RADHA GOVIND UNIVERSITY
RAMGARH, JHARKHAND

DEPARTMENT OF MATHEMATICS

NEP FYUGP CURRICULUM

MATHEMATICS HONOURS/ RESEARCH PROGRAMME

SUBJECT CODE - 017

FOR UNDERGRADUATE COURSES UNDER
RADHA GOVIND UNIVERSITY

Implemented w.e.f.
Academic Session 2023-24 & onwards

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Students are Instructed to

Refer Syllabus of Allied/ Opted Subjects from R.G.U. Website

HIGHLIGHTS OF REGULATIONS OF FYUGP

PROGRAMME DURATION

- The Full-time, Regular UG programme for a regular student shall be for a period of four years with multiple entry and multiple exit options.
- The session shall commence from **1st of July**.

ELIGIBILITY

- The selection for admission will be primarily based on availability of seats in the Major subject and marks imposed by the institution. Merit point for selection will be based on marks obtained in Major subject at Class 12 (or equivalent level) or the aggregate marks of Class 12 (or equivalent level) if Marks of the Major subject is not available. Reservation norms of The Government of Jharkhand must be followed as amended in times.
- UG Degree Programmes with Double Major shall be provided only to those students who secure a minimum of overall 75% marks (7.5 CGPA) or higher.
- Other eligibility criteria including those for multiple entry will be in light of the UGC Guidelines for Multiple Entry and Exit in Academic Programmes offered in Higher Education Institutions.

ADMISSION PROCEDURE

- The reservation policy of the Government of Jharkhand shall apply in admission and the benefit of the same shall be given to the candidates belonging to the State of Jharkhand only. The candidates of other states in the reserved category shall be treated as General category candidates. Other relaxations or reservations shall be applicable as per the prevailing guidelines of the University for FYUGP.

VALIDITY OF REGISTRATION

- Validity of a registration for FYUGP will be for maximum for Seven years from the date of registration.

ACADEMIC CALENDAR

- An Academic Calendar will be prepared by the university to maintain uniformity in the CBCS of the UG Honours Programmes, UG Programmes, semesters and courses in the college run under the university (Constituent/Affiliated).
- **Academic Year:** Two consecutive (one odd + one even) semesters constitute one academic year.
- **Semester:** The Odd Semester is scheduled from **July to December** and the Even Semester is from **January to June**. Each week has a minimum of 40 working hours spread over 6 days.
- Each semester will include – Admission, course work, conduct of examination and declaration of results including semester break.
- In order to undergo 8 weeks' summer internship/ apprenticeship during the summer camp, the Academic Calendar may be scheduled for academic activities as below:
  a) Odd Semester: **From first Monday of August to third Saturday of December**
  b) Even Semester: **From first Monday of January to third Saturday of May**
- An academic year comprising 180 working days in the least is divided into two semesters, each semester having at least 90 working days. With six working days in a week, this would mean that each semester will have 90/ 6 = 15 teaching/ working weeks. Each working week will have 40 hours of instructional time.
- Each year the University shall draw out a calendar of academic and associated activities, which shall be

strictly adhered to. The same is non-negotiable. Further, the Department will make all reasonable endeavors to deliver the programmes of study and other educational services as mentioned in its Information Brochure and website. However, circumstances may change prompting the Department to reserve the right to change the content and delivery of courses, discontinue or combine courses and introduce or withdraw areas of specialization.

PROGRAMME OVERVIEW/ SCHEME OF THE PROGRAMME

- Undergraduate degree programmes of either 3 or 4-year duration, with multiple entries and exit points and re-entry options within this period, with appropriate certifications such as:
  - UG Certificate after completing 1 year (2 semesters) of study in the chosen fields of study provided they complete one vocational course of 4 credits during the summer vacation of the first year or internship/ Apprenticeship in addition to 6 credits from skill-based courses earned during first and second semester.,
  - UG Diploma after 2 years (4 semesters) of study diploma provided they complete one vocational course of 4 credits or internship/ Apprenticeship/ skill based vocational courses offered during first year or second year summer term in addition to 9 credits from skill-based courses earned during first, second, and third semester,
  - Bachelor's Degree after a 3-year (6 semesters) programme of study,
  - Bachelor's Degree (Honours) after a 4-year (8 semesters) programme of study.
  - Bachelor Degree (Honours with Research) after a 4-year (8 semesters) programme of study to the students undertaking 12 credit Research component in fourth year of FYUGP.

CREDIT OF COURSES

The term 'credit' refers to the weightage given to a course, usually in terms of the number of instructional hours per week assigned to it. The workload relating to a course is measured in terms of credit hours. It determines the number of hours of instruction required per week over the duration of a semester (minimum 15 weeks).

a) One hour of teaching/ lecture or two hours of laboratory /practical work will be assigned per class/interaction.
One credit for Theory = 15 Hours of Teaching i.e., 15 Credit Hours
One credit for Practicum = 30 Hours of Practical work i.e., 30 Credit Hours

b) For credit determination, instruction is divided into three major components:
Hours (L) – Classroom Hours of one-hour duration.
Tutorials (T) – Special, elaborate instructions on specific topics of one-hour duration
Practical (P) – Laboratory or field exercises in which the student has to do experiments or other practical work of two-hour duration.

CALCULATION OF MARKS FOR THE PURPOSE OF RESULT

- Student's final marks and the result will be based on the marks obtained in Semester Internal Examination and End Semester Examination organized taken together.
- Passing in a subject will depend on the collective marks obtained in Semester internal and End Semester University Examination both. However, students must pass in Theory and Practical Examinations separately.

PROMOTION CRITERIA

First degree programme with single major:

i. The Requisite Marks obtained by a student in a particular subject will be the criteria for promotion to the next Semester.

ii. No student will be detained in odd Semesters (I, III, V & VII).

iii. To get promotion from Semester-II to Semester-III a student will be required to pass in at least 75% of Courses in an academic year, a student has to pass in minimum 9 papers out of the total 12 papers.

iv. To get promotion from Semester-IV to Semester-V (taken together of Semester I, II, III & IV) a student has to pass in minimum 18 papers out of the total 24 papers.

v. To get promotion from Semester-VI to Semester-VII (taken all together of Semester I, II, III, IV, V & VI) a student has to pass in minimum 26 papers out of the total 34 papers.

vi. However, it will be necessary to procure pass marks in each of the paper before completion of the course.

First degree programme with dual major:

vii. Above criterions are applicable as well on the students pursuing dual degree programmes however first degree programme will remain independent of the performance of the student in dual major courses.

viii. To get eligible for taking ESE, a student will be required to pass in at least 75% of Courses in an academic year.

ix. A student has to pass in minimum 3 papers out of the total 4 papers.

x. It will be a necessity to clear all papers of second major programme in second attempt in succeeding session, failing which the provision of dual major will be withdrawn and the student will be entitled for single first degree programme.

PUBLICATION OF RESULT

- The result of the examination shall be notified by the Controller of Examinations of the University in different newspapers and also on University website.
- If a student is found indulged in any kind of malpractice/ unfair means during examination, the examination taken by the student for the semester will be cancelled. The candidate has to reappear in all the papers of the session with the students of next coming session and his one year will be detained. However, marks secured by the candidate in all previous semesters will remain unaffected.
- There shall be no Supplementary or Re-examination for any subject. Students who have failed in any subject in an even semester may appear in the subsequent even semester examination for clearing the backlog. Similarly, the students who have failed in any subject in an odd semester may appear in the subsequent odd semester examination for clearing the backlog.

Regulation related with any concern not mentioned above shall be guided by the Regulations of the University for FYUGP.

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COURSE STUCTURE FOR FYUGP **'HONOURS/ RESEARCH'**

Table 1: Credit Framework for Four Year Undergraduate Programme (FYUGP) under State Universities of Jharkhand [Total Credits = 160]

Level of Courses	**Semester**	**MJ**; Discipline Specific Courses – Core or Major (80)	**MN**; Minor from discipline (16)	**MN**; Minor from vocational (16)	**MDC**; Multidisciplinary Courses [Life sciences, Physical Sciences, Mathematical and Computer Sciences, Data Analysis, Social Sciences, Humanities, etc.] (9)	**AEC**; Ability Enhancement Courses (Modern Indian Language and English) (8)	**SEC**; Skill Enhancement Courses (9)	**VAC**; Value Added Courses (6)	**IAP**; Internship/ Dissertation (4)	**RC**; Research Courses (12)	**AMJ**; Advanced Courses in lieu of Research (12)	**Credits**	**Double Major (DMJ)**
1	2	3	4	5	6	7	8	9	10	11	12	13	14
100-199: Foundation or Introductory courses	**I**	4	4		3	2	3	4				**20**	4+4
	II	4+4		4	3	2	3					**20**	4+4
	Exit Point: Undergraduate Certificate provided with Summer Internship/ Project (4 credits)												
200-299: Intermediate-level courses	**III**	4+4	4		3	2	3					**20**	4+4
	IV	4+4+4		4		2		2				**20**	4+4
	Exit Point: Undergraduate Diploma provided with Summer Internship in 1st or 2nd year/ Project (4 credits)												
300-399: Higher-level courses	**V**	4+4+4	4						4			**20**	4+4
	VI	4+4+4+4		4								**20**	4+4
	Exit Point: Bachelor's Degree												
400-499: Advanced courses	**VII**	4+4+4+4	4									**20**	4+4
	VIII	4		4						12	4+4+4	**20**	4+4
	Exit Point: Bachelor's Degree with Hons. /Hons. with Research											**160**	**224**

Note: Honours students not undertaking research will do 3 courses for 12 credits in lieu of a Research project / Dissertation.

