Date :- 01/08/2024

NOTIFICATION

Sub :- CBCS Syllabi of B. Sc. in Mathematics (Sem. III & IV)

Ref. :- Decision of the Academic Council at its meeting held on 27/07/2024.

The Syllabi of B. Sc. in Mathematics (Third and Fourth Semesters) as per **NATIONAL EDUCATION POLICY – 2020 (2023 Pattern)** and approved by the Academic Council as referred above are hereby notified for implementation with effect from the academic year 2024-25.

Copy of the Syllabi Shall be downloaded from the College Website (www.kcesmjcollege.in)

Sd/-
Chairman,
Board of Studies

To :

1) The Head of the Dept., M. J. College, Jalgaon.
2) The office of the COE, M. J. College, Jalgaon.
3) The office of the Registrar, M. J. College, Jalgaon.

Khandesh College Education Society's

Moolji Jaitha College, Jalgaon

An "Autonomous College"

Affiliated to

Kavayitri Bahinabai Chaudhari

North Maharashtra University, Jalgaon-425001

STRUCTURE AND SYLLABUS

B.Sc. Honours/Honours with Research (S.Y.B.Sc. Mathematics)

Under Choice Based Credit System (CBCS)

and

as per NEP-2020 Guidelines

[w.e.f.AcademicYear:2024-25]

Preface

The Moolji Jaitha College (Autonomous) has adopted a department-specific model as per the guidelines of UGC, NEP-2020 and the Government of Maharashtra. The Board of Studies in Mathematics of the college has prepared the syllabus for the second-year graduate of Mathematics. The syllabus cultivates theoretical knowledge and applications of different fields of Mathematics. The contents of the syllabus have been prepared to accommodate the fundamental aspects of various disciplines of Mathematics and to build the foundation for various applied sectors of Mathematics. The program will be enlightened the students with the advanced knowledge of Mathematics, which will help to enhance student's employability.

The overall curriculum of three/four year covers pure mathematics, applied mathematics and computational mathematics with programming. The syllabus is structured to cater the knowledge and skills required in the research field, Industrial Sector and Entrepreneurship etc.. The detailed syllabus of each paper is appended with a list of suggested readings.

Programme Outcomes (PO) for B.Sc. Mathematics honours/ Honours with Research

Upon successful completion of the B.Sc. program, student will be able to:

PO No.	PO
1	Understand the basic concepts and fundamental principles related to various science branches
2	Aquaintthe skills in handling scientific instruments and performing in laboratory experiments
3	Relate various scientific phenomena and their relevancies in the day-to-day life.
4	Analyse experimental data critically and systematically to draw the objective conclusions.
5	Develop various skills such as communication, leadership, teamwork, social, research etc., which will help in expressing ideas and views clearly
6	Develop interdisciplinary approach for providing better solutions and sustainable developments.

Programme Specific Outcome (PSO) for B.Sc. Mathematics Honours/Honours with Research:

After completion of this course, students are expected to:

PSO No.	PSO
1	Demonstrate the concepts involved in Real analysis, Matrix Theory, Differential equations, Algebra, Number Theory and Applied Mathematics.
2	Gain proficiency in mathematical techniques of both pure and applied mathematics and will be able to apply necessary mathematical methods to a scientific problem.
3	Acquire significant knowledge on various aspects related to Linear algebra, Metric spaces, Lattice theory, Integral transforms, Optimization techniques and Partial Differential equations.
4	Learn to work independently as well as a team to formulate appropriate mathematical methods.
5	Develop the ability to understand and practice the morality and ethics related to scientific research.
6	Realize the scope of Mathematics and plan continue their education as a Post-Graduate student of Mathematics and contribute to Mathematics through their research as a doctoral student.

Multiple Entry and Multiple Exit options:

The multiple entry and exit options with the award of UG certificate/ UG diploma/ or three-year degree depending upon the number of credits secured;

Levels	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
4.5	UG Certificate	40	44	2	1
5.0	UG Diploma	80	88	4	2
5.5	Three Year Bachelor's Degree	120	132	6	3
6.0	Bachelor's Degree- Honours **Or** Bachelor's Degree- Honours with Research	160	176	8	4

Credit distribution structure for Three/ Four year Honors/ Honors with Research Degree Programme with Multiple Entry and Exit

F.Y. B.Sc.

Year (Level)	Sem	Major (Core). Subjects		Minor Subjects (MIN)	GE/ OE	VSC, SEC (VSEC)	AEC, VEC, IKS	CC, FP, CEP, OJT/Int, RP	Cumulative Credits/Sem	Degree/ Cumulative Cr.
		Mandatory (DSC)	Elective (DSE)							
1 (4.5)	I	DSC-1 (2T) DSC-2 (2T) DSC-3 (2P)	—	MIN-1 (2T) MIN-2 (2P)	OE-1 (2T)	SEC-1 (2T) SEC-2(1P)	AEC-1 (2T) (ENG) VEC-1 (2T) (ES) IKS (1T)	CC-1 (2)	22	UG Certificate
	II	DSC-4 (2T) DSC-5 (2T) DSC-6 (2P)	...	MIN-3 (2T) MIN-4 (2P)	OE-2 (2T)	SEC-3(2T) SEC-4(1P)	AEC-2 (2T) (ENG) VEC-2 (2T) (CI) IKS (1T)	CC-2 (2)	22	
	Cum. Cr.	12	...	8	4	6	10	4	44	
Exit option: Award of UG Certificate in Major with 44 credits and an additional 4 credits core NSQF course/ Internship OR Continue with Major and Minor.										

S.Y. B.Sc.

Year (Level)	Sem	Subject-I (M-1) Major*		Subject-II (M-2) Minor #	Subject-III (M-3)	Open Elective (OE)	VSC, SEC (VSEC)	AEC, VEC, IKS	CC, FP, CEP, OJT/Int/RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
		Mandatory (DSC)	Elective (DSE)	(MIN)							
2 (5.0)	III	DSC-7(2T) DSC-8(2T) DSC-9(2P) DSC-10(2P)	---	MIN-5(2T) MIN-6(2T) MIN-7(2P)	---	OE-3(2T)		AEC-3(2T) (MIL)	CC-3(2T) CEP(2)	22	UG Diploma
	IV	DSC-11(2T) DSC-12(2T) DSC-13(2P) DSC-14(2P)	---	MIN-8(2T) MIN-9(2P)	---	OE-4(2T) OE-5(2P)		AEC-4(2T) (MIL)	CC-4(2T) ۞ FP(2)	22	
	Cum . Cr.	12	---	10	---	4	6	4	8	44	
	Exit option: Award of UG Diploma in Major and Minor with 88 credits and an additional 4 credits core NSQF course/ Internship OR Continue with Major & Minor.										

***** Student must choose one subject as a Major subject out of M-1, M-2 and M-3 that he/she has chosen at First year

#Student must choose one subject as a Minor subject out of M-1, M-2 and M-3 that he/she has chosen at First year (Minor must be other than Major)

۞ OJT/Internship/CEP should be completed in the summer vacation after 4th semester

T.Y. B.Sc.

Year (Level)	Sem	Subject-I (M-1) Major		Subject-II (M-2) Minor	Subject-III (M-3)	Open Elective (OE)	VSC, SEC (VSEC)	AEC, VEC, IKS	CC, FP, CEP, OJT/Int/RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
		Mandatory (DSC)	**Elective (DSE)**	**(MIN)**							
3 (5.5)	V	DSC-15(2T) DSC-16(2T) DSC-17(2T) DSC-18(2P) DSC-19(2P)	DSE-1A/B (2T) DSE-2A/B (2P)	---	---	---	VSC-1(2T) VSC-2(2P)	---	OJT/Int (4)	22	UG Degree
	VI	DSC-20(2T) DSC-21(2T) DSC-22(2T) DSC-23(2T) DSC-24(2T) IKS DSC-25(2P) DSC-26(2P)	DSE-3A/B (2T) DSE-4A/B (2P)	---	---	---	VSC-3(2T) VSC-4(2P)	---	---	22	
	Cum . Cr.	**24**	**8**	**---**	**---**	**---**	**8**	**---**	**4**	**44**	
	Exit option: Award of UG Degree in Major with 132 credits OR Continue with Major and Minor										

Fourth Year B.Sc. (Honours)

Year (Level)	Sem	Major Core Subjects		Research Methodology (RM)	VSC, SEC (VSEC)	OE	AEC, VEC, IKS	CC, FP, CEP, OJT/Int/RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
IV (6.0)	VII	DSC-27(4T) DSC-28(4T) DSC-29(4T) DSC-30(2P)	DSE-5A/B (2T) DSE-6A/B (2P)	RM(4T)	---	---	---	---	22	UG Honours Degree
	VIII	DSC-31(4T) DSC-32(4T) DSC-33(4T) DSC-34(2P)	DSE-7A/B (2T) DSE-8A/B (2P)	---	---	---	---	OJT/Int (4)	22	
	Cum. Cr.	**28**	**8**	**4**	**---**	**---**	**---**	**4**	**44**	
Four Year UG Honors Degree in Major and Minor with 176 credits										

Fourth Year B.Sc. (Honours with Research)

Year (Level)	Sem	Major Core Subjects		Research Methodology (RM)	VSC, SEC (VSEC)	OE	AEC, VEC, IKS	CC, FP, CEP, OJT/Int/RP	Cumulative Credits/Sem	Degree/ Cumulative Credit
IV (6.0)	VII	DSC-27(4T) DSC-28(4T) DSC-30(2P)	DSE-5A/B (2T) DSE-6A/B (2P)	RM(4T)	---	---	---	RP(4)	22	UG Honours with Research Degree
	VIII	DSC-31(4T) DSC-32(4T) DSC-34(2P)	DSE-7A/B (2T) DSE-8A/B (2P)	---	---	---	---	RP(8)	22	
	Cum. Cr.	**20**	**8**	**4**	**---**	**---**	**---**	**12**	**44**	
Four Year UG Honours with Research Degree in Major and Minor with 176 credits										

Sem- Semester, **DSC**- Department Specific Course, **DSE**- Department Specific Elective, **OE/GE**- Open/Generic elective, **VSC**- Vocational Skill Course, **SEC**- Skill Enhancement Course, **VSEC**- Vocation and Skill Enhancement Course, **AEC**- Ability Enhancement Course, **IKS**- Indian Knowledge System, **VEC**- Value Education Course, **T**- Theory, **P**- Practical,**CC**-Co-curricular **RM**- Research Methodology, **OJT**- On Job Training, **FP**- Field Project, **Int**- Internship, **RP**- Research Project, **CEP**- Community Extension Programme, **ENG**- English, **CI**- Constitution of India, **MIL**- Modern Indian Laguage

- Number in bracket indicate credit
- The courses which do not have practical 'P' will be treated as theory 'T'
- If student select subject other than faculty in the subjects M-1, M-2 and M-3, then that subject will be treated as Minor subject, and cannot be selected as Major at second year.

Details of S.Y. B.Sc. (Mathematics)

Course	Course Type	Course Code	Course Title	Credits	Teaching Hours/ Week			Marks			
					T	P	Total	Internal		External	
								T	P	T	P
Semester III, Level – 5.0											
DSC-7	DSC	MTH-DSC-231	Calculus of Several Variables	2	2	---	2	20	---	30	---
DSC-8	DSC	MTH-DSC-232	Abstract Algebra	2	2	---	2	20	---	30	---
DSC-9	DSC	MTH-DSC-233	Practical Course on Calculus of Several Variables	2	---	4	4	---	20	---	30
DSC-10	DSC	MTH-DSC-234	Practical Course on Abstract Algebra	2	---	4	4	---	20	---	30
MIN-5	MIN	MTH-MIN-231	Calculus of One Variable	2	2	---	2	20	---	30	---
MIN-6	MIN	MTH-MIN-232	Computational Algebra	2	2	---	2	20	---	30	---
MIN-7	MIN	MTH-MIN-233	Practical Course on MTH-MIN-231 and MTH-MIN-232	2	---	4	4	---	20	---	30
OE-3	OE	MTH-OE-231	Theory of Sets	2	2	---	2	20	---	30	---
CEP	CEP	MTH-CEP-231	Community Engagement Program	2	---	4	4	50	---	---	---
Semester IV, Level – 5.0											
DSC-11	DSC	MTH-DSC-241	Complex Variables	2	2	---	2	20	---	30	---
DSC-12	DSC	MTH-DSC-242	Differential Equations	2	2	---	2	20	---	30	---
DSC-13	DSC	MTH-DSC-243	Practical Course on Complex Variables	2	---	4	4	---	20	---	30
DSC-14	DSC	MTH-DSC-244	Practical Course on Differential Equations	2	---	4	4	---	20	---	30
MIN-8	MIN	MTH-MIN-241	Ordinary Differential Equations	2	2	---	2	20	---	30	---
MIN-9	MIN	MTH-MIN-242	Practical Course on MTH-MIN-241	2	---	4	4	---	20	---	30
OE-4	OE	MTH-OE-241	Mathematical Logic	2	2	---	2	20	---	30	---
OE-5	OE	MTH-OE-242	Matrices and Determinants	2	---	4	4	---	20	---	30
FP	FP	MTH-FP-241	Field Project	2	---	4	4	50	---	---	---

Examination Pattern

Theory Question Paper Pattern:

- 30 (External) +20 (Internal) for 2 credits
    - External examination will be of 1½ hours duration
    - There shall be 3 questions: Q1 carrying 6 marks and Q2, Q3 carrying 12 marks each. The tentative pattern of question papers shall be as follows;
    - Q1 Attempt any 2 out of 3 sub-questions; each 3 marks
    - Q 2 and Q3 Attempt any 3 out of 4 sub-question; each 4 marks.

Rules of Continuous Internal Evaluation:

The Continuous Internal Evaluation for theory papers shall consist of two methods:

1. Continuous & Comprehensive Evaluation (CCE): CCE will carry a maximum of 30% weightage (30/15 marks) of the total marks for a course. Before the start of the academic session in each semester, the subject teacher should choose any three assessment methods from the following list, with each method carrying 10/5 marks:

i. Individual Assignments
ii. Seminars/Classroom Presentations/Quizzes
iii. Group Discussions/Class Discussion/Group Assignments
iv. Case studies/Case lets
v. Participatory & Industry-Integrated Learning/Field visits
vi. Practical activities/Problem Solving Exercises
vii. Participation in Seminars/Academic Events/Symposia, etc.

viii. Mini Projects/Capstone Projects
ix. Book review/Article review/Article preparation
x. Any other academic activity
xi. Each chosen CCE method shall be based on a particular unit of the syllabus, ensuring that three units of the syllabus are mapped to the CCEs.

2. Internal Assessment Tests (IAT): IAT will carry a maximum of 10% weightage (10/5 marks) of the total marks for a course. IAT shall be conducted at the end of the semester and will assess the remaining unit of the syllabus that was not covered by the CCEs. The subject teacher is at liberty to decide which units are to be assessed using CCEs and which unit is to be assessed on the basis of IAT.The overall weightage of Continuous Internal Evaluation (CCE + IAT) shall be 40% of the total marks for the course. The remaining 60% of the marks shall be allocated to the semester-end examinations.The subject teachers are required to communicate the chosen CCE methods and the corresponding syllabus units to the students at the beginning of the semester to ensure clarity and proper preparation.

Practical Examination Credit 2: Pattern (30+20)

External Practical Examination (30 marks):

- Practical examination shall be conducted by the respective department at the end of the semester.
- Practical examination will be of 3 hours duration and shall be conducted as per schedule.
- Practical examination shall be conducted for 2 consecutive days for 2 hr/ day where incubation conditionis required.
- There shall be 05 marks for journal and viva-voce. Certified journal is compulsory to appear for practical examination.
- External practical examination of SEC will be of 25 marks and there will be no internal exam for SEC practical.

Internal Practical Examination (20 marks):

- Internal practical examination of 10 marks will be conducted by department as per schedule given.
- For internal practical examination student must produce the laboratory journal of practicals completed along with the completion certificate signed by the concerned teacher and the Head of the department.
- There shall be continuous assessment of 30 marks based on student performance throughout the semester. This assessment can include quizzes, group discussions, presentations and other activities assigned by the faculty during regular practicals. For details refer internal theory examination guidelines.
- Finally 40 (10+30) marks performance of student will be converted into 20 marks.

