The Kelkar Education Trust's
Vinayak Ganesh Vaze College of Arts, Science & Commerce
(Autonomous)
Mithaghar Road, Mulund East, Mumbai-400081, India
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Syllabus for B. Sc. Second Year Programme

Mathematics

Syllabus as per Choice Based Credit System (NEP-2020)

(June 2025 Onwards)

Board of Studies in Mathematics

V.G Vaze College of Arts, Science and Commerce (Autonomous)

Submitted by

Department of Mathematics
Vinayak Ganesh Vaze College of Arts, Science and Commerce (Autonomous)
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The Kelkar Education Trust's
Vinayak Ganesh Vaze College of Arts, Science & Commerce
(Autonomous)

❖ **Syllabus as per Choice Based Credit System (NEP 2020)**

Syllabus for Approval

Subject: Mathematics

Sr. No.	Heading	Particulars
1	Title of Programme	**Second Year B. Sc. Mathematics: Semester III and IV**
2	Eligibility for Admission	The First Year B.Sc. examination of this university with Mathematics as a Major or Minor subject or any other university recognized as equivalent thereto.
3	Passing marks	Minimum D Grade or equivalent minimum marks for passing at the Graduation level.
4	Ordinances/Regulations (if any)	---
5	No. of Years/Semesters	One year/Two semester
6	Level	U.G. Part-I : Level - 5.0
7	Pattern	Semester
8	Status	Revised
9	To be implemented from Academic year	2025-2026

Date: ……. **Signature:**

BOS Chairperson: …….

Second Year B. Sc. Program in Mathematics (Level 5.0)

Semester	Core Course & Credits		NSQF Course & Credits	
Sem - III	**MAJOR**	No. of Lectures	**VSC/SEC**	No. of Lectures
	Mandatory* Credits 08 (4 x 2)		**VSC Credits 2**	
	Course 1 Cr. 2: Multivariable Calculus I	2L	Course 1 Cr. 2: RDBMS & MYSQL	4L
	Course 2 Cr. 2: Laplace Transform	2L		
	Course 3 Cr. 2: Ordinary Differential Equations	2L		
	Course 4 Cr. 2: Practical (Practical Based on all Papers)	4L		
	MINOR Credits 4 (2+2)		**OJT/FP/CEP/CC/RP**	
	Course 1 Cr. 2: Ordinary Differential Equations	2L	**FP Credits 2**	
	Course 2 Cr. 2: Practical based on Ordinary Differential Equations	4L	Course 1 Cr. 2: Practical	4L
Sem - IV	**MAJOR**		**VSC/SEC**	No. of Lectures
	Mandatory* Credits 08 (4 x 2)		**VSC Credits 2**	
	Course 1 Cr. 2: Multivariable Calculus II	2L	Course 1 Cr. 2: Programming in C++	4L
	Course 2 Cr. 2: Fourier Transform	2L		
	Course 3 Cr. 2: Partial Differential Equation	2L		
	Course 4 Cr. 2: Practical (Practical Based on all Papers)	2L		
	MINOR Credits 2		**OJT/FP/CEP/CC/RP**	
	Course 1 Cr. 2: : Partial Differential Equation	2L	**CEP Credits 2**	
			Course 1 Cr. 2: Practical	4L
Total Cumulative credits = 16 + **06 + 04 + 04 = 30 Credits**				
Exit option: *Award of UG Diploma in Major and Minor with 80-88 credits OR continue with Major & Minor*				

B. Sc. Program in Mathematics: Cumulative Credit Structure

Level	Sem.	MAJOR Mandatory*	MINOR	VSC	FP/CEP	Cum. Credits	Degree
5.0	**Sem-III**	For Mathematics **Credits 08 (2+2+2+2)** Course 1 Cr. 2: Multivariable Calculus I Course 2 Cr. 2: Laplace Transform Course 3 Cr. 2: Ordinary Differential Equations Course 4 Cr. 2: Practical (based on all papers)	**Credits 4 (2+2)** Course 1: Cr. 2: Ordinary Differential Equations & Course 2: Cr. 2: Practical based on Ordinary Differential Equations	**Credits 2** (RDBMS & MYSQL) Practical	**Credits 2** FP Practical	**16**	**UG Diploma**
	Sem-IV	For Mathematics					
		Credits 10 (2+2+2+2) Course 1 Cr.2: Multivariable Calculus II Course 2 Cr.2: Fourier Transform Course 3 Cr.2: Partial Differential Equations Course 4 Cr. 2: Practical (based on all papers)	**Credits 2** Course 1: Cr. 2: Partial Differential Equations	**Credits 2** (Programming in C++) Practical	**Credits 2** CEP Practical	**14**	
Total Credits		**16**	**06**	**04**	**04**	**30**	

Programme Educational Objectives

PEO1	Mathematical Foundation – Develop strong problem-solving and analytical skills in core mathematical concepts.
PEO2	Real-World Application – Apply mathematical methods in science, engineering, and other fields.
PEO3	Critical Thinking – Enhance logical reasoning and problem-solving abilities.
PEO4	Technology Integration – Utilize modern mathematical software and computational tools.
PEO5	Communication & Teamwork – Effectively communicate mathematical ideas and collaborate in teams.
PEO6	Lifelong Learning – Engage in continuous learning and research in mathematics.
PEO7	Ethical Responsibility – Apply mathematics responsibly in professional and societal contexts.

