DEPARTMENT OF MATHEMATICS
RAMANUJAN SCHOOL OF MATHEMATICAL SCIENCES
PONDICHERRY UNIVERSITY

CURRICULUM FOR

FOUR YEAR B.Sc. HONOURS,
B.Sc. HONOURS WITH RESEARCH
&
FIVE YEAR INTEGRATED M. Sc.
IN MATHEMATICS

UNDER NATIONAL EDUCATION POLICY NEP-PU
Regulation-April 2023
(academic year 2023-24 onwards)

AND

Mathematics Courses and Syllabi for
B.Tech. Programmes
(academic year 2024-25 onwards)

PONDICHERRY UNIVERSITY
NEP 2020 – REGULATIONS

The UG programmes in Mathematics offered by the department of Mathematics has been framed in accordance with NEP Regulations, Pondicherry Univervity for UG programmes based on Curriculum and Credit Framework for UG programmes given by UGC and can be accessed using the following link: NEP-Regulations-Pondicherry-University.

1. **Duration of the Programme**

The duration of the UG programme is 4 years or 8 semesters. Students who desire to undergo a 3-year UG Programme will be allowed to exit after completion of the 3rd year. If a student wants to leave after the completion of the first or second year, the student will be given a UG Certificate or UG Diploma, respectively, provided they secure the prescribed number of credits (as given in table below). Students who exit with a UG certificate or UG diploma are permitted to re-enter within three years and complete the degree programme. Students may be permitted to take a break from the study, they are allowed to re- enter the degree programme within 3 years and complete the programme within the stipulated maximum period of seven years.

2. **Eligibility for the UG Programmes**

Senior Secondary School Leaving Certificate or Higher Secondary (12th Grade) Certificate obtained after successful completion of Grade 12 or equivalent stage of education corresponding to Level-4 (Levels in NHEQF) with Mathematics as one of the subject.

3. **AWARDING OF UG CERTIFICATE, UG DIPLOMA, AND DEGREES**

UG Certificate: Students who opt to exit after completion of the first year and have earned a minimum of 42 credits will be awarded a UG certificate in Mathematics if, in addition, they complete work based vocational course/internship of 4 credits during the summer vacation of the first year.

UG Diploma: Students who opt to exit after completion of the second year and have earned a minimum of 84 credits will be awarded the UG diploma in Mathematics if, in addition, they complete work based vocational course/internship of 4 credits during the summer vacation of the second year.

3- year UG Degree: Students who wish to discontinue after the 3- year UG programme will be awarded a UG Degree in Mathematics after successful completion of three years, earning a minimum of 124 credits and satisfying the minimum credit requirements as mentioned in the table below.

4- year UG Degree (Honours): A four-year UG Honours degree in Mathemtics will be awarded to those who complete a four-year degree programme, earning a minimum of 164 credits and have satisfied the credit requirements as mentioned in table below.

4- year UG Degree (Honours with Research): Students who secure a minimum of 7.5 CGPA in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should do a research project or dissertation under the guidance of a faculty member of the University. The research project/dissertation will be in Mathematics. The students who secure a minimum of 164 credits, including 12 credits from a research project/dissertation, will be awarded UG Degree (Honours with Research).

4. Breakup of Credits and Courses- Minimum requirement Outline

Sl.No.	Component	3 Year UG	4 Year UG (Honours/Honours With research)
1	Major Disciplinary/Interdisciplinary Courses	60 Credits (15 Courses of 4 credits)	80 Credits (20 Courses of 4 credits)
2	Minor Disciplinary/interdisciplinary Courses (Vocational programme included)	24 Credits (6 Courses of 4 Credits)	32 Credits (8 Courses of 4 credits)
3	Multi-Disciplinary Courses	9 Credits (3 courses of 3 credits)	9 Credits (3 courses of 3 credits)
4	Ability Enhancement Courses	12 Credits (4 courses of 3 credits)	12 Credits (4 courses of 3 credits)
5	Skill Enhancement Course	9 Credits (3 courses of 3 credits)	9 Credits (3courses of 3 credits)
6	Value-added courses	8 Credits (4 courses of 2 credits)	8 Credits (4 courses of 2 credits)
7	Summer internship	(4credits-Included in Major courses of 60 credits)	(4 credits-Included in Major courses of 80 credits)
7	Community engagement and service	2 Credits (1 course)	2 Credits (1 course)
8	Research Dissertation Project	-	12 Credits
9	Total	124	164

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

5. PROGRAMME COMMITTEE AND BOARD OF STUDIES FUNCTIONS, DUTIES AND RESPONSIBILITIES

i. For each Academic Programme of the University, a Programme Committee (PC) may be constituted consisting of the Head of the Department as its Chairperson (ex-officio), one nominee of the Vice-Chancellor from another department, all the faculty members of the department, and not more than two representatives from each batch of students. For programmes that are offered by more than one department in a School, the Dean of the School concerned shall appoint a Coordinator who shall act as the Chair of the Committee. For programmes involving more than one school, the University shall appoint a coordinator who shall serve as the Chair of the Committee.

ii. Programme Committee has the overall responsibility to implement the NEP guidelines in all Programmes of Study prescribed in a department. It reviews and monitors the implementation of approved

Course structure and Coverage of syllabus, Time Table, Distribution of workload of faculty members and Conduct of Assessments.

iii. Programme Committee shall review and recommend infrastructure requirements for smooth conduct of teaching- learning activities in every Department.

iv. Programme Committee provides an opportunity for individual teachers to initiate steps to float newer courses, new methods of teaching, ICT implementation and any other academic initiative.

v. The Programme Committee shall decide on the credits to be associated with SWAYAM and other similar platforms for on- line learning approved by the University.

vi. The Programme Committee shall meet at least thrice in every semester. At first, in the beginning of the semester to chalk out time table and course session plans/ evaluation methods of faculty. Second time, in the middle of the semester to review the progress of academic activities. Third meeting shall review the fairness of evaluation/distribution of scores/ maintenance of standards in evaluation procedures and will finalise and recommend the grades for all the courses offered by the department/ centre in that semester. Student members shall not take part in the last meeting of Programme Committee in a semester.

vii. The Learning Outcome-based curriculum planning requires that the pedagogical approaches are oriented towards enabling students to attain the defined learning outcomes relating to the courses within a programme. This outline for the programmes run by the department may be placed and approved in the BOS after the PC reviews them.

6. Continuous Assessment and End semester Examination marks and evaluation of skill based/vocational courses/ Internships and other hands on/field-based courses

- All theory courses in a UG programme shall carry a continuous assessment component of 40 marks and end semester assessment component of 60 marks.
- In case of skill-based courses, vocational education courses, internships, practical, lab/field/project works, community service and related skill-based activities, the evaluation pattern may be decided by the respective Programme Committees/BOS and be approved in Academic Council. The evaluation methods need to be drawn based on the learning outcomes planned for such courses following the NEP guidelines of Pondicherry University.

6.1 Continuous Assessment Component (Sessional)

- Evaluation will be based on continuous assessment carried out through activities spread over a complete semester based on the learning outcomes listed. Sessional work consists of class tests, at least one mid-semester examination, homework assignments, and any other innovative assessment methodology as determined by the faculty in charge of the course of study. Progress towards achievement of learning outcomes shall be assessed using the following: time- constrained examinations; closed-book and open-book tests; problem-based assignments; practical assignments; laboratory reports; observation of practical skills; individual project reports (case-study reports); team project reports; oral presentations, including seminar presentation; viva voce interviews; computerized adaptive assessments, examination on demand, modular certifications and other suitable assessments methods.

- Total Marks from continuous assessments may be up to 40% of the total. Departments/Centres/Schools need to design suitable continuous assessment models splitting the 40 marks into 2 to 4 different components including at least one mid semester test, duly approved by the PC/BOS. This splitting may match the requirements/nature of courses taught.

6.2 End- Semester Examination and Evaluation

6.2.1 End semester examinations shall be conducted for all courses offered in the department/centres after ensuring that the required number of classes and related activities are completed. The duration of the end semester examination may be 3 hours.

6.2.2 A schedule of End semester examinations will be announced by the department/centre about 15 days ahead of the conduct of examinations.

6.2.3 The responsibility of question paper setting, invigilation and valuation of answer papers lie with the course teachers. However, all assessments shall be conducted under the uniform practices of the department approved in the programme committee.

6.2.4 However, the departments/faculty members are free to decide the components of continuous assessment and the method of assessment based on the nature of the course and are expected to communicate these to students and respective HODs at the beginning of the semester.

6.2.5 Mid semester /end semester examinations schedule notified by the University in the academic calendar shall be uniformly followed.

6.3 Minimum Marks for Pass

A student shall be declared to have passed the course only if she/he gets,

6.3.1 A minimum of 40% marks in end semester exam and

6.3.2 A minimum of 40% marks in aggregate when continuous assessment and end semester examination marks are put together.

6.4 Supplementary examination

6.4.1 A student who gets F grade in a course shall be permitted to register for the supplementary examination in the following semester or in the subsequent semesters.

6.4.2 A student who gets F grade in a course shall be given an option either to retain the previously awarded continuous assessment mark or to improve it, and the higher mark out of these two options will be considered for the supplementary examination.

6.4.3 A student who gets Ab grade in a course/practicum/vocational course/internship/practicum or any other hands-on skill related course is mandated to repeat the course and undergo all the stages of assessment in subsequent semesters

6.5 Attendance Requirement

No student who has less than 70% attendance in any course shall be permitted to participate in end semester examination and she/he shall be given 'Ab' grade, -failure due to lack of attendance. she/he shall be required to repeat that course as and when it is offered.

7. LETTER GRADES AND GRADE POINTS

Performance of students in each paper will be expressed as marks as well as Letter Grades.

Letter Grade	Grade Point
O (outstanding)	10
A+ (Excellent)	9
A (Very good)	8
B+ (Good)	7
B (Above average)	6
C (Average)	5
P (Pass)	4
F (Fail)	0
Ab (Absent)	0

In case of fractions the marks shall be rounded off to nearest integer. The class interval K will be calculated by the formula given below:

$$K = (X-50)/6$$

where X is the highest mark secured.

According to K value, one of the following grading schemes will be followed.

(i) If $K \geq 5$, then the grades shall be awarded as given in Table II.

Table II		
Range of Marks in %	**Letter Grade Points for**	**Letter Grade Points for**
X to (X-K)+1	O	10
(X-K) to (X-2K)+1	A+	9
(X-2K) to (X-3K)+1	A	8
(X-3K) to (X-4K)+1	B+	7
(X-4K) to (X-5K)+1	B	6
(X-5K) to 50	C	5
40 – 49	P	4
Below 40	F	0
Absent (Lack of Attendance)	Ab	0

(ii) If $K<5$, then the grades shall be awarded as given in Table III.

Table III		
Range of Marks in %	**Letter Grade Points for**	**Letter Grade Points for**
80-100	O	10
71-79	A+	9
66-70	A	8
61-65	B+	7
56-60	B	6
50-55	C	5
40-49	P	4
Below 40	F	0
Absent (lack of attendance)	Ab	0

The Semester Grade Point Average (SGPA) is computed from the grades as a measure of the student's performance in a given semester. The SGPA is based on the grades of the current term, while the Cumulative GPA (CGPA) is based on the grades in all courses taken after joining the programme of study.

8. Computation of SGPA and CGPA

The following procedure shall be followed to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

The SGPA is the ratio of the sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student, i.e. **SGPA** (Si) = Σ(Ci x Gi) / ΣCi

Where Ci is the number of credits of the i^{th} course and Gi is the grade point scored by the student in the i^{th} course.

Example for Computation of SGPA where candidate has not failed in any course.

Semester	**Course**	**Credit**	**Letter Grade**	**Grade point**	**Credit Point** (Credit x Grade)
I	Course 1	3	A	8	3 X 8 = 24
I	Course 2	4	B+	7	4 X 7 = 28
I	Course 3	3	B	6	3 X 6 = 18
I	Course 4	3	O	10	3 X 10 = 30
I	Course 5	3	C	5	3 X 5 = 15
I	Course 6	4	B	6	4 X 6 = 24
		20			139
	SGPA				139/20=6.95

The CGPA shall be calculated as follows: CGPA=$\frac{\sum C_i S_i}{\sum C_i}$

Where Si is the SGPA of the i^{th} semester and Ci is the total number of credits in that semester

Example for computation of CGPA

Semester 1	**Semester 2**	**Semester 3**	**Semester 4**	**Semester 5**	**Semester 6**
Credit: 20 SGPA: 6.8	Credit: 25 SGPA: 7.2	Credit: 28 SGPA: 7.5	Credit: 22 SGPA: 6.9	Credit: 23 SGPA: 6.5	Credit: 26 SGPA: 7.1

CGPA = **7.02** (20x6.8+25x7.2+28x7.5+22x6.9+23x6.5+26x7.1)/144

In case of audit courses offered, the students may be given (P) or (F) grade without any credits. This may be indicated in the mark sheet. Audit courses will not be considered towards the calculation of CGPA.

9. Grade Card

The University shall issue a Grade card for the students, containing the marks and grades obtained by the student in the previous Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA).

The grade card shall list:

a. The title, semester and course code of the courses taken by the student.
b. The credits associated with the course.
c. The marks and grade secured by the student.
d. The total credits earned by the student in that semester.
e. The SGPA of the student.
f. The total credits earned by the students till that semester.The CPGA of the student.

On successful completion of the programme, students with a CGPA of 9.00 and above who passed all the courses in first attempt shall be awarded the degree in First Class with Distinction. University Rank in a programme will be awarded to the student who secures the highest CGPA in a batch and passed all the courses in first attempt. Students with CGPA between 6.00 and 8.99 shall be placed in First Class, students with CGPA between 5.00 and 5.99 shall be placed in Second Class, and students with CGPA between 4.00 and 4.99 shall be placed in Pass Class.

For further details and clarifications, please refer to the NEP regulations, Pondicherry University via the following link: NEP-Regulations-Pondicherry-University.

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STRUCTURE OF THE UNDERGRADUATE PROGRAMME UNDER NEP

BSc Honours & 5 Year MSc: Semester-I

Course Code	Type	Credits	Title	Offered by
BSMT 111	MAJOR -1	4	Calculus	Math
STAT	Minor -1	4	Descriptive Statistics (suggested)	Stat
MDC*-1	Multi-Disciplinary-1	3	Science and Society (suggested)	Phy
	Ability Enhancement -1	3	English – I	Eng
STAT	Skill Enhancement -1	3	Data Analysis with Excel-I	Stat
	Value Added- 1	2	Understanding India	Hist
	Value Added-2	2	Environmental Sciences	Envi
Semester Credits		**21**		

Semester-II

Course Code	Type	Credits	Title	Offered by
BSMT 121	MAJOR -2	4	Matrices and Theory of Equations	Math
STAT	Minor -2	4	Probability Theory (suggested)	Stat
MDC*-2	Multi-Disciplinary-2	3	(suggested)	Sociology
	Ability Enhancement -2	3	English – 2	Eng
STAT	Skill Enhancement -2	3	Data Analysis with Excel-II	Stat
	Value Added- 3	2	Health and well Being	Ph-Edu
	Value Added-4	2	Digital Technologies	Comp
Semester Credits		**21**		

Semester-III

Course Code	Type	Credits	Title	Offered by
BSMT 211	MAJOR -3	4	Sequences and Series	Math
BSMT 212	MAJOR -4	4	Elements of Discrete Mathematics	Math
STAT	Minor -3	4	Distribution Theory(suggested)	Stat
MDC*-3	Multi-Disciplinary-3	3	(suggested)	Perf Arts
	Ability Enhancement -3	3	Modern Indian Language-1	Language
STAT	Skill Enhancement -3	3	Exploratory DATA Analysis using R	Stat
Semester Credits		**21**		

MDC*: In each semester select any one course from the bouquet of **multi-disciplinary courses.** Minimum three courses have to be completed. But, exactly one course from any of the following categories: -
1. Natural Sciences/Physical Sciences 2. Statistics/Computer Applications 3. Lib. Information and Media Sciences 4. Commerce and Management 5. Humanities and Social Sciences.

Semester-IV

Course Code	Type	Credits	Title	Offered by
BSMT 221	MAJOR -5	4	Introduction to Real Analysis	Math
BSMT 222	MAJOR -6	4	Group Theory	Math
BSMT 223	MAJOR -7	4	Elements of Differential Equations	Math
STAT	Minor -4	4	Sampling Theory (suggested)	Stat
	Ability Enhancement -3	3	Modern Indian Language-2	Language
	Community Engagement	2	NSS/NCC	NSS
Semester Credits		**21**		

Semester-V

Course Code	Type	Credits	Title	Offered by
BSMT 311	MAJOR -8	4	Metric Spaces	Math
BSMT 312	MAJOR -9	4	Ring Theory	Math
BSMT 313	MAJOR -10	4	Multivariable Calculus	Math
PHYS	Minor -5	4	Newtonian Mechanics and waves (suggested)	Physics
BSMT 314	MAJOR- 11 (SEC-4)	4	Internship/Comprehensive Exam with Vivo voce	Maths
Semester Credits		**20**		

Semester-VI

Course Code	Type	Credits	Title	Offered by
BSMT 321	MAJOR -12	4	Fundamentals of Complex Analysis	Math
BSMT 322	MAJOR -13	4	Introduction to Linear Algebra	Math
BSMT 323	MAJOR -14	4	Introduction to Graph Theory	Math
BSMT 324	MAJOR- 15	4	Linear Programming	Maths
PHYS	Minor -6	4	Thermal Physics (suggested)	Physics
Semester Credits		**20**		

Semester-VII

Course Code	Type	Credits	Title	Offered by
BSMT 411	MAJOR -16	4	Advanced Algebra	Math
BSMT 412	MAJOR -17	4	Topology	Math
BSMT 413	MAJOR -18	4	Ordinary Differential Equations	Math
	Minor -7	4	From Annexure I	Math
	Minor -8	4	From Annexure I	Math
Semester Credits		**20**		

Semester-VIII

Course Code	Type	Credits	Title	Offered by
BSMT 421	MAJOR -19	4	Advanced Real Analysis	Math
BSMT 422	MAJOR -20	4	Advanced Linear Algebra	Math
BSMT 423		12	Research Project Dissertation	Math
OR				
	Minor -9	4	From Annexure I	Math
BSMT 424	Minor -10	4	Complex Analysis	Math
BSMT 425	Minor -11	4	Measure and Integration	Math
Semester Credits		**20**		

Semester-IX

Course Code	Type	Credits	Title	Offered by
MSMT 511	MAJOR -21	4	Functional Analysis	Math
MSMT 512	MAJOR -22	4	Galois Theory	Math
	Minor -12	4	From Annexure II\I	Math
	Minor -13	4	From Annexure II\I	Math
	Minor -14	4	From Annexure II\I	Math
Semester Credits		**20**		

Semester-X

Course Code	Type	Credits	Title	Offered by
	Minor -15	4	From Annexure II\I	Math
	Minor -16	4	From Annexure II\I	Math
Ability Enhancement -5				
MSMT 599		12	Research Project Dissertation	Math
OR				
	Minor -17	4	From Annexure II\I	Math
	Minor -18	4	From Annexure II\I	Math
	Minor -19	4	From Annexure II\I	Math
Semester Credits		**20**		

LIST OF MINORS FOR 4th Year (ANNEXURE - I)

Course Code	Type / Semester	Credits	Title	Offered by
BSMT 431	Minor	4	Cryptography	Math
BSMT 432	Minor	4	Numerical Analysis	Math
BSMT 433	Minor	4	Number Theory	Math
BSMT 434	Minor	4	Calculus of Variations	Math
BSMT 435	Minor	4	Partial Differential Equations	Math
BSMT 436	Minor	4	Lattice Theory	Math
BSMT 437	Minor	4	Advanced Graph Theory	Math

LIST OF MINORS FOR 5th Year (ANNEXURE - II)

Course Code	Type / Semester	Credits	Title	Offered by
MSMT 531	Minor	4	Integral Equations	Math
MSMT 532	Minor	4	Numerical Analysis for Ordinary Differential Equations	Math
MSMT 533	Minor	4	q-Series in Number Theory	Math
MSMT 534	Minor	4	Integral Transforms and Their Applications	Math
MSMT 535	Minor	4	An Introduction to Wavelets with Applications	Math
MSMT 536	Minor	4	Graphs and Algebras	Math
MSMT 537	Minor	4	Probability and Statistics	Math
MSMT 538	Minor	4	Algebraic Number Theory	Math
MSMT 539	Minor	4	Advanced Topics in Topology and Analysis	Math
MSMT 540	Minor	4	Advanced Topology	Math
MSMT 541	Minor	4	Commutative Algebra	Math
MSMT 542	Minor	4	Discrete Dynamical Systems	Math
MSMT 543	Minor	4	Advanced Special Functions	Math
MSMT 544	Minor	4	Advanced Functional Analysis	Math
MSMT 545	Minor	4	Non-Commutative Rings and Representations	Math
MSMT 546	Minor	4	Algebraic Graph Theory	Math
MSMT 547	Minor	4	Fixed Point Theory	Math
MSMT 548	Minor	4	Graph Coloring	Math
MSMT 549	Minor	4	Differential Geometry	Math
MSMT 550	Minor	4	Advanced Integral Transforms	Math
MSMT 551	Minor	4	Advanced Complex Analysis	Math
MSMT 552	Minor	4	Lie Groups of Transformations and Differential Equations	Math
MSMT 553	Minor	4	Dynamical Systems	Math
MSMT 901	Minor	4	Research Methodology	Math

ELIGIBILITY FOR LATERAL ADMISSION

Every student seeking admission in any year of the 5- year Integrated Master's program of the Department of Mathematics should have cleared the NTA_CUET entrance test after the 10+2 higher secondary schooling with Mathematics, Physics and Chemistry. Lateral entry will be governed under the PU-NEP Regulation April 2023 and its subsequent amendments.

MULTI DISPLINARY COURSE

Course Code	Type / Semester	Credits	Title	Offered by
BSMT 181	MDC / odd & even	3	Basic Mathematics	Math

SKILL ENHANSEMENT COURSE

Course Code	Type / Semester	Credits	Title	Offered by
BSMT 131	SEC-1 / odd & even	3	Latex for Mathematics	Math
BSMT 132	SEC-2 / odd & even	3	Mathematical Methods with MATLAB	
BSMT 133	SEC-3 / odd & even	3	Scilab for Mathematics	

MINOR COURSES (Offered For Mathematics Students)

Course Code	Type / Semester	Credits	Title	Offered by
BSMT 231	Minor / odd	4	Numerical Methods	Math
BSMT 232	Minor / even	4	Python	Math
BSMT 233	Minor / odd	4	Elements of Mechanics	Math
BSMT 331	Minor / even	4	Mathematical Modelling	Math
BSMT 332	Minor / odd	4	Automata Theory	Math
BSMT 333	Minor / even	4	Vector Analysis	Math

MINOR COURSES (Offered For Science Department Students)

These courses are designed for students from Statistics, Physics and etc. These courses will be floated depending on the =number of students registering and the availability of the faculty.

The number of students may be restricted depending on the available classroom facility and first-cum-first serve basis.

Course Code	Type / Semester	Credits	Title	Offered by
BSMT 161	Minor / odd	4	Basic Calculus	Math
BSMT 162	Minor / even	4	Basic Algebra and Theory of Equations	Math
BSMT 261	Minor / odd	4	Fundamentals of Real Analysis	Math
BSMT 262	Minor / even	4	Introduction to Differential Equations	Math
BSMT 361	Minor / odd	4	Calculus of several variables	Math
BSMT 362	Minor / even	4	Introduction to Linear Algebra	Math
BSMT 461	Minor / odd	4	Vector Calculus	Math
BSMT 462	Minor / even	4	Introduction to Complex Analysis	Math

Mathematics Courses for B. Tech Programs of Computer Science, Banking Technology, Electronics, Green Energy, Environmental Engineering and Nano Science Departments.

Code	Title	Semester	Credit	To Department
BTMT 171	**Mathematics- I**	**1**	**4**	**Common for All**
BTMT 172	**Mathematics- II**	**2**	**4**	**Except Banking Tech**
BTMT 173	**Applied Linear Algebra**	**2**	**3**	**Banking Tech**
BTMT 271	**Discrete Mathematics**	**3**	**4**	**Computer, Bank Tech and Pollution control**
BTMT 272	**Numerical Techniques**	**3**	**3**	**Electronics Dept**
BTMT 273	**Mathematics- III**	**3**	**4**	**Green & Nano Tech**

Programme Outcomes for B.Sc. Honors in Mathematics

PO 1	Acquiring strong foundation in Mathematics
PO 2	Developing critical thinking and logical reasoning skills
PO 3	Enhancing problem solving skills in Mathematical modelling and applications
PO 4	Fostering effective communication of Mathematical ideas
PO 5	Preparing for advanced studies and research in Mathematics
PO 6	Developing the ability to critically interpret numerical and graphical data and drawing valid conclusions
PO 7	Cultivating a scientific temper and attitude for learning Mathematics
PO 8	Understanding the interdisciplinary applications of Mathematics in sciences, engineering, economics and technology
PO 9	Developing skills in using computational tools for Mathematical analysis
PO 10	Equipping the graduates with competency for employability in education, industry, research and other sectors requiring quantitative skills

Programme Outcomes for M.Sc. Mathematics

PO 1	Acquiring advanced and in-depth knowledge in Pure and applied Mathematics
PO 2	Formulate and construct regress mathematical proofs with clarity and logical consistency
PO 3	Applying Mathematical reasoning and problem solving skills to tackle abstract and real world problems.
PO 4	Fostering effective communication of Mathematical ideas
PO 5	Cultivating a scientific temper and attitude for learning Mathematics
PO 6	Motivation for undertaking original research and project work in Mathematics
PO 7	Applying Mathematical expertise to interdisciplinary domains addressing practical or industrial challenges
PO 8	Preparing for pursuing higher education or research careers in Mathematics and related areas
PO 9	Engage with Mathematical literature, read and interpret current research papers and pursue independent study in advanced topics
PO 10	Preparing effectively for competitive examinations and teaching careers in higher education or research institutions

SEMESTER-I

MAJOR-1 **BSMT 111: CALCULUS** **(4 CREDITS)**

Course Objectives:

1. Able to analyse the derivatives and anti-derivatives of functions.
2. To understand the concept of applications of derivatives and integration

	Course Outcomes
CO 1	Evaluate limits of functions and Compute derivatives of elementary functions
CO 2	To find asymptotes and draw free hand diagram of a given function
CO 3	Analyse the methods and application of differentiation
CO 4	Analyse the methods and application of integration
CO 5	Apply integration techniques to calculate areas between curves, arc lengths, and areas of surfaces of revolution.

