VIT
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

Curriculum and Programme Structure

Integrated M.Sc in Mathematics

Programme Educational Objectives (PEOs)

PEO_01. Graduates will acquire knowledge and expertise to excel in professional career.

PEO_02. Graduates will obtain and apply the practical and technical skills to identify, analyse and solve the problems related to the industries.

PEO_03. Graduates will develop and possess professional attitude and skills to be socially responsible individual and work as team in their work place and society considering the professionals ethics, environmental factors, and contribute to the economic growth of the country.

PEO_04. Graduates will utilize their expertise gained to pursue higher studies and outshine in careers like teaching, research or technologists.

PEO_05. Graduates will be competent to exhibit their acquired multidisciplinary skills for the lifelong learning in their professional and personal upliftment.

Programme Outcomes (POs)

PO_01. **Fundamental Knowledge**: Having an ability to acquire in-depth knowledge of the fundamental concepts and techniques.

PO_02. **Problem analysis**: Having an ability to apply the imbibed knowledge in assessing, analysing and providing solution for the industry related real time issues

PO_03. **Design/development of solutions**: Having an ability to design, conduct experiments, capture data, analyse, interpret and synthesis the information for valuable decision making.

PO_04. **Technical skills**: Having an ability to obtain technical skills and apply the same for the discovery of new patterns and solutions for demanding needs in mankind.

PO_05. **Innovative solutions**: Having the ability to understand and update on the contemporary issues and changes in fields and become self-reliant to provide solutions in an innovative style.

PO_06. **Real time solutions**: Having the problem-solving ability to assess the environmental impact caused to the society and applies measures to tackle the issues.

PO_07. **Sustainability**: Having an ability to be apply and innovate considering the adaptivity of the products and solution for the sustainable growth of the ecosystem.

PO_08. **Ethics**: Having an ability to develop clear understanding of being a professional ethical individual.

PO_09. **Individual and team work**: Having an ability to exhibit competency to work as teams in a cross-cultural environment.

PO_10.Communication: Having an ability to display the command over the English language to communicate orally and in written.

PO_11.Management: Having an ability to develop and apply business management skills in career growth.

PO_12.Life-long learning: Having an ability to develop lifelong learning interest and application in day-to-day activities.

Programme Specific Outcomes (PSOs)

PSO_01. Develop a multi-disciplinary approach for solving real life problems through various Foundational Core courses.

PSO_02. Use advanced knowledge on mathematics to pursue higher degrees at reputed academic institutions around the world.

PSO_03. Pursue research or careers in industry in mathematical sciences and allied fields.

PSO_04. Interact with international researchers and developing collaborations..

Programme Credit Structure

Foundation Core Courses	**50**
Discipline Core Courses	**68**
Discipline Elective Courses	**45**
Project and Internship	**23**
Open Electives	**09**
Ability Enhancement Courses	**09**
Skill Enhancement Courses	**08**
Total Credit Requirement	**212**
Non-graded Core Requirements	**12**

Foundation Core courses (50 credits)

Calculus and Analytical Geometry	3-0-0-3
Calculus and Analytical Geometry Laboratory	0-0-2-1
Physics of Waves	3-0-0-3
Physics of Waves Laboratory	0-0-2-1
Inorganic and Organic Chemistry	3-0-0-3
Inorganic and Organic Chemistry Laboratory	0-0-2-1
Programming in Python	2-0-0-2
Programming in Python Laboratory	0-0-4-2
Ethics and Values	2-0-0-2
Ordinary and partial differential equations	3-1-0-4
Modern Physics	3-0-0-3
Modern Physics Laboratory	0-0-2-1
Biological Sciences	3-0-0-3
Biological Sciences Laboratory	0-0-2-1
Physical and Analytical Chemistry	3-0-0-3
Physical and Analytical Chemistry Laboratory	0-0-2-1
Structured and Object Oriented Programming (C & C++)	2-0-0-2
Structured and Object Oriented Programming (C & C++) Laboratory	0-0-4-2
Critical Thinking	2-0-0-2
Intra and Interpersonal skills	2-0-0-2
Principles of Management	3-0-0-3
Research Methodology	3-0-0-3
Foreign Language	2-0-0-2

