper 203)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3
CO5	2	3	2	3	2	2	2

Programme articulation matrix row for Paper 203

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 203	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 203)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2
CO5	2	3	2	3	3	2	3	2

Paper - 204: PROGRAMMING WITH C++ - I

Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:
Programming Language, Language C

Objective:
To expose the students to various tools in solving numerical problems. To enable the students to apply these methods in a computer environment using C++.

Syllabus:

Unit - I: **(12 Hours)**
Principles of object-oriented programming - Object oriented programming paradigm, Basic concept of OOP, benefits of OOP, applications of OOP., Structure of a C++ program - creating a source file, compiling and linking a C++ program.

Unit - II: **(12 Hours)**
Tokens, Expression and Control structures - Key words, Identifiers, Data types. User defined data types, Derived data types, Symbolic constant, Variables, Operators in C++.

Unit - III: **(12 Hours)**
Function in C++, Function prototyping, Call by reference, Inline function, Default argument, Function overloading. Classes and Objects Defining class and member function.

Unit - IV: **(12 Hours)**
Structures of a C++ program with class, nesting of member, memory allocation for objects, static data member, static member function, Friend function, pointers to data member.

Book Prescribed:
Object Oriented Programming with C++: E. Balagurusamy, (Chapter 1 to 5).

Reference Books:
1.Object Oriented Programming Turbo C++: Robert Lafore.
2.Mastering in C++: Venugopal.

Course Outcomes:
CO1: Understanding about object-oriented programming.
CO2: Gain knowledge about the capability to store information together in an object.
CO3: Understand the capability of a class to rely upon another class.
CO4: Learn how to store one object inside another object and use of one method can be used in variety of different ways.
CO5: Understanding the process of exposing the essential data to the outside of the world and hiding the low-level data

CO-PO Mapping (Paper 204)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	3
CO2	3	1	3	2	2	1	3
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	2
CO5	2	3	2	3	2	2	3

Programme articulation matrix row for Paper 204

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 204	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 204)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2
CO5	2	3	2	3	3	2	3	2

Paper - 205: PRACTICAL PROGRAMMING WITHC++ - I
Full Mark – 100

Pre-requisites:

Basic mathematical calculation skills and logic skills, C++ programming knowledge

Syllabus:

Following Programs Should be done in C ++

1. Write a program to enter a number and find the factorial.
2. Write a program to display the sum of digits of a number.
3. Write a program to find the sum of 1+2+3+…+n for given values of n.
4. Write a program to interchange the value of a and b.
5. Write a program to solve $\boldsymbol{ax^2 + bx + c = 0}$ for given value of a,b,c.
6. Using function overloading find the area of a circle, rectangle and square.
7. Test whether a given number is prime or not.
8. Test whether a given year is a leap year or not.
9. Find the largest of three given numbers.
10. Illustrate switch-case statement.
11. Find the grade of a student.
12. Find the largest of n given number.
13. Sort a list of n numbers in ascending order.
14. Using reference variable swap the values of two variables.
15. Test whether a given string is palindrome or not.

Course Outcome:

After the successful completion of all programmes, the students will be able to

CO1: write any programme of above type and apply to solve practical problem.

CO2: create similar type programming for other type of problems

CO3: apply the techniques and methods to analyze others problems

CO4: analyze the problems minutely and create their own algorithms to solve many mathematical problem

CO-PO Mapping (Paper 205)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 205

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 205	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 205)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

Paper - 206 A: MATHEMATICAL METHOD

Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Sequence and series, Function, Limit, Continuity, differentiation, integration

Objective:

The objective of the course is to acquaint the students with the knowledge of mathematical techniques frequently applied in various branches of engineering and sciences. Also, one of the objectives of this course is to equip the students with the mathematical background required for the development of such techniques.

Syllabus-:

Unit - I: **(12 Hours)**

Laplace Transforms.

Unit - II : **(12 Hours)**

Fourier Series

Unit III: **(12 Hours)**

Fourier Integrals.

Unit -IV: **(12 Hours)**

Calculus of Variation: Variation & its Properties, Euler equation.

Books Prescribed:

1.Advanced Engineering Mathematics: Erwin Kreyszig Wiley, Eastern Ltd., 5th edition, Chapters – 5 and 10,.