Unit I: (Sections: 1.1, 1.2, 1.3, 2.2, 2.6)
Functions and their graphs – Combining functions – shifting and scaling of graphs – Trigonometric functions – Limit of a function and limit laws – Limit involving infinity – Asymptotes of graphs.

Unit II: (Sections: 3.2-3.9, 4.1, 4.3, 4.4)
Derivative of standard functions, Application of derivatives - Increasing decreasing functions - Maxima minima, Test of concavity& convexity point of inflexion.

Unit III: (Sections: 2.6, 4.2, 10.8, 11.3, 11.4, 13.4)
Mean value theorems, Taylor theorem, Maclaurin's theorem, Polar coordinates and curvature, Asymptotes, Graphing in polar co-ordinates.

Unit IV: (Sections: 5.1, 5.2, 5.3, 5.4, 5.5, 8.1, 8.2, 8.3, 8.4, 8.5)
Definite integrals - Properties of definite integrals - Evaluation of integrals- Area and the mean value theorem, fundamental theorem of calculus, Substitution in definite integrals - Integration by parts, Integration of rational fractions.

Unit V: (Sections: 5.6, 6.1, 6.2, 6.3, 6.4)
Areas between curves, Volume using cross section- Finding volume by slicing, Volumes of solids of revolution - Disk and washers- Cylindrical shell-Arc length-- Areas of surface of revolution.

Text Book

1. George B.Thomas, Maurice D.Weir and Joel Hass, Thomas' Calculus 12th Edition, Pearson Education, 2015.

Reference Books

1. Richard Courant and Fritz John, Introduction to Calculus and Analysis, Vol.I, Springer 1999.
2. Serge Lang A First course in Calculus 5th edition, Springer, 1999.
3. N. P. Bali, Integral Calculus, Laxmi Publications, Delhi 1991.
4. Richard Courant and Fritz John, Introduction to Calculus and Analysis, Volumes I & II Springer, SIE, 2004.
5. Serge Lang A First course in Calculus 5th edition, Springer, 1999.
6. Tom Apostel, Calculus: One-Variable Calculus with An Introduction to Linear Algebra, Vol 1, 2ed, Wiley 2007.
7. Michael Spivak, Calculus, 4th edition, Publish or Perish, Inc., 2008.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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SEMESTER-II

MAJOR-2 BSMT 121: MATRICES AND THEORY OF EQUATIONS

Course Objectives:

This course enables the students to learn

1. To introduce about the algebra of matrices and to solve system of linear equations using matrix theory
2. About the relations between the roots and coefficients, Transformation of equation and solutions Reciprocal, cubic and biquadratic equations.
3.

	Course Outcomes On successful completion of this course, the student will be able to
CO 1	Understand the concepts of algebra of matrices
CO 2	Sole the system of linear equations using matrix theory
CO 3	Identify the relation between coefficients of the equation and its roots.
CO 4	Familiarize about the transformations of equations, Reciprocal equations and finding nature of roots using Descartes rule. .
CO 5	Know about the algebraic solutions of Cubic and Biquadratic equations.

Unit I: (Sections 1.1, 1.2, 1.3,1.4,1.5 of [1])

Linear systems - Matrices - Dot product and Matrix multiplication - Properties of Matrix operation, Matrix transformations.

Unit II: (Sections 1.6,1.7,1.8[1])

Solutions of Linear systems of equations - Row echelon from reduced row echelon form – Polynomial interpolation - The inverse of a Matrix. - Linear Systems and inverses - LU- Factorization Method.

Unit III: (Sections 5.1,5-2,.5.3 of [2])

Division algorithm - Relation between roots and coefficients - Sum of the powers of the roots.

Unit IV: (section 5.4,5.5,5.6 ,5.7 of [2])

Reciprocal equations - Transformation of equations: - Multiple roots - Nature of position of roots - Sturm's Theorem.

Unit V: (Sections 5.8,5.9,5.10 of [2])

Cardan's Method for solving Cubic equations – Ferrari's Method for solving biquadratic equations - New Newton's Method- Horner's Method

Text Books

1. Bernard Kolman Drid R. Hill, Introductory Linear Algebra, (8e),Pearson India (2011)
2. S. Arumugam and A Thangaand Isaac, Set Theory Number System and Theory of Equations, New Gamma publishing house(1997.).

References:

1. Hari Kishan, Theory of Equations, Atlantic Publishers, 2022.
2. Lalji Prasad, Theory of Equations, New Revised Edition, 2016.
3. Kenneth Hoffmann and Ray Kunze, Linear Algebra, (Second edition), Pearson, 2015.
4. Gilbert Strang, Linear Algebra and its Applications, 4th Edition, Cengage India Private Limited, 2005.
5. Serge Lang, Undergraduate Algebra, 3rd Edition, Springer, 2005.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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SEMESTER-III

MAJOR-3 BSMT 211: SEQUENCES AND SERIES (4 CREDITS)

Course Objectives:

1. To study the importance of the LUB property of the real number system
2. To study the property of convergence of sequences and series

	Course Outcomes
CO 1	Understanding the lub property and its consequences
CO 2	Concrete knowledge about the structure of the real number system
CO 3	Knowledge about convergent sequences, monotone sequences and Cauchy's sequences in R
CO 4	Ability to test the convergence of an infinite series using various tests
CO 5	Familiarize the algebra of convergent series and rearrangement of infinite series

Unit I: (Sections 1.1, 1.2 and 1.3)

Algebra of the Real Number system – Upper and lower bounds – LUB property and its applications – Archimedean property – Greatest integer function – Density of rational numbers – Existence of n^{th} roots of positive real numbers – Nested intervals theorem.

Unit II: (Sections 1.4, 2.1, 2.2, 2.3 and 2.4)

Absolute value and Triangle Inequality – Subsets of R defined by inequalities – Convergent sequences – Definition and examples – Properties of algebra of limits of sequences – Bounded sequences – Sandwich Lemma – Cauchy sequences – Cauchy completeness of R - Monotone sequences – Geometric sequence – The number e - Nested intervals theorem.

Unit III: (Sections 2.5, 2.6, 2.7 and 2.8)

Some important limits – Cesaro's Theorem – Sequences diverging to $+\infty$. – Existence of a monotone sequence of a real sequence – Bolzano Weierstrass Theorem – Sequences definedrecursively.

Unit IV: (Sections 5.1 and 5.2)

Convergence and sum of an infinite series – Geometric series – Cauchy criterion – Algebra of convergent series – Absolutely convergent series – Comparison Test – Harmonic p-series – D'Alembert's ratio Test – Cauchy's Root Test – Integral Test – Cauchy's Condensation Test – Abel's Summation by parts Formula – Dirichlet's Test – Leibmitz Test for alternating series.

Unit V: (Section: 5.3 and 5.4)

Rearrangement of an infinite series – Definition and examples – Riemann's Theorem – Cauchy product of two infinite series – Merten's Theorem – Abel's Theorem on Cauchy product – Existence of decimal expansion – characterization and rational numbers.

Text Book:

1. Ajith Kumar and S.Kumaresan, ***A Basic Course in Real Analysis***, CRC Press (2014)

Reference Books:

1. Robert G. Bartle, Donald R. Sherbert, *Introduction to Real Analysis*; John Wiley and sons (Fourth Edition).
2. Kenneth A. Ross, *Elementary Analysis : The Theory of Calculus*, springer , 2e (2013).
3. Ajithkumar, S.Kumaresan, Bhasa Kumar Sarma, *A Foundation Course in Mathematics*, Narosa– 2018.
4. Walter Rudin, Principles of Mathematical Analysis- McGraw Hill International Editions, Mathematics series, 1976.
5. Tom Apostol, Mathematical Analysis, Narosa Publishing House, Indian edition,2002.

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MAJOR-4 BSMT 212: ELEMENTS OF DISCRETE MATHEMATICS (4 CREDITS)

Course Objectives:

The course aims to:

1. Build a strong foundation in logic, set theory, functions, and proof techniques essential for mathematical reasoning and applications.
2. Develop analytical and problem-solving skills through combinatorics, recurrence relations, and algorithmic methods relevant to computer science and engineering.

	Course Outcomes By the end of this course, students will be able to:
CO 1	Apply logical reasoning, set theory, and relations to formulate and analyze mathematical statements.
CO 2	Demonstrate understanding of functions, divisibility, prime numbers, and number-theoretic algorithms.
CO 3	Solve problems using mathematical induction, recurrence relations, and generating functions.
CO 4	Apply counting principles, combinatorial methods, and binomial theorem to solve enumeration problems.
CO 5	Analyze algorithms for complexity, searching, and sorting, and apply combinatorial enumeration in computational problems.

Unit I: (Sections: 0.1, 0.2, 1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 2.4, 2.5)

Statements – Compound Statements – Contrapositive statements – Proofs in Mathematics (Types of proofs) – Direct proofs – Proof by cases – Proof by contradiction – Logic – Truth tables – The Algebra of Propositions – Logical arguments –Sets – Operations on sets – Binary relations – Equivalence relations – Partial orders.

Unit II: (Sections: 3.1, 3.2, 3.3, 4.1, 4.2, 4.3)

Functions – Inverses and composition – One-to-one correspondence and the cardinality of a set – The Integers – The Division algorithm – Divisibility – The Euclidean Algorithm – Prime numbers.

Unit III: (Sections: 5.1, 5.2, 5.3, 5.4, 6.1, 6.2)

Mathematical induction – Weak form and strong form – Recursively defined sequences – Solving recurrence relations – The characteristic polynomials – Solving recurrence relations – Generating functions – The principle of inclusion-Exclusion – The addition and multiplication rules.

Unit IV: (Sections: 6.3, 7.1, 7.2, 7.5, 7.6, 7.7)

The pigeonhole principle–Permutations – Combinations –Repetitions – Derangements – The binomial theorem.

Unit V: (Sections: 8.1, 8.2, 8.3, 8.4)

What is an Algorithm – Complexity – Searching and sorting – Enumeration of permutation and combination.

Text Books

Edgar G. Goodaire, Michael M. Parmenter, Discrete Mathematics with Graph Theory (Third Edition), PHI Learning Private Ltd., New Delhi - 2011.

Reference Books

1. Richard Johnson bauth, Discrete Mathematics, 5th Edition, Pearson Education Asia, New Delhi, 2002.
2. Ralph. R. Grimaldi - Discrete and Combinatorial Mathematics: An applied Introduction - 4th Edition, Pearson Education Asia, Delhi, 2002
3. C.L. Liu, Elements of Discrete Mathematics, The Mc Graw-Hill, India 1985.
4. Bernard Kolman, Robert C. Busby, Sharan Cutler Ross, Discrete Mathematical Structure, 4th Edition, Pearson Education Pvt. Ltd., New Delhi 2003

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SEMESTER-IV

MAJOR-5 **BSMT 221: INTRODUCTION TO REAL ANALYSIS** **(4 CREDITS)**

Course Objectives:

1. To introduce the concept of limit and continuity of functions
2. To introduce the notion of differentiability and some fundamental results on differentiation.

	Course Outcomes
CO 1	Understand the concept of continuity using the ε–δ definition, analyse the algebra of continuous functions, and apply important theorems such as the Intermediate Value Theorem and Extreme Value Theorem to monotonic functions and limits.
CO 2	Apply differentiability concepts, the chain rule, Rolle's Theorem, the Mean Value Theorem, Cauchy's Mean Value Theorem, and the Inverse Function Theorem to solve problems and interpret applications.
CO 3	Use L'Hospital's Rule for evaluating indeterminate forms, analyze convex functions, and apply Darboux's Theorem, Taylor's Theorem, and derivative tests to study function behavior.
CO 4	Develop understanding of Riemann integration through upper and lower sums, apply properties of integrals, and utilize the Fundamental Theorem of Calculus and Mean Value Theorem for integrals in problem solving.
CO 5	Evaluate improper integrals of the first and second kind, distinguish between absolute and conditional convergence, and apply the Integral Test and Cauchy Principal Value in advanced integration problems.

Unit I: (Sections 3.1, 3.2, 3.3, 3.4, 3.5 and 3.6 of [1])

Continuous functions– Algebra of continuous functions – ε-δ definition of continuity – Intermediate value theorem– Extreme value theorem– Monotonic function– Limit of a function – Limit at infinity.

Unit II: (Sections 4.1 and 4.2 of [1])

Differentiability of functions – Chain rule – Roll's theorem – Mean value theorems –Applications of mean value theorem – Inverse function theorem – Cauchy's form of mean value theorem.

Unit III: (Sections 4.3, 4.4, 4.5 and 4.6 of [1])

L'Hospital's rule–Darboux theorem – Taylor's theorem – Convex functions – Derivative test for convexity.

Unit IV: (Sections 6.1, 6.2, 6.3 and 6.4 of [1])

Riemann integration – Upper and lower sums –Properties of Riemann integration – Basic estimates for integrals – Fundamental theorem of calculus (I & II), Mean value Theorem for Integrals.

Unit V: (Sections 7.5 and 7.10 of [2])

Improper integrals (First and second kind) – Absolute Convergence – conditional convergence – integral test – Cauchy principal value.

Text book:

1. Ajith Kumar and S.Kumaresan, *A Basic Course in Real Analysis*, CRC Press (2014).
2. Richard R Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co. Pvt Ltd, New Delhi, Indian Edition 1970.

Reference Books

1. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, Third Edition, Wiley India edition, 2000.
2. Kenneth A. Ross, *Elementary Analysis: The Theory of Calculus*, springer, 2e (2013).
3. Walter Rudin, Principles of Mathematical Analysis- McGraw Hill International Editions, Mathematics series, 1976.
4. Tom Apostol, Mathematical Analysis, Narosa Publishing House, Indian edition,2002.

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MAJOR-6 **BSMT 222: GROUP THEORY** **(4 CREDITS)**

Course Objectives:

1. To introduce the concept of Group and Homomorphisms.
2. To introduce the notion of special subgroups and Symmetric group.

	Course Outcomes
CO 1	Understand and illustrate fundamental group concepts
CO 2	Analyze and classify cyclic and permutation groups
CO 3	Apply isomorphisms, cosets, and Lagrange's theorem
CO 4	Construct and use external/internal direct products, factor groups, and normal subgroups
CO 5	Utilize homomorphisms and classify finite abelian groups

Unit I

Introduction to Groups - Definition and Examples of Groups – Elementary Properties of Groups – Subgroups - Subgroup Tests - Examples of Subgroups.

Unit II

Cyclic Groups - Properties of Cyclic Groups - Classification of Subgroups of Cyclic Groups - Permutation Groups - Cycle Notation - Properties of Permutations.

Unit III

Isomorphisms - Cayley's Theorem - Properties of Isomorphisms – Automorphisms – Cosets - Properties of Cosets - Lagrange's Theorem and Consequences.

Unit IV

External direct product – Definition and examples- Properties of external direct product- Normal Subgroups – Factor Groups - Applications of Factor Groups- Internal direct product.

Unit V

Group Homomorphisms - Properties of Homomorphisms - The First Isomorphism Theorem – Fundamental Theorem of finite Abelian groups – The isomorphism classes of Abelian groups.

Text Book:

Joseph A. Gallian, Contemporary Abstract Algebra, 8th Edition, Cengage Learning India Private Limited. **Chapters 2,3,4,5,6,7,9,10 and 11.**

Reference books

1. M. Artin: Algebra, Prentice-Hall of India, 1991.
2. I.N.Herstein: Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
3. John B. Fraleigh and Neal Brand, A First Course in Abstract Algebra, 8th Edition, Pearson Education, 2022.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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MAJOR-7 BSMT 223: ELEMENTS OF DIFFERENTIAL EQUATIONS (4 CREDITS)

Course Objectives:

1. To understand ordinary and first order partial differential equations and their applications
2. To enable students to understand solving the first and second order ODES and first order PDEs.

	Course Outcome
CO 1	To understand ODEs and solve first order Ordinary Differential Equations
CO 2	To Solve the Second Order Ordinary Differential Equations
CO 3	To understand and Solve non homogeneous Differential Equations and Higher Order ODEs
CO 4	To Understand and Solve a system of ODEs and their characteristics
CO 5	To understand PDEs and solve first order Partial Differential Equations

Unit I:

Exact differential equations- Integrating factors – Linear differential equations- Bernoulli equation – Modeling: Electric circuits – Orthogonal trajectories of curves.

Unit II:

Homogeneous linear equations of second order – Second order homogeneous equations with constant coefficients – Case of complex roots- Complex exponential function – Differential operators – Modeling: Free oscillations – Euler-Cauchy equation – Existence and uniqueness theory – Wronskian.

Unit III:

Non homogeneous equations – Solution by undetermined coefficients – Solution by variation of parameters – Modeling of electric circuits – Higher order linear differential equations – Higher order homogeneous equations with constant coefficients.

Unit IV:

Introduction: vectors, matrices, eigenvalues – Introductory examples – Basic concepts and theory – Homogeneous systems with constant coefficients, phase plane, critical points – Criteria for critical points, Stability.

Unit V:

Non-linear first order PDEs : Compatible systems- Solutions of Quasi linear equations
Charpit's method- Special Types of Charpits Method, -Integral surfaces through a given curve-The Cauchy problem for Quasi Linear case and nonlinear first order PDEs

Text Book

Erwin Kreyszig, Advanced Engineering Mathematics, 8th Edition, John Wiley & Sons, 1999.
Unit-I: Sections 1.5-1.8; Unit-II: Sections 2.1-2.7; Unit-III: Sections 2.8-2.10, 2.13, 2.14;
Unit-IV: Sections 3.0-3.4;
K. Shankara Rao, Introduction to Partial Differential Equations, PHI Publications,
3rd Edition. 2011. – Chapter 1

Reference Books

1. George F. Simmons, Differential Equations, Tata McGraw-Hill, New Delhi, 1972.
2. Boyce and Di Prima, Differential Equations and Boundary Value Problems, Wiley,10th edition 2012.
3. Earl A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall of India Private Ltd, 1991.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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SEMESTER-V

MAJOR-8 **BSMT 311: METRIC SPACES** **(4 CREDITS)**

Course Objectives:

1. To study about some important inequalities and to introduce the notion of metric spaces
2. To learn the notion of connectedness, completeness and compactness

	Course Outcomes
CO 1	Acquire fundamental knowledge of the concept of metric spaces
CO 2	Clarity about continuous and discontinuous functions on metric spaces
CO 3	Understanding the notion of connectedness and completeness and their properties
CO 4	Knowledge about compactness and their equivalent forms.
CO 5	Ability to test pointwise and uniform convergences of sequence of functions

Unit I: (Section 3.10, 4.2, 4.3,5.3, 5.4, 5.5**)**
Metric Spaces – Definition – Examples – Holder inequality – Minkowski's inequality – Convergent sequence – Cauchy sequence – Equivalent metric spaces – Continuous functions on a Metric space – Open sets – Closed sets – Limit points.

Unit II: (Section 5.6, 6.1,6.2)
Oscillation of a function – $F_\sigma$set, $G_\delta$set – Dense and nowhere dense subsets –Baire's category Theorem – Subspaces – Connected sets – Connected subsets of R – Continuity and connectedness.

Unit III: (Section 6.3, 6.4)
Bounded sets – Totally bounded sets – Complete metric spaces – Cantor intersection theorem – Contraction mapping – Contraction mapping theorem.

Unit IV: (Section 6.5, 6.6, 6.7,6.8)
Compactness – Sequential compactness – Heine-Borel property – Finite intersection property- Continuity and compactness – Continuity of inverse functions – Uniform continuity.

Unit V: (Section 9.1, 9.2, 9.4)
Sequences and series of functions – The metric space C[a,b] – pointwise Convergence – Uniform Convergence – Cauchy's criterion for uniform convergence.

Text Book
R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co. Pvt. Ltd., 1970.

Reference Books

1. Ajith Kumar and S. Kumaresan, *A Basic Course in Real Analysis*, CRC Press (2014).
2. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, Third Edition, Wiley India edition 2000.
3. S. Kumaresan, Topology of Metric spaces, Second Edition, Narosa Publishing House, 2005.
4. Pawan K. Jain and Khalil Ahmad, Metric Spaces, (Second Edition), Narosa Publishing House 2004.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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MAJOR-9 **BSMT 312: RING THEORY** **(4 CREDITS)**

Course Objectives:

1. To introduce the concept of Rings and Homomorphisms of Rings.
2. To introduce the notion of special subrings and Integral Domains.

	Course Outcomes
CO 1	Explain the fundamental concepts of ring theory and demonstrate the properties of rings.
CO 2	Apply ring homomorphisms and their properties, and construct and manipulate polynomial rings
CO 3	Analyze special integral domains such as Euclidean Domains (ED), Principal Ideal Domains (PID), and Unique Factorization Domains
CO 4	Interpret the concepts of quotient rings and apply the Fundamental Theorem of Homomorphisms
CO 5	Establish and prove the relationships between PIDs, irreducibles, and primes.

Unit I

Introduction to Rings - Motivation and Definition of Rings – Examples of Rings – Properties of Rings – Subrings - Definition and Examples of Integral Domains – Fields - Characteristic of a Ring.

Unit II

Ideals - Factor Rings - Prime Ideals and Maximal Ideals - Definition and Examples of Ring Homomorphisms - Properties of Ring Homomorphisms - The Field of Quotients.

Unit III

Polynomial Rings - The Division Algorithm and Consequences - Principal ideal domain - Factorization of Polynomials - Reducibility Tests - Eisenstein's Criterion- Irreducibility Tests.

Unit IV

Unique Factorization in $Z[x]$ - Divisibility in Integral Domains – Irreducibles and Primes - PID Implies Irreducible Equals Prime.

Unit V

Unique Factorization Domains – PID Implies UFD – $F[x]$ Is a UFD – Euclidean Domains –ED Implies PID – ED Implies UFD.

Text Book:

Joseph A. Gallian, Contemporary Abstract Algebra, 8th Edition, Cengage Learning India Private Limited.
Chapter 12 to Chapter 18.

Reference books

1 M. Artin: Algebra, Prentice-Hall of India, 1991.
2. I.N.Herstein: Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
3. David S. Dummit and Richard M. Foote, Abstract Algebra (Third Edition), John Wiley and sons, 2004
4. C. Musili, Introduction to Rings and Modules, 2nd Revised Edition, Narosa Publishing House 1997.

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MAJOR-10 **BSMT 313: MULTIVARIABLE CALCULUS (4 CREDITS)**

Course Objectives:

1. To extend the fundamental concepts of differential and integral calculus from single-variable settings to functions of two or more independent variables, emphasizing analytical techniques and applications.
2. To develop a rigorous understanding of the geometry and visualization of curves and surfaces in both two-dimensional (planar) and three-dimensional (spatial) contexts, along with the application of multiple integrals in solving practical and theoretical problems.

	Course Outcomes
CO 1	Analyse the conceptual extensions when transitioning from single-variable calculus to multivariable calculus.
CO 2	Determine the maxima and minima of multivariable functions under specified constraints using appropriate mathematical techniques.
CO 3	Employ double and triple integrals for the computation of areas, volumes, and other related quantities.
CO 4	Evaluate multiple integrals over defined regions in Cartesian, polar, cylindrical, and spherical coordinate systems.
CO 5	Explore and apply integral calculus to solve problems arising in diverse branches of science and engineering.

Unit I (Sections: 1.5, 1.6, 2.1, 2.2, 2.3**):** The n-dimensional Euclidean space – Angle between the vectors - Graphs and level curves/ surfaces – Examples - Limits and continuity – Partial derivatives – Differentiability – The derivative matrix – The tangent planes.

Unit II (Sections: 2.4, 2.5, 2.6**):** The chain rule – Tangent to curves on surfaces - Algebra of derivatives - Gradients and directional derivatives – Tangent plane to a surface – Gradient and tangent planes – Implicit differentiation.

Unit III (Sections: 2.1, 3.2, 3.3, 3.4, 3.5**):** Higher order partial derivatives – Equality of mixed partial derivatives - Taylor's theorem – A second order Taylor formula - Maxima and minima – Critical points – First derivative test – Absolute maxima and minima on closed intervals - Second derivative test – Taylors formula near a critical point - Constrained extrema and Lagrange multipliers.

Unit IV (Sections: 5.1, 5.2, 5.3**):**
Volume and Cavalieri's principle – Double and iterated integrals – The double integral over a rectangle - Properties – Reduction to iterated integrals – The double integral over regions – Mean value theorem for double integrals.