Upgraded & Implemented from 3rd Sem. of Session 2022-26 & 1st Sem. of Session 2023-27 Onwards

COURSES OF STUDY FOR FOUR YEAR UNDERGRADUATE PROGRAMME **2022 onwards**

Table 2: Semester wise Course Code and Credit Points for Single Major:

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		
	Code	Papers	Credits
I	AEC-1	Language and Communication Skills (MIL 1 - Hindi/ English)	2
	VAC-1	Value Added Course-1	4
	SEC-1	Skill Enhancement Course-1	3
	MDC-1	Multi-disciplinary Course-1	3
	MN-1A	Minor from Discipline-1	4
	MJ-1	Major paper 1 (Disciplinary/Interdisciplinary Major)	4
II	AEC-2	Language and Communication Skills (MIL 2 - English/ Hindi)	2
	SEC-2	Skill Enhancement Course-2	3
	MDC-2	Multi-disciplinary Course-2	3
	MN-2A	Minor from Vocational Studies/Discipline-2	4
	MJ-2	Major paper 2 (Disciplinary/Interdisciplinary Major)	4
	MJ-3	Major paper 3 (Disciplinary/Interdisciplinary Major)	4
III	AEC-3	Language and Communication Skills (Language Elective 1 - Modern Indian language including TRL)	2
	SEC-3	Skill Enhancement Course-3	3
	MDC-3	Multi-disciplinary Course-3	3
	MN-1B	Minor from Discipline-1	4
	MJ-4	Major paper 4 (Disciplinary/Interdisciplinary Major)	4
	MJ-5	Major paper 5 (Disciplinary/Interdisciplinary Major)	4
IV	AEC-3	Language and Communication Skills (Language Elective - Modern Indian language including TRL)	2
	VAC-2	Value Added Course-2	2

	MN-2B	Minor from Vocational Studies/Discipline-2	4
	MJ-6	Major paper 6 (Disciplinary/Interdisciplinary Major)	4
	MJ-7	Major paper 7 (Disciplinary/Interdisciplinary Major)	4
	MJ-8	Major paper 8 (Disciplinary/Interdisciplinary Major)	4
V	MN-1C	Minor from Discipline-1	4
	MJ-9	Major paper 9 (Disciplinary/Interdisciplinary Major)	4
	MJ-10	Major paper 10 (Disciplinary/Interdisciplinary Major)	4
	MJ-11	Major paper 11 (Disciplinary/Interdisciplinary Major)	4
	IAP	Internship/Apprenticeship/Field Work/Dissertation/Project	4
VI	MN-2C	Minor from Vocational Studies/Discipline-2	4
	MJ-12	Major paper 12 (Disciplinary/Interdisciplinary Major)	4
	MJ-13	Major paper 13 (Disciplinary/Interdisciplinary Major)	4
	MJ-14	Major paper 14 (Disciplinary/Interdisciplinary Major)	4
	MJ-15	Major paper 15 (Disciplinary/Interdisciplinary Major)	4
VII	MN-1D	Minor from Discipline-1	4
	MJ-16	Major paper 16 (Disciplinary/Interdisciplinary Major)	4
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4
	MJ-18	Major paper 18 (Disciplinary/Interdisciplinary Major)	4
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4
VIII	MN-2D	Minor from Vocational Studies/Discipline-2	4
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4
	RC/ AMJ-1 AMJ-2 AMJ-3	Research Internship/Field Work/Dissertation OR Advanced Major paper-1 (Disciplinary/Interdisciplinary Major) Advanced Major paper-2 (Disciplinary/Interdisciplinary Major) Advanced Major paper-3 (Disciplinary/Interdisciplinary Major)	12/ 4 4 4
		Total Credit	**160**

NUMBER OF CREDITS BY TYPE OF COURSE

The hallmark of the new curriculum framework is the flexibility for the students to learn courses of their choice across various branches of undergraduate programmes. This requires that all departments prescribe a certain specified number of credits for each course and common instruction hours (slot time).

Table 3: Overall Course Credit Points for Single Major

Courses	Nature of Courses	3 yr UG Credits	4 yr UG Credits
Major	Core courses	60	80
Minor	i. Discipline/ Interdisciplinary courses and ii. Vocational Courses	24	32
Multidisciplinary	3 Courses	9	9
AEC	Language courses	8	8
SEC	**Courses to be developed by the University**	9	9
Value Added Courses	Understanding India, Environmental Studies, Digital Education, Health & wellness, Summer Internship/ Apprenticeship/ Community outreach activities, etc.	6	6
Internship (In any summer vacation for Exit points or in Semester-V)		4	4
Research/ Dissertation/ Advanced Major Courses	Research Institutions/ 3 Courses		12
	Total Credits =	**120**	**160**

Table 4: Overall Course Code and Additional Credit Points for Double Major

Courses	Nature of Courses	3 yr UG Credits	4 yr UG Credits
Major 1	Core courses	60	80
Major 2	Core courses	48	64
Minor	i. Discipline/ Interdisciplinary courses and ii. Vocational Courses	24	32
Multidisciplinary	3 Courses	9	9
AEC	Language courses	8	8
SEC	**Courses to be developed by the University**	9	9
Value Added Courses	Understanding India, Environmental Studies, Digital Education, Health & wellness, Summer Internship/ Apprenticeship/ Community outreach activities, etc.	6	6
Internship (In any summer vacation for Exit points or in Semester-V)		4	4
Research/ Dissertation/ Advanced Major Courses	Research Institutions/ 3 Courses		12
	Total Credits =	**168**	**224**

Table 5: Semester wise Course Code and Additional Credit Points for Double Major:

Semester	Double Major Courses		
	Code	Papers	Credits
I	DMJ-1	Double Major paper-1 (Disciplinary/Interdisciplinary Major)	4
	DMJ-2	Double Major paper-2 (Disciplinary/Interdisciplinary Major)	4
II	DMJ-3	Double Major paper-3 (Disciplinary/Interdisciplinary Major)	4
	DMJ-4	Double Major paper-4 (Disciplinary/Interdisciplinary Major)	4
III	DMJ-5	Double Major paper-5 (Disciplinary/Interdisciplinary Major)	4
	DMJ-6	Double Major paper-6 (Disciplinary/Interdisciplinary Major)	4
IV	DMJ-7	Double Major paper-7 (Disciplinary/Interdisciplinary Major)	4
	DMJ-8	Double Major paper-8 (Disciplinary/Interdisciplinary Major)	4
V	DMJ-9	Double Major paper-9 (Disciplinary/Interdisciplinary Major)	4
	DMJ-10	Double Major paper-10 (Disciplinary/Interdisciplinary Major)	4
VI	DMJ-11	Double Major paper-11 (Disciplinary/Interdisciplinary Major)	4
	DMJ-12	Double Major paper-12 (Disciplinary/Interdisciplinary Major)	4
VII	DMJ-13	Double Major paper-13 (Disciplinary/Interdisciplinary Major)	4
	DMJ-14	Double Major paper-14 (Disciplinary/Interdisciplinary Major)	4
VIII	DMJ-15	Double Major paper-15 (Disciplinary/Interdisciplinary Major)	4
	DMJ-16	Double Major paper-16 (Disciplinary/Interdisciplinary Major)	4
		Total Credit	**64**

Abbreviations:

AEC	Ability Enhancement Courses
SEC	Skill Enhancement Courses
IAP	Internship/Apprenticeship/ Project
MDC	Multidisciplinary Courses
MJ	Major Disciplinary/Interdisciplinary Courses
DMJ	Double Major Disciplinary/Interdisciplinary Courses
MN	Minor Disciplinary/Interdisciplinary Courses
AMJ	Advanced Major Disciplinary/Interdisciplinary Courses
RC	Research Courses

AIMS OF BACHELOR'S DEGREE PROGRAMME IN MATHEMATICS

The broad aims of the LOCF for Mathematics are to:

i. create deep interest in learning mathematics.
ii. develop broad and balanced knowledge and understanding of definitions, concepts, principles and theorems.
iii. familiarize the students with suitable tools of mathematical analysis to handle issues and problems in mathematics and related sciences.
iv. enhance the ability of learners to apply the knowledge and skills acquired by them during the programme to solve specific theoretical and applied problems in mathematics.
v. provide students/learners sufficient knowledge and skills enabling them to undertake further studies in mathematics and its allied areas on multiple disciplines concerned with mathematics.

encourage the students to develop a range of generic skills helpful in employment, internships and social activities.

PROGRAM LEARNING OUTCOMES

The broad programme learning outcomes in Mathematics are:

i. Bachelor's degree in mathematics is the culmination of in-depth knowledge of algebra, calculus, geometry, Mechanics and several other branches of mathematics. This also leads to study of related areas like computer science and statistics. Thus, this programme helps learners in building a solid foundation for higher studies in mathematics.

ii. The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilised in modelling and solving real life problems.

iii. Students undergoing this programme learn to logically question assertions, to recognise patterns and to distinguish between essential and irrelevant aspects of problems. They also share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn behave responsibly in a rapidly changing interdependent society.

iv. Students completing this programme will be able to present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics, describe mathematical ideas from multiple perspectives and explain fundamental concepts of mathematics to non-mathematicians.

v. Completion of this programme will also enable the learners to join teaching profession in primary and secondary schools.

This programme will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises

SEMESTER WISE COURSES IN MATHEMATICS MAJOR-1 FOR FYUGP **2022 onwards**

Table 7: Semester wise Examination Structure in Discipline Courses:

Semester	Courses		Examination Structure			
	Code	Papers	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	MJ-1	Geometry & Calculus	4	25	75	---
II	MJ-2	Multivariable Calculus	4	25	75	---
	MJ-3	Real Analysis-I & Matrices-I	4	25	75	---
III	MJ-4	Ordinary Differential Equations-I	4	25	75	---
	MJ-5	Abstract Algebra-I & Matrices-II	4	25	75	---
IV	MJ-6	Complex Analysis-I	4	25	75	---
	MJ-7	Mechanics	4	25	75	---
	MJ-8	Linear Programming	4	25	75	---
V	MJ-9	Real Analysis-II	4	25	75	---
	MJ-10	Linear Algebra & Hydrostatics	4	25	75	---
	MJ-11	Partial Differential Equations & Calculus of Variations	4	25	75	---
VI	MJ-12	Metric Space	4	25	75	---
	MJ-13	Abstract Algebra-II	4	25	75	---
	MJ-14	Probability & Statistics	4	25	75	---
	MJ-15	Numerical Analysis	4	25	75	---
VII	MJ-16	Advanced Mechanics	4	25	75	---
	MJ-17	Advanced Algebra	4	25	75	---
	MJ-18	Programming in C & Matlab	4	25	75	---
	MJ-19	Practical: Programming in C & Matlab	4	---	---	100
VIII	MJ-20	Ordinary Differential Equations-II	4	25	75	---
	AMJ-1	Real Analysis-III	4	25	75	---
	AMJ-2	Complex Analysis-II	4	25	75	---
	AMJ-3	Topology	4	25	75	---
	or RC-1	Research Methodology	4	25	75	---
	RC-2	Project Dissertation/ Research Internship/ Field Work	8	---	---	200
		Total Credit	**92**			

Table 8: Semester wise Course Code and Credit Points for Skill Enhancement Courses:

Semester	Skill Enhancement Courses		Examination Structure			
	Code	Papers	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	SEC-1	Theory of Sets, Numbers & Equations	3	---	75	---
II	SEC-2	Discrete Mathematics	3	---	75	---
III	SEC-3	Elementary Computer Application Softwares	3	---	75	---
		Total Credit	**9**			

Table 9: Semester wise Course Code and Credit Points for Minor Courses:

Semester	Minor Courses		Examination Structure			
	Code	Papers	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	MN-1A	Calculus	4	25	75	---
III	MN-1B	Set Theory & Algebra	4	25	75	---
V	MN-1C	ODE & Real Analysis	4	25	75	---
VII	MN-1D	PDE & Complex Analysis	4	25	75	---
		Total Credit	**16**			

INSTRUCTION TO QUESTION SETTER

SEMESTER INTERNAL EXAMINATION (SIE):

There will be Only One Semester Internal Examination in Major, Minor and Research Courses, which will be organized at college/institution level. However, Only One End semester evaluation in other courses will be done either at College/ Institution or University level depending upon the nature of course in the curriculum.