2.Calculus of Variations with Application: A. S. Gupta, PHI, Chapter – (Art 1, 2 only).

Course Outcome:

After the successful completion of this course the students will be able to

CO1: the methods to solve differential equations using Laplace transform

CO2: understand Fourier series expansion of a functions and apply to solve many practical problems

CO3: gain the Fourier transform and apply transform technique to solve problems

CO4: gain knowledge a new method to solve differential equation using Euler's equation

CO-PO Mapping (Paper 206A)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 206A

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 206A	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 206A)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

Paper - 206 B: DIFFERENTIAL GEOMETRY

Full Marks : 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Multivariable calculus, linear algebra and differential equations

Objective:

The objective of this course is to make students familiar with basic concepts of differential geometry so as to deal with geometry of curves and spaces using the methods of differential calculus.

Syllabus-:

Unit - I: **(12 Hours)**

The Theory of Space Curve

Unit - II: **(12 Hours)**

The Metric: Local Intrinsic Properties of a Surface

Unit III: **(12 Hours)**

The Second Fundamental Form: Local Intrinsic Properties of a Surface

Unit -IV: **(12 Hours)**

Differential Geometry of Surfaces in the Large.

Books Prescribed:

1. T. J. Willmore, *An Introduction to Differential Geometry*, Oxford University Press Ch: 1 (1.1 to 1.9), 2(2.1 to 2.12), 3(3.1 to 3.10), 4(4.1 to 4.9)
2. J.A Thorpe, *Elementary Topics in Differential Geometry*, Springer-Verlag New York Inc. 1st Edition. 1979.
3. A. Pressley, *Elementary Differential Geometry*, 2nd Edition, Springer International Edition,2014

Books of References:

1. E. Kreyszig, *Differential Geometry*, Dover Publication, New York, 2003.
2. B. O' Neill, *Elementary Differential Geometry*, 2nd Edition., Academic Press, 2004.
3. S. Lang, *Fundamentals of Differential Geometry*, 1st Edition, Springer-Verlag, New York Inc,1999.

Course Outcome:

Upon successful completion of this module students able to

CO 1: defines surfaces, their properties, parametrization of surfaces and tangent spaces of Surfaces

CO 2: lists topological aspects of surfaces

CO 3; recognize the basis of notions of the local theory of space curves and the local theory of surfaces

CO 4: explain concepts of curvature and Sernet-Frenet frame for space curves and the notion of torsion of a space curve

CO 5: explain the normal curvature and second fundamental form

CO 6: defines geodesic-equation of geodesic, geodesic on sphere, geodesic as distance minimizing curves

CO-PO Mapping (Paper 206B)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3
CO5	2	3	2	3	2	2	2
CO6	2	2	2	2	3	3	3

Programme articulation matrix row for Paper 206B

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 206B	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 206B)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2
CO5	2	3	2	3	3	2	3	2
CO6	3	3	3	2	2	3	3	3

Paper - 206C: ADVANCED CALCULUS
Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:
Functions, Derivative of function in one variable**.**

Objective:
Develop ability to solve problems in the geometry and analysis using in differential forms, develop capacity to both prove results and solve problems. Develop skills as a critical judge of mathematical arguments. Recognize the place of differential calculus in mathematics and the greater realm of scientific thoughts.

Syllabus-:

Unit - I: **(12 Hours)**
Derivatives for Function on R^n - Differentiation of Composite functions and Taylor's Theorem

Unit-II: **(12 Hours)**
Transformation, Linear function and Transformations, Differentials of Transformation, Inverse Transformations.

Unit-III: **(12 Hours)**
Implicit Function Theorems, Functional dependence, set Functions and Transformation of Multiple Integrals.

Unit -IV: **(12 Hours)**
Curve and Arc-Length, Surfaces and surface Area, Integrals over Curves and Surfaces, Differential Forms, Theorem of Green, Gauss and Stokes, Exact forms and Closed forms

Books Prescribed:
Advance calculus by R.C Beck, 3rd edition, Mc Graw Hill Publication Chapter-3 (3.3 to 3.8), 7 (7.2 to 7.7), 8 (8.2 to 8.6), 9 (9.2, 9.4, 9.5)

Course Outcome:
After the successful completion of this course the students will be able to

CO1: extend their ability of differentiation of functions in Euclidean space R^n

CO2: develop their mind transformation and their properties in general space.