Programme Outcomes

Upon successful completion of the B.Sc. (Mathematics) course from Vaze College affiliated to Mumbai University, graduates can expect the following outcomes:

PO1	Mathematical Knowledge – Demonstrate a strong understanding of fundamental mathematical concepts and theories.
PO2	Problem-Solving Skills – Apply mathematical techniques to solve real-world problems efficiently.
PO3	Logical and Analytical Thinking – Develop critical thinking, reasoning, and analytical abilities.
PO4	Computational Proficiency – Use mathematical software, programming, and computational tools effectively.
PO5	Data Analysis and Modeling – Interpret and analyze data using mathematical and statistical methods.
PO6	Effective Communication – Convey mathematical ideas clearly through written and verbal communication.
PO7	Interdisciplinary Approach – Apply mathematical knowledge across various fields like physics, economics, and computer science.

Programme Specific Outcomes

PSO1	**Core Mathematical Proficiency** – Demonstrate expertise in algebra, calculus, differential equations, and other fundamental areas of mathematics.
PSO2	Computational and Analytical Skills – Apply mathematical and computational techniques to solve theoretical and practical problems.
PSO3	Mathematical Modeling – Develop and analyze mathematical models for real-world applications in science, engineering, and economics.
PSO4	**Data Interpretation and Statistics** – Use statistical and probabilistic methods to analyze and interpret data effectively.
PSO5	Software and Programming Proficiency – Utilize mathematical software (such as MATLAB, Maxima, or Python) for problem-solving and research.
PSO6	**Research and Higher Studies Readiness** – Build a strong foundation for advanced studies and research in mathematics and related fields.

The Detailed Semester and Course Wise Syllabus as follows:

The total minimum credits required for completing the B.Sc. in Mathematics is **120-132**

SEMESTER - III					
Code	**Course of Study - Major**	**L**	**T**	**P**	**Cr.**
VSMA200	Course 1 Cr. 2: Multivariable Calculus I	2	-	-	2
VSMA201	Course 2 Cr. 2: Laplace Transform	2	-	-	2
VSMA202	Course 3 Cr. 2: Ordinary Differential Equations	2	-	-	2
VSMA203	Course 4 Cr. 2: Practical Based on Course 1 to 3	-	-	2	2
	VSC **Credits 2**		-		
VSMA204	Course 1 Cr. 2: R DBMS & MYSQL	-	-	2	2
	MINOR **Credits 4 (2+2)**		-		
VSMA205	Course 1 Cr. 2: Ordinary Differential Equations	2	-	-	2
VSMA206	Course 2 Cr. 2: Practical based on Ordinary Differential Equations	-	-	2	2
	FP **Credits 2**		-		
VSMA207	Course 1 Cr. 2: Practical	-	-	2	2
Total		08	-	08	**16**

***** **Note:** Students are allowed to select one elective out of two electives given in curriculum

SEMESTER – IV					
Code	**Course of Study – Major**	**L**	**T**	**P**	**Cr.**
VSMA250	Course 1 Cr. 2: Multivariable Calculus II	2	-	-	2
VSMA251	Course 2 Cr. 2: Fourier Transform	2	-	-	2
VSMA252	Course 3 Cr. 2: Partial Differential Equations	2	-	-	2
VSMA253	Course 4 Cr. 2: Practical Based on Course 1 to 3	-	-	2	2
	VSC **Credits 2**		-		
VSMA254	Course 1 Cr. 2: Programming in C++	-	-	2	2
	MINOR **Credits 2**		-		
VSMA255	Course 1 Cr. 2: Partial Differential Equations	2	-	-	2
VSMA256	**CEP** **Credits 4**		-		
	Course 1 Cr. 2: Practical	-	-	2	2
		08	-	06	**14**

***** **Note:** Students are allowed to select one elective out of two electives given in curriculum

Proposed Draft Syllabus for S. Y. B. Sc. Mathematics Semester III and IV

(Mathematics Specialization)

Choice Based Credit System (NEP 2020)

(To be implemented from the academic year, 2025-2026)

Semester – III

Paper I

Course Code: VSMA200

Credits: 2

MULTIVARIABLE CALCULUS -I

Course Learning Objectives

Upon completion of the course the student will be able to understand

1.	To understand the Euclidean Space $\mathbb{R}^n$and how it is different from $\mathbb{R}$.
2.	To differentiate between the scalar and vector fields and To learn the concept of sequence, continuity and differentiability.
3.	To understand the application of Differentiation of vector fields.

Course Outcome

Upon completing the course, the student will be able to understand

CO1	Learn conceptual variations while advancing from one variable to several variables in calculus & Understand the notion of Limits, continuity in $\mathbb{R}^n$
CO2	Find Differentiability of Scalar Field and Apply Chain rule for derivatives, Euler's Theorem.
CO3	Find Differentiability of Vector fields & Understand the Hessian matrix, Maxima, minima and saddle points.