A. (SIE 10+5=15 marks):

There will be two group of questions. **Question No.1 will be very short answer type in Group A** consisting of five questions of 1 mark each. **Group B will contain descriptive type** two questions of five marks each, out of which any one to answer.

The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks, (b) Class Attendance Score (CAS) of 5 marks.

B. (SIE 20+5=25 marks):

There will be two group of questions. **Group A is compulsory** which will contain two questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No.2 will be short answer type** of 5 marks. **Group B will contain descriptive type** two questions of ten marks each, out of which any one to answer.

The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 20 Marks, (b) Class Attendance Score (CAS) of 5 marks.

Conversion of Attendance into score may be as follows:

Attendance Upto 45%, 1mark; 45<Attd.<55, 2 marks; 55<Attd.<65, 3 marks; 65<Attd.<75, 4 marks; 75<Attd, 5 marks.

END SEMESTER UNIVERSITY EXAMINATION (ESE):

A. (ESE 60 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No.2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type five questions of fifteen marks each, out of which any three are to answer.

B. (ESE 75 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No. 2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type six questions of fifteen marks each, out of which any four are to answer.

C. (ESE 100 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of ten questions of 1 mark each. **Question No. 2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type six questions of twenty marks each, out of which any four are to answer.

FORMAT OF QUESTION PAPER FOR SEMESTER INTERNAL EXAMINATION

Question format for **10 Marks**:

Subject/ Code

F.M. =10 **Time**=1Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....

Group B

2. ..... [5]
3. ..... [5]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **20 Marks**:

Subject/ Code

F.M. =20 **Time**=1Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]

Group B

3. ..... [10]
4. ..... [10]

Note: There may be subdivisions in each question asked in Theory Examination.

FORMAT OF QUESTION PAPER FOR END SEMESTER UNIVERSITY EXAMINATION

Question format for **50 Marks**:

Subject/ Code

F.M. =50 **Time**=3Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer type **compulsory** questions.
ii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....

Group B

2. ..... [15]
3. ..... [15]
4. ..... [15]
5. ..... [15]
6. ..... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **60 Marks**:

Subject/ Code

F.M. =60 **Time**=3Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer type **compulsory** questions.
ii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [15]
5. ..... [15]
6. ..... [15]
7. ..... [15]
8. ..... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **75 Marks**:

Subject/ Code

F.M. = 75 **Time**=3Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer type **compulsory** questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [15]
5. ..... [15]
6. ..... [15]
7. ..... [15]
8. ..... [15]
9. ..... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **100 Marks**:

Subject/ Code

F.M. = 100 **Time**=3Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer type **compulsory** questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [10x1=10]
   i. ..... vi. .....
   ii. ..... vii. .....
   iii. ..... viii. .....
   iv. ..... ix. .....
   v. ..... x .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [20]
5. ..... [20]
6. ..... [20]
7. ..... [20]
8. ..... [20]
9. ..... [20]

Note: There may be subdivisions in each question asked in Theory Examination.

SEMESTER I

I. MAJOR COURSE –MJ 1: GEOMETRY & CALCULUS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) Theory: 60 Lectures

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Explain the properties of three dimensional shapes.
2. Understand the notion of successive differentiation and express some functions in an infinite series.
3. Evaluate integrals of different rational and irrational functions.
4. Evaluate n^{th} order integration by means of reduction formulae.
5. Sketch curves in Cartesian and polar coordinate systems.

Course Content:

Unit-I: Planes, Straight Lines and Spheres

Planes: Distance of a point from a plane, Angle between two planes, Pair of planes, Bisectors of angles between two planes; *Straight lines:* Equations of straight lines, Distance of a point from a straight line, Distance between two straight lines, Distance between a straight line and a plane; *Spheres:* Different forms, Intersection of two spheres, Orthogonal intersection, Tangents and normal.

Unit-II: Differential Calculus

Successive differentiation: n^{th} order differentiation of Standard functions e^{ax+b}, $(ax+b)^n$, $\log(ax+b)$, $\sin(ax+b)$, $\cos(ax+b)$, $e^{ax}\sin(bx+c)$, $e^{ax}\cos(bx+c)$, Leibnitz's theorem, *Series Expansion:* Maclaurin's and Taylor's theorems for expansion of a function in an infinite series, Taylor's theorem in finite form with Lagrange remainder.

Unit-III: Integral Calculus

Integration of rational and irrational functions, Evaluation of definite integrals, Reduction formulae of $\int \sin^n x\,dx$, $\int \cos^n x\,dx$, $\int \tan^n x\,dx$, $\int \sec^n x\,dx$ and $\int \sin^m x \cos^n x\,dx$, Special integrals, Differentiation and integration under the sign of integration (Beta and Gamma functions are excluded).

Unit-IV: Application of Integral Calculus

Curvature; Asymptotes of general algebraic curves, Asymptotes parallel to axes; Symmetry, Concavity and convexity, Points of inflection, Tangents at origin, Multiple points, Position and nature of double points; Tracing of Cartesian, polar and parametric curves, Length of plane curve and area bounded by plane curves, Volume and surface area of solid of revolution.

Reference Books:

1. D. Chatterjee (2009). *Analytical Geometry: Two and Three Dimensions*. Narosa Publishing House.
2. Lalji Prasad (2019). *Differential Calculus*, Paramount Publication.
3. A. D. Dasgupta, S. B. Prasad & R. S. Prasad (2021). *Degree level Integral Calculus*, Bharti Bhawan.

II. SKILL ENHANCEMENT COURSE- SEC 1: THEORY OF SETS, NUMBERS & EQUATIONS

Marks: 75 (ESE: 3Hrs) = 75	Pass Marks: Th (ESE) = 30

(Credits: Theory-03) **Theory: 45 Lectures**

Course Objectives & Learning Outcome:

This course will enable the students to:

1. Familiarize the basics of set, equivalence class and countability of sets which are essential part of the development of other important mathematical structures.
2. Learn basic number theory which is helpful in notion of higher algebra.
3. Generalize the idea of quadratic equations into higher degree polynomial equations.

UNIT-1: Set Theory

Relations, Equivalence relations, Equivalence classes, Functions, Composition of functions, Inverse of a function, Finite and infinite sets, Countable and uncountable sets, Cardinality of sets, cardinal numbers.

UNIT-2: Number Theory

The division algorithm, Divisibility and Euclidean algorithm, The fundamental theorem of arithmetic, Modular arithmetic and basic properties of congruences, Principles of mathematical induction and well ordering, Diophantine equations.

UNIT-3: Theory of Equations

Elementary theorems on the roots of an equations including Cardan's method, The remainder and factor theorems, Synthetic division, Factored form of a polynomial, The Fundamental theorem of algebra, Relations between the roots and the coefficients of polynomial equations, Imaginary roots, Integral and rational roots; The nth roots of unity, De Moivre's theorem for integer and rational indices and its applications.

Books Recommended:

1. M. K. Gupta (2008). *Discrete Mathematics.* Krishna Prakashan.
2. S. B. Malik (2008). *Basic Number Theory.* Vikas Publishing House.
3. Lalji Prasad (2016). *Theory of Equations.* Paramount Publications.

SEMESTER II

I. MAJOR COURSE- MJ 2:
MULTIVARIABLE CALCULUS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Learn conceptual variations while advancing from one variable to several variables in calculus.
2. Inter-relationship amongst the line integral, double and triple integral formulations.
3. Applications of multivariable calculus in understanding the architecture of curves and surfaces in plane and space etc.
4. Realize importance of Green, Gauss and Stokes' theorems in other branches of mathematics.

Course Content:

Unit-I: Partial Derivatives

Functions of several variables, Partial differentiation, Chain rule, Directional derivatives, Higher order partial derivatives, Total differential and differentiability, Jacobians, Change of variables, Euler's theorem for homogeneous functions, Envelopes and evolutes, Maxima and Minima of a function of two variables, Lagrange's multipliers.

Unit-II: Double & Triple Integration.

Double integration over rectangular and nonrectangular regions, Double integrals in polar coordinates, Applications of Double integrals (surface area), Triple integrals, Volume by triple integrals, Triple integration in cylindrical and spherical coordinates, Change of variables in double and triple integrals.

Unit-III: Vector Field

Vector point function, Scalar point function, Differentiation of a vector function, Derivatives of a sum of vectors, Derivatives of a product of vectors, Gradient, Divergence and Curl and vector identities.

Unit-IV: Green's, Stokes' and Gauss Divergence Theorem

Line integrals, Applications of line integrals: Mass and Work, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral, Surface integrals, Stokes' theorem, The Gauss divergence theorem.

Reference Books:

1. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.
2. James Stewart (2012). *Multivariable Calculus* (7th edition). Brooks/Cole. Cengage.
3. A. S. Dasgupta & S. B. Prasad (2017). *Degree Level Vector Analysis*. Bharti Bhawan.
4. Lalji Prasad (2019). *Differential Calculus*. Paramount Publication.

II. MAJOR COURSE- MJ 3:
REAL ANALYSIS-I & MATRICES-I

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Understand many properties of the real line $\mathbb{R}$ and learn to define sequence in terms of functions from $\mathbb{R}$ to a subset of $\mathbb{R}$.
2. Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
3. Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.
4. Learn some of the properties of Riemann integrable functions, and the applications of the fundamental theorems of integration.
5. Assimilate notions of matrix operations and cultivate them in calculating ranks and solve system of linear equations.

Course Content:

Unit-I: Real Number System

Algebraic and order properties of $\mathbb{R}$, Absolute value of a real number; Bounded above and bounded below sets, Supremum and infimum of a nonempty subset of $\mathbb{R}$, The completeness property of $\mathbb{R}$, Archimedean property, Density of rational numbers in $\mathbb{R}$, Definition and types of intervals, Neighborhood of a point in $\mathbb{R}$, Open, closed and perfect sets in $\mathbb{R}$

Unit-II: Sequences of Real Numbers

Convergent sequence, Limit of a sequence, Bounded sequence, Limit theorems, Monotone sequences, Weierstrass' theorem for–sequences, Monotone convergence theorem, Subsequences, Bolzano sequences, Limit superior and limit inferior of a sequence of real numbers, Cauchy sequence, Cauchy's convergence criterion.

Unit-III: Infinite Series

Convergence and divergence of infinite series of positive real numbers, Necessary condition for convergence, Cauchy criterion for convergence; Tests for convergence of positive term series; Basic comparison test, Limit comparison test, D'Alembert's ratio test, Cauchy's nth root test, Integral test; Alternating series, Leibniz test, Absolute and conditional convergence.

