Gandhinagar Institute of Science

Academic Regulation & Curriculum

for

Master of Science

In

Mathematics

MSc PROGRAMME

***w.e.f.* 2022-23**

Preamble

The Department of Mathematics at Gandhinagar University is dedicated to imparting high quality education, fostering analytical and logical reasoning, and promoting research-oriented learning in the field of mathematical sciences. The department endeavours to cultivate strong conceptual foundations, advanced problem-solving capabilities, and computational proficiency among students, thereby equipping them to meet the academic, and research-oriented challenges of the modern era.

With effect from the Academic Year 2022–23, Gandhinagar University has been recognized by the University Grants Commission (UGC). Furthermore, in consonance with the vision and directives of the National Education Policy 2020 (NEP-2020), the University implemented the NEP-2020 framework from the Academic Year 2023–24. In alignment with these reforms, the Mathematics Department has adopted a flexible, multidisciplinary, and learner-centric curriculum structure emphasizing holistic education, skill development, research aptitude, innovation, and outcome-based learning.

Mathematics Department continually strives to achieve academic excellence through the adoption of innovative pedagogical practices, organization of seminars, workshops, expert lectures, research projects, and interdisciplinary academic activities. It remains committed to nurturing intellectual growth and preparing students for higher education, competitive examinations, research pursuits, and professional careers in mathematics and allied disciplines.

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1. Institutional Vision & Mission

1.1 Vision:

Gandhinagar Institute of Science aims to strengthen quality science education and research by fostering innovation, ethical values, and scientific temperament for societal and sustainable development.

1.2 Mission:

- To provide quality education supported by modern infrastructure and an industry- oriented curriculum, while emphasizing ethics and critical thinking.
- To promote an innovative and research-oriented environment that fosters effective problems solving skills and entrepreneurial development.
- To encourage innovation, entrepreneurship, and scientific ethics for developing responsible and skilled graduates.
- To foster interdisciplinary learning, sustainability, and community engagement for national development.

2. Department Vision & Mission

2.1 Vision:

The mathematics develops calculating, computing, critical thinking, reasoning, problem solving and formulating the skills for the upcoming mathematicians, The discipline theory and techniques taught in mathematics courses are especially important in today's society. The faculty of the department recognizes this and strives to ensure that the student learner obtain this knowledge. Develop the student's ability to intelligently communicate mathematical results in both written and oral because the mathematical background to succeed discipline both academically and professionally.

2.2 Mission:

- To develop areas related to mathematical aspects of scientific computing in all its manifestations.
- To formulate the strategies for solving problems and acknowledge the importance of being intellectually curious throughout students adult lives.
- To develop young mathematician knowledge and discipline.
- To obtain abilities to critically assess the mathematical information.

3. Program Objectives

The objective of the program is to provide students with a strong theoretical background in mathematics for pursuing research in both pure and applied mathematics. The program aims to produce students with a good-firm background in theoretical and applied mathematics, supplemented with the required computational skills. Students have the flexibility to pursue higher studies or orient themselves towards a career in the industry.

4. Program Educational Objectives (PEOs)

- **PEO1**: To equip graduates with strong mathematical knowledge, professional competence, and entrepreneurial skills to excel as academicians, researchers, professionals, and innovators.
- **PEO2:** To prepare students for higher education, advanced research, and lifelong learning in the field of Mathematics and related interdisciplinary areas.
- **PEO3:** To develop a strong foundation in mathematical concepts, analytical thinking, logical reasoning, and problem-solving abilities among students.
- **PEO4:** To enhance students' teaching aptitude, communication skills, and subject expertise to enable successful careers in education, industry, information technology, and allied sectors.
- **PEO5:** To foster ethical values, leadership qualities, teamwork, and adaptability so that graduates can contribute effectively to society and professional environments.

5. Program Details

5.1 Program Structure & Duration

- Duration & Intake : 2 Years & 30 Seats
- Semesters: 4
- Mode: Full Time
- Credit Structure: As per NEP/University norms
- Medium of Instruction: English

5.2 Eligibility Criteria for Admission

Candidates who have obtained a bachelor's degree in Mathematics from a recognized University/Institution approved by UGC, with minimum 50% aggregate marks (45% for reserved category candidates as per applicable norms), shall be eligible for admission to the program.

5.3 Admission Procedure

- Students can apply offline on merit directly. Candidates may also visit the campus, attend an interaction session, and receive approval from the Admission Committee.

- Admission using GCAS Portal (Online mode):
- Quick Registration and login ID generation using Mobile number, Email ID and Aadhar details.
- Payment of Registration fees via online mode.

1. Fill the profile details and upload the required documents.
2. Select the preferences of universities and their affiliated colleges in best priority order.
3. Final Submission of details.
4. Merit List and Admission offers from the priority list of universities and their affiliated colleges.
5. Acceptance of admission offer and confirmation by paying the whole semester fees after verification of documents.
6. Student can further follow the same procedure for other admission rounds till he/she will not get proper admission offer.

The University reserves the right to revise admission procedures.

5.4 Credit Summary for MSc Course in Mathematics with effect from 2022-2023

Course Type-wise Distribution for M.Sc. Mathematics

Sr. No.	Course Type	Abbreviation	Description
1	Major Course	MJ	Core Mathematics subjects related to the discipline
2	Minor Course	MIN	Supporting interdisciplinary subjects

Semester-wise Credit Structure (M.Sc. Mathematics)

Semester	Total Credits
Semester I	20
Semester II	22
Semester III	22
Semester IV	20
Grand Total	**84 Credits**

Proposed Abbreviation Table for Mathematics Curriculum

Sr. No.	Category	Suggested Code
1	Major	MJ
2	Minor	MIN
3	Indian Knowledge System	IKS

6. Curriculum Structure

First Year 1st Semester:

Sr.No.	Category	Course Code	Course Name	Contact Hours/Week				Credit Points
				L	T	P	Total	
1	Major (**core**)	10260101	Ordinary Differential Equations	4	-	-	4	4
2	Major (**core**)	10260102	Numerical Analysis	4	-	-	4	4
3	Major (**core**)	10260103	Linear Algebra	4	-	-	4	4
4	Major (**core**)	10260104	Complex Analysis and Laplace Transforms	4	-	-	4	4
5	Major (**core**)	20260106	Programming using MATLAB	-	-	8	8	4
Total				16	0	8	24	20

First Year 2nd Semester:

Sr.No.	Category	Course Code	Course Name	Contact Hours/Week				Credit Points
				L	T	P	Total	
1	Major (**core**)	10260201	Partial Differential Equations	4	-	-	4	4
2	Major (**core**)	10260202	Applied Analysis	4	-	-	4	4
3	Major (**core**)	10260203	Applied Mechanics	4	-	-	4	4
4	Major (**core**)	10260204	Algebra	4	-	-	4	4

5	Major (**core**)	20260206	Programming using Python	-	-	8	8	4
6	IKS	IKS0201	Indian Ancient History and Cultural Heritage	2	-	-	2	2
Total				18	0	08	26	22

Second Year 3rd Semester:

Sr.No.	Category	Course Code	Course Name	Contact Hours/Week				Credit Points
				L	T	P	Total	
1	Major (**core**)	10260301	Numerical Methods for Partial Differential Equations	4	-	-	4	4
2	Major (**core**)	10260302	Fluid Dynamics	4	-	-	4	4
3	Major (**core**)	10260303	Mathematical Modelling	4	-	-	4	4
4	Major (**core**)	10260304	Optimization	4	-	-	4	4
5	Major (**core**)	20260305	Programming of Numerical Methods for Partial Differential Equations	-	-	8	8	4
6	IKS	10260306	Vedic Mathematics	1	-	1	2	2
Total				17	0	9	24	22

Second Year 4th Semester:

Sr.No.	Category	Course Code	Course Name	Contact Hours/Week				Credit Points
				L	T	P	Total	
1	Major (**core**)	10260401	Problem Solving (As Per NET Syllabus)	4	-	-	4	4

2	Major (**core**)	10260402	Assignment	-	-	-	-	4
3	Major (**core**)	10260403	Research Project	-	-	-	-	12
Total				4	0	0	4	20

7. Teaching, Learning & Evaluation

7.1 Teaching Methodology

The program shall adopt:

- Classroom Teaching
- Case Studies
- Workshops
- Software Training
- Research Projects
- Internships
- AI-based Learning Tools
- Blended and Digital Learning

7.2 Attendance Rules

- Minimum 75% attendance shall be mandatory in each course.
- Students below prescribed attendance may not be permitted to appear in examination.
- Additional attendance requirements may apply for practicals and internships.

