FYUGP

MATHEMATICS HONOURS/ RESEARCH

FOR UNDER GRADUATE COURSES UNDER RANCHI UNIVERSITY

Implemented from
Academic Session 2022-2026

UNIVERSITY DEPARTMENT OF MATHEMATICS
RANCHIUNIVERSITY
Morabadi Campus, Ranchi 834008, Jharkhand. (Ph. 0651-6555611)
Dr. C. S. P. Lugun, HOD Math & Director MCA, RU, Ranchi.

Date: 24/08/2022

The meeting of Board of Studies was held today dated 24/08/2022 (Thursday) at 01:00 PM in the Office chamber of the Head, under the chairmanship of the Head, University Department of Mathematics R.U. Ranchi.

The following members were present in the meeting:

1. Head, Univ. Deptt. of Mathematics, R. U. Ranchi (Chairperson)
2. Dr. A.K. Mahato, Ex. Pro V.C. B.B.M.K.U, Dhanbad.
3. Dr. N. K. Agrawal, Ex. Head, Deptt. of Mathematics, R. U. Ranchi.
4. Dr. L.K.K.N Shahdeo, Ex-Head, Deptt. of Mathematics, V. B. U. Hazaribagh.
5. Dr. Asha Lata Keshri, (Associate professor) faculty member.
6. Mrs. Rimil Nidhi Bhuinyan, (Assistant professor) faculty member.
7. Dr. Sheet Nihal Topno, (Assistant professor) faculty member
8. Mr. Amit Bara, (Assistant professor) faculty member

The Board of Studies gone through the previous syllabus of Under graduate Course; Curriculum framework and credit system for the Four Year Undergraduate Programme and the draft syllabus as per NEP-2020 for Major & Minor U.G., Course to be implemented from academic year 2022-2023.

After detail discussion the committee approved the draft syllabus for undergraduate course as per NEP-2020, to be implemented from 2022.

Amit Bara 24.08.22
Mr. Amit Bara

Rimil 24/08/22
Mrs. Rimil Nidhi Bhuinyan

Dr. L.K.K.N. Shahdeo, Shahdeo 24.8.22
Ex-Head, Univ. Deptt. of Mathematics.
V. B. U. Hazaribagh.

Dr. A. K. Mahato, 24.08.2022
Ex. Pro V.C., B.B.M.K.U. Dhanbad
Ex- Head, University Deptt. of Mathematics, R. U.

Sheet 24.08.2022
Dr. Sheet Nihal Topno

Asha 24.08.22
Dr. Asha Lata Keshri

Dr. N. K. Agrawal 24.08.2022
Ex-Head, Univ. Deptt. of Math,
R. U. Ranchi.

Dr. C.S.P Lugun, 24/8/22
Head, Univ. Dept.t of Mathematics,
Ranchi University, Ranchi.

Head,
Department of Mathematics
Ranchi University, Ranchi

23/9/2022
DIRECTOR
IQAC, RANCHI UNIVERSITY
RANCHI-834 001

Contents

INTRODUCTORY/ MINOR ELECTIVES

FORMAT OF QUESTION PAPERS

HIGHLIGHTS OF REGULATIONS OF FYUGP

PROGRAMME DURATION

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

ELIGIBILITY

- The selection for admission will be primarily based on availability of seats in the Major subject and marks imposed by the institution. Merit point for selection will be based on marks obtained in Major subject at Class 12 (or equivalent level) or the aggregate marks of Class 12 (or equivalent level) if Marks of the Major subject is not available. Reservation norms of The Government of Jharkhand must be followed as amended in times.

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.

ACADEMIC CALENDAR

- Each year the University shall draw out a calendar of academic and associated activities, which shall be strictly adhered to. The same is non-negotiable. Further, the Department will make all reasonable endeavors to deliver the programmes of study and other educational services as mentioned in its Information Brochure and website. However, circumstances may change prompting the Department to reserve the right to change the content and delivery of courses, discontinue or combine courses and introduce or withdraw areas of specialization.

PROGRAMME OVERVIEW/ SCHEME OF THE PROGRAMME

- Undergraduate degree programmes of either 3 or 4-year duration, with multiple entries and exit points and re-entry options within this period, with appropriate certifications such as:
  - a Certificate after completing 1 year (2 semesters) of study in the chosen fields of study,
  - a Diploma after 2 years (4 semesters) of study,
  - a Bachelor after a 3-year (6 semesters) programme of study,
  - a Bachelor (with Hons. / Research) after a 4-year (8 semesters) programme of study

VALIDITY OF REGISTRATION

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

CALCULATION OF MARKS FOR THE PURPOSE OF RESULT

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

PROMOTION AND SPAN PERIOD

i. The Requisite Marks obtained by a student in a particular subject will be the criteria for promotion to the next Semester.
ii. No student will be detained in odd Semesters (I, III, V & VII).
iii. To get promotion from Semester-II to Semester-III a student will be required to pass in at least 75% of Courses in an academic year (a student has to pass in minimum 9 papers out of the total 12 papers. However, it will be necessary to procure pass marks in each of the paper before completion of the course.
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 16 papers out of the total 22 papers.
v. Eligibility to get entry in Semester VII is to secure a minimum of 7.5 CGPA up to semester VI along with other criteria imposed by the Institution.

PUBLICATION OF RESULT

- The result if the examination shall be notified by the Controller of Examinations of the University in different newspapers and also on University website.

- If a student is found indulged in any kind of malpractice/ unfair means during examination, the examination taken by the student for the semester will be cancelled. The candidate has to reappear in all the papers of the session with the students of next coming session and his one year will be detained. However, marks secured by the candidate in all previous semesters will remain unaffected.

- There shall be no Supplementary or Re-examination for any subject. Students who have failed in any subject in an even semester may appear in the subsequent even semester examination for clearing the backlog. Similarly, the students who have failed in any subject in an odd semester may appear in the subsequent odd semester examination for clearing the backlog.