COURSE CONTENT

Unit	Contents	No. of lectures
Unit I	**Riemann Integration** Approximation of area, upper and lower Riemann sums and their properties, upper and lower integrals, definition of Riemann integral on a closed and bounded interval, Riemann criterion for integrability, and its properties.	**10**
Unit II	**Definite & Indefinite Integrals and their Applications** Continuity of $F(x)=\int_a^x f(t)dt$ where $f \in R[a,b]$ Fundamental theorem of calculus, Mean value theorem, Integration by parts, Leibnitz rule, Improper integrals-type I and type II, Absolute convergence of improper integrals, Comparison tests, Abel's and Dirichlet's tests.	**10**
Unit III	**Improper Integrals and Beta & Gamma Functions** β and Γ functions and their properties, relationship between β and Γ functions (without proof). Applications of definite Integrals: Area between curves, finding volumes by slicing, volumes of solids of revolution-Disks and Washers, Cylindrical Shells, Lengths of plane curves, Areas of surfaces of revolution.	**10**

List of suggested Practicals:

1) Riemann Sums
2) Riemann Integrability
3) Fundamental Theorem of Calculus
4) Improper Integrals (Type I)
5) Volume of Solids (Disk Method)
6) Beta and Gamma Functions
7) miscellaneous

Reference Books:

1. Calculus. Vol.2, T. Apostal, John Wiley
2. Calculus.J.Stewart, Brooke/cole Publishing Co.
3. Multivariable Calculus, Vipul Publication
4. Calculus of several variable by Serge Lang.

Paper II
Course Code: VSMA201
Credits: 2

LAPLACE TRANSFORMS

Course Learning Objectives

Upon completion of the course the student will be able to understand

1.	The basic need of this course is to understand the concepts and applications of Laplace transforms.
2.	The concepts and methods are useful for solving Differential Equations.

Course Outcome

Upon completing the course, the student will be able to understand

CO1	Know about piecewise continuous functions, Dirac delta function, Laplace transform and its properties and Know about Unit step, Periodic, Error, Gamma and Null functions.
CO2	Understand Laplace and Inverse Laplace transforms, Know the basic properties of Laplace and inverse Laplace transforms and Calculate the Laplace transform of basic functions using the definition.
CO3	Find the Laplace transform of derivatives of functions, Compute inverse Laplace transforms and Solve ordinary differential equations using Laplace transforms.

COURSE CONTENT

Unit	Contents	No. of lectures
Unit I	**Laplace Transform and Their Basic Properties** Basic concept & Definition of Integral Transform, Definition of the Laplace transform, Kernel of Laplace Transform, Definition of Sectional or piecewise continuity& Functions of exponential order, Sufficient conditions for existence of Laplace transform, Laplace transforms of elementary functions. Some important properties of Laplace transforms: Linearity property, first translation or shifting property, second translation or shifting property, change of scale property, Laplace transform of derivatives, Laplace transform of integrals, Multiplication by t, Division by t	**10**
Unit II	**Inverse Laplace Transform** Definition of inverse Laplace transform, Uniqueness of inverse Laplace transform. Inverse Laplace transform of some functions. Some important properties of inverse Laplace transforms. Linearity property, first translation or shifting property, second translation or shifting property, change of scale property, Inverse Laplace transform of derivatives, Inverse Laplace transform of integrals, Multiplication by s^n, Division by s. Convolution Theorem, Partial	**10**

	fraction Method.	
Unit III	**Applications to Differential Equations** Applications of Laplace transform to solve ordinary differential equations (ODEs) and partial differential equations (PDEs)	**10**

List of Practicals:

1) Laplace Transform of Elementary Functions
2) Properties of Laplace Transform
3) Inverse Laplace Transform and Its Properties
4) Solving ODEs Using Laplace Transforms
5) Inverse Laplace Transform Using Partial Fractions
6) Convolution Theorem and Its Application
7) Miscellaneous

Reference Books:

1. Murray R. Spiegel, Schaum's Outline Series, Theory and Problems of Laplace Transforms, Mc Graw Hill Ltd, New York, 1965.
2. Lokenath Debnath and Dambaru Bhatta, Integral Transforms and Their Applications, Second Edition, C. R. C. Press, London, 2007.
3. Phil Dyke, An Introduction to Laplace Transforms and Fourier Series, Second Edition, Springer-Verlag London, 2014.
4. Joel L. Schiff, The Laplace Transform: Theory and Applications (Undergraduate Texts in Mathematics), Springer.
5. E. Kreyszig, "Advanced Engineering Mathematics", 10th Edition, John & Wiley Sons, U.K., 2016

Paper III
Course Code: VSMA202
Credits: 2

ORDINARY DIFFERENTIAL EQUATIONS

Course Learning Objectives

Upon completion of the course the student will be able to understand

1.	The main objectives of this course are to introduce the students to the exciting world of differential equations.
2.	System of differential equations and their applications.

Course Outcome

Upon completing the course, the student will be able to understand

CO1	Understand the genesis of ordinary differential equations.
CO2	Learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
CO3	Grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.