7.3 Examination and Evaluation System

7.3.1 Evaluation Components

- The evaluation may consist of Continuous Internal Evaluation (CIE) and End Semester Examination (ESE)
- Continuous Internal Evaluation (CIE) may include:
  - Mid-Semester Examination
  - Assignments
  - Presentations
  - Class Test
  - AI Quiz & Viva Voce
  - Dissertation

- Project work

7.4 Suggested Weightage

- Continuous Internal Evaluation: 30%
- End Semester Examination: 70%

7.5 Passing Standards

- Minimum 50% marks in each component where applicable.
- Minimum 50% aggregate for passing the course/program.
- Separate passing may be required in theory and practical examinations.

7.6 Grading System

The program shall follow Gandhinagar University grading norms.

7.6.1 Grade Table

Grade	Grade Points	From Marks	To Marks
AA	10	80	100
AB	9	75	79
BB	8	70	76
BC	7	65	69
CC	6	60	64
CD	5	55	59
DD	4	50	54
DF	0	0	49

7.7 Dissertation / Project Work

Students shall undertake Research Project OR Industry-Based Dissertation. Requirements may include:

- Proposal Presentation
- Periodic Review
- Final Report Submission
- Viva Voce Examination

The dissertation shall be evaluated by internal and external examiners.

8. Rules and Regulations

8.1 Rules for Promotion

A student shall be promoted to the next semester as per Gandhinagar University rules subject to fulfilment of academic requirements, minimum attendance and Completion of required credits.

8.2 Maximum Duration for Completion

The maximum duration for completing the program shall be 2 years from the date of admission (or as prescribed by the University.)

8.3 Internship Guidelines

8.3.1 Students shall undergo mandatory internship/field training in:

- Educational Institutions and Coaching Centers
- Research and Development Organizations
- Data Science, Analytics and Statistical Consulting Organizations
- Banking and Financial Institutions
- Industries involving Mathematical Modeling, Operation Research and Quality Control

8.3.2 Students must submit:

- Internship Report
- Work Diary/Logbook
- Completion Certificate
- Presentation

8.4 Discipline Rules

Students shall maintain discipline, professional ethics, and proper conduct within the institution, during internships, project works, examinations, and all academic activities. Students are expected to attend classes regularly, follow institutional rules and regulations, respect faculty members, staff, fellow students, and institutional property, and maintain academic integrity in assignments, projects, and examinations. Any form of misconduct, ragging, indiscipline, use of unfair means in examinations, damage to institutional property, harassment, or behavior affecting the academic environment shall be treated seriously and may result in disciplinary action including warning, suspension, cancellation of examination, withholding of results, or expulsion from the program as per University rules and UGC regulations. Students shall also comply with all safety, ethical, and professional standards prescribed by the institution from time to time.

8.5 Anti-Ragging Policy

The program shall strictly follow:

- UGC Anti-Ragging Regulations
- Anti-Ragging Affidavit requirements
- Institutional disciplinary procedures
- Ragging in any form is strictly prohibited.

8.6 Ethical use of Technology and AI Tools

Students are encouraged to use:

- Various Software and AI Tools
- Data Analytics Tools
- AI-based Learning Platforms
- Computational Mathematics Tools

Use of AI tools shall be ethical and academic integrity must be maintained.

9. Student Support

9.1 Industry Collaboration

The department shall actively promote collaboration with Research Institutions, Information Technology Companies, Educational Organizations and Professional Bodies to enhance practical exposure of the program. Such collaborations may include internships, field training, projects, expert lectures, workshops, skill development programs, and placement support.

9.2 Research

The department shall encourage faculty members and students to actively engage in research, innovation, and applied studies in areas such as applied mathematics, data analytics, mathematical modelling, and Computational mathematics. Students may undertake research projects, data analysis studies, optimization studies and problem solving activities as part of their academic and professional training. Participation in seminars, conferences, workshops, funded projects, and collaborative research activities shall be encouraged to promote academic excellence, innovation, and industry- oriented learning.

9.3 Library and Laboratory Facilities

Adequate library, laboratory, and digital learning facilities shall be made available to support effective teaching, practical training, research, and skill development under the program. The department shall

facilitate access to relevant books, journals, research publications, e-resources, and digital learning platforms related to applied mathematics. Necessary computing facilities, software, data analytics tools, internet access, and other technical resources required for practical and project-based learning shall also be provided to enhance industry-oriented education, research capability, and professional competency among students.

9.4 Student Support and Mentoring

A structured system for student support, academic mentoring, and professional guidance shall be implemented for students enrolled in the program. The department shall facilitate academic counselling, mentoring, career guidance, research support, and skill development activities to assist students in their academic progression and professional growth. Students may also be provided opportunities for interaction with field experts, participation in workshops, seminars, training programs, and extracurricular activities aimed at enhancing employability, leadership qualities, communication skills, and overall personality development. Necessary support mechanisms for addressing academic and personal concerns shall also be made available as per institutional policies.

9.5 Placement and Career Development

The department shall promote placement assistance and career development activities for students through professional networking, training programs, internships, and campus engagement initiatives.. Career development activities such as aptitude training, resume preparation, soft skill development, entrepreneurship guidance, certification programs, expert sessions, and placement-oriented workshops may also be organized to enhance professional competency and employability of students.

10. Program Credibility

The Department of Mathematics is committed to achieving excellence in teaching, research, and academic development by providing a strong foundation in mathematical sciences. The department focuses on developing analytical thinking, logical reasoning, problem-solving abilities, and computational skills among students.

With qualified and experienced faculty members, the department ensures quality education through innovative teaching methodologies, practical applications, seminars, workshops, and research-oriented learning. The curriculum is designed in accordance with modern academic and industry requirements, enabling students to pursue higher studies, research, competitive examinations, and professional careers in

education, IT, finance, data science, and related fields.

The department also encourages students to participate in academic activities, projects, interdisciplinary learning, and skill development programs to enhance their overall personality and professional competence. Through continuous academic improvement and student-centered learning, the Department of Mathematics strives to maintain credibility, integrity, and excellence in higher education.

10.1 Scope and Career Opportunities

Graduates of the program may work in:

- Universities, Colleges, and Educational Institutions
- Research and Development Organizations
- Information Technology (IT) Companies
- Banks and Financial Institutions
- Insurance Companies
- Research and Development Organizations
- Government Departments and Public Sector Undertakings
- Educational Institutions and Academic Organizations
- Entrepreneurship and Start-up Ventures

10.2 Potential Job Roles

- Ph.D. Research Scholar
- Government Research Officer
- Academician/Lecturer
- Research Assistant
- Business Analyst
- Banking and Insurance Professional
- Software developer

10.3 Higher Study & Professional Opportunities

Students may pursue:

- Ph.D. in Mathematics and related disciplines
- Ph.D. in Statistics, Data Science, Operations Research, and Computational Sciences

- Research Fellowships in Mathematical and Interdisciplinary Sciences
- Academic and Teaching Eligibility Certifications (NET/SET and related examinations)
- Professional Certifications in Statistical Analysis and Computational Mathematics

11. Collaborative Field Work / Experimental Work

Students shall undertake collaborative field work, experimental work, or project-based learning activities in one or more of the following areas:

- Mathematical Modeling of Real-World Problems
- Data Collection, Analysis, and Statistical Interpretation
- Operations Research and Optimization Studies
- Computational Mathematics and Scientific Computing
- Machine Learning and Artificial Intelligence Applications
- Financial Mathematics and Risk Analysis
- Cryptography and Information Security Applications
- Survey-Based Research and Quantitative Analysis
- Interdisciplinary Research Projects involving Mathematics and Allied Sciences
- Industry-Oriented Projects in Data Analytics and Mathematical Computing
- Collaborative Research Projects with Academic Institutions, Research Organizations, and Industries

These activities shall provide practical exposure to the application of mathematical concepts, enhance research aptitude, promote teamwork, and prepare students for higher studies and professional careers in mathematics and allied disciplines.