CO3: analyze the implicit and multiple integrals in generalized form

CO4: get and think the physical interpretation of solid figures in n-dimensional space.

CO-PO Mapping (Paper 206C)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 206C

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 206C	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 206C)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

SEMESTER – III

Paper 301: OPERATION RESEARCH - I

Full Marks : 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Linear programming, simplex methods, artificial variables, primal, dual, transportation, assignment problem, travelling salesman problem.

Objective:

This module aims to introduce students to use quantitive methods and techniques for effective decisions–making; model formulation and applications that are used in solving business decision problems

Syllabus-:

Unit - I: **(12 Hours)**

Convex sets and function, Linear Programming.

Unit - II: **(12 Hours)**

Duality in Linear Programming,

Unit- III: **(12 Hours)**

Transportation Problem.

Unit - IV: **(12 Hours)**

Assignment Problems, Revised Simplex Method.

Book Prescribed:

S. D. Sharma, *Operations Research*, Kedar Nath Ram Nath, 2020th Edition, 2014

Reference Books:

1.S. I. Gass, Linear Programming and Application: *Methods and Applications*, 5th Edition, Dover Publications Inc, 2011.

2.G. Hadley, *Nonlinear and Dynamic Programming*, Addison-Wesley Pub. Co.; First 1964 Edition,

3. Kanti Swarup, *Operation Research*, Sultan & Chand, 2010.

Course Outcome:

CO 1: Solving LPP and its formulation

CO 2: Solution of LPP by graphical method and simplex iterations using slack and surplus variables

CO 3: Solution of Transportation problem and its optimal solution by Modi method

CO 4: Assignment problem has solved using Hungarian method

CO5: Study of revised simplex iteration

CO-PO Mapping (Paper 301)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3
CO5	2	3	2	3	2	2	2

Programme articulation matrix row for Paper 301

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 301	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 301)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2
CO5	2	3	2	3	3	2	3	2

Paper - 302: FUNCTIONAL ANALYSIS - I
Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Ordered Sets, Metric Spaces, Linear Algebra, Basis, Dimension, Transformations, Complex Analysis.

Objective:

This course will develop a deeper and rigorous understanding of fundamental concepts of functional analysis, their properties and related theorems.

Syllabus-:

Unit - I: **(12 Hours)**

Definition and Examples of Metric space, Inequality of Holder and Minkowski, Examples of 1p spaces, Complete Space, Contractions, Completion.

Unit-II: **(12 Hours)**

Category, Nowhere Differentiable, Continuous Functions, Compactness, Continuity, Uniform continuity,

Unit - III: **(12 Hours)**

Stoke Weirstrass Theorem, Semi continuity, Space of Compact Convex Sets, Vector Space, Subspace. Quotient Space, Basis.

Unit - IV: **(12 Hours)**

Algebraic Dual, Second Dual, Convex Sets, Ordered Groups, Hahn-Banach Theorem.

Book Prescribed:

Goffman and Pedrick *A First Course in Functional Analysis*- Prentice Hall, 1965, Chapter - I (1-1.3, 1.7-1.13, 1.15,1.16), Chapter - II (2.1 – 2.9).

Reference Books:

Functional Analysis with Application: B. Choudhury and S. Nanda, Wiley Eastern Limited.

Course Outcomes:

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

CO1: To learn to recognize the fundamental properties of normed spaces and of the transformations between them.

CO2: Understand the notions of dot product and Hilbert space and apply the spectral theorem to the resolution of integral equations.

CO3: Correlate Functional Analysis to problems arising in Partial Differential Equations, Measure Theory and other branches of Mathematics.

CO4- Students will be able to relate different abstract space with their different structures

CO-PO Mapping (Paper 302)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	3	3	2	3	3	2	2

Programme articulation matrix row for Paper 302

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 302	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 302)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	3	2	2	2	2

Paper - 303: COMPLEX ANALYSIS

Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:

A strong back ground in calculus of one and several real variables: Real analysis, Multivariable calculus

Objective:

The objective of this course is to introduce and develop a clear understanding of the fundamental concepts of Complex Analysis such as analytic functions, Cauchy-Riemann relations and harmonic functions and to make students equipped with the understanding of the fundamental concepts of complex variable theory. In particular, to enable students to acquire skill of contour integration to evaluate complicated real integrals via residue calculus.

