RADHA GOVIND UNIVERSITY
RAMGARH, JHARKHAND

DEPARTMENT OF MATHEMATICS

NEP FYUGP CURRICULUM

MATHEMATICS HONOURS/

MATHEMATICS HONOURS WITH RESEARCH PROGRAMME

SUBJECT CODE - 017

FOR UNDERGRADUATE COURSES UNDER
RADHA GOVIND UNIVERSITY

Implemented w.e.f.
Academic Session 2025-26 & onwards

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HIGHLIGHTS OF FYUGP CURRICULUM

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 the **1st of July**.

ELIGIBILITY

- The selection for admission will be primarily based on the availability of seats in the Major subject and marks imposed by the institution. Merit point for selection will be based on marks obtained in the Major subject at Class 12 (or equivalent level) or the aggregate marks of Class 12 (or equivalent level) if the 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 75% overall marks or 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 a maximum of **Seven years** from the date of registration.

ACADEMIC CALENDAR

- An Academic Calendar will be prepared by the University to maintain uniformity in the UG Honours/ Honours with Research Programmes and PG Diploma Programmes, running in the colleges 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, coursework, conduct of examination and declaration of results, including semester break.
- To undergo an 8-week summer internship/ apprenticeship during the summer camp, the Academic Calendar may be scheduled for academic activities as below:
  a) Odd Semester: **From the first Monday of August to the third Saturday of December**
  b) Even Semester: **From the first Monday of January to the 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 endeavours 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 the first and second semesters.,
  - 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 the first year or second year summer term, in addition to 9 credits from skill-based courses earned during the 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's Degree (Honours with Research) after a 4-year (8 semesters) programme of study to the students undertaking a 12-credit Research component in the 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 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
   One credit for Practicum = 30 Hours of Practical work
   One credit for Internship = 02 Weeks of Practical experience

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 a two-hour duration.
   Internship – For the Exit option after any academic year of a Four-year U.G. Programme for the award of U.G. Certificate, U.G. Diploma, U.G. Degree (Level 4.5, 5 or 5.5 respectively),Students can either complete two 4-week internships worth 2 credits each or one 8-week internship for all 4 credits. This practical experience connects academic learning with real-world applications, offering valuable exposure to professional environments in their fields of study

CHANGE OF MAJOR OR MINOR COURSES

- The change of Major or Minor courses may be allowed only once after the Second Semester and before the third Semester in the FYUG Programme, depending on the provisions laid by the FYUGP and the conditions laid by the Institution.**However, the student must clear the papers from the previous semesters of the new subject opted in the next Examination of the coming session.**

CALCULATION OF MARKS FOR THE PURPOSE OF THE RESULT

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

PROMOTION CRITERIA

First degree programme with a single major (160+4=164 credits):

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 the Courses in an academic year, a student has to pass in minimum 11 papers out of the total 14 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 7 papers in Semester-II.
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 of 20 papers out of the total 26 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 6 papers in Semester-IV.
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 of 27 papers out of the total 36 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 5 papers in Semester VI.
vi. However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

First degree programme with dual major (192+4=196 credits):

i. Please refer to the FYUGP Regulations for the detailed provisions of Double Major and Dual Degrees.
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 the Courses in an academic year, a student has to pass in minimum 11 papers out of the total 15 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 8 papers in Semester-II.
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 20 papers out of the total 27 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 7 papers in Semester-IV.
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 28 papers out of the total 37 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 6 papers in Semester VI.
vi. However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

PUBLICATION OF RESULTS

- The examination result shall be notified by the Controller of Examinations of the University in different newspapers and the same is to be posted also on the University website.
- If a student is found indulging in any malpractice/ unfair means during an 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 the next 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 to clear the backlog. Similarly, the students who have failed in any subject in an odd semester may appear in the subsequent odd semester examination to clear the backlog.

Regulations related to any concern not mentioned above shall be guided by the Regulations of the RADHA GOVIND UNIVERSITY, RAMGARH for FYUGP.

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COURSE STRUCTURE FOR FYUGP **'HONOURS/ RESEARCH/ PG DIPLOMA'**

Table 1: Credit Framework for Four-Year Undergraduate Programme (FYUGP) under State Universities of Jharkhand [Total Credits = 164]

Academic Level	Level of Courses	Semester	**MJ**: Discipline Specific Courses – Core or Major (80)	**AC**: Associated core courses from discipline/ Interdisciplinary/ vocational (8)		**ELC**: Elective courses may be opted from four paths [Follow table 2] (24)	**MDC**: Multidisciplinary Courses (From a pool of Courses) (9)	**AEC**: Ability Enhancement Courses (Modern Indian Language and English) (8)	**SEC**: Skill Enhancement Courses (9)	**VAC**: Value Added Courses (6)	**IKS**: (i) Indian Knowledge System (2) & **SA**:(ii) Social awareness (2)	**RC**: Research Courses (4+8)/	**AMJ**: Advanced Courses instead of Research (4+4+4)/ **PGD:** PG Diploma Level 6 (4+4+4)	**Total Credits**	**IAP**; Internship/Apprenticeship/ Project/ Vocational course/ Dissertation (4) **In between Sem I to Sem-VI**
	1	2	3 (Major- 80)	4 (Minor-32)			5	6	7	8	9	10	11	12	13
Level 4.5	Level 100-199: **Foundation or Introductory courses**	**I**	4	4	---	---	3	2	3	2	2	---	---	**20**	4
		II	4	---	4	---	3	2	3	2	2	---	---	**20**	
		Exit Point: Undergraduate Certificate provided with Summer Internship/ Project/Vocational course/ Dissertation (4 credits)													
Level 5	Level 200-299: **Intermediate-level courses**	**III**	4+4	---		4	3	2	3	---	---	---	---	**20**	
		IV	4+4+4	---		4	---	2	---	2	---	---	---	**20**	
		Exit Point: Undergraduate Diploma provided with Summer Internship/ Project/Vocational course/ Dissertation (4 credits)													
Level 5.5	Level 300-399: **Higher-level courses**	**V**	4+4+4+4	---		4	---	---	---	---	---	---	---	**20**	
		VI	4+4+4+4	---		4	---	---	---	---	---	---	---	**20**	
		Exit Point: Bachelor's Degree with Summer Internship/ Project/Vocational course/ Dissertation (4 credits)												**124**	
Level 6	Level 400-499: **Advanced courses** Hons with Research (>7.5 CGPA)/ Honours/ PG Diploma	**VII**	4+4+4	---		4	---	---	---	---	---	4	4	**20**	---
		VIII	4+4	---		4	---	---	---	---	---	8	4+4	**20**	
		Exit Point: Bachelor's Degree with Honours/ Honours with Research/ PG Diploma Level 6												**164**	

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

Implemented from Academic Session 2025-26& onwards

Table 2: Options for Elective Minor Courses

Path A	Path B	Path C	Path D
ELC-A; Elective courses from Interdisciplinary Subjects 1 & 2 (24)	**ELC-B**; Elective courses from discipline (24)	**ELC-C**; Elective courses from vocational (24)	**ELC-D**; Elective courses from discipline for Double Major (48)
This pathway may be recommended for students who wish to develop core competency in multiple disciplines of study. In this case, the credits for the minor pathway shall be distributed among the constituent disciplines/subjects. If students pursuing FYUGP are awarded a UG Degree in a Major discipline, they are eligible to mention their core competencies in other disciplines of their choice if they have earned 12 credits each from pathway courses of two particular disciplines. In the first three years of FYUGP, this pathway is composed of one Major discipline with 60 credits from 15 courses, and two other disciplines, with 12 credits from 3 courses in each discipline. In this pathway, if the students choose one of the two disciplines for 12 credits in one discipline then they should choose a different discipline for the other 12 credits. If the students continue to the fourth year of FYUGP, the students need to earn an additional 4 credits in both disciplines.	This pathway may be recommended to those students who wish for an in-depth study in more than one discipline with a focus on one discipline (Major) and relatively less focus on the other (Minor). If students exit at the end of the third year of FYUGP, they are awarded a Major Degree in a particular discipline and a Minor in another discipline of their choice, if they earn a minimum of 24 credits from the courses in the Minor discipline. If the students continue to the fourth year of FYUGP, they should earn a minimum of 32 credits in the Minor discipline, to be eligible for a UG Degree (Honours) with a Major and a Minor. For this, in the fourth year, they should earn an additional minimum of 8 credits through 2 courses in the Minor discipline.	This pathway may be recommended to those students who wish for exposure to a vocational discipline in addition to the in-depth study in the Major discipline. The credit requirements for Major and Vocational Minor disciplines in this pathway are the same as those for Major with Minor pathway, except that the Minor courses are in a vocational discipline. If students exit at the end of the third year of FYUGP, they are awarded a Major Degree in a particular discipline and a Minor in vocational discipline of their choice, if they earn a minimum of 24 credits from the Vocational courses. If the students continue to the fourth year of FYUGP, they should earn a minimum of 32 credits in the vocational discipline. For this, in the fourth year, they should earn an additional minimum of 8 credits through 2 courses in the Vocational discipline.	To secure the required minimum credits in each discipline, students who wish to opt for a Double Major should include the credits earned by them from the Multi-Disciplinary Courses, Skill Enhancement Courses, and Value-Added Courses offered by the respective Major disciplines. The Double Major pathway is extended to the fourth year. Shifting to a double major from a minor in the third semester will be allowed subject to clearance of the courses of double major (not studied earlier) in succeeding sessions. In the fourth year, the student can continue to earn the required credits in either Major A or Major B to qualify for a UG Degree (Honours)/ UG Degree (Honours with Research) in A or B. If he/she opts to continue with Major B in the fourth year, he/she should earn an additional 16 credits of 300-399 level in Major B through mandatory online courses. The institution will not provide the courses in physical mode in the fourth year of this segment.