12. Review and Revision of Regulation

The University reserves the right to interpret, modify, revise, amend, or update any provision, rule, regulation, curriculum structure, evaluation pattern, academic requirement, or operational guideline related to the program from time to time in accordance with University regulations, statutory requirements, industry developments, and academic needs.

In case of any ambiguity or dispute regarding interpretation of any provision of this manual, the decision of the University/Competent Authority shall be final and binding on all stakeholders. Any amendments, additions, or revisions approved by the appropriate academic or statutory bodies of the University shall automatically become applicable to the program.

Annexure I: Detailed Syllabus

Gandhinagar Institute of science
Master of Science - Mathematics
Semester 1

Subject Code: 10260101	**Subject Title: Ordinary Differential Equations**
Pre-requisite: Basic Knowledge of Ordinary differential Equation	

Course Objective:

1. Demonstrate a working knowledge of Strum Liouville's Problem.
2. Demonstrate a working knowledge transition matrix eigenvalue method, Peano-Backer series method.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
4	-	-	4	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	Mathematical modeling by means of ordinary differential equations and difference equations, Reduction of nth order equation into first order systems, Existence and uniqueness of solution of a nonlinear system of ordinary differential equations, Lispschitz condition, Gronwall's lemma.	14	25%
2	Phase plane Analysis Linearization of nonlinear systems, Autonomous and non-autonomous Linear system Theory: Linear Dependence and independence of solution, Wronskian.	10	17%
3	Transition matrix (fundamental matrix) for a linear system, solution of a nonlinear system by variation of parameters method, computation of transition matrix eigenvalue method, Peano-Backer series method.	10	17 %
4	Stability of dynamical systems, Lyapunov, exponential and asymptotic stability and their characterization.	10	17 %
5	Sturm -Liouville equations, Eigenvalue problems, Series solution of non-autonomous continuous systems, Bessel and Legandre series, Frobenius method.	12	24%

Course Outcome: After completion of this course, student will be able to

- Basic understanding of how any physical phenomena can be modeled by ordinary differential equations and difference equations.
- Understand existence and uniqueness of solutions in closed form and power series form.
- Gain a thorough understanding of the state transition matrix, its properties, its methods of computing and its role in the study of system dynamics.
- Qualitative analysis of a dynamical system using different tools, able to sketch a phase portrait of linear and non-linear one and two dimensional Systems of ODEs, Understand the phase plane analysis of the dynamical systems, Stability analysis of equilibrium solutions of linear systems.
- Bifurcation Sturm-Liouville eigen value problem, series solution of ODE's.

List of Text Books:

1. **S**.L. Ross, Differential equations, Blaisdell publishing company, First edition, 1964
2. Birkhoff G, Ordinary differential equations, Boston, 1962

List of Reference Books:

1. Coddington E. A and N. Levinson,Theory of ordinary differential equations, McGraw-Hill, New York, 1955.
2. An introduction to Differential Equations, Springer- verlag, Second edition, 1995
3. V.I. Arnold, Ordinary Differential Equations, Prentice- Hall of India, New Delhi, 1998
4. Verhulst, Nonlinear Equations

Open e-Resource: : NPTEL Ordinary differential Equation lecture: https://swayam.gov.in/

Gandhinagar Institute of Science
Master of Science - Mathematics
Semester 1

Subject Code: 10260102	**Subject Title: Numerical Analysis**
Pre-requisite: Various Mathematical Series, Calculus	

Course Objective:(1) To familiarize students with error analysis and its significance in numerical computations, including round-off and truncation errors.
(2) To equip students with the ability to solve nonlinear equations, systems of linear equations, and differential equations numerically.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
4	-	-	4	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Computer Arithmetic:** Floating point numbers and round off errors, Absolute and relative errors. **Approximation**: Different types of approximations, Least square polynomial approximation, polynomial approximation by use of orthogonal plynomials, approximation with Chebyshev polynomials.	09	15 %
2	**Numerical Integration** Gaussian quadrature, Romberg integration, adaptive quadrature. **Algebraic Eigen value problem:** Properties of eigenvalues and eigenvectors, Power method, Inverse power method, Jacobi's method, Given's method, Schur and Gershgorins theorem, Orthogonal factorization, QR algorithm for eigen value problem, Eigen values of complex matrix and complex eigenvectors.	18	30 %
3	**Numerical Solution of ODE:** Single step method-Runge Kutta methods, Multistep method - Milne Simpson's method. **Polynomial Interpolation**: Hermite's Interpolation formula with error analysis, Richardson Interpolation, Splines and spline Interpolation, Aitken Extrapolation.	15	25 %
4	**Matrix inversion:** Matrix inversion**,** Jordan's method, Escalator method and Cholesky factorizations. **Solution of system of linear equations:** Pivoting and constructing an algorithm based on Gaussian elimination method, solution of equations by iterative methods (Jacobi's method, Gauss-seidel method) LU factorizations. **System of nonlinear equations:** Newton Raphson's method.	18	30 %

Course Outcome:

After Completion of this Course Students will be able to:

- Understand the basics of computer arithmetic.
- Understand the concepts of numerical differentiation.
- Study numerically eigenvalue problems and different methods for finding eigenvalues and eigenvectors.
- Understand the numerical solution of ODE.
- Understand solution of nonlinear equations.
- Understand the different techniques of interpolation.
- Understand the different techniques of numerical integration.
- Learn about different techniques of matrix inversion and solution of system of linear equations.

List of Textbooks:

1. M.K. Jain: Numerical solution of differential equations, Wiley Eastern (1979), Second Edition.
2. C.F. Gerald and P.O. Wheatley: Applied Numerical Methods, Low- priced edition, Pearson Education Asia (2002), Sixth Edition.

List of Reference Books:

1. S.C. Chapra, and P.C. Raymond: Numerical Methods for Engineers, Tata Mc Graw Hill, New Delhi (2000)
2. S.D and Carl Deboor: Elementary Numerical Analysis: an algorithmic approach, Mc Graw Hill company, Third edition (1981)
3. R.L. Burden, and J. Douglas Faires: Numerical Analysis, P.W.S. Kent Publishing Company, Boston (1989), Fourth edition.
4. S.S. Sastry: Introductory methods of Numerical analysis, Prentice- Hall of India, New Delhi (1998).
5. M.K. Jain, S.R.K. Iyengar and R.K. Jain: Numerical methods for scientific and Engineering computation, Wiley Eastern (1993)
6. G.D. Smith: Numerical Solutions of partial differential equations 2nd edition London, Oxford University Press (1978)

Open e-Resources:

1. https://onlinecourses.nptel.ac.in/noc23_ma94/preview
2. https://onlinecourses.nptel.ac.in/noc23_ge35/preview

Gandhinagar Institute of Science
Master of Science - Mathematics
Semester 1

Subject Code: 10260103	**Subject Title: Linear Algebra**
Pre-requisite: Basic algebra.	