Unit V (Sections: 5.4, 5.5, 5.6**):** Triple integrals over a box – Triple integrals by iterated integration – Double integrals in polar coordinates – Triple integrals in cylindrical and periodical coordinates – General change of variable formula – Applications of multiple integrals – Average value – coordinates of the center of mass – Moment of inertia.

Text Book : J.E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer, 2004.

Reference Books

1. George B.Thomas, Jr. and Ross L. Finney, Calculus, 9th Edition, Pearson Education, 2006.
2. Richard Courant and Fritz John , Introduction to Calculus and Analysis, Volumes I & II, Springer, SIE, 2004.

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MAJOR-11 BSMT 314: INTERNSHIP / COMPREHENSIVE EXAM WITH VIVO VOCE (4 CREDITS)
(Two Months in Industries / Universities / Research Institutes etc.)

Course Objective: The internship program for mathematics graduates aims to provide real-world experience, enhance mathematical skills, and offer opportunities to apply mathematical knowledge in various professional settings. The curriculum may enable mathematics undergraduates to work on practical projects.

	Course Outcomes
CO 1	Acquiring hands-on experience by working in industry, research labs, or educational settings, enabling them to apply mathematical knowledge to real-world contexts
CO 2	Developing problem-solving skills and ability to use mathematical techniques
CO 3	Enhancing professional communication and teamwork abilities through collaborative tasks and presentations in their internship environment
CO 4	Gain exposure to workplace ethics and professional responsibilities which prepare the students for employment and further studies
CO 5	Ability to reflect on their internship experiences, identify personal strengths and areas for growth

The rules and regulations are as per UGC norms which can be seen in the link: Guidelines for Internship RI for UG students

Month 1: Foundation and Skill Development
Week 1-2: Orientation and Introduction to the Organization - Understanding the internship structure - Introduction to the team and projects - Introduction to specific mathematical problems in recent advancements of Mathematics

Week 3-4: Learning Basics in Program Specific Subject (e.g. Linear Algebra and Optimization, Differential Equations, Topology, Functional Analysis, Advanced Agebra, Graph Theory etc.)

Week 5-6: Mathematical Projects - Collaborate on real projects within the organization
- Apply mathematical concepts to solve problems - - Present project progress and results

Week 7-8: Final Project and Presentation - Work on an individual or group project
- Develop a presentation to showcase the project results - Presentation to the project supervisor.

Note: Students unable to arrange the above can make a project based on the first 2 years papers under the guidance of the Department faculties and should go through a comprehensive Exams and vivo under the approval of the Program Committee Meetings.

Evaluation Process:

1. Performance Assessment: Regular feedback from mentors on the intern's progress.
- Evaluation of assignments, projects, and tasks - Interns should have a mid-term review with their mentors to discuss their progress/improvement.

2. Final Evaluation: Evaluation of the final project, presentation, and report.
- Assessment of learning skills (with viva-voce).

3. Certificate of Completion: Successful interns may receive a certificate of completion, detailing their achievements and skills acquired during the internship.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	*	**	***	**	*	***	**	***	**	***
CO 2	*	**	***	**	*	***	**	***	**	***
CO 3	*	**	**	***	*	*	***	*	*	***
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CO 5	*	*	*	*	***	*	***	***	**	***

SEMESTER-VI

MAJOR-12 BSMT 321: FUNDAMENTALS OF COMPLEX ANALYSIS (4 CREDITS)

Course Objectives:

1. To study algebraic properties of complex numbers and the geometry of the complex plane.
2. To study theory and the applications of the complex analytic functions.

	Course Outcomes
CO 1	Able to understand plane geometry in the complex form.
CO 2	Understand the difference between real differentiability and complex differentiability.
CO 3	Understanding the connection between analytic functions and harmonic functions that appear in the theory of partial differential equations.
CO 4	Able to prove the fundamental theorems of complex Analysis and their applications.
CO 5	Approximation of analytic functions by power series.

Unit I: (Sections 1 to 23)

Complex conjugates - Exponential form – Products and powers in Exponential form- Arguments of Products and Quotients- Roots of Complex numbers- Regions in the Complex plane- Functions of a complex variable- Mappings- Mappings by the exponential function- Limits- Theorems on Limits- Limits involving point at infinity- Continuity- Derivatives, Differentiation Formulas, Cauchy-Riemann Equations, Sufficient conditions for Differentiability- Polar Coordinates.

Unit II: (Sections 24 to 36)

Analytic functions, Examples, Harmonic functions, uniquely determined Analytic functions, The Exponential functions, The Logarithmic Function, Branches and derivatives of Logarithms, Some Identities involving Logarithm, Complex Exponents, Trigonometric Functions, and Hyperbolic Functions.

Unit III: (Sections 37 to 54)

Derivatives of functions w(t), Definite Integrals, Some Examples, Upper bounds for Moduli, Anti derivatives, Cauchy-Goursat Theorem (Statement only) , Multiply Connected Domains, Cauchy Integral Formula, An extension of the Cauchy Integral Formula, Some Consequences of the Extension, Liouville's Theorm and The Fundamental Theorem of Algebra, Maximum Modulus Principle.

Unit IV: (Sections 55 to 62)

Taylor's Series, Proof of Taylor's Theorem, Examples, Laurent Series, Proof of Laurent's Theorem, Examples.

Unit V: (Sections 68 to 77)

Isolated Singular Points, Residues, Cauchy's Residue Theorem, Residue at Infinity, The Three Types of Isolated Singular Points, Residues at Poles, Examples, Zeros of Analytic Functions, Zeros and Poles, Behavior of Functions Near Isolated Singular Points.

Text Book:

James Ward Brown and Ruel V. Churchill. Complex Variables and Applications,. Tata McGraw - Hill Education. 8th Edition, 2009.

Reference Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 9th Edition, 2011
2. H.A. Priestley, Introduction to Complex Analysis, Second Edition, Oxford University Press, 2003
3. John B. Conway, Functions of One Complex Variable, Springer, ISE, 1973
4. Serge Lang, Complex Analysis, Springer Publishing Company, 4th Edition, 2009.
5. S. Ponnusamy, Foundations of Complex analysis, (2nd Edition), Narosa, 2011.
6. V. Karunakaran, Complex Analysis, (2nd Edition), Narosa 2005.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	***	***	**	*	***	*	***			**
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MAJOR-13 BSMT 322: INTRODUCTION TO LINEAR ALGEBRA (4 CREDITS)

Course Objectives:

1. To understand vector spaces by its definition and examples.
2. To know how to represent a linear transformation by a matrix

	Course Outcomes
CO 1	Understand and apply concepts of vector spaces and subspaces
CO 2	Analyze linear transformations and their matrix representations
CO 3	Perform matrix operations and solve systems of linear equations
CO 4	Compute determinants, eigenvalues, eigenvectors, and apply diagonalization
CO 5	Work with inner products, norms, and orthogonalization techniques

Unit I: Section 1.2 to 1.6

Abstract Algebra Concepts – Groups- Subgroups- Fields- examples Vector space- Subspace-linear combinations and systems of linear equations- Linear dependence and linear independence- Basis and dimension.

Unit II: Section 2.1 to 2.5

Linear Transformations- Null spaces- Range spaces- Dimension theorem- Matrix representation of linear transformation- composition of linear transformations and Matrix multiplication- Invert ability and Isomorphism- The change of coordinate matrix.

Unit III: Section 3.1 to 3.4

Elementary matrix Operations and elementary matrices- The rank of a matrix and matrix inverses- systems of linear equations- Theory and computation

Unit IV: Section 4.1 to 4.4 and 5.1 to 5.2, 5.4

Determinants of order 2 and order n- propertie4s of determinants- Important facts about determinants- Eigen values and Eigen vectors- Diagonalizability- Invariant spaces and Cayley- Hamilton theorem.

Unit V: Section 6.1, 6.2

Inner products and norms- The Gram-Schmidt orthogonalisation process and orthogonal complements.

Text Book

Stephen H. Friedberg, Arnold J. Insel and Lawrence E. Spence, Linear Algebra, 4th Edition, Printice Hall of India Pvt. Ltd., 2006

Reference Books

1. S. Kumaresan, Linear Algebra Geometric Approach, Prentice Hall of India Pvt. Ltd., 2000.
2. I. N. Herstein, Topics in Algebra, 2nd Edition, John Wiley & Sons, 2003.
3. David C. Lay, Linear Algebra and Applications (2nd Edition), Addison Wesley, 1997.
4. John B. Fraleigh, A First Course in Abstract algebra, (7th Edition), Pearson 2013.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	***	**	**	**	**	**	**	**	*	**
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MAJOR-14 BSMT 323: INTRODUCTION TO GRAPH THEORY (4 CREDITS)

Course Objectives:

1. To introduce the fundamental concepts and varieties of graphs, including trees, connectivity, Eulerian and Hamiltonian graphs, and their associated theorems, with emphasis on structural properties and problem-solving.
2. To develop analytical skills for applying graph theory concepts such as matchings, coverings, independent sets, cliques, and Ramsey theory in mathematical reasoning, modeling, and real-world applications.

	Course Outcomes
CO 1	Understand and analyze the fundamental concepts and varieties of graphs.
CO 2	Demonstrate understanding of bipartite graphs and trees, and apply theorems to construct spanning trees, cut-edges, cut-vertices, and use Cayley's formula in problem solving.
CO 3	Analyze connectivity in graphs, including vertex and edge connectivity, and apply theorems such as Whitney's theorem and Eulerian characterizations to determine structural properties.
CO 4	Examine classical graph theory problems such as Euler tours, Hamiltonian paths and cycles, the Chinese Postman Problem, and the Traveling Salesman Problem.
CO 5	Explore and evaluate matching and covering problems in graphs, particularly in bipartite graphs, including maximal and perfect matchings, minimal coverings, and assignment problems.

Unit – I:

Graphs and their varieties – complete and complement of graphs – Graph isomorphism – Self complementary graphs – Incidence and adjacency matrices – Sub graphs – Vertex degrees – Walks – Paths – Cycles – Connectedness and components – Bipartite graphs and their characterization theorem.

Unit – II:

Trees– Cut edges and cut vertices – Spanning trees – Cayley formula – Connectivity parameters and their related theorem – k connected and k edge connected graphs – Block and blocks of graph – Whitney theorem of 2 – connectivity.

Unit –III:

Euler tours and Eularian graphs – Characterization theorems on Eulerian graphs – Chinese Postman problem – Hamilton paths and cycles – Hamiltonian graphs – Dirac theorem – The necessary or sufficient conditions for a graph to be Hamiltonian – The travelling salesman problem (without algorithm).

Units – IV:

Matching – Properties of Maximal Matching – Prefect Matching – Covering – Properties of Minimal Covering – Matching and Covering in Bipartite graph – Personal Assignment Problem.

Unit – V:

Independent sets and cliques – Definition and some properties – Ramsey number – lower and upper bounds for ramsey numbers – Applications.

Text Books

1. Bondy, J.A and Murthy, U.S.R, Graph Theory with Applications, Macmillan Press Ltd, New Delhi – (1976) - Relevant partitions from Chapters 1,2,3,4,5 and 7.

Reference Books

1. G. Chartrand and P Zhang, Introduction to Graph Theory, Tata Mc Graw - Hill Publishing Company Ltd., New Delhi – (2005).
2. Harary F. Graph Theory, Addison – Wesley(1969).
3. T. Asir, M. Evangeline Prathibha and B. Surendranath Reddy, *Essential Graph Theory-Concepts and Algorithms*, Cambridge University press, 2025.
4. S.A. Choudum, A First Course in Graph Theory, Macmillan India Ltd, New Delhi (2007).
5. R. J. Wilson, Introduction to Graph Theory, Oliver and Boyd, Edinburgh (1972).

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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MAJOR-15 BSMT 324: LINEAR PROGRAMMING (4 CREDITS)

Course Objectives:

1. To learn the concept of LPP and Simplex Method.
2. To learn the concept of Transportation and Assignment Model.

	Course Outcomes
CO 1	To study about Linear Programming Model and Applications
CO 2	To study about Computational Details of Simplex Method
CO 3	To study about Artificial Starting Solution and Two-Phase Method
CO 4	To study about Transportation Model
CO 5	To study about Assignment problem and Duality

Unit – I: Modeling with Linear Programming (Chapter-2, Sections 2.1, 2.2, 2.4)

Two-Variable Linear Programming Model, Graphical LP Solution–Solution of a Maximization Model, Solution of a Minimization Model. Linear Programming Applications –Investment, Production Planning and Inventory Control, work force planning, Urban Planning,

Unit – II: The Simplex Method-I (Chapter-3, Sections 3.1, 3.2, 3.3)

LP model in Equation Form – Converting Inequalities into Equations with Nonnegative Righthand side, Dealing with Unrestricted variables. Transition from Graphical to Algebraic Solution, Iterative Nature of Simplex method, Computational Details of Simplex Method.

Unit – III: The Simplex Method-II (Chapter-3, Sections 3.4, 3.5,)

Artificial Starting Solution– Big-M-Method, Two-Phase Method. Special Cases – Degeneracy, Alternative Optima, Unbounded Solution, Infeasible Solution.

Unit – IV: Transportation Model (Chapter-5, Sections 5.1, 5.2, 5.3)

Definition of the Transportation Model, Nontraditional Transportation Models, The Transportation Algorithm, Determination of the Starting Solution, Iterative Computations of the Transportation Algorithm, Simplex Method Explanation of the Method of Multiplier.

Unit – V: Assignment Model and Duality (Chapter-5, Sections 5.4 & Chapter-7, Sections 7.4)

The Assignment Model, The Hungarian Method, Simplex Explanation of the Hungarian Method. Duality – Matrix Definition of the Dual Problem, Optimal Dual Problem.

Text Book:

1. Hamdy A Taha – Operations Research: An Introduction, 10th Edition, Pearson Prentice Hall, 2017.

Reference Books:

1. F. S. Hillier and G. J. Lieberman, *Introduction to Operations Research* (9th Edition), Tata McGraw Hill, Singapore, 2009.
2. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 2002.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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SEMESTER-VII

MAJOR-16 **BSMT 411: ADVANCED ALGEBRA** **(4 CREDITS)**

Course Objectives:

1. To learn isomorphism theorems group actions
2. To study about class equations and sylow theorems and its applications

	Course Outcomes
CO 1	Explain and apply the isomorphism theorems, composition series, transpositions, and properties of alternating groups.
CO 2	Analyze group actions and permutation representations, and apply Cayley's theorem to represent groups.
CO 3	Apply the concept of conjugation and the class equation, and evaluate group properties using automorphisms and Sylow theorems.
CO 4	Demonstrate understanding of direct and semi-direct products, and apply the fundamental theorem of finitely generated abelian groups.
CO 5	Explore polynomial rings, establish their properties over fields and UFDs, and apply irreducibility criteria to factor polynomials.

Unit I:

The isomorphism theorems -Composition Series - Transpositions and Alternating groups,

Unit II:

Group Actions: Group Actions and Permutation representations-Group acting on themselves by left multiplication-Cayley's theorem

Unit III:

Group acting on themselves by conjugation -The class equation- Automorphisms-The Sylow theorems- The simplicity of A_n.

Unit VI:

Direct and semi-direct products and abelian groups: Direct products- The fundamental theorem of finitely generated abelian groups.

Unit V:

Polynomial rings: Definitions and basic properties- Polynomial rings over fields- Polynomial rings that are unique factorization domains -Irreducible criteria.

Text Book:

David S. Dummit and Richard M. Foote, Abstract Algebra (Third Edition), John Wiley and sons, 2004.
Chapter 3 - Sections 3.3 to 3.5
Chapter 4 - Sections 4.1 to 4.6
Chapter 5 - Sections 5.1 and 5.2
Chapter 9 - Sections 9.1 to 9.4

Reference books

1 M. Artin: Algebra, Prentice-Hall of India, 1991.
2. I. N. Herstein: Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
3. N. Jacobson: Basic Algebra, Volumes I & II, W. H. Freeman, 1980.
4. S. Lang: Algebra, 3rd edition, Addison-Wesley, 1993.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	***	***	**	**	**	**	*	**	**	**
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MAJOR-17 BSMT 412: TOPOLOGY (4 CREDITS)

Course Objectives:

1. To introduce the notion of metric spaces and topological spaces
2. To discuss various types of topological spaces and their underlying difference

	Course Outcomes
CO 1	Acquire fundamental knowledge of the concept of metric spaces and topological spaces
CO 2	Clarity about continuous functions on topological spaces
CO 3	Understanding the notion of connectedness and completeness and their properties
CO 4	Knowledge about compactness and their equivalent forms.
CO 5	Understanding important results like Tychonoff's theorem, Heine-Borel theorem, – Urysohn's lemma and Tietze extension theorem and their applications

Unit I: (Revision of Sections 1-3, Section 4-8, 9-12)
Revision of sets - Functions - Product of sets – Relations – Countable sets – Uncountable sets – Partially ordered sets and lattices – Metric spaces – Definition and examples – Open sets and closed sets in metric spaces – Open subsets of real line.

Unit II: (Sections 16, 17 and 18)
Topological spaces -- Definitions and examples - Closure and related concepts – Open bases and open sub bases – Separability and second count ability -Lindloff's Theorem

Unit III: (Sections 21 – 23)
Compactness – Basic results -- Continuous maps on compact sets - Characterization of compactness by basic and sub basic open covers – Tychon off's theorem - Generalized Heine – Bore theorem.

Unit IV: (Sections 24,26)
Compactness for metric spaces – Sequential compactness - Lebesgue covering lemma - Sequential compactness and compactness coincide on metric spaces - T_1spaces - Hausdorff spaces.

Unit V: (Sections 27,28,31,32)
Completely regular spaces and normal spaces – Urysohn's lemma and Tietze extension theorem- –Connected spaces – Components of a space.

Text Book

G.F.Simmons, an Introduction to Topology and Modern Analysis, McGraw-Hill Kogakusha, Tokyo, 1963

Reference Books

1. J. R. Munkres, Topology, Pearson Education Inc., Second Edition, 2000.
2. Stephen Willard, General Topology, Dover Publication 2004.
3. J. Dugundgi, Topology, Allyn and Bacon, Boston, 1966.
4. Fred.H. Croom, Principles of Topology, Dover publications, 2016.
5. Tej Bahadur Singh, Elements of Topology, Chapman and Hall/CRC press, 2013.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	***	***	**	*	***		***			**
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CO 3	***	***	**	**	***		**		*	**
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CO 5	***	**	**	**	***	*	**			**

MAJOR-18 BSMT 413: ORDINARY DIFFERENTIAL EQUATIONS (4 CREDITS)

Course Objectives:

1. To study the qualities properties of ordinary differential equations.
2. To study the hypergeometric functions, Bessel functions and Legendre polynomials which arising as solution of ODEs.

	Course Outcomes
CO 1	To discuss about the Qualitative properties and series solutions of ODEs
CO 2	To study about the Gauss Hypergeometric equations and their properties
CO 3	To study about the Legendre and Bessel function and their properties
CO 4	To study about Homogeneous Linear equation systems
CO 5	To study the existence and uniqueness of solutions of first order ODEs.

Unit I: [Chapter-4, Sections: 25, Chapter-5, Sections: 26, 27, 28, 29, 30 & Chapter -7, Sections: 40 of [1]]
Qualitative properties of solutions – The Sturm Separation Theorem, The Sturm comparison theorem– Eigen values and Eigen functions and vibrating string. Series solutions of first order equations – Second order linear equations – Ordinary points - Regular singular points

Unit II: [Chapter-5, Sections: 31 of [1] & Chapters: 4 & 7 of [2]]
Gauss Hypergeometric equations. Gauss's hypergeometric and Confluent hypergeometric functions, integral representations, differentiation formulas, transformation formulas, summations formulas.

Unit III: [Chapter-8, Sections: 44, 45, 46 47 of [1]]
Legendre polynomials – Properties of Legendre polynomials – Bessel functions- The Gamma function - Properties of Bessel Function.

Unit IV: [Chapter-10, Sections: 55, 56 of [1]]
Linear systems – Homogeneous linear system with constant coefficients.

Unit V: [Chapter-13, Sections: 68, 69 of [1]]
The existence and uniqueness of solutions – The method of successive approximations – Picards's theorem.

Text Book

1) G. F. Simmons, Differential Equations with Applications and Historical Notes, 2nd Edition, McGraw Hill Education(India) Company, 2003.
Sections: 22-30, 32-35, 37-38 and 55-56.
2) E. D. Rainville, Special *functions*, Macmillan, New York, 1960.

References

1. Earl Coddington and Norman Levinson, Theory of ordinary Differential equations, TATA McGraw Hill, 2017.
2. N. M. Temme, *Special functions: An introduction to the classical functions of mathematical physics*, John Wiley& Sons, New York, 1996.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	***	**	***	**	***	*	*	*	*	*
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SEMESTER-VIII

MAJOR-19 **BSMT 421: ADVANCED REAL ANALYSIS** **(4 CREDITS)**

Course Objectives:

1. To learn about polynomial approximation of continuous functions on compact intervals.
2. To learn about the differential calculus of several variables.

	Course Outcomes
CO 1	Able to work with sequences of functions and function spaces.
CO 2	Familiarize with various types of polynomial approximations to continuous functions on compact intervals.
CO 3	Knowledge to define special functions using power series and to derive their properties.
CO 4	More general understanding of differentiability of functions.
CO 5	Familiarity with the geometrically important theorems such as: Inverse Function Theorem and The Implicit function Theorem.

Unit I:(Chapter:6 and Sections: 8.20 to 8.23, 8.26 and8.27 of [2])

Functions of bounded variation - Double sequences - Double series - Rearrangement theorem for double series- A sufficient condition for the equality of iterated series.

Unit II: (Chapter: 7 of [1], Subsections 7.1 to 7.25)

Sequence and Series of functions - Examples - Uniform convergence and Continuity - Uniform convergence and Integration - Uniform convergence and Differentiation - Double sequences and series - Iterated limits- Equicontinuous Families of Functions - Arzela – Ascoli Theorem

Unit III:(Chapter: 7 of [1] subsections: 7.26 to7.33 and chapter 8 of [1])

The Weierstrauss theorem for algebraic polynomials- The Stone - Weierstrauss Theorem - Power Series - The Exponential and Logarithmic Functions - The Trigonometric Functions - Fourier Series - The Weierstrauss theorem for the Trigonometric polynomials.

Unit IV: (Chapter:9 of [1], Subsections: 9.6 to 9.23)

Functions of Several Variables - Linear Transformation - Differentiation - The Contraction Principle.

Unit V:(Chapter: 9 of [1], Subsections:9.24 to 9.38)

The inverse function Theorem - The implicit Function Theorem - The Rank Theorem – Determinants.

Text Books

1. Walter Rudin, Principles of Mathematical Analysis- McGraw Hill International Editions, Mathematics series, 1976.
2. Apostol, Mathematical Analysis, Narosa Publishing House, Indian edition,2002.

Reference Books

1. Patrick M. Fitzpatrick Advanced Calculus, Amer. MATH. Soc. Pine and Applied Undergraduate Texts, Indian Edition, 2009.
2. Kenneth A. Ross, Elementary Analysis, The Theory of Calculus, Springer-Verlag,1980.
3. N.L.Carothers, *Real Analysis*, Cambridge University Press(2000)
4. G.F.Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 2017.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	***	***	**	*	***		**			***
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CO 5	***	**	**	*	***	*	*	*		***

MAJOR 20 **BSMT 422: ADVANCED LINEAR ALGEBRA (4 CREDITS)**

Course Objectives:

1. To understand linear transformations Characteristic roots- Similarity of linear transformations Invariant subspaces and matrices.
2. To understand triangular forms- Nilpotent transformations.

	Course Outcomes
CO 1	Analyze the algebra of linear transformations, characteristic roots, and similarity
CO 2	Examine invariant subspaces, triangularization, and minimal polynomials
CO 3	Understand nilpotent transformations and Jordan canonical forms
CO 4	Explore module theory, cyclic modules, and canonical forms
CO 5	Work with Hermitian, unitary, normal transformations, and quadratic forms

Unit I: Sections – 6.1,6.2, 6.3

The Algebra of linear transformations-Characteristic roots- Similarity of linear transformations- Rank of a linear transformation and matrices – Left/Right invertibility of linear transformations.

Unit II: Sections – 6.4 and 6.5

Invariant subspaces and matrices - Reduction to triangular forms – minimal polynomial.

Unit III: Sections – 6.6 and 4.5

Nilpotent transformations - Index of nil potency and invariant of nilpotent transformation. Jordan blocks and Jordan forms-

Unit IV: Sections - 6.7, 6.8 and 6.9

Modules - Cyclic modules - Fundamental theorem on modules over PID- Rational canonical form- Trace-Transpose and Determinants.

Unit V: Sections – 6.10 and 6.11

Hermitian - Unitary and Normal transformations - Real quadratic forms.

Text Book: I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.

Reference Books

1. M. Artin, Algebra, Prentice-Hall of India, 1991
1. N. Jacobson, Basic Algebra, Volumes I & II, W. H. Freeman, 1980.
2. S. Lang, Algebra, 3rd edition, Addison-Wesley, 1993
3. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra (2nd Edition)Cambridge University Press, Indian edition, 1997
4. Kenneth Hoffmann and Ray Kunze, Linear Algebra, (Second edition), Pearson, 2015
5. S. Friedberg, A. Insel and L. Spence, Linear Algebra, (4th Edition) Pearson, 2015.

		PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1		***	**	**	**	***	**	*	**	**	**
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CO 3		***	***	**	**	***	**	**	**	*	**
CO 4		***	***	***	**	***	**	**	***	**	***
CO 5		***	**	**	**	***	**	**	**	**	***

Minor-10 : **BSMT 424 : COMPLEX ANALYSIS** **(4 CREDITS)**

Course Objectives:

1. To Learn and understand about the properties of Line integral and Zeros and Poles.
2. To discuss about the theorems on Series expansion, Residue and Factorization.

	Course Outcomes
CO 1	To discuss about the Line integrals, Cauchy theorem and Cauchy integral formula
CO 2	To study about the Zeros and Poles of functions and the Maximum principle
CO 3	To study about the Calculus of Residues, Evaluation of Definite Integrals and Harmonic functions
CO 4	To study about Series Expansions and Partial Fractions and Factorization
CO 5	To study the Jenson Formula-Hadamard' Theorem and the Riemann Zeta Function

Unit I: [Chapter-4, Sections: 1 and 2]

A quick review of analytic function – Cauchy-Riemann equations. Line integrals-Cauchy's theorem for a Rectangle-Cauchy's theorem in a Disc-Cauchy's integral formula-Higher derivatives

Unit II: [Chapter-4, Sections: 3 and 4].

Local properties of Analytical Functions-Removable Singularities, Zeros and poles-The Maximum principle- The general form of Cauchy's theorem.

Unit III: [Chapter-4, Sections:5 and 6].

The Calculus of Residues-The Residue Theorem- The Argument principle-Evaluation of Definite Integrals. Harmonic functions- Poisson's formula- Schwarz's theorem- The Reflection Principle.

Unit IV: [Chapter-5, Sections: 1 and 2].

Power Series Expansions-Weierstrass's Theorem-The Taylor series-The Laurent's series. Partial Fractions and Factorization-Infinite Product-The Gamma function-Stirling formula.

Unit V: [Chapter-5, Sections: 3 and 4, Chapter-8, Sections: 1]

Entire Functions-Jenson Formula-Hadamard' Theorem. The Riemann Zeta Function-Extension of Riemann Zeta function to the Whole Plane-The Functional Equation-The Zeros of the Zeta Function. Analytic Continuation.

Text Book: L.V. Ahlfors, Complex analysis, Third Edition, McGraw Hill Book Company,1979.

References:

1. John. B. Conway, Functions of one Complex Variable, Second Edition, Narosa Publishing House, 2002.
2. B. C. Palka, An Introduction to the Complex function Theory, Springer, 1991.
3. H.A. Priestley, Introduction to Complex Analysis, Second Edition, Oxford University Press, 2003.
4. S. Ponnusamy, Foundations of Complex analysis, (2nd Edition), Narosa, 2011
5. Donald Sarason, Notes on Complex Function Theory, Hindustan Book agency, 1994.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor-11 : **BSMT 425: MEASURE AND INTEGRATION** **(4 CREDITS)**

Course Objectives:

1. To learn the motivation for studying Lebesgue measure theory and the introduction of Lebesgue outer measure
2. To study about Lebesgue measurable sets and their properties.

	Course Outcomes
CO 1	Acquire knowledge about motivation for studying Lebesgue measure theory
CO 2	Strong foundation of the concept of Lebesgue outer measure and Lebesgue measurable sets and their properties
CO 3	Knowledge about the Littlewood's three principles
CO 4	Understanding the notion of Lebesgue integrable functions and to prove some important convergence theorems
CO 5	Understanding absolutely continuous functions and the fundamental theorem of calculus for Lebesgue integral

Unit I: (Sections: 3.1, 3.2, 3.3, 3.6 of [1] and 2.1,2.2 of [2])

Motivation to Lebesgue Measure Theory – General extension Theory – Algebra of sets – Examples – Finitely/Countably additive set functions – Ulam's Theorem – Continuity from below/above of measures – The Lebesgue outer measure m^* - Examples – Properties.

Unit II: (Sections: 2.3, 2.4, 2.5, 2.6, 2.7 of [2])

Lebesgue measurable sets – Examples – The set of all Lebesgue measurable sets M is an algebra - $m^*$is finitely additive over M – M is a sigma algebra – m^* is a measure on M – Outer and inner approximation of Lebesgue measurable sets by open and closed sets respectively –Continuity of the Lebesgue measure – Example of a nonmeasurable set – The Cantor Lebesgue function.

Unit III: (Sections: 3.1, 3.2, 3.3 of [2])

Lebesgue measurable functions – Examples – Pointwise limit of sequence of measurable functions – Simple functions – The simple approximation Lemma – The simple approximation Theorem – Egoroff's Theorem – Lusin's Theorem.

Unit IV: (Sections: 4.2, 4.3, 4.4, 4.5,5.3 of [2])

The Lebesgue integral of a simple function – The Lebesgue integral of a bounded measurable function over a set of finite measure – Properties – The Bounded Convergence Theorem - The Lebesgue integral of a nonnegative measurable function – Properties – Chebychev's inequality – Fatou's Lemma – Monotony Convergence Theorem – The general Lebesgue integral – The Lebesgue dominated Convergence Theorem – Characterization of Riemann integrable functions – Improper Riemann integrals and their Lebesgue integrals.

Unit V: (Sections: 6.1, 6.2, 6.3(upto6.3.6) of [1])

Review of functions of bounded variation –Absolutely continuous functions – Lebesgue's Theorem on differentiability of monotony functions – The Lebesgue singular function – Fundamental Theorem of Calculus [I and II] for the Lebesgue integral

Text Books:

1. Inder K. Rana, *An Introduction to Measure Theory and Integration ,(2e)*, Narosa (2007)
2. H. L. Roylan, P. M. Fitzpatrick, *Real Analysis –Fourth Edition*, Prentice Hall of India (2013).

Reference books:

1. De Barra.G, *Measure Theory and Integration*, 2e, New Age International Publishers (2013).
2. Howard J.Wilcox, *An Introduction to Lebesgue Integration and Fourier Series*, Dover (1995).
3. Paul R. Halmos, *Measure Theory,* Springer (1976).
4. N.L.Carothers, *Real Analysis*, Cambridge University Press(2000).
5. C.D. Aliprantis and O.Burkinshaw, *Principles of Real Analysis*,3e, Academic Press (Elsevier).

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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LIST OF MINORS FOR 4th Year (ANNEXURE - I)

Minor **BSMT 431: CRYPTOGRAPHY** **(4 CREDITS)**

Course Objectives:

1. To provide an introduction and foundational understanding of classical and modern cryptographic methods, including both secret key and public key encryption techniques.
2. To develop the mathematical reasoning and technical skills needed to analyze, apply, and critique cryptographic systems used for data security, authentication, and privacy in networks.

	Course Outcomes
CO 1	Explain core concepts in classical cryptography and perfect secrecy such as one-time pads and stream ciphers.
CO 2	Apply and compare modern secret key encryption algorithms (DES, AES), understanding their structure, operation, and security properties.
CO 3	Demonstrate proficiency with public key cryptosystems (RSA, Diffie-Hellman, ElGamal), including the mathematical foundations and key exchange protocols.
CO 4	Describe digital signature schemes and secure hashing, evaluating their role in authentication, integrity, and network security.
CO 5	Understand and implement cryptographic primitives like Message Authentication Codes (MAC), secret sharing schemes (such as Shamir's threshold), and visual secret sharing, assessing their application in secure systems.

Unit I:

Introduction: Overview of course- Classical cryptography [parts of Chapter 1].

Unit II:

Secret Key Encryption: Perfect Secrecy - One time pads [Chapter 2.1], Stream ciphers and the Data Encryption Standard (DES) [Chapter 3 (excluding 3.6)], The Advanced Encryption Standard (AES) - adopted September 2000.

Unit III:

Public Key Encryption: Factoring and the RSA encryption [Chapter 4.1 -4.4], Discrete log- Diffie-Hellman Key Exchange [Chapter 8.4 (only pages 270-273)].

Unit IV:

ElGamal encryption [Chapter 5 (only pages 162-164)] , Digital Signatures [Chapter 6 (excluding 6.5 - 6.6)], One-time signatures- Rabin and ElGamal signatures schemes- Digital Signature Standard (DSS).

Unit V:

Hashing: Motivation and applications- Cryptographically Secure Hashing. [Chapter 7.1-7.3,7.6], Message Authentication Codes (MAC)- HMAC- Network Security - Secure Socket Layer (SSL)- I Psec.,Secret Sharing- Definition. Shamir's threshold scheme [Chapter 11.1], Visual secret sharing schemes.

Text Book

D. R. Stinson,s Cryptography, Theory and Practice, CRC Press, 1995.

Reference Books

1. Richard A. Mollin, An Introduction to Cryptography, Chapman & Hall / CRC, Boca Raton, 2000.

2. Dominic Walsh, Codes and Cryptography, Oxford Science Publications, Clarendon Press, Oxford, 1988.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor **BSMT 432: NUMERICAL ANALYSIS** **(4 CREDITS)**

Course Objectives:

1. To introduce and develop computational methodologies for determining approximate solutions of algebraic as well as transcendental equations.
2. To impart knowledge of systematic techniques for solving systems of linear equations and for obtaining numerical solutions of ordinary differential equations.

	Course Outcomes
CO 1	Develop proficiency in numerical techniques for locating roots of nonlinear equations in a single variable with specified accuracy.
CO 2	Acquire the ability to implement iterative methods, including Gauss–Jacobi and Gauss–Seidel, for the solution of linear systems of equations.
CO 3	Gain a comprehensive understanding of various interpolation methods and their practical applications.
CO 4	Apply numerical integration techniques to accurately approximate definite integrals.
CO 5	Formulate and obtain numerical solutions for initial and boundary value problems associated with ordinary differential equations.

Unit I: Nonlinear Equations in One Variable:
Fixed point iterative method – convergence Criterion -Aitken's Δ2- process - Sturm sequence method to identify the number of real roots – Newton - Raphson's methods convergence criterion Ramanujan's Method - Bairstow's Method.

Unit II: Linear and Nonlinear System of Equations:
Gauss eliminations with pivotal strategy jacobi and Gauss Seidel Itervative Methods with convergence criterion. LU - decomposition methods – (Crout's, Choleky and DeLittle methods) – consistency and ill conditioned system of equations - Tri-diagonal system of equations – Thomas algorithm. Iterative methods for Nonlinear system of equations, Newton raphson, Quasi newton and Over relaxation methods for Nonlinear system of equations.

Unit III: Interpolation:
Lagrange- Hermite- Cubic-spline's (Natural, Not a Knot and Clamped)- with uniqueness and error term, for polynomial interpolation- Bivariate interpolation- Orthogonal polynomials Grams SchmidthOrthogoralization procedure and least square- Chebyshev and Rational function approximation.

Unit IV: Numerical Integration: Gaussian quadrature, Gauss-Legendre- Gauss-Chebeshev formulas- Gauss Leguree, Gauss Hermite and Spline intergation – Integration over rectangular and general quadrilateral areas and multiple integration with variable limits.

Unit V: Numerical solution of ordinary differential equations: Initial value problems- Picard's and Taylor series methods – Euler's Method- Higher order Taylor methods - Modified Euler's method - RungeKutta methods of second and fourth order – Multistep method - The Adams - Moulton method - stability - (Convergence and Truncation error for the above methods). Boundary - Value problems – Second order finite difference and cubic spline methods.

Text books

1. M. K. Jain, S. R. K. Iyengar and R.K. Jain, Numerical methods for scientific and Engineering computation, Wiley Eastern Ltd. 1993, Third Edition.
2. C.F. Gerald and P.O. Wheatley, Applied Numerical Methods, Low- priced edition, Pearson Education Asia 2002, Sixth Edition.
3. M.K. Jain, Numerical solution of differential equations, Wiley Eastern (1979), Second Edition.

Reference books

1. S.C. Chapra and P.C. Raymond, Numerical Methods for Engineers, Tata McGraw Hill, New Delhi,2000
2. S.S. Sastry , Introductory methods of Numerical analysis, Prentice - Hall of India, New Delhi, 1998.
3. Kendall E.Atkinson, An Introduction to Numerical Analysis (2nd Edition), Wiley, 2008.

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Minor: **BSMT 433: NUMBER THEORY** **(4 CREDITS)**

Course Objectives:

1. To study primes.
2. To study solutions for congruences.

	Course Outcomes
CO 1	Understand the concepts of divisibility and primes, and apply fundamental properties in number theoretic problems.
CO 2	Solve linear and higher-degree congruences, including those with prime power moduli, using systematic methods.
CO 3	Analyse quadratic residues and apply the quadratic reciprocity law and Jacobi symbol in solving congruence problems.
CO 4	Explore arithmetic and recurrence functions, apply the Möbius inversion formula, and prove results related to the irrationality of numbers such as e and π.
CO 5	Examine continued fractions, establish their convergence, and represent irrational numbers and special quadratic surds through infinite continued fractions.

Unit II: Section : 1.1-1.3
Divisibility: Introduction -Divisibility- Primes.

Unit II: Section : 2.1-2.11
Solution of congruences – Congruences of higher degree – prime power moduli.

Unit III: Section :3.1-3.3
Quadratic Residues, Quadratic reciprocity law, Jacobi Symbol.

Unit IV: Section :4.1-4.3
Arithmetic functions-Recurrence functions, Mobious Inversion Formula, Irrational numbers, Irrationality of nth root of N, e and pi.

Unit V: Section : 5.6-5.11
Continued fractions and its convergence, representation of an irrational number by an infinite continued fraction. Some special quadratic surds.

Text Book
Treatment as in I. Niven, H.S. Zuckerman and H.L. Montgomery – An Introduction to the Theory of Numbers, New York, John Wiley and Sons, Inc., 2004, 5th Ed.

Books for Reference:

1. **T.M. Apostol** – Introduction to Analytic Number Theory, Narosa Publishing House, New Delhi.
2. **G.H. Hardy and E.M. Wright-** An Introduction to the Theory of Numbers, Oxford University Press, 1979, 5th Ed.

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Minor: **BSMT 434: CALCULUS OF VARIATIONS (4 CREDITS)**

Course Objectives:

1. To learn about functionals and solving related variational problems using Euler's equation
2. To understand and solve the variational problems functionals depending on higher-order derivatives

	Course Outcomes
CO 1	Apply the fundamental concepts of functionals and variational principles to solve basic problems using Euler's equation and related conditions.
CO 2	Analyse and formulate variational problems involving multiple variables, higher-order derivatives, and subsidiary conditions with fixed or variable endpoints.
CO 3	Evaluate the general variation of functionals and apply conditions such as Weierstrass–Erdmann to handle broken extremals and endpoint constraints on curves or surfaces.
CO 4	Demonstrate the canonical form of Euler's equations, Legendre transformations, and conservation laws through Noether's Theorem and Hamilton–Jacobi theory.
CO 5	Examine second variations and apply sufficient conditions, including Legendre conditions, to determine weak extrema of functionals.

Unit I:

Functionals- some simple variational problems-The variation of a functional- A necessary condition for an extremum-The simplest variational problem-Euler's equation-The case of several variables-A simple variable end point problem-The variational derivative-Invariance of Euler's equation.*[Chapter-1]*

Unit II:

The fixed end point problem for n-unknown functions - Variational problem in parametric form- Functionals depending on higher order derivatives-Variational problems with subsidiary conditions. *[Chapter-2]*

Unit III:

The general variational of a functional- derivation of the basic formula- End points lying on two given curves or surfaces- Broken extremals- The Weierstrass Erdmann conditions. *[Chapter-3]*

Unit IV:

The canonical form of Euler equations- First integrals of the Euler equations- The Legendre transformation- Canonical transformations- Noether's Theorem- The principle of least action- Conservation laws- The Hamilton Jacobi equation- Jacobi theorem.*[Chapter-4]*

Unit V:

The second variation of a functional- The formula for the second variation, Legendre conditions- Sufficient conditions for a weak extremum. *[Chapter-5]*

Text Book:

I.M. Gelfand and S.V.Fomin, *Calculus of Variations*, Dover Publications, 2000.

Reference Books:

1. A.S. Gupta, *Calculus of Variations with Applications*, Prentice-Hall of India, 2008.
2. M.L. Krasnov, G.I. Makarenko and A.I. Kiselev, *Problems and Exercises in the Calculus of Variations*, Mir Publishers, Moscow 1975.

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MINOR- **BSMT 435: PARTIAL DIFFERENTIAL EQUATIONS (4 CREDITS)**

Objectives:

To study first order PDEs, Non-linear first order PDEs
To Study and understand classification of second order PDEs, Wave Equations**,** Laplace equations, Heat Equations.
To Solev first and second order PDEs using Separation of Variables

	Course Outcome
CO 1	understand the relation between the theory and modelling in the problems arising in various fields, such as, economics, finance, applied sciences and etc
CO 2	Enhance their mathematical understanding in representing solutions of partial differential equations.
CO 3	classify the partial differential equations and transform into canonical form
CO 4	determine the solution representation for the three important classes of PDEs, such as Laplace, Heat and wave equation by various methods.
CO 5	Formulate fundamentals of partial differential equations, like Green's function, maximum principles, Cauchy problem, to take a research career in the area of partial differential equations

Unit – I: First Order PDEs

Surfaces and their Normals, Curves and tangents - Genesis of first order PDE- Classification of Integrals- Linear equations of first Order - Integral surface passing through a curve – Cauchy problem for first order PDE – Orthogonal Surfaces.

Non-linear first order PDEs : Compatible systems- Solutions of Quasi linear equations

Charpit's method- Special Types of Charpits Method, -Integral surfaces through a given curve-The Cauchy problem for Quasi Linear case and nonlinear first order PDEs.

Unit – II: Second Order PDEs

Genesis of Second order PDEs- Classification of second order PDEs- Canonical forms of Hyperbolic- Elliptic and parabolic type PDEs, Linear PDE with constant coefficients – Method of finding CF and particular integral- Homogeneous linear PDE

Unit – III **Hyperbolic PDEs / Wave Equation**

Derivation of One –dimensional wave equations- Initial Value Problem – D'Alembert Solution, Method of separation of variables, Forced Vibration, Solution of non-homogeneous equation Uniqueness of solution of wave equation.

Unit – IV: Elliptic PDEs/Laplace Equations

Derivation of Laplace equations & poisson equation- Boundary value problems- Properties of Harmonic functions- Spherical Mean, Mean value theorem- Maximum and minimum principles- Separation of variables- Dirichlet problem and Neumann problems for a rectangle and circle (Upto 2.10 in Text Book 1). Application - Irrotational Flow of an Incompressible Fluid (Section 2.13)

Unit – V: Heat Equations

Diffusion Equation, Boundary Conditions - Elementary solution- Solution by separation of variables- Classification in n-variables- Families of equipotential surfaces

Text Books

1. K. Shankara Rao, Introduction to Partial Differential Equations, PHI Publications,3rd Edition. 2011.
2. T. Amarnath, An Elementary Course in Partial Differential Equations, Narosa Publishing House, 2010.

Reference Books

1. I. N. Sneddon, Elements of Partial DifferentiaI Equations, McGraw Hill, International Edition, 1986.
2. F. John, Partial Differential Equations, Springer Verlag, 1975.
3. Lawrence C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, 1998.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor **BSMT 436: LATTICE THEORY** **(4 CREDITS)**

Course Objectives:

1. To explain the basic theory of partially ordered sets
2. To elaborate on basics of well-ordered sets

	Course Outcomes
CO 1	Explain and apply the isomorphism theorems, composition series, transpositions, and properties of alternating groups.
CO 2	Analyze group actions and permutation representations, and apply Cayley's theorem to represent groups.
CO 3	Apply the concept of conjugation and the class equation, and evaluate group properties using automorphisms and Sylow theorems.
CO 4	Demonstrate understanding of direct and semi-direct products, and apply the fundamental theorem of finitely generated abelian groups.
CO 5	Explore polynomial rings, establish their properties over fields and UFDs, and apply irreducibility criteria to factor polynomials.

Unit I: Partially Ordered Sets: (Chapter: 1**)**
Basic Definitions – Duality – Monotone Maps – Down-Sets and the Down Map – Height and Graded Posets – Chain Conditions – Chain Conditions and Finiteness – Dilworth's Theorem – Symmetric and Transitive Closures – The Poset of Partial Orders.

Unit II: Well- Ordered Sets: (Chapter: 2**)**
Well-Ordered Sets – Ordinal Numbers – Transfinite Induction – Cardinal Numbers – Ordinal and Cardinal Arithmetic – Complete Posets.

Unit III: Lattices: (Chapter: 3**)**
Closure and Inheritance – Semilattices – Arbitrary Meets Equivalent to Arbitrary Joins – Lattices – Meet-Structures and Closure Operators – Properties of Lattices – Irreducible Elements – Completeness – Sublattices – Denseness – Lattice Homomorphisms – Ideals and Filters – Prime and Maximal Ideals.

Unit IV: Modular and Distributive Lattices: (Chapter: 4**)**
Quadrilaterals – The definitions and Examples – Characterizations – Modularity and Semi modularity – Partition Lattices and Representations – Distributive Lattices.

Unit V:Boolean Algebras: **(**Chapter: 5**)**
Boolean Lattices – Boolean Algebras – Boolean Rings – Boolean Homomorphisms – Characterizing Boolean Lattices – Complete and Infinite Distributivity

Text Book:-

1. Steven Roman, Lattices and Ordered Sets, Springer Science, 2008.

   Chapters: 1,2,3,4,and 5.

Reference Books:-

1. Garrett Birkhoff, Lattice Theory, American Mathematical Society, Colloquim Publications, 1948.

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Minor **BSMT 437: ADVANCED GRAPH THEORY** **(4 CREDITS)**

Course Objectives:

1. To provide a solid foundation in advanced concepts of graph theory, including connectivity, coloring, planarity, and domination, and to understand their theoretical significance.
2. To develop analytical and problem-solving skills by applying graph-theoretic methods to construct proofs, derive bounds, and explore applications in mathematics and related fields.

	Course Outcomes
CO 1	Explain fundamental concepts of graphs, including subgraphs, isomorphisms, connectivity, cuts, and blocks.
CO 2	Apply theorems on matchings and coverings, such as Hall's theorem and Tutte's 1-factor theorem, to solve problems involving independent sets and matchings in bipartite graphs.
CO 3	Analyze vertex and edge colorings of graphs, determine chromatic numbers, and apply results such as Brooks' theorem and Vizing's theorem.
CO 4	Evaluate planarity in graphs using Euler's formula, Kuratowski's theorem, and characterize nonplanar graphs.
CO 5	Explore domination in graphs, compute domination numbers, and apply bounds for domination, independent domination, and irredundance.

Unit I **(12 hours)**

Graphs – Subgraphs – Isomorphism of graphs – Paths and Connectedness – Automorphism of a Simple Graph – Vertex Cuts and Edge Cuts – Connectivity and Edge-connectivity – Blocks.

Unit II **(12 hours)**

Vertex Independent sets and Vertex Coverings – Edge-Independent Sets – Matchings and Factors –M-Augmenting Paths – Matchings in Bipartite Graphs – Halls Theorem on Bipartite graphs – Tutte's 1-Factor Theorem (without proof).

Unit III **(12 hours)**

Vertex Coloring – Chromatic Number – Some bounds for the chromatic number – Critical Graphs – Brooks' Theorem – Triangle-free graphs.

Unit IV **(12 hours)**

Edge Colorings of Graphs – Vizing's Theorem (without proof) – Planar and Non-planar Graphs – Euler's Formula and its Consequences – K5 and K3,3 are Nonplanar Graphs – The Four-Color Theorem (without proof) – The Heawood Five-Color Theorem – Kuratowski's Theorem (without proof).

Unit V **(12 hours)**

Domination in Graphs – Domination Number – Bounds for the Domination Number – Bound for the Size m in Terms of Order n – Independent Domination – Irredundance.

Text Book:-

1. R. Balakrishnan and K. Ranganathan, A Textbook of Graph Theory (Universitext), Second Edition, Springer New York 2012.

Reference Books:-

1. Bondy, J.A and Murthy, U.S.R, Graph Theory with Applications, Macmillan Press Ltd, New Delhi – (1976).Douglas B. West, Introduction to Graph Theory, Second Edition, PHI Learning Private Ltd, New Delhi-2011.
2. G. Chartrand, Linda Lesniak and Ping Zhang, Graphs and Digraphs, Fifth Edition, CRC press 2011.

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SEMESTER-IX

MAJOR-21 **MSMT 511 - FUNCTIONAL ANALYSIS** **(4 Credits)**

Course Objectives:

1. To study the structure and analysis of normed linear spaces.
2. To study about the applications of Functional Analysis in other branches of sciences.

	Course Outcomes
CO 1	Understanding the interplay between the linear structure and the norm structure.
CO 2	Compare the geometry of finite dimensional spaces with infinite dimensional spaces.
CO 3	Able to study the behaviour of an operator/sequence of operators.
CO 4	Able to use major theorems of Functional analysis to other branches of Mathematics.
CO 5	Able to use the Hilbert space theory to understand the Fourier Analysis in a more general setting and able to use it in problems in Approximation theory.

Unit-I Sections: 1.2.3, 1.2.5, 2.1, 2.1.1, 2.1.2, 2.1.4

Review of linear spaces – Linear functionals – hyperspaces – projections – Cauchy Schwarz inequality – Holder's inequality –Minkowski inequality – Normed linear spaces – Definition and examples – Basic properties – Semi norms and quotient spaces – product spaces and the graph norm.

