SYLLABUS STRUCTURE

FOR

POST-GRADUATE PROGRAMME
IN
MATHEMATICS
(M.A./M.Sc. in Mathematics)
(2024-26)

2024-26

SCHOOL OF MATHEMATICS

GANGADHAR MEHER UNIVERSITY, AMRUTA VIHAR

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P. G. SEMESTER EXAMINATION REGULATIONS

CHAPTER – I

REGULATION OF GENERAL ACADEMIC MATTERS

1.1 The Departments shall follow Semester System of teaching and Examination based on continuous evaluation internally as well as externally subject to moderation of question papers. The system of evaluations of the students shall be based on Course Credit System.

1.1.1 Academic Year

The Academic Year of the department shall ordinarily be from JUNE to MAY. It may however, be modified by the Staff Council from time to time.

1.1.2 Semester

The academic year shall have two semesters, each of which shall be of 6 months duration.

1.2 Minimum working days in a Semester

A Semester shall have a minimum of 90 working/instructional days excluding examination days/Sundays/Holidays etc. The minimum number of classes in a semester shall not fall short of the number of classes as mentioned below.

1. One Credit hour courses = 10 classes minimum
2. Two Credit hour courses = 20 classes minimum
3. Three Credit hour courses = 30 classes minimum
4. Four Credit hour courses = 40 classes minimum
5. Five Credit hour courses = 50 classes minimum

1.3 ***Credit hours***

One credit shall signify the quantum of teaching imparted corresponding to one hour of theory class and two hours of laboratory/project work and two hours of seminar per week during a semester in respect of a particular course. Each teaching hour of theory class will be of 60 minutes and practical classes/project work will be of 120 minutes duration and seminar will be of 120 minutes duration. For field study outside headquarters, one working day will be considered as two teaching hours. However, the field study should not exceed 30 days (including Sundays) in one semester.

The P. G. Syllabus may be so designed that the total of credit hours for all four semesters shall be 88 spread equally over all semesters as far as practicable, tutorials and proctorials shall be treated as non-credit components.

1.4 ***Course***

A course is a Unit of instruction under any discipline carrying a specific number of credit hours describing its weightage. Those courses, which a student must take as compulsory requirement, are, called Core Courses. Those courses, which a student opts out of a list of specialized courses offered by the department, are called Elective Courses.

Choice Based Credit System (CBCS) is introduced at the P. G. Semester-I level uniformly in all the subjects to be taught in paper-103. The students of P. G. Arts stream can not opt for the CBCS course of Science stream. The details of the CBCS courses offered by different P. G. Departments are given in Annexure-II.

1.4.1 ***Grade***

The grade awarded to a student in any particular course shall be based on his/her performance in all the tests conducted during a semester and shall be awarded at the end of the semester. The grade in each course is expressed in numerical value in 10.00 scale. The marks of a student shall be converted to10.00 scale and the points scored thereby shall be called the "Grade Point" in the course. Respective "Grade Point Average" (GPA) and "Overall Grade Point Average" (OGPA) shall be awarded at the end of each semester and all semester respectively. A 3.0 Grade Point is required for passing in individual paper and 4.0 GPA to pass any semester examination. The G. P. shall be rounded to one decimal point and GPA to two decimal points.

1.4.2 Grade Point Average (G.P.A.)

Grade Point Average (G.P.A.) of a semester shall be calculated as:

$$\text{GPA} = \frac{\text{Summation of } \{(\text{Credits in each course}) \times (\text{Grade point in that course})\}}{\text{Total No. of Credits in that Semester}}$$

Where the summation is taken over all courses in a given semester, G.P.A. shall be rounded up to 2 decimal points.

1.4.3 O.G.P.A. (Overall Grade Point Average)

It is the average of accumulated grade points of a student, worked out by dividing the cumulative total of grade points by the cumulative total of credit hours of all the courses covered and completed by a student during all the Semesters. For the first semester of the programme the GPA and OGPA shall be the same.

$$\text{OGPA} = \frac{\text{Summation of } \{(\text{Credits in each semester}) \times (\text{Total Credits in that semester})\}}{\text{Total No. of Credits in that Semester}}$$

Where the summation is taken over all semesters in a given programme. OGPA shall be rounded up to e decimal points. For merit lists, in case of equality, the OGPA shall be calculated beyond two decimal places if necessary.

1.4.4 Conversion of grades to marks and classification of results under course credit system

The OGPA can be converted to percentage of marks in the following manner:

Percentage of Marks = (OGPA) ×10

A student after successful completion of all the semesters, Degree shall be awarded in the following manner:

O.G.P.A. ≥ 6.0	: FIRST CLASS
O.G.P.A. ≥ 5.0 - < 6.0	: SECOND CLASS
O.G.P.A. 4.0 - < 5.0	: THIRD CLASS
O.G.P.A. < 4.0	: FAIL

1.5 ***Academic Calendar***

The Examination Section and the academic section shall finalise the schedule of semester registration and other academic activities at the start of academic session. The Academic Calendar shall be prepared by the Academic Committee of the University in consultation with examination section.

The broad format for academic calendar for P. G. with regard to admission, registration and commencement of classes shall be as follows:

Admission and Registration and	
Commencement of Classes for 1st Semester	JULY
1st Semester Examination	DECEMBER
Commencement of Classes 2nd Semester	JANUARY-MAY
2nd Semester Examination	JUNE

Commencement of 3rd Semester Classes	JULY-NOVEMBER
3rd Semester Examination	DECEMBER
Commencement of 4th Semester Classes	JANUARY-APRIL
4th Semester Examination	APRIL & MAY
Final Results to be published in the month of	JUNE

1.5.1 Requirement of award of degree

The minimum credit hour requirement for the Master Degree shall be 80 (eighty) credits and the residence required for Master Degree shall be continuous four semesters from the first date of registration and the maximum time allowed to complete the Master Degree shall be 8 (eight) semesters.

1.6 Requirement for attendance

A candidate shall be required to attend 75% lectures, tutorials and practical classes separately during the semester (For late admitted students' attendance to be calculated from the date of admission). Condonation may be granted by the staff council only to the extent of 15% in exceptional cases. (Illness, accident, mishap in the family, deputation by University/Department). When a candidate has been deputed by the University to represent the University/state for any activity, the lectures delivered during his/her absence for the purpose shall not be counted towards the calculation of attendance provided the student submits a certificate to that effect from the appropriate authority.