SEMESTER-III

S.Y. B.Sc. Mathematics (Major)
Semester-III
MTH-DSC-231: Calculus of Several Variables

Total Hours: 30 **Credits: 2**

Course Objectives	• To know scope and importance of functions of two and more variables. • To study series expansions and extreme values. • To know integration techniques as well as applications of integrals.	
Course Outcomes	After successful completion of this course, students are expected to: • Understand limit and continuity of functions of several variables. • Explain fundamental concepts of multivariable calculus and series expansion of functions. • Explain extreme points of function and their maximum, minimum values at those points. • Understand meaning of definite integral as limit as sums. • Learn how to solve double and triple integration and use them to find area by double integration and volume by triple integration.	
Unit	**Content**	**Hours**
Unit I	**Functions of Two and Three Variables:** Explicit and implicit functions, Continuity, Partial derivatives, Differentiability, Necessary and sufficient conditions for differentiability, Partial derivatives of higher order, Schwarz's theorem, Young's theorem.	**7**
Unit II	**Composite Functions and Mean Value Theorems:** Composite functions (chain rule), Homogeneous functions, Euler's theorem on homogeneous functions, Mean value theorem for functions of two variables.	**8**
Unit III	**Taylor's Theorem and Extreme Values:** Taylor's theorem for functions of two variables, Maclaurin's theorem for functions of two variables, Absolute and relative maxima & minima, Necessary condition for extrema, Critical point, Saddle point, Sufficient condition for extrema.	**7**
Unit IV	**Double and Triple Integrals:** Double integrals by using Cartesian and polar coordinates, Change of order of integration, Area by double integral, Evaluation of triple integral as repeated integrals, Volume by triple integral.	**8**
Study Resources	• Malik S.C. and Arora Savita (1992).*Mathematical Analysis*. Wiley Eastern Ltd, New Delhi. (Ch.15 Art. 1, 2, 3, 4, 5, 7, 9, 10, 11, Ch.17 Art.2, 3, 7). • Rogers Robert C. (2011).*Calculus of Several Variables*. Schaum's Outline Series. • Apostol T. M.(1985).*Mathematical Analysis*. Narosa Publishing House, New Delhi.	

S.Y. B.Sc. Mathematics (Major)
Semester-III
MTH-DSC-232: Abstract Algebra

Total Hours: 30 **Credits: 2**

<table>
<tr><td>Course Objectives</td><td colspan="2">To know scope and importance of algebraic structures and their properties.
To study problems in many branches of Mathematics such as theory of equations, theory of numbers, Geometry etc.
To know properties of algebraic structures.</td></tr>
<tr><td>Course Outcomes</td><td colspan="2">After successful completion of this course, students are expected to:
Understand group and their types which is one of the building blocks of pure and applied mathematics.
Explain Lagrange’s, Euler’s and Fermat’s theorem.
Explain concepts of homomorphism, isomorphism and automorphism of groups.
Learn basic properties of permutations, even, odd permutation and permutation groups.</td></tr>
<tr><td>Unit</td><td>Content</td><td>Hours</td></tr>
<tr><td>Unit I</td><td>Groups:
Definition and examples of a group, Simple properties of group, Abelian group, Finite and infinite groups, Order of a group, Order of an element and its properties.</td><td>7</td></tr>
<tr><td>Unit II</td><td>Subgroups:
Definition and examples of subgroups, Simple properties of subgroup, Criteria for a subgroup, Cyclic groups, Coset decomposition, Lagrange’s theorem for finite group, Euler’s theorem and Fermat’s theorem.</td><td>8</td></tr>
<tr><td>Unit III</td><td>Homomorphism and Isomorphism of Groups:
Definition and examples of group homomorphism, Properties of group homomorphism, Kernel of a group homomorphism and it’s properties, Definition and examples of isomorphism and properties, Definition and examples of automorphism of groups.</td><td>7</td></tr>
<tr><td>Unit IV</td><td>Permutation Groups:
Definitions: Permutation, Cycle, Transposition, Permutations as a product of disjoint cycles and transpositions, Even and odd permutations, Permutation Groups, Alternating Groups.</td><td>8</td></tr>
<tr><td>Study Resources</td><td>Gopalakrishnan N. S.(2018). University Algebra. Wiley Eastern Limited, New Delhi. (Unit-I: 1.1-1.8, 1.11)
Herstein I. N. (1975). Topics in Algebra. John Wiley and Sons, New Delhi.
Fraleigh J. B.(2003). A first Course in Abstract Algebra. Pearson.
Khanna Vijay K and Bhambri S. K. (2003). A course in Abstract Algebra. Vikas Publishing House Pvt. Ltd., Noida.</td><td></td></tr>
</table>

S.Y. B.Sc. Mathematics (Major)
Semester-III
MTH-DSC-233: Practical Course on Calculus of Several Variables

Total Hours: 60 **Credits: 2**

Course objectives	• To know scope and importance of functions of two and more variables. • To study series expansions and extreme values. • To know integration techniques as well as applications of integrals.
Course outcomes	After successful completion of this course, students are expected to: • Understand limit and continuity of functions of several variables. • Explain fundamental concepts of multivariable Calculus and series expansion of functions. • Explain extreme points of function and their maximum, minimum values at those points. • Understand meaning of definite integral as limit as sums. • Learn how to solve double and triple integration and use them to find area by double integration and volume by triple integration.
Practical No.	**Title**
1	Functions of Two and Three Variables-I
2	Functions of Two and Three Variables-II
3	Composite Functions and Mean Value Theorems-I
4	Composite Functions and Mean Value Theorems-II
5	Taylor's Theorem and Extreme Values-I
6	Taylor's Theorem and Extreme Values-II
7	Double and Triple Integrals-I
8	Double and Triple Integrals-II

List of Practicals

Practical No.-1: Functions of Two and Three Variables-I

1) Evaluate: $\lim_{(x,y)\to(0,0)} \frac{xy^3}{x^2+y^6}$.

2) If $u = x^2y + y^2z+z^2x$, then show that $\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} + \frac{\partial u}{\partial z} = (x + y + z)^2$.

3) Let $(x,y) = \begin{cases} xy\frac{x^2-y^2}{x^2+y^2} & ,if\ (x,y) \neq (0,0) \\ 0 & ,if\ \ (x,y) = (0,0) \end{cases}$. Prove that $f_{xy}(0,0) \neq f_{yx}(0,0)$.

4) Show that the function $f(x,y) = \sqrt{|xy|}$ has first partial derivative at the origin but not differentiable there.

5) Using differentials, find the approximate value of $\sqrt{(1.02)^2 + (1.97)^3}$.

6) Evaluate: $\lim_{(x,y)\to(0,0)} \frac{x^2y^4}{(x^2+y^4)^2}$.

7) Examine the continuity of the function $f(x,y) = \begin{cases} \frac{xy}{\sqrt{x^2+y^2}} & ,if\ (x,y) \neq (0,0) \\ 0 & ,if\ \ (x,y) = (0,0) \end{cases}$.

8) If $u = x^2 \tan^{-1}\frac{y}{x} - y^2 \tan^{-1}\frac{x}{y}$, prove that $\frac{\partial^2 u}{\partial x \partial y} = \frac{x^2-y^2}{x^2+y^2}$.

9) If $(x, y) = \frac{x^2+y^2}{x+y}$, then prove that $\left(\frac{\partial u}{\partial x} - \frac{\partial u}{\partial y}\right)^2 = 4\left(1 - \frac{\partial u}{\partial x} - \frac{\partial u}{\partial y}\right)$.

10) Using differentials, find the approximate value of $(2.01)(3.02)^2$.

Practical No.-2: Functions of Two and Three Variables-II

1) Evaluate $\lim_{(x,y)\to(0,0)} \frac{xy}{x^2+y^2}$.
2) Evaluate $\lim_{(x,y)\to(0,0)} \frac{y+x}{y-x}$.
3) If $u = x^3 z + xy^2 - 2yz$find $\frac{\partial u}{\partial x}$,$\frac{\partial u}{\partial y}and\frac{\partial u}{\partial z}$.
4) If $u = e^{xy}$, then find $\frac{\partial^2 u}{\partial x \partial y}$.
5) Let $f(x, y) = \frac{x^2 y^2}{x^2+y^2}$,$x^2 + y^2 \neq 0$. Show that $f_{xy}(0,0) = f_{yx}(0,0)$.
6) Let $f(x, y) = \frac{x^2 y^2}{x^2+y^2}$,$x^2 + y^2 \neq 0$. Show that the function is not differential at (0,0).
7) Find the approximate value of the function $(3.9)^2(2.05) + (2.05)^3$.
8) Find the approximate value of the function $(3.98)^{202}$ take $log 2 = 0.6930$.
9) Examine the continuity of the following function at (0,0), where $f(x, y) = \begin{cases} \frac{x^2 y}{x^3+y^3} & if (x, y) \neq (0,0), \\ 0 & if (x, y) = (0,0). \end{cases}$
10) Examine the continuity of the following function at (0,0), where $f(x, y) = \begin{cases} \frac{x^2 y}{x^4+y^2} & if (x, y) \neq (0,0), \\ 0 & if (x, y) = (0,0). \end{cases}$

Practical No.-3: Composite Functions and Mean Value Theorems-I

1) Let $z = f(u, v)$, where $u = 2x - 3y$ and $v = x + 2y$. Prove that $\frac{\partial z}{\partial x} + \frac{\partial z}{\partial y} = 3\frac{\partial z}{\partial v} - \frac{\partial z}{\partial u}$.
2) If $u = f(x, y)$, where $x = r\cos\theta$ and $x = r\sin\theta$. Show that

$$\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial u}{\partial y}\right)^2 = \left(\frac{\partial u}{\partial r}\right)^2 + \frac{1}{r^2}\left(\frac{\partial u}{\partial \theta}\right)^2.$$

3) If $= \sin^{-1}\left[\frac{x^2+2xy}{\sqrt{x-y}}\right]^{\frac{1}{5}}$, then find the value of (1) $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y}$, (2) $x^2\frac{\partial^2 u}{\partial x^2} + 2xy\frac{\partial^2 u}{\partial x \partial y} + y^2\frac{\partial^2 u}{\partial y^2}$.
4) If $= \tan^{-1}\left[\frac{x^3+y^3}{x-y}\right]$, then find the value of (1) $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y}$, (2) $x^2\frac{\partial^2 u}{\partial x^2} + 2xy\frac{\partial^2 u}{\partial x \partial y} + y^2\frac{\partial^2 u}{\partial y^2}$.
5) If $f(x, y) = x^3 - xy^2$, then show that θ used in the mean value theorem applied to the points (2,1) and (4,1) satisfy the quadratic equation $3\theta^2 + 6\theta - 4 = 0$.
6) If $z = f(x, y) = \tan^{-1}\frac{x}{y}$, where $x = u + v$ and $y = u - v$, then show that $\frac{\partial z}{\partial u} + \frac{\partial z}{\partial v} = \frac{u-v}{u^2+v^2}$.
7) Find $\frac{dz}{dt}$ when $z = xy^2 + x^2 y$, $x = at^2$, $y = 2at^2$.
8) If $z = x^2 + y^2$ where $x = t^2 + 1$, $y = 2t$, then find $\frac{dz}{dt}$ at $t = 1$.
9) Verify Euler's theorem for the function $f(x, y) = x^3 + y^3 - 3x^2 y$.
10) If u $= \sin^{-1}\sqrt{x^2 + y^2}$, then prove that$x^2\frac{\partial^2 u}{\partial x^2} + 2xy\frac{\partial^2 u}{\partial x \partial y} + y^2\frac{\partial^2 u}{\partial y^2} = tan^3 u$.

Practical No.-4: Composite Functions and Mean Value Theorems-II

1) If $z = f(x, y)$, where $x = e^u + e^{-v}$ and $y = e^{-u} + e^v$, then show that $\frac{\partial z}{\partial u} - \frac{\partial z}{\partial v} = x\frac{\partial z}{\partial x} - y\frac{\partial z}{\partial y}$.
2) If $z = f(x, y) = tan^{-1}\frac{x}{y}$, where $x = u + v$ and $y = u - v$, then show that $\frac{\partial z}{\partial u} + \frac{\partial z}{\partial v} = \frac{u-v}{u^2+v^2}$.
3) If $z = f(y - z, z - x, x - y)$, then show that $\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} + \frac{\partial u}{\partial z} = 0$.
4) If $u = sin^{-1}\frac{x^2+y^2}{x+y}$, then find the value of $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y}$.
5) If $u = \log(x^3 + y^3 - x^2y - xy^2)$, then find the value of $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y}$.
6) If $f(x, y) = x^2y + 2xy^2$, then show that θ used in mean value theorem applied to the line segment joining (1,2) to (3,3) satisfied the equation $12\theta^2 + 13\theta - 19 = 0$.
7) If $u = G^{-1}f\left(\frac{y}{x}\right)$, then show that $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} = \frac{nG(u)}{G'u}$.
8) Verify the Euler's theorem for $f(x, y) = x^2 + y^2$.
9) Verify the Euler's theorem for $f(x, y) = x^2 + y^2 + xy$.
10) If $u = f(x, y)$ is a homogenous function of degree n, then show that $x^2\frac{\partial^2 u}{\partial x^2} + 2xy\frac{\partial^2 u}{\partial x \partial y} + y^2\frac{\partial^2 u}{\partial y^2} = n(n-1)u$.

Practical No.-5: Taylor's Theorem and Extreme Values-I

1) Expand $x^3 + y^3 + xy^2$ in powers of $(x - 1)$ and $(y - 2)$.
2) Expand $f(x, y) = x^2 + xy - y^2$ by Taylor's theorem in powers of $(x - 1)$ and $(y + 2)$.
3) Prove that $\sin(x + y) = (x + y) - \frac{(x+y)^3}{3!} + \cdots$
4) Expand $f(x, y) = \sin xy$ in powers of $(x - 1)$ and $\left(y - \frac{\pi}{2}\right)$ up to and including terms of second degree.
5) Discuss the maxima and minima of the function $(x, y) = x^2 + y^2 + \frac{2}{x} + \frac{2}{y}$.
6) Find the stationary points and determine the nature of the following function $f(x, y) = x^3 + y^3 - 3x - 12y + 20$.
7) A rectangular box open at the top is to have a volume 108 cubic unit. Find the dimension of the box if the total surface area is minimum.
8) Divide 24 in to three positive numbers such that their product is maximum.
9) Determine the minimum distance from origin to the plane $3x + 2y + z - 12 = 0$.
10) Expand $f(x, y) = \sin x \sin y$ about origin up to and including terms of third degree.

Practical No.-6: Taylor's Theorem and Extreme Values-II

1) Expand $e^x \log(1 + y)$ in powers of $x$and$y$.

2) Expand e^{2x}cosy as a Taylors series about $(0,0)$.
3) Find the critical point or stationary point for $f(x, y) = x^2 + y^2$.
4) Discuss the extreme values for $f(x, y) = 2(x^2 - y^2) - x^4 + y^4$.
5) Find the least value of the function $f(x, y) = xy + \frac{50}{x} + \frac{50}{y}$.
6) Express x^2y as polynomial in $x - 1$ and $y + 2$ by using Taylors theorem.
7) Expand $x^2 + 3y - 2$ in powers of $(x - 1)$ and $(y + 2)$.
8) Expand $x^3 + 3xy^2 + 5y^3$ in powers of $(x - 1)$ and $(y + 2)$.
9) Expand e^{x+y} in powers of $x$and$y$.
10) Expand $e^x siny$ in powers of $x$and$y$.