Unit-IV: Matrices and Applications

Matrix operations, Row reduction and echelon forms, The rank of a matrix, Systems of linear equations.

Reference Books:

1. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.
2. Shanti Narayan & M. D. Raisinghania (2020). *Elements of Real Analysis*. S. Chand.
3. Shanti Narayan & P. K. Mittal (2010). *A Textbook of Matrices*. S. Chand.
4. A. R. Vashishtha (2014). *Matrices*. Krishna Prakashan.

III. SKILL ENHANCEMENT COURSE- SEC 2:
DISCRETE MATHEMATICS

Marks: 75 (ESE: 3Hrs) = 75	Pass Marks: Th (ESE) = 30

(Credits: Theory-03) **Theory: 45 Lectures**

Course Objectives & Learning Outcome:

This course will enable the students to:

1. Stretch the concept of set theory into discrete mathematical structure called partially ordered set.
2. Study the lattices and related properties.
3. Learn representation of many physical problems diagrammatically (called graphs) and develop the methods of solution through various Graph theoretic techniques.

UNIT-I: Posets

Definitions, examples and basic properties of partially ordered sets (poset), Order isomorphism, Hasse diagrams, Dual of a poset, Duality principle, Maximal and minimal elements, Least upper bound and greatest upper bound, Building new poset, Maps between posets.

UNIT-II: Lattices

Lattice as Poset, Lattices as algebraic structures, Sublattices, Products and homomorphisms; Definitions, examples and properties of modular and distributive lattices; Complemented, relatively complemented and sectionally complemented lattices.

UNIT-III: Graph Theory

Definition, examples and basic properties of graphs, Königsberg bridge problem; Subgraphs, Complete graphs, Bipartite graphs, Isomorphism of graphs, Paths and circuits, Eulerian Circuits, Hamiltonian Cycles, Adjacency Matrix, Weighted Graph, Traveling Salesman's Problem, Shortest Path, Dijkstra's Algorithm.

Books Recommended:

1. M. K. Gupta (2008). *Discrete Mathematics.* Krishna Prakashan.
2. Edgar G. Goodaire and Michael M. Parmenter (2003). *Discrete Mathematics with Graph Theory.* Pearson.

SEMESTER III

I. MAJOR COURSE- MJ 4:
ORDINARY DIFFERENTIAL EQUATIONS-I

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Understand the genesis of ordinary differential equations.
2. Learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
3. Grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.
4. Formulate mathematical models in the form of ordinary differential equations to suggest possible solutions of the day to day problems arising in physical, chemical and biological disciplines.

Course Content:

Unit-I: First Order Differential Equations

Basic concepts and genesis of ordinary differential equations, Order and degree of a differential equation, Differential equations of first order and first degree, Equations in which variables are separable, Homogeneous equations, Linear differential equations and equations reducible to linear form, Exact differential equations, Integrating factor, First order higher degree equations solvable for x, y and p. Clairaut's form and singular solutions. Statement of Picard's theorem for the existence and uniqueness of the solutions of the first order differential equations.

Unit-II: Second Order Linear Differential Equations

Statement of existence and uniqueness theorem for linear differential equations, General theory of linear differential equations of second order with variable coefficients, Solutions of homogeneous linear ordinary differential equations of second order with constant coefficients, Transformations of the equation by changing the dependent/independent variable, Method of variation of parameters and method of undetermined coefficients.

Unit-III: Higher Order Linear Differential Equations

Linearly dependent and linearly independent solutions on an interval, Wronskian and its properties, Concept of a general solution of a linear differential equation, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler-Cauchy equation, Method of variation of parameters and method of undetermined coefficients.

Unit-IV: Applications

Orthogonal trajectories, Acceleration-velocity model, Minimum velocity of escape from Earth's gravitational field, Growth and decay models, Malthusian and logistic population models, Radioactive decay, Drug assimilation into the blood of a single cold pill.

Reference Books:

1. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.
2. M. D. Raisinghania (2013). *Ordinary and Partial Differential Equations* (15th edition). S. Chand.
3. B. Rai, D. P. Choudhury & H. I. Freedman (2013). *A Course in Ordinary Differential Equations* (2nd edition). Narosa.

II. MAJOR COURSE- MJ 5:
ABSTRACT ALGEBRA-I & MATRICES-II

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives &Learning Outcomes:

This course will enable the students to:

1. Recognize the mathematical objects called groups.
2. Link the fundamental concepts of groups and symmetries of geometrical objects.
3. Explain the significance of the notions of cosets, normal subgroups, and factor groups.
4. Analyze consequences of Lagrange's theorem.
5. Learn about structure preserving maps between groups and their consequences.
6. Comprehend the notion of eigenvalues and eigen functions and related results.

Course Content:

Unit-I: Groups and Subgroups

Definition and examples of groups including dihedral, permutation and quaternion groups, Elementary properties of groups. Subgroups and examples of subgroups, Cyclic groups, Properties of cyclic groups, Lagrange's theorem, Euler phi function, Euler's theorem, Fermat's little theorem.

Unit-II: Normal Subgroups and Permutation Groups

Properties of cosets, Normal subgroups, Simple groups, Factor groups, Cauchy's theorem for finite abelian groups; Centralizer, Normalizer, Center of a group, Product of two subgroups; Classification of subgroups of cyclic groups, Cycle notation for permutations, Properties of permutations, Even and odd permutations, alternating groups, Cayley's theorem and its applications.

UNIT-III: Group Homomorphisms

Group homomorphisms, Properties of homomorphisms, Group isomorphisms, Properties of isomorphisms; First, second and third isomorphism theorems for groups.

UNIT-IV: Eigenvalues & Eigen functions of a Matrix

Eigenvalues and eigen vectors, The characteristic equation and the Caley-Hamilton theorem.

Reference Books:

1. P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul (2003). *Basic Abstract Algebra (*2nd edition). Cambridge University Press.
2. S. Singh & Q. Zamiruddin (2022). *Modern Algebra.,* Vikas Publishing House.
3. John B. Fraleigh (2007). *A First Course in Abstract Algebra* (7th edition). Pearson.
4. Joseph A. Gallian (2017). *Contemporary Abstract Algebra* (9th edition). Cengage.
5. N. S. Gopalakrishnan (1986). *University Algebra.* New Age International Publishers.
6. N. Herstein (2006). *Topics in Algebra* (2nd edition). Wiley India.
7. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.
8. A. R. vashishtha (2014). *Matrices*. Krishna Prakashan.

III. SKILL ENHANCEMENT COURSE- SEC 3:
ELEMENTARY COMPUTER APPLICATION SOFTWARES

Marks: 75 (ESE: 3Hrs) = 75	Pass Marks: Th (ESE) = 30

A Common Syllabus for FYUGP (Credits: Theory-03) **45 Hours**

Instruction to Question Setter for
End Semester Examination (ESE):
*There will be **objective type test** consisting of **Seventy-five questions of 1 mark each**. Students are required to mark their answer on **OMR Sheet** provided by the University.*

Course Objectives:

The objective of the course is to generate qualified manpower in the area of Information Technology (IT) and Graphic designing which will enable such person to work seamlessly at any Offices, whether Govt. or Private or for future entrepreneurs in the field of IT.

A. INTRODUCTION TO COMPUTER SYSTEM

1. Basic Concept of Computer: What is Computer, Applications of Computer, Types of computer, Components of Computer System, Central Processing Unit (CPU) **(3 Hours)**

2. Concepts of Hardware: Input Devices, Output Devices, Computer Memory, Types of Memory, processing Concept of Computer **(4 Hours)**

3. Operating system: What is an Operating System, Operating System Examples, Functions of Operating System (Basic), Introduction to Windows 11, Working on Windows 11 environment, Installation of Application Software, My Computer, Control Panel, searching techniques in windows environment, Basic of setting **(6 Hours)**

4. Concept of Software: What is Software, Types of Software, Computer Software- Relationship between Hardware and Software, System Software, Application Software, some high level languages **(4 Hours)**

5. Internet & its uses: Basic of Computer networks; LAN, WAN, MAN, Concept of Internet, Applications of Internet; connecting to internet, what is ISP, World Wide Web, Web Browsing software's, Search Engines, URL, Domain name, IP Address, using e-governance website, Basics of electronic mail, getting an email account, Sending and receiving emails. **(6 Hours)**

B. MICROSOFT OFFICE 2016 AND LATEST VERSIONS

6. Microsoft Word: Word processing concepts, Creation of Documents, Formatting of Documents, Formatting of Text, Different tabs of word 2016 environment, Formatting Page, Navigation of Page, Table handling, Header and footer, Page Numbering, Page Setup, Find and Replace, Printing the documents **(7 Hours)**

7. Microsoft Excel (Spreadsheet): Spreadsheet Concepts, Creating, Saving and Editing a Workbook, Inserting, Deleting Work Sheets, Formatting worksheet, Excel Formula, Concept of charts and Applications, Pivot table, goal seek, Data filter, data sorting and scenario manager, printing the spreadsheet **(6 Hours)**

8. Microsoft Power Point (Presentation Package): Concept and Uses of presentation package, Creating, Opening and Saving Presentations, working in different views in Power point, Animation, slide show, Master Slides, Creating photo album, Rehearse timing and record narration **(5 Hours)**

9. Digital Education: What is digital education, Advantages of digital Education, Concept of e-learning, Technologies used in e learning **(4 Hours)**

Reference Books

1. Nishit Mathur, Fundamentals of Computer, APH publishing corporation (2010)
2. Neeraj Singh, Computer Fundamentals (Basic Computer), T Balaji, (2021)
3. Joan Preppernau, Microsoft Power Point 2016 step by step, Microsoft press (2015)
4. Douglas E Corner, The Internet Book 4th Edition, prentice –Hall (2009)
5. Steven Welkler, Office 2016 for beginners, Create Space Independent Publishing Platform (2016)
6. Wallace Wang, Microsoft Office 2019, Wiley (January 2018)
7. Noble Powell, Windows 11 User Guide For Beginners and Seniors, ASIN, (October 2021)

SEMESTER IV

I. MAJOR COURSE- MJ 6: COMPLEX ANALYSIS-I

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Visualize complex numbers as points of $\mathbb{R}^2$ and stereographic projection of complex plane on the Riemann sphere.
2. Understand the significance of differentiability and analyticity of complex functions leading to the Cauchy–Riemann equations.
3. Understand the convergence, term by term integration and differentiation of a power series.
4. Learn Taylor and Laurent series expansions of analytic functions
5. Understand notion of conformal representation and bilinear transformation.

Course Content:

Unit-I: Complex Plane and functions.

Complex numbers and their representation, algebra of complex numbers; Complex plane, Open set, Domain and region in complex plane; Stereographic projection and Riemann sphere; Complex functions and their limits including limit at infinity; Continuity.