Ability Enhancement Courses (09 credits)

Effective English Communication Laboratory	0-0-4-2
Technical English Communication	2-0-0-2
Technical English Communication Laboratory	0-0-2-1
Technical Report Writing Laboratory	0-0-2-1
Environmental Studies	3-0-0-3

Skill Enhancement Courses (08 credits)

Programming in Java	3-0-0-3
Programming in Java Laboratory	0-0-2-1
Scientific Computing Laboratory	0-0-4-2
Data Analysis Laboratory	0-0-4-2

Non-graded Core Requirement (12 credits)

Extra-curricular/Co-curricular

Project / Internship (23 Credits)

Project -III– 3 credits
Capstone Project Stage-I (6 credits)
Capstone Project Stage-II (14 credits)

Discipline Core courses (68 credits)

Linear Algebra	3-1-0-4
Real Analysis	3-1-0-4
Ordinary Differential Equations	3-1-0-4
Complex Analysis	3-1-0-4
Introduction to Probability and Statistics	3-0-0-3
Introduction to Probability and Statistics Laboratory	0-0-2-1
Numerical Analysis	3-0-0-3
Numerical Analysis Laboratory	0-0-2-1
Basic Abstract Algebra	3-1-0-4
Operations Research	3-1-0-4
Discrete Mathematical Structures	3-1-0-4
Topology	3-1-0-4
Calculus of Variations and Integral Equations	3-1-0-4
Graph Theory	3-1-0-4
Functional Analysis	3-1-0-4
Partial Differential Equations	3-1-0-4
Transform Techniques	3-1-0-4
Measure and Integration	3-1-0-4
Statistical Inference	3-0-0-3
Statistical Inference Laboratory	0-0-2-1

Discipline elective courses (45 credits)

Number Theory	3-0-0-3
Fuzzy Set Theory and its Applications	3-0-0-3
Mathematical Statistics	3-1-0-4
Optimization	3-1-0-4
Tensors and Differential Geometry	3-0-0-3
Classical Mechanics	3-1-0-4
Mathematical Ecology	3-0-0-3
Data Structures	3-1-0-4
Project-I	3-0-0-3
Mathematical Finance	3-0-0-3
Fluid Dynamics	3-1-0-4
Difference Equations and its Applications	3-0-0-3
Database Management	3-1-0-4
Project-II	3-0-0-3
Advanced Abstract Algebra	3-0-0-3
Advanced Complex Analysis	3-0-0-3
Numerical Solution to Partial Differential Equations	3-0-0-3

Stochastic Processes	3-0-0-3
Magnetohydrodynamics	3-0-0-3
Fractional Calculus with Applications	3-0-0-3
Finite Element Methods and Applications	3-0-0-3
Sobolev Spaces	3-0-0-3
Computational Fluid Dynamics	3-0-0-3
Mathematical Modelling and Simulation	3-0-0-3
Infinite Dimensional optimization and Control theory	3-0-0-3

Open elective courses (09 credits)

Exploratory Data Analysis and Visualisation	3-0-0-3
Artificial Intelligence	3-0-0-3
Principles of Neural Networks	3-0-0-3
Machine Learning	3-0-0-3
Quantum Computing	3-0-0-3
Deep Learning	3-0-0-3

Category		B.Sc	B.Sc Honours	M.Sc
CORE	Foundation Core Courses	47	47	50
	Discipline Core Courses	40	56	68
ELECTIVES	Discipline Elective Courses	30	33	45
	Open Elective Courses	-	06	09
AECC	Ability Enhancement Courses	09	09	09
SEC	Skill Enhancement Courses	06	08	08
PROJECT	Project/Capstone Project	-	08	23
EXC	Non-graded core requirements	12	12	12
Total		**132**	**167**	**212**