Syllabus-:

Unit-I: **(12 Hours)**

Complex numbers: The algebra of complex numbers, the geometric representation of complex numbers. Complex Functions: Introduction to the concept of analytic functions, elementary theory of power series, exponential and trigonometric function.

Unit-II: (**12 Hours)**

Analytical functions a mapping: Conformality, linear transformation, elementary conformal mapping. Complex Integration,

Unit -III: **(12 Hours)**

Fundamental theorems, Cauchy integral formula. Local properties of analytic functions,

Unit - IV: **(12 Hours)**

The integral forms of Cauchy's Theorem. Cauchy's Residue Theorem, Contour Integration

Books Prescribed:

1. Complex Analysis: L. V. Ahlfors, Mc Graw Hill, Kogakusha Ltd., Chapter - I, II, III (excluding 3.1), IV
2. Function of one Complex Variable: J. B. Conway Narosa Publisher House, Chapter - 4.

Book of References:

1.J.W. Brown, R. V. Churchill, *Complex Variables and Application*, 8th Edition, McGraw-Hill International Edition, 2009.

2.S. Ponnuswamy, *Complex Variables with Applications*, Herb Silverman, Bizkhauser Baston, USA, 2006.

3.J. Bak, Donald. Newman, *Complex Analysis*, 2nd Edition., Springer-Verlag, New York, 1997.

Course Outcome:

Upon successful completion of this module students able to

CO 1; work with functions (polynomials, reciprocals, exponential, trigonometric. hyperbolic) of single complex variable and describe mappings in the complex plane

CO 2: work with multi-valued functions (logarithmic, complex power) and determine branches of these functions

CO 3: evaluate a contour integral using parameterization, fundamental theorem of calculus and Cauchy's integral formula, find the Taylor series of a function and determine its circle or annulus of convergence

CO 4: compute the residue of a function and use the residue theory to evaluate a contour

integral

CO 5: recognize and apply the Liouville's theorem, the mean-value property of a function and the maximum modulus principle, Rouches theorem, Argument principle, fundamental theorem of algebra

CO-PO Mapping (Paper 303)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	3
CO4	2	2	3	2	3	2	3
CO5	2	3	2	3	2	2	2

Programme articulation matrix row for Paper 303

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course Paper 303	3	2	3	2	3	2

CO-PSO Mapping (Paper 303)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2
CO5	2	3	2	3	3	2	3	2

Paper - 304: PROGRAMMING IN C++ - II

Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Programming in C, C++-I and Object-oriented Programming features

Objective:

The objective of course is to develop programming skills of students, using object-oriented programming concepts, learn the concept of class and object using C++ and develop classes for simple applications.

Syllabus:

Unit-I: **(12 Hours)**

Constructors and destructors – Default constructors and parameterized constructor, copy constructor, dynamic constructor, constructor with default arguments, dynamic initialization of objects, constructors overloading, destructors and its function.

Unit – II: **(12 Hours)**

Operator overloading and type conversation - Defining operators overloading, overloading unary and binary operators, overloading binary operators using friend function, manipulation of strings using operators, rule for overloading operators, type conversions.

Unit – III: **(12 Hours)**

Inheritance: Extending classes - Defining derived classes, single inheritance, making a private member inheritable, multiple inheritance, Hierarchical inheritance, Hybrid inheritance,

Unit – IV: **(12 Hours)**

Virtual base class, Abstract classes, constructors in derived classes, Nesting of classes. Pointers, Virtual functions and polymorphisms - pointers to objects, this pointer, pointers to derive data classes, virtual functions, pure virtual function.

Book Prescribed:

E. Balagurusamy, Object *Oriented Programming with C++*, McGraw Hill; 8th Edition 2020 (Chapter 6 to 9).

Reference Books:

1.Robert Lafore, *Object Oriented Programming in Turbo C++*, Galgotia Publications Pvt Ltd, 1991.
2.K. Venugopal, *Mastering in C++*, McGraw Hill Education, 1997.

Course Outcome:

Upon successful completion of this module students able to

CO1: Understand about constructors which are special type of functions. Learn how to write code in a way that it is independent of any particular type.

CO2: Learn to derive a new class from the existing class.

CO3: Learn about one of the key features of class inheritance is that a pointer to a derived class is type-compatible with a pointer to its base class.