Table 3: Credit Distribution in Elective Minor Courses during the Four Years of FYUGP

Academic Level	Level of Courses	Semester	Path A ELC; Elective courses from Interdisciplinary Subjects 1 & 2 (24)		Path B ELC; Elective courses from the discipline (24)	Path C ELC; Elective courses from vocational (24)	Path D ELC; Elective courses from the discipline for Double Major (64)
	1	2	3A. Subject 1	3B. Subject 2	4	5	6
Level 4.5	Level 100-199: **Foundation or Introductory courses**	**I**	---	---	---	---	4+4
		II	---	---	---	---	4+4
		Exit Point: Bachelor's Degree with Hons. with Research					
Level 5	Level200-299: **Intermediate-level courses**	**III**	4	---	4	4	4+4
		IV	---	4	4	4	4+4
		Exit Point: Bachelor's Degree with Hons.					
Level 5.5	Level 300-399: **Higher-level courses**	**V**	4	---	4	4	4+4
		VI	---	4	4	4	4+4
		Exit Point: P.G. Diploma Degree					
Level 6	Level 400-499: **Advanced courses** Hons with Research (>7.5 CGPA)/ Honours/ PG Diploma	**VII**	4	---	4	4	4+4
		VIII	---	4	4	4	4+4
		Exit Point: (A) Bachelor's Degree with Hons. with Research/ (B) Bachelor's Degree with Hons./ (C) P.G. Diploma Degree					

COURSES OF STUDY FOR FOUR-YEAR UNDERGRADUATE PROGRAMME2025 onwards

Table 4: Semester-wise Course Code and Credit Points for Single Major during the First Three Years of FYUGP

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
I	AEC-1	Language and Communication Skills (MIL-1; Modern Indian language Hindi/ English)	2	7 Papers (20 credits)
	VAC-1	Value Added Course-1	2	
	IKS-1	Indian Knowledge System-I	2	
	SEC-1	Skill Enhancement Course-1	3	
	MDC-1	Multi-disciplinary Course-1	3	
	AC-1	Associated core courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-1	Major paper 1 (Disciplinary/ Interdisciplinary Major)	4	
II	AEC-2	Language and Communication Skills (MIL-1; Modern Indian language English/ Hindi)	2	7 Papers (20 credits)
	VAC-2	Value Added Course-2	2	
	SA	Social Awareness Activities	2	
	SEC-2	Skill Enhancement Course-2	3	
	MDC-2	Multi-disciplinary Course-2	3	
	AC-2	Associated core courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-2	Major paper 2 (Disciplinary/ Interdisciplinary Major)	4	
III	AEC-3	Language and Communication Skills (MIL-2; MIL including TRL)	2	6 Papers (20 credits)
	SEC-3	Skill Enhancement Course-3	3	
	MDC-3	IK as a Multi-disciplinary Course-3	3	
	ELC-1	Elective courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-3	Major paper 3 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-4	Major paper 4 (Disciplinary/ Interdisciplinary Major)	4	
IV	AEC-4	Language and Communication Skills (MIL-2; MIL including TRL)	2	6 Papers (20 credits)
	VAC-3	Value Added Course-3	2	
	ELC-2	Elective courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-5	Major paper 5 (Disciplinary/ Interdisciplinary Major having IKS)	4	
	MJ-6	Major paper 6 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-7	Major paper 7 (Disciplinary/ Interdisciplinary Major)	4	
V	ELC-3	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-8	Major paper 8 (Disciplinary/ Interdisciplinary Major)	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	
VI	ELC-4	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	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	
Total Credits, excluding one Internship (IAP) of 4 credits =			**120**	**120**

Note: It is mandatory to take One Internship of 4 credits in any one of the semesters during the first three years in FYUGP or before exit at any of the exit points if a student wishes to opt for the same.

Table 5A: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (Honours with Research)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII A	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-16	Major paper 16 (Research Methodology)	4	
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4	
	MJ-18	Major paper 18 (Disciplinary/Interdisciplinary Major)	4	
	RC-1	Research proposal – Planning & Techniques (Disciplinary/Interdisciplinary Major)	4	
VIII A	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	4 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	RC-2	Research Internship/Field Work/Project/Dissertation/Thesis	8	
		Total Credits, excluding one Internship of 4 credits =	**160**	**160**

Table 5B: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (Honours)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII B	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	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	
	AMJ-1	Advanced Major pape-1 (Disciplinary/Interdisciplinary Major)	4	
VIII B	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	AMJ-2 AMJ-3	Advanced Major paper-2 (Disciplinary/Interdisciplinary Major) Advanced Major paper-3 (Disciplinary/Interdisciplinary Major)	4 4	
		Total Credits, excluding one Internship of 4 credits =	**160**	**160**

Table 5C: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (with Postgraduate Diploma)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII C	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	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	
	JOC-1	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
VIII C	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	JOC-2	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
	JOC-3	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
		Total Credits, excluding one Internship of 4 credits =	**160**	**160**

AIMS OF BACHELOR'S DEGREE PROGRAMME IN MATHEMATICS

The broad aims of the bachelor's degree programme in Mathematics are:

1. To provide a deep and systematic understanding of fundamental mathematical concepts, beginning with foundational courses in calculus, algebra, geometry, set theory, number theory, and logic. The programme progressively builds on these to develop analytical thinking and mathematical maturity essential for advanced study and research.
2. To nurture the ability to reason abstractly and solve complex problems, through rigorous training in abstract algebra, real and complex analysis, linear algebra, metric spaces, topology, and discrete mathematics. These courses enable students to engage deeply with mathematical structures and arguments, preparing them for a wide variety of theoretical and applied contexts.
3. To integrate pure and applied mathematics, enabling students to appreciate and apply mathematical tools in real-world situations. Topics such as differential equations (ODEs and PDEs), mechanics, vector calculus, Fourier analysis, and variational principles are introduced with strong theoretical grounding and practical significance, creating a balance between abstraction and application.
4. To develop a research-oriented mindset and methodological competence, by incorporating courses in research methodology, research planning, and the option of dissertation or project work. These components prepare students for independent inquiry, academic writing, critical reading of mathematical texts, and participation in mathematical discussions.
5. To ensure a well-rounded mathematical education, which includes exposure to modern topics such as measure theory, complex function theory, conformal mappings, and topology. The programme also develops mathematical communication skills, computational fluency (where applicable), and an appreciation for the historical development of mathematical ideas.
6. To recognize and integrate contributions of Indian mathematicians and traditions through a meaningful incorporation of Indian Knowledge Systems (IKS)—including ancient number systems, combinatorics, geometry, calculus precursors, and astronomical mathematics—thereby deepening cultural understanding and awareness of the Indian mathematical heritage and its relevance to contemporary learning.
7. To empower students for diverse career and academic trajectories, including postgraduate education, teaching, mathematical modelling, data analysis, and interdisciplinary research. The programme emphasizes both theoretical depth and versatility, equipping students with the knowledge and adaptability needed in academia, industry, education, and technology sectors.

In summary, the Bachelor's degree programme in Mathematics is designed to cultivate a holistic and rigorous mathematical mindset, fostering lifelong learning, critical thinking, and the capacity to contribute meaningfully to mathematics and its applications—grounded in both global developments and India's rich intellectual traditions.

PROGRAM LEARNING OUTCOMES

The broad aim of the bachelor's degree programme in Mathematics is to acquire Knowledge and Understanding as follows:

1. **Knowledge and Understanding**
   - Understand core areas of mathematics including algebra, calculus, analysis, geometry, number theory, and differential equations, and apply them in solving mathematical and real-life problems.
   - Gain conceptual clarity and technical proficiency in both pure and applied mathematical topics such as vector calculus, Fourier analysis, mechanics, and variational calculus.
   - Acquire familiarity with advanced mathematical theories such as metric spaces, topology, measure theory, and complex analysis to prepare for higher studies and research.
   - Understand the structure and logic of mathematical proofs and develop the ability to read, analyze, and construct rigorous mathematical arguments.
   - Appreciate the historical development of mathematical ideas, including the profound contributions of Indian mathematicians**,** such as those in number systems, combinatorics, geometry, trigonometry, and early calculus, as part of an integrated understanding of global and indigenous mathematical traditions.

2. **Application of Knowledge**
   - Model physical, biological, or social phenomena using mathematical tools such as ODEs, PDEs, and difference equations.
   - Apply techniques of linear algebra, numerical methods, and function theory in various scientific and engineering contexts.
   - Use abstract mathematical structures (e.g., groups, rings, fields, topological spaces) in theoretical problem-solving and interdisciplinary research.
   - Connect ancient Indian mathematical concepts**,** such as recursive techniques, combinatorial patterns, and astronomical models, to modern problem-solving contexts where appropriate.

3. **Analytical and Problem-Solving Skills**
   - Develop the capacity to reason logically, think critically, and solve structured and unstructured problems using a mathematical approach.
   - Formulate and analyze mathematical models, evaluate their limitations, and interpret results effectively.

4. **Research and Inquiry Skills**
   - Formulate research questions, review mathematical literature, and use appropriate techniques and tools to explore open-ended problems.
   - Gain experience with mathematical research methods, including literature review, formal writing, presentation, and, where applicable, computational or project-based work.
   - Explore themes in the philosophy and methodology of Indian mathematics**,** including algorithmic thinking, approximation methods, and empirical observation as seen in historical texts.

5. **Communication and Collaboration**
   - Communicate mathematical ideas clearly, both orally and in writing, using appropriate notation, language, and presentation techniques.
   - Collaborate effectively in groups to explore mathematical problems, present findings, and engage in peer learning.

6. **Ethical and Professional Awareness**
   - Recognize the role of mathematics in the broader scientific and social context, including its impact on technology, ethics, and public policy.
   - Develop discipline, precision, and integrity in academic work and foster a lifelong learning attitude in the pursuit of mathematical knowledge.
   - Appreciate mathematics as a universal language shaped by diverse cultural traditions**,** including Indian Knowledge Systems, fostering respect for interdisciplinary and intercultural perspectives.

7. **Preparation for Higher Studies and Career**
   - Be prepared for postgraduate programmes in mathematics or related disciplines such as data science, physics, economics, or computer science.

Acquire the skills necessary for careers in academia, education, research, analytics, software, and other fields requiring quantitative reasoning and analytical ability.

SEMESTER WISE COURSES IN MATHEMATICS HONOURS **2025 onwards**

Table 6: Semester-wise Course Code and Credit Points of Major Courses in Mathematics

Semester	Courses		Examination Structure			
	Code	Coursesin NEP FYUGP Syllabus of Mathematics Session 2025-26 & onwards	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	MJ-1	Geometry and Calculus	4	25	75	---
	SEC-1	Theory of Sets, Numbers and Equations	3	---	75	---
II	MJ-2	Real Analysis-I	4	25	75	---
	SEC-2	Discrete Mathematics	3	---	75	---
III	MJ-3	Ordinary Differential Equations-I	4	25	75	---
	MJ-4	Group Theory and Matrices	4	25	75	---
	SEC-3	Elementary Computer Application Softwares	3	---	75	---
IV	MJ-5	IKS in Mathematics	4	25	75	---
	MJ-6	Real Analysis-II	4	25	75	---
	MJ-7	Multivariable Calculus	4	25	75	---
V	MJ-8	Complex Analysis-I	4	25	75	---
	MJ-9	Mechanics	4	25	75	---
	MJ-10	Linear Programming Problem	4	25	75	---
	MJ-11	Ring Theory	4	25	75	---
VI	MJ-12	Probability and Statistics	4	25	75	---
	MJ-13	Partial Differential Equation and Laplace Transform	4	25	75	---
	MJ-14	Linear Algebra	4	25	75	---
	MJ-15	Numerical Analysis	4	25	75	---
VII	MJ-16	Research Methodology	4	25	75	---
	MJ-17	Real Analysis-III	4	25	75	---
	MJ-18	Ordinary Differential Equations-II	4	25	75	---
	AMJ-1/	Metric Space	4	25	75	---
	RC-1	Research Planning & Techniques	4	25	75	---
VIII	MJ-19	Analytical Dynamics and Calculus of Variations	4	25	75	---
	MJ-20	Complex Analysis-II	4	25	75	---
	AMJ-2	Measure Theory	4	25	75	---
	AMJ-3/	Topology	4	25	75	---
	RC-2	Project Dissertation/ Research Internship/ Field Work	8	50	---	150

* It is mandatory to take Either One Internship of 4 credits or Two Internships of 2 credits each in any one of the semesters during the first three years in FYUGP or before exit at any of the exit points if a student wishes to opt for the same.