Unit-II Sections:3.1, 3.1.1, 3.2, 3.2.1, 3.4.1, 2.2, 2.2.1, 2.2.2, 2.2.3, 2.4

Bounded linear Maps – Properties – Norm of a bounded linear Map – Banach spaces – Completeness of $l_p(1 \leq p \leq \infty), L_p[a,b], C[a,b], BV[a,b]$ – Completeness of the space of all bounded linear Maps – The completeness of the quotient space – The completion of a normed linearspace – Completeness and absolutely convergent series – Finite dimensional normed linear spaces – Riesz Lemma.

Unit-III Sections: 5.1, 5.2, 5.3, 5.4, 3.4, 6.1

The Hahn – Banach Extension Theorem anditscorollaries – The Hahn Banach Separation Theorem – Convergence of sequence of operators – The uniform Boundedness principle – The Banach Steinhauss Theorem – Weakly bounded sets – Schauder basis and separability.

Unit-IV Sections: 7.1, 7.2, 7.3, 8.1, 8.1.2

The closed graph Theorem – The bounded inverse theorem – The open mapping Theorem – The dual of $l_p(1 \leq p < \infty)$, the dual of $(C_{00}, ||.||_p)$ when $(1 \leq p < \infty)$ - The dual of $(C, \|.\|_\infty)$.

Unit-V Sections: 2.1.5, 4.1, 4.2, 4.3, 4.4, 2.5, 2.6, 3.3

Inner product spaces – Orthonormal sets –Gram Schmidt Orthogonalization process – Bessel's inequality – Hilbert spaces - Parseval's Theorem – Example of a nonseparable Hilbert space – Best approximation Theorems – Projection Theorem – Riesz Fischer Theorem – The Riesz representation Theorem.

Text Book:

1. M.Thamban Nair, *Functional Analysis: A First Course*, Prentice Hall of India, 2002.

Reference Books:

1. Joseph Muscat, *Functional Analysis*, Springer(2008).
2. BalmohanV.Limaye, *Functional Analysis*, New Age International Publishers (2014).
3. Erwin Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley(2007).
4. Martin Schecter, *Principle of Functional Analysis*, American Mathematical Society (2009)
5. BelaBollobas, *Linear Analysis:An Introductory Course,*2e, Cambridge Univ. Press (1999).
6. Bryan P. Rynne and Martin.AYoungson, *Linear Functional Analysis*, Springer (2008).

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MAJOR 22: **MSMT 512- GALOIS THEORY** **(4 credits)**

Course Objectives:

1. Introduce fundamental concepts of field extensions and algebraic closures
2. Explain and apply Galois theory principles to solve polynomial equations and study field automorphisms

	Course Outcomes
CO 1	Demonstrate understanding of field extensions and algebraic extensions
CO 2	Explain splitting fields, algebraic closures, and separable extensions
CO 3	Apply the fundamental theorem of Galois theory and concepts of solvability
CO 4	Analyze Galois groups over rational numbers and finite fields
CO 5	Explore classical constructions and related Galois extensions

Unit I: Field theory: Basic theory of field extensions-Algebraic Extensions.

Unit II: Splitting fields and Algebraic closures - Separable and inseparable extensions - Cyclotomic polynomials and extensions.

Unit III: Galois Theory: Basic definitions- The fundamental theorem of Galois Theory - Solvable by radicals.

Unit IV: - Galois groups over the rationales. Finite Fields- Wedderburn's theorem(First proof only)

Unit V: Classical straightedge and compass constructions, Cyclotomic extensions and Abelian extensions, Galois group of polynomials.

Text Book:

1. Abstract Algebra (Second Edition) by David S. Dummit and Richard M. Foote, Wiley Student Edition (1999) for Units I to III, (Chapter 13), (Sections 14.1 to 14.3 and 14.5-14.6).

2. Topics in Algebra by I.N. Herstin (Section 5.6 - 5.8), and (Section 7.1 -7.2).

Reference books

1. M. Artin: Algebra, Prentice-Hall of India, 1991.
2. N.Jacobson: Basic Algebra, Volumes I & II, W.H.Freeman, 1980.
3. S.Lang: Algebra, 3rd edition, Addison-Wesley, 1993.

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ANNEXURE - II
LIST OF MINORS FOR 5th Year

Minor:12-19 **MSMT 531 INTEGRAL EQUATIONS** **(4 Credits)**

Course Objectives:

The main objectives of this course are to:

1. Introduce the various types of integral equations & Study the methods of successive approximations and Fredholm theory.
2. Acquire knowledge on applications to Ordinary Differential Equations.

	Course Outcomes : After successful completion of the course the student will be able to
CO 1	Find the eigen values and eigen functions of Integral Equations with Separable Kernels
CO 2	Understand about the method of successive approximation and Fredholm integral equations
CO 3	Understand the concept of Volterra integral equations and method of successive approximation.
CO 4	Apply the Ordinary Differential Equations in initial and boundary value problem.
CO 5	Identify and Construct the solutions for singular and Abels integral equations

Unit–I Introduction – Definition – Regularity conditions – Special kinds of Kernels – Eigen values and Eigen functions – Convolution integral – The Inner or Scalar Product of Two Functions - Integral Equations with Separable Kernels - Reduction to a system of algebraic equations – Examples
Chapter1: Sections 1.1 to 1.6 **Chapter2:** Sections 2.1 to 2.2

Unit–II Fredholm alternative–Examples – An approximation method - Fredholm Integral Equation of the First Kind - Method of successive approximations – Method Of Successive Approximations -Iterative scheme – Examples
Chapter2: Sections 2.3 to 2.6 **Chapter3:** Sections 3.1 to 3.2

Unit–III Volterra integral equations – Examples – Some results about the resolvent kernel – Classical Fredholm Theory - The method of solution of Fredholm equation – Fredholm first theorem – Examples.
Chapter 3: Sections 3.3 to 3.5 **Chapter 4:** Sections: 4.1 to 4.3

Unit–IV Applications to Ordinary Differential Equations-Initial value problems – Boundary value problems – Examples – Green's Function Approach-Examples
Chapter 5: Sections 5.1 to 5.3, 5.5, 5.6

Unit-V Singular integral equations – The Abel integral equations – Examples, Cauchy Principal Value for Integrals-The Cauchy-Type Integrals.
Chapter8: Sections 8.1 to 8.4

Text Book:

1. R. P. Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, NewYork,1997.

Reference Books:

1. Porter and Stirling, *Integral Equations*, Cambridge University press, 1996
2. M.D. Raisinghania, *Integral Equations and Boundary Value Problems*, S. Chand & Co., New Delhi, 2007.
3. Sudir K. Pundir and Rimple Pundir, *Integral Equations and Boundary Value Problems*, Pragati Prakasam, Meerut, 2005.
4. F. G. Tricomi, *Integral Equations*, Inter science Publishers, Inc Newyork, 1985

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Minor:12-19 **MSMT 532: NUMERICAL ANALYSIS FOR ORDINARY DIFFERENTIAL EQUATIONS (4 CREDITS)**

Course Objectives:

1. To investigate and apply diverse numerical methodologies for the solution of ordinary differential equations.
2. To analyse the stability characteristics of numerical schemes and develop a rigorous understanding of error estimation and control strategies.

	Course Outcomes
CO 1	Develop proficiency in fundamental numerical methods such as the Trapezoidal Rule, Euler's Method, and the Theta Method for solving differential equations.
CO 2	Analyse the order of accuracy and convergence behaviour of selected numerical techniques.
CO 3	Acquire a comprehensive understanding of explicit and implicit Runge–Kutta methods and their applications.
CO 4	Perform stability analysis of various numerical schemes to evaluate their reliability under different conditions.
CO 5	Investigate error estimation and control strategies for selected numerical methods to enhance computational accuracy.

Unit-I

Euler's method - Trapezoidal rule - Theta method.

Unit-II

Adams - Bashforth method - Order and convergence - Backward differentiation formula.

Unit-III

Gaussion quadrature - Explicit Runge - Kutta scheme - Implicit Runge Kutta scheme - Collocation.

Unit-IV

Stiff equations - Linear stability domain and A- Stability -- A-stability of RK and multistep methods.

Unit-V

Error Control - Milne Device - Embedded Runge Kutta method.

Text Book

1. Arieh Iserles, A First Course in the Numerical Analysis of Differential Equations, Cambridge University press, 2nd edition, 2008.

Reference Books:

1. Richard L. Burden and J.Douglas faires, Numerical Analysis(9th Edition), Cengage Learning India, 2012.

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Minor:12-19 **MSMT 533: q-SERIES IN NUMBER THEORY** **(4 CREDITS)**

Course Objectives:

1. To understand basic hypergeometric series.
2. To study unilateral series

	Course Outcomes
CO 1	Understand the basic hypergeometric series, apply the binomial theorem, q-binomial theorem, and use Heine's and Jackson's transformation formulas.
CO 2	Apply Jacobi's triple product identity, quintuple product identity, and Gaussian polynomials in q-series and combinatorial problems.
CO 3	Analyze bilateral series, Ramanujan's $1\psi1$ summation, and theta function identities involving Lambert series.
CO 4	Explore Ramanujan's entries (18–30) on q-series and theta functions from his notebooks and interpret their mathematical significance.
CO 5	Relate classical theta functions to hypergeometric series and apply their interconnections in advanced mathematical analysis.

Unit I

Introduction to Basic hyper Geometric series- Bionomial theorem- q- bionomial theorem Heine's Trasformation formula- Jackson transformation formula

Unit II

Jacobi's triple product identity and its applications and Quintuple product identity and Gaussian polynomials.

Unit III

Bilateral Series- Ramanujan I Ψ 1summation and related identities- Ramanujan theta function identities involving Lambert series.

Unit IV

q- series and theta functions Entries 18 to 30 Chapter 16 of Ramnujan's notebook.

Unit V

Classical theta functions to hypergeometric series and its applications.

Text Book

1. Gasper and Rahman, Basic hyper geometric series, Cambridge University press 1990.(Unit I-III)
2. BC Berndt Ramanujans notebooks Part II Springer Verlag New York 1991.(Unit IV-V)

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor: 12-19 MSMT -534: INTEGRAL TRANSFORMS AND THEIR APPLICATIONS (4 CREDITS)

Course Objectives:

1. To develop a comprehensive understanding of the fundamental concepts of the Laplace transform and its inverse, including their essential properties and diverse applications in mathematical and engineering contexts.
2. To acquire a rigorous knowledge of the Fourier transform and its inverse, emphasizing their theoretical foundations, key properties, and practical applications in analysis and problem-solving.

	Course Outcomes
CO 1	Examine and comprehend the formal definitions of the Laplace transform and Fourier transform, establishing a foundation for advanced analysis.
CO 2	Analyse the fundamental properties of Laplace and Fourier transforms, including linearity, time and frequency shifting, and convolution, and understand their theoretical implications.
CO 3	Apply Laplace transform techniques for the systematic solution of ordinary differential equations and initial value problems in engineering and applied sciences.
CO 4	Employ Fourier series and Fourier transform methodologies to represent, decompose, and analyse periodic and aperiodic signals within the time and frequency domains.
CO 5	Interpret and relate transform-domain representations to physical phenomena, including spectral characteristics and frequency responses, within practical applications.

Unit- I The Laplace Transform ([1]: Sections- 1.1, 1.2, 1.3, 2.2, 2.3, 2.4, 2.6)
Laplace transforms- Definition and Examples, Elementary Properties of Laplace Transform, Derivative Properties of Laplace Transform, Integral Properties of Laplace Transform, Heaviside's Unit Step Function, Inverse Laplace Transform and Examples, The Impulse Function.

Unit- II Convolution and Applications of Laplace Transform ([1]: Sections- 3.1-3.5, [2]: 4.2-4.5)
Convolution Theorem and Properties of Convolution, Solution of Ordinary Differential Equations, Solution of Simultaneous Differential Equations, Solution using Step and Impulse Function, Solution of Initial and Boundary Value Problems, Solution of Integral Equations.

Unit- III Fourier Series ([1]: Sections-4.1-4.6)
Bessel's Inequality, Riemann-Lebesgue Theorem, Definition of Fourier Series, Odd and Even Functions, Complex Fourier Series, Half Range Series, Properties of Fourier Series.

Unit-IV Fourier Transforms ([2]: Sections- 2.1, 2.2, 2.3, 2.5, 2.8, 2.9, 2.13)
The Fourier Integral Formulae, Definition of Fourier Transform and Examples, Basic Properties of Fourier Transforms, Gibb's Phenomenon, Heisenberg's Uncertainty Principle, Fourier Cosine and Sine Transforms with Examples.

Unit- V Applications of Fourier Transforms ([2]: Sections- 2.10, 2.11, 2.12, 2.16)
Solution of Ordinary Differential Equations, Solution of Integral Equations, Solution of Partial Differential Equations, Evaluation of Integrals, Filters and Convolution in Fourier Domain.

Text Book:

1. P.P.G Dyke, An Introduction to Laplace Transforms and Fourier Series, Second Edition, Springer, 2014.
2. Lokenath Debnath and Dambaru Bhatta, Integral Transforms and Their Applications, Third Edition, CRC Press, A Chapman & Hall Book, 2015.

Reference Books:

1. B. Davies, Integral Transforms and Their Applications, Third Edition, Springer, Texts in Applied Mathematics, 2009.

2. Ian N. Snedden, The Use of Integral Transforms, McGraw Hill, 1972**.**

3. Alexander D. Poularikas, Transforms and Applications Handbook, Third Edition, CRC Press, Taylor & Francis Group, 2010.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor: 12-19 MSMT 535: AN INTRODUCTION TO WAVELETS WITH APPLICATIONS

Course Objectives:

1. To develop a comprehensive understanding of the fundamental concepts of Fourier Series and Fourier Transform, along with their essential properties and theoretical foundations.
2. To explore the foundational principles of wavelet theory and examine their practical applicability in solving real-world problems.

	Course Outcomes
CO 1	Demonstrate a thorough understanding of the principles and rules governing Fourier series and Fourier transforms.
CO 2	Analyse and implement discrete Fourier transform (DFT) for practical signal processing applications.
CO 3	Comprehend various classes of wavelets and characterize the structure of different Haar spaces.
CO 4	Perform signal decomposition and reconstruction effectively using the discrete wavelet transform (DWT).
CO 5	Apply wavelet-based techniques for advanced signal processing and image processing tasks.

Unit-I: Fourier Series and Fourier Transforms

Fourier series, Convergence of Fourier series, Examples of Fourier series. Fourier transforms and inverse Fourier transforms, Rules for computing Fourier transforms, Parseval's identity and Plancherel's identity.

Unit–II: Discrete Fourier Transforms and Wavelets

Discrete Fourier transform of a digital signal, Inverse discrete Fourier transform, Window Fourier transform, Short time Fourier transform, Admissibility condition for a wavelet, Wavelet series, Classes of wavelets: Haar, Morlet, Maxican hat, Meyer and Daubechies wavelets; Wavelets with compact support.

Unit-III: Haar Scaling Function and Haar Wavelet Spaces

Orthogonal functions, Orthonormal functions, Function spaces, Orthogonal basis functions, Haar scaling function, Haar spaces: Haar space V_0, general Haar space V_j; Haar wavelet, Haar wavelet spaces: Haar wavelet space W_0, general Haar wavelet space

Unit–IV: Discrete Wavelet Transforms (DWT)

Stationary and non-stationary signals, Conservation and compaction of energy, Multiresolution analysis (MRA), Decomposition and reconstruction of signals using discrete wavelet transform, Time-frequency analysis, Example of multiresolution analysis

Unit–V: Applications

Estimation of noise in noisy signals, Computing energy and entropy of signals, Applications in signal compression, Analysis and classification of signals using DWT, Signal de-noising: Image and ECG signals.

Text Books:

1. Charles K. Chui (1992). *An Introduction to Wavelets*. Academic Press.
2. David K. Ruch & Patrick J. Van Fleet (2009), *Wavelet Theory***:** *An Elementary Approach with Applications*. John Wiley & Sons.

Unit-I Text Book 2: 1.2, 2.1, 2.2, 2.3
Unit-II Text Book 1: 3.1, 3.2, 3.3, 3.4, 3.6
Unit-III Text Book 2: 3.1, 3.2, 3.3, 3.4, 3.5
Unit-IV Text Book 2: 3.5, 5.1, 5.2, 5.3
Unit-IV Text Book 2: 4.1, 4.2, 4.3

References:

1. Ingrid Daubechies (1999). *Ten Lectures on Wavelets*. SIAM
2. Michael W. Frazier (1999). *An Introduction to Wavelets Through Linear Algebra*. Springer-Verlag.
3. Stéphane Mallat (2008). *A Wavelet Tour of Signal Processing* (3rd edition). Academic Press.
4. David F. Walnut (2002). *An Introduction to Wavelet Analysis,* Birkhäuser, Boston.
5. James S. Walker (2008). *A Primer on Wavelets and Their Scientific Applications* (2nd edition). Chapman & Hall/CRC, Taylor & Francis.

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Minor:12-19 **MSMT 536 GRAPHS AND ALGEBRAS (4 Credits)**

Course Objectives:

1. To introduce and analyze graphs arising from algebraic structures such as groups and rings, and to explore their spectral and structural properties.
2. To develop the ability to investigate specialized algebraic graphs, interpret their invariants, and apply theoretical results to solve problems in abstract algebra and graph theory.

	Course Outcomes
CO 1	Explain the concepts of graph isomorphism, automorphism, adjacency algebra, and apply spectral methods such as characteristic polynomials to study algebraic graphs.
CO 2	Construct and analyze graphs defined on groups, including Cayley graphs, circulant graphs, power graphs, commuting graphs, and other group-based graphs.
CO 3	Explore zero-divisor graphs and total graphs of rings, and examine their fundamental properties.
CO 4	Investigate invariants of algebraic graphs on rings, such as girth and diameter, for both zero-divisor and total graphs.
CO 5	Examine advanced ring-based graphs, including co-maximal, unit, cozero-divisor, Jacobson, intersection, and annihilator graphs, and interpret their properties.

Unit-I: **Algebraic structures from graphs**: Isomorphism of graphs – Isomorphism as a relation – Automorphism of graphs – Graphs and Groups –The spectrum of a graph – Characteristic polynomial – Adjacency Algebra.

Unit-II: **Graphs defined on groups:** Cayley Graph – Circulant graph – Power graph – Commuting graph, commuting graph – Non-generating graph – Nilpotence graph – Solvability graph – Engel graph – Aut(G)-invariant graph.

Unit-III: **Graphs defined on rings**: Zero-divisor Graph of a ring-Introduction – Basic Properties of zero-divisor Graphs – Total graph of a ring- Introduction – Basic properties of total graphs.

Unit-IV: **Properties of Graphs defined on rings**: Girth of zero-divisor graph of a commutative ring – Diameter of zero-divisor graph of a commutative ring – Girth of total Graph of a commutative ring – Diameter of total graph of a commutative ring.

Unit-V: **More graphs on rings**: Cayley graphs – Co-maximal graphs – Unit graphs – Cozero-divisor graphs – Jacobson graphs – Intersection graphs – Annihilator graphs.

Text Book:-

1. Gary Chartrand, Ping Zhang, Introduction to Graph Theory, Tata McGraw-Hill, 2006. (Unit-I)
2. Norman Biggs, Algbraic Graph Theory, Second Edition, Cambridge University Press, 1993. (Unit-I)
3. Peter J. Cameron, Graphs defined on groups, International Journal of Group Theory, 11(2), 2022, 53-107. (Unit-II)
4. David F. Anderson, T. Asir, Ayman Badawi, T. Tamizh Chelvam, Graphs from rings, Springer Switzerland, 2021. (Unit-III,IV,V)

Reference Books:-

1. Chris Godsil and Gordon Royle, Algebraic Graph Theory, Springer 2009.
2. R. Balakrishnan and K. Ranganathan, A Textbook of Graph Theory (Universitext), Second Edition, Springer New York, 2012.

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Minor: 12-19 **MSMT 537: PROBABILITY AND STATISTICS** **(4 CREDITS)**

Course Objectives:

1. To learn the basics of Probability density function, Special distributions, Distributions of functions of one and bivariate random variables.
2. To learn about Statistical inference.

	Course Outcomes
CO 1	To study and discuss about various probability distribution functions of one random variable
CO 2	To study and discuss Bivariate Random variable and their joint probability distributions
CO 3	To study about the b, t and *F* distributions
CO 4	To study about Expectations, moment generating functions and the Central limit theorem
CO 5	To study about discuss statistical inference and correlations and regression analysis.

Unit I: The probability set function – Random variables – Probability density function – Distribution function – Mathematical expectation – Special mathematical expectations – Chebyshev's Inequality – Conditional probability – Marginal and conditional distributions – Stochastic independence. *[Chapters 1 and 2 (except 1.1and 1.2) of the text book]*

Unit II: Some special distributions: The Binomial and related distributions – The Poisson distribution – The Gamma and Chi-Square Distributions – The Normal distribution- The Bivariate normal distribution. *[Chapter -3 of the text book]*

Unit III: Distributions of functions of random variables - Sampling theory – Transformations of variables of the discrete type – Transformations of variables of the continuous type – The b, t and F distributions- Distributions of order statistics- The moment generating function technique. *[Chapter 4 [sections 4.1 to 4.7] of the text book.]*

Unit IV: The distributions of $\bar{X}$ and nS^2/σ^2 - Expectations of functions of random variables – Limiting distributions: Limiting moment generating functions – The Central limit theorem. *[Chapter-4 [sections 4.8 and 4.9] and Chapter-5 of the text book.]*

Unit V: Introduction to statistical inference: Point Estimation – Confidence intervals for means – Confidence intervals for differences of means - Confidence intervals for variances – Correlation and Regression analysis . *[Chapter-6 of the text book]*

Text Book:

Robert V. Hogg and Allen T. Craig , *Introduction to Mathematical Statistics* (Fifth Edition) Pearson Education, 2005.

Reference Books:

1. Paul L.Meyar, *Introductory to Probability and Statistical Applications*, Oxford&IBH Publishers Co. Pvt .Ltd, 1969.
2. Arnold Naiman, Gene Zirkel and Robert Rosenfield, *Understanding Statistics*, McGraw- Hill, 1986.
3. William Feller, *An Introduction to Probability Theory and its Applications, Vol.I*, John Wiley, Third Edition, 2008.
4. A.Mood, F.Graybill, and D.Boes, *Introduction to the Theory of Statistics*, Tata McGraw Hill (Third Edition) 2008.

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Minor:12-19 **MSMT 538: ALGEBRAIC NUMBER THEORY (4 CREDITS)**

Course Objectives:

1. To provide a strong foundation in elementary number theory and algebraic structures within rings and fields
2. To develop understanding of key concepts including Euclidean rings, unique factorization, primality, and classical Diophantine equations.

	Course Outcomes
CO 1	Understand elementary number theory including unique factorization and classical equations
CO 2	Explain structure and properties of Euclidean rings and unique factorization domains
CO 3	Define and characterize algebraic numbers and algebraic integers
CO 4	Determine integral bases and study discriminants of algebraic number fields
CO 5	Describe properties of Dedekind domains and related algebraic structures

Unit I: Elementary Number Theory (Sections 1.1 and 1.2)

Integers – Greatest common divisor – Infinitude of primes – Unique factorization in Z – Fermat's little theorem – Euler's Φ function and Euler's theorem – Multiplicative property of Φ function – Applications of unique factorization – The equation $x^2 + y^2 = z^2$ – The equation $x^4 + y^4 = z^2$ – The equation $x^4 – y^4 = z^2$ – Fermat numbers and their properties.

Unit II: Euclidean Rings(Sections 2.1, 2.2 and 2.3)

Preliminaries: Units, Associates, Irreducible elements, Norm map, Unique factorization domain, Principal ideal domain, Euclidean domain – Gauss' lemma – Gaussian integers – Units and primes in the ring of Gaussian integers – Eisenstein integers – Units in the ring of Eisenstein integers – Factorization of 3 – Order of $Z[\rho] / (\lambda)$.

Unit III: Algebraic Numbers and Integers (Sections 3.1, 3.2 and 3.3)

Basic concepts – Algebraic number – Algebraic integer – Minimal polynomial Count ability of algebraic numbers – Liouville's theorem for R – Algebraic number fields – Theorem of the primitive element –Liouville's theorem for C – Characterization of algebraic integers.

Unit IV: Integral Bases (Sections 4.1, 4.2 and 4.3)

The norm and the trace – Integral basis for an algebraic number field – Algebraic integers of $Q(\sqrt{-5})$ – Existence of an integral basis – Discriminant of an algebraic number field – Index – Determination of an integral basis for the ring of integers of a quadratic number field.

Unit V: Dedekind Domains (Sections 5.1 and 5.2)

Integral closure – Integrally closed ring – Noetherian ring – Dedekind domain – Characterizing Dedekind domains.

Text Book

J. E. Smonde and M. RamMurty, Problems in Algebraic Number Theory,
Graduate Texts in Mathematics, Volume 190, Springer Verlag, New York,1999.

Reference Books:

1. Pierre Samuel and Allan J Silberger, Algebraic Theory of Numbers, Dover Pub. Inc, 2008.

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Minor:12-19 MSMT 539: ADVANCED TOPICS IN TOPOLOGY AND ANALYSIS (4 CREDITS)

Course Objectives:

1. To learn Metrizable topological spaces, Quotient spaces and locally compact spaces.
2. To learn about the L_p spaces in detail.

	Course Outcomes
CO 1	Able to identify metrizable and spaces having compactifications.
CO 2	Able to use various compactification theorems to prove more extension theorem of continuous real functions.
CO 3	Familiarity with different kinds of compactness and countability axioms that implies metrizability.
CO 4	Good understanding of the theory of L_p spaces.
CO 5	Able to use the knowledge of L_p spaces in the theory of partial differential equations.