CO4: Create and process data in files using file I/O functions

CO-PO Mapping (Paper 304)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 304

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 304	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 304)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

Paper - 305: PRACTICAL
PROGRAMMING WITH C++ - II
Full Mark - 100

The candidates should be able to do the following programmes by using C^{++}Languages

1. Matrix Algebra:
   (a) Matrix addition using function or pointer
   (b) Matrix multiplication using function or pointer
   (c) Matrix Inverse
2. Solution of System of linear equation by following method
   (a) Gauss Elimination Method
   (b) Gauss Seidal iteration Method
   (c) Gauss Jordan Elimination Method
3. Rank of a matrix
4. Determinant of a Matrix
5. Solution of System of linear equation by Crammers Rule
6. Eigen value and Eigen vector of a matrix
7. Differential Equations: Solution of Initial value problem using following methods:
   (a) Euler's Method
   (b) Backward Euler Method
   (c) Eulere-Richardson's Method
   (d) Second order Ranga-Kutta Method
   (e) Milne's predictor corrector Method
   (f) (f) Gauss predictor corrector Method
8. Solution of boundary value problem.
9. Following curve should be trace using "graphic.h" in C
   (i) Circle (ii) Elipse (iii) Hyperbola (iv) Sine Curve (v) Cosine curve (vi) Cissoid (vii) Cardioid (r = a(1+cos(t)) (viii) Limacon (r= a+bcos(t)) (xi) Laminscate ($a(x^2 + y^2) = (x^2 + y^2)^2$)
10. Linear Programming Problem:
    (a) Solution of LPP by Simplex Method
    (b) Solution of LPP by Revise Simplex Method
11. Transportation Problem
12. Assignment Problem

The students may use Mathematica, matlab to run some of the above programs

Course Outcome:

After the successful completion of all programmes, the students will be able to

CO1: write any programme of above type and apply to solve practical problem.

CO2: create similar type programming for other type of problems

CO3: apply the techniques and methods to analyze others problems

CO4: analyze the problems minutely and create their own algorithms to solve many mathematical problem

CO-PO Mapping (Paper 305)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 305

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 305	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 305)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

Paper - 306 A: OPERATION RESEARCH

Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Integer programming, bounded methods, dynamic programming, zero-sum game, dominance principle, arithmetic methods, convex programming, and quadratic programming.

Objective:

The objective of this course is to develop an ability in the students to understand and analyze managerial problems in industry so that they are able to use resources (capitals, materials, staffing, and machines) more effectively, formulate mathematical models for quantitative analysis of managerial problems in industry, develop skills in the use computer tools in solving real problems in industry.

Syllabus-:

Unit - I: **(10 Hours)**

Convex sets and function, Linear Programming.

Unit - II: **(13 Hours)**

Duality in Linear Programming,

Unit - III: **(13 Hours)**

Transportation Problem.

Unit - IV : **(12 Hours)**

Assignment Problems.

Book Prescribed:

Kanti Swarup, *Operation Research*, Sultan & Chand, 2010.

Reference Books:

1. S. I. Gass, *Linear Programming and Application: Methods and Applications*: 5th Edition., Dover Publications Inc, 2011
2. G. Hadley, *Nonlinear and Dynamic Programming*, Addison-Wesley Pub. Co.; 1st Edition.1964
3. S. D. Sharma, Operations Research, Kedar Nath Ram Nath, 2020th edition, (2014)

Course Outcome:

CO 1: Solving LPP and its formulation

CO 2: Solution of LPP by graphical method and simplex iterations using slack and surplus variables

CO 3: Solution of Transportation problem and its optimal solution by Modi method

CO 4: Assignment problem has solved using Hungarian method

CO 5: Study of revised simplex iteration

CO-PO Mapping (Paper 306A)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3
CO5	3	3	2	2	3	3	2

Programme articulation matrix row for Paper 306A

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 306A	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 306A)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2
CO5	3	2	3	2	3	2	2	3

Paper - 306 B: ELEMENTS OF NUMBER THEORY

Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Number system, Function,

Objective:

The main goal of the course is to provide an introduction to elementary and contemporary number theory. It will include many examples of intermediate and advanced techniques, methods of proofs, and rigorous analytic thinking used in upper-level mathematics.