1.7 ***Registration in a semester***

A student has to register his/her name at the beginning of every semester in the prescribed form, for the course he/she wants to take in that semester. Examination Section (General) shall notify the registration dates and the list of registered students for the semester shall be given to the Head of the Department within two weeks of the commencement of the Semester.

CHAPTER – II
REGULATIONS ON EXAMINATION MATTERS

2.1 Mid Term Examination

In each Semester there shall be one Mid Term Assessment examination of 60 minutes duration. The Mid Term examination shall be conducted by COE like that of End Term examination. The answer scripts shall be evaluated by the external and internal examiners and the marks along with answer scripts shall be retained in COE.

2.2 Semester Examination

After the end of each semester there shall be an examination of each theory paper of 2 hours duration and of each practical paper of 4 hours duration, which shall be called Term End / "Semester Examination". The maximum marks for each theory paper shall be 50 out of which 40 marks for term end and 10 marks for Mid Term. The maximum marks for each practical/ semester/ project/ dissertation/ review examination shall be 50 for Arts and Commerce and 100 marks for Science. The classes shall remain suspended ten days (including Sundays and holidays, if any) before the date of commencement of semester test for preparation by the students.

2.3 Results of Examinations

The results shall be declared ordinarily within four weeks of completion of the examinations. A students who seeks re-addition of his/her marks in a course shall be allowed to do so by submitting an application to Registrar along with a required fees in the fee counter of the University. All such cases/complaints if any shall be disposed of by the Examination Section in a prefixed day and necessary corrections if any shall be reflected in the mark/grade sheet. The candidates shall have to appear in all the Units of a semester examination to be eligible to be a declared 'pass' provided he/she secures minimum pass marks/grade.

2.4 Promotion to the next semester

A student shall be admitted to the next semester only when he/she appears in all the papers of the concerned semester examination. However, a student failing to appear semester examination in some or of all papers due to some reasons as mentioned in 2.5 may be admitted to the next semester. Such a student shall produce sufficient proof in favour of his/her reason for not being able to appear in some or all papers of the Semester Examination on the next academic session in the corresponding semesters.

2.5 ***Absence from Examination***

If a student is unable to appear a semester examination in some or all papers the Registrar shall consider his/her case for admission into the next higher semester only the following cases:

(a) When he/she is hospitalized.

(b) When he/she is not be able to appear in the examination due to serious illness or death of parents, brothers, sisters, spouse or children.

(c) When he/she met an accident of serious nature.

(d) When the department/University or any official directive deputes him/her

2.6 ***Procedure for Repeat/Improvement***

A student who wants to sit for the semester examination of first and/or second semester in the subsequent academic session (for repeat or improvement) he/she shall have to apply to the Registrar in plain paper before fifteen days of the commencement of the said examination. If allowed by the Registrar, he/she shall deposit the required fees for each paper with centre charge and produce the proof to the teacher in-charge examination with permission letter from the Registrar.

In a semester to appear improvement examination the candidates must have passed the semester examination. A candidate can appear repeat examination of papers in which he/she has failed or not appeared for reasons mentioned in 2.5.

The Master Degree student seeking to appear/improvement examination in any course(s) shall get 3 chances for 1st and 2nd semester within 8 semesters.

Candidates appearing in repeat/improvement examination shall not be considered in the merit list and it shall be reflected in the Provisional Certificate cum Mark sheet (PCM) but not in the final degree certificate.

2.7 Award of Degree Certificate, Grade/Mark sheet

A Degree certificate under the official seal of the university and signed by the Vice-Chancellor shall be presented at the Convocation or in absentia to each of the successful students of particular degree. The Controller of Examinations shall issue the mark/grade sheet of each semester to the candidates in the sheet of each semester to the candidates in the prescribed format by depositing the required fees for marks/Grade Sheet to be deposited in the University counter.

2.8 **Guideline for filling up of Forms for PG Classes (IMP/ Repeat)**

A student shall repeat all the theory and practical papers in which he/she failed in the semester examination within a period of eight semesters from the date of first registration. Such students shall have to apply to the Head of the Department/Registrar in plain paper during the filling up of form for the ensuing semester examination. If allowed, he/she shall deposit the fees as prescribed by the University

If a candidate secures less than 3.0 Grade point in a paper(s) and less than 4.0 Grade point average in a Semester examination he/she has to appear all the papers in that Semester.

If a candidate secures less than 3.0 Grade Point in a paper(s) and a minimum 4.0 Grade point average in a semester examination, he/she has to appear only the paper(s) in which he/she secured less than 3.0 Grade point.

A candidate is eligible to sit for improvement in a paper(s) only when he/she has passed the semester examination concerned. Further, he/she can improve in a maximum of EIGHT paper(s) in the entire course. The Master Degree students seeking to take improvement examination in any course(s) shall get chances within 8 semesters from the year of admission to the course. The candidates taking this advantage (improvement) will be examined on the basis of current syllabus and the higher marks shall be retained during computation of result.

2.9 If a candidate fails to appear in any paper of the said examination and marked ABSENT his/her results will be declared only when he/she clears that paper/those papers.

2.10 ***Disciplines in the Examination***

(A)Late Comers: A student arriving in the examination hall/room fifteen minutes after the commencement of the examination shall not be ordinarily allowed to sit for the examination. No examinee shall be allowed to go out of the examination hall within one hour of commencement of examination. The invigilators shall keep a record of temporary absence of students from the examination hall/room during the examination.

(B) Adoption of unfair means in the Examination:

Possession of unauthorized materials and using it, copying from scripts of other students or from any other source, showing his/her answer script to others during the examination, creating disturbance or acting in a manner so as to cause inconvenience to other students in the examination hall or near about shall be treated as adoption of unfair means or malpractice.