Unit-II: Analytic Functions and Cauchy–Riemann Equations

Differentiability of a complex valued function, Cauchy–Riemann equations, Harmonic functions, necessary and sufficient conditions for differentiability, Analytic functions; Analyticity and zeros of exponential, trigonometric and logarithmic functions; Branch cut and branch of multi-valued functions.

Unit-III: Power Series

Sequences, Series and their convergence, Taylor series and Laurent series of analytic functions, Power series, Radius of convergence, Integration and differentiation of power series, Absolute and uniform convergence of power series.

Unit-IV: Conformal Representation

Transformation, Jacobian, Conformal transformation, Some general transformations, Bilinear transformation, Critical points, Fixed points, Cross ratio, Preservance of cross ratio, Fixed points of bilinear transformation.

Reference Books:

1. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.
2. J. W. Brown & R. V. Churchill (2009). *Complex Variables and Applications.* McGraw-Hill International Ed.
3. Lars V. Ahlfors (2017). *Complex Analysis* (3rd edition). McGraw-Hill Education.
4. J. N. Sharma (2014). *Functions of a complex variable.* Krishna Prakashan.
5. J. K. Goyal & K. P. Gupta (2008). *Functions of a complex variable.* Pragati Prakashan

II. MAJOR COURSE- MJ 7:
MECHANICS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Familiarize with subject matter, which has been the single centre, to which were drawn mathematicians, physicists, astronomers, and engineers together.
2. Understand necessary conditions for the equilibrium of particles acted upon by various forces and learn the principle of virtual work for a system of coplanar forces acting on a rigid body.
3. Determine the centre of gravity of some materialistic systems and discuss the equilibrium of a uniform cable hanging freely under its own weight.
4. Deal with the kinematics and kinetics of the rectilinear and planar motions of a particle including the constrained oscillatory motions of particles.
5. Learn that a particle moving under a central force describes a plane.

Course Content:

Unit-I: Statics

Equilibrium of a particle, Equilibrium of a system of particles, Necessary conditions of equilibrium, Moment of a force about a point, Moment of a force about a line, Couples, Moment of a couple, Equipollent system of forces, Work and potential energy, Principle of virtual work for a system of coplanar forces acting on a particle or at different points of a rigid body, Forces which can be omitted in forming the equations of virtual work.

Unit-II: Centre of Gravity and Common Catenary

Centre of gravity of plane area including a uniform thin straight rod, triangle, circular arc, Semicircular area and quadrant of a circle, Centre of gravity of a plane area bounded by a Curve, Centre of gravity of a volume of revolution; Flexible strings, Common catenary, Intrinsic and Cartesian equations of the common catenary, Approximations of the catenary.

Unit-III: Rectilinear Motion

Simple harmonic motion (SHM) and its geometrical representation, SHM under elastic forces, Motion under inverse square law, Motion in resisting media, Concept of terminal velocity, Motion of varying mass.

Unit-IV: Motion in a Plane

Kinematics and kinetics of the motion, Expressions for velocity and acceleration in Cartesian, Polar and intrinsic coordinates; Motion in a vertical circle, projectiles in a vertical plane and cycloidal motion.

Reference Books:

1. P. L. Srivatava (1964). Elementary Dynamics. Ram Narin Lal, Beni Prasad Publishers Allahabad.
2. S. Ramsey (2009). Statics. Cambridge University Press.
3. S. Ramsey (2009). Dynamics. Cambridge University Press.
4. R. S. Varma (1962). A Text Book of Statics. Pothishala Pvt. Ltd.
5. A. R. Vashishtha (2020). *Statics and Dynamics*. Krishna.

III. MAJOR COURSE- MJ 8:
LINEAR PROGRAMMING

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Analyze and solve linear programming models of real life situations.
2. Provide graphical solutions of linear programming problems with two variables, and illustrate the concept of convex set and extreme points.
3. Understand the theory of the simplex method.
4. Know about the relationships between the primal and dual problems, and to understand sensitivity analysis.
5. Learn about the applications to transportation and assignment.

Course Content:

Unit-I: Linear Programming Problem, Convexity and Basic Feasible Solutions

Formulation, Canonical and standard forms, Graphical method; Convex and polyhedral sets, Hyperplanes, Extreme points; Basic solutions, Basic Feasible Solutions, Reduction of feasible solution to basic feasible solution, Correspondence between basic feasible solutions and extreme points.

Unit-II: Simplex Method

Optimality criterion, Improving a basic feasible solution, Unboundedness, Unique and alternate optimal solutions; Simplex algorithm and its tableau format; Artificial variables, Two-phase method, Big-M method.

Unit-III: Duality

Formulation of the dual problem, Duality theorems, Complimentary slackness theorem, Economic interpretation of the dual, Dual-simplex method.

Unit-IV: Applications to Transportation & Assignment Problems

Definition and formulation, Methods of finding initial basic feasible solutions: Northwest-corner rule, Least-cost method, Vogel approximation method; Algorithm for obtaining optimal solution. Assignment Problem: Mathematical formulation and Hungarian method.

Reference Books:

1. Mokhtar S. Bazaraa, John J. Jarvis & Hanif D. Sherali (2010). *Linear Programming and Network Flows* (4th edition). John Wiley & Sons.
2. G. Hadley (2002). *Linear Programming*. Narosa Publishing House.
3. Hamdy A. Taha (2017). *Operations Research: An Introduction* (10th edition). Pearson.
4. S. D. Sharma (2012). *Operation Research (Theory Methods and Applications*). Kedar Nath.
5. R. K. Gupta (2014). *Linear Programming.* Krishna prakashan.
6. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.

SEMESTER V

I. MAJOR COURSE- MJ 9:
REAL ANALYSIS-II

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Know analytical approach to limit and continuity of a real function.
2. Understand the differentiability of a real function from analytical stand point.
3. Learn theory of Integration from Riemann's approach.
4. Determine the convergence of improper integrals.
5. Grasp the Beta & Gamma functions and their properties along with multiple integrals and their extensions.

Course Content:

Unit-II: Limit and Continuity

Limit: δ-s definition of limit of a real valued function, Limit at infinity and infinite limits; *Continuity:* Continuity of a real valued function, Properties of continuous functions, Intermediate value theorem, Geometrical interpretation of continuity, Types of discontinuity; Uniform continuity.

Unit-III: Differentiability

Differentiability of a real valued function, Geometrical interpretation of differentiability, Relation between differentiability and continuity, Differentiability and monotonicity, Chain rule of differentiation; Darboux's theorem, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Geometrical interpretation of mean value theorems.

Unit-IV: Riemann Integration

Riemann integral, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, First mean value theorem, Bonnet and Weierstrass forms of second mean value theorems.

Unit-V: Improper integrals

Improper integrals, Dirichlet test and Abel's test for improper integrals, Definition & convergence of Beta & Gamma functions and their properties, duplication formula, inter-relation, Multiple Integrals of Dirichlet's form, Liouville's extension, Change of order of integration and change of variables.

Reference books:

1. Shanti Narayan & M. D. Raisinghania (2020). *Elements of Real Analysis.* S. Chand.
2. J. N. Sharma & A. R. Vashishtha (2014). *Mathematical Analysis-II.* Krishna Prakashan.
3. Robert G. Bartle & Donald R. Sherbert (2015). *Introduction to Real Analysis* (4th edition).Wiley India.

II. MAJOR COURSE- MJ 10:
LINEAR ALGEBRA & HYDROSTATICS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Find eigenvalues and corresponding eigenvectors for a square matrix.
2. Understand the concepts of vector spaces, subspaces, bases, dimension and their properties.
3. Relate matrices and linear transformations, compute eigen values and eigen vectors of linear transformations.
4. Know isomorphisms of vector spaces and their duality.
5. Understand the basic properties of fluids under different circumstances.

Course Content:

Unit-I: Vector Spaces

Definition and examples, Subspace, Linear span, Quotient space and direct sum of subspaces, Linearly independent and dependent sets, Bases and dimension.

Unit-II: Linear Transformations

Definition and examples, Algebra of linear transformations, Matrix of a linear transformation, Change of coordinates, Rank and nullity of a linear transformation and rank-nullity theorem.

Unit-III: Further Properties of Linear Transformations

Isomorphism of vector spaces, Isomorphism theorems, Dual and second dual of a vector space, Transpose of a linear transformation, Eigen vectors and eigen values of a linear transformation, Characteristic polynomial and Cayley–Hamilton theorem, Minimal polynomial.

Unit-IV: Hydrostatics

Nature and properties of fluid pressure, Pressure of heavy liquids, Equilibrium of fluids under given system of forces, Centre of pressure, Thrust on plane and curved surfaces.

Reference Books:

1. A. R. Vashishtha, J. N. Sharma & A. K. Vashishtha (2010). *Linear Algebra.* Krishna Publication.
2. Kenneth Hoffman & Ray Kunze (2015). *Linear Algebra* (2nd edition). Prentice-Hall.
3. Vivek Sahai & Vikas Bist (2013). *Linear Algebra* (2nd Edition). Narosa Publishing House.
4. Gilbert Strang (2014). *Linear Algebra and its* Applications (2nd edition). Elsevier.
5. M. Rahman (2009). Hydrostatics (2nd edition). New Central Book Agency.

III. MAJOR COURSE- MJ 11:
PARTIAL DIFFERENTIAL EQUATIONS & CALCULUS OF VARIATIONS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Apply a range of techniques to solve first & second order partial differential equations.
2. Model physical phenomena using partial differential equations such as the heat and wave equations.
3. Understand problems, methods and techniques of calculus of variations.

Course Content:

Unit-I: First Order Partial Differential Equations

Order and degree of Partial differential equations (PDE), Concept of linear and non-linear partial differential equations, Partial differential equations of the first order, Lagrange's method, Some special type of equation which can be solved easily by methods other than the general method, Charpit's general method.

Unit-II: Second Order Partial Differential Equations with Constant Coefficients

Classification of linear partial differential equations of second order, Homogeneous and nonhomogeneous equations with constant coefficients.

Unit-III: Second Order Partial Differential Equations with Variable Coefficients

Partial differential equations reducible to equations with constant coefficient, Second order PDE with variable coefficients, Classification of second order PDE, Reduction to canonical or normal form; Monge's method; Solution of heat and wave equations in one and two dimensions by method of separation of variables.

Unit-IV: Calculus of Variations-Variational problems with fixed boundaries

Euler's equation for functional containing first order and higher order total derivatives, Functionals containing first order partial derivatives, Variational problems in parametric form, Invariance of Euler's equation under coordinates transformation.

Reference books:

1. M. D. Raisinghania (2013). *Ordinary and Partial Differential Equations* (15th edition). S. Chand.
2. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.
3. A. S. Gupta (2004). *Calculus of Variations with Applications*. PHI Learning.