Practical No.-7: Double and Triple Integrals-I

1) Evaluate $\iint_R xy(x + y)dxdy$ where R is the region bounded by $y = x^2$ and $y = x$.
2) Evaluate $\iint ydxdy$ over the region bounded by $y = x^2$ and $x + y = 2$.
3) Using double integration, find the area of the region bounded by $y^2 = 4x$ and $x^2 = 4y$.
4) Using double integration, find the area of the circle $x^2 + y^2 = a^2$.
5) Evaluate $\iiint (x + y + z)dxdydz$ over the tetrahedron $x = 0, y = 0, z = 0$ and $x + y + z = 1$.
6) Using triple integration, find the volume of sphere having radius a.
7) Find the area bounded by the parabola $y^2 = 2x$ and $x^2 = 2y$.
8) Evaluate $\iint xydxdy$ over the region $x = 0, y = 0$ and $x + y = 1$.
9) Evaluate $\int_0^1 \int_0^2 \int_0^3 (x + y + z)dxdydz$.
10) Evaluate $\int_0^1 \int_0^{\sqrt{1-x^2}} \int_0^{\sqrt{1-x^2-y^2}} \frac{dxdydz}{\sqrt{1-x^2-y^2-z^2}}$.

Practical No.-8: Double and Triple Integrals-II

1) Evaluate $\int_0^a \int_0^b (x^2 + y^2)dxdy$.
2) Evaluate $\int_0^a \int_{\frac{x}{a}}^x \frac{x}{x^2+y^2} dxdy$.
3) Evaluate $\int_0^1 \int_0^{x^2} e^{y/x} dxdy$.
4) Evaluate $\int_0^a \int_0^x \frac{x}{x^2+y^2} dxdy$.
5) Evaluate $\int_0^1 \int_0^1 \int_0^1 (x + y + z)dxdydz$.
6) Evaluate $\int_0^1 \int_0^{1-x} \int_0^{x+y} e^z dxdydz$.
7) Using the double integration find the area between the curve $y^2 = 2x$and$x^2 = 2y$.
8) Find the area of the circle $x^2 + y^2 = 25$.
9) Evaluate $\iint (x^2 + y^2)dxdy$ over the region bounded by $x \geq 0 , y \geq 0 , x + y \leq 1$.

10) Evaluate $\iint xy\,dx\,dy$ over the region bounded by $x = 2$, $x = 5$, $y = 1$, $y = 2$.

Total Hours: 60	Credits: 2
Course objectives	• To know scope and importance of algebraic structures and their properties. • To study problems in many branches of Mathematics such as theory of equations, theory of numbers, Geometry etc. • To know properties of algebraic structures.
Course outcomes	After successful completion of this course, students are expected to: • Understand group and their types which is one of the building blocks of pure and applied mathematics. • Explain Lagrange's, Euler's and Fermat's theorem. • Explain concepts of homomorphism, isomorphism and automorphism of groups. • Learn basic properties of permutations, even, odd permutation and permutation groups.
Practical No.	**Title**
1	Infinite Groups
2	Finite Groups and Order of Elements
3	Subgroups
4	Cyclic Groups and Fermat's Theorem
5	Homomorphism of Groups
6	Isomorphism of Groups
7	Permutation Groups-I
8	Permutation Groups-II

List of Practicals

Practical No.-1: Infinite Groups

1) Verify $\mathbb{N}$ for a group under usual addition operation.
2) Show that $\mathbb{Z}$ is an abelian group under the operation $a * b = a + b + 1$ for all $a, b \in \mathbb{Z}$.
3) Show that $\mathbb{C}^* = \mathbb{C} - \{0\}$ is a group under the usual multiplication operation.
4) Let $\mathbb{Q}^+$ denotes the set of all positive rational numbers and for any $a, b \in \mathbb{Q}^+$, define $a * b = \frac{ab}{2}$.

   Show that $(\mathbb{Q}^+, *)$ is an abelian group.
5) Find the identity element in the group $G = \mathbb{Q} - \{-1\}$ with respect to the operation $a * b = a + b + ab$ for all $a, b \in G$.
6) Find the inverse of an element $a$in the group $G = \mathbb{R} - \{1\}$ with respect to the operation $a * b = a + b - ab \; \forall \, a, b \in G$.
7) Let $G = \{(a, b): a, b \in \mathbb{R}, \; a \neq 0\}$ and $(a, b) \odot (c, d) = (ac, bc + d)$ for all (a, b), $(c, d) \in G$. Show that the group$(G, \odot)$ is non-abelian.
8) Show that $G = \left\{ \begin{bmatrix} a & a \\ a & a \end{bmatrix} : a \in \mathbb{Q}^+ \right\}$ is a group under usual matrix multiplication.
9) Show that $G = \left\{ \begin{bmatrix} \cos\alpha & -\sin\alpha \\ \sin\alpha & \cos\alpha \end{bmatrix} : \alpha \in \mathbb{R} \right\}$ is a group under usual matrix multiplication.

10) Let $G = \left\{\begin{bmatrix} a & b \\ c & d \end{bmatrix}:\ a, b, c, d \in \mathbb{R},\ ad - bc \neq 0\right\}$. Prove that G is a non-abelian group under usual matrix multiplication.

Practical No.-2: Finite Groups and Order of Elements

1) Show that $G = \{1, -1,\ \mathrm{i}, -\mathrm{i}\}$ is an abelian group under usual multiplication.
2) Let $f_1(x) = x$ and $f_2(x) = 1 - x$ for all $x \in \mathbb{R}$. Show that $G = \{f_1, f_2\}$ is an abelian group under the operation composition of mappings.
3) Show that $G = \left\{\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}, \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}\right\}$ is an abelian group under usual matrix multiplication.
4) Show that $\mathbb{Z}_6$ is an abelian group under the addition modulo 6.
5) Verify $\mathbb{Z}_6$ for a group under the multiplication modulo 6.
6) Prove that $G = \{\bar{2}, \bar{4}, \bar{6}, \bar{8}\}$ is a group under usual multiplication modulo 10.
7) Find order of every element in the group $G = \{1, -1,\ \mathrm{i}, -\mathrm{i}\}$ under usual multiplication.
8) Find order of every element in the group $(\mathbb{Z}_6, +_6)$.
9) Find order of every element in the group $(\mathbb{Z}_8', \times_8)$.
10) In the group $(\mathbb{Z}_{11}', \times_{11})$, find i) $(\bar{4})^3$ ii) $(\bar{5})^{-1}$ iii) $(\bar{6})^{-5}$ iv) $(\bar{3})^4$.

Practical No. - 3: Subgroups

1) Let $G = \{1, -1,\ \mathrm{i}, -\mathrm{i}\}$ be a group under usual multiplication. Show that $H = \{1, -1\}$ is a subgroup of G.
2) Let G be a group of all non-zero complex numbers under multiplication. Show that $H = \{a + ib : a^2 + b^2 = 1\}$ is a subgroup of G.
3) Let $G = \mathrm{GL}(2, \mathbb{R})$ be the group of 2×2 non-singular matrices over reals under usual matrix multiplication. Prove that $H = \left\{\begin{bmatrix} a & b \\ c & d \end{bmatrix} \in G:\ ad - bc = 1\right\}$ is a subgroup of G.
4) Let $G = \mathrm{GL}(2, \mathbb{R})$ be the group under usual matrix multiplication. Prove that $H = \left\{\begin{bmatrix} a & b \\ 0 & 1 \end{bmatrix} :\right.$ $: a, b \in \mathbb{R}, a \neq 0$ is a subgroup of G.
5) Let $G = \mathrm{GL}(2, \mathbb{R})$ be the group under usual matrix multiplication. Prove that $H = \left\{\begin{bmatrix} 1 & b \\ 0 & 1 \end{bmatrix} : b \in\right.$ $\mathbb{R}$ is a subgroup of G.
6) Show that $N(a)$ is a subgroup of a group G where $a \in G$ and $N(a) = \{x \in G :\ ax = xa\}$.

7) Show that the center of G, $Z(G)$ is a subgroup of a group G where $Z(G) = \{a \in G : ax = xa, \forall x \in G\}$.
8) Let H be a subgroup of a group G and $gHg^{-1} = \{ghg^{-1} : h \in H\}$ is a subgroup of G.
9) Let $G = \{1, -1, i, -i, j, -j, k, -k\}$ be a group under multiplication and $H = \{1, -1, i, -i\}$ be its subgroup. Find all the left and right cosets of H in G.
10) Let $H = \{\bar{0}, \bar{4}, \bar{8}\}$ be a subgroup of the group $(\mathbb{Z}_{12}, +_{12})$. Find all the left and right cosets of H in $\mathbb{Z}_{12}$.

Practical No. - 4: Cyclic Groups and Fermat's Theorem

1) Let $G = \{1, -1, \mathrm{i}, -\mathrm{i}\}$ be a group under usual multiplication. Show that G is a cyclic group.
2) Verify the group $(\mathbb{Z}_8', \times_8)$ for a cyclic group.
3) Show that $(\mathbb{Z}_7', \times_7)$ is a cyclic group. Find all its generators.
4) Find all subgroups of the group $(\mathbb{Z}_{12}, +_{12})$.
5) Show that every proper subgroup of a group of order 35 is cyclic.
6) Show that every proper subgroup of a group of order 77 is cyclic.
7) Show that the number $3^{10} - 5^{10}$ is divisible by 11.
8) Find the remainder when 3^{54} is divided by 11.
9) Find the remainder obtained when 33^{19} is divided by 7.
10) Find the remainder obtained when 15^{27} is divided by 8.

Practical No. -5: Homomorphism of Groups

1) Let $(\mathbb{R}, +)$ be the group. Show thatthefunction $f: \mathbb{R} \longrightarrow \mathbb{R}$ defined by $f(x) = 2x$ for all $x \in \mathbb{R}$isa group homomorphism.
2) Let $(\mathbb{R}, +)$ be the group. Examine thefunction $g: \mathbb{R} \longrightarrow \mathbb{R}$ defined by $g(x) = 2x + 1$ for all $x \in \mathbb{R}$ for a group homomorphism.
3) Let $(\mathbb{Z}, +)$ be the group and $G = \{2^n : n \in \mathbb{Z}\}$, a group under usual multiplication. Show that the function $f: \mathbb{Z} \longrightarrow G$ defined by $f(n) = 2^n$ for all $n \in \mathbb{Z}$, is a group homomorphism. Find its kernel.
4) Let $(\mathbb{Z}, +)$ be the group and $G = \{1, -1, i, -i\}$, a group under usual multiplication. Show that the function $f: \mathbb{Z} \longrightarrow G$ defined by $f(n) = i^n$ for all $n \in \mathbb{Z}$, is an onto group homomorphism.

5) Let$(\mathbb{R},+)$ be the group and$G=\left\{\begin{bmatrix} a & b \\ c & d \end{bmatrix}:\ a,b,c,d\in\mathbb{R},\ ad-bc\neq 0\right\}$, the group under matrix multiplication. Examine thefunction $g:G\longrightarrow\mathbb{R}$ defined by $g\left(\begin{bmatrix} a & b \\ c & d \end{bmatrix}\right)=a+b+c+d$ for all $\begin{bmatrix} a & b \\ c & d \end{bmatrix}\in G$ for a group homomorphism..

6) Let $G=\{A : A \text{is} n\times n \text{matrix over } \mathbb{R} \text{ and } |A|\neq 0\}$, the group under matrix multiplication and $\mathbb{R}^*=\mathbb{R}-\{0\}$, the group under multiplication. Define $f:\ G\ \to\ \mathbb{R}^*$ by $f(A)=\ |A|$, for all $A\in G$. Show that f is an onto group homomorphism.

7) Prove that the mapping $f:(\mathbb{R},+)\to(\mathbb{R}-\{0\},\ \cdot)$ such that $f(x)=e^x$ is a group homomorphism. Find its kernel. Is f one-one? Justify.

8) If $\phi:(\mathbb{Z},+)\to(\mathbb{Z}'_{11},\ \times_{11})$ is a group homomorphism such that $\phi(1)=\bar{4}$, then find $\phi(10)$ and $\phi(25)$.

9) If $\psi:(\mathbb{Z},+)\to(\mathbb{Z}'_{11},\ \times_{11})$ is a group homomorphism such that $\psi(1)=\bar{4}$, then find its kernel.

10) Let $G=\{a\ ,a^2,a^3,\dots,a^{11},a^{12}=e\ \}$ be a cyclic group of order 12 generated by a. Show that $f\ :G\to G$ defined by $(x)=x^4$, $\forall\ x\ \in\ G$ is a group homomorphism. Find the kernel of f.

Practical No. - 6: Isomorphism of Groups

1) Show that the function $f\ :\ (\mathbb{Z},+)\to\ (\mathbb{Z},+)$defined by $f(x)=-x$ for all $x\in\mathbb{Z}$ is an isomorphism.

2) Show that the function $f\ :\ (\mathbb{R},+)\to\ (\mathbb{R}^+,\ \cdot)$ defined by $f(x)=2^x$ for all $x\in\mathbb{R}$ is an isomorphism.

3) Show that the group $(\mathbb{Q},+)$ is not isomorphic to the group $(\mathbb{Q}^+,\ \cdot)$.

4) Let G be a group and $a\in G$. Show that $f_a\ :\ G\ \to\ G$ defined by $f_a(x)=axa^{-1}$ for all $x\in G$ is an automorphism.

5) Let G be a group and $f:G\longrightarrow G$ be a map defined by $f(x)=\ x^{-1}$ for all $x\in G$. If G is an abelain group, then prove that f is an isomorphism.

6) Let G be a group and $f:G\longrightarrow G$ be a map defined by $f(x)=\ x^{-1}$ for all $x\in G$. If f is a group homomorphism, then prove that G is abelian.

7) Let $G=\left\{\begin{bmatrix} a & b \\ -b & a \end{bmatrix}:\ a,b\in\mathbb{R},\ a^2+b^2=1\right\}$ be a group under usual matrix multiplication and $\mathbb{C}^*$ be a group of non-zero complex numbers under multiplication. Show that $f\ :\ G\ \to\ \mathbb{C}^*$defined by $f\left(\begin{bmatrix} a & b \\ -b & a \end{bmatrix}\right)=a+ib$ is an isomorphism.

8) Consider the groups $G = \{1, -1, i, -i\}$ under usual multiplication and $\mathbb{Z}_8' = \{\bar{1}, \bar{3}, \bar{5}, \bar{7}\}$ under multiplication modulo 8. Show that G and $\mathbb{Z}_8'$ are not isomorphic.
9) Show that $G \cong \mathbb{Z}_3$ where $G = \{1, w, w^2\}$ is a group under usual multiplication and w is a cube root of unity.
10) If $G = \{1, -1, i, -i\}$ is a group under multiplication and $G_1 = \{\bar{2}, \bar{4}, \bar{6}, \bar{8}\}$ is a group under usual multiplication modulo 10, then show that G and G_1 are isomorphic.

Practical No. - 7: Permutation Groups-I

1) If $\sigma = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 5 & 4 & 1 & 6 & 3 & 2 \end{pmatrix}$ and $\mu = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 2 & 3 & 4 & 1 & 6 & 5 \end{pmatrix}$ in S_6, then find
i) σ^2 ii) $\mu\sigma$.
2) Prepare a Cayley's table of the permutations on set $A = \{1, 2, 3\}$ for the composition of mappings.
3) If $\begin{pmatrix} 1 & 2 & 3 \\ 3 & 1 & 2 \end{pmatrix} \circ \sigma = \begin{pmatrix} 1 & 2 & 3 \\ 1 & 3 & 2 \end{pmatrix}$ in S_3, then find σ.
4) If $\delta = (8\ 9\ 7\ 6)(5\ 4\ 1)(2\ 3)$ in S_9, then find δ^{-1}.
5) If $\sigma = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ 2 & 5 & 4 & 6 & 8 & 9 & 3 & 1 & 7 \end{pmatrix}$ in S_9, then find order of the permutation σ^{-1}.
6) If $\mu = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\ 3 & 2 & 1 & 6 & 8 & 7 & 4 & 5 \end{pmatrix}$ in S_8, then express μ as a product of disjoint cycles.
7) Is $\gamma = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ 1 & 6 & 7 & 9 & 8 & 5 & 3 & 2 & 4 \end{pmatrix}$ a cyclic permutation in S_9?
8) If $\sigma = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 5 & 4 & 1 & 6 & 3 & 2 \end{pmatrix}$ in S_6, then express σ as a product of disjoint cycles.
9) Compute $(2\ 3\ 4)(1\ 4\ 3\ 2)(2\ 4)$ in S_4.
10) Compute $(5\ 2\ 4\ 1)(4\ 1\ 2)(3\ 4)$ in S_5.