COURSE CONTENT

Unit	Contents	No. of lectures
Unit I	**First Order First Degree Differential Equations** Definitions of: Differential Equation, Order and Degree of a differential Equation, Ordinary Differential Equation (ODE), Linear ODE, non- linear ODE. Existence and uniqueness Theorem for the solution of a second order initial value problem (statement only). Definition of Lipchitz function. Examples based on verifying the conditions of existence and uniqueness theorem. Review of solution of homogeneous and non-homogeneous linear differential equations of first order and first degree. Exact Equations: General Solution of Exact equations of first order and first degree, Necessary and sufficient condition for $Mdx + Ndy = 0$ to be exact. Non-exact equations: Rules for finding integrating factors (without proof) for non-exact equations such as: i) $\frac{1}{Mx+Ny}$ is an $I.F.$ if $Mx + Ny \neq 0 and Mx + Ny = 0$ is homogeneous. ii) $\frac{1}{Mx-Ny}$ is an $I.F.$ if $Mx - Ny \neq 0 and Mx + Ny = 0$ is of the form $f_1(x,y)ydx + f_2(x,y)xdy = 0$. iii) $e^{\int f(x)dx}$ $(resp\ e^{\int f(y)dy})$ is an $I.F.$ if $N \neq 0 (resp\ M \neq 0$ and $\frac{1}{N}(\frac{\partial M}{\partial y} - \frac{\partial N}{\partial x})$ $(resp \frac{1}{M}(\frac{\partial M}{\partial y} - \frac{\partial N}{\partial x}))$ is a function of x $(resp\ y)$ alone, say	**10**

	$f(x)(resp\ g(y))$. Linear and reducible linear equations of first order. Finding solutions of first order differential equations, applications to orthogonal trajectories, population growth, and finding the current at a given time	
Unit II	**Second Order Linear Differential Equations** Homogeneous and non-homogeneous second order linear differentiable equations: The space of solutions of the homogeneous equation as a vector space. Wronskian and linear independence of the solutions. The general solution of homogeneous differential equations. The general solution of a non homogeneous second order equation. Complementary functions and particular integrals. The homogeneous equation with constant coefficients, auxiliary equation. The general solution corresponding to real and distinct roots, real and equal roots and complex roots of the auxiliary equation. Non-homogeneous equations: The method of undetermined coefficients. The method of variation of parameter	**10**
Unit III	**Linear Differential Equations with constant coefficients** Complementary function and particular integral. General solution of $f(D)y = X$. Solution of $f(D)y = 0$, for non-repeated, repeated, real and complex roots of $f(D)y = X$ where X is of the form e^{ax}, $sinax, cosax, x^m, e^{ax}V, xV$.	**10**

List of suggested Practicals:

1. Solving First Order Exact Differential Equations.
2. Solving First Order Non-Exact Differential Equations and Finding Integrating Factors.
3. Applications of First Order Differential Equations: Orthogonal Trajectories and Population Growth.
4. Solving Second Order Linear Homogeneous Differential Equations with Constant Coefficients.
5. Solving Non-Homogeneous Second Order Differential Equations: Method of Undetermined Coefficients and Variation of Parameters.
6. Solving Linear Differential Equations with Constant Coefficients for Non-Repeated, Repeated, Real, and Complex Roots.
7. Miscellaneous.

Reference Books:

1. William F Trench, Elementary Differential Equations with Boundary Value Problems, E book (Free download)
2. Frank Ayres JR, Theory and Problems on Differential Equations, Schaum's outline Series, SI (metric) edition.
3. M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand Pub. Ltd 2009.
4. Elementary Differential Equations seventh edition by Earl D. Rainville and Philip E Bedient.
5. George F. Simmons and Stevan G. Krantz, Differential Equations, Tata McGraw-Hill.
6. W. R. Derrick and S. I. Grossman, A First Course in Differential Equations with Applications CBS Publishers and Distributors, Delhi 110032, Third Edition.

Semester – III
Paper : VSC
Course Code: VSMA204
Credits: 2
(RDBMS & MYSQL)

Course Learning Objectives

Upon completion of the course the student will be able to understand

1.	Provide for mass storage of relevant data and Allow multiple users to be active at one time.
2.	Provide data integrity and Protect the data from physical harm and unauthorized access.
3.	Provide security with a user access privilege.

COURSE OUTCOME

Upon completing the course the student will be able to

CO1	Describe the fundamental elements of relational database management systems.
CO2	Explain the basic concepts of relational data model, entity-relationship model, relational database design, relational algebra and SQL AND Design ER-models to represent simple database application scenarios.
CO3	Convert the ER-model to relational tables, populate relational database and formulate SQL queries on data.

COURSE CONTENT

Unit	**Contents**	No. of lectures
Unit-1	**Relational Data Base Management System**	**10**
	Introduction to Data base Concepts: Database, Overview of data base management system. Data base Languages- Data Definition Languages (DDL) and Data Manipulation Languages (DML).Entity Relation Model: Entity, attributes, keys, relations, Designing ER diagram, integrity Constraints over relations, conversion of ER to relations with and without constrains	
Unit-2	**MySQL Basics**	**10**
	Statements (Schema Statements, Data statements, Transaction statements), names (table & column names), data types (Char, Varchar, Text, Medium text, Long text, Smallint, Bigint, Boolean, Decimal, Float, Double, Date, Date Time, Timestamp, Year, Time), Creating Database, inserting data, Updating data, Deleting data, expressions, built-in-functions – lower, upper, reverse length, ltrim, rtrim, trim, left, right, mid, concat, now, time, date, curdate, day, month, year, dayname, monthname, abs, pow, mod, round, sqrt missing data(NULL and NOT NULL DEFAULT values)	

	CREATE,USE, ALTER (Add, Remove, Change columns), RENAME, SHOW, DESCRIBE (CREATE TABLE, COLUMNS, STATUS and DATABASES only) and DROP (TABLE, COLUMN, DATABASES statements), PRIMARY KEY FOREIGN KEY (One and more columns) Simple Validity checking using CONSTRAINTS	
Unit-3	**MySQL Queries**	**10**
	MySQL Simple queries: The SELECT statement (From, Where, Group By, Having, Order By, Distinct, Filtering Data by using conditions. Simple and complex conditions using logical, arithmetic and relational operators (=,!, =, <, >, <>, AND, OR, NOT, LIKE) Aggregate Functions: count, sum, avg, max, min. Multi-table queries: Simple joins (INNER JOIN), SQL considerations for multi table queries (table aliases, qualified column names, all column selections self joins). Nested Queries : Using sub queries, sub query search conditions, sub queries & joins, nested sub queries, correlated sub queries, sub queries in the HAVING clause. Simple Transaction illustrating START, COMMIT, and ROLLBACK.	