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

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

Table 1: Credit Framework for Four Year Undergraduate Programme (FYUGP) under State Universities of Jharkhand [Total Credits = 176]

	Common Courses (29)									**Introductory Courses (15)**		**Internship/ Project (4)**	**Major* (54) + Adv. Major (24)**	**Minor** (32)**		**Research Courses (18)**				**Total Credit**
Semester	Language and Communication Skills (Modern Indian Language including TRL) (6)	Language and Communication Skills (English) (6)	Environmental Studies (3)	Understanding India (2)	Health & Wellness, Yoga Education, Sports & Fitness (2)	Digital Education (3)	Mathematical & Computational Thinking and Analysis (2)	Value-Based Course/ Global Citizenship Education (2)	Community Engagement/ NCC/ NSS/ (3)	Introductory Courses [Natural Sc./ Humanities/ Social Sc./Commerce] (9)	Introductory Course [Vocational Studies] (6)			Natural Sc./ Humanities/ Social Sc./ Commerce (18)	Vocational Studies (14)	Research Methodology Courses (6)	Research Proposal, Review of literature (4)	Research Internship/ Field Work (4)	Preparation of the Research Project Report (4)	**176**
1	2	3	4	5	6	7	8			9	10	11	14	15	16	17	18	19	20	21
I	6			2	2					3	3		6							**22**
II		6					2	2		3	3		6							**22**
Exit Point: Undergraduate Certificate																				
III			3			3			3	3		4	6							**22**
IV													6+6	6	4					**22**
Exit Point: Undergraduate Diploma																				
V													6+6	6	4					**22**
VI													6+6	6	4					**22**
Exit Point: Bachelor's Degree																				
VII													6+6 (Adv. Topics)			6	4			**22**
VIII													6+6 (Adv. Topics)		2			4	4	**22**
Exit Point: Bachelor's Degree with Hons. /Research																				

*There will be four disciplinary areas: A-Natural Science, B-Humanities, C-Social Science, and D-Commerce; each having basket of courses. A student will have to select a 'Major' from any of the four disciplinary areas (out of A, B, C & D). The selection for admission will be primarily based on availability of seats in Major and marks imposed by the institution.

**A student has to select three subjects for 'Introductory Regular Courses' from a pool of subjects associated with the Major offered by the institution. One of the three subjects will continue as 'Minor' from semester IV onwards, based on the academic interest and performance of the student.

COURSES OF STUDY FOR FOUR YEAR UNDERGRADUATE PROGRAMME

Table 2: Course structure for Undergraduate Certificate Programme *[May Exit after Sem.-II]*

Semester	Common Courses			Introductory Courses		Major	Total Credits
Sem.-I	LCS (MIL/TRL) (6 Credits)	Understanding India (2 Credits)	Health & Wellness, Yoga Education, Sports & Fitness (2 Credits)	IRC-1 (3 Credits)	IVS-1A (3 Credits)	MJ-1 (6 Credits)	**(22)**
Sem.-II	LCS (English) (6 Credits)	Global Citizenship Education (2 Credits)	Mathematical & Computational Thinking (2 Credits)	IRC-2 (3 Credits)	IVS-1B (3 Credits)	MJ-2 (6 Credits)	**(22)**

Total = 44 Credits

(LCS: Language and Communication Skills; MIL: Modern Indian Languages; TRL: Tribal Regional Languages; IRC: Introductory Regular Courses; IVS: Introductory Vocational Studies, MJ: Major)

Table 3: Course structure for Undergraduate Diploma Programme *[May Exit after Sem.-IV]*

Semester	Common Courses			Introductory Courses	Major	Minor	Internship/ Project	Vocational	Total Credits
Sem.-III	Environmental Studies (3 Credits)	Community Engagement/ NCC/ NSS (3 Credits)	Digital Education (3 Credits)	IRC-3 (3 Credits)	MJ-3 (6 Credits)		Internship/ Project (4 Credits)		**(22)**
Sem.-IV					MJ-4, MJ-5 (6+6=12 Credits)	MN-1 (6 Credits)		VS-1 (4 Credits)	**(22)**

Total = 88 Credits

(MN: Minor; VS: Vocational Studies)

Table 4: Course structure for Bachelor's Degree Programme *[May Exit after Sem.-VI]*

Semester	Major Courses	Minor Courses	Vocational	Total Credits
Sem.-V	MJ-6, MJ-7 (6+6 = 12 Credits)	MN-2 (6 Credits)	VS-2 (4 Credits)	**(22)**
Sem.-VI	MJ-8, MJ-9 (6+6= 12 Credits)	MN-3 (6 Credits)	VS-3 (4 Credits)	**(22)**

Total = 132 Credits

Table 5: Course structure for Bachelor's Degree with Hons./Research Programme

Semester	Advance Courses	Research Courses		Vocational	Total Credit
Sem.-VII	AMJ-1, AMJ-2	Research Methodology (6+6=12 Credits)	Research Proposal (6 Credits)	(4 Credits)	**(22)**
Sem.-VIII	AMJ-3, AMJ-4 (6+6=12 Credits)	Research Int./Field Work (4 Credits)	Research Report (4 Credits)	VSR (2 Credits)	**(22)**

Total = 176 Credits

(AMJ: Advance Major; VSR: Vocational Studies associated with Research)

Table 6: Semester wise Course Code and Credit Points:

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		
	Code	Papers	Credits
I	CC-1	Language and Communication Skills (Modern Indian language including TRL)	6
	CC-2	Understanding India	2
	CC-3	Health & Wellness, Yoga Education, Sports & Fitness	2
	IRC-1	Introductory Regular Course-1	3
	IVS-1A	Introductory Vocational Studies-1	3
	MJ-1	Major paper 1 (Disciplinary/Interdisciplinary Major)	6
II	CC-4	Language and Communication Skills (English)	6
	CC-5	Mathematical & Computation Thinking Analysis	2
	CC-6	Global Citizenship Education & Education for Sustainable Development	2
	IRC-2	Introductory Regular Course-2	3
	IVS-1B	Introductory Vocational Studies-2	3
	MJ-2	Major paper 2 (Disciplinary/Interdisciplinary Major)	6
III	CC-7	Environmental Studies	3
	CC-8	Digital Education (Elementary Computer Applications)	3
	CC-9	Community Engagement & Service (NSS/ NCC/ Adult Education)	3
	IRC-3	Introductory Regular Course-3	3
	IAP	Internship/Apprenticeship/ Project	4
	MJ-3	Major paper 3 (Disciplinary/Interdisciplinary Major)	6
IV	MJ-4	Major paper 4 (Disciplinary/Interdisciplinary Major)	6
	MJ-5	Major paper 5 (Disciplinary/Interdisciplinary Major)	6
	MN-1	Minor Paper 1 (Disciplinary/Interdisciplinary Minor)	6