Unit I: (Sections 22,25, relevant parts from section 24 of [1])

Quotient topology and quotient maps - Examples of quotient spaces - Path connectedness - Standard results - Example of a connected but not path connected space- Locally connected spaces.

Unit-II: (Sections29, 34,38, 43,44 of [1])

The Uryshon's metrization theorem – Locally compact spaces-One point compactification - Stone- Cech compactification – The uniform metrric on Y^J and the Space filling curve.

Unit-III: (Sections 39, 40,41 of [1])

Local finiteness- Countably locally finite refinement of open coverings of metric spaces – Paracompactness - Standard results - Metric spaces are paracompact.

Unit-IV: (Chapter:7 of [2])

L^p- spaces – Completeness - Dual of $L^p[a,b]$for $1 \leq p < \infty$.

Unit-V: (Sections 8.1, 8.2 and 8.3 from Chapter:8 of [2])

Weak sequential convergence of $L^p[a,b]$ – the Riemann Lebesgue lemma – the Radon Riesz theorem - weak sequential compactness of $L^p[a,b]$.

Text Books:

1. James R. Munkres, Topology by James R. Munkres, Pearson, 2nd edition, 2000.
2. H.L.Royden, and P.M. Fitzpatrick, Real Analysis, (Fourth Edition) PHI Learning Private Limited, 2013.

Reference Books:

1. James Dugundji, General Topology, Allyn and Bacon, Inc.(1966).
2. Inder K. Rana, *An Introduction to Measure Theory and Integration, (2e)*, Narosa (2007).
3. B.V. Limaye, Functional Analysis, Wiley Eastern, New Delhi, 1981.

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Minor:12-19 **MSMT 540: ADVANCED TOPOLOGY** **(4 CREDITS)**

Course Objectives:

1. To learn Metrizable topological spaces, Quotient spaces and locally compact spaces.
2. To learn the basics of algebraic topology.

	Course Outcomes
CO 1	Able to identify metrizable and spaces having compactifications.
CO 2	Able to use various compactification theorems to prove more extension theorem of continuous real functions.
CO 3	Familiarity with different kinds of compactness and countability axioms that implies metrizability.
CO 4	Constructing examples of space filling curves and nowhere differentiable continuous functions.
CO 5	Understanding the idea of fundamental groups- a beginning of Algebraic Topology.

Unit I: (Sections- 25 and 29 of [1])

Connected components- Local connectedness - Locally path connected spaces- Local compactness, One point Compactification, Uryshon Metrization Theorem.

Unit II:(Chapter-10 of [2] and Sections- 22 and 36 of [1])

Nets and Filters- Quotient topology- Introduction to topological groups.

Unit III:(Sections-38, 39, 40, 41 and 42 of [1])

The Stone -Cech Compactification- Locally finite spaces- Nagata- Smirnov Metrization theorem- Paracompactness- Smirnov Metrization theorem.

Unit IV: (Sections-44 48 and 49 of [1])

The Peano space-filling curve – Barie Spaces – Nowhere differentiable functions.

Unit V: (Sections 48, 49, of [1])

Homotopy of paths- The fundamental group- Covering spaces- The fundamental group of the circle.

Text Books:

1. James R. Munkres, Topology, Second edition, Pearson Education Inc.,(2002).
2. K.D.Joshi, Introduction to General Topology, First edition (revised), New Age International Publishers, 2004.

Reference Books:

1. Stephen Willard, General Topology, Dover, 2004.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor:12-19 **MSMT 541: COMMUTATIVE ALGEBRA** **(4 CREDITS)**

Course Objectives:

1. **Develop foundational knowledge of prime ideals, maximal ideals, radicals, and operations on ideals**
2. Understand module operations, tensor products, Noetherian and Artinian rings, and primary decomposition

	Course Outcomes
CO 1	Describe and analyze prime ideals, maximal ideals, radicals, and their properties
CO 2	Apply operations on submodules, direct sums, exact sequences, and tensor products
CO 3	Understand localization, rings of fractions, and primary decomposition
CO 4	Explain integral dependence and chain conditions in commutative rings
CO 5	Characterize Noetherian and Artinian rings and their significance

Unit-I

Prime ideals- Maximal ideas- Nil radical- Jacobson radical- Operation on ideals- Extension and contraction.

Unit-II

Operation on sub-modules- Direct sum and product- Finitely generated modules- Exact sequences- Tensor product- Restriction and extension of Scalars.

Unit-III

Rings and Modules of Faction and Primary decomposition Local properties extended and contracted Primary decomposition.

Unit-IV

Integral dependence and chain conditions.

Unit -V

Noetherian rings and Artinian rings

Text Book

M. K. Atiyah and I. G. Macdonald, Introduction to Commutative Algebra, Addison-Weseley, 1994.

Reference Books

1. H. Matsumura, Commutative Ring Theory, Cambridge University Press,1989.
2. I. Kaplansky, Commuatavie Rings, University of London press,1966.
3. O. Zariski and P. Samuel, Commutative Algebra, Springer 1976.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor:12-19 **MSMT 542 DISCRETE DYNAMICAL SYSTEMS (4 CREDITS)**

Course Objectives:

1. To study about basics of orbits, symbolic dynamics, Topological Conjugacy and different definitions of chaos.
2. To study about the dynamics of some numerical methods.

	Course Outcomes
CO 1	Understanding the analysis of some simple dynamical system, Sharkoviski's theorem.
CO 2	Able to study dynamical systems using the knowledge of Real analysis.
CO 3	Classification of dynamical systems up to topological conjugacy,
CO 4	Describing the chaotic dynamical systems and analysis of the convergence of iterative procedures in numerical analysis.
CO 5	Knowledge about complex dynamics and familiarity about fractal geometry.

Unit-I

Orbits - Phase portraits- Periodic points and stable sets. Sarkovskii's theorem

Unit-II

Attracting and repelling periodic points- Differentiability and its implications – Parametrized family of functions and bifurcations- The logistic map.

Unit-III

Symbolic dynamics - Devaney's definition of Chaos - Topological Conjugacy.

Unit-IV

Newton's method-Numerical solutions of differential equations.

Unit-V

The dynamics of Complex functions- The quadratic family and the Mandelbrot set.

Text Book

Richard A. Holmgren, A First Course in Discrete Dynamical Systems, Springer Verlag (1994).

Unit-I [Chapters: 1, 2, 4 and 5], Unit-II [Chapters: 6, 7 and 8], Unit-III [Chapters: 9, 10 and 11], Unit-IV [Chapters: 12 and 13], Unit-V [Chapters 14 and 15].

Reference Books:

1. Robert L.Devaney, A First Course in Chaotic Dynamical Systems, Addison-Wesley Publishing Company, Inc. 1992.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor: 12-19 **MSMT 543 ADVANCED SPECIAL FUNCTIONS** **(4 CREDITS)**

Course Objectives:

1. To learn and understand about generalized hypergeometric function and their properties.
2. To learn and understand about Laguree and Hermite polynomials including properties.

	Course Outcomes
CO 1	To study and discuss about hypergeometric function and various properties and summation formulas
CO 2	To study about generalized hypergeometric function and summation formulas
CO 3	To study about Hermite Polynomials and their properties
CO 4	To study about Laguree Polynomials and their properties
CO 5	To study about Appell hypergoemetric function of two variables with properties

Unit I: (Chapter 4)

Basics and Introduction to Gauss's hypergeometric and Confluent hypergeometric functions, integral representations, differentiation formulas, transformation formulas, contiguous function relations, summations formulas. **(12 hours)**

Unit- II (Chapter 5)

Generalized Hypergeometric Functions: The function pFq, The contiguous function relations, A simple integral, The pFq with unit argument, Saalschutz' theorem, Whipple's, Dixon's, **(12 hours)**

Unit- III (Chapter 11)

Hermite Polynomials- Definition, recurrence relation, Rodrigues formula, orthogonality property, generating relations and general properties. **(12 hours)**

Unit IV (Chapter 12)

Laguree Polynomials-. Definition, recurrence relation, Rodrigues formula, orthogonality property, generating relations and general properties **(12 hours)**

Unit V: (Chapter 9 of Ref 2)

Appell's hypergoemtric function of two variables, Transformation formulas, integral representation of Euler and Laplace type **(12 hours)**

Text Books :

1. E. D. Rainville, Special functions, Macmillan, New York, 1960. (Chapter 5)
2. W.N. Bailey, Generalized Hypergeometric Series, Cambridge University Press, Cambridge, (1935)

Reference Books:

1. W.N. Bailey, Generalized Hypergeometric Series, Cambridge University Press, Cambridge, (1935)
2..L.J. Sater, Generalized Hypergeometric function, Cambridge University Press, London and New York, 1966

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor: 12-19 **MSMT 544 ADVANCED FUNCTIONAL ANALYSIS (4 CREDITS)**

Course Objectives:

1. To study the basics of Canonical isometry, Compact operators, Eigen values and the eigen spectrum of a linear operator.
2. To study about the applications of functional Analysis to Integral equations and Calculus of Variations.

	Course Outcomes
CO 1	Knowledge about reflexive spaces, best approximation in reflexive spaces, weak convergence and its applications to the theory of partial differential equations.
CO 2	Application of the theory of compact operators to integral equations.
CO 3	Familiarity with eigen values and eigen spectrum of a linear operator and the applications of the spectral mapping theorem.
CO 4	Knowledge about the adjoint of an operator and the compactness of an adjoint operator.
CO 5	Able to classify different types of operators and their properties.

Unit-I

Duals of $C[a,b]$ and $L_p[a,b]$– Separability – The Canonical isometry – The transpose of a bounded linear Map – Reflexivity – Weak convergence – Schur's Lemma – EberleinShmulyan Theorem – Best approximation in reflexive spaces.

Unit-II

Compact operators – Examples – Properties – The completeness of the space of compact operators – Compactness of the transpose.

Unit-III

Eigen values and the eigen spectrum of a linear operator – examples – spectrum and resolvent set – Spectral radius – Spectral Mapping Theorem – Resolvent Identity – The specrtral radius formula – The RieszSchauder Theory.

Unit-IV

The adjoint of an operator – Existence – Compactness of the adjoint operator – Sesquilinearfunctionals – Closed range Theorem.

Unit-V

Self-adjoint, normal, unitary operators – Numerical range and numerical radius – Spectral results for Hilbert's space operators – Properties of the Spectrum.

Text Book:

1. M.Thamban Nair, *Functional Analysis: A First Course*, Prentice Hall of India, 2002.

Unit-I Sections: 8.1.3, 8.1.4, 8.2.1, 8.2.2,8.2.3
Unit-II Sections: 9.1, 9.2, 9.3
Unit-III Sections: 10.1, 10.2, 10.2.1, 10.2.2, 10.2.3, 10.4
Unit-IV Sections: 11.1, 11.1.1, 11.1.2
Unit-V Sections: 11.2, 12.1, 12.1.1, 12.2

Reference Books:

1. Joseph Muscat, *Functional Analysis*, Springer (2008).
2. BalmohanV.Limaye, *Functional Analysis*,3e, New Age International Publishers (2014).
1. Erwin Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley (2007).
2. Martin Schecter, *Principles of Functional Analysis*, American Mathematical Society (2009)
3. BelaBollobas, *Linear Analysis: An Introductory Course,*2e, Cambridge Univ. Press (1999).
4. Bryan P. Rynne and Martin.AYoungson, *Linear Functional Analysis*, Springer (2008).

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor: 12-19 MSMT 545 NON-COMMUTATIVE RINGS AND REPRESENTATIONS (4 CREDITS)

Course Objectives:

1. To study the basics of Modules, Semisimple Rings, Structure theory of rings.
2. To study the properties of Representations.

	Course Outcomes
CO 1	Understanding the basic Module theory.
CO 2	Knowledge about Semi simple rings and properties of radicals.
CO 3	Strong knowledge about Group Algebra and its radical-Maschkes Theorem.
CO 4	Understanding the structure theory of Rings.
CO 5	Basic Understanding of the Representations Theory.

Unit-I Modules

Modules - Artinian and Notherian modules - Tensor products - Restricted and induced modules. - Indecomposable modules – Completely reducible module - Schur Lemma.

Unit-II Radical

Semi simple rings - The radical of a rings – The properties of Jacobson radical

Unit-III Group algebras - The Jacabson radical of Group Algebra – Maschke's Theorem.

Unit-IV Structure theory

Structure theory of ring - Density theorem - Widderburn-Artin theorem for semi simple rings.

Unit-V Representations

Representations - linear representation - Matrix representation - Equivalent representation - Invariant subspaces - Irreducible representations - Direct sum of representations - Induced representation – restricted representation - Tensor product of representations - Inner products of representation.

Text Book

1. I. N Herstein, Non-Commutative Rings, The Mathematical Association of America, 5th Edition, 2005 (Chapter 1: Units I-III, Chapter 2: Unit IV and Chapter 5: Unit V)

Reference Books:

1. William Fulton and Joe Harris, Representation Theory - A First Course, Springer International Edition, Springer-Verlag, New York, 2004.
2. Jacobson, Basic Algebra II, Hindustan Publishing Corporation (India), 1983.
3. Charles W. Curtis and Irving Reiner, Representation Theory of Finite Groups and Associative Algebras, Inter Science Publishers, 1962.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor: 12-19 **MSMT 546: ALGEBRAIC GRAPH THEORY** **(4 CREDITS)**

Course Objectives:

1. To study the fusion of Algebra and Graph Theory.
2. To introduce some fundamental concepts in Algebraic graph theory

	Course Outcomes
CO 1	Acquire fundamental knowledge of the concept of Algebraic Graph Theory
CO 2	Some applications of Algebra in Graph Theory
CO 3	Understanding the concept of vertex partition and the spectrum
CO 4	Knowledge about the multiplicative expansion and Tutte polynomials
CO 5	Learning results like Wilf's theorem on the chromatic number, Whitney's theorem on counting subgraphs and Baler's theorem

Unit -I: Linear Algebra in Graph Theory – The Spectrum of a Graph – Characteristic polynomial – Adjacency Algebra - Reduction Formula for χ – Regular Graphs and Line Graphs – Circulant Graph – Spectrum of the Strongly Regular Graph – Cycles and Cuts – The Incidence Matrix – The Laplacian Spectrum.

Unit -II: Spanning Trees and Associated Structures – Kirchhoff's Law – Thomson's Principle – The Tree-Number – A Bound for the Tree Number of Regular Graphs – Determinant Expansions – Elementary Graphs.

Unit -III: Vertex-Partition and the Spectrum – Color Partition – Wilf's Theorem on the Chromatic Number of a Graph – Coloring Problems – The Chromatic Polynomial – Recursive Relation for the Chromatic Polynomial – Quasi-Separable Graphs – Subgraph Expansions – The Rank Polynomial.

Unit -IV: The Multiplicative Expansion – Whitney's Theorem on Counting Subgraphs – The Induced Subgraph Expansion – Baker's Theorem.

Unit -V: The Tutte Polynomial – The λ-operator – The Deletion-Contraction Property – Chromatic Polynomial and Spanning Trees – The Chromatic Invariant.

Text Book:-

1. Norman Biggs, Algbraic Graph Theory, Second Edition, Cambridge University Press, 1993.

Reference Books:-

1. Chris Godsil and Gordon Royle, Algebraic Graph Theory, Springer 2009.
2. R. Balakrishnan and K. Ranganathan, A Textbook of Graph Theory (Universitext), Second Edition, Springer New York 2012.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor: 12-19 **MSMT 547: FIXED POINT THEORY** **(4 CREDITS)**

Course Objectives:

1. To learn about various fixed point theorems.
2. To learn about the applications of fixed point theorems to other branches of Mathematics.

	Course Outcomes
CO 1	Able to prove many existence theorems using the Banach contraction principle.
CO 2	Knowledge of hyperconvex spaces and set valued contractions and their applications.
CO 3	Able to extend the Banach contraction principle more general settings.
CO 4	Knowledge of non-expansive mappings and their fixed points.
CO 5	Able to understand the structure of the fixed point set and the idea of stability.

Unit I (I Sections: 2.5,3.1 to 3.4**):** Metric convexity and convexity structure-Bananch contraction principle and its extensions-The Casristi-Ekelandprincipleand its equivalent.

Unit II (Sections 3.5,3.6, 4.1 to 4.5**):** Set valued contractions-Generalised contractions-Hyperconvexity-Propertiesof hyper convex spaces.

Unit III (Sections: 4.6, 4.7, 5.1 to 5.4**):** Approximate fixed points-Isbell's hyper convexhull-Normal structures in metric spaces-Structure of fixed point sets-Uniform normal structures- Uniform relative normal structure-

Unit IV (Sections: 5.5 to 5.7 , 7.1 to 7.6**):** Quasi normal structure-stability and normal structure- Ultrametric spaces- Continuous mappings in Banach spaces-Brouwer's Theorem-Schauder's Theorem- Stability of Schauder's theorem—Continuous mappings in hyper convex spaces.

Unit V (Sections8.1 to 8.8**):** Basic theorems for nonexpansive maps-Stability results in arbitrary spaces- The Gobel_Karlovitz Lemma-Orthogonol Convexity-Structure of fixed point set-Asymptotically regular mapppings.

Text Book: M. A. Khamsuans W.A. Kirk, An Introduction to Metric Spaces and Fixed Point Theory, John Wiley & Sons, 2001.

Reference Books:

1. Kazimierz Goebel and W. A. Kirk, *Topics in Metric Fixed Point Theory*, Cambridge University Press, 1990.
2. M.C.Joshi and R.K.Bose, *Some topics in Nonlinear Functional Analysis*, John Wiley &sons 1986.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor: 12-19 **MSMT 548 GRAPH COLORING** **(4 CREDITS)**

Course Objectives:

1. To study in detail graph coloring and many variations of graph coloring
2. To give an exposure to the current aspects in graph coloring extension.

	Course Outcomes
CO 1	Acquire strong knowledge in the concept of graph coloring and their variations
CO 2	Clarity about the four color problem
CO 3	Understanding the notions like perfect graphs, color-critical, greedy coloring, nowhere zero-flow
CO 4	Knowledge about many variations of graph coloring like total coloring, list coloring, complete coloring, grundy coloring, T-coloring, L(2,1)-coloring, Radio coloring and hamiltonian coloring
CO 5	Some directions to take up research in graph coloring

Unit I: Vertex Colorings and Bounds of the Chromatic number (Sec: 6.1, 6.3, 7.1-7.2) :
The Chromatic Number of a Graph– Perfect Graphs – Color-Critical Graphs – Upper Bounds and Greedy Colorings –The Chromatic Number of Cartesian Products.

Unit II: Coloring Graphs on Surfaces & Restricted Vertex Colorings (7.4, 8.1- 8.3**):**
The Four Color Problem – The Conjectures of Hajós and Hadwiger – Chromatic Polynomials –Uniquely Colorable Graphs – List Colorings – Precoloring Extensions of Graphs.

Unit III: Edge Colorings of Graphs (9.1-9.3, 10.1-10.4, 10.6 **):** The Chromatic Index and Vizing's Theorem – Class One and Two Graphs – Tait Colorings – Nowhere-Zero Flows –Total Colorings of Graphs.

Unit IV: Complete Colorings (12.1-12.3**):** The Achromatic Number of a Graph – Graph Homomorphisms – The Grundy Number of a graph.

Unit V: Colorings, Distance and Domination (14.1-14.4**):** T-Colorings – L(2,1)-Colorings – Radio Colorings – Hamiltonian Colorings.

Text Book: Gary Chartrand, Ping Zhang, Chromatic Graph Theory, Chapman & Hall/CRC press, 2009.

Reference books:

1. Douglas B. West, Introduction to Graph Theory, Second Edition, PHI Learning Private Ltd, New Delhi-2011.
2. G. Chartrand, Linda Lesniak and Ping Zhang, Graphs and Digraphs, Fifth Edition, CRC press 2011.
3. Michael Molloy and Bruce Reed, Graph Colouring and the Probabilistic Method, Springer 2002.
4. Tommy R. Jensen and Bjarne Toft, Graph Coloring Problems, John Wiley and Sons, 1995.

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Minor: 12-19 **MSMT 549: DIFFERENTIAL GEOMETRY** **(4 CREDITS)**

Course Objectives:

1. To develop a deep understanding of the geometry of curves and surfaces by exploring arc length, curvature, torsion, and key theorems
2. To equip students with analytical and computational skills for studying smooth surfaces, fundamental forms, mappings, and curvature concepts, preparing for further research and interdisciplinary applications.

	Course Outcomes
CO 1	Compute arc length, curvature, and torsion for plane and space curves using parametric equations.
CO 2	Apply Serret-Frenet equations, prove and interpret geometric theorems (isoperimetric, four vertex), and classify curves.
CO 3	Describe and work with smooth surfaces, including tangent planes, normal vectors, orientability, and examples such as quadratic surfaces.
CO 4	Determine and utilize the first and second fundamental forms, study isometries, conformal and equiareal maps, and calculate surface area.
CO 5	Calculate and interpret normal curvature, principal curvature, and the geometric significance of the Euler theorem on surfaces.

Unit I: [Sections: 1.1 to 1.4 and Sections 2.1,2. 2.]

Curves- arc length- Reparameterization-Level curves - Curvature - Plane curves.

Unit II: [Sections 2.3 and Sections 3.1 to 3.3.]

Space curves-Torsion- Serret Frenet equations- Simple closed curves- The Isoperimetric Inequality- The Four vertex Theorem.

Unit III: [Sections 4.1 to 4.7]

Smooth surface- Tangents, normal and orient ability- Examples of surfaces- Quadratic surfaces- Triple orthogonal systems- Applications of Inverse function theorem

Unit IV: [Sections: 5.1 to 5.5]

Lengths of curves on surfacesa- First fundamental form- Isometries of surfaces- Conformal mapping of surfaces- Surface area- Equiareal maps and a theorem of Archimedes.

Unit V: [Sections: 6.1 to 6.4]

The Second Fundamental form- The Curvature of curves on a surface- The normal and principal curvature- Euler's theorem- The geometric interpretation of principal curvatures.

Text Book:

1. Andrew Pressley, *Elementary Differential Geometry*, Springer, 2004.

Reference Books:

1. Christian Bar, *Elementary Differential Geometry*, Cambridge University Press, 2011.
2. Thomas F. Banchoff and Stephen T. Lovett, *Differential Geometry of Curves and Surfaces*, A.K Peters/CRC press, 2010.
3. W. Klingenberg, *A course in Differential Geometry*, Springer-Verlag, New York, 1978.
4. J. A. Thorpe, Elementary Topics in Differential Geometry (Undergraduate Texts in Mathematics), Springer-Verlag New York Inc, 2011.
5. Barrett O'Neill, Elementary Differential Geometry, Revised 2nd Edition, Academic press 2006.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor: 12-19 MSMT 550 ADVANCED INTEGRAL TRANSFORMS (4 CREDITS- 60 HOURS)

Course Objectives:

1 To learn and understand Hankel transforms and Mellin transforms with properties and Applications.
2 To learn and understand Stieltjes and Z transform with properties and Applications

	Course Outcome
CO 1	To study Hankel transform with properties and to solve the PDE
CO 2	To study about Applications of Laplace transform
CO 3	To study Hilbert transforms with properties and to solve the PDE
CO 4	To study Stieltjes transforms with properties and to study generalized Stieltjes transforms
CO 5	To study and understand about Z- transform with properties and to apply for solving the difference equations

Unit II: Hankel Transforms (12 hours)

Introduction, The Hankel Transform and Examples, Operational Properties of the Hankel Transform, Applications of Hankel Transforms to Partial Differential Equations.(Chapter-7 Sections-7.1 to 7.4)

Unit II: Mellin Transforms (12 hours)

Introduction, Definition of the Mellin Transform and Examples, Basic Operational Properties of Mellin Transforms, Applications of Mellin Transforms, Application of Mellin Transforms to Summation of Series.(Chapter-8 Sections-8.1 to 8.4 & 8.6)

Unit III: Hilbert Transforms (12 hours)

Introduction, Definition of the Hilbert Transform and Examples, Basic Properties of Hilbert Transforms, Hilbert Transform in complex plane, Applications Hilbert. (Chapter-9 Sections-9.1 to 9.5)

Unit IV: Stieltjes Transforms (12 hours)

Introduction, Definition of the Stieltjes Transform and Examples, Basic Operational Properties of Stieltjes Transforms, Inversion Theorem for the Stieltjes transform, Applications of Stieltjes Transforms, The generalized Stieltjes transform, Basic Operational Properties of generalized Stieltjes Transforms. (Chapter-9 Sections- 9.7 to 9.12)

Unit V: Z Transforms (12 hours)

Introduction, Dynamic Linear Systems and Impulse Response, Definition of the Z Transform and Examples, Basic Operational Properties of Z Transforms, The Inverse Z Transform and Examples, (Chapter-12 Sections-12.1 to 12.5)

Text Book

1. Lokenath Debnath and Dambaru Bhatta, Integral Transforms and Their Applications, Third Edition, CRC Press, Taylor and Francis Group, A Chapman and Hall Book, 2015.