List of Practicals:

1. Introduction to MySQL, Database creation, Table creation.
2. Data insertion, update/modification/Delete and retrieval through MySQL.
3. Basic SQL structure. Query implementation 2 Enforcing integrity constraints (Domain, Key constraints (Primary/Foreign keys), not null, unique, default, Check) .
4. Creating and updating View. Query implementation using View.
5. Use of string functions (Lower, Upper, Proper, mid, len, substring, etc.)
6. Use of aggregate functions (AVG, COUNT, MIN, MAX, SUM)
7. Use of Date and Time function
8. Use of Join operator (Natural join, Outer join (left, right and full)
9. Query optimization through Nested Query (Use of logical connectives, set comparison operators, Union, Intersect, Except, Exists clauses)
10. Use of Group By and Having clause.

Reference Books:

1. Elsmasri and Navathe, “Fundamentals of Database Systems” Pearson Education.
2. MySQL: The Complete Reference by VASWANI, McGraw Hill.
3. Martin Gruber, “Understanding MYSQL”, B.P.B. Publications.
4. Data base management system, Ramakrishnan, Gehrke, McGraw-Hill.

Semester – III
Paper: MINOR
Course Code: VSMA205
Credits: 4

ORDINARY DIFFERENTIAL EQUATION

Course Learning Objectives

Upon completion of the course the student will be able to understand

1.	The main objectives of this course are to introduce the students to the exciting world of differential equations.
2.	System of differential equations and their applications.

Course Outcome

Upon completing the course, the student will be able to understand

CO1	Understand the genesis of ordinary differential equations.
CO2	Learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
CO3	Grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.

COURSE CONTENT

Unit	**Contents**	No. of lectures
Unit I	**First Order First Degree Differential Equations** Definitions of: Differential Equation, Order and Degree of a differential Equation, Ordinary Differential Equation (ODE), Linear ODE, non- linear ODE. Existence and uniqueness Theorem for the solution of a second order initial value problem (statement only). Definition of Lipchitz function. Examples based on verifying the conditions of existence and uniqueness theorem. Review of solution of homogeneous and non-homogeneous linear differential equations of first order and first degree. Exact Equations: General Solution of Exact equations of first order and first degree, Necessary and sufficient condition for $Mdx + Ndy = 0$ to be exact. Non-exact equations: Rules for finding integrating factors (without proof) for non-exact equations such as: iv) $\frac{1}{Mx+Ny}$ is an $I.F.$ if $Mx + Ny \neq 0 and Mx + Ny = 0$ is homogeneous. v) $\frac{1}{Mx-Ny}$ is an $I.F.$ if $Mx - Ny \neq 0 and Mx + Ny = 0$ is of the form $f_1(x,y)ydx + f_2(x,y)xdy = 0$. vi) $e^{\int f(x)dx}$ $(resp\ e^{\int f(y)dy})$ is an $I.F.$ if $N \neq 0 (resp\ M \neq 0$ and $\frac{1}{N}\left(\frac{\partial M}{\partial y} - \frac{\partial N}{\partial x}\right)$ $\left(resp\ \frac{1}{M}\left(\frac{\partial M}{\partial y} - \frac{\partial N}{\partial x}\right)\right)$ is a function of x $(resp\ y)$ alone, say $f(x)(resp\ g(y))$.	**10**

	Linear and reducible linear equations of first order. Finding solutions of first order differential equations, applications to orthogonal trajectories, population growth, and finding the current at a given time	
Unit II	**Second Order Linear Differential Equations** Homogeneous and non-homogeneous second order linear differentiable equations: The space of solutions of the homogeneous equation as a vector space. Wronskian and linear independence of the solutions. The general solution of homogeneous differential equations. The general solution of a non homogeneous second order equation. Complementary functions and particular integrals. The homogeneous equation with constant coefficients, auxiliary equation. The general solution corresponding to real and distinct roots, real and equal roots and complex roots of the auxiliary equation. Non-homogeneous equations: The method of undetermined coefficients. The method of variation of parameter	**10**
Unit III	**Linear Differential Equations with constant coefficients** Complementary function and particular integral. General solution of $f(D)y = X$. Solution of $f(D)y = 0$, for non-repeated, repeated, real and complex roots of $f(D)y = X$ where X is of the form e^{ax}, $sinax$, $cosax$, x^m, $e^{ax}V$, xV.	**10**

List of suggested Practicals:

1) Solving First Order Exact Differential Equations.
2) Solving First Order Non-Exact Differential Equations and Finding Integrating Factors.
3) Applications of First Order Differential Equations: Orthogonal Trajectories and Population Growth.
4) Solving Second Order Linear Homogeneous Differential Equations with Constant Coefficients.
5) Solving Non-Homogeneous Second Order Differential Equations: Method of Undetermined Coefficients and Variation of Parameters.
6) Solving Linear Differential Equations with Constant Coefficients for Non-Repeated, Repeated, Real, and Complex Roots.
7) Miscellaneous.