	VS-1	Vocational Studies-1 (Minor)	4
V	MJ-6	Major paper 6 (Disciplinary/Interdisciplinary Major)	6
	MJ-7	Major paper 7 (Disciplinary/Interdisciplinary Major)	6
	MN-2	Minor Paper 2 (Disciplinary/Interdisciplinary Minor)	6
	VS-2	Vocational Studies 2 (Minor)	4
VI	MJ-8	Major paper 8 (Disciplinary/Interdisciplinary Major)	6
	MJ-9	Major paper 9 (Disciplinary/Interdisciplinary Major)	6
	MN-3	Minor Paper 3 (Disciplinary/Interdisciplinary Minor)	6
	VS-3	Vocational Studies 3 (Minor)	4
VII	AMJ-1	Advance Major paper 1 (Disciplinary/Interdisciplinary Major)	6
	AMJ-2	Advance Major paper 2 (Disciplinary/Interdisciplinary Major)	6
	RC-1	Research Methodology	6
	RC-2	Research Proposal	4
VIII	AMJ-3	Advance Major paper 3 (Disciplinary/Interdisciplinary Major)	6
	AMJ-4	Advance Major paper 4 (Disciplinary/Interdisciplinary Major)	6
	RC-3	Research Internship/Field Work	4
	RC-4	Research Report	4
	VSR	Vocational Studies (Associated with Research)	2
		Total Credit	**176**

Abbreviations:

CC Common Courses
IRC Introductory Regular Courses
IVS Introductory Vocational Studies
IAP Internship/Apprenticeship/ Project
VS Vocational Studies
MJ Major Disciplinary/Interdisciplinary Courses
MN Minor Disciplinary/Interdisciplinary Courses
AMJ Advance Major Disciplinary/Interdisciplinary Courses
RC Research Courses
VSR Vocational Studies associated with Research

Table 7: Semester wise Examination Structure in Discipline Courses:

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Examination Structure			
	Code	Papers	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	MJ-1	Calculus & Geometry	6	25	75	---
II	MJ-2	Multivariate Calculus	6	25	75	---
III	MJ-3	Ordinary and Partial Mechanics	6	25	75	---
IV	MJ-4	Real Analysis	6	25	75	---
	MJ-5	Mechanics	6	25	75	---
V	MJ-6	Abstract Algebra	6	25	75	---
	MJ-7	Linear Algebra	6	25	75	---
VI	MJ-8	Complex Analysis & Metric Space	6	25	75	---
	MJ-9	Numerical Analysis	6	25	75	---
VII	AMJ-1	Linear Programming	6	25	75	---
	AMJ-2	Advance Mechanics	6	25	75	---
	RC-1	Research Methodology	6	25	75	---
	RC-2	Research Proposal	4	25	75	---
VIII	AMJ-3	Probability & Statistics	6	25	75	---
	AMJ-4	Discrete Mathematics	6	25	75	---
	RC-3	Research Internship/Field Work	4	---	---	100
	RC-4	Research Report	4	---	---	100
	VSR	Vocational Studies (Associated with Research)	2	---	---	100
		Total Credit	**98**			

Table 8: Semester wise Course Code and Credit Points:

Semester	Introductory, Minor Courses		Examination Structure			
	Code	Papers	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I/ II/ III	IRC	Introductory Mathematics	3	---	100	---
IV	MN-1	Differential, Integral & Vector Calculus	6	25	75	---
V	MN-2	Geometry, Group Theory, Differential Equation	6	25	75	---
VI	MN-3	Real Analysis, Complex Analysis, Matrices	6	25	75	---
		Total Credit	**21**			

AIMS OF BACHELOR'S DEGREE PROGRAMME IN MATHEMATICS

The broad aims of the LOCF for Mathematics are to:

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

PROGRAM LEARNING OUTCOMES

The broad programme learning outcomes in Mathematics are:

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

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

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

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

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

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

SEMESTER I

I. MAJOR COURSE –MJ 1: (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*

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

CALCULUS & GEOMETRY

Theory: 90 Lectures

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

1. Understand the consequences of various mean value theorems for differentiable functions.
2. Sketch curves in Cartesian and polar coordinate systems.
3. Apply derivative tests in optimization problems appearing in social sciences, physical sciences, life sciences and a host of other disciplines.
4. Evaluate integrals of different rational and irrational functions
5. Evaluate nth order integration by means of reduction formulae
6. Explain the properties of three dimensional shapes.

Course Content:

Unit-I: Differentiability

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

Unit-II: Expansions of Functions

Maclaurin's and Taylor's theorems for expansion of a function in an infinite series, Taylor's theorem in finite form with Lagrange, Cauchy and Roche–Schlomilch forms of remainder; Maxima and minima.

Unit-III: Curvature, Asymptotes and Curve Tracing

Curvature; Asymptotes of general algebraic curves, Parallel asymptotes, Asymptotes parallel to axes; Symmetry, Concavity and convexity, Points of inflection, Tangents at origin, Multiple points, Position and nature of double points; Tracing of Cartesian, polar and parametric curves.

Unit-IV: Integral Calculus

Integration of rational and irrational functions. Evaluation of definite integrals, Special integrals, differentiation and integration under the sign of integration (Beta and Gamma functions are excluded), reduction formulae.

Unit-V: Geometry of Integral Calculus

Point of inflexion, double point, Length of plane curve and area bounded by plane curves. Volume and surface area of solid of revolution.

Unit-VI: Planes, Straight Lines and Spheres

Planes: Distance of a point from a plane, Angle between two planes, pair of planes, Bisectors of angles between two planes; Straight lines: Equations of straight lines, Distance of a point from a straight line, Distance between two straight lines, Distance between a straight line and a plane; Spheres: Different forms, Intersection of two spheres, Orthogonal intersection, Tangents and normal, Radical plane, Radical line, Coaxial system of spheres, Pole, Polar and Conjugacy.