Reference Books:

1. Ian N. Snedden, The Use of Integral Transforms, McGraw Hill, 1972
2. B. Davies, Integral Transforms and Their Applications, Springer, Texts in Applied Mathematics 41, Third Edition,2009.
3. Alexander D. Poularikas, Transforms and Applications Handbook, Third Edition, CRC Press, Taylor and Francis Group, 2010.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor: 12-19 **MSMT-551: ADVANCED COMPLEX ANALYSIS (4 CREDITS)**

Course Objectives:

1. To learn and discuss the basics of the space of continuous functions, The Riemann Mapping Theorem and Weierstrass factorization theorem.
2. To learn and discuss about the Mittag-Leffler theorem, Schwarz Reflection Principle and Jensen's formula.

	Course Outcomes
CO 1	To study about the space of continuous functions and The Riemann Mapping Theorem
CO 2	To study about the Weierstrass factorization theorem
CO 3	To study about the Mittag Leffler's Theorem
CO 4	To study about Monodromic theorem and Schwarz Reflection Principle
CO 5	To study about the Jenson Formula

Unit-I

The space of continuous functions - Spaces of analytic functions – Spaces of meromorphic functions - The Riemann Mapping Theorem.[Chapter-7, Sections: 1,2 ,3 and 4.]

Unit-II

Weierstrass factorization theorem - Factorization of sine function – The gamma function - The Riemann zeta function. [Chapter-7, Sections: 5,6,7 and 8]

Unit-III

Runge's Theorem Simple Connectedness- Mittag Leffler's Theorem [Chapter-8]

Unit-IV

Schwarz Reflection Principle - Analytic continuation along a path – Monodromic theorem.
[Chapter-9 Sections1, 2 and 3]

Unit-V

Jensen's formula - The genus and order of an entire function. [Chapter-11, Sections:1,2 and 3]

Text Book:

John. B. Conway, Functions of one Complex Variable, Second Edition, Narosa Publishing House, 2002.

Reference Books:

1. B.C.Palka, An Inroduction to the Complex function Theory, Springer, 1991.
2. H.A. Priestley, Introduction to Complex Analysis, Second Edition, Oxford University Press, 2003.
3. Donald sarason, Notes on Complex Function Theory, Hindustan Book agency ,1994.
4. L.V.Ahlfors, Complex analysis, Third Edition, McGraw Hill Book Company,1979
5. S. Ponnusamy, Foundations of Complex analysis, (2nd Edition), Narosa, 2011

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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Minor: 12-19 **MSMT-552 : LIE GROUPS OF TRANSFORMATIONS AND DIFFERENTIAL EQUATIONS (4 CREDITS)**

Course Objectives:

To study the basics of Lie groups of transformation, Lie Algebras of ODEs and PDEs

To derive the Invariance of first and second order differential equations.

	Course Outcome
CO 1	To understand Lie groups of transformation derive the Infinitesimal transformations.
CO 2	To derive Group of Transformations and generate Symmetries
CO 3	To Analyse theory commutators to derive the Underlying Lie Algebra
CO4	To derive the Invariance of first and second order ODEs
CO5	To derive the Invariance of first and second order PDEs with Simple Examples

Unit-I

Introduction–Lie groups of transformation – Infinitesimal transformations.

Unit-II

Extended group transformations and infinitesimal transformations (one independent – one dependent and two independent – two dependent).

Unit-III

Lie Algebras and Applications.

Unit-IV

Invariance of first and second order differential equations.

Unit-V

Invariance of partial differential equations of first and second order – elementary examples.

TextBook

Treatment as in G. W. Blueman and S. Kumei, Symmetries and Differential Equations, Springer – Verlag , 1980.

Unit 1 – Chapter 2 (Sections 2.1 – 2.2);
Unit 2 – Chapter 2 (Sections 2.3.1 – 2.3.3) ;
Unit 3 – Chapter 2 (Sections 2.4.1 – 2.4.4);
Unit 4 – Chapter 3 (Sections 3.1.1 – 3.3.3);
Unit 5 – Chapter 4 (Sections 4.4.1 – 4.2.2).

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Minor: 12-19 **MSMT-553 : DYNAMICAL SYSTEMS** **(4 CREDITS)**

Objectives:

To study the basics of Planar systems and its classifications, Nonlinear systems, Stability and Hamiltonian systems and Bifurcations.

	Course Outcome
CO 1	To study and solve the first and second order differential equations and understand the linear systems and phase portraits.
CO 2	To understand the classification of planar and higher-dimensional linear systems and their subsequent behaviours.
CO 3	To study the nonlinear systems and the fundamentals of the associated solutions of the respective systems.
CO4	To study the nonlinear techniques to understand the solutions efficiently, such as nullclines, Poincaré maps, and the Poincaré–Bendixson theorem.
CO5	To understand the discrete dynamical systems and discuss the nature of the solutions using bifurcations, chaos, and symbolic dynamics including the logistic map and Cantor set.

Unit-I (Chapters 1, 2 and 3 of [1])

First order differential equations, The logistic population model, second order differential equations, planar systems, Planar linear systems, Solving linear systems, The linearity principle, Phase portraits for planar systems.

Unit-II (Chapters: 4 and 6 of [1])

Classification of planar systems, higher dimensional linear systems- Harmonic oscillators -The exponential of a matrix- Nonautonomous linear system.

Unit-III (Chapters 7 and 8 of [1])

Nonlinear systems-Dynamical systems-The existence and uniqueness theorem-continuous dependence of solutions- The variational equation. Equilibiria in nonlinear systems- Nonlinear sinks and sources-saddles and stability-bifurcations.

Unit-IV (Chapters 9 and 10 of [1])

Global nonlinear Techniques- Nullclines -Stability of equilibria – Gradient systems- Hamiltonian systems, closed orbits and limit sets-Local sections and flow boxes- The Poincare Map- Monotone sequences in planar Dynamical systems- The Poincare_ Bendixson theorem-Applications.

Unit-V (Chapter 15 of [1])

Discrete dynamical systems-Bifurcations-The discrete logistic model- Chaos- Symbolic dynamics-The shift map –The Cantor middle_third set.

Text Book:

1. Morris W.Hirsch, Stephen Smale, Robert L.Devaney, Differential Equations and Dynamical systems and An Introduction to Chaos, Second edition, Academic Press(Elsevier) 2004.

Reference Books:

1. Robert L.Devaney, A First Course in Chaotic Dynamical Systems, Addison-Wesley Publishing Company, Inc. 1992.
2. Lawrence Perko, Differential equations and Dynamical Systems, (3rd Edition), Springer 2001.

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Minor: MSMT-901 Research Methodology (4 CREDITS)

(Pre-Ph.D Course for all the Ph.D. Students of Department of Mathematics)

Course Objectives:

The course aims to:

1. Equip students with knowledge of research fundamentals, design, and data collection methods.
2. Develop skills in applying computational tools and report writing techniques for effective presentation and dissemination of research findings.

	Course Outcomes : By the end of this course, students will be able to:
CO 1	Explain the meaning, objectives, and characteristics of research and the process of defining a research problem.
CO 2	Design suitable research methodologies and experimental designs for addressing identified research problems.
CO 3	Apply appropriate methods for collecting primary and secondary data, and evaluate their suitability for different research contexts.
CO 4	Utilize computer applications for data analysis, visualization, and presentation.
CO 5	Prepare and present structured research reports and oral presentations using LaTeX and/or MS Office tools.

UNIT -1: Introduction: Meaning of Research - Objectives of Research - Motivation in Research-Research Methods versus Methodology -Research and Scientific Method - Criteria of Good Research - Defining the Research Problem - Selecting the Problem- Necessity of Defining the Problem - Technique Involved in Defining a Problem.

UNIT -2: Research Design: Meaning of Research Design - Need for Research Design - Research Methodology Features of a Good Design -Important Concepts Relating to Research Design -Different Research Designs - Basic Principles of Experimental Designs.

UNIT -3: Data Collection: Collection of Primary Data - Observation Method - Interview Method - Collection of Data through Questionnaires - Collection of Data through Schedules -Difference between Questionnaires and Schedules - Some Other Methods of Data Collection Guidelines for Constructing Questionnaire/Schedule.

UNIT -4:Computer Applications : Features for data analysis, generating charts/graphs & other features- Presentation tool: Introduction to presentation tool, features & functions, creating presentations

Unit – 5 : Report Writing: Significance of Report Writing - Different Steps in Writing Report - Layout of the Research Report - Types of Reports - Oral Presentation - Mechanics of Writing a Research Report - Precautions for Writing Research Reports.

Use of Latex (and/or) MS Office for generating, storing and interpreting data
Report Writing using either Latex or MS Office

Text Book:

Kothari C.R, Research Methodoloy – Methods and Techniques , New Age International, New Delhi.
Unit –1: Chapters 1 & 2, Unit –2 : Chapter 3, Unit – 3 : Chapter 6 , Unit – 4 & 5 :Chapter 14

Reference Book:

Ranjit Kumar, Research Methodology – A step by step Guide for Beginners,Pearson Education, Delhi.
Chawla D and Sondhi N,Research Methodology Concepts and cases,Vikas Publishing House Pvt. Ltd., New Delhi.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
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MULTIDISCIPLINARY COURSE

MTMD 181 **BASIC MATHEMATICS** **(3 CREDITS)**

Course Objectives:

This course enables the students to learn

1. The basic idea of matrices and set theory
2. Acquire Knowledge of logics, Combinatorics and addition and multiplication rules

	Course Outcomes After successful completion of the course the student will be able to
CO 1	Understand the basic idea of matrices and learn about the algebra of matrices
CO 2	Solve system linear equations using matrix Theory
CO 3	The understand logics, truth table and basic set theory.
CO 4	Learn about the addition and multiplication rules and Principle of inclusion- exclusion
CO 5	Understand the basic concept of Permutation-Combinations

Unit I:

Linear System – Matrices – dot Product – Matrix multiplication – properties of Matrix operations – Matrix transformation.

Unit II:

Solution of linear system of equations – row echelon form – reduced row echelon form – Polynomial interpolation – inverse of a matrix – linear systems.

Unit III:

Logic – truth table – algebra of propositions- logical arguments – sets- operations on sets.

Unit IV:

Principle of inclusion – exclusion – the addition and multiplication rules – pigeonhole principles.

Unit V:

Permutations – Combinations – Elementary Probability.

Text Book:

1. Bernard Kolman, Dred. R. Hill, Introductory Linear Algebra, 8th edition – peasson, India 2011.
2. Edgar G. Goodaire, Michael. M. Parmenter, Discrete Mathematics with Graph Theory, 3e PHI, India, 2011.

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SKILL ENHANCMENT COURSE

SEC-1 BSMT 131 LATEX FOR MATHEMATICS (3 CREDITS)

Course Objectives:

1. To introduce students to the LaTeX typesetting system, enabling them to create and compile high-quality documents, including mathematical content.
2. To develop practical skills in structuring scientific documents, using fonts, lists, tables, equations, graphics, and references effectively.

	Course Outcomes
CO 1	Understand and perform installation and compilation procedures in LaTeX for document preparation.
CO 2	Create well-structured documents with titles, sections, subsections, and apply various font styles and sizes.
CO 3	Design and format tables, enumerated lists, and itemized lists within LaTeX documents
CO 4	Typeset complex mathematical equations correctly using LaTeX environments and symbols.
CO 5	Incorporate graphics, footnotes, and bibliographic references to prepare professional standard scientific documents.

Unit I:

Installation of the software LaTeX Understanding Latex compilation

Unit II:

Creating different kind of documents - Creating Title, sections, subsections, Using various types and sizes of fonts.

Unit III:

Creating Tables, enumeration list, itemized list.

Unit IV:

Constructing Mathematical equations,

Unit V:

Including pictures in a document- Inserting foot notes and references

Reference books:

1. L. Lamport: A Document Preparation System, User's Guide and Reference Manual, Addison - Wesley, New York, second edition, 1994.
2. M.R.C. van Dongen: LATEX and Friends, Springer-Verlag Berlin Heidelberg 2012.
3. Stefan Kottwitz: LATEX Cookbook, Packt Publishing 2015.
4. David F. Griffths and Desmond J. Higham: Learning LATEX (second edition), Siam 2016.

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SEC-2 BSMT 132 Mathematical Methods with MATLAB (3 CREDITS)

	Course Outcomes
CO 1	Acquire fundamental knowledge of MATLAB environment and its core functionalities.
CO 2	Comprehend various data types in MATLAB and their appropriate applications in computational tasks.
CO 3	Develop proficiency in creating and utilizing script files, function files, and language-specific constructs.
CO 4	Understand the applications of MATLAB in diverse areas of Mathematical Sciences.
CO 5	Gain the ability to generate and interpret graphical outputs and leverage MATLAB toolboxes for specialized computations.

Unit-I: Basics of MATLAB (Sec: 1.1, 1.6 (1.6.1, 1.6.3-1.6.6), 2.2-2.6, 2.8, 2.9)

Programming, Basics of MATLAB, Input-output, File types, General commands, Creating and working with arrays of numbers, Printing simple plots, Creating; saving and executing a script file, Creating and executing a function file, Arrays and matrices, Symbolic computation Importing and exporting data.

Unit–II: Interactive Computation (3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8)

Matrices and vectors, Matrix and array operations, Character strings, A special note on array operations, Command-Line functions, Built-in functions, Saving and loading data, Plotting simple graphs.

Unit-III: Scripts and Functions (4.1, 4.2, 4.3, 4.4, 4.5)

Script files, Function files, Language-specific features, Advanced data objects, Publishing reports.

Unit–IV: Applications in Mathematical Sciences (5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7)

Linear Algebra, Curve fitting and interpolation, Data analysis and statistics, Numerical integration, Ordinary differential equations, Nonlinear algebraic equations, Partial differential equations.

Unit–V: Graphics and Toolbox (6.1, 6.2, 6.3, 6.4, 6.6, 6.7, 8.1, 8.2, 8.5)

Basic 2-D plots, Using subplot for multiple graphs, 3-D plots, Handle graphics, Saving and printing graphs, Animation, The symbolic math toolbox, Numeric versus symbolic computation, Using MuPAD notebook.

Text Book:

1. Rudra Pratap (2010), Getting Started with MATLAB, Oxford University Press.

References:

1. Gilat A (2012), Matlab An Introduction with Applications (4th Edition), John Wiley.
2. R K Bansal, A K Goyal, M K Sharma, MATLAB and its Applications in Engineering, 2nd Edition, Pearson.
3. S S Alam S N Alam (2019), Understanding MATLAB A Textbook for Beginners, Wiley India.

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CO 5	*	***	***	**	***	***	*	**	***	***

SEC-3 BSMT 133 SCILAB FOR MATHEMATICS (3 CREDITS)

Course Objectives:

1. learn about the SCILAB free and Open source software
2. To familiarize with commands, operations and how to evaluate and compute mathematical equations using SCILAB.
3. To learn to plot functions using SCILAB

	Course Outcome
CO 1	To enable learners to Install the FOSS SCILAB into their Desktops/Laptops
CO 2	To learn to familiarize with various SCILAB Commands to perform calculations
CO 3	To evaluate, compute various Mathematical equations and Plotting functions
CO 4	To compute Differentiation, Integration using Scilab commands
CO 5	To apply Scilab commands to solve Linear Equations

Unit-I: SCILAB Basics: Overview of SCILAB – Get started – Basic elements of the language – Matrices

Unit-II: SCILAB Programming, Looping and Branching – Functions – Plotting

Unit-III: SCILAB for Differential Calculus

Unit-IV: Scilab for Integration

Unit-V: Scilab for Linear Algebra

Text Books:

1. Introduction to SCILAB – Michael Baudin From SCILAB Consortium, 2010
2. SCILAB Online Materials:
3.https://help.scilab.org/docs/5.5.2/en_US/section_33491857221a48388b878311e9f4b67e.html

Reference Books:

1. https://www.scilab.org/tutorials
2. SCILAB help documentation – Statistics
3.https://www.scilab.org/sites/default/files/Basic%20Statistics%20and%20Probability%20with%20SCILAB%20-%20Gilberto%20E.%20Urroz%20-%202001.pdf

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MINOR COURSES OFFERED FOR MATHEMATICS STUDENTS

Minor **BSMT 231: NUMERICAL METHODS** **(4 CREDITS)**

Course Objectives:

1. To develop the ability to compute numerical solutions of algebraic and transcendental equations with accuracy and efficiency.
2. To understand and apply various numerical techniques for solving systems of linear and nonlinear equations, ordinary differential equations, and evaluating definite integrals.

	Course Outcomes
CO 1	Acquire proficiency in numerical techniques for determining the roots of nonlinear single-variable functions with specified accuracy.
CO 2	Analyse errors and evaluate the convergence behaviour of selected numerical algorithms.
CO 3	Understand and implement a range of interpolation and extrapolation methods for data approximation.
CO 4	Perform numerical differentiation and integration with accuracy and efficiency.
CO 5	Apply appropriate numerical methods to solve linear and nonlinear systems of equations effectively.

Unit I (Sections: 1.2, 1.3, 2.1,2.2,2.3**):** Roundoff errors and computer arithmetic-The rate of convergence of a sequence of real numbers- Bisection method-Fixed point iteration method-Newton's Method-Secant Method-Method of False position.

Unit II (Sections: 2.4,2.5,3.1,3.2,3.4**) :** Error Analysis for iterative methods-Accelerating convergence-Muller's Method-Lagrange's interpolation polynomial-Divided Differences-Newton's divided difference formula-Cubic Spline interpolation.

Unit III (Sections: 4.1, 4.3,4.4**):** Numerical differentiation-Numerical Integration-Trapezoidal rule – Simpson's rules-Composite Numerical integration

Unit IV (Sections: 6.1,6.2,6.4,6.5,6.6**):** System of linear equations-Gauss elimination method-Gauss Jordan Method-Pivoting strategies-LU factorization- Crout's Method.

Unit V (Sections: 7.1,7.2,9.2**):** Norms of vectors and matrices-Jacobi iterative method-Gauss Seidel iterative method-The power method.

Text Book: Richard L. Burden and J. Douglas Faires, Numerical Analysis, (7^{th} edition) CENGAGE Learning 2001.

Reference Books

1. Brian Bradle, A Friendly Introduction to Numerical Analysis , Pearson India, 2007
2. M.K.Jain, S.R.K.Iyengar and R.K Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publishers 2012.
3. Sauel D Conte and Carl de Boor, Elementary Numerical Analysis(3e), Tata Mcgraw Hill.

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Minor **BSMT 232 : PYTHON** **(4 CREDITS)**

Course Objectives:

1. To develop the capability to formulate, analyse, and computationally solve mathematical problems through the application of Python programming techniques.
2. To investigate and demonstrate the utility of open-source computational frameworks for performing both numerical analysis and symbolic computation.

	Course Outcomes
CO 1	Demonstrate proficiency in generating and visualizing diverse geometric shapes and graphical representations programmatically.
CO 2	Apply numerical methods to solve mathematical problems arising in calculus, linear algebra, and differential equations.
CO 3	Derive symbolic solutions for mathematical problems in calculus, linear algebra, and differential equations using computational tools.
CO 4	Solve standard mathematical problems symbolically, emphasizing algorithmic and analytical approaches.
CO 5	Develop automated documents integrating computed values, plots, and visualizations using Python for reproducible scientific reporting.

Unit I: Drawing Shapes, Graphing and Visualization: Drawing diverse shapes using code and Turtle; Using matplotlib and NumPy for data organization, Structuring and plotting lines, bars, markers, contours and fields, managing subplots and axes; Pyplot and subplots, Animations of decay, Bayes update, Random walk.

Unit II: Numerical Solutions of Mathematical Problems: NumPy for scalars and linear algebra on n-dimensional arrays; Computing eigenspace, Solving dynamical systems on coupled ordinary differential equations, Functional programming fundamentals using NumPy

Unit III: Symbolic Solutions-I : Symbolic computation and SymPy: Differentiation and integration of functions, Limits, Solution of ordinary differential equations, Computation of eigenvalues, Solution of expressions at multiple points (lambdify), Simplification of expressions.

Unit IV: Symbolic Solutions-II : Factorization, Collecting and canceling terms, Partial fraction decomposition, Trigonometric simplification, Exponential and logarithms, Series expansion and finite differences, Solvers, Recursive equations.

Unit V: Document Generation with Python : Pretty printing using SymPy; Pandas API for IO tools: interfacing Python with text/csv, HTML, LaTeX, XML, MSExcel, OpenDocument, and other such formats; Pylatex and writing document files from Python with auto-computed values, Plots and visualizations.

Text Books

1. Peter Farrell, Math Adventures with Python, No Starch Press, US 2019.
2. Farrell, Peter and et al. The Statistics and Calculus with Python Workshop, 1st edition, Packt Publishing 2020.
3. Amit Saha, Doing Math with Python, No Starch Press, US 2015.

Reference Book

1. Sam Morley, Applying Math with Python, 2nd edition, Packt Publishing 2022.
2. Online resources and documentation on the libraries, viz
https://patrickwalls.github.io/mathematicalpython/
https://matplotlib.org, https://sympy.org,
https://pandas.pydata.org, https://numpy.org, https://pypi.org,

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Minor **BSMT 233 : ELEMENTS OF MECHANICS (4 CREDITS)**

Course Objectives:

1. To introduce the concepts of space, time, and paths; Equations of Motion
2. To make the students understand the moving frames of reference, rotating frames.
3. To enable the students to learn Rigid Body motions.

	Course Outcomes
CO 1	Apply Newton's laws of motion and central force concepts to analyse one-, two-, and three-dimensional particle motions, including stability of circular orbits.
CO 2	Demonstrate understanding of energy conservation principles and evaluate particle motion in inertial and rotating frames of reference, including motions on Earth's surface.
CO 3	Examine many-particle systems by formulating equations of motion for the center of mass, angular momentum, and rigid bodies with different degrees of freedom.
CO 4	Analyse rigid body dynamics through inertia tensors, angular velocity, angular momentum, and energy relations, and apply these to real-world problems.
CO 5	Evaluate and solve problems in rigid body motion, such as dynamical symmetry, axial symmetry (tops, precession), and rolling motions using mathematical methods.

Unit I:Newton's laws and Central forces: Introduction, Space, time, and paths, forces, Newton's second law, One-dimensional motions, Particle motion in two and three dimensions, Moving frames of reference Central forces and angular momentum, The scalar equations of motion in place polar coordinates, the equation of path, Condition for stability of circular orbits, General examples.

Unit II:Energy and Rotating frames: The one-dimensional case, the general case, Conservation of energy, Application to central forces, Motion of a particle on a surface under gravity. Two dimensional Rotating Frame, Angular Velocity Vector, Particle moving in a rotating frame of reference, Motion on the surface of the earth.

Unit III:Many-particle systems, Rigid bodies: equations: Motion of centre of mass, Angular momentum and moment of force, Rigid bodies: degrees of freedom, the angular velocity.

Unit IV:Rigid bodies: equations: The equations of motion, Angular momentum and angular velocity, Calculation of the inertia tensor, Application to calculation of angular momentum, Energy.

Unit V:Soluble problems in rigid body motion: Bodies with dynamical symmetry, Bodies with axial symmetry: top, Precession, General rotation of a rigid body fixed at one point, Rolling spheres.

Text Book: Mary Lunn, A First Course in Mechanics, Oxford New York, Tokyo, Oxford University Press 1991.

Reference Books

1. Mechanics -P. Duraipandian S. Chand Limited, 1995
2. Classical Mechanics: Goldstein, Pearson Education India 2002
3. Classical Mechanics: Rana & Joag, Rana, Tata McGraw-Hill Education, 2001

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Minor **BSMT 331: MATHEMATICAL MODELLING** **(4 CREDITS)**

Course Objectives:

1. To develop the ability to analyse and visualize mathematical concepts and methods using MATLAB as a computational tool.
2. To acquire proficiency in structured programming and algorithmic problem-solving through the MATLAB environment.

	Course Outcomes
CO 1	Acquire fundamental knowledge of MATLAB environment and its core functionalities.
CO 2	Comprehend various data types in MATLAB and their appropriate applications in computational tasks.
CO 3	Develop proficiency in creating and utilizing script files, function files, and language-specific constructs.
CO 4	Understand the applications of MATLAB in diverse areas of Mathematical Sciences.
CO 5	Gain the ability to generate and interpret graphical outputs and leverage MATLAB toolboxes for specialized computations.

Unit I: History of Mathematical Modeling, Latest development in Mathematical Modeling, Merits and Demerits of Mathematical Modeling, Quantitative and Qualitative approach of modeling, Conceptual and Physical models, stationary and nonstationary models, distributed and lumped models, models in real world problems

Unit II: Introduction to difference equations, Non-linear Difference equations, Steady state solution and linear stability analysis. Discrete dynamical systems: equilibrium and long-term behavior, Linear Models, Growth models, Decay models, Drug Delivery Problem, Linear Prey-Predator models, Volterra's principle, Lanchester combat model.

Unit III: Application of first order differential equations to acceleration-velocity model, Growth and decay model. Introduction to Continuous Models, Drug Distribution in the Body, Interacting population models, Epidemic Models (SI, SIR, SIRS, SIS, SEIR), Steady State solutions, Linearization and Local Stability Analysis, logistic, predator-prey model, Competition models.

Unit IV: Introduction to compartmental models, Lake pollution model (with case study of Lake Burley Griffin), Exponential growth of population, Limited growth of population, Limited growth with harvesting, Battle model and its analysis.

Unit V: Spline, Random numbers, Generating discrete and continuous random variables, Multiple Regression, Variance reduction techniques, Statistical validation techniques, Markov chain, Monte Carlo methods and applications.

Text Book

1. Barnes, Belinda & Fulford, Glenn R., Mathematical Modelling with Case Studies, Using Maple and MATLAB, 3rd edition, CRC Press, Taylor & Francis Group 2015.
2. J. N. Kapur, Mathematical Modeling, New Age International 2005.