Reference Books:

1) William F Trench, Elementary Differential Equations with Boundary Value Problems, E book (Free download)
2) Frank Ayres JR, Theory and Problems on Differential Equations, Schaum's outline Series, SI (metric) edition.
3) M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand Pub. Ltd 2009.
4) Elementary Differential Equations seventh edition by Earl D. Rainville and Philip E Bedient.
5) George F. Simmons and Stevan G. Krantz, Differential Equations, Tata McGraw-Hill.
6) W. R. Derrick and S. I. Grossman, A First Course in Differential Equations with Applications CBS Publishers and Distributors, Delhi 110032, Third Edition.

Semester – IV

Paper I

Course Code: VSMA250

Credits: 2

MULTIVARIABLE CALCULUS -II

Course Learning Objectives

Upon completion of the course the student will be able to understand

1.	Define Euclidean space $\mathbb{R}^2$ and $\mathbb{R}^3$, and the Euclidean norm, open balls, and open sets.
2.	Understand limits, continuity, and differentiability of scalar and vector fields in $\mathbb{R}^2$ and $\mathbb{R}^3$.
3.	Learn directional and partial derivatives, and the gradient of scalar field and Apply the second derivative test and Hessian matrix to classify critical points
4.	Apply the method of Lagrange multipliers to solve constrained optimization problems.

Course Outcome

Upon completing the course, the student will be able to understand

CO1	Learn conceptual variations while advancing from one variable to several variables in calculus and Understand the notion of Limits, continuity in $\mathbb{R}^n$.
CO2	Find Differentiability of Scalar Field and Apply Chain rule for derivatives, Euler's Theorem.
CO3	Find Differentiability of Vector fields and Understand the Hessian matrix, Maxima, minima and saddle points.

COURSE CONTENT

Unit	**Contents**	No. of lectures
Unit I	**Functions of several variable** Euclidean space $\mathbb{R}^n$, Euclidean norm function on $\mathbb{R}^n$, open ball and open sets in $\mathbb{R}^n$, sequences in $\mathbb{R}^n$, convergence of sequences and basic properties (These concepts should be specifically discussed for $\mathbb{R}^2$ and $\mathbb{R}^3$). Functions from $\mathbb{R}^n$ to $\mathbb{R}$ (scalar fields) and from $\mathbb{R}^n$ to $\mathbb{R}^m$ (vector fields), limits and continuity of scalar fields and vector fields, basic results on algebra of limits and continuity, nonexistence of limits, relation between continuity of vector field and its component functions. Directional Derivatives and Partial derivatives of scalar fields, gradient of a scalar field, mean value theorem for derivatives of scalar fields.	**10**

Unit II	**Differentiability of scalar fields** Differentiability of a scalar field at a point of $\mathbb{R}^n$ (in terms of linear transformation) and on open subsets of $\mathbb{R}^n$, the total derivative and its properties, uniqueness of total derivative of differentiable functions, differentiability of scalar field implies its continuity, necessary condition for differentiability, sufficient condition for differentiability. Chain rule for derivatives of scalar fields, homogeneous functions and Euler's theorem, sufficient condition for equality of mixed partial derivatives (without proof).	**10**
Unit III	**Differentiability of Vector fields and its Applications** Differentiability of vector fields, definition of differentiability of a vector field at a point, Jacobian matrix, differentiability of scalar field implies its continuity, chain rule for derivatives of vector fields (without proof). Mean value inequality. Hessian matrix, Maxima, minima and saddle points, Second derivative test for extrema of functions of two variables. Method of Lagrange Multipliers	**10**

List of suggested practicals:

1) Convergence of Sequences in $\mathbb{R}^2$ and $\mathbb{R}^3$
2) Directional and Partial Derivatives
3) Differentiability of Scalar Fields
4) Chain Rule for Scalar Field
5) Hessian Matrix and Extrema
6) Lagrange Multipliers
7) Miscellaneous

Reference Books:

1. Tom M. Apostol, Calculus Vol. 2, second edition, John Wiley, India.
2. Jerrold E. Marsden, Anthony J. Tromba, Alan Weinstein, Basic Multivariable Calculus, Indian edition, Springer-Verlag.
3. Jerrold E. Marsden, Anthony J. Tromba, Vector Calculus, fifth edition, W.H. Freeman and Co, New York.
4. S.C. Malik, Savita Arora, Mathematical Analysis, third edition, New Age International Publishers, India.
5. D. Somasundaram, A Second Course in Mathematical Analysis, Narosa Publishing House, India.
6. Dennis G. Zill, Warren S. Wright, Calculus Early Transcendentals, fourth edition, Jones and Bartlett Publishers.
7. Sudhir R. Ghorpade, Balmohan V. Limaye, A Course in Multivariable Calculus and Analysis, Springer.
8. Satish Shirali, Harkrishnan Lal Vasudeva, Multivariable Analysis, Springer.
9. William Trench, Introduction to Real Analysis, Free hyperlinked edition

Paper II
Course Code: VSMA251
Credits: 2

FOURIER TRANSFORM

Course Learning Objectives

Upon completion of the course the student will be able to understand

1.	To enable the students to study Fourier Transforms and some concepts of infinite Fourier Sine and Cosine transforms.
2.	Finite Fourier Sine and Cosine transforms and applications to solve some infinite and boundary value problems using finite and infinite transforms.