Reference Books:

1. Howard Anton, I. Bivens & Stephan Davis (2016). Calculus (10th edition). Wiley India.
2. Gabriel Klambauer (1986). Aspects of Calculus. Springer-Verlag.
3. Gorakh Prasad (2016). Differential Calculus (19th edition). Pothishala Pvt. Ltd.
4. George B. Thomas Jr., Joel Hass, Christopher Heil & Maurice D. Weir (2018). Thomas' Calculus (14th edition). Pearson Education.
5. Integral Calculus – Lalji Prasad.
6. Higher Engineering Mathematics – B S Grewal
7. D. Chatterjee (2009). Analytical Geometry: Two and Three Dimensions. Narosa Publishing House.

SEMESTER II

I. MAJOR COURSE- MJ 2: (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*

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

MULTIVARIATE CALCULUS

Theory: 90 Lectures

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

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

Course Content:

Unit-I: Partial Differentiation

Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Tangent planes, Chain rule, Directional derivatives, The gradient, Maximal and normal properties of the gradient, Tangent planes and normal lines.

Unit-II: Differentiation

Higher order partial derivatives, Total differential and differentiability, Jacobians, Change of variables, Euler's theorem for homogeneous functions, Taylor's theorem for functions of two variables and more variables, Envelopes and evolutes.

Unit-III: Differentiation of a vector function

Vector point function, Scalar point function, Differentiation of a vector function. Derivatives of a sum of vectors. Derivatives of a product of vectors (both scalar and vector products)

Unit-IV: Extrema of Functions and Vector Field

Extrema of functions of two and more variables, Method of Lagrange multipliers, Constrained optimization problems, Definition of vector field, Divergence, curl, gradient and vector identities.

Unit-V: Double and Triple Integrals

Double integration over rectangular and nonrectangular regions, Double integrals in polar coordinates, Triple integral over a parallelepiped and solid regions, Volume by triple integrals, Triple integration in cylindrical and spherical coordinates, Change of variables in double and triple integrals, Dirichlet integral.

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

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

Reference Books:

1. Jerrold Marsden, Anthony J. Tromba & Alan Weinstein (2009). Basic Multivariable Calculus, Springer India Pvt. Limited.
2. James Stewart (2012). Multivariable Calculus (7th edition). Brooks/Cole. Cengage.
3. Monty J. Strauss, Gerald L. Bradley & Karl J. Smith (2011). Calculus (3rd edition). Pearson Education. Dorling Kindersley (India) Pvt. Ltd.
4. George B. Thomas Jr., Joel Hass, Christopher Heil & Maurice D. Weir (2018). Thomas' Calculus (14th edition). Pearson Education.
5. Vector Calculus – Dasgupta.

SEMESTER III

I. MAJOR COURSE- MJ 3: (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*

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

ORDINARY AND PARTIAL MECHANICS

Theory: 90 Lectures

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

1. Understand the genesis of ordinary differential equations.
2. Learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
3. Know Picard's method of obtaining successive approximations of solutions of first order differential equations, passing through a given point in the plane.
4. Grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.
    a. Apply a range of techniques to solve first & second order partial differential equations.
    b. Model physical phenomena using partial differential equations such as the heat and wave equations.

Course Content:

Unit-I: First Order Differential Equations

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

Unit-II: Second Order Linear Differential Equations

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

Unit-III: Higher Order Linear Differential Equations

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

Unit-IV: First Order Partial Differential Equations

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

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

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

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

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

Reference Books:

1. Daniel A. Murray (2003). Introductory Course in Differential Equations, Orient.
2. B. Rai, D. P. Choudhury & H. I. Freedman (2013). A Course in Ordinary Differential Equations (2nd edition). Narosa.
3. Shepley L. Ross (2007). Differential Equations (3rd edition), Wiley India.
4. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley.
5. Ian N. Sneddon (2006). Elements of Partial Differential Equations. Dover Publications.
6. Differential Equations – M D Raisinghania.

SEMESTER IV

I. MAJOR COURSE- MJ 4: (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*

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

REAL ANALYSIS

Theory: 90 Lectures

Course Objectives & Learning Outcomes:

1. This course will enable the students to:
2. Understand many properties of the real line $\mathbb{R}$ and learn to define sequence in terms of functions from $\mathbb{R}$ to a subset of $\mathbb{R}$.
3. Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
4. Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.
5. Learn some of the properties of Riemann integrable functions, and the applications of the fundamental theorems of integration.

Course Content:

Unit-I: Real Number System

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

Unit-II: Sequences of Real Numbers

Convergent sequence, Limit of a sequence, Bounded sequence, Limit theorems, Monotone Weierstrass theorem for–sequences, Monotone convergence theorem, Subsequences, Bolzano

sequences, Limit superior and limit inferior of a sequence of real numbers, Cauchy sequence, Cauchy's convergence criterion.

Unit-III: Infinite Series

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

Unit-IV: Riemann Integration

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

Unit-V: Uniform convergence of sequence and series of functions

Pointwise and uniform convergence of sequence and series of functions, Weierstrass's M-test, Dirichlet test and Abel's test for uniform convergence, Uniform convergence and continuity, Uniform convergence and differentiability,

Unit-VI: Convergence of Improper integrals

Convergence of improper integrals, comparison tests, absolute convergence, Abel's and Dirichlet's tests. Frullani's Integrals. Definition & convergence of Beta & Gamma functions and their properties, duplication formula, inter-relation.Evaluation of double and triple integrals. Multiple Integrals of Dirichlet's form, Liouville's extension. Change of order of integration and change of variables.

Reference Books:

1. Robert G. Bartle & Donald R. Sherbert (2015). Introduction to Real Analysis (4th edition). Wiley India.
2. Gerald G. Bilodeau, Paul R. Thie & G. E. Keough (2015). An Introduction to Analysis (2nd edition), Jones and Bartlett India Pvt. Ltd.
3. K. A. Ross (2013). Elementary Analysis: The Theory of Calculus (2nd edition). Springer.
4. Shanti Narayan & M. D. Raisinghania. Elements of Real Analysis

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II. MAJOR COURSE- MJ 5: (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*

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

MECHANICS

Theory: 90 Lectures

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

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

Course Content:

Unit-I: Statics

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

Unit-II: Centres of Gravity

Centres of gravity of plane area including a uniform thin straight rod, triangle, circular arc, semicircular area and quadrant of a circle, Centre of gravity of a plane area bounded by a curve, Centre of gravity of a volume of revolution; Flexible strings,

Unit-III Common Catenary

Common Catenary, Intrinsic and Cartesian equations of the common catenary, Approximations of the catenary.