Practical No. - 8: Permutation Groups-II

1) If $\mu = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ 4 & 6 & 2 & 5 & 8 & 9 & 3 & 1 & 7 \end{pmatrix}$ in S_9, then find the order ofa permutation μ^{-1}.
2) Find order of the permutation $(2\ 3\ 4)(1\ 4\ 3\ 2)(2\ 4)$ in S_4.
3) If $\sigma = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 5 & 4 & 1 & 6 & 3 & 2 \end{pmatrix}$ in S_6, then examine σ is even or odd permutation.
4) Check whether the permutation $\sigma = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ 6 & 4 & 7 & 5 & 2 & 3 & 1 \end{pmatrix}$ in S_7 is even or odd.
5) List all even permutations in the permutation group S_3.
6) List all even permutations in the permutation group S_4.
7) Find $\sigma^{-1}\rho\sigma$ where $\rho = (1\ 3\ 4)(5\ 6)(2\ 7\ 8\ 9)$ and $\sigma = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ 7 & 8 & 9 & 6 & 4 & 5 & 2 & 3 & 1 \end{pmatrix}$.
8) Show that there does not exists a permutation $\sigma \in S_7$ such that $\sigma(2\ 3)\sigma^{-1} = (1\ 5\ 7)$.
9) Show that there does not exists a permutation $\sigma \in S_8$ such that $\sigma(3\ 6)\sigma^{-1} = (2\ 5\ 8)$.
10) Show that $W = \{I, (1\ 2)(3\ 4), (1\ 3)(2\ 4), (1\ 4)(2\ 3)\}$ is a subgroup of A_4.

S.Y. B.Sc. Mathematics (Minor)
Semester-III
MTH-MIN-231: Calculus of One Variable

Total Hours: 30 **Credits: 2**

Course Objectives	• Use the fact that the derivative is the slope of the tangent line to the curve at a given point • To determine the derivatives of simple linear functions. • To understand the concepts Limits, Derivative and applications of calculus. • Use the Intermediate Value Theorem to identify an interval where a continuous function has a root. • To improve problem solving and logical thinking abilities of the students.	
Course outcomes	After successful completion of this course, students are expected to: • Understand basic concepts on limits and continuity. • Understand use of differentiations in various theorems. • Know the Mean value theorems and its applications. • Make the applications of Taylor's and Maclaurin's theorem.	
Unit	**Content**	**Hours**

Unit I	**Limit and Continuity**
	• Epsilon-delta definition of limit of a function
	• Basic properties of limit, Indeterminate form
	• L-Hospital's rule
	• Examples of limit
	• Continuous function
	• Properties of continuous function on closed and bounded interval.
	    ○ Boundedness
	    ○ Attains its bounds
	    ○ Indeterminate mean value theorem
		7

Unit II	**Mean Value Theorems** • Differentiability • Definition of derivative • Theorem on continuity and examples • Roll's theorem • Langrage's Mean value theorem • Cauchy's mean value theorem • Examples on Roll's theorem • Langrage's Mean value theorem & Cauchy's mean value theorem • Geometrical interpretation and application • Increasing and Decreasing function	**8**

Unit III	**Successive Differentiation**
	• The nth derivative of some standard functions:
	    ○ e^{ax+b}
	    ○ x^m
	    ○ $(ax+b)^m$
	    ○ $\frac{1}{ax+b}$
	    ○ $\log(ax+b)$
	    ○ $\sin(ax+b)$
		7

	○ $\cos(ax+b)$ ○ $e^{ax}\sin(ax+b)$ ○ $e^{ax}\cos(ax+b)$ • Leibnitz's Theorem and examples on it	
Unit IV	**Application of differential Calculus** • Taylor's theorem with Lagrange's form of remainder and related examples • Maclaurin' theorem with Lagrange's form of remainder and related examples	**8**
Study Resources	• Wrede, R., and Spiegel M. R. (2002). *Theory and Problems of Advanced Calculus* (2nd ed.). McGraw-Hill Company, New York. • Prasad, G. (1959). *Text Book on Differential calculus*. Pothishala Private Ltd., Allahabad.(Ch.II, Ch.V, Ch.VII) • Prasad, G. *Integral calculus*. Pothishala Private Ltd., Allahabad. • Maron, I. A.*Problems in Calculus of One Variable*.CBS Publishers & Distributors	

S.Y. B.Sc. Mathematics (Minor)
Semester-III
MTH-MIN-232: Computational Algebra

Total Hours: 30 **Credits: 2**

Course Objectives	• To know the scope and importance of algebraic structures and their properties • To study problems in many branches of Mathematics and computer science such as theory of equations, theory of numbers, theory of computations, cryptography etc. • To know properties of algebraic structures.	
Course Outcomes	After successful completion of this course, students are expected to: • Understand group and their types which is one of the building blocks of pure and applied mathematics. • Explain Lagrange's, Euler's and Fermat's theorem. • Explain concepts of homomorphism, isomorphism and automorphism of groups. • Learn basic concepts in coding theory.	
Unit	**Content**	**Hours**
Unit I	**Groups:** Definition and examples of a group, Simple properties of group, Abelian group, Finite and infinite groups, Order of a group, Order of an element and its properties.	**7**
Unit II	**Subgroups:** Definition and examples of subgroups, Simple properties of subgroup, Criteria for a subgroup, Cyclic groups, Coset decomposition, Lagrange's theorem for finite group, Euler's theorem and Fermat's theorem.	**8**
Unit III	**Homomorphism and Isomorphism of Groups:** Definition and examples of group homomorphism, Properties of group homomorphism, Kernel of a group homomorphism and it's properties, Definition and examples of isomorphism and properties, Definition and examples of automorphism of groups.	**7**
Unit IV	**Group Codes:** Message, word, (m, n)-encoding function, Code words, Detection of k or fewer errors, Weight, Parity check code, Hamming distance, Properties of the distance function, Minimum distance of an encoding function, Group codes, (n, m)-decoding function, Maximum likelihood decoding function, Decoding procedure for a group code given by a parity check matrix.	**8**
Study Resources	• Gopalakrishnan N. S.(2018).*University Algebra*. Wiley Eastern Limited, New Delhi.(Unit-I: 1.1-1.8) • Kolman Bernard, Busby Robert C. and Ross.*Discrete Mathematical Structures*. Prentice Hall of India (Eastern Economy Edition), New Delhi. (Unit-XI: 11.1-11.2) • Herstein I. N. (1975).*Topics in Algebra*. John Wiley and Sons, New Delhi. • Fraleigh J. B.(2003).*A first Course in Abstract Algebra*. Pearson. • Jones G. A. and Jones J. M., (2000).*Information and Coding Theory*. Springer.	

S.Y. B.Sc. Mathematics (Minor)
Semester-III
MTH-MIN-233: Practical Course on MTH-MIN-231 andMTH-MIN-232

Total Hours: 60 **Credits: 2**

Course objectives	• To know problem solving skills in Calculus of one variables. • To know problem solving skills in group theory. • To know problem solving skills in coding theory.
Course outcomes	After successful completion of this course, students are expected to: • Understand basic concepts on limits and continuity. • Make the applications of Mean value theorem, Taylor's, Maclaurin's theorem. • Apply theorems of Lagrange, Euler and Fermat to solve problems. • Explain concepts and solve problems on homomorphism, isomorphism and automorphism of groups. • Apply concepts of coding theory to solve problems.
Practical No.	**Title**
1	Limit and Continuity
2	Mean Value Theorems
3	Successive Differentiation
4	Application of Differential Calculus
5	Groups
6	Subgroups
7	Homomorphism and Isomorphism of Groups
8	Group Codes

List of Practicals

Practical No. - 1:Limit and Continuity

1) Evaluate $\lim_{x\to 5}\frac{x^2-4x-5}{x^2+2x-35}$.
2) Evaluate $\lim_{x\to 0}\frac{\tan x-x}{x-\sin x}$.
3) Evaluate $\lim_{x\to 0}\frac{e^{-x}-e^{x}+2x}{x-\sin x}$.
4) Evaluate $\lim_{x\to 0}\frac{xe^{x}-\log(1+x)}{x^2}$.
5) Evaluate $\lim_{x\to 0}\frac{\log x}{x-1}$.
6) Evaluate $\lim_{x\to 0}\frac{\log(x-\frac{\pi}{2})}{\tan x}$.
7) Evaluate $\lim_{x\to 0} x^{x}$.
8) Evaluate $\lim_{x\to 0}\frac{1}{x}-\frac{1}{\sin x}$.

9) Examine the continuity of the following function at $x = 2$, where $f(x) = \begin{cases} \frac{x^2-4}{x-2} & \text{if } x \neq 2 \\ 4 & \text{if } x = 2 \end{cases}$.

10) Examine the continuity of the following function at $= \frac{1}{2}$, where $f(x) = \begin{cases} \frac{1}{2} - x & \text{if } 0 \leq x < \frac{1}{2} \\ 1 & \text{if } x = \frac{1}{2} \\ \frac{3}{2} - x & \text{if } \frac{1}{2} < x \leq 1 \end{cases}$.

Practical No. - 2:Mean Value Theorems

1) Verify Rolle's theorem for $f(x) = x^2 - 6x + 5$ in$[1,5]$.
2) Verify Rolle's theorem for $f(x) = sinx$ in $[0, \pi]$.
3) Verify Rolle's theorem for $f(x) = (x-a)^m(x-b)^n$in$[a, b]$.
4) Verify Rolle's theorem for $f(x) = \frac{sinx}{e^x}$ in$[0, \pi]$.
5) Verify Lagrange'sMean Value Theorem for $f(x) = 2x^2 - 7x + 10$ in$[2,5]$.
6) Verify Lagrange'sMean Value Theorem for $f(x) = x(x-1)(x-2)$ in$\left[0, \frac{1}{2}\right]$.
7) For $0 < a < b$, show that $1 - \frac{a}{b} < \log\frac{b}{a} < \frac{b}{a} - 1$.
8) Verify Cauchy's Mean Value Theorem for $f(x) = \sin x$and $g(x) = \cos x$in$\left[0, \frac{\pi}{2}\right]$.
9) If $f(x) = e^x$and $g(x) = e^{-x}$ in $[a, b]$, then show that c is the arithmetic mean between a and $b$by using Cauchy's Mean Value Theorem.
10) If $f(x) = \sqrt{x}$and $g(x) = \frac{1}{\sqrt{x}}$ in $[a, b]$, thenshow that $c$is a geometric mean between a and b by using Cauchy's Mean Value Theorem.

Practical No. - 3:Successive Differentiation

1) Find n^{th} derivative of x^m.
2) Find n^{th} derivative of $(ax + b)^m$.
3) If $y = e^{ax+b}$, then find y_n.
4) If $= \frac{1}{ax+b}$, then find y_n.
5) If $y = \log{(ax + b)}$, then find y_n.
6) Find n^{th} derivative of $\frac{1}{1-5x+6x^2}$.
7) If $= \frac{x^2+1}{(x-1)(x-2)(x-3)}$, then find y_n.
8) Find n^{th} derivative of $y = \log\sqrt{\frac{5x+3}{3x-2}}$.
9) If $y = \tan^{-1} x$, then prove that $(1 + x^2)y_{n+1} + 2nxy_n + n(n-1)y_{n-1} = 0$
10) If $y = \mathrm{a}\cos(\log x) + b\sin(\log x)$, then show that
    i)$\mathrm{x^2y_2 + xy_1 + y = 0}$, ii)$\mathrm{x^2y_{n+2} + (2n+1)xy_{n+1} + (n^2+1)y_n = 0}$.

Practical No. - 4:Application of differential Calculus

1) Expand $x^4 - 3x^3 + 2x^2 - x + 1$ in powers of $x - 3$.
2) Expand $f(x) = 2x^3 + 7x^2 + x - 1$ in powers of $x - 2$.
3) Expand $f(x) = 2x^3 + 7x^2 + x - 6$ in powers of $x - 2$.
4) Expand the polynomial $x^3 + 2x + 1$ in powers of $x - 2$.
5) Expand x^3 in powers of $x - 1$.
6) Expand $\sin x$ about $x = \frac{\pi}{2}$.
7) Write the expansion of $\sin x$ about origin.
8) Expand e^x about origin.
9) Expand $\cos x$ about origin.
10) Expand $\log(1 + x)$ about origin.

Practical No.-5: Groups

1) Verify $\mathbb{N}$ for a group under usual addition operation.
2) Show that $\mathbb{Z}$ is an abelian group under the operation $a * b = a + b + 1$ for all $a, b \in \mathbb{Z}$.
3) Let $\mathbb{Q}^+$ denotes the set of all positive rational numbers and for any $a, b \in \mathbb{Q}^+$, define $a * b = \frac{ab}{2}$. Show that $(\mathbb{Q}^+, *)$ is an abelian group.
4) Let $G = \{(a, b): a, b \in \mathbb{R}, a \neq 0\}$ and $(a, b) \odot (c, d) = (ac, bc + d)$ for all (a, b), $(c, d) \in G$. Show that the group $(G, \odot)$ is non-abelian.
5) Show that G $= \left\{\begin{bmatrix} a & a \\ a & a \end{bmatrix} : a \in \mathbb{Q}^+\right\}$ is a group under usual matrix multiplication.
6) Show that $G = \{1, -1, \mathrm{i}, -\mathrm{i}\}$ is an abelian group under usual multiplication.
7) Show that $\mathbb{Z}_6$ is an abelian group under the addition modulo 6.
8) Find order of every element in the group $(\mathbb{Z}_6, +_6)$.
9) Find order of every element in the group $(\mathbb{Z}_8', \times_8)$.
10) In the group $(\mathbb{Z}_{11}', \times_{11})$, find i) $(\bar{4})^3$ ii) $(\bar{5})^{-1}$ iii) $(\bar{6})^{-5}$ iv) $(\bar{3})^4$.

Practical No. - 6:Subgroups

1) Let G be a group of all non-zero complex numbers under multiplication. Show that $H = \{a + ib: a^2 + b^2 = 1\}$ is a subgroup of G.
2) Let $G = \mathrm{GL}(2, \mathbb{R})$ be the groupof 2×2 non-singular matrices over reals under usual matrix multiplication. Prove that $H = \left\{\begin{bmatrix} a & b \\ 0 & 1 \end{bmatrix} : a, b \in \mathbb{R}, a \neq 0\right\}$ is a subgroup of G.
3) Show that $N(a)$ is a subgroup of a group G where $a \in G$ and $N(a) = \{x \in G : ax = xa\}$.
4) Let H be a subgroup of a group G and $gHg^{-1} = \{ghg^{-1}: h \in H\}$ is a subgroup of G.

5) Let $G = \{1, -1,\ i, -i,\ j\ , -j,\ k, -k\}$ be a group under multiplication and $H = \{1, -1, i, -i\}$ be its subgroup. Find all the left and right cosets of H in G.

6) Let $G = \{1, -1,\ \mathrm{i}, -\mathrm{i}\}$ be a group under usual multiplication. Show that G is a cyclic group.

7) Verify the group $(\mathbb{Z}_8', \times_8)$ for a cyclic group.

8) Show that every proper subgroup of a group of order 35 is cyclic.

9) Show that the number $3^{10} - 5^{10}$ is divisible by 11.

10) Find the remainder when 3^{54} is divided by 11.

Practical No. - 7:Homomorphism and Isomorphism of Groups

1) Let $(\mathbb{R}, +)$ be the group. Show that the function $f : \mathbb{R} \longrightarrow \mathbb{R}$ defined by $f(x) = 2x$ for all $x \in \mathbb{R}$ is a group homomorphism.

2) Let $(\mathbb{R}, +)$ be the group. Examine the function $g : \mathbb{R} \longrightarrow \mathbb{R}$ defined by $g(x) = 2x + 1$ for all $x \in \mathbb{R}$ for a group homomorphism.

3) Let $(\mathbb{Z}, +)$ be the group and $G = \{2^n : n \in \mathbb{Z}\}$, a group under usual multiplication. Show that the function $f : \mathbb{Z} \longrightarrow G$ defined by $f(n) = 2^n$ for all $n \in \mathbb{Z}$, is a group homomorphism. Find its kernel.