SEMESTER VI

I. MAJOR COURSE- MJ 12: METRIC SPACE

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Generalize the idea obtained in Real analysis.
2. Develop the concept of metric space and related properties.
3. Learn the idea of completeness of a space with its properties.
4. Understand the compactness of metric space.
5. Assimilate the idea of connectedness in metric space.

Course Content:

Unit-I: Concepts in Metric Spaces

Definition and examples of metric spaces, Open spheres and closed spheres, Neighbourhoods, Open sets, Interior, exterior and boundary points, Closed sets, Limit points and isolated points, Interior and closure of a set, Boundary of a set, Bounded sets, Distance between two sets, Diameter of a set, Subspace of a metric space.

Unit-II: Complete Metric Spaces and Continuous Functions

Cauchy and Convergent sequences, Completeness of metric spaces, Cantor's intersection theorem, Dense sets and separable spaces, Nowhere dense sets and Baire's category theorem, Continuous and uniformly continuous functions, Homeomorphism, Banach contraction principle.

Unit-III: Compactness

Weierstrass property, Compactness and–Compact spaces, Sequential compactness, Bolzano Borel theorem, Totally bounded sets, Equivalence of–finite intersection property, Heine compactness and sequential compactness, Continuous functions on compact spaces.

Unit-IV: Connectedness

Separated sets, Disconnected and connected sets, Components, Connected subsets of $\mathbb{R}$, Continuous functions on connected sets.

Reference books:

1. P. K. Jain & Khalil Ahmad (2019). *Metric Spaces*. Narosa.
2. G. F. Simmons (2004). *Introduction to Topology and Modern Analysis*. McGraw-Hill.
3. Shanti Narayan & M. D. Raisinghania (2020). *Elements of Real Analysis.* S. Chand.
4. Satish Shirali & Harikishan L. Vasudeva (2006). *Metric Spaces*. Springer-Verlag.

II. MAJOR COURSE- MJ 13:
ABSTRACT ALGEBRA-II

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Know the fundamental concepts in ring theory such as the concepts of ideals, quotient rings, integral domains, and fields.
2. Learn about structure preserving maps among Rings and their properties.
3. Deal with the Polynomial Rings over commutative rings and rational fields.
4. Grasp the idea of irreducibility of polynomials in a Ring.
5. Familiarize with Factorization theory and related algebra.

Unit-I: Rings and Ideals

Definitions and examples of Rings, commutative ring, ring with unity, unit in a ring, Matrix ring, Boolean ring, Ring of continuous functions, Nilpotent element, idempotent element, Integral domain, Division Ring and Field, Properties of ring, Subrings and Ideals, Prime ideal, maximal ideal, Algebra of Ideals, Characteristic of a ring.

Unit-II: Ring Homomorphism and Fields

Quotient rings, Ring Homomorphism and Isomorphism, Properties of Ring Homomorphism, Kernels and related properties, Fundamental theorem of Homomorphism, First and second theorems of Isomorphism, Field of Quotients.

Unit-III: Polynomial Rings

Polynomial rings over commutative ring and their basic properties, The division algorithm; Remainder theorem, Factor theorem, Polynomial rings over rational field, Irreducible and Reducible Polynomial, Primitive polynomial, Gauss lemma and Eisenstein's criterion.

Unit-IV: Factorization Theory

Divisibility, Euclidean Domains, Principal Ideal domain, Unique Factorization domain. Relationship among Euclidean domain, Principal Ideal domain, Unique factorization domain.

Reference books:

1. S. Singh & Q. Zamiruddin (2008). *Modern Algebra.* Vikas Publishing House.
2. P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul (2003). *Basic Abstract Algebra* (2nd edition). Cambridge University Press.
3. John B. Fraleigh (2007). *A First Course in Abstract Algebra* (7th edition). Pearson.
4. Joseph A. Gallian (2017). *Contemporary Abstract Algebra* (9th edition). Cengage.
5. N. S. Gopalakrishnan (1986). *University Algebra.* New Age International Publishers.
6. I. N. Herstein (2006). *Topics in Algebra* (2nd edition). Wiley India

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III. MAJOR COURSE- MJ 14:
PROBABILITY & STATISTICS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Understand distributions in the study of the joint behaviour of two random variables.
2. Establish a formulation helping to predict one variable in terms of the other that is, correlation and linear regression.
3. Understand central limit theorem, which establish the remarkable fact that the empirical frequencies of so many natural populations, exhibit a bell-shaped curve.

Course Content:

Unit-I: Probability Functions and Moment Generating Function

Basic notions of probability, Conditional probability and independence, Baye's theorem; Random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions; Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function.

Unit-II: Univariate Discrete and Continuous Distributions

Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution.

Unit-III: Bivariate Distribution

Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations.

Unit-IV: Sampling and Estimation Theory

Sampling Theory, Random samples and Random numbers, Sampling with and without Replacement, Sampling distribution of Means, Proportions, differences and Sums, Unbiased Estimates, Efficient estimates, Point and Interval estimates, Confidence-interval estimates of population parameters.

Reference Books:

1. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.
2. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, (2013). *Introduction to Mathematical Statistic.* Pearson Education, Asia.
3. Irwin Miller and Marylees Miller, John E. Freund (2014). *Mathematical Statistics with Applications*, 7th Ed., Pearson Education, Asia.
4. S C Gupta & V K Kapoor (2014). *Fundamentals of Mathematical Statistics*. S. Chand.

IV. MAJOR COURSE- MJ 15: NUMERICAL ANALYSIS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Obtain numerical solutions of algebraic and transcendental equations.
2. Find numerical solutions of system of linear equations and check the accuracy of the solutions.
3. Learn about various interpolating and extrapolating methods.
4. Apply various numerical methods to differentiation and integration.

Course Content:

Unit-I: Numerical Methods for Solving Algebraic and Transcendental Equations

Round-off error and computer arithmetic, Local and global truncation errors, Algorithms and convergence; Bisection method, False position method, Fixed point iteration method, Newton's method and secant method for solving equations.

Unit-II: Numerical Methods for Solving Linear Systems

Partial and scaled partial pivoting, Lower and upper triangular (LU) decomposition of a matrix and its applications, Thomas method for tridiagonal systems; Gauss–Jacobi, Gauss–Seidel and successive over-relaxation (SOR) methods.

Unit-III: Interpolation

Lagrange and Newton interpolations, Piecewise linear interpolation, Cubic spline interpolation, Finite difference operators, Gregory–Newton forward and backward difference interpolations.

Unit-IV: Numerical Differentiation and Integration

First order and higher order approximation for first derivative, Approximation for second derivative; Derivative using forward, backward and central difference interpolation formulae, General quadrature formula, Trapezoidal rule, Simpson's rules and error analysis, Weddle's rule, Newton-Cote's method. Solution of ordinary differential equations: Picard's method of successive approximations.

Reference Books:

1. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.
2. Wiley Brian Bradie (2006), *A Friendly Introduction to Numerical Analysis*. Pearson.
3. P.P. Gupta, G.S. Malik, J.P. Chauhan (2020). *Calculus of Finite Differences & Numerical Analysis,* Krishna Publication.
4. G. Shankar Rao (2018). *Numerical Analysis*. New Age.

SEMESTER VII

I. MAJOR COURSE- MJ 16:
ADVANCED MECHANICS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives &Learning Outcomes:

This course will enable the students to:

1. Understand the reduction of force system in three dimensions to a resultant force acting at a base point and a resultant couple, which is independent of the choice of base of reduction.
2. Learn about a nul point, a nul line, and a nul plane with respect to a system of forces acting on a rigid body together with the idea of central axis.
3. Know the inertia constants for a rigid body and the equation of momental ellipsoid together with the idea of principal axes and principal moments of inertia and to derive Euler's equations of motion of a rigid body, moving about a point which is kept fixed.
4. Study the kinematics and kinetics of fluid motions to understand the equation of continuity in Cartesian, cylindrical polar and spherical polar coordinates which are used to derive Euler's equations and Bernoulli's equation.

Course Content:

Unit-I: Statics in Space

Forces in three dimensions, Reduction to a force and a couple, Equilibrium of a system of particles, Central axis and Wrench, Equation of the central axis, Resultant wrench of two wrenches; Null points, lines and planes with respect to a system of forces, Conjugate forces and conjugate lines.

Unit-II: Motion of a Rigid Body

Moments and products of inertia of some standard bodies, Momental ellipsoid, Principal axes and moments of inertia; Motion of a rigid body with a fixed point, Kinetic energy of a rigid body with a fixed point and angular momentum of a rigid body, Euler's equations of motion for a rigid body with a fixed point, Velocity and acceleration of a moving particle in cylindrical and spherical polar coordinates, Motion about a fixed axis, Compound pendulum.

Unit-III: Kinematics of Fluid Motion

Lagrangian and Eulerian approaches, Material and convective derivatives, Velocity of a fluid at a point, Equation of continuity in Cartesian, cylindrical polar and spherical polar coordinates, Cylindrical and spherical symmetry, Boundary surface, Streamlines and pathlines, Steady and unsteady flows, Velocity potential, Rotational and irrotational motion, Vorticity vector and vortex lines.

Unit-IV: Kinetics of Fluid Motion

Euler's equations of motion in Cartesian, cylindrical polar and spherical polar coordinates; Bernoulli's equation, Impulsive motion.

Reference Books:

1. S. Ramsay (1960). *A Treatise on Hydromechanics, Part-II Hydrodynamics*. G. Bell & Sons.
2. F. Chorlton (1967). *A Textbook of Fluid Dynamics*. CBS Publishers.
3. Michel Rieutord (2015). *Fluid Dynamics, An Introduction*. Springer.
4. E. A. Milne (1965). *Vectorial Mechanics*, Methuen & Co. Limited. London.
5. A. R. Vashishtha (2007). *Dynamics*. Krishna Publication.
6. S. Swarupa (2003). *Fluid Dynamics*. Krishna Publication.

II. MAJOR COURSE- MJ 17:
ADVANCED ALGEBRA

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Learn in detail finite permutation groups and using group action they will be able to prove Sylow's theorems.
2. Familiarize the concept of solvability of groups.
3. Obtain matrix of a linear transformation, and its reduction to standard forms.
4. Explore the idea of various field extensions.
5. Know finite fields in detail and Fundamental theorem of Galois theory.

Course Content:

Unit-I: Solvable Groups and Sylow Theorems

Finite permutation groups S_n and A_n, Group action, Conjugate class, Class equation, Orbit -stabilizer theorem, Sylow's theorems (proofs using group actions), Normal and Subnormal series, Jordan-Holder theorem, Solvable groups, Nilpotent groups.

Unit-II: Linear Algebra

Matrix of a linear transformation, Canonical Forms – Similarity of linear transformations, Invariant subspaces, Eigen values and Eigen vectors, Reduction to diagonal, triangular and Jordan forms, The primary decomposition theorem.