Unit-IV: Rectilinear Motion

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

Unit-V: Motion in a Plane

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

Unit-VI: Central Orbits

Equation of motion under a central force, Differential equation of the orbit, (p, r) equation of the orbit, Apses and apsidal distances, Areal velocity, Characteristics of central orbits, Kepler's laws of planetary motion

Reference Books:

1. S. L. Loney (2006). An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies. Read Books.
2. P. L. Srivatava (1964). Elementary Dynamics. Ram Narin Lal, Beni Prasad Publishers Allahabad.
3. J. L. Synge & B. A. Griffith (1949). Principles of Mechanics. McGraw-Hill.
4. S. Ramsey (2009). Statics. Cambridge University Press.
5. S. Ramsey (2009). Dynamics. Cambridge University Press.
6. R. S. Varma (1962). A Text Book of Statics. Pothishala Pvt. Ltd.

SEMESTER V

I. MAJOR COURSE- MJ 6: (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*

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

ABSTRACT ALGEBRA

Theory: 90 Lectures

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

1. Recognize the mathematical objects called groups.
2. Link the fundamental concepts of groups and symmetries of geometrical objects.
3. Explain the significance of the notions of cosets, normal subgroups, and factor groups.
4. Analyze consequences of Lagrange's theorem.
5. Learn about structure preserving maps between groups and their consequences.
6. Know the fundamental concepts in ring theory such as the concepts of ideals, quotient rings, integral domains, and fields.
7. Learn about polynomial rings, fundamental properties of finite field extensions, and classification of finite fields

Course Content:

Unit-I: Groups and Subgroups

Symmetries of a square, 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

Unit-II: Normal Subgroups & Permutation Groups

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

Unit-III: Group Homomorphisms

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

Unit-IV Rings and Fields

Definition, examples and elementary properties of rings, Commutative rings, Integral domain, Division rings and fields, Characteristic of a ring, Ring homomorphisms and isomorphisms, Ideals and quotient rings. Prime, principal and maximal ideals, Relation between integral domain and field, Euclidean rings and their properties, Wilson and Fermat's theorems.

Unit-V: Polynomial Rings

Polynomial rings over commutative ring and their basic properties, The division algorithm; Polynomial rings over rational field, Gauss lemma and Eisenstein's criterion, Euclidean domain, principal ideal domain, and unique factorization domain.

Unit-VI: Field Extensions and Finite Fields

Extension of a field, Algebraic element of a field, Algebraic and transcendental numbers, Perfect field, Classification of finite fields.

Reference Books:

1. Michael Artin (2014). Algebra (2nd edition). Pearson.
2. P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul (2003). Basic Abstract Algebra (2nd edition). Cambridge University Press.
3. David S. Dummit & Richard M. Foote (2008). Abstract Algebra (2nd edition). Wiley.
4. John B. Fraleigh (2007). A First Course in Abstract Algebra (7th edition). Pearson.
5. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th edition). Cengage.
6. N. S. Gopalakrishnan (1986). University Algebra, New Age International Publishers.
7. N. Herstein (2006). Topics in Algebra (2nd edition). Wiley India.
8. Thomas W. Hungerford (2004). Algebra (8th edition). Springer.
9. Nathan Jacobson (2009). Basic Algebra I & II (2nd edition). Dover Publications.
10. Serge Lang (2002). Algebra (3rd edition). Springer-Verlag.
11. S. Luthar & I. B. S. Passi (2013). Algebra: Volume 1: Groups. Narosa.
12. S. Luthar & I. B. S. Passi (2012). Algebra: Volume 2: Rings. Narosa.

II. MAJOR COURSE- MJ 7: (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*

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

LENEAR ALGEBRA

Theory: 90 Lectures

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

1. Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix, using rank.
2. Find eigenvalues and corresponding eigenvectors for a square matrix.
3. Explain the significance of the notions of cosets, normal subgroups, and factor groups.
4. Analyze consequences of Lagrange's theorem.
5. Learn about structure preserving maps between groups and their consequences.
6. Know the fundamental concepts in ring theory such as the concepts of ideals, quotient rings, integral domains, and fields.
7. Learn about polynomial rings, fundamental properties of finite field extensions, and classification of finite fields.

Course Content:

Unit-I: Row Echelon Form of Matrices and Applications

Systems of linear equations, Row reduction and echelon forms, Linear independence, The rank of a matrix and applications; Introduction to linear transformations, The matrix of a linear transformation, Matrix operations, Determinants, The inverse of a matrix, Characterizations of invertible matrices; Applications to Computer Graphics; Eigenvalues and eigenvectors, The characteristic equation and the Cayley–Hamilton theorem.

Unit-II: Vector Spaces

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

Unit-III: Linear Transformations

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

Unit-IV: Further Properties of Linear Transformations

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

Unit-V: Inner Product Spaces

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

Unit-VI: Adjoint of a Linear Transformation and Canonical Forms

Adjoint of a linear operator; Hermitian, unitary and normal linear transformations; Jordan canonical form, Triangular form, Trace and transpose, Invariant subspaces.

Reference Books:

1. Bernard Kolman & David R. Hill (2003). Introductory Linear Algebra with Applications (7th edition). Pearson Education Pvt. Ltd. India.
2. David C. Lay, Steven R. Lay & Judi J. McDonald (2016). Linear Algebra and its Applications (5th edition). Pearson Education Pvt. Ltd. India
3. Stephen H. Friedberg, Arnold J. Insel & Lawrence E. Spence (2003). Linear Algebra (4thedition). Prentice-Hall of India Pvt. Ltd.
4. Kenneth Hoffman & Ray Kunze (2015). Linear Algebra (2nd edition). Prentice-Hall.
5. M. Gel'fand (1989). Lectures on Linear Algebra. Dover Publications. UGC DOCUMENT ON LOCF MATHEMATICS 30
6. Nathan Jacobson (2009). Basic Algebra I & II (2nd edition). Dover Publications.
7. Serge Lang (2005). Introduction to Linear Algebra (2nd edition). Springer India.
8. Vivek Sahai & Vikas Bist (2013). Linear Algebra (2nd Edition). Narosa Publishing House.
9. Gilbert Strang (2014). Linear Algebra and its Applications (2nd edition). Elsevier.