4) Let $G = \{A : A \text{ is } n \times n \text{ matrix over } \mathbb{R} \text{ and } |A| \neq 0\}$ be the group under matrix multiplication and $\mathbb{R}^* = \mathbb{R} - \{0\}$, the group under multiplication. Define $f : G \to \mathbb{R}^*$ by $f(A) = |A|$, for all $A \in G$. Show that f is an onto group homomorphism.

5) Show that the function $f : (\mathbb{Z}, +) \to (\mathbb{Z}, +)$ defined by $f(x) = -x$ for all $x \in \mathbb{Z}$ is an isomorphism.

6) Show that the function $f : (\mathbb{R}, +) \to (\mathbb{R}^+, \cdot)$ defined by $f(x) = 2^x$ for all $x \in \mathbb{R}$ is an isomorphism.

7) Show that the group $(\mathbb{Q}, +)$ is not isomorphic to the group $(\mathbb{Q}^+, \cdot)$.

8) Let G be a group and $f : G \to G$ be a map defined by $f(x) = x^{-1}$ for all $x \in G$. If f is a group homomorphism, then prove that G is abelian.

9) Let $G = \left\{\begin{bmatrix} a & b \\ -b & a \end{bmatrix} : a, b \in \mathbb{R},\ a^2 + b^2 \neq 0\right\}$ be a group under usual matrix multiplication and $\mathbb{C}^*$ be a group of non-zero complex numbers under multiplication. Show that $f : G \to \mathbb{C}^*$ defined by $f\left(\begin{bmatrix} a & b \\ -b & a \end{bmatrix}\right) = a + ib$ is an isomorphism.

10) Consider the groups $G = \{1, -1,\ i, -i\}$ under usual multiplication and $\mathbb{Z}_8' = \{\bar{1}, \bar{3}, \bar{5}, \bar{7}\}$ under multiplication modulo 8. Show that G and $\mathbb{Z}_8'$ are not isomorphic.

Practical No. - 8:Group Codes

1) Consider the (3,9) encoding function $e : B^3 \to B^9$ defined by $e(abc) = abcabcabc$ for all $(abc) \in B^3$. Determine whether an error will be detected for each of the following received words:

   (a) 011111011 (b) 111110110.

2) How many errors will e detect? Consider the (3,8) encoding function $e : B^3 \to B^8$ defined by $e(000) = 00000000$, $e(001) = 10111000$, $e(010) = 00101101$, $e(011) = 10010101$, $e(100) = 10100100$, $e(101) = 10001001$, $e(110) = 00011100$, $e(111) = 00110001$.
   (a) Find the minimum distance of e.
   (b) How many errors will e detect?
3) Show that the (3,6) encoding function $e : B^3 \to B^6$ defined by $e(000) = 000000$, $e(001) = 001100$, $e(010) = 010011$, $e(011) = 011111$, $e(100) = 100101$, $e(101) = 101001$, $e(110) = 110110$, $e(111) = 111010$ is a group code. Also find the minimum distance of e.
4) Compute: (a) $\begin{bmatrix} 1 & 0 & 1 \\ 1 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \oplus \begin{bmatrix} 1 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 1 & 0 \\ 0 & 1 & 0 \end{bmatrix}$ (b) $\begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix} * \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$.
5) Consider the (2 , 5) encoding function defined by $e(00) = 00000, e(10) = 10110\,, e(01) = 01011\,, e(11) = 11101$. Show that $e : B^2 \to B^5$ is a group code.
6) Let $H = \begin{bmatrix} 0 & 1 & 1 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ be a parity check matrix. Determine the (2 , 5) group code $e_H : B^2 \to B^5$.
7) Consider the (3,5) encoding function $e : B^3 \to B^5$ defined by $e(000) = 00000$, $e(001) = 00110$, $e(010) = 01001$, $e(100) = 10011$, $e(101) = 10010$, $e(110) = 11010$, $e(011) = 01111$, $e(111) = 11100$. Decode the following words relative to a maximum likelihood decoding function :
   $a)$ 11001 $b)$ 01010 $c)$ 00111.
8) Consider the parity check matrix: $H = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$. Decode the following words relative to a maximum likelihood decoding function associated with e_H:
   $a)$ 10100 $b)$ 01101 $c)$ 11011.
9) Consider the parity check matrix: $H = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$. Determine the coset leaders for $N = e_H(B^3)$. Also compute the Syndrome for each coset leader and decode the code 001110 relative to maximum likelihood decoding function.
10) Let the (9, 3) decoding function $d : B^9 \to B^3$ be defined by $d(y) = z_1 z_2 z_3$, where for all i, $z_i = \begin{cases} 1, & \text{if } \{y_i, y_{i+3}, y_{i+6}\} \text{ has at least two 1's} \\ 0, & \text{if } \{y_i, y_{i+3}, y_{i+6}\} \text{ has less than two 1's} \end{cases}$.
    If $y \in B^9$, then determine $d(y)$, where $(i)\ y = 101111101$ $(ii)\ y = 100111100$.
    (a) Find the minimum distance of e. (b) How many errors will e detect?

S.Y. B.Sc. Mathematics (Open Elective)
Semester-III
MTH-OE-231: Theory of Sets

Total Hours: 30 **Credits: 2**

Course Objectives	• To acquire concepts of sets, operations on sets and Venn diagrams. • To know the concepts of countable and uncountable sets. • To acquire concepts of relations, equivalence relations. • To know the concept of functions and their types.	
Course Outcomes	After successful completion of this course, students are expected to: • Uses of the language of set theory, designing issues in different subjects of mathematics. • Understand the issues associated with different types of finite and infinite sets via countable and uncountable sets. • Learn how to identify, represent and recognize relations and functions from schematic descriptions, arrow diagrams and graphs.	
Unit	**Content**	**Hours**
Unit I	**Sets and Subsets:** Sets, Null Set, Singleton set, Subset, Superset, Power set, Equality of two Sets, Universal set, Complement of a set.	**7**
Unit II	**Operations on Sets:** Union and intersection of sets, Disjoint sets, Difference of two sets, Symmetric difference of two sets, Venn diagram, Equivalent sets, Finite Set and Infinite set, Countable and uncountable sets.	**8**
Unit III	**Relations:** Cartesian product of sets, Relations and its types,Equivalence relations and Equivalence class.	**7**
Unit IV	**Functions:** Function and its types, One-one, Onto, Even, Odd, Inverse function, Composite functions.	**8**
Study Resources	• Halmons, P. R.(1974). *Naïve Set Theory*(Revised ed.). Springer.(Unit: I-VIII) • Kamke, E. (1950).*Theory of Sets*, Dover Publishers. • Lipschutz Seymour (1998).*Set Theory and Related Topics*. Schaum's Series, McGraw-Hill, New York.	

S.Y. B.Sc. Mathematics (Major)
Semester-III
MTH-CEP-231:Community Engagement Program (CEP)

Course Structure : 2 Credits **Contact hours : 60 hours**

In alignment with the National Education Policy (NEP) 2020, Moolji Jaitha College (Autonomous), Jalgaon is introducing the Community Engagement Program at the undergraduate level. The NEP 2020 emphasizes holistic development, inclusivity, and integrating vocational education with academic learning, aiming to nurture socially responsible individuals. Inspired by NEP 2020, the Community Engagement Program aim to produce knowledgeable, compassionate, and proactive graduates, contributing to a more just, equitable, and sustainable society. This course fosters a strong connection between education and socioeconomic problems of real-world. Students will learn about the challenges faced by vulnerable households and appreciate local wisdom and lifestyles.

Objectives

- To engage students in activities that promote emotional, social, and intellectual growth, fostering a well-rounded approach to personal and academic development.
- To provide hands-on experiences that complement classroom learning, enabling students to apply their knowledge insocioeconomic problems of real-world.
- To instil a sense of responsibility towards the community by encouraging students to actively participate in social and environmental initiatives, appreciate rural culture, lifestyle, and wisdom.

Learning Outcomes

After completing this course, students will be able to

- Understand rural and/or urban culture, ethos, and socioeconomic realities.
- Develop a sense of empathy with the local community while appreciating the significant contributions of local communities to society and the economy.
- Learn to value the local community wisdom and identify opportunities for contributing to the community’s socioeconomic improvements.

Activities

- Conduct workshops and interactive sessions on emotional intelligence and social skills.
- Organize debates, discussions, and intellectual challenges that stimulate critical thinking and socioeconomic problem-solving using concern subject.
- Organize field visits where students can work on real-world problems, such as environmental conservation, rural and/or urban planning, or community health.
- Organize internships or service-learning opportunities with local businesses, NGOs, or government agencies.
- Facilitate project-based learning activities that require students to use their academic knowledge to develop solutions to community issues.
- Engage students in community service activities that address local social and environmental issues.
- Organize cultural exchange programs or field trips to rural areas to foster an appreciation of rural culture and wisdom.
- Facilitate collaborative projects involving students, educators, and community members to develop solutions for local challenges, promoting teamwork and collective problem-solving.
- Conduct educational sessions on the status of various agricultural and development programs and the challenges faced by vulnerable households, ensuring inclusivity and accessibility for all students.

S. No.	Module Title	Module Content	Assignment submission	Teaching/ Learning Methodology
1	**Appreciation of Rural Society**	Rural lifestyle, rural society, caste and gender relations, rural values with respect to community, nature and resources, elaboration of "soul of India lies in villages', rural infrastructure.	Prepare a map (physical, visual or digital) of the village you visited and write an essay about inter-family relations in that village.	– Classroom discussions – Field visit – Assignment
2	**Understanding rural and local economy and livelihood**	Agriculture, farming, land ownership, water management, animal husbandry, non-farm livelihoods and artisans, rural entrepreneurs, rural markets, migrant labour.	Describe your analysis of the rural house hold economy, its challenges and possible pathways to address. Circular economy and migration patterns.	– Field visit – Group discussions in class – Assignment
3	**Rural and local Institutions**	Traditional rural and community organisations, Self-help Groups, Panchayati raj institutions (Gram Sabha, Gram Panchayat, Standing Committees), Nagarpalikas and municipalities, local civil society, local administration.	How effectively are Panchayati Raj and Urban Local Bodies (ULBs) institutions functioning in the village? What would you suggest to improve their effectiveness? Present a case study (written or audio-visual).	– Classroom – Field visit – Group presentation of assignment
4	**Rural and National Development Programmes**	History of rural development and current national programmes in India: Sarva Shiksha Abhiyan, Beti Bachao, Beti Padhao, Ayushman Bharat, Swachh Bharat, PM AwaasYojana, Skill India, Gram Panchayat Decentralised Planning, National Rural Livelihood Mission (NRLM), Mahatma Gandhi National Rural Employment Guarantee Act 2005 (MGNREGA), SHRAM, Jal Jeevan Mission, Scheme of Fund for Regeneration of Traditional Industries (SFURTI), Atma Nirbhar Bharat, etc.	Describe the benefits received and challenges faced in the delivery of one of these programmes in the local community; give suggestions about improving the implementation of the programme for the poor. Special focus on the urban informal sector and migrant households.	– Classroom – Each student selects one program for field visit – Written assignment

Note: The modules are suggestive in nature and students can opt any one activities for community engagement program and field project based on topic appropriate to their regional community context.

Some additional suggestive themes for field-based / community engagement activities are listed below:

- Management curriculum may include aspects of micro-financing in a rural context;
- Chemistry syllabus can have a component of conducting water and soil analysis in surrounding field areas;
- Political science syllabus could include a mapping of local rural governance institutions and their functioning.
- Environment education will include areas such as climate change, pollution, waste management, sanitation, conservation of biological diversity, management of biological resources and biodiversity, forest and wildlife conservation, and sustainable development and living
- Understanding panchayats and constitutional mandate of local governance
- Panchayat administration, Gram Sabha, Mahila Sabha, Gram Panchayat Development Plan (GPDP), local planning of basic services.
- Micro-finance, SHGs, system of savings and credit for local business, linkages to banks, financial inclusion.
- Rural – entrepreneurship, opportunities for small business in local communities, access to financial and technical inputs to new entrepreneurs.
- Renewable energy, access to household and community level solar and bio-mass systems for sustainable energy use.
- Participatory Monitoring and evaluation of socio-economic development programmes, and cost-benefit analysis of project proposals.
- Migrant workers' livelihood security and social services.
- Hygiene and sanitation, improving health and personal behaviours, locally manageable decentralised systems and awareness against stubble burning.
- Water conservation, traditional practices of storage and harvesting, new systems of distribution and maintenance.
- Women's empowerment, gender inequality at home, community and public spaces, safety of girls and women, access to skills, credit and work opportunities.
- Child security, safety and good parenting, nutrition and health, learning and training for child care.
- Rural Marketing, market research, designing opportunities for rural artisans and crafts, and new products based on demand assessment.
- Community Based Research in Rural Settings, undertaking research that values local knowledge, systematises local practices and tools for replication and scale-up.
- Peri-urban development of informal settlements, mapping and enumeration, design of local solutions.

Assessment:

- Readings from related literature including e-content and reflections from field visits should be maintained by each student in the form of Field Diary (20 Marks)
- Submission of assignments based on modules assignment submission (details mentioned above) (20 Marks)
- Oral/ Group discussion/ Presentation (10 Marks)

SEMESTER-IV

S.Y. B.Sc. Mathematics (Major)
Semester-IV
MTH-DSC-241: Complex Variables

Total Hours: 30 **Credits: 2**

Course Objectives	• To know the concept of analytic function and harmonic function. • To study generalization of real number system and calculus. • To know integration techniques as well as applications of integrals.	
Course Outcomes	After successful completion of this course, students are expected to: • Understand the theory for functions of complex variables. • Explain fundamental concepts of analytic function and Cauchy Riemann Equations. • Explain extreme points of function and their maximum, minimum values at those points. • Understand meaning of complex integration. • Learn how to solve problems on calculus of residues and contour integrations.	
Unit	**Content**	**Hours**
Unit I	**Complex Numbers:** Complex numbers, Modulus and amplitude, Polar form, Triangle inequality and Argand's diagram, Riemann Sphere, De-Moivre's theorem for rational indices and applications, n^{th} roots of a complex number.	**7**
Unit II	**Functions of Complex Variables:** Limits, Continuity and derivative, Analytic functions, Necessary and sufficient conditions for analytic functions, Cauchy-Riemann equations, Laplace equations and Harmonic functions, Construction of analytic functions.	**8**
Unit III	**Complex Integrations:** Line integral and theorems on it, Statement and verification of Cauchy-Gaursat's theorem, Cauchy's integral formulae (for simple connected domain) for $f(a)$, $f'(a)$ and $f^n(a)$, Taylor's and Laurent's series.	**7**
Unit IV	**Calculus of Residues:** Zeros, poles and singularities of a function, Residue of a function, Cauchy's residue theorem, Evaluation of integrals by using Cauchy's residue theorem, Contour integrations of the type $\int_0^{2\pi} f(\cos\theta, \sin\theta)d\theta and$ $\int_{-\infty}^{\infty} f(x)dx$.	**8**
Study Resources	• Brown J. W. and Churchill R. V. (2009). *Complex Variables and Applications*. McGraw-Hill; 8th Edition. (Ch.1 1-8, Ch.2 9-15, 19-20, Ch.4 29, 33, 37, 44-46, Ch.6 54-55, 57, 60, 62) • Narayan Shanti and Mittal P.K (2005). *Theory of Functions of Complex Variables*. S. Chand and Company New Delhi. • Spiegel Murray R, (2009). *Complex variables*. Schaum's Outline Series, The McGraw-Hill, New York.	