Course Outcome

Upon completing the course, the student will be able to understand

CO1	Calculate the Infinite Fourier transform, Fourier Sine and Cosine transform of elementary functions from the definition.
CO2	Demonstrate their understanding of the shifting theorems, Fourier integral theorems and Inverse Fourier sine and cosine transforms by applying them to appropriate examples.
CO3	Calculate the Finite Fourier cosine and sine transform and apply it in solving boundary value problems.

COURSE CONTENT

Unit	**Contents**	No. of lectures
Unit I	**Fourier Series** Fourier Series: Periodic functions. Fourier co-efficient. Fourier series of functions with period 2π and $2l$. Fourier series of even and odd functions. Half range cosine and sine series.	**10**
Unit II	**Fourier Transform** Fourier Transforms: Fourier integrals, Fourier sine and cosine integrals, Complex form of Fourier integral representation, Fourier transform, Fourier transform of derivatives and integrals, Fourier sine and cosine transforms and their properties, Convolution theorem..	**10**
Unit III	**Application of Fourier transforms** Application of Fourier transforms to solve ordinary differential equations (ODEs) and partial differential equations (PDEs).Boundary Value Problems.	**10**

List of Suggested Practicals

1) Fourier Coefficients Calculation
2) Fourier Series of Even/Odd Functions
3) Half-Range Sine and Cosine Series
4) Fourier Transform and Properties
5) Fourier Transforms for ODEs
6) Fourier Transforms for PDEs
7) Miscellaneous.

Reference Books:

1. "Fourier Transforms and Representation Theory" by David M. Roark
2. "Fourier Transforms: Mathematics and Applications" by Mohammed S. Saad
3. "Fourier Transform Methods for Digital Signal Processing" by Françoise A. Yao
4. "Fourier Transform with Fluctuation Threshold" by Tomasz O. Jelitsin
5. "Fourier Transform of Signals and Time-Series" by Wu Wanxiong

Paper III
Course Code: VSMA252
Credits: 2

PARTIAL DIFFERENTIAL EQUATION

Course Learning Objectives

Upon completion of the course the student will be able to understand

1.	The main objectives of this course are to introduce the students to the exciting world of differential equations.
2	System of differential equations and their applications

Course Outcome

Upon completing the course, the student will be able to understand

CO1	To understand the genesis of ordinary differential equations.
CO2	To learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
CO3	To grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.

COURSE CONTENT

Unit	**Contents**	No. of lectures
Unit I	**Introduction To Partial Differential Equations** Partial Differential Equation, Order & Degree of PDE, Surface and Normals, parametric equation of surface, Curves and tangents, Origin of first order partial differential equation. Classification of first order partial differential equation. Linear Equation, Semi-Linear Equation, Quasi Linear Equation, Non-Linear Equation, Formation of first order partial differential equation, By Elimination of arbitrary constants, By Elimination of arbitrary functions.	**10**
Unit II	**Linear & Non-Linear Partial Differential Equations of order one** Lagrange's method, working rule for solving $Pp + Qq = R$ By Lagrange's method, Four types of problems based on $Pp + Qq = R$ The Cauchy problem for first order Quasi Linear PDE Existence and Uniqueness of integral surface passing through a given curve. Surface orthogonal to Given System of surface. The linear PDE with n independent variables. Types of solutions (Complete Integral, General Integral, Singular Integral) Method of getting Singular Integral. Charpit's method.	**10**
Unit III	**Second order Partial Differential Equation** Introduction of second order PDE. Classification of second order PDE. Characteristic curves, Reduction to canonical forms, Introduction of Heat, Wave & Laplace's Equation.	**10**

List of suggested practicals:

1. Formation of First-Order Partial Differential Equations
2. Solving First-Order Linear and Non-Linear PDEs Using Lagrange's Method
3. Cauchy Problem for First-Order Quasi-Linear PDE
4. Existence and Uniqueness of Integral Surface
5. Surface Orthogonal to a Given System of Surfaces
6. Solving Second-Order Partial Differential Equations
7. Miscellaneous

Reference Books:

1. Ian Sneddon, Element of Partial Differential Equations, McGraw-Hill Book Company, McGraw-Hill Book Company.
2. J.N. Sharma, Kehar Singh, Partial Differential equations for Engineers and Scientists, second Edition, Narasa Publications
3. T. Amarnath, An Elementary Course in Partial Differential Equations, Narosa Publishing, House 2nd Edition, 2003 (Reprint, 2006).
4. K. Sankara Rao, Introduction to Partial Differential Equations, Third Edition, PHI.
5. M.D.Raisinghania, Ordinary and Partial Differential Equations, 20th Edition, S Chand

Semester -VI
Paper : SEC
Course Code: VSMA254
Credits: 2
(C++ PROGRAMMING)

Course Learning Objectives

Upon completion of the course the student will be able to understand

1.	To introduce students to the syntax and structure of the C++ programming language and to develop problem-solving skills through hands-on programming exercises.
2.	To familiarize students with the principles of object-oriented programming (OOP) in C++.
3.	To cultivate good programming practices and coding standards and To prepare students for more advanced programming courses.