SEMESTER VI

I. MAJOR COURSE- MJ 8: (Credits: Theory-06)

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

Instruction to Question Setter for
Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*
***Note:** There may be subdivisions in each question asked in Theory Examinations.*

COMPLEX ANALYSIS & METRIC SPACE

Theory: 90 Lectures

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

1. Visualize complex numbers as points of ℝ2 and stereographic projection of complex plane on the Riemann sphere.
2. Understand the significance of differentiability and analyticity of complex functions leading to the Cauchy□Riemann equations.
3. Learn the role of Cauchy□Goursat theorem and Cauchy integral formula in evaluation of contour integrals.
4. Understand several standard concepts of metric spaces and their properties like openness, closedness, completeness, Bolzano□Weierstrass property, compactness, and connectedness.
5. Identify the continuity of a function defined on metric spaces and homeomorphisms.

Course Content:

Unit-I: Complex Plane and functions.
Complex numbers and their representation, algebra of complex numbers; Complex plane, Open set, Domain and region in complex plane; Stereographic projection and Riemann sphere; Complex functions and their limits including limit at infinity; Continuity, Linear fractional transformations and their geometrical properties.

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

Unit-III: Conformal representation

Transformation, Jacobian, conformal transformation, some general transformations, bilinear transformation. critical points, fixed points, cross ratio, preservance of cross ratio, fixed points of bilinear transformation.

Unit-IV: Concepts in Metric Spaces

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

Unit-III: Complete Metric Spaces and Continuous Functions

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

Unit-IV: Compactness

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

Reference Books:

1. Lars V. Ahlfors (2017). Complex Analysis (3rd edition). McGraw-Hill Education.
2. Joseph Bak & Donald J. Newman (2010). Complex Analysis (3rd edition). Springer.
3. James Ward Brown & Ruel V. Churchill (2009). Complex Variables and Applications (9th edition). McGraw-Hill Education.
4. E. T. Copson (1988). Metric Spaces. Cambridge University Press.
5. Satish Shirali & Harikishan L. Vasudeva (2006). Metric Spaces. Springer-Verlag.
6. Micheál O'Searcoid (2009). Metric Spaces. Springer-Verlag.
7. G. F. Simmons (2004). Introduction to Topology and Modern Analysis. McGraw-Hill.

II. MAJOR COURSE- MJ 9: (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*

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

NUMERICAL ANALYSIS

Theory: 90 Lectures

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

1. Obtain numerical solutions of algebraic and transcendental equations.
2. Find numerical solutions of system of linear equations and check the accuracy of the solutions.
3. Learn about various interpolating and extrapolating methods.
4. Solve initial and boundary value problems in differential equations using numerical methods.
5. Apply various numerical methods in real life problems.

Course Content:

Unit-I: Numerical Methods for Solving Algebraic and Transcendental Equations
Round-off error and computer arithmetic, Local and global truncation errors, Algorithms and convergence; Bisection method, False position method, Fixed point iteration method, Newton's method and secant method for solving equations.

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

Unit-III: Interpolation
Lagrange and Newton interpolations, Piecewise linear interpolation, Cubic spline interpolation, Finite difference operators, Gregory–Newton forward and backward difference interpolations.

Unit-IV: Numerical Differentiation
First order and higher order approximation for first derivative, Approximation for second derivative; Derivative using forward, backward and central difference interpolation formulae.

Unit-V: Numerical Integration

General quadrature formula, Trapezoidal rule, Simpson's rules and error analysis, Bulirsch–Stoer extrapolation methods, Richardson extrapolation, Weddle's rule, Newton-Cote's method. Solution of ordinary differential equations: Picard's method of successive approximations.

Unit-VI: Initial and Boundary Value Problems of Differential Equations

Euler's method, Runge–Kutta methods, Higher order one step method, Multi-step methods; Finite difference method, Shooting method, Real life examples: Google search engine, 1D and 2D simulations, Weather forecasting.

Reference Books:

1. Brian Bradie (2006), A Friendly Introduction to Numerical Analysis. Pearson.
2. C. F. Gerald & P. O. Wheatley (2008). Applied Numerical Analysis (7th edition), Pearson Education, India.
3. F. B. Hildebrand (2013). Introduction to Numerical Analysis: (2nd edition). Dover Publications.
4. M. K. Jain, S. R. K. Iyengar & R. K. Jain (2012). Numerical Methods for Scientific and Engineering Computation (6th edition). New Age International Publishers.

SEMESTER VII

I. ADVANCE MAJOR COURSE- AMJ 1: (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*
***Note:** There may be subdivisions in each question asked in Theory Examinations.*

LINEAR PROGRAMMING

Theory: 90 Lectures

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

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

Course Content:

Unit-I: Linear Programming Problem, Convexity and Basic Feasible Solutions
Formulation, Canonical and standard forms, Graphical method; Convex and polyhedral sets, Hyperplanes, Extreme points; Basic solutions, Basic Feasible Solutions, Reduction of feasible solution to basic feasible solution, Correspondence between basic feasible solutions and extreme points.

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

Unit-III: Duality

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

Unit-IV: Sensitivity Analysis

Changes in the cost vector, right-hand side vector and the constraint matrix of the linear programming problem.

Unit-V: Applications to Transportation & Assignment Problems

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

Unit-VI: Application to Game Theory

Game Theory: Formulation and solution of two-person zero-sum games, Games with mixed strategies, Linear programming method for solving a game.

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. Frederick S. Hillier & Gerald J. Lieberman (2015). Introduction to Operations Research (10th edition). McGraw-Hill Education.
4. Hamdy A. Taha (2017). Operations Research: An Introduction (10th edition). Pearson.
5. Paul R. Thie & Gerard E. Keough (2014). An Introduction to Linear Programming and Game Theory (3rd edition). Wiley India Pvt. Ltd.

II. ADVANCE MAJOR COURSE- AMJ 2: (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*
***Note:** There may be subdivisions in each question asked in Theory Examinations.*

ADVANCE MECHANICS

Theory: 90 Lectures

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

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

Course Content:

Unit-I: Statics in Space

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

Unit-II: Motion of a Rigid Body

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

Unit-III: Kinematics of Fluid Motion

Lagrangian and Eulerian approaches, Material and convective derivatives, Velocity of a fluid at a point, Equation of continuity in Cartesian, cylindrical polar and spherical polar coordinates, Cylindrical and spherical symmetry, Boundary surface

Unit-IV: Kinds of Fluid Motions

Streamlines and pathlines, Steady and unsteady flows, Velocity potential, Rotational and irrotational motion, Vorticity vector and vortex lines.