Course Objective:(1) The aim of this course is to make students to learn about abstract concepts of vector spaces, linear transformations and their properties.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
4	-	-	4	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	Quick review of vector spaces, examples of sequence and function spaces. Linear spans; linear dependence/independence and basis, examples of finite dimensional and infinite dimensional vector spaces, quotient space and its dimension, dual space, dual basis, dimension of the annihilator. Solution of the system of simultaneous linear homogeneous equations.	15	25 %
2	Definitions and examples of algebra, algebra analogue of Cayley theorem, minimal polynomial of a linear transformation, rank of a linear transformation, characteristic roots, characteristic vectors, and results related to characteristic vectors, matrix associated with a linear transformation on finite dimensional vector space, isomorphism between the space of linear transformations and the space of matrices, similarity of matrices and similarity of linear transformations.	15	25 %
3	Relation of the minimal polynomials of a linear transformation and its induced linear transformation on a quotient space, triangular matrix associated to a linear transformation, nilpotent linear transformation, canonical matrix associated to a nilpotent linear transformation, existence, and uniqueness of invariants of a nilpotent linear transformation. Jordan form of a linear transformation.	15	25 %
4	Trace and its applications, Jacobson's lemma, transpose of a matrix. Definition of the determinant of a matrix, determinant of a triangular matrix, a matrix with equal rows, a product of matrices, application of determinant: regularity of a matrix, Cramer's rule to solve system of simultaneous non-homogeneous linear equations, quadratic forms: diagonalization of a symmetric matrix, symmetric matrix associated to a quadratic form, classification of quadrics.	15	25 %

Course Outcome:

After Completion of this Course Students will be able to:

- Understand the properties of vector spaces and related illustrations.
- Analyze the properties exhibited by linear transformation and their relationships with matrices.
- Apply results of vector spaces and linear transformations to draw valid conclusions.
- Evaluate various types of Canonical forms of linear transformation and matrix theory associated with Vector spaces.

List of Textbooks:

1. Herstein I. N., Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975. Sections: 4.1, 4.2, 4.3, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.8, 6.9.
2. Kwak J. H., Hong S., Linear Algebra, (Second Edition), Birkhauser, 2004. Sections: 8.1, 8.2.

List of Reference Books:

1. Kumaresan S., Linear Algebra: A Geometric Approach, Prentice Hall of India, 2000.
2. Simmons G. F., Introduction to Topology and Modern Analysis, McGraw-Hill Co., Tokyo, 1963.
3. Helson H., Linear Algebra, (Second Edition), Hindustan Book Agency, TRIM-4, 1994.
4. Ramachandra Rao A. and Bhimasankaram P., Linear Algebra (Second Edition), Hindustan Book Agency, TRIM-19, 2000.

Open e-Resources:

1. https://onlinecourses.nptel.ac.in/

Gandhinagar Institute of Science
Master of Science - Mathematics
Semester -1

Subject Code: 10260104	**Subject Title: Complex Analysis and Laplace Transforms**
Pre-requisite: Strong foundation in calculus and familiarity with elementary functions.	

Course Objective: (1) Develop a solid understanding of complex numbers, their properties, and operations, enabling students to manipulate and work with complex numbers confidently.

(2) Gain proficiency in techniques such as differentiation, integration, and series representation for complex-valued functions, allowing students to solve problems involving complex functions.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
4	-	-	4	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	Functions of complex variable, Continuity and Differentiability of function of complex variable, necessary and sufficient conditions for differentiability of $f(z)$, Holomorphic and Homomorphic functions, Elementary properties of holomorphic functions, Harmonic functions and its applications to potential theory. Mapping and transformations: Linear transformation, Inversion and Linear fractional transformation, Conformal mapping and its applications, Mapping by elementary functions and some special functions.	20	32 %
2	Complex Integrals: contour and contour integrals, different theorems due to Cauchy, Consequences of Cauchy's theorems, Morera's theorem. Liouville's Theorem, Maximum modulus theorem, Fundamental theorem of algebra.	12	20 %
3	Power series representations of $f(z)$, Singularities and Residues of $f(z)$, Residue theorem. Applications of residue theory.	16	28 %
4	Reorientation of Laplace Transform and Inverse Laplace transforms, Existence theorem of Laplace Transform, Laplace Transform of Heaviside function and its applications, step functions, Unit impulse function, Laplace transform of Dirac's Delta function and Periodic function, Applications of Laplace transform to ODE (involving Heaviside function and Dirac delta function), PDE and Integral equations, Inversion integral.	12	20 %

Course Outcome:

After Completion of this Course Students will be able to:

- Understand the limitations of functions of real variables and importance of studying functions of complex variables and its applications in physical phenomenon.
- Learn about the exploration of the algebraic operations on the complex number along with geometry in argand diagram.
- Able to apply continuity, differentiability, analyticity, integral of complex function f(z) in particular domain.
- Able to describe the ideas of Laplace Transforms and their applications to solve initial and boundary value problems.

List of Textbooks:

1. L.V.Ahlfors, Complex analysis, Third Edition, McGraw Hill Book Company,1979
2. R. V. Churchill and James Ward Brown: Complex Variables and Applications, McGraw-Hill, Inc (VI Edition).
3. Erwin Kreysig, Advance Engineering mathematics, (10th Edition), John Wiley 2011.

List of Reference Books:

1. B.C.Palka, An Inroduction to the Complex function Theory, Springer, 1991.
2. H.A. Priestley, Introduction to Complex Analysis, Second Edition, Oxford University Press,
3. 2003.
4. Serge Lang: Complex Analysis, (Third Edition), Springer.
5. Donald Sarason, Notes on Complex Function Theory, Hindustan Book agency ,1994.
6. John. B. Conway, Functions of one Complex Variable, Second Edition, Narosa Publishing House, 2002.

Open e-Resources:

GANDHINAGAR INSTITUTE OF SCIENCE

MASTER OF SCIENCE - Mathematics

SEMESTER - 1

Subject Code: 20260105	**Subject Title:** Programming using MATLAB and C++
Pre-requisite: To study this course, a student must have subject Mathematics in BSc.	

Course Objective:

(1) To gain proficiency in programming languages.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
-	-	08	04	-	-	140	60	200

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Matlab programs:** - Polynomial and matrix operations - Finding mean, median, mode and frequency distribution - Plotting Graphs Arithmetic operations on numbers, vectors and matrices - Area of circle, square, rectangle and triangle - Volume of cube, cylinder, cone - Simple and compound interest Control Structures: - Branching Structures: if, if – else, if – elseif – else and switch statements. - Looping Structures: do – while, while, for statements	30	25%
2	To calculate series expansion of function(sin x, cos x, e_x, etc.) Implementation of Numerical and Mathematical Algorithms computation : Using function file: To find out square root of the number using an iterative algorithm - Bisection Method, Runge-Kutta Method Trapezoidal Rule, Simpson's Rule	30	25%
3	**Numerical methods implementation using 'C++':** **Using function and class:** For obtaining roots of Non – linear equations: - Bisection Method - Regula Falsi Method - Newton Raphson Method For obtaining the approximate value of numerical integration: - Trapezoidal Rule - Simpson's 1/3rd Rule - Simpson's 3/8th Rule - Weddle's rule For solving the initial value problem: - Euler's Method For solving the linear system of equations:	30	25%

	- Gauss Elimination - Gauss – Jacobi Method - Gauss – Seidal Method		
4	For obtaining the finite difference table and finding the value of y for an unknown x(not given in the table) using Interpolation - Newton – Forward Interpolation Formula - Newton – Backward Interpolation Formula - Langrange interpolation formula - Newton divided difference formula Operations on Complex Numbers using structure Area of circle, square ,rectangle and triangle**,**Volume of cube, cylinder ,cone**,**Simple and compound interest**,**Multiplication Table To calculate series expansion of function(sin x, cos x, exp x, etc.)	30	25%

Course Outcome: After completion of this course, student will be able to

- Understand concepts of MATLAB Program.
- Solve real world problems using MATLAB techniques.
- Understand the use of Packages and Interface in MATLAB.
- Design real life situational problems and think creatively and provide a program giving solutions.
- Apply a solution clearly and accurately in a program using C++.
- Apply the programming skills for the best features of mathematics, engineering and natural sciences dealing real life problems.

List of References:

1. E.V. Krishnamurthy and S.K. Sen, Computer based numerical Algorithms, East – West press Pvt. Ltd. (1976)
2. S.S. Sastri, Introductory Methods of Numerical Analysis, Prentice Hall of India, New Delhi (1997)
3. J.D.Faires and R. Burden, Numerical methods, Brooks/Cole publishing Co., second edition (1998)

Open e-Resource:

1. National Programme on Technology Enhanced Learning (NPTEL) (https://nptel.ac.in)
2. Massachusetts Institute of Technology (MIT) Open Learning. (https://ocw.mit.edu/search/?d=Mathematics)

Gandhinagar Institute of science

Master of Science - Mathematics

Semester 2

Subject Code: 10260201	**Subject Title: Partial Differential Equations**
Pre-requisite: Real analysis, multivariable calculus, and ordinary differential equations.	