Table 7: Semester-wise Course Code and Credit Points of Minor Courses in Mathematics

Courses		Examination Structure			
Code	**Minor Coursesin NEP FYUGP Syllabus of Mathematics** Session 2025-26 & onwards	**Credits**	**Mid Semester Theory (F.M.)**	**End Semester Theory (F.M.)**	**End Semester Practical/ Viva (F.M.)**
MN-A	Introduction to Higher Mathematics	4	25	75	---
MN-B	Calculus	4	25	75	---
MN-C	Differential Equations	4	25	75	---
MN-D	Real Analysis	4	25	75	---
MN-E	Higher Algebra	4	25	75	---
MN-F	Linear Programming Problem	4	25	75	---
MN-G	Complex Analysis and Linear Algebra	4	25	75	---

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 50 marks):

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

B. (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.

C. (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.

D. (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 MID/ END SEMESTER EXAMINATIONS

Question format for **15 Marks**:

Subject/ Code

F.M. =15 **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 subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

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

Group B

2. ..... [10]
3. ..... [10]

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 subparts of a question in one place.
v. Numbers in the right indicate full marks for 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 the Theory Examination.

Question format for **50 Marks**:

Subject/ Code

F.M. =50 **Time**= 1.5 Hrs. 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 subparts of a question in one place.
v. Numbers in the right indicate full marks for 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 the Theory Examination.

Question format for **60 Marks**:

Subject/ Code

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

General Instructions:

vi. **Group A** carries very short answer-type compulsory questions.
vii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
viii. Answer in your own words as far as practicable.
ix. Answer all subparts of a question in one place.
x. Numbers in the right indicate full marks for the question.

Group A

7. [5x1=5]
   vi. .....
   vii. .....
   viii. .....
   ix. .....
   x. .....
8. ..... [5]
9. ..... [5]

Group B

10. ..... [15]
11. ..... [15]
12. ..... [15]
13. ..... [15]
14. ..... [15]

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

Question format for **75 Marks**:

Subject/ Code

F.M. =75 **Time**= 3 Hrs. 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 subparts of a question in one place.
v. Numbers in the right indicate full marks for 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 the Theory Examination.

Question format for **100 Marks**:

Subject/ Code

F.M. =100 **Time**= 3 Hrs. 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 subparts of a question in one place.
v. Numbers in the right indicate full marks for 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 the Theory Examination.

SEMESTER I

I. MAJOR COURSE –MJ 1:
GEOMETRY AND CALCULUS

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand and apply the geometric concepts of planes, straight lines, and spheres in three-dimensional space.
2. Master the techniques of differential calculus including successive differentiation and Taylor/Maclaurin series expansion.
3. Develop proficiency in integral calculus including evaluation of definite and special integrals using standard methods and reduction formulae.
4. Apply integral calculus to solve geometric problems involving curves, areas, volumes, and surface areas of revolution.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Calculate distances and angles between geometric elements and analyze intersections and tangents of spheres and planes.
2. Perform higher-order differentiation of standard functions and apply Taylor's and Maclaurin's theorems to expand functions.
3. Evaluate definite and indefinite integrals of rational and irrational functions using reduction formulas and known techniques.
4. Apply integral calculus in determining curvature, tracing curves, and calculating areas, volumes, and surface areas of solids.

Course Content:

UNIT-I: Planes, Straight Lines and Spheres(12 Hours) [1 Question]

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(18 Hours) [2 Questions]

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(18 Hours) [2 Questions]

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 (12 Hours) [1 Question]

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 AND EQUATIONS

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

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

Course Objectives:

By the end of this course, students will be able to:

1. Understand fundamental concepts of set theory including functions, relations, cardinality, and foundational axioms.
2. Apply principles of number theory such as divisibility, congruences, and Diophantine equations in problem-solving.
3. Explore and analyze polynomial equations, roots, and algebraic identities.
4. Utilize algebraic techniques to solve equations and interpret root behaviors based on given theorems.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

1. Define and classify sets, relations, functions, and apply concepts such as countability, Zorn's Lemma, and Axiom of Choice.
2. Use algorithms like Euclidean algorithm and apply modular arithmetic in solving arithmetic problems.
3. Solve Diophantine equations and apply mathematical induction and well-ordering principles.
4. Analyze polynomial equations using factor/remainder theorems and find roots using algebraic methods including Cardan's method.

Course Content:

UNIT-1: Set Theory(15 Hours) [2 Questions]

Relations, Equivalence relations, Equivalence classes, Functions, Types of functions. Composition of functions, Inverse of a function, Finite and infinite sets, Countable and uncountable sets, Cardinality of sets, cardinal numbers.Partially ordered set, Zorn's lemma and Axiom of choice.

UNIT-2: Number Theory(15 Hours) [2 Questions]

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(15 Hours) [2 Questions]

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.

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:
REAL ANALYSIS-I

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

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

Course Objectives:

By the end of this course, students will be able to:

1. Understand and explain the foundational properties of the real number system and related topological concepts.
2. Analyze the behavior of sequences of real numbers using formal definitions and theorems.
3. Evaluate convergence or divergence of infinite series using various mathematical criteria.
4. Apply standard tests effectively to determine the convergence of positive term series.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

1. Use properties of real numbers to solve problems involving bounds, intervals, and neighborhoods.
2. Determine convergence of sequences using limit theorems, monotonicity, and Cauchy criteria.
3. Classify series based on convergence properties such as absolute, conditional, and alternating convergence.
4. Select and apply appropriate convergence tests (e.g., ratio test, root test, comparison tests) to analyze series.

Course Content:

UNIT-I: Real Number System(12 Hours) [1 Question]

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(18 Hours) [2 Questions]

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 (12 Hours) [1 Question]

Convergence and divergence of infinite series of positive real numbers, Necessary condition for convergence, Cauchy criterion for convergence; Alternating series, Leibniz test, Absolute and conditional convergence. Absolute and conditional convergence. Dirichlet's test, Abel's test.

UNIT-IV: Tests for Convergence of Infinite Series (18 Hours) [2 Questions]

Tests for convergence of positive term series; Basic comparison test, Limit comparison test, D'Alembert's ratio test, Cauchy's nth root test, Raabe's test, De Morgan's and Bertrand's test, Second logarithmic test, Kummer's teat, Gauss' test, Cauchy's Integral test, Cauchy's condensation test.

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. SKILL ENHANCEMENT COURSE- SEC 2: DISCRETE MATHEMATICS

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

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

Course Objectives:

By the end of this course, students will be able to:

1. Understand the fundamental concepts and properties of partially ordered sets (posets) and their visual representations.
2. Explore lattice structures as both posets and algebraic systems with various properties.
3. Gain foundational knowledge of graph theory and its applications in solving path and circuit-related problems.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

1. Represent and analyze posets using Hasse diagrams, and determine minimal/maximal elements and bounds.
2. Identify and classify different types of lattices, including modular, distributive, and complemented lattices.
3. Construct and analyze various types of graphs such as bipartite, complete, and weighted graphs.
4. Apply graph algorithms, including Dijkstra's algorithm, to solve shortest path, Eulerian, and Hamiltonian problems.

CourseContents:

UNIT-I: Posets (15 Hours) [2 Questions]

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(15 Hours) [2 Questions]

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(15 Hours) [2 Questions]

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 3:
ORDINARY DIFFERENTIAL EQUATIONS-I

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

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

Course Objectives:

By the end of this course, students will be able to:

1. Understand the formation and classification of first-order and higher-order differential equations.
2. Learn methods for solving linear differential equations of various orders.
3. Explore the existence and uniqueness of solutions to differential equations.
4. Apply differential equations to real-world problems in physics, biology, and engineering.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

1. Classify and solve first-order differential equations using standard techniques including exactness and integrating factors.
2. Solve second-order and higher-order linear differential equations with constant and variable coefficients.
3. Determine linear independence of solutions using the Wronskian and apply solution methods like variation of parameters and undetermined coefficients.
4. Model and solve real-life problems such as population growth, radioactive decay, and motion using differential equations.

Course Content:

UNIT-I: First Order Differential Equations(18 Hours) [2 Questions]

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(20 Hours) [2 Questions]

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. Higher order linear differential equation: Linearly dependent and linearly independent solutions on an interval, Wronskian and its properties.

UNIT-III: Laplace Transforms (10 Hours) [1 Question]

Basic notions. Laplace transforms: Definition and Proprties. Inverse Laplace transform:Definition and Properties. Applications to Ordinary Differential Equations.

UNIT-IV: Applications (12 Hours) [1 Question]

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.

I. MAJOR COURSE –MJ 4:
GROUP THEORY AND MATRICES

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

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

Course Objectives:

By the end of this course, students will be able to:

1. Understand the foundational concepts of groups, subgroups, and their algebraic properties.
2. Analyze group structures using normal subgroups, factor groups, and permutation groups.
3. Apply the concepts of homomorphisms and isomorphisms along with fundamental isomorphism theorems.
4. Perform operations on matrices, solve linear systems, and compute eigenvalues and eigenvectors.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

1. Identify and construct various types of groups such as cyclic, permutation, and dihedral groups.
2. Determine cosets, analyze normal subgroups, and classify permutations using cycle notation.
3. Apply group homomorphisms and isomorphisms to deduce structural properties of groups.
4. Solve systems of linear equations using matrix techniques and compute matrix invariants like rank and eigenvalues.

Course Content:

UNIT-I: Groups and Subgroups (18 Hours) [2 Questions]

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(20 Hours) [2 Questions]

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(12 Hours) [1 Question]

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

UNIT-IV: Matrices (10 Hours) [1 Question]

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

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.

II. 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
*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.

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: Operating System, 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)**

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 rMATrd narration **(5 Hours)**

9. Digital Education: Introduction & 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. Wallace Wang, *Microsoft Office 2019*,Wiley (January 2018)
6. Noble Powell, *Windows 11 User Guide For Beginners and Seniors*, ASIN, (October 2021)

SEMESTER IV

I. MAJOR COURSE- MJ 5:
IKS IN MATHEMATICS

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

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

Course Objectives:
This course aims to:

1. To provide a historical and philosophical foundation of Indian mathematics, including its unique concepts and numeral systems.
2. To introduce geometric principles from ancient Indian sources like the Sulba Sütras and their applications in ritual and architecture.
3. To explore classical Indian contributions to algebra, arithmetic, and number theory, including concepts like zero, series, and combinatorics.
4. To develop competence in modern mathematical techniques such as Trigonometry and its applications.
5. To study conic sections using coordinate geometry and calculus.
6. To integrate traditional Indian mathematical thought with contemporary mathematical problem-solving skills.