Syllabus:

Unit - I: **(12 Hours)**

Divisibility and Distribution of Primes

Unit - II: **(12 Hours)**

The Theory of Congruences and Fermat's Theorem

Unit - III: **(12 Hours)**

Number- Theoretic Functions and Euler's Generalization of Fermat's Theoram

Unit - IV : **(12 Hours)**

The Quadratic Reciprocity Law.

Book Prescribed:

Elementary number theory by David M. Burton, Tata McGraw Hill Edn. Pvt. Ltd.
Chapter-2 (2.2 to 2.4), 3(3.1, 3.2), 4(4.2, 4.4), 5(5.2, 5.3), 6(6.1 to 6.3), 7(7.2, 7.3), 9(9.1 to 9.4)

Reference Books:

1. Hardy and Wright, *An Introduction to the Theory of Numbers*, Oxford University Press; 6th Edition (2008)
2. K. Chandrashekaram, *Introduction to Analytic Number Theory*, Springer-Verlag Berlin and Heidelberg GmbH & Co. K; Softcover reprint of the original 1st Edition. 1968

3 K. Chandrashekaram, *Arithmetical Functions*, Springer-Verlag Berlin and Heidelberg GmbH & Co. K; 1970th edition, 2012.

Course Outcome:

After the successful completion of this course the students will be able to

CO1: get knowledge of divisibility in integers and existence and properties of primes in integers

CO2: understand and analyze the congruence and apply in number theoretic system.

CO3: analyze and think of many number theory functions in number theory

CO4: apply the concept of congruence and their properties for some standard formulas and apply the formulas in practical problems.

CO-PO Mapping (Paper 306B)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 306B

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 306B	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 306B)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

Paper 306 C: ELEMENTS OF COMPUTER PROGRAMMING

Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Computer skills, Basic mathematical calculation skills and logic skills

Objective:

The course is designed to provide complete knowledge of basics for Computer Programming. Students will be able to develop logics which will help them to create programs. Also they will learn the Algorithms, Flow chart for different numerical methods, which helps to write program in future.

Syllabus:

Unit – I **(12 Hours)**

Binary system, Octal and Hexadecimal systems. Conversion to and from Decimal systems. Codes, Bits, Bytes and Words. Memory of a computer, Arithmetic and Logical operations on numbers. Precisions, AND, OR, XOR, NOT and Shift operators, Basic logic gates and Truth Tables.

Unit – II **(12 Hours)**

Boolean Algebra, Normal Forms, Representation of unsigned integers, Signed integer, Real, Double precisions numbers, Long integers.

Unit – III **(12 Hours)**

1.Algorithm and Flow chart for solving the following Numerical Analysis problems.
2. Solution of algebraic an transcendental equation of one variable by Bisection, Regula-Falsi and Newton-Raphson methods.
3. Solution of system of linear equations by Gaussian elimination and Gauss-Jordan (direct), Gauss Seidel (iterative) methods.
4. Newton's (forward and backward), Lagrange's interpolation methods.

Unit IV: **(12 Hours)**

1. Numerical integration by Trapezoidal rule, Simpson's rules, Gaussian quadrature formula.
2. Numerical solution of ordinary differential equations by Euler and Runga-Kutta methods.

Reference Books:

1.Structured Computer Organization: Andrew S. Tanenbaum (PHI).
2.Computer Oriented Statistical & Numerical Methods: E. Balagurusamy (MacMillan India Limited).
3.Discrete Mathematics: M. K. Gupta (Krishna's).
4.C Language and Numerical Methods: C. Xavier (New Age).
5.Discrete Mathematics – K. Rosen

Course Outcome

Upon completion of this course, students will acquire knowledge about:

CO 1: explain the algorithm and draw flowcharts for solving Mathematical and Engineering problems

CO 2: design and develop computer programs, analyzes and interprets the concepts of pointers, declaration, initialization, operations on pointers and their usage

CO 3: define data types and use them in simple data processing applications also he/she must able to use the concepts of array of structures

CO 4: develop confidence for self -education and ability to life- long learning needed for computer language

CO-PO Mapping (Paper 306C)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 306C

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 306C	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 306C)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

SEMESTER – IV

Paper - 401: OPERATION RESEARCH - II

Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Integer programming, bounded methods, dynamic programming, zero-sum game, dominance principle, arithmetic methods, convex programming, and quadratic programming.