S.Y. B.Sc. Mathematics (Major)
Semester-IV
MTH-DSC-242: Differential Equations

Total Hours: 30 **Credits: 2**

Course Objectives	• To know the techniques of formation of differential equations and their solutions • To study method of variation of parameters for second order L.D.E. • To know Pfaffian differential equations and method of their solutions.	
Course Outcomes	After successful completion of this course, students are expected to: • Understand formation of differential equations and their solutions, concept of Lipschitz condition. • Explain method of variation of parameters for second order L.D.E. • Explain concepts of simultaneous linear differential equations and method of their solutions. • Learn Pfaffian differential equations, difference equations and method of their solutions.	
Unit	**Content**	**Hours**
Unit I	**Theory of Ordinary Differential Equations:** Lipschitz condition, Existence and uniqueness theorem, Linearly dependent and independent solutions, Definition of Wronskian and properties related to solution of L.D.E., Super position principle, Method of variation of parameters for second order L.D.E.	**7**
Unit II	**Simultaneous Differential Equations:** Simultaneous linear differential equations of first order, Simultaneous D.E. of the form $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$, Rule I: Method of combinations, Rule II: Method of multipliers, Rule III: Properties of ratios.	**8**
Unit III	**Total Differential or Pfaffian Differential Equations:** Pfaffian differential equations, Necessary and sufficient conditions for the integrability, Conditions for exactness, Method of solution by inspection, Solution of homogenous equation.	**7**
Unit IV	**Difference Equations:** Introduction, Order of difference equation, Degree of difference equations, Solution to difference equation and formation of difference equations, Linear difference equations, Linear homogeneous difference equations with constant coefficients, Non-homogenous linear difference equation with constant coefficients viz. a^x and $f(x)$ (a polynomial of degree m).	**8**
Study Resources	• Raisinghania M. D. (2021). *Ordinary and Partial Differential Equation*. S. Chand & Co. 20th Edition. (Part-I: Unit-I: Art.1.12-1.16, Unit-VII:Art.7.3, Part-II: Unit-I: Art.1.4-1.5, Unit-II: Art.2.2, 2.4-2.8, Unit-III: Art.3.2-3.8) • Vedamurthy, V. N. and Iyengar, N. Ch. S. N. (1998). *Numerical methods*, Vikash Publishing House. (Ch.10: Art.10.1-10.8) • Simmons G. F. (1972).*Differential equations*. Tata Mcgrawhill. • Murray D. A. (1997).*Introductory course in Differential Equations*.(5th Edition) Longmans Green and co. London and Mumbai. • Coddington E. A. (1981).*An Introduction to Ordinary Differetial Equations*. Dover Publications, INC.	

S.Y. B.Sc. Mathematics (Major)
Semester-IV
MTH-DSC-243: Practical Course on Complex Variables

Total Hours: 60 **Credits: 2**

Course Objectives	• To know the concept of analytic function, harmonic function. • To study generalization of real number system and calculus. • To know integration techniques as well as applications of integrals.
Course Outcomes	After successful completion of this course, students are expected to: • Understand the theory for functions of complex variables. • Explain fundamental concepts of analytic function and Cauchy Riemann Equations. • Explain extreme points of function and their maximum, minimum values at those points. • Understand meaning of complex integration. • Learn how to solve problems on calculus of residues and contour integrations.
Practical No.	**Title**
1	Complex Numbers-I
2	Complex Numbers-II
3	Limit and Continuity
4	Analytic Functions
5	Complex Integration-I
6	Complex Integration-II
7	Calculus of Residues-I
8	Calculus of Residues-II

List of Practicals

Practical No.-1: Complex Numbers-I

1) Find $Re(z), Im(z)$ and conjugate of $z = \left(\frac{2+i}{3-2i}\right)^2$.

2) Show that z is real if and only if $\bar{z} = z$.

3) Find two complex numbers whose sum is 6 and product is 12.

4) Express $-1 - i$ and $(-1, \sqrt{3})$ in the polar form.

5) Compute the modulus and principal arguments of each of the following complex numbers.

   a) $i^7 + i^{10}$ b) $\frac{1}{1+i}$ c) $(-1+i)^3$

6) Find the modulus argument form (polar form) of i) $1 + i$, ii) $-i$, iii) $3 + 4i$.

7) If $\frac{z-1}{z+i}$ is purely imaginary, then find the locus of z.

8) If $|z_1| = |z_2| = |z_3| = 5$ and $z_1 + z_2 + z_3 = 0$ then, Show that

   $\frac{1}{z_1} + \frac{1}{z_2} + \frac{1}{z_3} = 0$.

9) Prove that for any two complex numbers z_1 and z_2

$$|z_1 + z_2|^2 + |z_1 - z_2|^2 = 2|z_1|^2 + 2|z_2|^2.$$

10) Find cube root of unity.

Practical No.-2: Complex Numbers-II

1) Find all values of $(1 - i\sqrt{3})^{\frac{1}{4}}$.
2) Solve the equation $x^4 - x^3 + x^2 - x + 1 = 0$.
3) Solve the equation $x^4 + x^3 + x^2 + x + 1 = 0$.
4) Find all the values of $(1 + i)^{\frac{1}{5}}$. Show that their continued product is $1 + i$.
5) Show that $\cos^6\theta = \frac{1}{32}[\cos 6\theta + 6\cos 4\theta + 15\cos 2\theta + 10]$.
6) Using De-Moivre's theorem to prove the following

   $\cos 5\theta = \cos^5\theta - 10\cos^3\theta\sin^2\theta + 5\cos\theta\sin^4\theta$ and

   $\sin 5\theta = 5\cos^4\theta\sin\theta - 10\cos^2\theta\sin^3\theta + \sin^5\theta$.
7) Express $\cos^6\theta$ in terms of cosines of multiples of θ.
8) Express $\sin^7\theta$ in terms of sines of multiples of θ.
9) If z_1 and z_2 are complex numbers, then show that $\cos(z_1 + z_2) = \cos z_1 \cos z_2 - \sin z_1 \sin z_2$.
10) Separate $\sin(x + iy)$ and $\tan(x + iy)$ into real and imaginary parts.

Practical No.-3: Limit and Continuity

1) Find $\lim_{z\to 1+i} \frac{z^4+4}{z-1-i}$.
2) Find $\lim_{z\to 1-i}[x + i(2x + y)]$.
3) Evaluate $\lim_{z\to 1+i} \frac{(z^4+4)(1+i-z)}{(z^2-2iz+2i-2z)}$.
4) Evaluate $\lim_{z\to i} \frac{z^5-i}{z+i}$.
5) Prove that $\lim_{z\to 0} \frac{\bar{z}}{z}$ does not exist.
6) Show that $\lim_{z\to 0} \frac{x^2y}{x^4+y^2}$ does not exist.
7) Let $f(z) = \bar{z}$. Show that $f(z)$ is continuous at every point in the z-plane but not differentiable.
8) Examine the following functions for continuity at $z = i$

$$f(z) = \begin{cases} \dfrac{3z^4 - 2z^3 + 8z^2 - 2z + 5}{z - i} & , if\ z \neq i \\ 2 + 3i & , if\ z = i \end{cases}$$

9) Discuss the continuity of $f(z)$ at $z = 2i$, where $f(z) = \begin{cases} \frac{z^2+4}{z-2i} & , if\ z \neq 2i \\ 3 + 4i & , if\ z = 2i \end{cases}$.
10) Let $f(z) = z^2 + 5z + C$, where C is any arbitrary constant. Find $f'(z_0)$ by the definition of derivative.

Practical No.-4: Analytic Functions

1) Let $(z) = \begin{cases} \frac{xy^2(x+iy)}{x^2+y^4} & , if\ z \neq 0 \\ 0 & , if\ z = 0 \end{cases}$. Show that $f(z)$ satisfies the C-R equations at origin and not differentiable at origin.
2) If $f(z)$ and $\overline{f(z)}$ are analytic functions of z, then show that $f(z)$ is a constant function.
3) If $f(z)$ is an analytic function with constant modulus, then show that $f(z)$ is a constant function.
4) Show that $\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} = 4\frac{\partial^2}{\partial z \partial \bar{z}}$.
5) Show that the function $f(z) = \sqrt{|xy|}$ is not differentiable at origin even though the C-R equations satisfies there.
6) Show that the real and imaginary parts of the function e^z satisfy C-R equations and they are harmonic.
7) Using Milne-Thomson method, find the analytic function $f(z) = u + iv$ if $u = x^3 - 3xy^2 + 3x^2 - 3y^2 + 1$.
8) Using Milne-Thomson method, find the analytic function $f(z) = u + iv$

   if $v = e^{-y} \sin x$ such that $f(0) = 1$.
9) Show that if $u = \frac{1}{2}\log(x^2 + y^2)$ satisfy the Laplace equation. Find it's harmonic conjugate.
10) If $f(z)$ is analytic function with constant modulus. Show that $f(z)$ is constant function.

Practical No.-5: Complex Integration-I

1) Evaluate $\int_C (x^2 + y^2 - xyi)\, dz$, where C is the line segment joining from $z = 0\ to\ \ z = 1 + i$.
2) Evaluate $\int_C z\, dz$, where C is the arc of the parabola $y^2 = 4ax$ from (0,0) to $(a, 2a)$.
3) If $f(z) = y - x - 3x^2 i$, then evaluate $\int_C f(z)\, dz$, where C consists of two straight line segments one from $z = 0$ to $z = i$ and then from $z = i$ to $z = 1 + i$.
4) Show that the integral of $\frac{1}{z}$ along a semicircular arc from -1 to 1, has the value $-\pi i$ or πi according as the arc lies above or below the real axis.
5) Verify the Cauchy's integral theorem for $f(z) = z + 1$ round the contour $|\ z\ | = 1$.
6) Use Cauchy's integral theorem to evaluate $\int_C e^z\, dz$, where $C: |z| = 1$ and hence deduce

   a) $\int_0^{2\pi} e^{\cos\theta} \sin(\theta + \sin\theta)\, d\theta = 0$

   b) $\int_0^{2\pi} e^{\cos\theta} \cos(\theta + \sin\theta)\, d\theta = 0$.
7) Evaluate $\int_C \frac{e^z}{z-2} dz$, where C is the circle $|z - 2| = 1$, by the Cauchy's integral formula.
8) Evaluate $\int_C \frac{dz}{z^3(z+4)} dz$, where $C: |z| = 2$, by Cauchy's integral formula.
9) Evaluate $\int_C \frac{e^{2z}}{(z-1)^4} dz$, where $C: |z| = 2$, by Cauchy's integral formula.

10) Evaluate $\int_C \frac{1}{(z^2+4)^2} dz$, where C is the circle $|z-i| = 2$.

Practical No.-6: Complex Integration-II

1) Evaluate $\int_{|z|=1} \frac{e^z}{z} dz$ and hence deduce that

   a) $\int_0^{2\pi} e^{\cos\theta} \cos(\sin\theta)\, d\theta = 2\pi$

   b) $\int_0^{2\pi} e^{\cos\theta} \sin(\sin\theta)\, d\theta = 0$.

2) Evaluate $\int_C \frac{ze^z}{(z-1)^3} dz$, wher $C: |z-1| = 2$.

3) Evaluate $\int_C \frac{sin^6 z}{\left(z-\frac{\pi}{6}\right)^3} dz$, where $C: |z| = 1$.

4) Find the expansion of $f(z) = \frac{1}{(z^2+1)(z^2+2)}$ in powers of z when $|z| < 1$.

5) Expand $f(z) = \frac{z^2-4}{z^2+5z+4}$, for the region $1 < |z| < 4$.

6) Expand $f(z) = \frac{1}{z-2}$ in Laurent's series valid for $|z| > 2$.

7) Expand $\frac{z^2-2z+5}{(z-2)(z^2+1)}$ in the annulus $1 < |z| < 2$.

8) Prove that $\frac{1}{4z-z^2} = \sum_{n=0}^{\infty} \frac{z^{n-1}}{4^{n+1}}$, where $0 < |z| < 4$.

9) Find the Laurent's series expansion of $f(z) = z^2 e^{\frac{1}{z}}$ about $z = 0$.

10) Expand $f(z) = \frac{e^{2z}}{(z-1)^3}$ about $z = 1$ as a Laurent's series. Also, indicate the region of convergence of the series.

Practical No.-7: Calculus of Residues-I

1) Find all zeros and poles of $\frac{z^2+4}{z^3+2z^2+2z}$.

2) Find the singularities of the function $\frac{e^{\frac{c}{z-a}}}{e^{\frac{z}{a}}-1}$, indicating the type of each singularity.

3) Specify the nature of the singularity at $z = -2$ of $f(z) = (z-3)\sin\left(\frac{1}{z+2}\right)$.

4) Find the poles and residues of $f(z) = \frac{1}{z(z-1)^2}$ also find the sum of residue.

5) Find the residue of $f(z) = \frac{z^2}{(z-1)(z-2)(z-3)}$ at its poles.

6) Find the residue of $f(z) = \frac{ze^z}{(z-1)^3}$ at its poles.

7) Find the sum of residues of $\frac{e^z}{z^2+a^2}$ at its poles.

8) Compute residues at double poles of $f(z) = \frac{z^2+2z+3}{(z-i)^2(z+4)}$.

9) Prove that $\underset{z=\frac{\pi}{2}}{Res} \tan z = -1$.

10) Evaluate $\int_C \frac{5z-2}{z(z-1)} dz$, where $C: |z| = 2$, by the Cauchy's residue theorem.

Practical No.-8: Calculus of Residues-II

1) Evaluate $\int_C \frac{z^2}{(z-2)(z+3)} dz$, where $C: |z| = 4$, by the Cauchy's residue theorem.

2) Evaluate $\int_C \frac{3z^2+2}{(z^2+9)(z-1)} dz$, where $C: |z-2| = 2$, by the Cauchy's residue theorem.

3) Evaluate $\int_{|z|=2} \frac{dz}{z^3(z+4)}$.

4) Use the Contour integration to evaluate $\int_0^{2\pi} \frac{d\theta}{5+\cos\theta}$.

5) Prove that $\int_0^{2\pi} \frac{d\theta}{4+\sin^2\theta} = \frac{2\pi}{\sqrt{1-a^2}}, -1 < a < 1$.

6) Evaluate $\int_0^{\pi} \frac{d\theta}{3+2\cos\theta}$.

7) Evaluate by Contour integration $\int_{-\infty}^{\infty} \frac{1}{x^4+13x^2+36} dx$.

8) Evaluate $\int_0^{\infty} \frac{x^2}{(x^2+1)(x^2+4)} dx$.

9) Show that $\int_{-\infty}^{\infty} \frac{1}{x^2+x+1} dx = \frac{2\pi}{\sqrt{3}}$.

10) Show that $\int_{-\infty}^{\infty} \frac{1}{x+1} dx = \pi$.

S.Y. B.Sc. Mathematics (Major)
Semester-IV
MTH-DSC-244: Practical Course on Differential Equations

Total Hours: 60 **Credits: 2**

Course Objectives	• To know the techniques of formation of differential equations and their solutions • To study method of variation of parameters for second order L.D.E. • To know Pfaffian differential equations and method of their solutions.
Course Outcomes	After successful completion of this course, students are expected to: • Understand formation of differential equations and their solutions, concept of Lipschitz condition. • Explain method of variation of parameters for second order L.D.E. • Explain concepts of simultaneous linear differential equations and method of their solutions. • Learn Pfaffian differential equations, difference equations and method of their solutions.
Practical No.	**Title**
1	Theory of Ordinary Differential Equations-I
2	Theory of Ordinary Differential Equations-II
3	Simultaneous Differential Equations-I
4	Simultaneous Differential Equations-II
5	Total (Pfaffian) Differential Equations-I
6	Total (Pfaffian) Differential Equations-II
7	Difference Equations-I
8	Difference Equations-II

List of Practicals

Practical No.-1: Theory of Ordinary Differential Equations-I

1) Show that $f(x,y) = xy^2$satisfies the Lipchitz condition on the rectangle$|x| \leq 1, |y| \leq 1$ but does not satisfy the Lipchitz condition $|x| \leq 1, |y| \leq \infty$.
2) Examine the existence and uniqueness of solution of the initial value problem
   $\frac{\partial y}{\partial x} = y^{\frac{1}{3}}, y(0) = 0$.
3) Show by an example that continuous function may not satisfies the Lipchitz condition on a rectangle.
4) Show that the solution of the initial value problem $\frac{\partial f}{\partial y} = f(x,y) = \sqrt{|y|}, y(0) = 0$ may not have unique although $f(x,y)$ is continuous.
5) Let the function $f(x,y) = x^2 + y^2 \ \forall\ (x,y) \in S$, where S is rectangle defined by
   $|x| \leq a, |y| \leq b$ show that $f(x,y)$ satisfies Lipschiz condition. Find Lipschitz constant.

6) If S is defined on the rectangle $|x| \leq a, |y| \leq b$ show that the function $f(x, y) = x \sin y + y \cos x$ satisfies the Lipchitz condition find Lipchitz constant.