Course Objective: The objective of this course is to acquaint students with partial differential equations and diverse solution techniques.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
4	-	-	4	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	Formation of Partial Differential Equations, Singular Integrals, Solution of First Order Partial Differential Equation Using Lagrange's Method, Non-Linear First Order Partial Differential Equations: Compatible System of First Order Partial Differential Equations, Solution By Charpit's Method And Jacobi's Method.	14	25%
2	Origin of Second Order Partial Differential Equations, Linear Second Order Partial Differential Equations With Constant Coefficients, Solutions for F(D, D')Z=F(X, Y) to be Polynomial, Exponential, Sin/Cos Functions, General Method for Homogeneous Equations.	14	25%
3	Solution to Homogeneous and Nonhomogeneous Linear Partial Differential Equations Second and Higher Order by Complementary Function and Particular Integral Method. Separation of Variables Method to Simple Problems in Cartesian Coordinates and Polar Coordinate Systems.	14	25%
4	Second-Order Linear Equations and Their Classification, Initial and Boundary Conditions, Modeling and Solution of The One Dimensional Heat, One Dimensional Wave and Laplace Equation Two and Three Dimensional, Nonlinear Equations of The Second-Order, Green's Functions and Integral Representations.	14	25%

Course Outcome:

- Classify the formation of partial differential equations.
- Discovering the solution to both linear and non-linear first-order partial differential equations
- Categorize second-order partial differential equations and explore their solution through Charpit's method and Jacobi's method.
- Provide a detailed explanation of the solution techniques for the heat equation, wave equation, Laplace equation and Nonlinear equations of the second-order.

List of Text Books:

1. Grewal B. S. and Grewal, J. S., Higher Engineering Mathematics, Khanna Pub., New Delhi, 2000
2. Ramana.B.V., "Higher Engineering Mathematics", Tata Mc-GrawHill Publishing Company limited, New Delhi (2007).

List of Reference Books:

1. T. Amarnath, An Elementary Course in Partial Differential Equations, (2nd edition), Narosa Publishing House, 1997.
2. R.K. Gupta, Partial Differential Equations, Krishna Prakashan, Meerut, 2014
3. F. John, Partial Differential Equations, 3rd ed. Narosa Publ. Co., New Delhi, 1979.
4. Ian N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill Company, New York,1957.
5. Erwin Kreyszig, "Advanced Engineering Mathematics", 8th edition, Wiley India

Open e-Resource: : NPTEL Partial differential Equation lecture: https://swayam.gov.in/

Gandhinagar Institute of Science

Master of Science - Mathematics

Semester 2

Subject Code: 10260202	**Subject Title: Applied Analysis**
Pre-requisite: To study this course, a student must have subject real analysis in BSc.	

Course Objective:

- Main objective of this course is to give a knowledge and idea of the theory of Hilbert spaces and Lebesgue theory.
- Students will learn modern mathematical analysis.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
4	-	-	4	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Lebesgue Measurable Sets:** Algebra and σ-algebra of sets; Borel sets and Borel σ-algebra in $\mathbb{R}$; Structure Theorem for open subsets of $\mathbb{R}$; G_δ-sets and F_σ-sets; (Lebesgue) Outer measure in $\mathbb{R}$; Basic results on outer measure; Lebesgue Measurable sets; Lebesgue measure on $\mathbb{R}$; Basic results on Lebesgue measure; Construction of a non-measurable set, and a non-Borel set	14	25%
2	**Lebesgue Measurable Functions**: Simple function and its canonical form; (Lebesgue) Measurable functions; Basic results on measurable functions; Littlewood's three principles; Egoroff's theorem; Simple Approximation Theorem; Convergence in measure; Relation between pointwise convergence & convergence in measure Monotone function and its continuity; Riemann Integral	14	25%

3	**Hilbert Space-1:** Inner product spaces, normed linear spaces, examples of inner product spaces, Polarization identity, Schwarz inequality, parallelogram law, uniform convexity of the norm induced by inner product, orthonormal sets, Pythagoras theorem, Gram-Schmidt orthonormalization, Bessel's inequality, Riesz-Fischer theorem, Hilbert spaces, orthonormal basis, characterization of orthonormal basis, separable Hilbert spaces.	14	25%
4	**Hilbert Space-2:** Uniqueness of best approximation from a convex subset of inner product space to a point, orthogonality and best approximation, existence and uniqueness of best approximation from a convex subset of a Hilbert space to a point, continuity of a linear mapping, projection theorem and Riesz representation theorem, weak convergence and weak boundedness.	14	25%

Course Outcome: After completion of this course, student will be able to

1. Familiarize with the concept of Lebesgue theory.
2. Understand and apply the fundamental results in the theory of Hilbert spaces including the Riesz-representation theorem, Gram-Schmidt orthonormalization process, etc.

List of Reference Books:

1. De Barra G., Introduction to Measure Theory, Van Nostrand Reinhold Co., 1974.
2. Royden H. L. and Fitzpatrick P. M., Real Analysis, Pearson, Fourth Edition, 2010.
3. Rana I. K., An Introduction to Measure and Integration, Narosa Publication House, New Delhi, 1997.
4. Limaye B.V., Functional Analysis, New Age International Publ. Ltd., New Delhi, 1996.
5. Simmons, G.F., Introduction to Topology and Modern Analysis, McGraw-Hill Co., Tokyo, 1963.
6. Thumban Nair, Functional Analysis: A First Course, Prentice-Hall of India, New Delhi, 2002.

Gandhinagar Institute of Science

Master of Science -Mathematics

Semester 2

Subject Code: 10260203	**Subject Title: Applied Mechanics**
Pre-requisite: Fundamental concepts of Physics	

Course Objective:

- Main objective of the course is to familiarize students with various motion equations and impart knowledge of the mathematical techniques used in theoretical physics.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
4	-	-	4	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	Kinematics Equations of particle motion, General Principles of Mechanics, Equilibrium of a system of particles and rigid bodies, Generalized coordinates, Eulerian Angles, Work, Potential Energy, Principle of virtual work	14	25%
2	Kinematics of Particles and rigid bodies, Moments of Inertia, Kinetic Energy and Angular Momentum, Dynamics of particle and a system of particles, Moving frames of reference, Dynamics of a rigid body	14	25%
3	D'Alembert's Principle, Principle of Virtual Work, Classification of Constraints, Lagrange's equation for holonomic systems and Examples,	14	25%

	Lagrange's equation in velocity dependent potential and non-commutative forces		
4	Euler-Lagrange's equation, Hamilton's variation principle, Derivation of Lagrange's equation from Hamilton's variational principle, General Conservation theorem, Hamilton's Canonical equations of motion using Legendre's transform	14	25%

Course Outcome: After completion of this course, student will be able to

1. Recognise the behavior of a particle system.
2. Learn how rigid bodies and particles behave in terms of kinematics and dynamics.
3. Derive, examine and use Lagrange's equation of motion.
4. Study Hamilton's principle
5. Create, analyse and use Hamilton's equation of motion.

List of Text Books:

1. P. M. Mathews and K. Venkatesan, A textbook of Quantum Mechanics, Tata McGraw Hill,2007.
2. D. J. Griffiths, Introduction to quantum mechanics, Pearson Education International,2005.

List of Reference Books:

1. Goldstein, H., Poole, C. and Safko, J., Classical Mechanics, Pearson Education, Inc., Indian Low-Price Edition,3rd Edition, 2018.
2. Upadhyay, J.C., Classical Mechanics, Himalaya Publishing House, Second Edition, 2014.
3. Waghmare, Y.R., Classical Mechanics, PHI Pvt. Ltd., 1990.
4. Sears and Salinger, Thermodynamics, Kinetic theory and statistical thermodynamics, Narosa Publishing House, 1989.

Open e-Resource:

- https://nptel.ac.in/courses/115106123

Gandhinagar Institute of Science
Master of Science - Mathematics
Semester -2

Subject Code: 10260204	**Subject Title: Algebra**
Pre-requisite: Strong foundation in group theory.	