Sd/-
REGISTRAR

P. G. Mathematics Science/ Arts

Abbreviations Used:

IA = Internal Assessment, PA = Practical Assessment, EA = End-Semester Assessment

Subject Code	Subject Name	L-T-P	Credit	Maximum Marks			
				IA	EA	PA	Total
Paper – 101	Algebra	4-0-0	4	20	80	-	100
Paper - 102	Ordinary Differential Equation	4-0-0	4	20	80	-	100
Paper - 103	Real Analysis	4-0-0	4	20	80	-	100
Paper - 104	Programming in C	4-0-0	4	20	80	-	100
Paper - 105	Practical	0-0-4	4	00	100	-	100
	Total		**20**				**500**
Paper - 201	Complex Analysis	4-0-0	4	20	80		100
Paper – 202	Topology	4-0-0	4	20	80		100
Paper – 203	Numerical Analysis	4-0-0	4	20	80		100
Paper - 204	Programming with C++ - I	4-0-0	4	20	80		100
Paper - 205	Practical	0-0-4	4	00	100		100
Paper –206A	Mathematical Method	4-0-0	4	20	80		100
Paper – 206B	Graph Theory	4-0-0	4	20	80		100
Paper – 206C	Advance Calculus	4-0-0	4	20	80		100
	Total		**24**				**600**
Paper - 301	Fourier Analysis	4-0-0	**4**	20	80		100
Paper- 302	Functional Analysis	4-0-0	**4**	20	80		100
Paper - 303	Differential Geometry	4-0-0	**4**	20	80		100
Paper - 304	Programming with C++ - II	4-0-0	**4**	20	80		100
Paper - 305	Practical	**0-0-4**	**4**	00	100		100
Paper – 306 A	Operation Research	4-0-0	**4**	20	80		**100**
Paper – 306 B	Elements of Number Theory	4-0-0	**4**	20	80		**100**
Paper –306 C	Elements of Computer Programming	4-0-0	**4**	20	80		**100**
	Total		**24**				**600**
Paper - 401	Operation Research	4-0-0	**4**	20	80		**100**
Paper - 402	Partial Differential Equations	4-0-0	**4**	20	80		**100**
Paper - 403	Operator Theory	4-0-0	**4**	20	80		**100**
Paper - 404	Number Theory	4-0-0	**4**	20	80		**100**
Paper - 405	Practical/Project	**0-0-4**	**4**	0	100		**100**
	Total		**20**				**500**
	Grand Total		**88**				**2200**

STRUCTURE

Paper	Subject	Mark	Credit
SEMESTER - I			
Paper – 101	Algebra	20+80	4
Paper - 102	Ordinary Differential Equation	20+80	4
Paper - 103	Real Analysis	20+80	4
Paper - 104	Programming in C	20+80	4
Paper - 105	Practical	100	4
	Total	**500**	**20**
SEMESTER - II			
Paper - 201	Complex Analysis	20+80	4
Paper – 202	Topology	20+80	4
Paper – 203	Numerical Analysis	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	Graph Theory	20+80	4
Paper - 206 C	Advance Calculus	20+80	4
		600	**24**
SEMESTER - III			
Paper - 301	Fourier Analysis	20+80	4
Paper- 302	Functional Analysis	20+80	4
Paper - 303	Differential Geometry	20+80	4
Paper - 304	Programming with C++ - II	20+80	4
Paper - 305	Practical	100	4
IDSE Papers**			
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
		600	**24**
SEMESTER - IV			
Paper - 401	Operation Research	20+80	4
Paper - 402	Partial Differential Equations	20+80	4
Paper - 403	Operator Theory	20+80	4
Paper - 404	Number Theory	20+80	4
Paper - 405	Project	100	4
		500	**20**
	Grand Total	**2200**	**88**

SEMESTER – I

Paper - 101: ALGEBRA (4L-0T-0P)

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 hrs)**

Ideals and Quotient rings: to a field theorem of ring homomorphism, Maximal ideals, Imbedded ring to a field, The Field of Quotients of an Integral Domain, Euclidean rings: Principal ideal domains, Unit, Associates, Unique factorization theorem.

Unit – II **(12 hrs)**

Polynomial Rings: The division algorithm, Reducible and Irreducible polynomials, Polynomials over the Rational Field: Gauss's Lemma, The Eisenstein Criterion, Polynomial Rings over Commutative Rings: Rings of polynomial in the n-variables, Primitive polynomials, Unique factorization domain,

Unit – III **(12 hrs)**

Fields, Extension Fields: Algebraic extension, Roots of Polynomials, Remainder theorem, Splitting fields, Construction with Straightedge and compass.

Unit- IV **(12 hrs)**

More about root: Roots of polynomial and their derivatives, The Elements of Galois Theory: Symmetric polynomial, Elementary symmetric function, Normal extension, Solvability by Radicals: Solvable group, Solvability of symmetric group, Solvability of polynomials, Galois group, Fixed fields.

Book Prescribed:

1. I.N.Herstein, Topics in Algebra, John Wiley and Sons; 2nd Revised Edition, 1975.
2. J. B. Fraleigh, A Text Course in Algebra, Pearson, 7th Ed., 2013.

Book of References:

1. J. Gallian Contemporary Abstract Algebra, Brooks/Cole Pub Co. 8th Edition (13 July2012).
2. M. Artin Abstract Algebra, Pearson, 2nd Ed., 2011.
3. David S. Dummit and Richard M. Foote, Abstract Algebra 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.

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

Paper - 102: ORDINARY DIFFERENTIAL EQUATION (4L-0T-0P)
Full Marks: 100 (20 Mid Term + 80 End Term)

Perquisites: Differential equations, fundamental matrix, Picard's theorem, oscillation, Sturm's theorem, Green's function, Boundary value theorem.

Objective: The Objective of this course is to introduce ordinary differential equations and fundamental theorems for existence and uniqueness. This course further explains the analytic techniques in computing the solutions of various ordinary differential equations appearing in various fields of science and technology.

Syllabus

Unit- I **(12 hrs)**
System of Linear Differential Equations: - System of first order equations, Existence and Uniqueness theorems, Fundamental Matrix, Homogeneous and Non Homogeneous linear Systems with constant Coefficient, linear system with periodic Coefficient.

Unit- II **(12 hrs)**
Existence and Uniqueness of Solutions: - Successive approximation Picard's Theorem, Non Uniqueness of solutions, Continuation and dependence on Initial conditions, Existence of Solutions in the large, Existence and uniqueness of solution of systems.