7) Find the Wronskian of $e^{ax} cosbx$ and $e^{ax} \sin bx \, (b \neq 0)$.

8) Find the Wronskian of the function $y_1 = \sin x$ and $y_2 = \sin x - \cos x$.

9) Find the Wronskian of the function $e^{m_1 x}, e^{m_2 x}, e^{m_3 x}$.

10) Using Wronskian show that function x, x^2, x^3 are linearly independent.

Practical No.-2: Theory of Ordinary Differential Equations-II

1) Show that the following function x^2, e^x, e^{-x} are linearly independent

2) Show that x and xe^x are linearly independent.

3) Examine whether the set of function $x^2 - x + 1, x^2 - 1, 3x^2 - x - 1$ are linearly independent or not.

4) Show that the function $1 + x, x^2, 1 + 2x$ are linearly independent.

5) Show that $\sin 2x$ and $\cos 2x$ are solution of differential equation $y'' + 4y = 0$ and these are linearly independent.

6) Show that $y_1 = \sin x$ and $y_2 = \sin x - \cos x$ are linearly independent solution of $y'' + y = 0$.

7) Using method of variation of parameters, solve $y'' - 2y' + y = e^x$.

8) Solve by the method of variation parameters $y'' - 3y' + 2y = 2$.

9) Solve by the method of variation of parameters $y'' + y = x$.

10) Using method of variation of parameters, solve $\frac{d^2y}{dx^2} + a^2 y = \operatorname{cosec} ax$.

Practical No.-3: Simultaneous Differential Equation-I

1) Solve: $\frac{dx}{yz} = \frac{dy}{zx} = \frac{dz}{xy}$.

2) Solve: $\frac{dx}{z^2} = \frac{dy}{xz^2} = \frac{dz}{xy}$

3) Solve: $\frac{dx}{x^2+2y^2} = \frac{dy}{-xy} = \frac{dz}{xz}$

4) Solve: $dx = dy = dz$

5) Solve : $\frac{dx}{z} = \frac{dy}{0} = \frac{dz}{-x}$

6) Solve: $\frac{dx}{\tan x} = \frac{dy}{\tan y} = \frac{dz}{\tan z}$.

7) Solve: $\frac{dx}{x+y} = \frac{dy}{y} = \frac{dz}{z+y^2}$

8) Solve: $\frac{dx}{xy} = \frac{dy}{y^2} = \frac{dz}{zxy-2x^2}$

9) Solve: $\frac{dx}{y^2 z} = \frac{dy}{x^2} = \frac{dz}{x^2 y^2 z^2}$.

10) Solve: $\frac{dx}{z} = \frac{dy}{-z} = \frac{dz}{z^2+(x+y)^2}$.

Practical No.-4: Simultaneous Differential Equation-II

1) Solve: $\frac{dx}{y} = \frac{dy}{x} = \frac{dz}{xyz^2(x^2-y^2)}$.
2) Solve: $\frac{dx}{1} = \frac{dy}{3} = \frac{dz}{3z+\tan(y-3x)}$.
3) Solve: $\frac{dx}{x(y-z)} = \frac{dy}{y(z-x)} = \frac{dz}{z(x-y)}$.
4) Solve: $\frac{dx}{y^2(x-y)} = \frac{dy}{-x^2(x-y)} = \frac{dz}{z(x^2+y^2)}$
5) Solve: $\frac{dx}{x(y^2+z)} = \frac{dy}{-y(x^2+z)} = \frac{dz}{z(x^2-y^2)}$
6) Solve: $\frac{dx}{z^2} = \frac{dy}{xz^2} = \frac{dz}{xy}$
7) Solve: $\frac{adx}{bc(y-z)} = \frac{bdy}{ca(z-x)} = \frac{cdz}{ab(x-y)}$
8) Solve: $\frac{yz\,dx}{y-z} = \frac{zx\,dy}{z-x} = \frac{xy\,dz}{x-y}$.
9) Solve: $\frac{dx}{x(2y^4-z^4)} = \frac{dy}{y(z^4-2x^4)} = \frac{dz}{z(x^4-y^4)}$.
10) Solve: $\frac{dx}{y^2z} = \frac{dy}{zx} = \frac{dz}{y^2}$.

Practical No.-5: Total (Pfaffian) Differential Equation-I

1) Show that $(2x + y^2 + 2xz)dx + 2xydy + x^2dz = 0$ is integrable.
2) Verify the condition of inerrability for $zdx + zdy + 2(x + y + sinz)dz = 0$
3) Show that the equation $yz^2(x^2 - yz)dx + zx^2(y^2 - xz)dy + xy^2(z^2 - xy)dz = 0$ is integrable.
4) Show that the equation $(yz + 2x)dx + (zx - 2z)dy + (xy - 2y)dz = 0$ is exact.
5) Show that the equation $(yz - x^3)dx + (zx - y^3)dy + (xy - z^3)dz = 0$ is exact.
6) Solve: $(x^2 - yz)dx + (y^2 - zx)dy + (z^2 - xy)dz = 0$.
7) Solve: $(y + z)dx + dy + dz = 0$.
8) Solve: $2yzdx + zxdy - xy(1 + z)dz = 0$.
9) Solve: $xdy - ydx - 2x^2zdz = 0$.
10) Verify that the differential equation $(y + z)dx + (z + x)dy + (x + y)dz = 0$ is exact and find the solution.

Practical No.-6: Total (Pfaffian) Differential Equation-II

1) Solve: $yz\log z\,dx - zx\log z\,dy + xy\,dz = 0$.
2) Solve: $x(y^2 - a^2)dx + y(x^2 - z^2)dy - z(y^2 - a^2)dz = 0$.

3) Solve: $yzdx + 2zx - 3xydz = 0$.

4) Solve $z(z-y)dx + z(z+x)dy + x(x+y)dz = 0$.

5) Solve: $xdy - ydx - 2x^2z\,dz = 0$.

6) Solve: $yz(y+z)dx + zx(z+x)dy + xy(x+y)dz = 0$ by homogenous method.

7) Solve: $(y^2+yz)dx + (z^2+zx)dy + (y^2-xy)dz = 0$ by homogenous method.

8) Solve: $(y^2+z^2-x^2)dx - 2xydy - 2xzdz = 0$ by homogenous method.

9) Solve: $(yz+z^2)dx - xy\,dy + xy\,dz = 0$ by homogenous method.

10) Solve: $(x-y)dx - x\,dy + z\,dz = 0$ by homogenous method.

Practical No.-7: Difference Equations-I

1) Solve the difference equation $3y_{x+2} - 6y_{x+1} + 4y_x = 0$.

2) From the difference equation given that $y_n = A3^n + B5^n$, where A and B are arbitrary constants.

3) Prove that $y_x = 3^x(A+Bx)$ satisfy $y_{x-2} - 6y_{x+1} + 9y_x = 0$.

4) Solve the difference equation $y_{x+3} - 3y_{x+2} - 10y_{x+1} + 24y_x = 0$.

5) Solve: $y_{x+2} - 7y_{x+1} + 12y_x = 0$.

6) Solve: $y_{k+2} - 6y_{k+1} + 8y_k = 0$.

7) Solve: $y_{k+2} - 2y_{k+1} + 5y_k = 0$.

8) Solve: $y_{x+2} - 2y_{x+1} + 2y_x = 0$.

9) Solve: $y_{x+4} - 4y_{x+3} + 6y_{x+2} - 4y_{x+1} + y_x = 0$.

10) Solve: $y_{x+4} - 8y_{x+3} + 18y_{x+2} - 27y_x = 0$.

Practical No.-8: Difference Equations-II

1) Solve: $9y_{x+2} - 6y_{x+1} + y_x = 0$, also find the particular solution when$y_0 = 0$ and $y_1 = 1$.

2) Solve: $y_{x+2} - 3y_{x+1} + 2y_x = 1$.

3) Solve $y_{x+2} - 3y_{x+1} + 2y_x = a^x$,where a is constant.

4) Solve: $y_{x+2} - 4y_{x+1} + 4y_x = 3^x + 2^x + 4$.

5) Solve: $y_{x+2} - 4y_{x+1} + 3y_x = 3^x + 1$.

6) Solve: $y_{x+2} - 4y_{x+1} + 4y_x = 3x + 2^x$.

7) Solve: $y_{x+2} - 4y_x = 9x^2$.

8) Solve: $y_{x+2} - 5y_{x+1} + 6y_x = 2$.

9) Solve: $u_{x+2} - 5u_{x+1} + 6u_x = 36$.

10) Solve: $\Delta y_x + \Delta^2 y_x = \sin x$.

S.Y. B.Sc. Mathematics (Minor)
Semester-IV
MTH-MIN-241: Ordinary Differential Equations

Total Hours: 30 **Credits: 2**

<table>
<tr><td>Course Objectives</td><td colspan="2">The basic need of this course is to understand the different methods of solving differential equations and their applications to solve problems arrives in engineering and technology.
Evaluate first order differential equations including homogeneous, exact and linear differential equations.
Solve second order and higher orders linear differential equations.
To know the concept of homogeneous linear differential equations.</td></tr>
<tr><td>Course Outcomes</td><td colspan="2">After successful completion of this course, students are expected to:
understand basic concepts in differential equations.
understand method of solving differential equations
understand use of differential equations in various fields.
understand the method of solving the homogeneous linear differential equation.</td></tr>
<tr><td>Unit</td><td>Content</td><td>Hours</td></tr>
<tr><td>Unit I</td><td>Differential Equations of First Order and First Degree:
Partial derivatives of first order and second orders
Exact differential equations and condition for exactness
Integrating factor and rules for finding integrating factors
Linear differential equations
Bernoulli’s Differential Equation
Equation reducible to linear form</td><td>7</td></tr>
<tr><td>Unit II</td><td>Differential Equations of First Order and Higher Degree:
Differential equations of first order and higher degree
Equation solvable for p, y and x
Clairaut’s form</td><td>8</td></tr>
<tr><td>Unit III</td><td>Linear Differential Equations of Second and Higher Order:
Linear differential equations with constant coefficients
Complementary functions
Particular integrals of $f(D)y = X$, where $X = e^{ax}$, $\sin(ax)$, $\cos(ax)$, x^n, $e^{ax}V$, xV with usual notations</td><td>7</td></tr>
<tr><td>Unit IV</td><td>Homogeneous Linear Differential Equations:
Homogeneous linear differential equations (Cauchy’s differential equations)
Example of Homogeneous linear differential equations
Equations reducible to homogeneous linear differential equations (Legendre’s equations)
Example of equations reducible to homogeneous linear differential equations</td><td>8</td></tr>
<tr><td>Study Resources</td><td>Raisinghania M. D. (2021). Ordinary and Partial Differential Equation. S. Chand & Co. 20th Edition.(Part-I: Unit-II: Art. 2.12, 2.25, 2.25(A), Unit-IV: Art. 4.1-4.8, Unit-V: Art. 5.1-5.22, Unit-VI: 6.1-6.10)
Murray, D. A. (1967). Introductory Course in Differential Equations. Orient Congman (India).
Simmons, G. F. (1972).Differential Equations, Tata McGraw Hill.</td><td></td></tr>
</table>

S.Y. B.Sc. Mathematics (Minor)
Semester-IV
MTH-MIN-242: Practical Course on MTH-MIN-241

Total Hours: 60 **Credits: 2**

Course Objectives	• The basic need of this course is to understand the different methods of solving differential equations and their applications to solve problems arrives in engineering and technology. • Evaluate first order differential equations including homogeneous, exact and linear differential equations. • Solve second order and higher orders linear differential equations. • To know the concept of homogeneous linear differential equations.
Course Outcomes	After successful completion of this course, students are expected to: • Understand basic concepts in differential equations. • Understand method of solving differential equations • Understand use of differential equations in various fields. • Understand the method of solving the homogeneous linear differential equation.
Practical No.	**Title**
1	Differential Equations of First Order and First Degree-I
2	Differential Equations of First Order and First Degree-II
3	Differential Equations of First Order and Higher Degree-I
4	Differential Equations of First Order and Higher Degree-II
5	Linear Differential Equations of Second and Higher Order-I
6	Linear Differential Equations of Second and Higher Order-II
7	Cauchy's Homogeneous Differential Equations
8	Legendre's Homogeneous Differential Equations

List of Practicals

Practical No.-1: Differential Equations of First Order and First Degree-I

1) Find $\frac{\partial u}{\partial x}$ and $\frac{\partial u}{\partial y}$ for $u = e^x \sin xy$.
2) Find $\frac{\partial u}{\partial x}$ and $\frac{\partial u}{\partial y}$ for $u = \frac{x^2+y^2}{x+y}$.
3) Solve $(2x^3 + 3y)dx + (3x + y - 1)dy = 0$.
4) Solve $(\sec x \tan x \tan y - e^x)dx + \sec x \sec^2 y\, dy = 0$.
5) Solve $(e^y + 1)\cos x\, dx + e^y \sin x\, dy = 0$.
6) Solve $\cos y - x \sin y \frac{dy}{dx} = \sec^2 x$.
7) Solve $(2x - y + 1)dx + (2y - x - 1)dy = 0$.
8) Solve $(4x^3 - y^3 + 3x^2y)dx + (x^3 - 3xy^2 + 4y^3)dy = 0$.
9) Solve $(x^2 + y^2)dx - 2xydy = 0$.
10) Solve $(xy + 1)ydx + (1 + xy + x^2y^2)xdy = 0$.

Practical No.-2: Differential Equations of First Order and First Degree-II

1) Solve $(xy\sin(xy)+\cos(xy))ydx+(xy\sin(xy)-\cos(xy))xdy=0$.
2) Solve $(x-y^2)dx+2xydy=0$.
3) Solve $(x^2+y^2+x)dx+xydy=0$.
4) Solve $(x^3+xy^4)dx+2y^3dy=0$.
5) Solve $(y^4+2y)dx+(xy^3+2y^4-4x)dy=0$.
6) Solve $\frac{dy}{dx}+\frac{y}{x}=x^2$.
7) Solve $\frac{dy}{dx}+2y\tan x=\sin x$.
8) Solve $(1+x^2)\frac{dy}{dx}+2xy-1=0$.
9) Solve $\frac{dy}{dx}+2xy+xy^4=0$.
10) Solve $\frac{dy}{dx}=x^3y^3-xy$.

Practical No.-3: Differential Equations of First Order and Higher Degree-I

1) Solve $p^2-7p+10=0$.
2) Solve $p-\frac{1}{p}=\frac{x}{y}-\frac{y}{x}$.
3) Solve $xyp^2+(x^2+xy+y^2)p+x(x+y)=0$.
4) Solve $p(p-y)=x(x+y)$.
5) Solve $xy(p^2+1)=(x^2+y^2)p$.
6) Solve $xyp^2+p(3x^2-2y^2)-6y=0$.
7) Solve $y+px=x^4p^2$.
8) Solve $xp^2-2yp+ax=0$, where a is arbitrary constant.
9) Solve $4y=x^2+p^2$.
10) Solve $y=3px+6y^2p^2$.

Practical No.-4: Differential Equations of First Order and Higher Degree-II

1) Solve $y=2px+p^2y$.
2) Solve $x=y+p^2$.
3) Solve $x=y+a\log p$.
4) Solve $y=px+a\sqrt{1+p^2}$, where a is arbitrary constant.
5) Solve $y=2px-p^2$.
6) Solve $xp^2-yp+a=0$, where a is arbitrary constant.
7) Solve $p=\tan(px-1)$.

8) Solve $\sin px \cos y = \cos px \sin y + p$.
9) Solve $p^2 - xp + y = 0$.
10) Solve $y = px + p - p^2$.

Practical No.-5: Linear Differential Equations of Second and Higher Order-I

1) Solve $\frac{d^2y}{dx^2} - 5\frac{dy}{dx} + 6y = 0$.
2) Solve $\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y = 0$.
3) Solve $\frac{d^3y}{dx^3} - 3\frac{dy}{dx} + 4y = 0$.
4) Solve $\frac{d^2y}{dx^2} + 4y = 0$.
5) Solve $(D^2 - 6D + 13)y = 0$.
6) Solve $(D-1)^3(D^2-9)(D+3)y = 0$.
7) Solve $\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + y = e^x$.
8) Solve $(D^2 - 5D + 6)y = e^{4x}$.
9) Solve $\frac{d^2y}{dx^2} - 5\frac{dy}{dx} + 6y = x$.
10) Solve $(D^3 + 3D^2 + 2D)y = x^2$.