COURSE OUTCOME

Upon completing the course the student will be able to

CO1	Identify importance of object-oriented programming and difference between structured.
CO2	oriented and object-oriented programming features and make use of objects and classes for developing programs.
CO3	use various object-oriented concepts to solve different problems.

COURSE CONTENT

Unit	**Contents**	No. of lectures
Unit-1	**Introduction to C++**	**10**
	Object Oriented Methodology: Introduction, Advantages and Disadvantages of Procedure Oriented Languages, Application of OOPS, Principles of OOPS: Objects, Classes, Data Abstraction and Data Encapsulation, Inheritance, Polymorphism, Dynamic Binding, Message Passing. Classes and Objects: Simple classes (Class specification, class members accessing), Defining member functions, passing object as an argument, Returning object from functions, friend classes, friend function. Constructors and Destructors: Introduction, Default Constructor, Parameterized Constructor and examples, Destructors.	
Unit-2	**Inheritance**	**10**
	Program development using Inheritance: Introduction, Advantages provided by inheritance, choosing the access specifier, Derived class declaration, derived class constructors, class hierarchies, multiple inheritance, multilevel inheritance, hybrid	

	inheritance. Polymorphism: Concept of function overloading, overloaded operators, overloading unary and binary operators.	
Unit-3	**Advanced Concepts and Application Development**	**10**
	Virtual Functions: Introduction and need, Pure Virtual Functions, this Pointer, abstract classes, virtual destructors. Exception Handling: Introduction, Exception Handling Mechanism, Concept of throw & catch with example. Working with Files: Introduction, File Operations, Various File Modes, File Pointer and their Manipulation.	

List of Practicals:

1. program for Adding two numbers
2. To Check if a number is even or odd
3. program to swap two numbers, printing Fibonacci series, factorial of given number
4. program to find the largest number among three numbers
5. Program to Find the sum of all the natural numbers from 1 to n
6. To check whether a number is prime or not.
7. Defining function to find the length of a string
8. Program to create an array of pointers. Invoke functions using array objects

Reference Books:

1. Object Oriented Programming with C++ by E Balaguruswamy Tata McGraw Hill India
2. Programming: Principles and Practice Using C++" by Bjarne Stroustrup.
3. C++ Primer" by Stanley B. Lippman, Josée Lajoie, and Barbara E. Moo
4. D. Parasons, Object Oriented Programming with C++, BPB Publication.

Semester – VI
Paper: MINOR
Course Code: VSMA255
Credits: 2

PARTIAL DIFFERENTIAL EQUATION

Course Learning Objectives

Upon completion of the course the student will be able to understand

1.	The main objectives of this course are to introduce the students to the exciting world of differential equations.
2	System of differential equations and their applications

Course Outcome

Upon completing the course, the student will be able to understand

CO1	To understand the genesis of ordinary differential equations.
CO2	To learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
CO3	To grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.

COURSE CONTENT

Unit	Contents	No. of lectures
Unit I	**Introduction To Partial Differential Equations** Partial Differential Equation, Order & Degree of PDE, Surface and Normals, parametric equation of surface, Curves and tangents, Origin of first order partial differential equation. Classification of first order partial differential equation. Linear Equation, Semi-Linear Equation, Quasi Linear Equation, Non-Linear Equation, Formation of first order partial differential equation, By Elimination of arbitrary constants, By Elimination of arbitrary functions.	**10**
Unit II	**Linear & Non-Linear Partial Differential Equations of order one** Lagrange's method, working rule for solving $Pp + Qq = R$ By Lagrange's method, Four types of problems based on $Pp + Qq = R$ The Cauchy problem for first order Quasi Linear PDE Existence and Uniqueness of integral surface passing through a given curve. Surface orthogonal to Given System of surface. The linear PDE with n independent variables. Types of solutions (Complete Integral, General Integral, Singular Integral) Method of getting Singular Integral. Charpit's method.	**10**
Unit III	**Second order Partial Differential Equation** Introduction of second order PDE. Classification of second order PDE. Characteristic curves, Reduction to canonical forms, Introduction of Heat, Wave & Laplace's Equation.	**10**

List of suggested practicals:

1) Formation of First-Order Partial Differential Equations
2) Solving First-Order Linear and Non-Linear PDEs Using Lagrange's Method
3) Cauchy Problem for First-Order Quasi-Linear PDE
4) Existence and Uniqueness of Integral Surface
5) Surface Orthogonal to a Given System of Surfaces
6) Solving Second-Order Partial Differential Equations
7) Miscellaneous

Reference Books:

1) Ian Sneddon, Element of Partial Differential Equations, McGraw-Hill Book Company, McGraw-Hill Book Company.
2) J.N. Sharma, Kehar Singh, Partial Differential equations for Engineers and Scientists, second Edition, Narasa Publications
3) T. Amarnath, An Elementary Course in Partial Differential Equations, Narosa Publishing, House 2nd Edition, 2003 (Reprint, 2006).
4) K. Sankara Rao, Introduction to Partial Differential Equations, Third Edition, PHI.
5) M.D.Raisinghania, Ordinary and Partial Differential Equations, 20th Edition, S Chand

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