Unit-III: Field Extension

Extension fields, Finite extension, Algebraic and transcendental extensions, Splitting fields, Existence and uniqueness, Separable and inseparable extension, Normal extensions, Perfect fields.

Unit-IV: Finite Field

Finite fields, Theorems on finite fields, Primitive elements, Algebraically closed fields, Automorphism of extensions, Galois extension, Fundamental theorem of Galois Theory.

Reference books:

1. D.S. Dummit, R.M. Foote (2003). *Abstract Algebra*. John Wiley & Sons.
2. I.N. Herstein (1975). *Topics in Algebra.* Wiley Eastern Ltd., New Delhi.
3. M. Artin (1991). *Algebra.* Prentice-Hall of India.
4. K. Hoffman and R. Kunze (1997). *Linear Algebra* (2nd edition). Prentice Hall of India, New Delhi.
5. N.S. Gopala Krishnan (2008). *University Algebra.* New Age Int. Publ.
6. William J Gilbert (2005). *Modern Algebra with Applications.* Wiley India.

III. MAJOR COURSE- MJ 18:
PROGRAMMING IN C & MATLAB

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Familiarize with two computer programming languages C & MATLAB.
2. Understand various terms of C & MATLAB necessary to write a computer program.
3. Learn various inbuilt functions and to create function files.
4. Use MATLAB as calculator to solve many mathematical problems.
5. Solve various mathematical problems Numerically and plot Graphs.

Course Content:

Unit-I: Introduction to C Language

Overview of C: History of C, Importance of C, Structure of a C Program. *Elements of C*: C character set, identifiers and keywords, Data types, Constants and Variables, Assignment statement, Symbolic constant. *Input/output*: Unformatted & formatted I/O function, Input functions viz. scanf(), getch(), getche(), getchar(), gets(), output functions viz. printf(), putch(), putchar(), puts(). *Operators & Expression*: Arithmetic, relational, logical, bitwise, unary, assignment, conditional operators and special operators. Arithmetic expressions, evaluation of arithmetic expression, type casting and conversion, operator hierarchy & associativity. *Decision making & branching*: Decision making with IF statement, IF-ELSE statement, Nested IF statement, ELSE-IF ladder, switch statement, goto statement. *Decision making & looping*: For, while, and do-while loop, jumps in loops, break, continue statement. *Understanding header files*: stdio.h, math.h, ctype.h and its function prototypes.

Unit-II: Functions

Definition, prototype, passing parameters, recursion. *Storage classes in C*: auto, extern, register and static storage class, their scope, storage, & lifetime. Structure, Union, enum. *Arrays*: Definition, types, initialization, processing an array, Strings & arrays. Pointer and Its implementation using Function, Structure, Union, *Array File Handling*: Needs of File Handling, File Modes, Type of Files, Open/Create, Read, Write, Delete, Copy, Rename, Searching etc.

Unit-III: Introduction to MATLAB

Elementary MATH Built-in –Functions, Creating Arrays, one-dimensional, two-dimensional arrays, Variables, Strings. Mathematical operations with arrays, Script files, Two dimensional plots, Functions and Function files.

Unit-IV: Programming in MATLAB

Relational and Logical operators, Conditional statements, the switch-case statement., Loops, Nested Loops and Nested conditional statements, The break and continue commands, , Polynomials, Curve Fitting and Interpolation, Applications to Numerical Analysis.

Reference books:

1. E. Balagurusamy (2018). *Computing Fundamentals and C Programming.* Tata McGraw-Hill.
2. Yashwant P. Kanetker (2016). *Let Us C.* BPB.
3. V. Rajaraman (1994). *Computer Programming in C*. PHI.
4. Amos Gilat (2012). *MATLAB- An Introduction with Applications.* Wiley India.

IV. MAJOR COURSE- MJ 19:
PRACTICAL: PROGRAMMING IN C & MATLAB

Marks: Pr (ESE: 3Hrs) =100	Pass Marks: Pr (ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

Course Objectives & Learning Outcome:
This course will enable the students to:

1. Be able to write programs in C language as well as MATLAB. They'll be benefited with the use of computer programming in their academics and future research work

Course Content:
Programming in C:

1. Write programs to understand different logics using Flow chart.
2. Write programs to understand printf, scanf, gets, getchar, puts, sqrt etc functions.
3. Write programs to illustrate the concepts of constants, variables and data types.
4. Write programs to illustrate operators and expressions in C.
5. Write programs to illustrate decision making and branching in C.
6. Write programs to illustrate decision making and looping in C Analysis of various programs, i.e, Find the syntax error, logical error and outputs.
7. Write programs to illustrate array in C.
8. Write programs to illustrate of user defined functions.
9. Write programs to illustrate structures and unions.
10. Write programs to illustrate concept of pointers, character strings and string manipulations.
11. Write programs to illustrate of user defined functions using pointers, array, structure, union etc.
12. Write programs to illustrate File Handling in C.

Programming in MATLAB:

1. Write programs to illustrate Built-in functions and Arrays
2. Write Programs to illustrate Script files, functions and function files
3. Write programs to illustrate two dimensional plots
4. Write programs to illustrate curve fitting and interpolation

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SEMESTER VIII

I. MAJOR COURSE- MJ 20:
ORDINARY DIFFERENTIAL EQUATIONS-II

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcome:

This course will enable the students to:

1. Know Picard's method of obtaining successive approximations of solutions of first order differential equations, passing through a given point in the plane and Power series method for higher order linear equations, especially in cases when there is no method available to solve such equations.
2. Learn the methods of solution of second and higher order ordinary differential equation.
3. Solve the Linear system of ordinary differential equations using eigenvalues and eigen functions and other methods.
4. Understand Strum-Lioville BVP and their solution using Green's function technique.

Course Content:

Unit-I: First Order ODE

Existence and uniqueness of the solution to ODE, Picard's existence theorem, Lipschitz condition, Uniqueness theorem, Picard's method of successive approximation.

Unit-II: Second and Higher Order ODE

Algebraic properties of solutions of homogeneous equations & Wronskian of second order ODE, n^{th} order ODE, Wronskian of a functions and its properties, Annihilator method to solve non homogeneous ODE with constant coefficients, initial value problem, Existence and uniqueness theorem.

Unit-III: Linear System of ODE's

Linear system of ODEs, Existence and Uniqueness of linear system, linear homogeneous system with constant coefficients, method of eigen value and eigen vectors, Fundamental solution, Reduction of higher order linear equation into first order linear equations

Unit-IV: Boundary Value Problem

Strum-Lioville boundary value problem with homogenous boundary conditions. Green's function, Green's function techniques for solving self-adjoint boundary value problem

Reference books:

1. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.
2. E.A. Coddington and N. Levinson (1955). *Theory of Ordinary Differential Equations*. Mc Graw-Hill, NY.
3. M. Brawn (1992). *Differential equations and their applications*. Springer-Verlag New York.
4. A. Chakrabarti (1990). *Elements of ordinary differential equations and special functions*. New Age, Int. Publ.
5. M. D. Raisinghania (2001). *Advanced differential equations.* S. Chand and Company.
6. A. Coddington (1987). *An introduction to Ordinary Differential equations.* Prentice Hall of India, New Delhi

II. ADVANCED MAJOR COURSE- AMJ 1:
REAL ANALYSIS-III

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcome:

This course will enable the students to:

1. Relate concepts of uniform convergence of sequence and series of functions.
2. Upgrade the concept of function of one variable to the several variables and understand the generalized concept of derivatives as a linear transformation.
3. Understand the generalized concepts of Chain rule and Taylor's theorem.
4. Assimilate the notion of inverse function theorem, implicit function theorem and Jacobians.
5. Be familiar with the notion of measure theory and its generalizations.
6. Upgrade the concept of integration to that of Lebesgue theory.

Course Content:

Unit-I: Uniform Convergence

Sequences and series of functions, pointwise and uniform convergence. Cauchy criterion for uniform convergence, M_n-Test, Weierstrass M-test, Abel's and Dirichlet's test for uniform convergence, uniform convergence and continuity, preservation of differentiability and integrability theorems.

Unit-II:– Functions Of Several Variables

Derivative of functions in an open subset of R^n into R^m as a linear transformation, Chain rule, Partial derivatives, Taylor's theorem, Inverse function theorem, Implicit function theorem, Jacobians.

Unit-III: Measure Theory

Motivation and Concept of Measure of a set, Outer measure, Measurable sets, Lebesgue measures, A non-measurable set, Measurable functions, Littlewood's three principles.

Unit-IV: The Lebesgue Integral

Lebesgue integral of a bounded function over a finite measure, The integral of a non-negative unction, The general Lebesgue integral, Convergence theorems, Convergence in measure.

Reference books:

1. Walter Rudin (2017). *Principles of Mathematical Analysis.* 3 rd ed. McGraw-Hill.
2. I. K. Rana (2007). *An Introduction to Measure and Integration.* Narosa.
3. H. K. Pathak (2021). *Real Analysis.* Shree Shiksha Sahitya Prakashan.
4. P. P. Gupta, G. S. Malik & S. K. Mittal (2008). *Measure Theory.* Pragati Prakashan.
5. J. N. Sharma & A. R. Vashishtha (2014). *Mathematical Analysis-II.* Krishna Prakashan.

III. ADVANCED MAJOR COURSE- AMJ 2: COMPLEX ANALYSIS-II

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcome:

This course will enable the students to:

1. Learn the role of Cauch-Goursat theorem and Cauchy integral formula in evaluation of contour integrals.
2. classify the nature of singularity, poles and residues and application of Cauchy Residue theorem.
3. Study the meromorphic function and related results.
4. Develop the understanding of Analytic continuation and its applications.

Course Content:

Unit –I: Complex Integration

Line integral, Path independence, Complex integration, Cauchy-Goursat Theorem, Cauchy's Integral formula, Higher order derivatives, Morera's Theorem, Cauchy's inequality, Liouville's theorem, Maximum modulus principle, Minimum modulus principle.

Unit-II: Singularities and Cauchy Residue Theorem

Zero of a function, Singular point, Types of singularities, isolated poles and zeros, limiting point of poles and zeros, Residue at a pole, Residue at infinity, Cauchy Residue theorem, Jordan's lemma, Evaluation of integrals.

Unit-III: Meromorphic Functions

Definitions of Meromorphic and entire functions, Mittag-Lefler's expansion, Number of poles and zeros of a meromorphic function, Principle of argument, Rouche's theorem, Fundamental theorem of Algebra.

Unit-IV: Analytic Continuation and Its Application

Definition of Analytic continuations and related problems, Uniqueness theorem of Analytic continuation, Standard method/ Power series method of Analytic continuation along a curve, Singularity on the circle of convergence of power series.