Unit- III **(12 hrs)**
Oscillations of second Order Equations: - Fundamental Results, Sturm's Comparison theoremOfHille wiener Oscillations of $x'' + a(t)x = 0$.

Unit- IV **(12 hrs)**
Boundary Value Problems: - Introduction; Strum Liouville's Problem Green's func- tions, Picard's throrem.

Book Prescribed:
1. S. G. Deo and V. Raghavendra, Ordinary Differential Equations and stability theory by TATA McGraw Hill ltd.

Book of References:
1. G. Birkhoff and G. C. Rota-Ordinary Differential Equations-John Wiley and Sons, N.Y., 1989.

2. Coddington and Levinson, Theory of Ordinary Differential Equations, Krieger Pub Co (June 1984)
3. Tyn-Myint-U Ordinary Differential Equations, Elsevier North-Holland, 1987.
4. L. Elsgolts -Differential Equations and calculus of Variation, Mir Publication, 1980

Course Outcome:

CO 1: Understand the concept of fundamental matrix and formulation of system of Differential equation of physical problems.

CO 2: Solving system of differential equations by Eigen value and vectors.

CO 3: Study the existence and uniqueness of solutions for system of equations.

CO 4: Learn to solve oscillation of second order equations.

CO 5: Provides the Concept of Sturm comparison theorem and Hille wiener oscillations.

CO 6: Solutions for Boundary value problems are developed using Green's function

Paper - 103: REAL ANALYSIS (4L-0T-0P)

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

Prerequisites:
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- **(08 hrs)**
Measure on the Real Line: Lebesgue Outer Measure, Measurable Sets, Regularity, Measurable Functions, Borel and Lebesgue Measurability

Unit-II **(14 hrs.)**
Integration of Functions of a Real Variable: Integration of Non-negative Functions, The General Integral, Integration of Series, Riemann and Lebesgue Integrals

Unit III **(14 hrs)**
Differentiation: The Four Derivatives, Continuous Non-differentiable Functions, Function of a bounded variations, Lebesgue's Differentiation Theorem, Differentiation and Integration, The Lebesgue Set.

Unit-IV **(12hrs)**
Abstract Measure Space: Measure and Outer Measure, Extension of a Measure, Uniqueness of the Extension, Completion of a Measure, Measure Space, Integration with respect to a Measure. Inequalities and the L^p space: The L^p space, Convex Functions, Jensen's inequality, The inequalities of Holder and Minkowski, Completeness of $L^p(\mu)$.

Text book:

1. Measure theory and Integration: G. de. Barra. Wiley Eastern Ltd., Chapter – 1 (1.5 - 1.7), II, III, IV, V. VI.

Reference Books:

1. Real and Abstract Analysis: E. Hewitt and K. Stromberg. Springer International Student

Edition, Narosa Publishing House.
2. Real and Complex Analysis: W. Rudin, Tata Mc Graw Hill

Course Outcome:
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

Paper - 104: PROGRAMMING IN C (4L-0T-0P)
Full Marks: 100 (20 Mid Term + 80 End Term)

Prerequisites: 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 hrs)**
Overview of C, Constants, Types of constants, Variables, Types of variables, Rules for constructing variable names, Data types, Operators and Expressions, Managing I/O operators.

Unit - II: **(12 hrs)**
Decision making and Branching, Looping: for, do, while, do…while loops, Arrays: Defining and manipulating arrays, Array variable, Syntax rules for arrays, Use of multiple subscripts in arrays, for loops with array, Character, Strings.

Unit – III **(12 hrs)**
User defined Functions: Introduction, Defining and using functions, Syntex rules for functions declaration, arrays in functions.

Unit- IV: **(12 hrs)**
Structure and Union:Definition, Using structures, Use of structure in arrays and arrays in structure, create union variables, access members of a union, Pointers: Pointer data type, pointers and array, pointers and functions.

Book Prescribed:
Programming in ANSI C by E. Balagurusamy.

Reference Books:

1. Let us C by Y. Kanetkar.
2. Mastering in C by Venugopal.
3. Computer Programming in C by V. Rajaraman.

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

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

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

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

Students have to practise 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 upto 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 analyse others problems

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

SEMESTER- II

Paper - 201: COMPLEX ANALYSIS (4L-0T-0P)

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

Prerequisites:

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 hrs)**

Introduction to analytic and harmonic Functions, Necessary and sufficient conditions for functions to be analytic, stereographic projection, Lucas theorem on zeros of polynomials, mappings of complex functions, elementary transformations, cross ratio, fractional linear transformation, conformal mappings.

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

Complex integration*:* line integrals, index of a point with respect to a closed curve, Cauchy theorems for rectangle, triangles and disc, Fundamental theorems, Cauchy's Integral Formula, Higher derivatives, Morera's theorem, Liouville's theorem, fundamental theorem of algebra, open mapping theorem, zero of complex functions.

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

Power series representation and local properties of analytic functions: Taylor's series, Laurent's series, types of singularities, zero and poles, calculus of residues.

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

Evaluation of real integrals using complex integration, the argument principle, Rouche's theorem, Maximum principle, Schwarz's lemma.

Books for Prescribed:

1. Complex Analysis, L. V. Ahlfros, McGrawHill, Kogakusha Ltd.
1. Function of one Complex Variable, J. B. Conway, Narosa Publisher House

Book of References:

1. Complex Variables and Application, J.W. Brown, R. V. Churchill, 8th Ed., McGraw-Hill International Edition, 2009.
2. Complex Variables with applications, S. Ponnusomy, Herb Silverman, BizkhauserBaston, USA, 2006.
3. Complex analysis, J. Bak, Donald. Newman, 2nd Ed., 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,etc) 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 Lioville's theorem, the mean-value property of a function and the maximum modulus principle, Rouches theorem, Argument principle, fundamental theorem of algebra

Paper - 202: TOPOLOGY (4L-0T-0P)

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

Prerequisites: 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 hrs)**

Basic concepts of Topology, Examples, Bases, Subbases, Closed sets, Limit Points, Continuous functions, Subspace topology, Hausdorff Toplogical Saces.

Unit-II **(12 hrs)**

Product topology, Box Topology and Quotient topology, Connectedness, Local connectedness, Path-connectedness.