Course Learning Outcomes:
After successful completion of this course, students will be able to:

1. Describe the evolution of Indian mathematics and major contributions by mathematicians such as Aryabhata, Bhaskaracharya and Ramanujan.
2. Apply geometric and measurement principles from Vedic texts, particularly in relation to symmetry, altar construction and architecture.
3. Solve problems involving algebraic expressions, series, permutations, and number theory using methods from Indian and modern traditions.
4. Apply De Moivre's Theorem in solving various problems, understand Trigonometric and Exponential functions of complex arguments and hyperbolic functions and obtain summation of Trigonometric series.
5. Students can analyze conics, transform equations, and apply geometric and calculus-based methods
6. Understand and analyze functions and their derivatives, applying them to problems involving rate of change, optimization and interpretation of the Mean Value Theorem.

Course Content:

UNIT-I: Foundations of Indian Mathematics(10 Hours) [1 Question]
Historical development of mathematics in ancient India**.** Concept of Sankhya, Ank and Ganit. Evolution of numerical systems: Brahmi and Devanagari numerals. Overview of major mathematicians: Baudhayana, Aryabhata, Bhaskaracharya, Mahaviracharya and Ramanujan. Classification of Indian mathematical texts: Sutra, Bhashya and Vartika.

UNIT-II: Geometry and Trigonometry(10 Hours) [1 Question]
Sulba Sutras: Geometrical constructions and measurements. Pythagorean theorem in Indian context (Baudhayana Theorem). Trapezium, Quadrilateral, Triangle, Circle, Volumes and Surfaces of Solid. Indian Sines and Cosines. Sine of difference of two angles.

UNIT-III: Algebra, Arithmetic, and Number Theory(10 Hours) [1 Question]
Algebra in Aryabhatiya and Lilavati. Permutations and Combinations in Jain mathematics.Series and Progressions in Indian texts. Zero and Decimal system in India. Divisibility rules and digital root methods (Navank Method).

UNIT-IV: Contemporary Trigonometry (10 Hours) [1 Question]
De Moivre's theorem for integer and rational indices and its applications.Trigonometric and Exponential functions of complex arguments and hyperbolic functions.Summation of Trigonometric Series.

UNIT-V: Analytical Geometry of 2D(10 Hours) [1 Question]
Change of rectangular axes.Condition for the general equation of second degree to represent parabola, ellipse, hyperbola and reduction into standard forms.Equations of tangent and normal (Using Calculus).Chord of contact, Pole and Polar. Pair of tangents in reference to general equation of conic.Axes, centre, director circle in reference to general equation of conic, Introduction of Polar equation of different conic sections.

UNIT-VI: Functions, Derivatives and Applications(10 Hours) [1 Question]
Functions of a single variable, Types of functions, Domain & Range. Geometrical interpretation of derivatives. Application of Derivative as rate measure. Maxima & Minima. Mean Value Theorem.

Reference Books

1. Datta, B., & Singh, A. N. (1962). *History of Hindu Mathematics (Vols. 1-2).* Bombay: Asia Publishing House.
2. Saraswati Amma, T. A. (1979). *Geometry in Ancient and Medieval India*. Varanasi Motilal Banarsidass.
3. Rao, S. Balachandra. (2000). *Indian Mathematics and Astronomy: Some Landmarks*. Bangalore: Jnana Deep Publications.
4. Kapoor, K. (2005). *Text and Interpretation: The Indian Tradition*. New Delhi. D. K. Printworld.
5. Jyeshthadeva. (2009). *Ganitayuktibhāṣā* (Trans & ed. with commentary by K. Ramasubramanian, M. D. Srinivas, & M. S. Sriram). Hindustan Book Agency.
6. Danino, M. (2014). *Indian Roots of Science A Journey through the Ancient and Medieval Contributions to Science and Technology*. New Delhi Aryan Books International.
7. IGNOU. (2005). *Indian Culture and Heritage Mathematics Module*. New Delhi: Indira Gandhi National Open University
8. Jagadguru Shankaracharya. (1992). *Vedic Mathematics.* New Delhi: Motilal Banarsidass.
9. A R Mazumdar, Ashit Das Gupta and Surya Bhushan Prasad (2021). *Degree Level Trigonometry*. Bharti Bhawan.
10. Ashit Das Gupta, Surya Bhushan Prasad, A B B Lal (2021) **.** *Degree Level Analytical Geometry of Two Dimensions*. Bharti Bhawan.
11. S K Mishra, Ashit Das Gupta, Surya Bhushan Prasad (2021)**.** *Degree Level Differential Calculus*. Bharti Bhawan.

II. MAJOR COURSE- MJ 6:
REAL ANALYSIS-II

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand the foundational concepts of limit and continuity using rigorous δ\deltaδ-ε\varepsilonε definitions and their graphical interpretations.
2. Grasp the concepts of differentiability and mean value theorems with a clear understanding of their applications and geometric significance.
3. Learn the theory of Riemann integration and apply key theorems to determine the integrability of functions.
4. Explore improper integrals, Beta and Gamma functions, and multiple integrals with variable transformations and convergence tests.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Apply ε-δdefinition to determine the limit and continuity of real-valued functions and identify different types of discontinuities.
2. Analyze the differentiability of functions, apply the chain rule, and interpret and prove mean value theorems geometrically and algebraically.
3. Evaluate Riemann integrals, determine integrability of functions, and apply fundamental and mean value theorems of integral calculus.
4. Solve improper integrals using convergence tests, understand and apply Beta and Gamma functions, and compute multiple integrals with variable changes.

Course Content:

UNIT-I: Limit and Continuity(12 Hours) [1 Question]

*Limit:*ε-δ 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-II: Differentiability(18 Hours) [2 Questions]

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-III: Riemann Integration (10 Hours) [1 Question]

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-IV: Improper integrals(20 Hours) [2 Questions]

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.

III. MAJOR COURSE –MJ 7:
MULTIVARIABLE CALCULUS

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand and apply partial derivatives in functions of several variables.
2. Evaluate double and triple integrals in various coordinate systems.
3. Analyze vector functions using gradient, divergence, and curl.
4. Apply Green's, Stokes', and Gauss divergence theorems in physical contexts.

Learning outcomes

After successful completing this course, students will be able to:

1. Compute partial derivatives, Jacobians, and apply Lagrange multipliers.
2. Solve problems involving double/triple integrals and coordinate transformations.
3. Calculate and interpret gradient, divergence, curl, and related vector identities.
4. Apply fundamental theorems of vector calculus to evaluate line, surface, and volume integrals.

Course Content:

UNIT-I: Partial Derivatives(18 Hours) [2 Questions]

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 (18 Hours) [2 Questions]

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 order of integration, Change of variables in double and triple integrals.

UNIT-III: Vector Field (12 Hours) [1 Question]

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(12 Hours) [1 Question]

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.
1. Lalji Prasad (2019). *Differential Calculus*. Paramount Publication.

SEMESTER V

I. MAJOR COURSE- MJ 8:
COMPLEX ANALYSIS-I

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

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

Course Objectives:
By the end of this course, students will be able to:

1. Understand complex numbers, their geometric representation, and basic topology of the complex plane.
2. Explore differentiability and analyticity of complex functions using Cauchy–Riemann equations.
3. Study convergence and representation of functions using power series.
4. Learn conformal mappings and transformations including bilinear transformation.

Course Learning Outcomes:
After successful completion of this course, students will be able to:

1. Represent complex numbers geometrically and analyze functions on the complex plane including limits and continuity.
2. Apply Cauchy–Riemann equations to determine analyticity and examine harmonic functions.
3. Construct and manipulate Taylor and Laurent series; determine radius and interval of convergence.
4. Perform and interpret conformal and bilinear transformations, and analyze critical/fixed points using the cross ratio.

Course Content:

UNIT-I: Complex Plane and functions (12 Hours) [1 Question]
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(18 Hours) [2 Questions]
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 (13 Hours) [1 Question]
Sequences, Series and their convergence, Cauchy Theorem, 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(17 Hours) [2 Questions]
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

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II. MAJOR COURSE- MJ 9:
MECHANICS

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

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

Course Objectives:

By the end of this course, students will be able to:

1. Understand the principles of equilibrium in statics and apply the concept of virtual work.
2. Determine the center of gravity for various plane areas and solids of revolution.
3. Analyze different types of rectilinear motion under various forces.
4. Study two-dimensional motion using multiple coordinate systems.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

1. Apply equilibrium conditions to particles and rigid bodies, and use virtual work principles.
2. Calculate the center of gravity of standard geometric shapes and volumes of revolution; derive and analyze the catenary.
3. Solve problems involving SHM, motion under inverse-square law, and motion in resisting media.
4. Analyze plane motion using Cartesian, polar, and intrinsic coordinates; study projectile and circular motions.

Course Content:

UNIT-I: Statics (18 Hours) [2 Questions]

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.

UNIT-II: Centre of Gravity and Common Catenary(18 Hours) [2 Questions]

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 aCurve, Centre of gravity of a volume of revolution; Flexible strings.

UNIT-III: Rectilinear Motion(12 Hours) [1 Question]

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(12 Hours) [1 Question]

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 10:
LINEAR PROGRAMMING PROBLEM

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

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

Course Objectives:

By the end of this course, students will be able to:

1. Understand the formulation and geometry of linear programming problems.
2. Learn and apply the Simplex method and related algorithms to solve LPPs.
3. Study duality theory and interpret dual problems.
4. Apply optimization techniques to solve transportation and assignment problems.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

1. Formulate linear programming problems and identify feasible and basic feasible solutions.
2. Solve LPPs using the Simplex method, including Big-M and two-phase methods.
3. Construct and interpret dual problems; apply duality theorems and complementary slackness.
4. Solve transportation and assignment problems using suitable algorithms like Vogel's.

Course Content:

UNIT-I: Linear Programming Problem, Convexity and Basic Feasible Solutions(18 Hours) [2 Questions]

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(12 Hours) [1 Question]

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(12 Hours) [1 Question]

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 (18 Hours) [2 Questions]

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.

IV. MAJOR COURSE –MJ 11:
RING THEORY

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

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

By the end of the course, students will be able to:

1. Understand the foundational concepts of rings, subrings, ideals, and various types of ring structures.
2. Study ring homomorphisms, quotient rings, and explore the structure-preserving properties of ring maps and related theorems.
3. Analyze polynomial rings and apply factorization techniques and criteria to study irreducibility over fields and rings.
4. Explore advanced factorization domains and understand the relationships among Euclidean domains, PID, and UFD.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Identify and classify rings, subrings, ideals, and distinguish among integral domains, division rings, and fields.
2. Apply the concepts of ring homomorphism and isomorphism, and use related theorems to analyze ring structures and kernels.
3. Perform algebraic operations in polynomial rings and apply theorems such as Gauss Lemma and Eisenstein's criterion to determine irreducibility.
4. Demonstrate understanding of divisibility, and distinguish between Euclidean domains, Principal Ideal Domains, and Unique Factorization Domains.