Practical No.-6: Linear Differential Equations of Second and Higher Order-II

1) Solve $\frac{d^2y}{dx^2} - 9y = e^{2x} + x^2$.
2) Solve $(D^3 + D)y = \sin 3x$.
3) Solve $(D^2 + 4)y = \cos 2x$.
4) Solve $(D^2 + 4)y = \sin 3x + e^x + x^2$.
5) Solve $(D^2 - 2D + 1)y = x^2e^{3x}$.
6) Solve $(D^2 - 6D + 13)y = e^{3x}\sin 2x$.
7) Solve $\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + y = x\sin x$.
8) Solve $(D^2 - 1)y = xe^{2x}$.
9) Solve $(D^2 + 13D + 36)y = \sinh x$.
10) Solve $(D^2 - 5D + 6)y = 2^x + 1$.

Practical No.-7: Cauchy's Homogeneous Differential Equations

1) Solve $x^2\frac{d^2y}{dx^2} + x\frac{dy}{dx} - 4y = 0$.
2) Solve $x^2\frac{d^2y}{dx^2} - 3x\frac{dy}{dx} + 4y = 2x^2$.

3) Solve $\frac{d^2y}{dx^2} - \frac{1}{x}\frac{dy}{dx} + \frac{y}{x^2} = \frac{2\log x}{x^2}$.

4) Solve $x^2\frac{d^2y}{dx^2} - x\frac{dy}{dx} - 3y = x^2 \log x$.

5) Solve $x^2\frac{d^2y}{dx^2} - 3x\frac{dy}{dx} + 5y = x^2 \sin(\log x)$.

6) Solve $x^2\frac{d^2y}{dx^2} + 4x\frac{dy}{dx} + 2y = e^x$.

7) Solve $x^2\frac{d^2y}{dx^2} - 2x\frac{dy}{dx} - 4y = x^2 + 2\log x$.

8) Solve $\frac{d^2y}{dx^2} - \frac{2}{x}\frac{dy}{dx} - \frac{4y}{x^2} = x^2$.

9) Solve $x^2\frac{d^2y}{dx^2} - x\frac{dy}{dx} + 2y = x\log x$.

10) Solve $x^2\frac{d^2y}{dx^2} - 3x\frac{dy}{dx} + 3y = x^2$.

Practical No.-8: Legendre'sHomogeneous Differential Equations

1) Solve $(2x+1)^2\frac{d^2y}{dx^2} - 2(2x+1)\frac{dy}{dx} - 12y = 6x$.

2) Solve $(1+2x)^2\frac{d^2y}{dx^2} - 6(1+2x)\frac{dy}{dx} + 16y = 8(1+2x)^2$.

3) Solve $(3x+2)^2\frac{d^2y}{dx^2} + 3(3x+2)\frac{dy}{dx} - 36y = 0$.

4) Solve $(3x+2)^2\frac{d^2y}{dx^2} + 3(3x+2)\frac{dy}{dx} - 36y = 3x^2 + 4x + 1$.

5) Solve $(1+x)^2\frac{d^2y}{dx^2} + (1+x)\frac{dy}{dx} + y = 2\sin(\log(1+x))$.

6) Solve $(1+x)^2\frac{d^2y}{dx^2} + (1+x)\frac{dy}{dx} + y = 4\cos(\log(1+x))$.

7) Solve $(x+3)^2\frac{d^2y}{dx^2} - 4(x+3)\frac{dy}{dx} + 6y = \log(x+3)$.

8) Solve $(x+2)^2\frac{d^2y}{dx^2} - (x+2)\frac{dy}{dx} + y = 3x + 4$.

9) Solve $(2x-1)^3\frac{d^3y}{dx^3} + (2x-1)\frac{dy}{dx} - 2y = 0$.

10) Solve $(1+x)^4\frac{d^3y}{dx^3} + 2(1+x)^3\frac{d^2y}{dx^2} - (1+x)^2\frac{dy}{dx} + (1+x)y = 0$.

S.Y. B.Sc. Mathematics (Open Elective)
Semester-IV
MTH-OE-241: Mathematical Logic

Total Hours: 30 **Credits: 2**

Course Objectives	• To acquire concepts of statements, truth values and logical equivalences. • Understanding formal systems, logical reasoning, proof techniques, and applications in various fields such as computer science, philosophy, and mathematics. • To learn about different logical systems, propositional and predicate calculus, proof methods like induction and deduction, and how to analyze and construct logical arguments rigorously. • To know concepts of universal and existential quantifiers.	
Course Outcomes	After successful completion of this course, students are expected to: • Identify statement in logic and truth value of it. • Combine two or more statements. • Construct the truth table and examine logical equivalence of statement patterns. • Use truth tables and logical operators to solve the mathematical problems. • Study the applications of logic to switching circuits.	
Unit	**Content**	**Hours**
Unit I	**Algebra of Propositions:** • Statements, Conjunction, Disjunction. • Negation, Conditional and Bi-Conditional statements. • Propositions • Truth table	**7**
Unit II	**Arguments:** • Tautology and Contradiction • Law of Detachment, • Logical equivalence and Logical equivalent statements • Logical Implication	**8**
Unit III	**Quantifiers:** • Propositional functions and Truth sets • Universal quantifier, Existential quantifier • Negation of proposition which contain quantifiers and counter examples	**7**
Unit IV	**Logic Gates:** • Electronic gates • The AND, OR, NOT, NAND, NOR gates • The Exclusive-OR and Exclusive-NOR gates	**8**
Study Resources	• Lipschutz Seymour (1998).*Set Theory and Related Topics*. Schaum's Series, McGraw-Hill, New York. (Ch.10) • Stoll, R. (1979). *Set Theory and Logic*. Dover Publication, Inc, New York. (Ch.4) • Jan Friso Groote, Rolf Morel, Julien Schmaltz, Adam Watkins (2021). *Logic Gates, Circuits, Processors, Compilers and Computers*. Springer, Switzerland. (Ch.1: 1.1)	

S.Y. B.Sc. Mathematics (Open Elective)
Semester-IV
MTH-OE-242: Matrices and Determinants

Total Hours: 60 **Credits: 2**

Course objectives	• To know the basic need of this course is to understand the concepts and applications of matrices and determinant. • It will improve problem solving and logical thinking abilities of the students. • The concepts of matrices are usefull in finance,animation and robotics. • To use theory of matrices in solving linear equations.
Course outcomes	Upon successful completion of this course the student will be able to: • Understand definition and expansion of determinant. • Understand the concept of Minor and cofactor of determinant and matrices. • Understand the properties and application of matrices and determinat. • Understand the concept of operation on matrices.
Practical No.	**Title**
1	Types of Matrices
2	Addition of Matrices
3	Multiplication of Matrices-I
4	Multiplication of Matrices-II
5	Determinant of Order 2
6	Determinant of Order 3
7	Minor
8	Cofactor
9	Expansion of Determinat-I
10	Expansion of Determinat-I
11	Inverse Matrix-I
12	Inverse Matrix-I
13	Applications of Determinant-I
14	Applications of Determinant-II
15	Applications of Determinant-III

S.Y. B.Sc. Mathematics (Major)
Semester-IV
MTH-FP-241: Field Project

Credits : 2 **Contact hours : 60**

Preamble

In alignment with the National Education Policy (NEP) 2020, Moolji Jaitha College (Autonomous), Jalgaon is introducing the Field Project at the undergraduate level. The NEP 2020 emphasizes holistic development, inclusivity, and integrating vocational education with academic learning, aiming to nurture socially responsible individuals. This course fosters a strong connection between education and real-world applications. These initiatives aim to bridge the gap between theoretical knowledge and practical experience, helping students develop critical thinking, problem-solving skills, and a sense of civic responsibility.

Objectives

- To provide students with practical exposure in rural and urban socioeconomic context.
- To develop students abilities to apply subject knowledge to address real world problems
- To foster critical thinking and innovative approaches to solve socioeconomic issues.

Outcomes

After completing this course, students will be able to

- Participateactively in filed projects that benefit local communities and promote sustainable development practices.
- Analyse the socio economic data using appropriate methods showcasing improved problem-solving skills, technical proficiency.
- Demonstrate the ability to apply theoretical knowledge to real-world situations effectively and exhibit communication skills.

Course structure

The course is divided in to four probable phases

I] Orientation and preparation

- Introduce to the course, objectives and expectation
- Overview of socioeconomic development issues in rural and urban context
- Training on working methodology and data collection techniques
- Review existing literature related to topic to understand the background and context.

II] Work planand Field visit

- Visit the potential sites to get a sense of the environment and logistical requirements.
- Create a detailed project plan outlining the steps, timeline, resources needed, and roles of team members.
- Obtain necessary approvals (Ethical/ local authorities/organizations/communities)
- Gather materials and resources (recording devices, cameras, notebooks and supplies)
- Conduct Preliminary Survey, choose appropriate methods for data collection and analysis (e.g., surveys, interviews, observations).

III] Data collection and analysis

- Pilot test to identify issues with data collection.
- Collect data systematically, ensuring consistency and accuracy.
- Keep detailed records of all data (field notes, recordings, photographs etc)
- Organize and analyse the data (manual/ software)

IV] Interpretation and Reporting

- Interpret your findings in the context to objectives.
- Write and submit a comprehensive report detailing your methodology, findings, analysis, and conclusions. (Include visuals - charts, graphs, and photographs).
- Prepare a presentation to share findings with peers/ instructors/ community.

Assessment

- Field work participation, field note book, team work etc. (10 Marks)
- Data Collection and Analysis (15 Marks)
- Field project report (15 Marks)
- Presentation of Findings(10 Marks)

Examples of activities to be conducted under field projects

- **Biodiversity Survey**: Conduct a biodiversity survey in a local park or nature reserve, documenting plant and animal species.
- **Water Quality Testing**: Test water samples from different sources (e.g., rivers, lakes, groundwater) for pollutants and compare results.
- **Soil Analysis**: Collect soil samples from various locations and analyse their composition and quality.
- **Wildlife Tracking**: Use camera traps or tracking devices to monitor and study the behaviour of local wildlife.
- **Urban Heat Island Effect**: Measure and map temperature differences in various parts of a city.
- **Land Use Mapping**: Create maps showing different land uses in a region and analyze changes over time.
- **Cultural Heritage Documentation**: Document and analyze local cultural heritage sites or practices.
- **Community Interviews**: Conduct interviews with community members to understand social dynamics and traditions.
- **Ethnographic Study**: Participate in and observe community events to gather ethnographic data.
- **Crop Yield Analysis**: Study the factors affecting crop yield in different fields or under different farming practices.
- **Pest Management**: Investigate the effectiveness of various pest management techniques in local farms.
- **Sustainable Farming Practices**: Evaluate the impact of sustainable farming practices on soil health and crop productivity.
- **Community Needs Assessment**: Conduct surveys and interviews to identify the needs and concerns of a community.
- **Social Network Analysis**: Study the social networks within a community to understand relationships and influence.
- **Public Health Study**: Investigate public health issues in a community, such as access to healthcare or prevalence of diseases.
- **Infrastructure Survey**: Assess the condition and effectiveness of local infrastructure, such as roads, bridges, and buildings.
- **Renewable Energy Potential**: Evaluate the potential for renewable energy sources (e.g., solar, wind) in a specific area.
- **Water Management**: Study and improve local water management systems, including irrigation and drainage.
- **Literacy Program Evaluation**: Evaluate the effectiveness of local literacy programs and suggest improvements.
- **Educational Resource Assessment**: Assess the availability and quality of educational resources in local schools.
- **Market Analysis**: Conduct a market analysis for a local business or industry.
- **Entrepreneurship Project**: Develop a business plan for a local entrepreneurial venture
- **Local History Documentation**: Research and document the history of a local site, building, or community.

- **Oral History Project**: Conduct interviews with local residents to collect oral histories and preserve community memories.
- **Archival Research**: Explore local archives to uncover historical documents and artifacts related to a specific topic or period.
- **Community Mural**: Design and create a mural in collaboration with community members that reflects local culture and history.
- **Public Art Installation**: Develop and install a public art project that engages the local community.
- **Art Exhibit Curation**: Curate an exhibit featuring works by local artists, highlighting themes relevant to the community.
- **Music Documentation**: Record and document traditional or contemporary music from the local area.
- **Community Concerts**: Organize and perform in community concerts that showcase local musical talent.
- **Community Theatre Production**: Develop and produce a play that involves community members as actors and crew.
- **Site-Specific Theatre**: Create a theatrical performance that takes place in a non-traditional venue, such as a historic site or public space.
- **Cultural Mapping**: Map cultural resources and heritage sites within the community and analyze their significance.
- **Festival Documentation**: Document and analyze local festivals or cultural events, exploring their history and impact.
- **Ethnographic Study**: Conduct an ethnographic study of a particular cultural practice or community group.
- **Public Philosophy Discussions**: Organize and facilitate public discussions on philosophical topics relevant to the community.
- **Community Documentary**: Create a documentary film about a local issue, event, or group.
- **Digital Storytelling**: Develop digital storytelling projects that capture and share local stories.
- **Language Survey**: Conduct a survey of languages spoken in the community and analyze patterns of language use and change.
- **Dialect Study**: Study and document local dialects or accents, exploring their features and origins.
- **Language Preservation**: Work with community members to document and preserve endangered languages or dialects.
- **Gentrification Impact Study**: Examine the effects of gentrification on local communities, including displacement and economic changes.
- **Crime and Safety Analysis**: Study crime patterns and perceptions of safety within a community.
- **Ritual and Festival Study**: Participate in and document local rituals or festivals to understand their social and cultural significance.
- **Migration Patterns Study**: Analyze migration patterns and their effects on both the sending and receiving communities.
- **Food and Culture Study**: Investigate the role of food in cultural practices and social interactions within a community.
- **Local Governance Analysis**: Study the structure and functioning of local government and its impact on the community.
- **Political Participation Study**: Analyze patterns of political participation and engagement within a community.
- **Public Policy Impact Assessment**: Evaluate the impact of specific public policies on local communities.
- **Election Study**: Analyze voting behavior and patterns in local elections.
- **Mental Health Survey**: Conduct surveys to assess the mental health needs and resources in a community.
- **Social Behavior Observation**: Observe and analyze social behaviors in public spaces, such as parks or markets.
- **Stress and Coping Study**: Investigate sources of stress and coping mechanisms within a community.
- **Community Support Systems**: Study the role and effectiveness of community support systems and networks.
- **Youth Development Programs**: Evaluate the impact of youth development programs on community wellbeing.
- **Educational Equity Study**: Assess disparities in educational resources and outcomes in local schools.

- **Parent and Teacher Interviews**: Conduct interviews to understand perceptions of educational quality and challenges.
- **After-School Program Evaluation**: Evaluate the effectiveness of after-school programs in supporting student development.
- **Educational Attainment Study**: Analyze factors influencing educational attainment in a community.
- **Local Economy Analysis**: Study the structure and dynamics of the local economy, including key industries and employment patterns.
- **Small Business Survey**: Conduct surveys of local small businesses to understand their challenges and successes.
- **Economic Impact of Events**: Analyze the economic impact of local events or festivals on the community.
- **Income Inequality Study**: Investigate patterns and causes of income inequality within a community.
- **Housing Affordability Analysis**: Study housing affordability issues and their impact on residents.
- **Gender Roles and Expectations**: Study gender roles and expectations within a community and their impact on individuals.
- **Women's Health Study**: Investigate issues related to women's health and access to healthcare.
- **Gender-Based Violence Survey**: Conduct surveys to understand the prevalence and impact of gender-based violence.
- **Workplace Equality Study**: Analyze gender equality in local workplaces, including pay equity and job opportunities.
- **Urban Development Projects**: Study the impact of urban development projects on local communities.
- **Public Space Usage**: Analyze how public spaces are used and perceived by different community members.
- **Transportation Study**: Investigate transportation needs and challenges within a community.
- **Green Space Analysis**: Study the availability and usage of green spaces in urban areas and their impact on residents.