Unit-III **(12 hrs)**

Compact Spaces, compactness in metric spaces, locally compacts spaces,One point Compactification of a Topological Space, Compact open topology

Unit-IV **(12 hrs)**

First and Second Countable Topological Spaces, Properties, Separation axioms, Regular and completely regular space, Normal spaces, Urysohn Lemma, Urysohn metrization Theorem

Books Prescribed:

1. J.R. Munkres-Topology - A First Course in Topology, Pearson 2nd edition, 2000.

Books for Reference:

1. M. A. Armstrong, Basic Topology, Springer, 1983
2. TW Gamelin and RE Greene. Introduction to Topology. 2nd ed. Dover Publications
3. Stephen Willard, General Topology, Dover Publication

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.

Paper - 203: NUMERICAL ANALYSIS (4L-0T-0P)

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

Perquisites:

Iteration methods, algebraic equations, transcendental equations, Interpolation, Difference operator, order of convergence, Numerical integration,solution of system of linear equations

Objective: This course is designed to introduce the basic concepts of Numerical Mathematics in order to solve the problems arising in various fields of application, for example in science, engineering and economics etc. that do not possess analytical solutions or difficult to deal with analytically. This course addresses development, analysis and application of different numerical methods to solve the problems, viz. system of linear & nonlinear equations, numerical initial and boundary value problems of ordinary differential equations etc.

Syllabus:

Unit-I **(12 hrs)**

Errors: Root finding for non-linear equations: Bisection method, Iteration methods based on first degree equations (Secant method, Regula-Falsi method, Newton Raphson method), Iter- ation methods based on second degree equation (Muller method, Chebysev method), Rate of convergence, Iteration methods.

Unit-II **(12 hrs)**

Interpolations: Lagrange and Newton interpolations, Finite differences, interpolating polynomials using finite differences, Hermite interpolation, Piecewise and Spline interpolation.

Unit-III **(12 hrs)**

Differentiation: Methods based on Interpolation, Methods based on Finite Differentials, Meth- ods based on undetermined coefficients, optimum choice of step length, Interpolation method. Integration: Methods based on Interpolation(Trapezoidal rule , Simpson's rule), Method based on undetermined coefficients (Gausses Legendre Integration method, Lobatto integra- tion method, Radon integration method, Gauss-Chebysev Integration method(without derivation), Gauss-Laguerre Integration method (without derivation) , Gauss-Hermite Integration methods(without derivation), Composite integration methods.

Unit-IV **(12 hrs)**

Numerical Solution of system of linear equations: Direct methods, Gauss Elimination methods, Gauss-Jordan Elimination method, Triangularization method, Cholesky method, Iteration methods(Jacobi iteration method, Gauss-siedel iteration method, Iterative method for A^{-1}) Eigen value problems(Jacobi method for symmetric matrices) Givers Method for symmetric matrices, Rutishauser method for arbitrary matrices). Numerical solution of ordinary differential equation: Euler Method, Backward Euler method, Mid-point method, Single Step
Methods (Tayler series method, Range-kutta method(Second order, Fourth order method)

Prescribed Books:- 1 M.K. Jain , S.R.K Iyengar, R.K. Jain: Numerical Methods for Scientific and Engineering Computation , Willey Eastern Ltd. New Delhi (1995) (2.1-2.6,3.1-3.5, 4.5-4.10, 5.1-5.9, 6.1-6.3)

Book of References:

1. B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.

2. Kendall E. Atkinson: An Introduction to Numerical Analysis

3. C. F. Gerald and P. O. Wheatley, App.ied Numerical Analysis, Pearson Education, India, 7 th Edition, 2008

4. S. D. Conte & S. de Boor: Elementary Numerical Analysis: An Algorithmic Approach.

Course Outcome:

CO 1: Concept of error analysis in data handling.
CO 2: Study of numerical methods to solve algebraic, transcendental equations and system of equations
CO 3: Use of difference operators and different numerical methods to interpolate and extrapolate the given set of data.
CO 4 : Numerical evaluation of differentiations and integrations.
CO 5: Know the concept of solving numerically the initial and boundary value problems of ODEs.

CO 6: Solve ODE numerically by single step and multi-step method.

Paper - 204: PROGRAMMING WITH C++ - I (4L-0T-0P)

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

Prerequisite: 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 hrs)

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 hrs)

Tokens, Expression and Control structures - Key words, Identifiers, Data types. User defined data types, Derived data types, Symbolic constant, Variables, and Operators in C++.

Unit - III: (12 hrs)

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 hrs)

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 Outcome:

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.

Paper - 205: PRACTICAL (0L-0T-4P)

PROGRAMMING WITH C++ - I

Full Mark – 100

Prerequisites:

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

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

Paper - 206 A: MATHEMATICAL METHOD(3L-1T-0P)

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

Prerequisites:

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: Laplace Transforms: **14 hrs**

Laplace Transform. Linearity. First Shifting Theorem (*s*-Shifting), Transforms of Derivatives and Integrals. ODEs, Unit Step Function (Heaviside Function). Second Shifting Theorem (*t*-Shifting), Short Impulses. Dirac's Delta Function. Partial Fractions, Convolution. Integral Equations,Differentiation and Integration of Transforms.ODEs with Variable Coefficients, Systems of ODEs Laplace Transform: General Formulas

Unit - II: **(10 hrs)**

Volterra Integral Equations: Basic concepts, Relationship between Linear differential equations and Volterra integral equations, Resolvent Kernel of Volterra In- tegral equations, Solution of

Integral equations by Resolvent Kernel, The Method of successive approximations, Convolution type equations, Solutions of integral differential equations with the aid of Laplace transformations.

Unit-III

Fredholm Integral equations: Fredholm equations of the second kind Fundamental, Iterated Kernel, Constructing the resolvent Kernel with the aid of iterated Kernels, Integral equations with degenerate Kernels, Characteristic numbers and eigen functions, solution of homogeneous integral equations with degenerate Kernel- non homogeneous symmetric equations Fredholm alternative.