Course Content:

UNIT-I: Rings and Ideals(18 Hours) [2 Questions]

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(18 Hours) [2 Questions]

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(14 Hours) [1 Question]

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(10 Hours) [1 Question]

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

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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SEMESTER VI

I. MAJOR COURSE- MJ 12:
PROBABILITY AND STATISTICS

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand foundational concepts of probability, random variables, and key functions such as moment generating and characteristic functions.
2. Study important discrete and continuous probability distributions and their applications.
3. Explore joint distributions of two random variables and analyze marginal, conditional, and expectation-based properties.
4. Learn the principles of sampling and estimation, and apply various estimation techniques to infer population parameters.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Apply the rules of probability, including Bayes' theorem, and analyze discrete and continuous random variables using probability and distribution functions.
2. Identify and use standard discrete and continuous probability distributions (e.g., Binomial, Poisson, Normal) and apply normal approximation techniques.
3. Evaluate joint distributions, compute marginal and conditional distributions, and derive expectations and moment generating functions for bivariate cases.
4. Use random sampling methods, derive and interpret sampling distributions, and construct point and interval estimates with appropriate confidence levels.

Course Content:

UNIT-I: Probability Functions and Moment Generating Function(18 Hours) [2 Questions]

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(18 Hours) [2 Questions]

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 (12 Hours) [1 Question]

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(12 Hours) [1 Question]

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.

II. MAJOR COURSE- MJ 13:
PARTIAL DIFFERENTIAL EQUATION AND LAPLACE TRANSFORM

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

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

Course Objectives:

By the end of this course, students will be able to:

1. Understand the classification, formation, and solutions of first and second order partial differential equations.
2. Apply analytical methods like Lagrange's and Charpit's methods to solve first order PDEs.
3. Solve second order PDEs with constant and variable coefficients using canonical forms and separation of variables.
4. Use Laplace transforms and their inverses to solve ordinary differential equations and PDEs.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

1. Identify and classify first and second order PDEs as linear or non-linear, homogeneous or non-homogeneous.
2. Apply Lagrange's and Charpit's methods to solve suitable first order PDEs.
3. Reduce second order PDEs with variable coefficients to canonical form and solve standard models like the heat and wave equations.
4. Compute Laplace and inverse Laplace transforms and apply them to solve initial value problems.

Course Content:

UNIT-I: First Order Partial Differential Equations(20 Hours) [2 Questions]

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(12 Hours) [1 Question]

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(18 Hours) [2 Questions]

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: Laplace Transform (10 Hours) [1 Question]

Application of Laplace Transform to Partial Differential Equations.

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. J. K. Goyal and K. P. Gupta (2016). *Laplace and Fourier Transforms.* Pragati Prakashan.

III. MAJOR COURSE- MJ 14:
LINEAR ALGEBRA

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

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

Course Objectives:

By the end of this course, students will be able to:

1. Understand and apply the fundamental concepts of vector spaces, subspaces, and basis.
2. Analyze linear transformations and utilize the rank-nullity theorem.
3. Explore structural properties such as isomorphisms, eigenvalues, minimal polynomials, and the Cayley-Hamilton theorem.
4. Apply concepts of inner product spaces to solve problems involving orthogonality and diagonalisation.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

1. Identify and construct bases, subspaces, and quotient spaces of vector spaces.
2. Represent linear transformations using matrices and determine their rank and nullity.
3. Compute eigenvalues, eigenvectors, and use the Cayley-Hamilton and minimal polynomial theorems.
4. Apply orthogonality principles, Gram-Schmidt process, and diagonalisation to symmetric matrices.

Course Content:

UNIT-I: Vector Spaces(17 Hours) [2 Questions]

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(17 Hours) [2 Questions]

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(13 Hours) [1 Question]

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, Annihilating, Characteristic and minimal polynomial and Cayley–Hamilton theorem.

UNIT-IV: Inner Product Spaces (13 Hours) [1 Question]

Inner product spaces and orthogonality, Cauchy-Schwarz inequality, Gram-Schmidt orthogonalisation,Diagonalisation of symmetric matrices.

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.

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) **60 Hours**

Course Objectives:

By the end of the course, students will be able to:

1. Understand and apply numerical methods to solve algebraic and transcendental equations with an emphasis on error analysis and convergence.
2. Develop and implement algorithms for solving systems of linear equations using direct and iterative methods.
3. Learn various interpolation techniques and finite difference operators for estimating values and constructing interpolating polynomials.
4. Apply numerical techniques for differentiation, integration, and solving ordinary differential equations with error estimation.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Analyze round-off and truncation errors and apply iterative methods such as bisection, Newton's, and secant methods to solve nonlinear equations.
2. Solve linear systems using LU decomposition, Thomas method, and iterative techniques like Gauss–Seidel and SOR methods.
3. Perform interpolation using Newton's, Lagrange's, spline, and Gregory–Newton methods, and use finite difference operators effectively.
4. Approximate derivatives and integrals using finite difference and quadrature formulas, and apply Picard's method to solve ordinary differential equations.

Course Content:

UNIT-I: Numerical Methods for Solving Algebraic and Transcendental Equations(12 Hours) [1 Question]

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(12 Hours) [1 Question]

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 (18 Hours) [2 Questions]

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(18 Hours) [2 Questions]

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.

Note: *Use of Scientific calculator is allowed in the exam.*

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:
RESEARCH METHODOLOGY

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand the fundamental concepts of research methodology, including research problems, objectives, design, and the overall research process.
2. Develop skills in scientific writing for proposals, research papers, dissertations, and theses with proper structure, clarity, and referencing.
3. Gain awareness of research ethics and publication integrity, including issues of plagiarism, misconduct, authorship, and research metrics.
4. Acquire proficiency in using digital tools, presentation techniques, and online resources for effective research communication.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Formulate well-defined research problems, design research plans, and conduct literature surveys effectively.
2. Write high-quality research proposals, papers, dissertations, and theses following academic and scientific standards.
3. Apply principles of research ethics and publication practices to ensure integrity, originality, and responsible authorship.
4. Use LaTeX, MS Office, PowerPoint, Beamer, and online databases to prepare and present professional research outputs.

Course Content:

UNIT-I: Introduction of Research Methodology (12 Hours) **[1 Question]**

Introduction to Research: Meaning of research, objectives of research, types of research, significance of research, research and scientific method, research process. *Research Problem*: Definition, necessity and techniques of defining research problem. Formulation of research problem. Objectives of research problem. *Research Design*: Meaning, need and features of good research design. Literature survey of the topic and a problem, Role of a supervisor, Funding agencies.

UNIT-II: Scientific Writing(18 Hours) **[2 Questions]**

Research Proposal: Title, State of the Art, Research Problem, Objective, Significance, Contribution to the society, Methodology, Tools to be used, References;*Research Papers:* Title, Running Title, Authors- Single and Multiple-authorship, Abstract, Key Words, Introduction section, Formulation of problem, method of solution/Analytical proofs, Result Section, Figures- Design Principles, Legends, fable components. Graphs; Types, Style. Discussion Section: Format. Grammar Style, Content, Acknowledgements, References and citations; *Dissertation/ Thesis:*Format of a dissertation/ thesis; Review of literature, formulation; Writing methods, results; preparation of tables, figures; writing discussion; writing conclusion; writing summary and synopsis; Reference citing and listing/bibliography.

UNIT-III: Ethics in Research and Scholarly Publishing(18 Hours) **[2 Questions]**

Scientific Conduct: Ethics with respect to science and research, Intellectual honesty and research integrity; *Scientific misconducts*: Falsification, Facbrication and Plagiarism; *Redundant publications*: Duplicate and overlapping publications, salami slicing; Selective reporting and misrepresentation of data. *Publication Ethics:* Definition, introduction and importance of publication ethics; Conflicts of interest; *Publication misconduct*: Definition, concept, problems that led to unethical behaviour and vice versa, types; Violation of publication ethics, authorship and contributorship; *Journals*: Predatory publishers and journals, Open Access Publishing. *Database*: Indexing databases; Citation databases: Web of science, Scopus, etc.; *Research Metrics*: Impact factor of journal, CiteScore; *Metrics*: h-index, g index, i10 index.

UNIT-IV: Tools and Techniques for Research Communication(12 Hours) **[1 Question]**

Writing tools: MS Office 2007- Word basics, Macros, Math Type, Equation Editor; LaTeX. *Presentation tools*: Power Point basics; Animations; Poster and Oral; Beamer as a tool for paper and thesis presentations. *Web Search*: Search engines; Searching hints; Using advanced search techniques; Mathematical & Scientific Websites & Databases.

Reference Books:

1. C. R. Kothari and Gaurav Garg (201 0). *Research Methodology (Methods & Techniques*), New Age Int. Pub.
2. Ranjit Kumar (2019). *Research Methodology: A Step-by-Step Guide for Beginners*, SAGE Pub.
3. Gurumani, N. (2010). *Scientific Thesis Writing and Paper Presentation*. MJP Publishers.
4. Santosh Kumar Yadav (2023). *Research and Publication Ethics,* Springer.
5. M. Otey (2013). *Creating Research and Scientific Documents Using Microsoft Word*. O'Reilly Media.
6. S. Kottwitz (2015). *LaTeX Cookbook*. Packt Publishing.

II. MAJOR COURSE- MJ 17:
REAL ANALYSIS-III

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand the concepts of pointwise and uniform convergence of sequences and series of functions, and their impact on continuity, integrability, and differentiability.
2. Develop a deep understanding of the Riemann-Stieltjes integral, its properties, and its connection to the Riemann integral.
3. Analyze functions of several variables using partial derivatives, Jacobians, and apply key theorems like the Inverse and Implicit Function Theorems.
4. Learn to construct and analyze Fourier series representations of functions and apply convergence theorems and identities like Bessel's and Parseval's.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Apply uniform convergence tests (Cauchy, Mn-Test, Weierstrass M-test, Abel's and Dirichlet's) and explain their implications on function properties.
2. Compute Riemann-Stieltjes integrals and use the related theorems including change of variable and mean value theorems.
3. Differentiate multivariable functions, apply the chain rule, and use Taylor's expansion, Inverse and Implicit Function Theorems.
4. Construct Fourier series for periodic functions on various intervals and use Fourier–Dirichlet, Bessel's, and Parseval's theorems to analyze convergence and energy.

Course Content:

UNIT-I: Uniform Convergence(18 Hours) [2 Questions]

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: Riemann Stiltjes Integral (12 Hours) [1 Question]

Definition of Reimann Stiltjes (R-S) integral. Properties of upper and lower R-S Sums. Theorems on existence of R-S integrals. Integral as a limit of sum. Relation between Riemann and Reimann-Stiltje's integrals. Change of variable. Mean value theorems.

UNIT-III: Functions of Several Variables(18 Hours) [2 Questions]

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-IV: Fourier Series (12 Hours) [1 Question]

Definitions. Theorems on sum. Fourier –Dirichlet Theorem. Necessary and Sufficient conditions. Fourier series on even and odd functions. Bessel's Theorem. Perseval's Theorem. Fourier series on $[0, \pi]$ and on $[0, 2\pi]$. Fourier series on [-l, l], [0, l] and on [a, b].

Reference Books:

1. Walter Rudin (2017). *Principles of Mathematical Analysis.* 3 rd ed. McGraw-Hill.
2. H. K. Pathak (2021). *Real Analysis.* Shree Shiksha Sahitya Prakashan.
3. J. N. Sharma & A. R. Vashishtha (2014). *Mathematical Analysis-II.* Krishna Prakashan.
4. Dipak Chatterjee (2005). *Real Analysis*. PHI.
5. S. L. Gupta and N. R. Gupta (2003). *Principles of Real Analysis*. Rearson Education.