Reference books:

1. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley
2. Churchill and Brown (2009), *Complex variables and applications.* McGraw-Hill Pub.Company.
3. Walter Rudin (1966). *Real and Complex Analysis*. Mc Graw Hill Book Co.
4. E.C. Titchmarsh (1976). *The Theory of Functions.* Oxford University Press. London.
5. J. N. Sharma (2014). *Functions of a complex variable.* Krishna Prakashan.
6. J. K. Goyal & K. P. Gupta (2008). *Functions of a complex variable.* Pragati Prakashan.
7. H. K. Pathak (2021). *Complex Analysis.* Shree Shiksha Sahitya Prakashan

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IV. ADVANCED MAJOR COURSE- AMJ 3: TOPOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives & Learning Outcome:

This course will enable the students to:

1. Be familiar with the Fundamental properties of a Topological space.
2. Learn concept of continuity and connectedness in Topological spaces.
3. Know countability and separation axioms of Topological spaces.
4. Study the compactness and related results.

Course Content:

UNIT-I: Fundamentals of A Topological Space

Definition and examples of topological spaces. Closed sets, Closure. Dense subsets. Neighbourhoods, Interior, exterior and boundary. Accumulation points and derived sets. Bases and sub-bases. Subspaces and relative topologies. Quotient topology

Unit-II: Continuity and Connectedness

Continuity and homeomorphism, Product of topological spaces, connected space and its properties.

Unit-III: Countability and Separation Axioms

First and Second countable spaces. Lindelof's theorem, separable spaces, second countability and separability. Separation axioms To, T1, T2, T3, T4: their Characterizations and basic properties. Urysohn's Lemma. Tietze extension theorem.

Unit-IV: Compactness

Compactness. continuous image of compact sets. Basic property of compactness. Compactness and finite intersection property Tychonoff's Theorem, One point compactification of a topological space.

Reference books:

1. K.D. Joshi (1983). *Introduction to General Topology.* Wiley Eastern Ltd.
2. W.J. Pervin (1964). *Foundations of General Topology.* Academic Press Inc. New York.
3. G.F. Simmons (2017). *Introduction to Topology and Modern Analysis.* Mc Graw Hill Int. book company.
4. J.R. Munkres (1974). *Topology A first course.* Prentice hall India Pvt. Ltd.
5. S. Lipschutz (1968). *General Topology.* Schaum's outline series.

COURSES OF STUDY FOR FYUGP IN **"MATHEMATICS" MINOR**

MINOR COURSE-1A **(SEM-I)**

I. MINOR COURSE- MN 1A:
CALCULUS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives &Learning Outcomes:
This course will enable the students to:

1. Study the successive differentiation, expansions of functions, integration of rational and irrational functions and reduction formulae.
2. Trace curves and obtain length of curves along with volume and surface area of solid of revolution.
3. Familiarize with the idea of partial derivatives and its properties.
4. Evaluate double and triple integrals along with their applications.

Course Content:

Unit-I: Differential and Integral Calculus

Successive differentiation and Leibnitz theorem, Maclaurin's and Taylor's theorems for expansion of a function, Taylor's theorem in finite form with Lagrange remainder. Integration of rational and irrational functions, Evaluation of Definite Integrals, Reduction Formulae of $\int \sin^n x\,dx$, $\int \cos^n x\,dx$, $\int \tan^n x\,dx$ and $\int \sec^n x\,dx$.

Unit-II: Curvature, Asymptotes and Curve Tracing

Curvature; Asymptotes of general algebraic curves, Parallel asymptotes, Asymptotes parallel to axes; Symmetry, Concavity and convexity, Points of inflection, Tangents at origin, Multiple points, Position and nature of double points; Tracing of Cartesian, polar and parametric curves, Length of plane curve and area bounded by plane curves, Volume and surface area of solid of revolution.

Unit-III: Functions of Several Variables

Limit, continuity and first order partial derivatives, Higher order partial derivatives, Change of variables, Euler's theorem for homogeneous functions, Taylor's theorem, Total differentiation and Jacobians.

Unit-IV: Double and Triple Integrals

Double integration over rectangular and nonrectangular regions, Double integrals in polar coordinates, Triple integral over a parallelepiped and solid regions, Volume by triple integrals, Line integrals, Green's theorem, Area as a line integral, Surface integrals, Stokes' theorem, The Gauss divergence theorem.

Reference Books:

1. Lalji Prasad (2019). *Differential Calculus.* Paramount Publication.
2. A. D. Dasgupta, S. B. Prasad & R. S. Prasad (2021). *Degree level Integral Calculus.* Bharti bhawan.
3. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley
4. James Stewart (2012). *Multivariable Calculus* (7th edition). Brooks/Cole. Cengage.

MINOR COURSE-1B **(SEM-III)**

II. MINOR COURSE- MN 1B: SET THEORY & ALGEBRA

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives &Learning Outcomes:

This course will enable the students to:

1. Grasp the elementary idea of set theory like equivalence and countability.
2. Learn the algebraic structure of groups.
3. Study subgroups, cyclic and permutation groups.
4. Handle matrices and obtain their ranks, eigenvalues, eigenvectors and apply them in the solution of system of linear equations.

Course Content:

Unit-I: Set Theory and Algebra

Sets, Relations, Equivalence relations, Equivalence classes; Finite, countable and uncountable sets; The division algorithm, Divisibility and the Euclidean algorithm, Modular arithmetic and basic properties of congruences;

Unit-II: Groups, Subgroups

Definition and properties of a group, Abelian groups, Examples of groups including D_n (dihedral groups), Q_8 (quaternion group), $GL_n(R)$ or GL(n, R) (general linear groups) and $SL_n(R)$ or SL(n, R) (special linear groups); Subgroups and examples, Cosets and their properties, Lagrange's theorem and its applications.

Unit-III: Cyclic and Permutation Groups

Cyclic groups and properties, Classifications of subgroup of cyclic groups, Cauchy theorem for finite Abelian groups; Centralizer, Normalizer, Center of a group, Product of two subgroups, Permutation group and properties, Even and odd permutations, Cayley's theorem.

Unit-IV: Row Echelon Form of Matrices and Applications

Systems of linear equations, Row reduction and echelon forms, The rank of a matrix and its applications in solving system of linear equations; Matrix operations, Symmetric, skew- symmetric, self-adjoint, orthogonal, Hermition, skew-Hermition and unitary matrices; Eigenvectors and eigen values, The characteristic equation and the Cayley–Hamilton theorem.

Reference Books:

1. A. D. Dasgupta & S. N. Thakur (2021). *Degree Level Set Theory.* Bharti Bhawan.
2. A. D. Dasgupta & S. B. Prasad (2021). *Degree Level Abstract Algebra.* Bharti Bhawan.
3. A. D. Dasgupta & S. B. Prasad (2021). *Degree Level Matrices.* Bharti Bhawan.

MINOR COURSE-1C **(SEM-V)**

III. MINOR COURSE- MN 1C:
ODE & REAL ANALYSIS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives &Learning Outcomes:

This course will enable the students to:

1. Solve first and second order ordinary differential equations.
2. Understand the basic structure of set of real numbers.
3. Study the convergence of sequence and series of real numbers.

Course Content:

Unit-I: First Order Differential Equations

Basic concepts and genesis of ordinary differential equations, Order and degree of a differential equation, Differential equations of first order and first degree, Equations in which variables are separable, Homogeneous equations, Linear differential equations and equations reducible to linear form, Exact differential equations, Integrating factor, First order higher degree equations solvable for x, y and p, Clairaut's form and singular solutions.

Unit-II: Second Order Linear Differential Equations

Statement of existence and uniqueness theorem for the solution of linear differential equations, General theory of linear differential equations of second order with variable coefficients, Solutions of homogeneous linear ordinary differential equations of second order with constant coefficients, Method of variation of parameters and method of undetermined coefficients.

Unit-III: Real Numbers

The set of real numbers ($\mathbb{R}$) as an ordered field, Least upper bound properties of $\mathbb{R}$, Metric property and completeness of $\mathbb{R}$, Archimedean property of $\mathbb{R}$, Dense subsets of $\mathbb{R}$, Idea of Neighborhood of a point in $\mathbb{R}$, Open sets, limit point of a set and closed sets in $\mathbb{R}$, Convergence of Sequences in $\mathbb{R}$ Bounded and monotonic sequences, Convergent sequence and its limit, Limit theorems, Monotone convergence theorem, Subsequences, Cauchy sequence, Cauchy's convergence criterion.

Unit-IV: Infinite Series

Convergence of a series of positive real numbers, Necessary condition for convergence, Cauchy criterion for convergence; Tests for convergence: Comparison test, Limit comparison test, D'Alembert's ratio test, Cauchy's nth root test, Alternating series, Absolute and conditional convergence, Leibniz theorem.

Reference Books:

1. M. D. Raisinghania (2020). *Ordinary and Partial Differential Equations.* S. Chand.
2. Lalji Prasad (2016). *Real Analysis.* Paramount Publications.
3. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley

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MINOR COURSE-1D **(SEM-VII)**

IV. MINOR COURSE- MN 1D:
PDE & COMPLEX ANALYSIS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **Theory: 60 Lectures**

Course Objectives &Learning Outcomes:

This course will enable the students to:

1. Solve first and second order partial differential equations.
2. Evaluate simultaneous and iterated limits of a function of two variables.
3. Familiarize with the complex number representations and their algebra.
4. Study the analyticity of a function of complex variable.

Course Content:

Unit-I: First Order Partial Differential Equations

Genesis of Partial differential equations (PDE), Concept of linear and non-linear PDEs, Methods of solution of Simultaneous differential equations of the form: $dx/P(x,y,z) = dy/Q(x,y,z) = dz/R(x,y,z)$, Lagrange's method for PDEs of the form: $P(x,y,z)p+Q(x,y,z)q=R(x,y,z)$, where $p=\partial z/\partial x$ and $q=\partial z/\partial y$.

Unit-II: Second Order Partial Differential Equations with Constant Coefficients

Principle of superposition for homogeneous linear PDEs, Relation between solution sets of non-homogeneous linear PDEs and their corresponding homogeneous equations, Reducible and irreducible homogeneous equations and their solutions in various possible cases, Solution of non-homogeneous reducible equations using Lagrange's method for first order equations.

UNIT III: Function of two variables and Complex plane

Real Functions of Two Variables: Simultaneous and Iterated limits: Continuity, Partial Derivatives, Complex numbers and their representation, algebra of complex numbers; Complex plane Complex functions and their limits including limit at infinity; Continuity.

Unit-IV: Analytic Functions and Cauchy–Riemann Equations

Differentiability and analyticity; Cauchy–Riemann equations, Harmonic functions, Sufficient conditions for differentiability and analyticity.

Reference Books:

1. M. D. Raisinghania (2020). *Ordinary and Partial Differential Equations.* S. Chand.
2. Lalji Prasad (2019). *Complex Analysis.* Paramount Publications.
3. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley

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