Unit -IV: Calculus of Variation: (14 hrs)

Variation & its Properties, Euler equation, Variational Problems for Functional of the Form, Functional Dependence on Higher Higher Order derivatives, Functional Dependence on Functions of Several Independent Variable, Variational Problems in parametric Form

Books Prescribed:

1. Advanced Engineering Mathematics: Erwin Kreyszig Wiley, Eastern Ltd, 5thedition, 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 Lapalce 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 methods to solve differential equation using Euler's equation

Paper – 206B: GRAPH THEORY (4L-0T-0P)

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

Prerequisites:

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 hrs)

Introduction: Graph, Applications of graphs, Finite and infinite graphs, Incidence and Degree, Isolated vertex, Pendant vertex, Null graph, Paths and Circuits: Isomorphism, Sub graphs, Walks, Paths, Circuits, Connected graphs, Disconnected graphs, Components, Euler graphs, Operations on Graph, Hamiltonian paths and circuits.

Unit -II: (12 hrs)

Trees : Trees, Some properties of trees, Pendant vertices in a tree, Distance and centers in a tree, Rooted and binary tree, On counting tree, spanning trees.

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

Fundamental circuits: Spanning tree of a graph, Spanning tree in a weighted graph, Cut sets and Cut Vertices: Cut sets, Some properties of cut set, Cut sets in a graph, Fundamental circuits and cut sets, Connectivity, Separability, Network flows, 1-Isomorphism, 2-Isomorphism.

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

Planar and Dual graphs: Combinatorial vs Geometric graph, Planer graphs, Kurotowski's two graphs, Different representation of a planar graph, Detection of planarity, Geometric dual, Combinatorial dual, Criteria of planarity, Thickness and crossings.

Books for Prescribed:

1 .Graph Theory and its Application to Engineering and Computer Science, N. Dec, PHI,1979.

2. Graph Theory, F. Harury,Addison Wesley Publishing company,1969.

3. Introduction to Graph Theory, R. J. Wilson ,Longman GroupLtd., 1985.

Book of References:

1. A Textbook of Graph Theory, R. Balakrishnan and K. Ranganathan, 2nd Ed., Springer, New York, 2012.
2. Introduction to Graph Theory, Richard J. Trudeau, Dover Publication, 1999.
3. Graph theory with applications, J.A Bondy, U.S.R Murty, North-Holland, New York, Oxford, 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 colouring vertices, 4 colourproblrm, planar graph notion, dual graphs

Paper - 206 C: ADVANCED CALCULUS(4L-0T-0P)

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

Prerequisites:
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 hrs)
Derivatives for Function on $R^{\wedge n}$- Differentiation of Composite Functionsand Taylor's Theorem

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

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

Unit -IV: (12 hrs)

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: analyse the implicit and multiple integrals in generalized form

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

SEMESTER – III

Paper 301: Fourier Analysis (4L-0T-0P)

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

Perquisites:
Real Analysis,

Objective: The learning objectives of the development of the discipline "Fourier analysis and its applications" are the formation of students' basic knowledge in the field of modern Fourier analysis and approximation theory.

Syllabus:

UNIT-I **(12hrs)**

Fourier Series: Trigonometric series, Fourier Series, Fourier Sine Series and Cosine Series, Other type of whole range series, Half range series, Uniqueness of Fourier series, The Riemann- Lebesgue Lemma, Dirichlet Kernel, Criterion and tests for Pointwise convergence of Fourier Series, Dirichlet's Pointwise convergence theorem.

UNIT-II **(12hrs)**

Convergence of Fourier Series:, Uniform convergence, The Gibb's phenomenon, Termwise integration, Termwise differentiation, Cesaro summability, Toeplitz summability, Abel summability, Fejer Theory, Lebesgue's Pointwise convergence.

UNIT-III **(12hrs)**

Fourier transform : Finite Fourier transform, Convolution on T, Fourier transform, Basic properties of Fourier transform, The Fourier map, Convolution on R, Inversion, Criterion and tests for convergence of Fourier integral formula, (C,1) summability for Integrals.

UNIT-IV **(12hrs)**

The Fejer-Lebesgue Inversion theorem, Integrability of Fourier Transform, Transforms of Derivative and Integrals, Fourier Sine and cosine transforms, Parseval's identities, L2-Theory, The Plancheral theorem, Discrete Fourier transform(DFT), Inversion theorem for the DFT, Parseval's Identities.

Book Prescribed:

1. G. Bachman, L. Narici, E. Beckenstein, (2000), Fourier and Wavelet Analysis, Springer.
2. I.N. Sneddon, (1969), Fourier Series by Dover Publications.
3. Lokenath Debnath and Dambaru Bhatta, (2007), Integral Transforms and Their Applications, Chapman and Hall/CRC, New York.

Reference Books:

4. Fourier Analysis, T.W. Korner, (1988) Cambridge University press.
5. Elian M Stein and Rami Shakarchi, (2003), Fourier Analysis: An Introduction, Princeton Lectures in Analysis, Princeton University Press, Princeton and Oxford.

Course Outcome:

CO 1: Understand the Fourier Series expansion.

CO 2: Learn the convergence of Fourier Series.

CO 3: Study on Fourier Transform and its application.

Paper - 302: FUNCTIONAL ANALYSIS (4L-0T-0P)

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

Prerequisites:

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 hrs)**

Review of Metric spaces, Lp - spaces, Inequalities in Lp - spaces, Completeness of Lp, Normed linear spaces, Inner product spaces, examples, properties of Normed linear spaces and inner product spaces, Continuity of linear maps.

Unit –II **(12 hrs)**

Hilbert spaces, Examples, orthonormal sets, Gram-Schist orthonormalizations, orthonormal polynomials, Bessel's inequality, Riesz-Fisher Theorem, Orthonormal basis, Fourier Expansion, Parseval's formula, Projection theorem, Riesz Representation Theorem.

Unit – III **(12 hrs)**

Banach Spaces, Hahn Banach Theorem, Baire's category theorem, Open mapping Theorem, Closed graph theorem, Uniform boundedness Principle, duals and transpose dual of $L_p[a, b]$ and C [a,b], Reflexivity.

Unit – IV **(12 hrs)**

Bounded Linear Operators on Banach Spaces, Banach algegra, defination, Examples, Spectrum of a bounded operator, Resolvent Set, Compact operators on Banach spaces, spectrum of a Compact operator, Elementary ideas on integral equations, Unbounded Operators and fixed point theorems.