Unit-V: Kinetics of Fluid Motion

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

Unit-VI: Motion in Two-Dimensions

Stream function, Complex potential, Basic singularities: Sources, sinks, doublets, complex potential due to these basic singularities; Image system of a simple source and a simple doublet with regard to a line and a circle, Milne–Thomson circle theorem.

Reference Books:

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

SEMESTER VIII

I. ADVANCE MAJOR COURSE- AMJ 3: (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*

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

PROBABILITY & STATISTICS

Theory: 90 Lectures

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

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

Course Content:

Unit-I: Probability Functions and Moment Generating Function

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

Unit-II: Univariate Discrete and Continuous Distributions

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

Unit-III: Bivariate Distribution

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

Unit-IV: Sampling and Estimation Theory

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

Unit-V: Correlation, Regression and Central Limit Theorem

The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, The method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers.

Unit-VI: Modeling Uncertainty

Uncertainty, Information and entropy, Uniform Priors, Polya's urn model and random graphs.

Reference Books:

1. Robert V. Hogg, Joseph W. McKean & Allen T. Craig (2013). Introduction to Mathematical Statistics (7th edition), Pearson Education.
2. Irwin Miller &Marylees Miller (2014). John E. Freund's Mathematical Statistics with Applications (8thedition). Pearson. Dorling Kindersley Pvt. Ltd. India.
3. Jim Pitman (1993). Probability, Springer-Verlag.
4. Sheldon M. Ross (2014). Introduction to Probability Models (11th edition). Elsevier.
5. M. Yaglom and I. M. Yaglom (1983). Probability and Information. D. Reidel Publishing Company. Distributed by Hindustan Publishing Corporation (India) Delhi.

II. ADVANCE MAJOR COURSE- AMJ 4: (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*

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

DISCRETE MATHEMATICS

Theory: 90 Lectures

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

1. Know the notion of mathematical logic.
2. Learn about partially ordered sets, lattices and their types.
3. Understand Boolean algebra and Boolean functions, logic gates, switching circuits and their applications.
4. Solve real-life problems using finite-state and Turing machines.
5. Assimilate various graph theoretic concepts and familiarize with their applications.

Course Content:

Unit-I: Mathematical Logic

Statements, Truth Tables, Conditional and Biconditional statements, Tautologies and contradictions, Equivalent statements, Principle of duality, Quantifiers

Unit-II: Partially Ordered Sets

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-III: Lattices

Lattices as posets, 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-IV: Boolean Algebras and Switching Circuits

Boolean algebras, De Morgan's laws, Boolean homomorphism, Representation theorem; Boolean polynomials, Boolean polynomial functions, Disjunctive and conjunctive normal forms, Minimal

forms of Boolean polynomials, Quine–McCluskey method, Karnaugh diagrams, Switching circuits and applications.

Unit-V: Finite-State and Turing Machines

Finite-state machines with outputs, and with no output; Deterministic and nodeterministic finite-state automaton; Turing machines: Definition, examples, and computations.

Unit-VI: Graphs

Definition, examples and basic properties of graphs, Königsberg bridge problem; Subgraphs, Pseudographs, Complete graphs, Bipartite graphs, Isomorphism of graphs, Paths and circuits, Eulerian circuits, Hamiltonian cycles, Adjacency matrix, Weighted graph, Travellingsalesman problem, Shortest path and Dijkstra's algorithm.

Reference Books:

1. B. A. Davey & H. A. Priestley (2002). Introduction to Lattices and Order (2nd edition). Cambridge University Press.
2. Edgar G. Goodaire & Michael M. Parmenter (2018). Discrete Mathematics with Graph Theory (3rd edition). Pearson Education.
3. Rudolf Lidl & Günter Pilz (1998). Applied Abstract Algebra (2nd edition). Springer.
4. Kenneth H. Rosen (2012). Discrete Mathematics and its Applications: With Combinatorics and Graph Theory (7th edition). McGraw-Hill.
5. C. L. Liu (1985). Elements of Discrete Mathematics (2nd edition). McGraw-Hill.

COURSES OF STUDY FOR **INTRODUCTORY/ MINOR ELECTIVE** FYUGP IN **"MATHEMATICS"**

SEMESTER I/ II/ III INTRODUCTORY REGULAR COURSE 1 Paper

I. INTRODUCTORY REGULAR COURSE (IRC)

(Credits: Theory-03)

- All Four Introductory & Minor Papers of Mathematics to be studied by the Students of **Other than Mathematics Honours.**

- Students of **Mathematics Honours** must Refer Content from the **Syllabus of Opted Introductory & Minor Elective Subject**.

Marks: 100 (ESE: 3Hrs) = 100	**Pass Marks: Th (ESE) = 40**

Instruction to Question Setter for

End Semester Examination (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.*

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

INTRODUCTORY MATHEMATICS

Theory: 45 Lectures

Course Objectives & Learning Outcomes:

1. This course will enable the students to:
2. Be familiar with the upcoming concepts of Differential calculus, Integral calculus, Vector calculus, Analytical Geometry 2D, Set theory and Trigonometry in minor paper

Course Content:

Unit-I: Differential Calculus
Successive Differentiation. n^{th} order derivatives of standard functions. Partial derivatives

Unit-II: Integral Calculus
Integration of rational & irrational functions. Partial fractions.

Unit-III: Vector Calculus
Scalar point functions. vector point functions. Differentiation of a vector of scalar variables.

Unit-IV: Analytical Geometry 2D
Change of rectangular axes. Rotation & shifting of origin.

Unit-V: Set Theory
Indexed family of sets. Generalized set operations. DeMorgan's Law.

Unit-VI: Trigonometry
DeMoivre's theorem & its Applications.