Indicative Programme Structure of Integrated M.Sc in Mathematics

First Year

SEMESTER-I				SEMESTER -II			
Course Code	**Course**	**L-T-P**	**C**	**Course Code**	**Course**	**L-T-P**	**C**
ENGXXX	Effective English Communication Laboratory	0-0-4	2	ENGXXX	Technical English Communication	2-0-0	2
CHY1003	Environmental Studies	3-0-0	3	ENGXXX	Technical English Communication Laboratory	0-0-2	1
CSEXXX	Programming in Python	2-0-0	2	CSEXXX	Structured and Object Oriented Programming (C & C++)	2-0-0	2
CSEXXX	Programming in Python Laboratory	0-0-4	2	CSEXXX	Structured and Object Oriented Programming (C & C++)Laboratory	0-0-4	2
MATXXX	Calculus and Analytical Geometry	3-0-0	3	MATXXX	Ordinary and partial differential equations	3-1-0	4
MATXXX	Calculus and Analytical Geometry Laboratory	0-0-2	1	PHYXXX	Modern Physics	3-0-0	3
PHYXXX	Physics of Waves	3-0-0	3	PHYXXX	Modern Physics Laboratory	0-0-2	1
PHYXXX	Physics of Waves Laboratory	0-0-2	1	BITXXX	Biological Sciences	3-0-0	3
CHYXXX	Inorganic and Organic Chemistry	3-0-0	3	BITXXX	Biological Sciences Laboratory	0-0-2	1
CHYXXX	Inorganic and Organic Chemistry Laboratory	0-0-2	1	CHYXXX	Physical and Analytical Chemistry	3-0-0	3
EXCXXX (NGC)	Extra Co-curricular	2-0-0	2	CHYXXX	Physical and Analytical Chemistry Laboratory	0-0-2	1
				EXCXXX (NGC)	Extra Co-curricular	2-0-0	2
Total Credits			**21**	**Total Credits**			**23**

Second Year

SEMESTER -III				SEMESTER –IV			
Course Code	**Course**	**L-T-P**	**C**	**Course Code**	**Course**	**L-T-P**	**C**
LFSXXX	Critical thinking	2-0-0	2	LFSXXX	Intra and Interpersonal skills	2-0-0	2
ENGXXX	Technical Report Writing Laboratory	0-0-2	1	FLPXXX	Foreign Language	2-0-0	2
CSEXXX	Programming in Java	3-0-0	3	MATXXX	Ordinary Differential Equations	3-1-0	4
CSEXXX	Programming in Java Laboratory	0-0-2	1	MATXXX	Complex Analysis	3-1-0	4
HUM1032	Ethics and Values	2-0-0	2	MATXXX	Introduction to Probability and Statistics	3-0-0	3
IMSXXX	Research Methodology	3-0-0	3	MATXXX	Introduction to Probability and Statistics Laboratory	0-0-2	1
MATXXX	Linear Algebra	3-1-0	4	MATXXX	Discipline Elective-I	3-0-0	3
MATXXX	Real Analysis	3-1-0	4	MATXXX	Discipline Elective-II	3-1-0	4
EXCXXX (NGC)	Extra Co-curricular	2-0-0	2	EXCXXX (NGC)	Extra Co-curricular	2-0-0	2
Total Credits			20	Total Credits			23