Books Prescribed:-

1. Kreyszig E., Functional Analysis -John Wiley, 1978.
2. Limaye, B.V., -Functional Analysis, 3rd Ed, 2014.

Reference Books:

1. Goffman and Pedrick A first Course in Functional Analysis- Prentice Hall (1 June 1965)
2. Bachmen and Narici, Functional Analysis, Dover Publications Inc.; 2nd edition (28 March 2003).

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.

Paper - 303: DIFFERENTIAL GEOMETRY(4L-0T-0P)

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

Prerequisites: 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

Review of calculus in Rn ,Inverse and implicit function theorem, Rank theorem. Review of local theory of curves and surfaces, Serret Frenet formula, First fundamental forms, Normal curva- ture, Geodesic curvature, Gauss formula, second fundamental form, Weiengarten map, principal curvatures, Gaussian curvature mean curvature.

Unit-II

Introduction to Manifolds, Differential manifolds, Examples, Submanifolds, Tangent vector and tangent space at a point of the manifold, vector fields, Integration on manifolds, Stoke's theorem.

Unit-III

Multi linear Algebra(Dual space, tenser of type(r.s), Operations with tenser, contractions, metric tenser, symmetric and antisymmetric tenser) Exterior Algebra.

Unit-IV

Calculus of forms. Riemannian manifold, Riemannian metric, co-variant differentiation, Levi Civita Connection, Curvature, parallel transport, Fundamental theorem of Riemannian Geometry.

Books for Prescribed:

1.An Introduction to Differential Geometry by T. J. Willmore, Oxford University Press

2.Elementary topics in Differential geometry by J.A Thorpe, Springer verlag,1979

3.Elementary differential geometry, A. Pressley, Springer international edition,2014

Books of References:

1.Differential Geometry, E. Kreyszig, Dover Publication, New York, 1991.

2.Elementary Differential Geometry, B. O' Neill, 2nd Ed., Academic Press, 2004.
3.Fundamentals of Differential Geometry, Spinger, 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

Paper - 304: PROGRAMMING IN C++ - II(4L-0T-0P)

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

Prerequisite:
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 hrs)**

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 hrs)**

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 hrs)**

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

Unit – IV **(12 hrs)**

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:

Object Oriented Programming with C++: E. Balagurusamy, (Chapter 6 to 9).

Reference Books:

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

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

Paper - 305: PRACTICAL (0L-0T-4P)
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) 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

Paper - 306 A: OPERATION RESEARCH (4L-0T-0P)

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

Perquisites: 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 hrs)**

Introduction to linear Programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison.

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

Duality, formulation of the dual problem, primal-dual relationships, Fundamental Theorem of Duality, economic interpretation of the dual.

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

Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem.

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

Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem and Travelling Salesman Problem.

Book Prescribed:

1. Operations Research:S.D.Sharma.

Reference Books:

1. Linear Programming and Application, :S.I.Gass.
2. Non-Linear Programming: C.Hadley.
3. Operation Research: KantiSwarup

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

Paper - 306 B: ELEMENTS OF NUMBER THEORY (4L-0T-0P)

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

Prerequisites:
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: Divisibility Theory in Integers and Distribution of Primes: (**12 hrs)**
Early Number Theory, the Division Algorithm, the Greatest Common, Divisior, the Euclidean Algorithm, The Fundamental Theorem of Arithmetic, The Sieve of Eratosthenes, The Goldbach Conjecture

Unit - II: The Theory of Congruence and Fermat's Theorem: (14 **hrs)**
Basic Properties of Congruence, Binary and Decimal Representation of Integers, Linear Congruence and the Chinese Remainder Theorem, Fermat's Little Theorem and Pseudo primes, Wilson's Theorem, The Fermat- Kraitchik Factorisation Method

Unit - III: Number-Theoretic Functions and Euler's Generalization (14 hrs)
Fermat's Theorem: The sum and Number of Divisors, The Mobious Inversion Formula, The Greatest Integers Function, An Application to the Calendar

Unit - IV: The Quadratic Reciprocity Law: (**10 hrs)**
Euler's Criterion, the Legendre Symbol and its Properties, Quadratic Reciprocity, Quadratic Congruence and Composite Moduli

Book Prescribed:
Elementary number theory by David M. Burton, Tata Mc.HGraw 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. An Introduction to the Theory of Numbers: Hardy and Wright.
2. Introduction to Analytic Number Theory: K. Chandrashekaram.
3. Arithmetical Functions: K. Chandrashekaram.

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 analyse 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.

Paper 306 C: ELEMENTS OF COMPUTER PROGRAMMING (4L-0T-0P)

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

Prerequisites: 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 **hrs)**

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 **hrs)**

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

Unit - III (12 **hrs)**

Algorithm and Flow chart for solving the following Numerical Analysis problems**.**

Solution of algebraic an transcendental equation of one variable by Bisection, Regula-Falsi and Newton-Raphson methods. Solution of system of linear equations by Gaussian elimination and Gauss-Jordan (direct), Gauss Seidel (iterative) methods. Newton's (forward and backward), Lagrange's interpolation methods.

Unit IV: (12 **hrs)**

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

Books for prescribed:

1. C Language and Numerical Methods, C. Xavier, New Age International Publishers
2. Computer Oriented Statistical & Numerical Methods, E. Balagurusamy , MacMillan India Limited
3. Discrete Mathematics, K. Rosen, 8th Ed., McGraw Hill Education, New York, 2019.

Reference Books:

1. Structured Computer Organization, Andrew S. Tanenbaum (PHI).
2. Discrete Mathematics, M. K. Gupta.

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

SEMESTER – IV

Paper - 401: OPERATION RESEARCH (4L-0T-0P)

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

Perquisites:

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 **hrs)**

Upper Bounding Technique, Integer Programming Problems, Branch & Bounds, Gomary's cutting plane Method.

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

Recursive approach, characteristics of Dynamic Programming, solution of discrete Dynamic Programming problem, solution of LPP by Dynamic Programming

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

Two person zero sum game, some basic terms, maxmini-minimax principle, Games without saddle point-mixed strategies, graphic solution of $2 \times n$ and $m \times 2$ games, dominance property, Arithmetic method, rectangular games.