Course Objective:

To study ring theory further, and to introduce Galois theory with some applications

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
4	-	-	4	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	A brief review; ideals and factor rings; ring homomorphisms.	14	25 %
2	Polynomial rings; irreducibility tests; unique factorization in Z[X]; divisibility in integral domains.	14	25 %
3	Splitting fields; finite extensions of fields; properties of algebras extensions; finite fields; geometric constructions.	14	25 %
4	Fundamental theorem of Galois theory; solvability of polynomials by radicals; insolvability of a quantic; cyclotomic polynomials.	14	25 %

Course Outcome:

After Completion of this Course Students will be able to:

- Understand fundamental ring concepts, including ideals and factor rings, and develop proficiency in analyzing and applying ring homomorphisms.
- Grasp polynomial rings, learn irreducibility tests, understand unique factorization and explore divisibility in integral domains.
- Master splitting fields, finite extensions of fields, properties of algebraic extensions, finite fields, and geometric constructions.
- explore the solvability of polynomials by radicals, cyclotomic polynomials, the insolvability of a quantic, and the fundamental theorem of Galois theory.

List of Textbooks:

1. Contemporary Abstract Algebra (Eighth Edition) by Joseph A. Gallian, Cengage India Learning Private Limited, 2013. Chapters: 12-23, 32,33

List of Reference Books:

1. A Course in Algebra by E. B. Vinberg, American Mathematical Society, 2003.
2. Basic Abstract Algebra (Second Edition) by P. B. Bhattacharya, S. K. Jain, S. R. Nagpal, Cambridge University press, 1995.

Open e-Resources:

GANDHINAGAR INSTITUTE OF SCIENCE
Master of Science - Mathematics
SEMESTER - 2

Subject Code: 20260205	**Subject Title:** Programming using JAVA and Python
Pre-requisite: To study this course, a student must have subject Mathematics in BSc.	

Course Objective:

(1) To gain proficiency in programming languages.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
-	-	8	04	-	-	140	60	200

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Java programs:** Introduction to Editor and Terminal in Ubuntu, Compiling and running Programs in Ubuntu, Programs based on printing Message, letters and patterns using System.out.println ( ). Programs based on demonstration of various datatypes and operators, printing size and range of datatypes, casting, wrapper class. Programs based on taking user inputs using command line arguments and Scanner class. Java program based on conditional statements (if, if-else, if-elseif, nested if-else, switch case	48	27%
2	Programs based on one dimensional and two dimensional arrays Programs based on Loop statements (for loop, while loop, do-while loop) Programs based on making class having various constructors, members and methods. Programs based on inheritance, polymorphism, interface and packages. Programs based on abstract class and exception handling Programs based on file handling, reading a text file, counting number of characters and digits in a text file.	45	23%
3	**Python programs:** - Programs to develop logic - Polynomial and matrix operations - Finding mean, median , mode and frequency distribution - Plotting Graphs Operators: - Arithmetic operations on numbers, vectors and matrices - Area of various shapes - Volume of various shapes	48	27%
4	Control Structures: - Branching Structures: if, if – else, if – elseif – else and switch statements. - Looping Structures: do – while, while, for statements. To calculate series expansion of function(sin x, cos x, e_x, etc.)	45	23%

Course Outcome: After completion of this course, student will be able to

- Understand concepts of JAVA Program.
- Understand concepts of Python Program.

List of References:

1. Herbert Schildt, Java™ : The Complete Reference, Seventh Edition, The McGraw-Hill Companies (2007).
2. Eric Matthes,Python Crash Course, Second Edition, No Starch Press, (2019).
3. John M Zelle, Python Programming: An Introduction to Computer Science, Ingram short title, (2016).
4. Sam Morley, Applying Math with Python, (2022).

Open e-Resource:

1. National Programme on Technology Enhanced Learning (NPTEL) (https://nptel.ac.in)
2. Massachusetts Institute of Technology (MIT) Open Learning. (https://ocw.mit.edu/search/?d=Mathematics)

Gandhinagar University UG/PG
Semester- II

Subject Code: IKS0201	Subject Title: Indian Ancient History and Cultural Heritage

Course Objective:

- Foster an appreciation for the composite nature of Indian history, culture and heritage.
- Instill a sense of love and belonging among learners, contributing to nation-building efforts.
- Provide an overview of various components of cultural heritage, including fairs, festivals, dances, art, architecture, and historical landmarks, which are crucial for a deeper understanding of history.

Teaching Scheme (Hours per week)				Evaluation Scheme (Marks)				
				Theory		Practical		
Lecture	Tutorial	Practical	Credit	University Assessment	Continuous Assessment	University Assessment	Continuous Assessment	Total
02	-	-	02	-	-	25/ Project	25/ Project	50

Subject Contents			
Sr. No	**Topics**	**Total Hours**	**Credit**
1	**Indian Ancient History:** Introduction of Ancient India. Harappan Civilization. Rigvedic & Later Vedic Period. India in the 6th Century B.C. Persian and Greek invasions and its impact. Mauryan and Gupta Periods. Post – Mauryan. Brief History of the Sanskrit literature: The Vedas, The Brahmanas and Upanishads & Sutras, Epics: Ramayana and Mahabharata & Puranas.	15	1
2	**Indian Cultural Heritage:** Ethnic Indian Cultural Construct – Fairs & Festivals and their historical background. Indian dances as Cultural Heritage. Indian Architecture: Temples, Stupas, Caves, Chaityas. Medieval Architecture and Colonial Architecture. Social culture in India- Vedic culture. Ancient period- varna and jati, family and marriage in India, position of women in ancient India, Contemporary period; caste system and communalism.	15	1

Course Outcome:

After completion of this course, students will be able to

- Demonstrate knowledge of the key events, periods, and figures that have shaped Indian history from ancient to modern times, including their impact on the socio- political and economic landscape.
- Analyze the rich cultural heritage of India, including art, architecture, literature, and philosophy, while recognizing the contributions of various communities to India's pluralistic society.

List of Text Books:

1. An advanced history of India – causes and decline of Guptas by B.C. Majumdar and others, 1967, Macmillan.
2. Ancient India by R.C. Majumdar, 1977, Motilal Banarasi Das.
3. History of Ancient India by Rama sankar Tripati, 1942, Motilal Banarasi Das.
4. History and culture of India to 1000 A.D. by H.V. Srinivasa Murthy, 1980, S. Chand and Co.
5. History of South India by K.A. Nilakanta Sastry 1976, Oxford University Press.
6. History of Ancient India by Krishnaswamy Aiyangar, 1980, Seema Publishers.
7. Ancient India by V.D. Mahajan, 1985, S.Chand and Company.
8. Advance History of India by K.A. Nilakantasastry and C.S.Srinivasachari, 1980, Allied Publishers.
9. Ancient Indian History and Civilization by Silendranath Sen, 1988, Wiley Eastern.
10. Lothal and Indus Civilizations by S.R.Rao, 1972, Asia Publishers, Madras

Gandhinagar Institute of Science
Master of Science - Mathematics
Semester 3

Subject Code: 10260301	**Subject Title: Numerical Methods for Partial Differential Equations**
Pre-requisite: Knowledge of Partial differential equations.	