III. MAJOR COURSE –MJ 18:
ORDINARY DIFFERENTIAL EQUATIONS-II

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand the existence and uniqueness theorems for first-order differential equations and apply iterative methods to approximate solutions.
2. Analyze second and higher-order differential equations using algebraic methods, Wronskian properties, and solution techniques for both homogeneous and non-homogeneous cases.
3. Study linear systems of ODEs, their solutions using eigenvalue methods, and techniques for reduction to first-order systems.
4. Learn to solve boundary value problems using Sturm–Liouville theory and Green's function techniques.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Determine the existence and uniqueness of solutions to first-order ODEs using Picard's theorem and apply successive approximation techniques.
2. Analyze and solve second and higher-order ODEs using Wronskian, annihilator method, and initial value problem techniques.
3. Solve linear systems of ODEs using eigenvalues and eigenvectors, and reduce higher-order equations to first-order systems.
4. Formulate and solve Sturm–Liouville boundary value problems using Green's functions for self-adjoint differential operators.

Course Content:

UNIT-I: First Order ODE(12 Hours) [1 Question]

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 (18 Hours) [2 Questions]

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(18 Hours) [2 Questions]

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(12 Hours) [1 Question]

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

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IV. ADVANCED MAJOR COURSE- AMJ 1: METRIC SPACE

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

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

Course Objectives:

By the end of this course, students will be able to:

1. Understand fundamental concepts in metric spaces including open/closed sets, limit points, and subspaces.
2. Analyze convergence, completeness, and continuity in metric spaces using key theorems.
3. Explore and apply criteria for compactness and sequential compactness in metric spaces.
4. Examine connectedness in metric spaces and apply related theorems to subsets and functions.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

1. Identify and describe open spheres, closed sets, closures, interiors, and other topological properties in metric spaces.
2. Determine completeness of metric spaces and verify continuity using concepts like uniform continuity and Banach's contraction principle.
3. Apply the Heine-Borel theorem and other compactness criteria to solve problems in analysis.
4. Classify connected and disconnected sets, and analyze the behavior of continuous functions on connected spaces.

Course Content:

UNIT-I: Concepts in Metric Spaces(18 Hours) [2 Questions]

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(18 Hours) [2 Questions]

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.

UNIT-III: Compact Metric Space(14 Hours) [1 Question]

Compact spaces, Sequential compactness, Bolzano-Weierstrass property, Compactness andfinite intersection property, Heine-Borel theorem, Totally bounded sets, Equivalence ofcompactness and sequential compactness, Continuous funnctions on compact spaces, Lebesgue covering lemma, locally compact spaces.

UNIT-IV: Connectednessin Metric Space (10 Hours) [1 Question]

Separated sets, Disconnected and connected sets, Properties of connected and disconnected 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.
5. S. C. Mallik and Savita Arora (2022). *Mathematical Analysis*. New Age International.
6. Mícheál O'Searcoid (2007). *Metric Spaces*. Springer.

OR RESEARCH COURSES- RC 1:(In lieu of AMJ 1)

RESEARCH PLANNING & TECHNIQUES

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand the principles of research planning in mathematics, including problem identification, formulation, and resource management.
2. Acquire skills for conducting effective literature surveys, analyzing existing work, and identifying research gaps.
3. Develop proficiency in applying core mathematical research techniques such as proof strategies, counterexamples, and abstraction.
4. Explore advanced and interdisciplinary techniques, integrating computational and applied approaches to formulate coherent research proposals.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Formulate precise mathematical research questions and design structured project plans with clear objectives and timelines.
2. Conduct critical literature reviews, evaluate the validity of results, and organize bibliographic resources systematically.
3. Apply appropriate mathematical proof techniques, construct counterexamples, and refine results through generalization and specialization.
4. Integrate computational and interdisciplinary methods into mathematical research and prepare mini research proposals with originality and rigor.

Course Content:

UNIT-I: Fundamentals of Research Planning in Mathematics (15 Hours) [1.5 Questions]

Introduction to research planning: Differences between coursework and research in mathematics. *Identifying research problems*: Sources of inspiration (open problems, conjectures, applications). *Formulating research questions*: From vague ideas to precise statements, including hypotheses and conjectures. *Project planning*: Setting objectives, creating timelines, milestones, and risk assessment. *Resource management*: Identifying necessary mathematical background, collaborators, and computational needs.

UNIT-II: Literature Survey and Analysis Techniques (15 Hours) [1.5 Questions]

Searching mathematical literature: Using databases like MathSciNet, zbMATH, arXiv, and Google Scholar. *Reading strategies*: Skimming abstracts, understanding proofs, identifying key results and gaps. *Analyzing and synthesizing information*: Mapping connections between papers, noting patterns and unresolved issues. *Critical evaluation*: Assessing validity of arguments, spotting errors, and extending existing work. *Building a research bibliography*: Organizing references and tracking influences.

UNIT-III: Core Mathematical Research Techniques (15 Hours) [1.5 Questions]

Proof development strategies: Direct proofs, contradiction, induction, and case analysis. *Constructing counterexamples and examples*: Role in testing conjectures and refining theorems. *Generalization and specialization*: Scaling problems up or down to gain insights. *Pattern recognition and abstraction*: Identifying structures in mathematical objects (e.g., groups, graphs). *Iterative refinement*: Debugging proofs, handling edge cases, and adapting techniques.

UNIT-IV: Advanced Techniques and Integration (15 Hours) [1.5 Questions]

Computational techniques in mathematics: Introduction to algorithmic approaches, simulations, and verification. *Modeling in applied mathematics*: Translating real-world problems into mathematical frameworks. *Interdisciplinary techniques*: Incorporating ideas from computer science, physics, or statistics into math research. *Case studies*: Analyzing famous mathematical discoveries- Fermat's Last Theorem planning, graph theory applications. *Integrating planning and techniques*: Developing a mini-research proposal combining all units.

Reference Books:

1. George Pólya (1945). *How to Solve It: A New Aspect of Mathematical Method*. Princeton University Press.
2. John D'Angelo and Douglas West (2000). *Mathematical Thinking: Problem-Solving and Proofs*. Pearson.
3. Paul Zeitz (2006). *The Art and Craft of Problem Solving*. Wiley.
4. Arthur Engel (1998). *Problem-Solving Strategies*. Springer.
5. Imre Lakatos (1976). *Proofs and Refutations: The Logic of Mathematical Discovery*. Cambridge University Press.
6. Robert E. White (2012). *A First Course in Computational Mathematics*. CRC Press.

SEMESTER VIII

I. MAJOR COURSE- MJ 19:
ANALYTICAL DYNAMICS AND CALCULUS OF VARIATIONS

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand the foundational principles of Lagrangian mechanics and apply them to different types of mechanical systems.
2. Formulate and analyze physical systems using Hamiltonian and Routhian dynamics.
3. Apply techniques from the calculus of variations to solve classical optimization problems in physics and geometry.
4. Explore variational principles in dynamics and use bracket operations to study symmetries and conserved quantities.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Formulate equations of motion using Lagrange's first and second kind, and derive energy relations in conservative systems.
2. Derive and apply Hamilton's canonical equations and Routh's equations for dynamical systems involving cyclic coordinates.
3. Solve variational problems involving geodesics, shortest paths, and minimal surfaces using Euler's equation.
4. Apply Hamilton's principle, derive Hamilton–Jacobi equations, and use Lagrange and Poisson brackets in the study of dynamical systems and symmetries.

Course Content:

UNIT-I: Lagrangian Dynamics(19 Hours) [2 Questions]

Moment of Inertia, Generalized coordinates, Holonomic and Non-holonomic systems, Scleronomic and Rheonomic systems, Generalized potential. Lagrange's equations of first and second kind, Energy equation for conservative fields.

UNIT-II: Equations of Hamilton and Routh(12 Hours) [1 Question]

Hamilton canonical equations. Equation of energy from Hamilton's equations, Cyclic coordinates, Routh's equations, Jacobi-Poisson Theorem.

UNIT-III: Calculus of Variations (12 Hours) [1 Question]

Motivating problems of calculus of variations fundamental lemma of calculus of variations Euler's equation, Brachistochrone problem Shortest distance, Geodesic, Minimum surface of revolution.

UNIT-IV: Variational Principal in Dynamics and Brackets (17 Hours) [2 Questions]

Hamilton's Principle, Principle of least action. Jacobi's equations. Hamilton-Jacobi equations. Jacobi theorem. Lagrange brackets and Poisson brackets. Invariance of Langrange brackets and Poisson brackets under canonical transformations.

Reference Books:

1. H.Goldstein (1980). *Classical Mechanics*(2nd edition),Narosa Publishing House, New Delhi.
2. I.M.Gelfand and S.V.Fomin (2000).*Calculus of variation*, prentice Hall.
3. S.L. Loney (1979).*An elementary treatise on Statics*, Kalyani Publishers, N. Delhi.
4. A.S.Ramsey (1940), *Newtonian Gravitation*. The English Language Book Society and the Cambridge University Press.
5. N.C. Rana & P.S.Chandra Joag (1991).*Classical Mechanics*. Tata McGraw Hill.
6. Lours N. Hand and Janel, D. Finch (1999). *Analytical Mechanics*, Cambridge University Press.
7. P. P. Gupta and G. S. Malik (2008). *Rigid Dynamics-I & II*. Krishna Prakashan.

II. MAJOR COURSE –MJ 20: COMPLEX ANALYSIS-II

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand the theory of complex integration and fundamental results like Cauchy's theorems and their consequences.
2. Analyze singularities, compute residues, and apply the residue theorem and Jordan's lemma to evaluate complex integrals.
3. Explore the nature and behavior of meromorphic and entire functions using powerful results like Rouche's theorem and the principle of argument.
4. Learn the concept of analytic continuation and methods to extend analytic functions beyond their original domains.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Evaluate complex integrals using Cauchy's theorems, and apply the maximum and minimum modulus principles and Liouville's theorem.
2. Identify and classify singularities, calculate residues at poles and infinity, and apply the residue theorem to solve contour integrals.
3. Analyze meromorphic functions, apply Mittag-Leffler's theorem, and use Rouche's theorem to determine zeros and poles.
4. Perform analytic continuation using power series methods, and determine the uniqueness and behavior near singularities on the circle of convergence.

Course Content:

UNIT –I: Complex Integration(18 Hours) [2 Questions]

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(18 Hours) [2 Questions]

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(12 Hours) [1 Question]

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(12 Hours) [1 Question]

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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III. ADVANCED MAJOR COURSE- AMJ 2: MEASURE THEORY

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand the concept of measure, outer measure, and measurable sets including examples like Cantor and non-measurable sets.
2. Develop the ability to identify and work with measurable functions, including step and Borel measurable functions, and apply foundational principles.
3. Learn the construction and properties of the Lebesgue integral and compare it with the Riemann integral.
4. Explore various modes of convergence of measurable functions and apply major convergence theorems in integration.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Define and identify measurable sets, explain outer measure, Carathéodory's criterion, and describe examples like the Cantor ternary set and Borel sets.
2. Analyze measurable functions and their properties, and explain the significance of Littlewood's three principles.
3. Compute Lebesgue integrals for different classes of functions and distinguish them from Riemann integrals.
4. Apply theorems related to convergence in measure, including Egoroff's, Riesz, Fatou's lemma, and the Dominated and Monotone Convergence Theorems.