Third Year							
SEMESTER -V				**SEMESTER-VI**			
Course Code	**Course**	**L-T-P**	**C**	**Course Code**	**Course**	**L-T-P**	**C**
MATXXX	Numerical Analysis	3-0-0	3	MATXXX	Scientific computing Laboratory	0-0-4	2
MATXXX	Numerical Analysis Laboratory	0-0-2	1	MATXXXX	Discrete Mathematical Structures	3-1-0	4
MATXXX	Basic Abstract Algebra	3-1-0	4	MATXXX	Topology	3-1-0	4
MATXXX	Discipline Elective-III	3-0-0	3	MATXXX	Operations Research	3-1-0	4
MATXXX	Discipline Elective-IV	3-0-0	3	MATXXX	Discipline Elective-VII	3-0-0	3
MATXXX	Discipline Elective-V	3-1-0	4	MATXXX	Discipline Elective-VIII	3-1-0	4
MATXXX	Discipline Elective-VI (Theory/Project-I)	3-0-0	3	MATXXX	Discipline Elective-IX (Project-II)	3-0-0	3
EXCXXX (NGC)	Extra Co-curricular	2-0-0	2	EXCXXX (NGC)	Extra Co-curricular	2-0-0	2
Total Credits			21	Total Credits			24
B.Sc Mathematics Exit with 132 credits							
Fourth Year							
SEMESTER-VII				**SEMESTER-VIII**			
Course Code	**Course**	**L-T-P**	**C**	**Course Code**	**Course**	**L-T-P**	**C**
MATXXX	Data analysis Laboratory	0-0-4	2	MGTXXX	Principles of Management	3-0-0	3
MATXXX	Calculus of Variations and Integral Equations	3-1-0	4	MATXXX	Project-III	0-0-0	3
MATXXX	Graph Theory	3-1-0	4	MATXXX	Transform Techniques	3-1-0	4
MATXXX	Functional Analysis	3-1-0	4	MATXXX	Measure and Integration	3-1-0	4
MATXXX	Partial Differential Equations	3-1-0	4	MATXXX	Statistical Inference	3-0-0	3
MATXXX	Open Elective-I	3-0-0	3	MATXXX	Statistical Inference Laboratory	0-0-2	1
MATXXX	Open Elective-II	3-0-0	3	MATXXX	Open Elective-III	3-0-0	3
MATXXX	Discipline Elective-X	3-0-0	3	MATXXX	Discipline Elective-XI	3-0-0	3
				MATXXX	Discipline Elective-XII	3-0-0	3
Total Credits			27	Total Credits			27
B.Sc Honours Exit with 167 credits (132+27+8) 8th sem project							
Fifth Year							
SEMESTER-IX				**SEMESTER -X**			
Course Code	**Course**	**L-T-P**	**C**	**Course Code**	**Course**	**L-T-P**	**C**
MATXXX	Capstone Project Stage-I	0-0-0	6	MATXXX	Capstone Project Stage-II	0-0-0	14
MATXXX	Discipline Elective-XIII	3-0-0	3				
MATXXX	Discipline Elective-XIV	3-0-0	3				
Total Credits			12	Total Credits			14
M.Sc Mathematics Exit with 212							

MATXXX Calculus and Analytical Geometry

3 Credits (3-0-0)

Successive differentiation, Taylor's and Maclaurin's expansions, Tangent and Normal, Curvature, Evolutes and envelopes, Limit and continuity, Partial Differentiation, Maxima and minima, Definite integral, Length of a plane curve, Areas, Volumes, Improper integral, Double and triple integrals, Direction cosines, Equation of plane, Sphere, Vector Differentiation, Vector Integration

MATXXX Calculus and Analytical Geometry Laboratory

1 Credit (0-0-2)

Introduction to MATLAB, Plotting of 2D curves, limits and derivatives, Applications of differentiation, Maxima and Minima, Taylor's and Maclaurin's series, Area and volume, Double Integrals, Triple Integrals, Equation of line and angle between two planes, Divergence, Curl and Gradient and visualization of vector fields

MATXXX Ordinary and Partial Differential Equations

4 Credits (3-1-0)

Differential equation of first order, Linear equations, Homogeneous linear equations with constant coefficients, Nonhomogenous equation, Power Series method, Method of Frobenius, Construction of Partial Differential equations, Nonlinear Equation, Homogeneous linear equation with constant co-efficient, Nonhomogenous linear equations of any order, Non-linear equations of second order, Laplace Transform, Application to the solution of Differential Equations, Fourier Series, Complex Fourier Series, Fourier Transform

Course code	Course title	L	T	P	C
xxxx	Calculus and analytical geometry	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1. 0			

Course Objectives

1. To reinforces calculus to give a better understanding of the mathematical concepts underlying them and to prepare students for more advanced mathematics.
2. To Learn to analyze and solve problems relating analytical geometry and vector calculus
3. To consider problems that could be solved by applying appropriate theories, principles and concepts relevant to functions, continuity, derivatives, analytic geometry and vectors.