Reference Books:

1. Differential Calculus: Lalji Prasad
2. Integral Calculus: Dasgupta & Prasad.
3. Vector Calculus: Dasgupta& Prasad
4. Coordinate Geometry: A Das Gupta
5. Set Theory: K K Jha
6. Trigonometry: Dasgupta& Prasad

SEMESTER IV **MINOR ELECTIVE-1** **1 Paper**

I. MINOR ELECTIVE (MN 1) (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*

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

DIFFERENTIAL, INTEGRAL & VECTOR CALCULUS

Theory: 90 Lectures

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

1. Expand different functions in series form
2. Handle partial differentiations and related geometry
3. Evaluate maxima & minima of function of two variables
4. Integrate rational and irrational functions and definite integrals
5. Understand differentiation and integration under the sign of integration
6. Familiarize with curve tracing and to calculate related area and volume.
7. Evaluate Gradient, Divergence & Curl

Course Content:

UNIT 1: Differential calculus

Leibnitz's Theorem. Taylor's and Macularuins's series expansions of functions. Applications of Taylors's and Maclaurins' Series. Tangent and Normal, (Cartesian, Parametric form), Angle between two Curves. Length of tangent, Normal, Sub Tangent, Subnormal in Cartesian Forms. Partial Differention: Eulers' Theorem, Curvature. Asymptotes. Maxima and Minima of functions of two variables.

UNIT 2: Integral Calculus

Integration by Transformation, Integration by Substitution, Integration by Parts. Evaluation of Definite Integrals, Reduction Formulae, Curve Tracing, Length and Area, Surface Area and Volume of Solids of Revolution.

UNIT 3: Vector Calculus

Differentiation of a vector function. Derivatives of a sum of vectors, Derivatives of a product of vectors (both Scalar and Vector Products). Gradient, Divergence and Curl and Second Order Vector Differential Operators in Cartesian coordinates systems.

Reference Books:

1. Differential Calculus: A Das Gupta & S B Prasad.
2. Differential Calculus: Lalji Prasad
3. Integral Calculus: Dasgupta& Prasad.
4. Integral Calculus: Lalji Prasad
5. Vector Calculus: Dasgupta & Prasad
6. Vector Calculus: Lalji Prasad

SEMESTER V **MINOR ELECTIVE-2** **1 Paper**

I. MINOR ELECTIVE (MN 2) (Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*

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

GEOMETRY, GROUP THEORY, DIFFERENTIAL EQUATION

Theory: 90 Lectures

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

1. Reduce the general equation of second degree to the standard forms
2. Know the polar equation of the conic
3. Learn the first order ordinary and partial Mechanics and methods of their solutions
4. Recognize and handle mathematical objects called group
5. Analyze concept of Lagrange's theorem.

Course Content:

UNIT 1: Co-ordinate Geometry

Transformation of General Equation of
the Second Degree. Conditions for General Equation of Second Degree to Represent a Parabola, Ellipse and Hyperbola. Equations of the Tangent and Normal to a Curve via calculus. Polar Equation.

UNIT 2: Mechanics

Differential Equations of First Order and Higher Degree, Clairaut's Form, Singular Solution, Orthogonal Trajectories. Linear Equation with Constant Co-efficient, Homogenous Linear Equation with variable coefficients. Simultaneous equations,

$\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$ and Total Differential Equations $Pdx + Qdy + Rdz = 0$ together with Geometric Significance.

UNIT 3: Group Theory

Binary Operations, Notion of Group, Abelian Group and Non-Abelian group with Examples. Uniqueness of Identity element and Inverse elements in a group, Different ways of Defining a Group, Concept of Subgroup and Cyclic Group, Cosets, Lagrange's Theorem.

Reference Books:

1. Coordinate Geometry: A Das Gupta
2. Coordinate Geometry: Lalji Prasad
3. Abstract algebra: A R Vashishtha
4. Modern Algebra: Lalji Prasad
5. Differential Equations: MD Raisinghania

SEMESTER VI **MINOR ELECTIVE-3** **1 Paper**

I. MINOR ELECTIVE (MN 3)

(Credits: Theory-06)

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

Instruction to Question Setter for

Semester Internal Examination (SIE 20+5=25 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. **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 10 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 Examination (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.*

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

REAL ANALYSIS, COMPLEX ANALYSIS, MATRICES

Theory: 90 Lectures

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Understand the notion of bounds in the subset of real numbers
2. Recognize the sequence & series of real numbers and their convergence
3. Be familiar with the concept of Analyticity of the function of complex variables
4. Calculate simultaneous and iterated limits
5. Understand operations and types of Matrices and to calculate their eigenvalues and eigen vectors

Course Content:

UNIT 1: Real Analysis

Sequence: Definition, Bounds, Limit of a sequence, Monotonic Sequence and their convergence, Algebraic Operations and Limit, Cauchy Sequence, General Principle of Convergence of a sequence.

Series: Definitions, Convergent Series, Divergent Series, Pringsheim's Theorem, Comparison tests, Cauchy's Root Test, D'Alembert's Ratio Test, Alternating Series and Leibnitz Test, Absolutely Convergent Series.

UNIT 2: Complex Analysis

Real Functions of Two Variables: Simultaneous and Iterated limits: Continuity, Partial Derivatives, Differentiability and related Necessary and Sufficient conditions. Functions of Complex variables Limit, Continuity, Derivative, Cauchy – Reimann Equations, Analytic Function, Harmonic function.

UNIT 3: Matrices

Definitions, Operations on Matrices, Matrix Algebra, Type of Matrices, Transpose, Adjoint and Inverse of a matrix, Solution of system of linear equations. Eigen Values & Eigen Vectors

Reference Books:

1. Real Analysis, Shanti Narayan & M D Raisinghania
2. Real Analysis: Lalji Prasad.
3. Complex Variables: J N Sharma.
4. Matrices: A. R. Vasishtha

FORMAT OF QUESTION PAPER FOR SEMESTER INTERNAL EXAMINATION

Question format for **10 Marks**:

Subject/ Code

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

General Instructions:

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

Group A

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

Group B

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

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

Question format for **20 Marks**:

Subject/ Code

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

General Instructions:

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

Group A

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

Group B

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

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

FORMAT OF QUESTION PAPER FOR END SEMESTER UNIVERSITY EXAMINATION

Question format for **50 Marks**:

Subject/ Code

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

General Instructions:

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

Group A

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

Group B

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

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

Question format for **60 Marks**:

Subject/ Code

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

General Instructions:

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

Group A

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

Group B

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

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

Question format for **75 Marks**:

Subject/ Code

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

General Instructions:

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

Group A

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

Group B

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

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

Question format for **100 Marks**:

Subject/ Code

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

General Instructions:

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

Group A

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

Group B

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

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