Objective:

The objective of this course is to develop an ability in the students to understand and analyze managerial problems in industry so that they are able to use resources (capitals, materials, staffing, and machines) more effectively, formulate mathematical models for quantitative analysis of managerial problems in industry, develop skills in the use computer tools in solving real problems in industry.

Syllabus-:

Unit - I: **(12 Hours)**

Upper Bounding Technique, Integer Programming Problems, Branch & Bounds.,Gomary Method.

Unit - II: **(12 Hours)**

Dynamic Programming,

Unit- III: **(12 Hours)**

Game Theory

Unit - IV: **(12 Hours)**

K. T. Conditions, Quadratic Programming.

Book Prescribed:

S. D. Sharma, Operations Research, Kedar Nath Ram Nath, 2020th edition, (2014)

Reference Books:

1. S. I. Gass, *Linear Programming and Application: Methods and Applications*: 5th Edition., Dover Publications Inc, 2011.
2. G. Hadley, *Nonlinear and Dynamic Programming*, Addison-Wesley Pub. Co.; 1st Edition.1964
3. Kanti Swarup, *Operation Research*, Sultan & Chand, 2010

Course Outcome:

CO 1: Solving Integer LPP by branching and cutting plane method.

CO 2: Discrete DPP and Solution of LPP dynamic programming.

CO 3: Study of nonlinear programming problem with Kuhn-Tucker conditions

CO 4: Solution of quadratic programming problem with and without Kuhn-Tucker conditions

CO-PO Mapping (Paper 401)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 401

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 401	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 401)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

Paper - 402: FUNCTIONAL ANALYSIS - II
Full Marks : 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Ordered Sets, Metric Spaces, Linear Algebra, Basis, Dimension, Transformations, Complex Analysis.

Objective:

This course will develop a deeper and rigorous understanding of fundamental concepts of functional analysis, their properties and related theorems.

Syllabus

Unit-I **(12 Hours)**

Banach Space, Dual Space, Hahn – Banach Theorem in Normed Space, Uniform Bounded Principal

Unit – II **(12 Hours)**

Lemma of F. Riesz, Applications, Application to Compact Transformations, Second Dual space, Dual of Lp, Hillbert space

Unit – III **(12 Hours)**

Projection Theorem, Dual, Mean Ergodic Theorem, Fourier Expansion.

Unit – IV **(12 Hours)**

Isoperimetric Theorem. Riesz – Fischer Theorem, Complete Orthogonal Sets.

Book Prescribed:

First Course in Functional Analysis: G. Goffman and G. Pedrick. Printice Hall of India Pvt. Ltd., Chapter - II (2.11-2.15, 2.17, 2.18), Chapter - IV (4.1-4.5, 4.7,4.10).

Reference Books:

Kreyszig E., *Introductory Functional Analysis with Applications*, Wiley; Edition, 2007.

Course Outcomes:

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

CO1: To learn to recognize the fundamental properties of normed spaces and of the transformations between them.

CO2: Understand the notions of dot product and Hilbert space and apply the spectral theorem to the resolution of integral equations.

CO3: Correlate Functional Analysis to problems arising in Partial Differential Equations, Measure Theory and other branches of Mathematics.

CO4- Students will be able to relate different abstract space with their different structures

CO-PO Mapping (Paper 402)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	3	3	2	3	3	2	2

Programme articulation matrix row for Paper 402

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 402	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 402)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	3	2	2	2	2

Paper - 403: OPERATOR THEORY

Full Marks : 100 (20 Mid Term + 80 End Term)

Pre-requisitse:

Functional Analysis, Banach Space, Hilbert Space, Operators, Abstract Algebra

Objective:

To teach the fundamentals of Banach Algebras and Spectral Operator Theory which are necessary for a deeper understanding of many adjacent mathematical fields (integral and differential equations, mathematical physics, harmonic analysis, operator theory etc.)

Syllabus:

Unit - I: **(12 Hours)**

Banach Algebra: Introduction, Complex homomorphism, Basic properties of spectra.

Unit - II: **(12 Hours)**

Commutative Banach Algebra: Ideals, and homomorphism, Geifand transform, Involution

Unit-III: **(12 Hours)**

Bounded operators in a Hillbert Space: Basic facts, Bounded operators, Fuglede- Putnam – Rosenblum Theorem, Resolution of the identity.