Course Outcome

At the end of this course the students should be able to

1. To Apply single variable differentiation and integration to solve applied problems in engineering and find the maxima and minima of functions
2. Evaluate partial derivatives, limits, total differentials, Jacobians, Taylor series and optimization problems involving several variables with or without constraints
3. Apply integrals to find area and volume and to find masses, moments, force, work and energy
4. Study the equations of lines, planes and spheres and the role of direction cosines and direction ratio
5. Evaluate the line, surface and volume integral of a scalar and vector fields and apply Green's, Gauss' and Stoke's theorems

Module:1	Differential calculus and its geometrical applications	7 hours

Review of continuity and differentiability, Successive differentiation, Leibnitz's rule, Taylor's and Maclaurin's expansions, Indeterminate forms, Tangent and Normal, Curvature, Evolutes and envelopes

Module:2	Functions of several variables	6 hours

Limit and continuity, Partial Differentiation-Euler's Theorem, Chain rule, Total differentiation, Differentiation of implicit functions, Taylor's series expansion, Jacobians-Change of variables, Maxima and minima, Lagrange multiplier method

Module:3	Integral calculus	6 hours

Integration-Definite integral, Average value, Length of a plane curve, Areas, Volumes-washer method, disk method, Area of a surface of revolution, Fundamental theorem of Calculus and its consequences, Improper integral, Differentiation under Integral sign- Leibnitz rule

Module:4	Multiple integrals and their applications	5 hours

Double and triple integrals, Change of order of integration, Change of variables, Areas and volumes, Masses, moments, Force, Work and energy

Module:5	Analytical solid geometry	7 hours

Coordinate systems and their interrelation, Direction cosines and direction ratios, Projection on a straight line, Angle between straight lines, Equation of plane, Shortest distance between the skew-lines, length of perpendicular from a given point to a given plane, Bisectors of the angles between two planes, Orthogonal projection on a plane, Sphere.

Module:6	Vector differentiation	6 hours

Scalar, vector fields and level Surfaces, Differentiation-Gradient, Tangent plane and normal, Directional derivative, Divergence and curl

Module:7	Vector integration	6 hours

Vector Integration, Line integrals, Surface integrals, Green's theorem in plane, Stokes's theorem, volume integrals, Divergence theorem

Module:8	Contemporary issues	2 hours

Guest Lecture from industry and R&D organisations

	Total Lecture hours:		**45 hours**
Text Book(s)			
1.	George B. Thomas, Joel Hass, Christopher Heil, Maurice D. Weir, Thomas' Calculus, 2018, 14th edition, Pearson, India		
2.	Shanti Narayan, P. K. Mittal, Analytical Solid Geometry, 2007, 17th edition, S. Chand & Co., India		
Reference Books			
1.	Karl J. Smith, Monty J. Strauss, Magdalena D. Toda, Calculus, 2017, 7th edition, Kendall Hunt Publishing Company, USA		
2.	Saturnino L. Salas, Garret J. Etgen, Einar Hille, Calculus One and Several Variables, 2021, 10th edition, Wiley, India		
Mode of Evaluation: CAT , Written assignment , Quiz , FAT			
Recommended by Board of Studies	DD-MM-YYYY		
Approved by Academic Council	No. xx	Date	DD-MM-YYYY

Course code	Calculus and Analytical Geometry Laboratory	L	T	P	C
xxxx		0	0	2	1
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. To familiarize with the basic syntax, semantics and library functions of MATLAB which serves as a tool not only in calculus but also many courses in engineering and sciences
2. To visualize mathematical functions and its related properties.
3. To evaluate single and multiple integrals and understand it graphically.

Course Outcome

At the end of the course the student should be able to:

1. Demonstrate MATLAB code for challenging problems in engineering
2. Using plots/displays, interpret and illustrate elementary mathematical functions and procedures.

Indicative Experiments (Any 10 experiments to be performed)

1.	To plot and visualize curves and surfaces in MATLAB – Symbolic computations using MATLAB
2.	To evaluate limits and Derivatives of functions
3.	To investigate applications of differentiation and study maxima and minima of a function of single variable
4.	To analyze maxima and minima of a function of two variables
5.	To write Taylor's and Maclaurin's series up to finite terms
6.	To evaluate integrals and find area, volume of solid of revolution
7.	To calculate double and triple integrals
8.	To find equation of line and angle between two planes
9.	To study divergence, curl and gradient and visualize vector fields
10.	To evaluate line integral and work done
	Total Laboratory Hours: 30 hours

Text Book(s)