Course Content:

UNIT-I: Measurable Sets (18 Hours) [2 Questions]

Motivation and Concept of Measure of a set, Outer measure, Caratheodory postulates. Measurable sets, Cantor Ternary Set. Lebesgue measures, Properties of Measurable Sets, Borel Sets. A non-measurable set,

UNIT-II: Measurable Functions (12 Hours) [1 Question]

Measurable functions, Properties of measurable functions. Step function, Characteristic function, Continuous function, Borel measurable functions. Littlewood's three principles.

UNIT-III: The Lebesgue Integral(12 Hours) [1 Question]

Lebesgue integral of a bounded function over a finite measure, First Mean Value Theorem, The integral of a non-negative function, The general Lebesgue integral, Theorems on General Lebesgue integrals. Riemann vs Lebesgue integrals.

UNIT-IV: Convergence in Measure(18 Hours) [2 Questions]

Definitions. Convergence in measure, Riesz theorem, Egoroffs theorem, Bounded convergence theorem, Dominated Convergence theorem, Monotone convergence theorem. Fatou's lemma.

Reference books:

1. G. de Barra (2013). *Measure Theory and Integration*. New Age Int.
2. P. K. Jain, V. P. Gupta and P. Jain (2011). *Lebesgue Measure and Integration*. New Age International.
3. I. K. Rana (2007). *An Introduction to Measure and Integration.* Narosa.
4. H. K. Pathak (2021). *Real Analysis.* Shree Shiksha Sahitya Prakashan.
5. P. P. Gupta, G. S. Malik & S. K. Mittal (2008). *Measure Theory.* Pragati Prakashan.

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) **60 Hours**

Course Objectives:

By the end of the course, students will be able to:

1. Understand the basic definitions, examples, and fundamental structures of topological spaces including subspaces and quotient topology.
2. Explore the concepts of continuity, homeomorphism, and connectedness in topological spaces.
3. Study countability properties and separation axioms with the help of essential theorems like Urysohn's Lemma and Tietze extension theorem.
4. Examine the concept of compactness and its implications, including important results like Tychonoff's theorem and one-point compactification.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Define and work with topological spaces, closed sets, interiors, closures, derived sets, and construct topologies using bases, subbases, and quotient topology.
2. Analyze continuous functions and homeomorphisms, and determine connectedness and related properties in topological spaces.
3. Apply countability conditions and separation axioms, and utilize Urysohn's Lemma and Tietze extension theorem to study space separation.
4. Determine compactness using finite intersection property, apply Tychonoff's theorem, and understand compactification techniques like one-point compactification.

Course Content:

UNIT-I: Fundamentals of A Topological Space (18 Hours) [2 Questions]

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(10 Hours) [1 Question]

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

Unit-III: Countability and Separation Axioms(18 Hours) [2 Questions]

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 (14 Hours) [1 Question]

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.

OR RESEARCH COURSES- RC 2:(In lieu of AMJ 2 & AMJ 3)

RESEARCH/ PROJECT DISSERTATION/ TEACHING APTITUDE

Marks: 50 (SIE: 25 Synopsis + 25 Viva on Synopsis: 1Hr) + 100 (ESE Pr: 6Hrs) + 50 (Viva) = 200	**Pass Marks = 80**

(Only for Hons with Research Degree)

GuidelinestoExaminersfor Semester Internal Examination(SIE):

Evaluationofprojectdissertationworkmaybeasperthefollowingguidelines:

Project Synopsis *=25marks*

Project Synopsis presentationandviva-voce *=25 marks*

GuidelinestoExaminersfor EndSemesterExamination(ESE):

Evaluationofprojectdissertationworkmaybeasperthefollowingguidelines:

Project model (if any) and the Project record notebook *=70marks*

Projectpresentationandviva-voce *=30 marks*

Overallprojectdissertationmaybeevaluatedunderthefollowingheads:

- *Motivation for the choice of topic*
- *Project dissertation design*
- *Methodology and Content depth*
- *Results and Discussion*
- *Future Scope & References*
- *Participation in Internship programme with reputed organization*
- *Application of Research technique in Data collection*
- *Report Presentation*
- *Presentation style*
- *Viva-voce*

Course Objectives:

By the end of the course, students will be able to:

1. Identify and undertake an appropriate mathematical research project based on theoretical, computational, or applied interests.
2. Apply mathematical reasoning, tools, and research methods to explore, model, or analyze a defined problem.
3. Develop a well-structured research report using appropriate academic writing, referencing, and presentation standards.
4. Demonstrate academic integrity, self-management, and effective communication through project execution and presentation.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Choose a research topic and formulate clear objectives, hypotheses, or questions suitable for mathematical investigation.
2. Conduct independent or collaborative research using literature, theoretical analysis, computational tools, or field data.
3. Compile findings into a logically structured report with proper use of mathematical language, notation, LaTeX, and citation styles.
4. Present and defend the research outcomes in written and oral formats while adhering to academic integrity standards.

Course Content:

Types of Work Permitted:

Students may undertake **one** of the following:

1. Theoretical Research Project
   - Focused on pure or applied mathematics.
   - Exploration of a conjecture, theorem, new proof or literature-based study.
   - Could involve extensions of known results or critical review of a mathematical topic.
2. Computational/Experimental Mathematics Project
   - Use of programming tools Python/ MATLAB/ SageMath for simulation, visualization or experimentation.
   - Projects may involve fractals, number theory computations, optimization or algorithm design.
3. Research Internship
   - Carried out at research institutes, universities or organizations.
   - Mandatorily include a defined project with mentor evaluation.
4. Field Work / Mathematical Modelling Project
   - Application of mathematics to real-world problems.
   - Could involve surveys, data collection, analysis or model building.
   - Interdisciplinary or community-based research.

Research Project

Research project under a Supervisor of the Department/Institution may be allocated to the eligible and qualifying candidate.

Project Dissertation/ Research Internship/ Field Work

The studentsof Post-Graduation must work Thirty-Six(36) days asInternsunder Any Organisation having an MoU with the RADHA GOVIND UNIVERSITY, RAMGARH, which may include GovernmentOrganizations/judiciary/ HealthCareSectors/ EducationalInstitutions/ NGOsetc.

- The nature and the place of working must be informed in writing, seeking permission from the head of the department or the institution before undertaking the Project dissertation.

Project Components: Every student must submit a **project report/dissertation** that includes:

- ❖ Title Page and Abstract
- ❖ Introduction and Literature Review
- ❖ Objectives and Methodology
- ❖ Mathematical Framework and Analysis
- ❖ Results/Findings and Discussion
- ❖ Conclusion and Scope for Further Work
- ❖ References in IEEE style
- ❖ Appendix

Supervision and Mentoring

- ➢ Each student shall be assigned a faculty supervisor.
- ➢ Students are expected to meet their supervisor at least bi-weekly for feedback and guidance.
- ➢ In case of internship or external projects, joint supervision with a host mentor is encouraged.

Academic Integrity

- ➢ Plagiarism and unethical practices will result in disqualification**.**
- ➢ Students must sign a Declaration of Originality and follow standard referencing norms.

Use of Tools and Resources (Recommended)

- ➢ MS Word or LaTeX for report writing.
- ➢ Python, SageMath, R or MATLAB for computations.
- ➢ Access to online libraries: arXiv, MathSciNet, JSTOR, Project Euclid.

Topics

Project work related to the Industrial/socially relevant topics may be given.

NB: Students will select topics for the project work in consultation with a teacher of the department.

The Seminar will be held in the respective P.G. Department, RADHA GOVIND UNIVERSITY, RAMGARH, RAMGARH.

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

ASSOCIATED CORE COURSE-MN A **Either may be opted in Sem-I or Sem-II**

ASSOCIATED CORE COURSE- MN A:

INTRODUCTION TO HIGHER MATHEMATICS

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand and apply the basic principles of differential and integral calculus to elementary functions.
2. Gain conceptual clarity of vector calculus and its role in multivariable systems. Develop problem-solving techniques for first-order differential equations. Acquire foundational knowledge in group theory and basic real analysis.
3. Explore the algebra and geometry of complex numbers and their applications.
4. Understand the structure and graphical solution methods of linear programming problems.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Compute higher-order and partial derivatives of functions and apply them in solving basic calculus problems.
2. Evaluate definite and indefinite integrals of rational and irrational functions using appropriate techniques.
3. Differentiate scalar and vector point functions and understand basic vector calculus operations.
4. Solve first-order differential equations using standard methods and interpret their general and particular solutions.
5. Demonstrate understanding of elementary group structures and foundational properties of the real number system.
6. Perform algebraic operations with complex numbers and solve basic linear programming problems using graphical methods.

Course Content:

UNIT-I: Differential Calculus(10 Hours) [1 Question]

Successive differentiation of standard functions, nth-order derivatives, Partial derivatives of functions with two variables.

UNIT-II: Integral Calculus(10 Hours) [1 Question]

Integration of rational and irrational algebraic functions, Integration by substitution, Decomposition of rational functions into partial fractions.

UNIT-III: Vector Calculus(10 Hours) [1 Question]

Scalar and vector point functions, Differentiation of scalar and vector fields, Introduction to gradient ($\nabla\varphi$) and directional derivatives (basic idea only).

UNIT-IV: Differential Equations (10 Hours) [1 Question]

General and particular solutions, First-order, first-degree differential equations: Separable equations, Homogeneous equations, Linear equations.

UNIT-V: Algebra and Real Analysis(10 Hours) [1 Question]

Binary operations; definition and examples of groups, Properties of real numbers: Completeness property, Archimedean property. Introduction to bounds: upper bound, lower bound.

UNIT-VI: Complex Numbers and Linear Programming (10 Hours) [1 Question]

Algebra of complex numbers: modulus, conjugate, argument, polar form. Introduction to Linear Programming: Objective function and constraints, Mathematical formulation of LPP, Graphical method for two-variable LPP, Feasible and infeasible regions, optimal solution.

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.
5. Shanti Narayan & M. D. Raisinghania (2020). *Elements of Real Analysis*. S. Chand.
6. A. D. Dasgupta & S. B. Prasad (2021). *Degree Level Abstract Algebra.* Bharti Bhawan.
7. R. K. Gupta (2014). *Linear Programming.* Krishna prakashan.
8. Shanti Narayan and P. K. Mittal (2005). *Theory of Functions of a Complex Variable*. S. Chand & Co.
9. Lalji Prasad (2017). *Complex Analysis*. Paramount Publications.
10. A. R. Vashishtha, J. N. Sharma & A. K. Vashishtha (2010). *Linear Algebra.* Krishna Publication.