Course Objective: The aim of this course is to make students to learn about abstract concepts of finite difference and finite elements methods.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
4	-	-	4	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**FINITE DIFFERANCE METHOD** **Numerical methods for parabolic PDE** • Finite difference method: Explicit methods, implicit methods and Crank- • Nicolson implicit method, Stability, Convergence and error of these methods, Predictor -Corrector methods **Numerical methods for hyperbolic PDE** • Explicit methods, implicit methods, stability, convergence and error of these methods, • Method of characteristics, Lax-Wendroff method, method of artificial viscosity, Courant – Friedrichs -Lewy condition. **Numerical Methods for elliptic PDE :** • Numerical solutions of Laplace and Poisson equation using forward difference scheme and its error.	15	25 %
2	**FINITE ELEMENT METHOD** • Introduction, Advantages of FEM over other methods, Basic steps in FEM, Springs in series analogy, Under standing about weak solution, Relay Ritz Method • Different approaches in FEM formulation, Variational and Galerkin's approach. Descretization of problem, Descretization of geometry • Element types, Shape functions, Element equations, Assembly procedure, Imposition of Essential boundary conditions, Properties of assembled matrix, Methodology for solving system of equations. • Formulation of the FEM for elliptic problems Variational and Glerkian formulation	15	25 %
3	**Finite element discretizations in 1D**	15	25 %

	• Variational approach • Galerkin approach **Finite element discretization in 2D** • A FEM for Poisson's equation, steady state heat equation, General second order pde • Galerkin approach Second order pde in different domain with physical parameter's description.		
4	**Formulation of the FEM for elliptic problems** • Variational and Glerkian Formulation FEM as a tool for solving boundary value problems	15	25 %

Course Outcome:

After Completion of this Course Students will be able to:

- To learn about finite difference approximation to partial derivatives and the solution of Partial Differential Equation (PDE) using different algorithms using Finite difference of parabolic PDE.
- To learn about the Solution of hyperbolic and elliptic PDE using finite difference algorithms and their convergence and stability.
- To be able to Understand the general steps of finite element methods, To be able to understand the Engineering aspects for FEM.
- To be able to Understand the basic finite element formulation techniques. To be able to understand the mathematical methods for FEM in one and dimension and three dimension, be able to formulate and solve basic problems in heat transfer, solid mechanics and fluid mechanics.
- Understanding of FEM Open source software/License software.
- Understanding of application of FEM software to industrial problems related to BVP and IVP-BVP.
- Advantages of FEM over other Methods.

List of Textbooks:

1. G. D. Smith, Numerical solution of Partial Differential Equations: Finite Difference Methods, Third edition, Oxford University Press, 1986.
2. Cook, Malkus and Plesha, Concepts and Applications of finite element analysis, Third edition, John Wiley and sons, 1989.

List of Reference Books:

1. K. W. Morton and D. F. Mayers, Numerical solution of Partial Differential Equations, Cambridge University Press, New York, 1993.
2. A. R. Mitchell and D. F. Griffiths, The Finite Difference Methods in Partial Differential Equations, Wiley, April, 2001.
3. A. Quarteroni and A. Valli, Numerical Approximation of Partial Differential Equations, Springer, 1994.
4. S. Brenner and L.R.Scott, The Mathematical theory of Finite element methods, Springer-Verlag, 1994.
5. C.Johnson, Numerical solution of partial differential equations by the FEM, Cambridge University Press, 1994.

6. B. Szabo and I. Babuska, Finite element analysis, Wiley and Sons,1991.
7. K.H. Huebner, The Finite element Method for Engineers, John Wile and Sons, 1975.
8. J.N Reddy, An introduction to Finite Element Method, MacGrawHill.

Gandhinagar Institute of Science
Master of Science - Mathematics
Semester 3

Subject Code: 10260302	**Subject Title: Fluid Dynamics**
Pre-requisite: knowledge of Partial differential equations and vector algebra.	

Course Objective:(1) The aim of this course is to make students to learn about abstract concepts of fluid kinematic, Navier Stokes equations and Laminar flow.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
4	-	-	4	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	Review of vector notation and vector operators in various coordinate systems. Brief outline of Cartesian Tensor Analysis. Properties of second order tensors. Fundamental equation of fluid statics and derivation of Hydrostatic equation and Torricelli's Principle. **Fluid kinematics:** Flow description using Lagrangian and Eulerian methods. Stream lines and path lines. Material derivative and fluid acceleration, vorticity. Equation of continuity in cartesian and general vector form. Expression in cylindrical and spherical coordinates, stream tube flow. Boundary conditions. Euler's equation of motion in general vector form and derivation of Bernouilli's equation. Application to flow through orifices, Pitot's tube and Venturi meter.	15	25 %
2	**Navier Stokes equations:** General theory of stress and rate of strain in fluid flow. Nature of stresses. Transformation of stress components. Nature of strains. Transformation of rates of strain. Derivation of the Navier-stokes equations. Derivation of Euler's equations as a special case of Navier – Stokes equation. Potential, the harmonic oscillator, multiple potential wells, splitting of energy levels, energy bands	15	25 %
3	**Potential flow of ideal fluids :** • Velocity potential and irrotational flow, circulation and Kelvin's theorem, flows with axial symmetry • Three dimensional singularities. Image systems. Stoke's stream function. Singularities in two-dimensional flow. Stream function in two dimensions. • Complex velocity potential. • Flow net. Superposition of simple flows. Rankine's method for construction of stream lines.	15	25 %

	• Indication of the use of complex analysis and conformal transformations in flow problems.		
4	• Laminar flow of viscous incompressible fluids. Similarity of flows – Reynold's and Froude number. • Flow between parallel plates – Couette flow and plane Poiseuille flow. • Hagen – Poiseuille flow through pipes. Laminar boundary layer : • Definition of boundary layer • Boundary layer equations in two- dimensional flow. • Blasius solution for the boundary layer along a flat plate.	15	25 %

Course Outcome:

After Completion of this Course Students will be able to:

- To be able to understand the basics for Fluid Dynamics. To be able to Classify and exploit fluids based on the physical of a fluid, To be able to compute the Kinematical properties of a fluid element.
- To be able to apply the conservation principles of mass, linear momentum, and energy to fluid flow systems. To be able to understand flow equations with applications.
- To be able to understand the Navier-Stokes' equation, and Demonstrate the ability to model inviscid, steady fluid flow.
- To be able to understand the complex Potential flow and related applications
- To be able to understand the viscous incrompressible flow using Navier- Stokes equation.
- To be able to understand the Boundary layer and its application
- To be able to solve Industry related flow problems.

List of Textbooks:

1. Textbook of Fluid Dynamics, F. Chorlton, Van Nostrand (1967).
2. An Introduction to Fluid Dynamics, Batchelor G. K, Cambridge University Press (1999)

List of Reference Books:

1. Foundations of fluid Mechanics, S. W. Yuan, Prentice – Hall International (1970).
2. Ideal and Incompressible fluid dynamics, M. E. O'Neill and F. Chorlton John Wiley & Sons (1986).
3. Analytical Fluid Dynamics, Emanuel G, CRC Press, Boca Raton, Second edition, FL (1999).
4. Incompressible Flows, Panton R. L., Wiley Interscience (1984).
5. Fundamental Mechanics of Fluids, Currie I. G, McGrow-Hill, New-york (1993).
6. Mathematical introduction to Fluid Mechanics, Chorin, Springer Verlag, Fourth edition.

Gandhinagar Institute of Science
Master of Science - Mathematics
Semester 3

Subject Code: 10260303	**Subject Title: Mathematical Modelling**
Pre-requisite: knowledge of Mathematics.	

Course Objective: The aim of this course is to make students to learn about abstract concepts of mathematical modaling.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
4	-	-	4	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	Random numbers: Generating uniform random variables: Pseudo – random numbers, congruential generators and their properties, alternative approaches. Testing random numbers: empirical and theoretical tests or sequences of uniform random numbers, General methods: Inversion method, acceptance-rejection, composition methods. Particular methods for non–uniform random variables, Box–Muller methods to generate normal variates. Exponential, Binomial and Poisson variates.	15	25 %
2	Discrete Event simulation modeling: Introduction to simulation modeling, Queuing models, Simulation of queueing systems, Output analysis of short and long term performance, Verification and validation, Statistical simulations: Monte-Carlo simulation, Variance reduction technique: Arithmetic variables, conditioning, control variates, importance sampling and common random numbers, Simulation inference.	15	25 %
3	Needs and Techniques of mathematical modeling: Idea of mathematical modeling, need for mathematical modeling, steps in mathematical modeling, Characteristics of mathematical modeling, Interpretation. Models in mechanical vibration :Spring mass system, pendulum problems. Models in population dynamics:One species model, logistic model, growth model in time delays, Predator-Prey models, Volterra-Lotka models.	15	25 %
4	Models of chemical processes, Electrical network and Diffusion processes, Partial Differential Equations models, Traffic flow models and different pde models pertaining to human physiology. Models of chemical processes, Electrical network and Diffusion processes, Modeling dynamical systems: differential equations and their numerical solution, linear and non–linear dynamics, stability, convergence, attractors. Physical systems: System types and characteristics behaviour, Continuous-time, discrete – time and discrete -event systems, linear and nonlinear systems.	15	25 %

Course Outcome:

After Completion of this Course Students will be able to:

- Understand different methods for random number generation.
- Have a clear understanding of the need for the development process to initiate the real problem.
- Have a clear understanding of principle and techniques of mathematical and simulation methods
- Be able to describe the components of continuous and discrete systems and simulate them.
- Be able to model any system from different fields.
- Be able to implement numerical algorithm to solve the mathematical model that meet the real life requirements.
- Be able to discuss the simulation methods and select the suitable technique to apply on the several problems.
- Know how to simulate any system.
- Have a clear understanding of the system to be studied.