1.	Cesar Lopez, MATLAB Differential and Integral Calculus, 2014, 1st Edition, Apress
2.	Ronald L. Lipsman, Jonathan M. Rosenberg, Multivariable Calculus with MATLAB: With Applications to Geometry and Physics, 2018, 1st edition Springer

Mode of assessment: Continuous assessments, Oral, FAT

Recommended by Board of Studies	DD-MM-YYYY		
Approved by Academic Council	No. xx	Date	DD-MM-YYYY

Course code	Course title	L	T	P	C
xxxx	Ordinary and partial differential equations	3	1	0	4
Pre-requisite	Calculus and analytical Geometry	Syllabus version			
		1.0			

Course Objectives

1. To develop mathematical skills so that students can apply mathematical methods & principals in solving problems arising in real life.
2. To understand how real-life problems can give rise to differential equations
3. To solve the problems choosing the most suitable method.
4. To utilise Laplace and Fourier transform techniques to solve the differential equations

Course Outcomes

1. Recognize the order and degree of differential equations and solve first order differential equations by different methods.
2. Understand the role of complementary functions and particular integrals in finding solution and should be able to apply variation of parameters and method of undetermined coefficients in solving differential equations.
3. Apply Frobenius' method to obtain series solution of second order differential equations
4. Utilize the method of characteristics in handling partial differential equations of first order and should be able to solve partial differential equations of second and higher order.
5. Apply Laplace and Fourier Transform to solve differential equations.

Module:1	Differential equations of first order	7 hours + 3 hours

Differential equation of first order-exact and linear differential equations, First order equations of higher degree, Clairaut's form, singular solutions. Orthogonal trajectories, Applications in geometrical and mechanical problems

Module:2	Differential equations of higher order	6 hours + 2 hours

Linear equations, linearity, linear independence and Wronskian, Reduction of order, Homogeneous linear equations with constant coefficients, Nonhomogenous equation-Cauchy-Euler Equation, Solution by method of Undetermined Coefficients and Variation of Parameters

Module:3	Series solution	4 hours + 2 hours

Power Series representation of functions, Power Series method, Method of Frobenius, Series solution of Legendre and Bessel differential equations

Module:4	First order partial differential equations	8 hours + 2 hours

Formation of Partial Differential equations, Solution of first order PDE (Standard forms), Complete integral, General Solution, Singular Solution, Lagrange's Linear Equation, Nonlinear Equation-Charpit's method

Module:5	Higher order partial differential equations	6 hours + 2 hours

Homogeneous linear equation with constant co-efficient, Nonhomogenous linear equations of any order, Non-linear equations of second order-Monge's method

Module:6	Laplace transform	6 hours + 2 hours

Laplace Transform, Sufficient conditions for existence, Translation theorems, Operational properties, Periodic functions, Inverse Laplace Transform, Convolution, Application to the solution of Differential Equations, Heaviside Functions and Pulses, Impulses and Delta Function

Module:7	Fourier transform	6 hours + 2 hours

Fourier Series, Convergence, Fourier Sine and Cosine series, Complex Fourier Series, Fourier Transform and its properties, Fourier Cosine and Sine Transform, Parseval's theorem

Module:8	Contemporary Issues	2 hours

Guest Lecture from industry and R&D organisations

	Total Lecture hours:			**45 hours+ 15 hours tutorial**
Text Book(s)				
1.	G. F. Simmons, Differential Equations with Applications and Historical Notes, 2017, 3rd edition, CRC Press, USA			
2.	B. S. Grewal, Higher Engineering Mathematics, 2018, 44th edition, Khanna Publishers, India			
Reference Books				
1.	Shepley L. Ross, Differential Equations, 2007, 3rd edition, Wiley, India			
2.	Ian N. Sneddon, Elements of Partial differential equations, 2006, 1st edition, Dover, USA			
3.	Murray R. Spiegel, Schaum's outline of Theory and Problems of Laplace Transform, 1965, 1st edition, McGraw Hill, USA			
Mode of Evaluation: CAT , Written assignment , Quiz , FAT				
Recommended by Board of Studies		DD-MM-YYYY		
Approved by Academic Council		No. xx	Date	DD-MM-YYYY