MINOR COURSE-B

MINOR COURSE- MN B:
CALCULUS

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

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

Course Objectives:
By the end of the course, students will be able to:

1. Understand and apply the principles of successive differentiation and vector calculus, including gradient, divergence, and curl operations.
2. Develop proficiency in solving definite and indefinite integrals, including reduction formulas and applications to areas and volumes.
3. Analyze and interpret the geometrical features of algebraic curves such as curvature, asymptotes, symmetry, and trace various types of curves.
4. Gain a conceptual and computational understanding of functions of several variables, including partial derivatives, Jacobians, and multivariable Taylor expansions.

Course Learning Outcomes:
After successful completion of this course, the students will be able to:

1. Apply Leibnitz's theorem and Taylor/Maclaurin series to expand functions and compute vector derivatives involving gradient, divergence, and curl.
2. Evaluate definite and indefinite integrals using standard techniques and reduction formulas; calculate arc length, area, and volume using integration.
3. Determine key geometric properties of curves, including curvature and asymptotes, and accurately trace Cartesian, polar, and parametric curves.
4. Perform operations involving multivariable functions, including finding partial derivatives, using Euler's theorem, computing Jacobians, and applying Taylor's theorem for several variables.

Course Content:

UNIT-I: Differential and Vector Calculus (18 Hours) [2 Questions]

Successive differentiation: Leibnitz theorem, Maclaurin's and Taylor's theorems for expansion of a function, Taylor's theorem in finite form with Lagrange remainder. Derivatives of a sum of vectors, Derivatives of a product of vectors, Gradient, Divergence and Curl and vector identities.

UNIT-II: Integral Calculus(18 Hours) [2 Questions]

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 $\int \sec^n x dx$. Length of plane curve and area bounded by plane curves, Volume and surface area of solid of revolution.

UNIT-III: Geometry of Curves(14 Hours) [1 Question]

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.

UNIT-IV: Functions of Several Variables (10 Hours) [1 Question]

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.

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

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MINOR COURSE-C

MINOR COURSE- MN C:
DIFFERENTIAL EQUATIONS

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

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

Course Objectives:
By the end of the course, students will be able to:

1. Understand and solve first-order differential equations using standard techniques such as separable, homogeneous, linear, and exact forms.
2. Learn the theory and methods to solve second-order linear differential equations with constant coefficients.
3. Develop foundational knowledge of first-order partial differential equations and apply Lagrange's method for solving them.
4. Explore the classification and solution of second-order partial differential equations with constant coefficients, including homogeneous and non-homogeneous cases.

Course Learning Outcomes:
After successful completion of this course, the students will be able to:

1. Identify and solve first-order differential equations using appropriate methods including integrating factors and reduction to linear form.
2. Apply theoretical results such as existence and uniqueness to solve second-order linear ODEs with constant coefficients.
3. Derive and solve first-order PDEs using the method of characteristics and Lagrange's method for equations of the form Pp+Qq=RPp + Qq = RPp+Qq=R.
4. Classify and solve second-order PDEs with constant coefficients using superposition principles and distinguish between reducible and irreducible forms.

Course Content:

UNIT-I: First Order Differential Equations(18 Hours) [2 Questions]
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.

UNIT-II: Second Order Linear Differential Equations(12 Hours) [1 Question]
Statement of existence and uniqueness theorem for the solution of linear differential equations, Solutions of homogeneous linear ordinary differential equations of second order with constant coefficients.

UNIT-III: First Order Partial Differential Equations(18 Hours) [2 Questions]
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-IV: Second Order Partial Differential Equations with Constant Coefficients(12 Hours) [1 Question]
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.

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.

MINOR COURSE-D

MINOR COURSE- MN D:

REAL ANALYSIS

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand the foundational concepts of set theory, including relations, functions, cardinality, and types of sets.
2. Develop a deep understanding of the structure of real numbers, their properties, and topological concepts in $\mathbb{R}$.
3. Learn the principles and techniques of analyzing the convergence of sequences in real numbers.
4. Acquire skills to test the convergence of infinite series using standard analytical methods and theorems.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Define and classify relations, functions, and sets; distinguish between countable and uncountable sets, and determine cardinality.
2. Analyze the properties of the real number system, including completeness, Archimedean property, and topological notions like open and closed sets.
3. Examine and determine the convergence of sequences using limit theorems, monotonicity, and Cauchy's criterion.
4. Evaluate the convergence of series using comparison tests, ratio/root tests, and identify absolute and conditional convergence using the Leibniz test.

Course Content:

UNIT-I: Set Theory(12 Hours) [1 Question]

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-II: Real Numbers (12 Hours) [1 Question]

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 $\mathbb{R}$.

UNIT-III: Convergence of Sequences(18 Hours) [2 Questions]

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 (18 Hours) [2 Questions]

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. A. D. Dasgupta & S. N. Thakur (2021). *Degree Level Set Theory.* Bharti Bhawan.
2. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.
3. Shanti Narayan & M. D. Raisinghania (2020). *Elements of Real Analysis*. S. Chand.

MINOR COURSE-E

MINOR COURSE- MN E:
HIGHER ALGEBRA

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

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

Course Objectives:
By the end of the course, students will be able to:

1. Understand and apply algebraic theorems related to polynomial equations and their roots, including classical methods such as Cardan's method.
2. Develop a foundational understanding of group theory, including basic definitions, subgroup properties, and examples of standard groups.
3. Explore special classes of groups like cyclic and permutation groups, and analyze their structure through centralizers, normalizers, and symmetry operations.
4. Learn and apply concepts from linear algebra such as matrix echelon forms, rank, eigenvalues and eigenvectors to solve linear systems and characterize matrices.

Course Learning Outcomes:
After successful completion of this course, the students will be able to:

1. Solve polynomial equations using elementary theorems, factorization methods, and analyze relationships between roots and coefficients.
2. Identify and verify group structures, analyze properties of subgroups, and apply Lagrange's theorem to group-related problems.
3. Classify and work with cyclic and permutation groups; compute centralizers, normalizers, and use Cayley's theorem to represent finite groups.
4. Perform row reduction to echelon forms, determine rank, solve systems of linear equations, and compute eigenvalues and eigenvectors of matrices.

Course Content:

UNIT-I: Theory of Equations(13 Hours) [1 Question]
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.

UNIT-II: Groups, Subgroups(17 Hours) [2 Questions]
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 (18 Hours) [2 Questions]
Cyclic groups and properties, Classifications of subgroup of cyclic groups, Cauchy theorem for finite Abelian groups; Centralizer, Normalizer, Center of a group, Permutation group and properties, Even and odd permutations, Cayley's theorem.

UNIT-IV: Row Echelon Form of Matrices and Applications(12 Hours) [1 Question]
Row reduction and echelon forms, The rank of a matrix and its applications in solving system of linear equations; Eigenvectors and eigen values, The characteristic equation.

Reference Books:

1. Lalji Prasad (2016). *Theory of Equations.* Paramount Publications.
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-F

MINOR COURSE- MN F:

LINEAR PROGRAMMING PROBLEM

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand the formulation of linear programming problems and the geometric concepts of convexity, extreme points, and feasible solutions.
2. Learn and apply the simplex method, including special techniques like the two-phase and Big-M methods, to find optimal solutions.
3. Develop theoretical understanding of duality in linear programming and use it to analyze and solve optimization problems.
4. Gain practical skills in solving transportation and assignment problems using systematic algorithms and optimization techniques.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Formulate linear programming problems, convert them into canonical/standard forms, and identify basic feasible solutions using convexity and geometric interpretations.
2. Solve linear programming problems using the simplex method, and apply the two-phase and Big-M methods for problems involving artificial variables.
3. Construct and solve dual problems, interpret duality theorems, and analyze unbounded or infeasible cases using duality theory.
4. Formulate and solve transportation and assignment problems using initial solution methods and optimality techniques like the Hungarian method.

Course Content:

UNIT-I: Linear Programming Problem, Convexity and Basic Feasible Solutions(12 Hours) [1 Question]

Formulation and examples**,** Canonical and Standard forms, Graphical solution, Convex and polyhedral sets, Extreme points, Basic solutions, Basic Feasible Solutions, Correspondence between basic feasible solutions and extreme points.

UNIT-II: Simplex Method(18 Hours) [2 Questions]

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

UNIT-III: Duality(12 Hours) [1 Question]

Formulation of the dual problem, Duality theorems, Unbounded and infeasible solutions in the primal, Solving the primal problem using duality theory.

UNIT-IV: Transportation and Assignment Problems(18 Hours) [2 Questions]

Formulation of transportation problems, Methods of finding initial basic feasible solutions: North-west corner rule, Least cost method, Vogel approximation method, Algorithm for obtaining optimal solution; Formulation of assignment problems, 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.

MINOR COURSE-G

MINOR COURSE- MN G:

COMPLEX ANALYSIS AND LINEAR ALGEBRA

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

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

Course Objectives:

By the end of the course, students will be able to:

1. Understand the structure of the complex plane and the behavior of complex functions in terms of limits and continuity.
2. Explore the concepts of analyticity and differentiability of complex functions through Cauchy–Riemann equations and harmonic functions.
3. Develop foundational knowledge of vector spaces, subspaces, and basis concepts essential for linear algebra.
4. Study linear transformations and their matrix representations, and understand coordinate changes and the rank-nullity theorem.

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. Represent and manipulate complex numbers, analyze functions of a complex variable, and describe sets in the complex plane using geometric and topological terms.
2. Determine analyticity using Cauchy–Riemann equations, evaluate harmonic functions, and verify sufficient conditions for differentiability.
3. Identify and construct vector spaces and subspaces, determine linear dependence/independence, and compute the basis and dimension of a space.
4. Apply linear transformations to vector spaces, represent them with matrices, compute rank and nullity, and apply the rank-nullity theorem.

Course Content:

UNIT-I: Complex Plane and Functions (12 Hours) [1 Question]

Complex numbers and their representation, Algebra of complex numbers, Complex plane: open set, domain, and region, Stereographic projection and Riemann sphere, Complex functions and their limits (including limits at infinity), Continuity of complex functions.

UNIT-II: Analytic Functions and Cauchy–Riemann Equations(18 Hours) [2 Questions]

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

UNIT-III: Vector Spaces (13 Hours) [1 Question]

Definitions of field and vector space with examples, Subspaces, linear span, Linearly independent and dependent sets, Basis and dimension, Quotient space and direct sum.

UNIT-IV: Linear Transformations and Matrix Representations(17 Hours) [2 Questions]

Linear transformations, Matrix of a linear transformation, Change of coordinates, Rank and nullity of a linear transformation, Rank-nullity theorem.

Reference Books:

1. J. N. Sharma (2014). *Functions of a complex variable.* Krishna Prakashan.
2. J. K. Goyal & K. P. Gupta (2008). *Functions of a complex variable.* Pragati Prakashan
3. Lalji Prasad (2017). *Complex Analysis*. Paramount Publications.
4. A. R. Vashishtha, J. N. Sharma & A. K. Vashishtha (2010). *Linear Algebra.* Krishna Publication.