List of Textbooks:

1. J.N.Kapur: Mathematical modelling ,Wiley eastern Ltd.,1994.

List of Reference Books:

1. M.M. Gibbons: A concrete approach to Mathematical modeling , John Wiley and sons, 1995.
2. H. Neunzert and A.H. Siddiqu: Topics in Industrial Mathematics, Kluwer Academic Publishers, London, 2000.
3. P. E. Wellstead: Introduction to Physical system modeling, Academic Press, 1979.
4. Richard Haberman: Mathematical Models, Practice- Hall Inc., NJ, 1979.
5. Jery Banks, John S., Carson II, Barry Nelson and David M.Nicol: Discrete – Event system simulation , Prentice hall, 2001
6. J.N.Kapoor: Mathematical modeling in biology & medicine, Eastwest press

Gandhinagar Institute of Science
Master of Science - Mathematics
Semester 3

Subject Code: 10260304	**Subject Title: Optimization**
Pre-requisite: knowledge of matrix theory.	

Course Objective: The aim of this course is to make students to learn about abstract concepts of linear and nonlinear programming problems

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Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
4	-	-	4	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Optimization problems in engineering and industries** Optimization problem formulation Classification of optimization problem **Classical optimization techniques** Single variable optimization, Multivariable optimization, Constrained optimization: Lagrangain multiplier method, Khun-Tucker conditions.	15	25 %
2	**Single variable optimization techniques** Bracketing method - Exchaust search Region elimination method - Interval halving method, Golden section method, Interpolation method - Quadratic interpolation method, Gradient based methods – Newton's method, bisection method.	15	25 %
3	**Multivariable optimization techniques (Unconstrained and Constrained)** Univariate method, Direct Search method - Simplex search method, Powell's conjugate direction method, Gradient based methods - steepest descent (Cauchy) method , conjugate gradient (Fletcher-Reeves) method. Box complex method, Sequential linear programming method, Interior and Exterior Penalty function methods	15	25 %
4	**Constraint linear optimization problem** Overview of linear optimization problem Sensitivity analysis **Quadratic programming** Wolf's modified simplex method Balyes methods **Integer programming problem**	15	25 %

	Gomoreys cutting plane method branch and bound techniques		

Course Outcome:

After Completion of this Course Students will be able to:

- Able to formulate and choose appropriate methodology to solve an optimization problem according the classification in terms of Linear/Non-Linear, Single Variable/Multi-Variable, With Constraint/Without Constraint.
- Understand and can successfully apply the classical theory of optimization, to solve various problems which belongs to classes; viz. single/multivariate problems without constraints, Lagrange method for problems having equality constraints and theory of Kuhn-Tucker for problems having inequality constraints.
- Able to choose and apply an appropriate method from various methods designed for single variable optimization problems.
- Develops an ability to choose appropriately from various available methods designed for solving Multivariable optimization problems (Unconstrained and Constrained) and apply them successfully for desired solution.
- Apply optimization methods to various real life areas, engineering problems, industrial problems
- Interpreting results and effects of change in the structure or parameters of Optimization problems.
- Understand and apply constrained optimization theory for continuous problems, involving integer solutions or including the Kuhn-Tucker conditions for quadratic programming.

List of Reference Books:

1. Rangrajan K. Sundaram: A first Course in Optimization Theory, Cambridge University Press, First edition,1996.
2. S. S. Rao: Engineering Optimization (Theory and Practice), New Age International Publishers, New Delhi, Third edition, 2001.
3. Edwin K. P. Chong, Stanislaw H. Zak, An Introduction to Optimization, Wiley-India publishers, Second edition,2001.
4. Mohan C. Joshi, Kannan M. Moudgalya: Optimization (Theory and Practice),Narosa Publishing House, First edition,2004.
5. Kalyanmoy Deb: Optimization for Engineering Design (Algorithms andExamples), Prentice-Hall of India Private Limited, New Delhi,1995.
6. Kantiswarup, P.K.Gupta and Manmohan: Operations Research , Sultan chand andSons.
7. S.D. Sharma: Operations Research (Theory, Methods and Applications), Kedar Nath, Ram Nath & Co., Fifteenth edition,2005.
8. H.A. Taha :Operation research an Introduction, Prentice-Hall of India PrivateLimited, New Delhi, Sixth edition,2001.
9. B.E. Gillet : Introduction to Operations Research-Computer OrientedAlgorithm.
10. K. V. Mittal, Chandra Mohan: Optimization Methods in Operations Research and System Analysis, New-Age international Publishers,2008.
11. J. C. Pant: Introduction to Optimization: Operations Research, Jain Brothers, NewDelhi, 2010.
12. Wayne L. Wilson: Operations Research: Applications and Algorithms, Cengage Learning India Pvt. Ltd.,2011.

GANDHINAGAR INSTITUTE OF SCIENCE
Master of Science - Mathematics
SEMESTER - 3

Subject Code: 20260305	**Subject Title:** Programming of Numerical Methods for Partial Differential Equations
Pre-requisite: To study this course, a student must have knowledge of partial differential equations.	

Course Objective:

(1) To provide students with practical knowledge and hands-on programming skills to implement numerical methods for solving PDEs using tools such as Python, MATLAB, or C++.

(2) The course focuses on finite difference, finite element, and finite volume approaches applied to parabolic, hyperbolic, and elliptic equations.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
-	-	8	04	-	-	140	60	200

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Introduction to PDEs and Classification** • Overview of Partial Differential Equations • Classification of PDEs: Elliptic, Parabolic, Hyperbolic • Initial and boundary conditions • Analytical vs numerical methods • Introduction to numerical errors: truncation, round-off, stability, convergence	30	25%
2	**Finite Difference Methods (FDM) – Fundamentals** • Discretization of space and time • Taylor series and finite difference approximations • Forward, backward, and central differences • Error analysis and consistency • Introduction to mesh/grid generation	30	25%
3	**Finite Volume and Finite Element Methods (Intro)** • Concept of control volumes • Weak formulation of PDEs • Shape functions and interpolation • Assembly of global matrices • Applications to elliptic problems (brief intro)	30	25%
4	**Implementation and Programming** • Code structure for PDE solvers • Writing reusable functions/modules • Visualization of results (2D/3D plots, surface plots)	30	25%

	• Handling boundary conditions in code • Performance tips for large grids • Debugging and validation		

Course Outcome: After completion of this course, student will be able to

- Understand the classification of partial differential equations and their physical significance.
- Formulate finite difference approximations for various types of PDEs (elliptic, parabolic, and hyperbolic)
- Solve real-world engineering or physics problems modeled by PDEs using appropriate numerical methods.
- Compare different numerical methods in terms of efficiency, accuracy, and computational cost for solving PDEs.

List of References:

1. Numerical Solution of Partial Differential Equations – K.W. Morton & D.F. Mayers
2. Numerical Methods for Engineers – Steven C. Chapra, Raymond P. Canale
3. Finite Difference Methods for Ordinary and Partial Differential Equations – Randall J. LeVeque
4. Partial Differential Equations with Numerical Methods – Stig Larsson, Vidar Thomee

Open e-Resource:

- MIT Open Courseware – Numerical Methods for PDEs
- Numerical Recipes
- Python libraries: NumPy, SciPy, Matplotlib, FEniCS, FiPy