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

Kuhn-Tucker necessary and sufficient Conditions with non-negative constraints, graphical solution, Quadratic Programming, Wolfe's method, Beale's method, separable convex programming.

Book Prescribed:

1. Operations Research, :S.D.Sharma

Reference Books:

1. Linear Programming: S.I.Gass.

2. Non-Linear and Dynamic Programming: G.Hadley.

3. Operation Research: KantiSwarup

Course Outcome:

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

CO 2: Discrete DPP and Solution of LPPdynamic 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

Paper - 402: PARTIAL DIFFERENTIAL EQUATIONS (4L-0T-0P)

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

Perquisites:

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 hrs)**

Meaning of Partial differential equation, Classification of first order Partial differential equations,Semi-linear and quasi-linear equations, Pfaffian differentialequations, Lagrange'smethod, Compatible systems,Charpit'smethod, Jacobi'smethod,

Unit-II **(12 hrs)**

Integral surfaces passing through a given curve, Cauchy problem, method of characteristics for quasi-linear and nonlinear partial differential equation, Monge cone, characteristic strip. First order non-linear equations in two independent variables, complete integral.

Unit-III **(12 hrs)**

Linear Second order partial Differential Equations : Origin of second order PDE's, Classification of Second order Partial Differential Equations., One dimensional Wave equation,Vibration of an infinite string, origin of the equation, D'Alembert's solution,Vibrations of a semi finite string, Vibrations of a string of finite length, existence and uniqueness of solution, Riemann method

Unit-IV **(12 hrs)**

Laplace equation, Boundary value problems, Maximum and minimum principles, Uniqueness and continuity theorems, Dirichlet problem for a circle, Dirichlet problem for a circular annulus, Neumann problem for a circle, Theory of Green's function for Laplace equation, Heat equation, Heat conduction problem for an infinite rod, Heat conduction in a finite rod, existence and uniqueness of the solution, Classification in higher dimension, Kelvin's inversion theorem,Equi potential surfaces.

Book Prescribed:

1.Tyn-Myint-U - Partial Differential Equations North Holland Publication, New York,1987.

Books for Reference:

1. Phoolan Prasad and Renuka Ravindran, Partial, Differential Equations, New Age International, 1985.
2. F.John-PartialDifferentialEquations,Springer-Verlag,New York,1978.
3. Tyn-Myint-U - Partial Differential Equations North Holland Publication, New York,1987.4 Amarnath- An elementary course in partial differential equation, Alpha ScienceInternational,2003.

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.

Paper - 403: OPERATOR THEORY (4L-0T-0P)

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

Prerequisite: 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 hrs)**

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

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

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

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

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

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

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

Books Recommended:

1. 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 Hilbert Speces, Springer: Weildman.

Course Outcoms

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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.

Paper - 404: ANALYTIC NUMBER THEORY (4L-0T-0P)

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

Prerequisites:

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: **Arithmetical function and Dirichlet multiplication.** (**12 hrs)**

Introduction, The Mobius Function, The Euler-totient function, A relation connecting Phi and Mu , A Product Formula for Phi, The Dirichlet product of arithmetical function, Dirichlet, inverses and The Mobious Inversion Formula, The Mangoldt Function, Multiplicative Function, Multiplicative functions and Dirichletmultiplication, The inverse of a completely multiplicative function, Liouville's function, The Divisior function, Generalized convolution, Bell series and Dirichlet multiplication, Derivative of an arithmetic function, The Selberg Identity

Unit - II:

Averages of arithmetic Functions: (10 hrs)

The big O Notation, Asymptotic equality of functions, Euler Summation formula, Some elementary asymptotic formulas, The average order of d(n), The average order of divisior function $\sigma_s(n)$, The average order of phi(n)an application of to the distribution of lattice points visible from the origin, The average order of mu(n) and gamma (n)

Dirichlet's Theorem on Primes in Arithmetic Progressions: Introduction, Dirichlet,s theorem for proimes of the form 4n-1 and 4n+1, The plan of proof of Dirichlet's theorem, Proof of Lemma

7.4, Proof of Lemma 7.5, Proof of Lemma 7.6, Proof of Lemma 7.7, Distribution of primes in arithmetic progression

Unit - III: Congruence: 12 hrs

Definition and basic properties of congruence, Residue classes and complete residue system, Linear congruence, Reduced residue system and the Euler-Fermat theorem, Polynomial congruence modulo p, Lagrange's theorem, Application of Lagrange's theorem, Simultaneous linear congruence, Chinese Remainder Theorem. Application of Chinese Remainder Theorem

Quadratic Residues and the Quadratic Reciprocity Law:

Quadratic Residue, Legendre's symbol, and its properties, Evaluation of (-1/p) and (2/p), Gauss Lemma, The quadratic reciprocity law, Applications of the reciprocity law, The Jacobi symbol,

Unit - IV: (14 hrs)

Dirichlet Series and Euler Product:

Introduction, The half plane of absolute convergence of a Dirichlet series, The function defined by a Dirichlet series, Multiplication of Dirichlet series, Euler products, The half plane of convergence of a Dirichlet series, Analytical properties of Dirichlet series, Dirichlet series with nonnegative coefficients, Dirichlet series expressed as exponential of Dirichlet series, Mean value theorem for Dirichlet series, An integral formula for the coefficients of a Dirichlet series, An integral formula for the partial sums of a Dirichlet series

The Function $\zeta(s)$ and $L(s, \chi)$:

Introduction, Properties of the gamma function, Integral representation for the Hurwitz zeta function, A contour integral representation for the $\zeta(s)$ and $L(s, \chi)$, Hurwitz's formula for $\zeta(s, a)$, The functional equation for the Riemann zeta function , A functional equation for the Hurwitz zeta function, The functional equation for L-function,

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) , 11(11.1-11.12), 12(12.1-10)

Reference Books:

1. An Introduction to the Theory of Numbers: Hardy and Wright.
2. Introduction to Analytic Number Theory: K. Chandrashekaram.
3. Arithmetical Functions: 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 number theoretic problems using reciprocity law

Paper - 405 (PROJECT + VIVA-VOCE) (4L-0T-0P)

MARKS - (50 +50)