Unit - IV: **(12 Hours)**

The Spectral Theorem, Eigen – values of normal operators, Positive operators and square roots

Books Recommended:

Functional Analysis – Walter Rudin- Tata Mcgraw Hill {Ch – 10 (10.1 – 10.20), Ch-11 (11.1 – 11.20), Ch-12 (12.1 – 12.36)}

Reference Books:

1.Basic Operator Theory: Gohberg and Goldberg.
2.Principle of Functional Analysis: M. Schecter.
3.Theory of Linear Operator, Vol. I, II, Pitman Publishing House: Akhietzer and Glazeman.
4.Linear Operator, Vol. I, II, III: Donford and Schwarz.
5.Linear Operator on Hilbort Speces, Speringer: Weildman.

Course Outcomes:

CO1: Understand the Banach Algebra, and properties of homomorphism on a Banach algebra, Basic properties of Spectra.
CO2: Learn Commutative Banach Algebra and mapping on the Space.
CO3: Analyze the Properties of bounded linear operators on Hilbert spaces.
CO4: Understand the spectrum and characterize the eigenvalues of normal, positive, Unitary operators.

CO-PO Mapping (Paper 403)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 403

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 403	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 403)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

Paper - 404: NUMBER THEORY

Full Marks: 100 (20 Mid Term + 80 End Term)

Pre-requisites:

Number system, infinite series, Divisibility, Prime Numbers, Working knowledge of Group and ring theory.

Objective:

To illustrate how general methods of analysis can be used to obtain results about integers and prime numbers. To investigate the distribution of prime numbers. To consolidate earlier knowledge of analysis through applications

Syllabus-:

Unit - I: **(12 Hours)**

Arithmetical function and Dirichlet multiplication.

Unit - II: **(12 Hours)**

Congruences & Dirichlet theorem on primes in arithmetic progression,

Unit - III: **(12 Hours)**

Periodic arithmetical functions & Gauss sums.

Unit - IV : **(12 Hours)**

Quadratic residues and Quadratic reciprocity law.

Book Prescribed:

Introduction to Analytic Number Theory: T. M. Apostol (Springer, International students End) Narosa Publ. House. Chapter – 2(2.1 to 2.14, 2.16, 2.17), 5 (5.1 -5.8), 7(7.2 to 7.9), 8(8.1 to 8.12), 9 (9.1-9.10)

Reference Books:

1.An Introduction to the Theory of Numbers: Hardy and Wright.
2.Introduction to Analytic Number Theory: K. Chandrashekaram.

Course Outcome:

After the successful completion of this course the students will be able to

CO1: understand different types of arithmetic functions with applications

CO2: apply congruence to solve many problems for different arithmetic functions

CO3: analyze periodic arithmetic functions and Gauss sums

CO4: evaluate many numbers theoretic problems using reciprocity law

CO-PO Mapping (Paper 404)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3

Programme articulation matrix row for Paper 404

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 404	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 404)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2

Paper - 405 (PROJECT + VIVA-VOCE)
MARKS - (50 +50)

Objective

The main objective of the paper is to increase the creativity of students. They can develop cognitive skills and independently navigate in the information space. Apart from these, they can produce and design knowledge independently

Course Outcomes

At the end of this project, students will

CO1- engage in the study or research of a topic that is beyond the regular math department offerings in both rigor and content

CO2- produce a document (paper or honors thesis) that exhibits both the background and the conclusions reached as a result such study or research.

CO3- can develop the skill of presentation

CO4- can compile existing work and learn to prepare report using Latex.

CO-PO Mapping (Paper 405)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO1	3	2	1	1	2	1	1
CO2	3	1	3	2	2	1	2
CO3	2	3	3	3	2	2	2
CO4	2	2	3	2	3	2	3
CO5	2	3	2	3	2	2	2

Programme articulation matrix row for Paper 405

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
Course Paper 405	3	2	3	2	3	2	3

CO-PSO Mapping (Paper 405)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CO1	3	3	3	3	3	3	2	2
CO2	3	2	3	2	2	2	3	3
CO3	3	3	3	3	2	2	3	3
CO4	2	3	3	2	3	3	2	2
CO5	2	3	2	3	3	2	3	2