Reference Books:

1.Albright B., Mathematical Modeling with Excel, Jones and Bartlett Publishers 2010.
2. F. R. Marotto, Introduction to Mathematical Modeling using Discrete Dynamical Systems, Thomson Brooks/Cole 2006.
3. Willy, Mathematical modelling and simulation: introduction for scientist and engineers, , Kai Velten 2008.

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Minor **BSMT 332: AUTOMATA THEORY** **(4 CREDITS)**

Course Objectives:

1. To introduce finite state automata – deterministic and non-deterministic.
2. To learn the concept of grammars and regular expressions and their relations.

	Course Outcomes
CO 1	Fundamental knowledge to the concepts of finite state automata – deterministic and non-deterministic
CO 2	Understanding regular expression and algebraic laws of regular expression
CO 3	Learning regular languages and their relation with finite automata
CO 4	Knowledge about grammars in automata theory
CO 5	Understanding Pushdown automata and the equivalence of Pushdown automata and contest free grammar

UNIT I (Sections 1.5, 2.1-2.3**) :** Alphabets, strings, and languages. Finite Automata deterministic and non-deterministic finite automata – Properties of transition functions – The equivalence of DFA and NFA.

UNIT II (Sections 3.1,3.2,3.4**):** Regular expressions, finite automata and regular expressions – algebraic laws for regular expressions.

UNIT III (Sections 4.1,4.2**):**Regular languages and their relationship with finite automata, pumping lemma for regular languages – closure properties of regular languages.

UNIT IV (Sections 5.1.5.2.5.4**):**Context Free Grammars – parse trees – ambiguities in grammars and languages.

UNIT V (Sections 6.1-6.4**):**Pushdown automata – the language of a Pushdown automata – Equivalence of Pushdown automata and context free grammar – deterministic PDA.

Text book

3. John E. Hopcroft, Rajeev Motwani and J.D. Ullman, Introduction to Automata Theory Languages and Computation, Third Edition, Pearson Addison-Wesley, 2006.

Reference books

1. J.A. Anderson, Automata theory with modern applications, Cambridge University Press, 2006.

2. H.R. Lewis, C.H. Papadimitriou, C. Papadimitriou, Elements of the Theory of Computation, 2nd Ed., Prentice-Hall, NJ, 1997.

3. K L P Mishra and N Chandrasekaran, Theory of Computer Science Automata, Languages and Computation, Third Edition, Prentice Hall India, New Delhi, 2006.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	**	**	**	**	**	*	**	**	*	***
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Minor **BSMT 333 :VECTOR ANALYSIS**

Course Objectives:

1. To learn about the geometry of curves and surfaces in R^2 and R^3.
2. To learn curl of a vector field and the divergence of a scalar field and the fundamental theorems of vector calculus

	Course Outcomes
CO 1	Able to understand geometry of curves and surfaces using vectors.
CO 2	Understanding the line integrals and its applications in physics
CO 3	Able to understand the surface integrals and its application to study the fluid flow.
CO 4	Knowledge of Green's, Stokes and gauss Theorems and their applications to physics.
CO 5	Able to prove Fundamental Theorem of Calculus and its connection with Conservation of vector fields.

Unit I (Sections: 1.1-1.6 and 4.1-4.4**) :** Vectors in the plane and space- The inner product and the distance-The cross product and the planes-Curves in the plane and space-Tangents, velocity and speed-Arc length- Vector fields-flow lines-Divergence and curl

Unit II (Sections: 6.1, 6.2**) :** Line Integrals-Line integrals of gradient fields-Independence of parametrization-Line integrals along geometric curves- Work done by a force field- parametrized surfaces- tangent plane.

Unit III (Sections: 6.3, 6.4**) :** Area of a surface-Integral of a scalar function over a surface-Surface integral-The surface integral for Graphs-Surface integral for fluid flow-Area of a shadow.

Unit -IV (Sections: 7.1, 7.2**):** Green's Theorem-Area of a region in Green's Theorem-Vector form of Green's theorem-Gauss Divergence Theorem in the plane-Stokes Theorem for graphs-Circulation and curl.

Unit-V (Sections: 7.3, 7.4**) :** Gauss Theorem-Divergence and Flux-Path independence and the Fundamental Theorem of Calculus-Conservation of vector fields-Curl and gradient-Cross derivative test in the plane-Antiderivative of vector fields-Divergence and Curl.

Text Book: J.E Marsden, A.J Tromba, and A. Weinstein, Basic Multivariable calculus, Springer, 2004.

Reference Books

1. Howard Anton, Irl Bivens, Stephens Davis, Calculus 10e, Wiley India.
2. James Stewart, Calculus, Early Transendentals, 7e CENGAGE India.
3. George B. Thomas, Maurice D Weir, Joel Hass, Frank R Giordono, Thomas calculus 11e, Pearson India.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	***	***	**	*	***		**	***	***	**
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NEP MINOR COURSES
[to other departments STAT & PHY, etc….]

Minor: **BSMT 161: BASIC CALCULUS** **(4 CREDITS)**

Course Objectives:

This course enables the students to learn

1. Derivatives of functions and analyse Maxima and Minima.
2. To understand the idea of applications of integrations

	Course Outcomes On successful completion of this course, the student will be able to
CO 1	Solve derivatives of some function and Maxima and Minima
CO 2	Understand the concepts of Asymptotes, concavity & convexity point of inflexion
CO 3	Understand the basics idea of integration, evaluation of integrals
CO 4	Determine the Integration by parts and Integration of rational fractions
CO 5	Apply the integration concepts in finding area between the curves, volumes of slicing etc.

Unit I:

Quick review of Derivative of some familiar functions Application of Derivatives - Increasing decreasing functions - Maxima minima-Error –Approximation- Optimization-Newton method- Mean value theorems.

Unit II:

Asymptotes- Test of concavity& convexity point of inflexion- Multiple point training curves in Cartesian & Polar co-ordinates. Successive differentiation- Leibnitz rule- Problems and examples.

Unit III:

Definite integrals - Properties of definite integrals - Integral as the limits of a sum- Evaluation of integrals- Area and the mean value theorem-The fundamental theorem(without proof)- Substitution in definite integrals.

Unit IV:

Integration by parts (theorem and examples) – Integration of rational fractions-Reduction formulas.

Unit V:

Areas between curves- Finding volume by slicing- Volumes of solids of revolution - Disk and washers- Cylindrical shell- Lengths of plane curves- Areas of surface of revolution.

Text Book

1. George B.Thomas, Maurice D.Weir and Joel Hass, Thomas' Calculus 12th Edition, Pearson Education, 2015.

Reference Books

8. Richard Courant and Fritz John, Introduction to Calculus and Analysis, Vol.I, Springer 1999.
9. Serge Lang A First course in Calculus 5th edition, Springer, 1999.
10. N. P. Bali, Integral Calculus, Laxmi Publications, Delhi 1991.
11. Richard Courant and Fritz John, Introduction to Calculus and Analysis, Volumes I & II Springer, SIE, 2004.
12. Serge Lang A First course in Calculus 5th edition, Springer, 1999.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	***	**	***	**	*	**	**	**	*	**
CO 2	**	**	***	**		**	**	**		**
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Minor: BSMT 162: BASIC ALGEBRA AND THEORY OF EQUATIONS (4 CREDITS)

Course Objectives:

This course enables the students to learn

1. To introduce about the algebra of matrices and to solve system of linear equations using matrix theory
2. About the relations between the roots and coefficients, Transformation of equation and solutions Reciprocal, cubic and biquadratic equations.

	Course Outcomes On successful completion of this course, the student will be able to
CO 1	Understand the concepts of algebra of matrices
CO 2	Sole the system of linear equations using matrix theory
CO 3	Identify the relation between coefficients of the equation and its roots.
CO 4	Familiarize about the transformations of equations, Reciprocal equations and finding nature of roots using Descartes rule. .
CO 5	Know about the algebraic solutions of Cubic and Biquadratic equations.

Unit I: (Sections 1.1, 1.2, 1.3,1.4,1.5 of [1])

Linear systems - Matrices - Dot product and Matrix multiplication - Properties of Matrix operation, Matrix transformations.

Unit II: (Sections 1.6,1.7,1.8[1])

Solutions of Linear systems of equations - Row echelon from reduced row echelon form – Polynomial interpolation - The inverse of a Matrix. - Linear Systems and inverses - LU- Factorization Method.

Unit III: (Sections 5.1,5-2,.5.3 of [2])

Division algorithm - Relation between roots and coefficients - Sum of the powers of the roots.

Unit IV: (section 5.4,5.5,5.6 ,5.7 of [2])

Reciprocal equations - Transformation of equations: - Multiple roots - Nature of position of roots - Sturm's Theorem.

Unit V: (Sections 5.8,5.9,5.10 of [2])

Cardan's Method for solving Cubic equations – Ferrari's Method for solving biquadratic equations - New Newton's Method- Horner's Method

Text Books

1. Bernard Kolman Drid R. Hill, Introductory Linear Algebra, (8e),Pearson India (2011)
3. S. Arumugam and A Thangaand Isaac, Set Theory Number System and Theory of Equations, New Gamma publishing house(1997.).

References:

1. Theory of Equations, Hari Kishan, Atlantic Publishers, 2022
2.Theory of Equations, Lalji Prasad, New Revised Edition, 2016

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	***	**	***	*	**		*	**		*
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Minor: **BSMT 261: FUNDAMENTALS OF REAL ANALYSIS** **(4 CREDITS)**

Course Objectives:

1. To study the importance of the lub property of the real number system.
2. To study the properties of a convergent sequence.

	Course Outcomes
CO 1	Understand convergent sequences, monotonic sequences, and apply the Bolzano–Weierstrass theorem.
CO 2	Apply convergence tests (Comparison, Ratio, Root, Integral, Alternating, Abel's) to determine the convergence of infinite series.
CO 3	Demonstrate understanding of limits of functions, sequence version of limits, and apply limit theorems, including one-sided limits.
CO 4	Analyse continuity of functions, apply the Intermediate Value Theorem, Maximum–Minimum Theorem, and establish the existence of roots.
CO 5	Differentiate functions and apply algebra of derivatives, Rolle's Theorem, Mean Value Theorem, Darboux's Theorem, and Taylor's Theorem for problem solving.

Unit I:[Sections: 3.1, 3.2, 3.3, 3.4]

Convergent sequence Examples – convergent sequences – Limit Theorems – Monotorie sequences Bolzano – Weinerstrars Theorem.

Unit II: [Sections: 3.7, 9.2, 9.3]

Infinite Series – The Cauchy criterion - Examples - Comparison Test - Limit Comparison Test - The Canchy Condensation Test - Absolute Convergence - The root Test – The ratio Test - The Integral Test- Alternating Serier Test - Abel's Test.

Unit III: [Sections: 4.1 4.2, 4, 3].

Limits of function – Examples – Sequence version of the limit of a function - Limit Theorems -One-sided limits.

Unit IV: [Sections: 5.1,5-2, 5·3]

Continuous functions - Examples – Algebra - Continuous functions on intervals - Continuous functions - Intervals Maximum Minimum Theorem – Location of Roots Theorem – Bolzanos Intermediate value theorem

Unit V: [Sections: 6.1,6.2,6.4]

Differentiable functions - Algebra of differentiable functions – Chain Rule - Interior Extremum Theorem - Rolle's Theorem -Mean value Theorem - First derivative Test - Darboux's Theorem - Taylor's Theorem.

Text book:

R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis 4e Wiley India, 2016.

Reference Books

1. Richard R Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co. Pvt Ltd, New Delhi, Indian Edition 1970.
2. Kenneth A. Ross, *Elementary Analysis: The Theory of Calculus*, springer, 2e (2013).

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	**	**	***	**	**		***	**	***	
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Minor: BSMT 262: INTRODUCTION TO DIFFERENTIAL EQUATIONS (4 CREDITS)

Course Objectives:

1. To understand ordinary and first order partial differential equations and their applications
2. To understand the first and second order ordinary differential equations and their solution procedures.

	Course Outcome
CO 1	To solve a system of first order ODEs
CO 2	To analyze the stability of a Dynamical System using Differential Equations and their solutions
CO 3	To Solve First Order Partial Differential Equations
CO 4	To Understand and Solve a system of ODEs and their characteristics
CO 5	To understand PDEs and solve first order Partial Differential Equations

Unit I: [Sections 1.5-1.8 from [1]**]**
Exact differential equations- Integrating factors – Linear differential equations- Bernoulli equation – Modeling: Electric circuits – Orthogonal trajectories of curves.

Unit II: [Sections 2.1-2.7 from [1]**]**
Homogeneous linear equations of second order – Second order homogeneous equations with constant coefficients – Case of complex roots- Complex exponential function – Differential operators – Modeling: Free oscillations – Euler-Cauchy equation – Existence and uniqueness theory – Wronskian.

Unit III: [Sections 2.8-2.10, 2.13, 2.14 from [1]]
Non homogeneous equations – Solution by undetermined coefficients – Solution by variation of parameters – Modeling of electric circuits – Higher order linear differential equations – Higher order homogeneous equations with constant coefficients.

Unit IV: [Sections 3.0-3.4 from [1]]
Introduction: vectors, matrices, eigenvalues – Introductory examples – Basic concepts and theory – Homogeneous systems with constant coefficients, phase plane, critical points – Criteria for critical points, Stability.

Unit V: Chapter 1 from [2]
Non-linear first order PDEs : Compatible systems- Solutions of Quasi linear equations
Charpit's method - Special Types of Charpits Method,

Text Book

1. Erwin Kreyszig, Advanced Engineering Mathematics, 8th Edition, John Wiley & Sons, 1999.
2. K. Shankara Rao, Introduction to Partial Differential Equations, PHI Publications, 3rd Edition. 2011. – Chapter 1

Reference Books

1. George F. Simmons, Differential Equations, Tata McGraw-Hill, New Delhi, 1972.
2. Boyce and Di Prima, Differential Equations and Boundary Value Problems, Wiley,10th edition 2012.
3. Earl A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall of India Private Ltd, 1991.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	**	**	***	**	*	*	**	**	*	**
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CO 5	**	**	***	*	*	**	*	**	*	***

Minor: **BSMT 361: CALCULUS OF SEVERAL VARIABLES** **(4 CREDITS)**

Course Objectives:

1. To learn about differentiation, partial differentiation and to calculate directional derivatives and gradients.
2. To learn about maxima and minima of two and more variables.

	Course Outcomes
CO 1	To study about partial derivatives and the chain rule
CO 2	To study about maxima and minima Extreme values and saddle points
CO 3	To study about Fubini's theorem for calculating double integrals
CO 4	To apply the double to find volume and area of curves
CO 5	To study about triple integrals and change of integrals

Unit I: [Sections: 14.1, 14,2,14,3 and 14.4]

Functions of several variables-Level set and graphs-Limit and continuity-Two path test for nonexistence of a limit-Partial derivatives-The chain rule..

Unit II: **[Sections: 14.5, 14.6, 14.7 and 14.8]**

Directional derivatives and gradient vectors- Gradients and tangents to level curves- Tangent planes and normal lines- Linear approximation- Extreme values and saddle points- Second derivative test for local extrema-Lagrange multipliers.

Unit III: [Sections: 14.10, 15.1 and 15.2]

Taylor's formula for two variables- Double integral over rectangles- Fubini's Theorem for calculating double integrals- Area, moments and centre of mass

Unit IV: [Sections: 15.3, 15.4 and 15.5]

Double integrals in polar form-Changing Cartesian integrals into polar integrals- Finding area in polar coordinates – Triple integrals in rectangular coordinates- Volume in triple integrals – Mass and moments in three dimensions.

Unit V: [**Sections: 15.6 and 15.7**]

Triple integrals in Cylindrical and spherical coordinates- Changing the order of integration in cylindrical and spherical coordinates.

Text Book:

George B. Thomas, Maurice D Weir, Joel Hass , Frank R Giordono, ***Thomas calculus 11e,*** Pearson India.

Reference Books:

1. Howard Anton, Irl Bivens, Stephens Davis, ***Calculus*** 10e, Wiley India.
2. James Stewart, ***Calculus, Early Transendentals,*** 7e CENGAGE India.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	***	**	***	**	**	**	**	*	*	**
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Minor: **BSMT-362: INTRODUCTION TO LINEAR ALGEBRA** **(4 CREDITS)**

Course Objectives:

1. To understand vector spaces by its definition and examples.
2. To know how to represent a linear transformation by a matrix

	Course Outcomes
CO 1	Understand and apply concepts of vector spaces and subspaces
CO 2	Analyze linear transformations and their matrix representations
CO 3	Perform matrix operations and solve systems of linear equations
CO 4	Compute determinants, eigenvalues, eigenvectors, and apply diagonalization
CO 5	Work with inner products, norms, and orthogonalization techniques

Unit I: Section 1.2 to 1.6

Abstract Algebra Concepts – Groups- Subgroups- Fields- examples Vector space- Subspace-linear combinations and systems of linear equations- Linear dependence and linear independence- Basis and dimension.

Unit II: Section 2.1 to 2.5

Linear Transformations- Null spaces- Range spaces- Dimension theorem- Matrix representation of linear transformation- composition of linear transformations and Matrix multiplication- Invert ability and Isomorphism- The change of coordinate matrix.

Unit III: Section 3.1 to 3.4

Elementary matrix Operations and elementary matrices- The rank of a matrix and matrix inverses- systems of linear equations- Theory and computation

Unit IV: Section 4.1 to 4.4 and 5.1 to 5.2, 5.4

Determinants of order 2 and order n- propertie4s of determinants- Important facts about determinants- Eigen values and Eigen vectors- Diagonalizability- Invariant spaces and Cayley- Hamilton theorem.

Unit V: Section 6.1, 6.2

Inner products and norms- The Gram-Schmidt orthogonalisation process and orthogonal complements.

Text Book

Stephen H. Friedberg, Arnold J. Insel and Lawrence E. Spence, Linear Algebra, 4th Edition,
Printice Hall of India Pvt. Ltd., 2006

Reference Books

1. S. Kumaresan, Linear Algebra Geometric Approach, Prentice Hall of India Pvt. Ltd., 2000.
2. I. N. Herstein, Topics in Algebra, 2nd Edition, John Wiley & Sons, 2003.
3. David C. Lay, Linear Algebra and Applications (2nd Edition), Addison Wesley, 1997.
4. John B. Fraleigh, A First Course in Abstract algebra, (7th Edition), Pearson 2013.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	***	**	**	**	**	**	**	**	*	**
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CO 5	***	**	**	**	**	**	**	**	*	**

Minor: **BSMT 461: VECTOR CALCULUS** **(4 CREDITS)**

Course Objectives:

1. To learn about the geometry of curves and surfaces in R^2 and R^3.
2. To learn curl of a vector field and the divergence of a scalar field and the fundamental theorems of vector calculus

	Course Outcomes
CO 1	Able to understand geometry of curves and surfaces using vectors.
CO 2	Understanding the line integrals and its applications in physics
CO 3	Able to understand the surface integrals and its application to study the fluid flow.
CO 4	Knowledge of Green's, Stokes and gauss Theorems and their applications to physics.
CO 5	Able to prove Fundamental Theorem of Calculus and its connection with Conservation of vector fields.

Unit I: [Sections: 13.1, 13,2,13,3, 13.4 and 13.5]

Vector functions- Modelling projectile motion- Arc length and the unit tangent vector- Curvature and the unit normal vector- Torsion and the unit binormal vector.

Unit II: **[Sections: 16.1 and 16.2]**

Line integrals- Mass and moment calculations- Vector fields- work, circulation and flux- Gradient vector field- work over a smooth curve- Flow integrals and circulation for velocity fields- Flux across a plane- Flux across a smooth closed curve..

Unit III: [Sections: 16.3 and 16.4]

Path dependence of line integrals – The fundamental Theorem of line integrals- Exact differential forms- Green's Theorem in the plane (normal form and tangential form)-Divergenc(flux density)-The Green's Theorem area formula.

Unit IV: [Sections: 16.5, and 16.6]

Surface area and surface integrals- Orientation- Moments and masses of thin shells- Flux across a surface- Parametrized surfaces- Area of a smooth surface- Parametric surface integral- Finding the center of mass.

Unit V: [**Sections: 16.7 and 16.8**]

The Curl of a vector field- Stoke's Theorem- Conservative fields and Stoke's theorem – The Divergence Theorem- The proof of divergence theorem for special regions- Properties of Curl and divergence.

Text Book:

George B. Thomas, Maurice D Weir, Joel Hass , Frank R Giordono, ***Thomas calculus 11e,*** Pearson India.

Reference Books:

1. Howard Anton, Irl Bivens, Stephens Davis, ***Calculus*** 10e, Wiley India.
2. James Stewart, ***Calculus, Early Transendentals,*** 7e CENGAGE India.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	***	***	**	*	***		**	***	***	**
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CO 3	***	**	**	**	**		**	***	***	**
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CO 5	***	**	**	*	***	*	*	***	***	**

Minor: **BSMT 462: INTRODUCTION TO COMPLEX ANALYSIS**

Course Objectives:

1. To develop a comprehensive understanding of analytic functions and the fundamental principles underlying series expansions.
2. To acquire a rigorous knowledge of conformal mappings and the associated elementary transformations, along with their mathematical properties and applications.

	Course Outcomes
CO 1	Comprehend the concept of differentiability for complex-valued functions and develop a rigorous understanding of the Cauchy–Riemann equations.
CO 2	Analyse and visualize complex-valued functions, including a detailed study of linear fractional (Möbius) transformations.
CO 3	Examine and apply the theory of line integrals, Cauchy's theorem, and Cauchy's integral formula in complex analysis.
CO 4	Classify singularities such as zeros and poles, and investigate fundamental results like the Maximum Modulus Principle.
CO 5	Determine residues and employ the residue theorem to evaluate complex and definite integrals, and represent complex functions through Taylor and Laurent series expansions.

Unit I: [Sections 12.1-12.5;**]** Complex numbers- Complex plane - Polar form of complex numbers- Powers and roots – Derivative- Analytic function - Cauchy- Riemann equations. Laplace's equation - Geometry of Analytic Functions- Conformal mapping.

Unit II: [Sections 12.6-12.9;] Exponential function - Trigonometric functions- Hyperbolic functions – Logarithm- General power - Linear fractional transformation.

Unit III: [Sections 13.1-13.4**]** Line integral in the complex plane - Cauchy's integral theorem - Cauchy's integral formula - Derivatives of analytic functions.

Unit IV: [Sections 14.1-14.4**]** Sequences- Series- Convergence tests - Power series - Functions given by power series - Taylor series and maclaurin Series

Unit V: [Sections 15.1-15.4**]** Laurent series - Singularities and zeros, Infinity - Residue integration method evaluation of real integrals.

Text Book:

Erwin Kreyszig, Advanced Engineering Mathematics, 8th Edition, John Wiley & Sons, 1998.

Reference Books

1. L. Ahlfors, Complex Analysis, McGraw-Hill International Edition, 1979.
2. R.V. Churchill, Complex Variables and Applications, 4th Edition, Mc Graw –Hill, 1948.
3. A.Mood, F.Graybill, and D.Boes, *Introduction to the Theory of Statistics*, Tata McGraw Hill (Third Edition) 2008.
4. George Grätzer, Lattice Theory: Foundation, Springer Basel AG, 2011.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	***	**	*	***	**	*	***	*	*	*
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CO 3	***	**	**	**	***	**	***	**	*	*
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MATHEMATICS Syllabi
for B. Tech Programs of
Computer Science, Banking Technology, Electronics, Green Energy, Nano Science and Environment Science Departments

BTMT 171	Mathematics-I	Sem- 1	3L:1T:0P:4 C

Course Objectives:

The course aims to:

1. Build a strong foundation in linear algebra, differential equations, multivariable calculus, and vector calculus, emphasizing their applications to science and engineering.
2. Develop analytical and problem-solving skills required to model, analyze, and solve real-world engineering problems using mathematical concepts

	Course Outcomes : By the end of this course, students will be able to:
CO 1	Apply concepts of matrix algebra, eigenvalues, eigenvectors, and quadratic forms to solve systems of linear equations and perform diagonalization.
CO 2	Solve first-order and higher-order ordinary differential equations using standard methods such as exact equations, variation of parameters, and Euler's equation.
CO 3	Analyze functions of several variables using partial derivatives, Taylor series, and optimization techniques for maxima and minima.
CO 4	Evaluate double and triple integrals in Cartesian, polar, cylindrical, and spherical coordinates, and apply them to compute areas and volumes.
CO 5	Interpret and compute vector differential operators (gradient, divergence, curl) and apply integral theorems of vector calculus to engineering problems.

Course Contents:

MODULE I LINEAR ALGEBRA(MATRICES) : Rank of a matrix - Consistency of a system of linear equations - Characteristic equation of a matrix - Eigen values and Eigen vectors - Properties of Eigen values and Eigen vectors - Cayley-Hamilton theorem (excluding proof)- Verification- Application (Finding Inverse and Power of a matrix)- Diagonalization of a matrix by orthogonal and similarity transformation- Quadratic form – Nature of Quadratic Form- Orthogonal reduction of quadratic form to canonical form.

MODULE II ORDINARY DIFFERENTIAL EQUATIONS: Differential Equations of First Order- Exact equations- Leibnitz's linear equations- Bernoulli's equation- Differential equations of Higher order- Linear differential equations of higher order with constant coefficients- Euler's linear equation of higher order with variable coefficients- Method of variation of parameters.

MODULE III MULTIVARIABLE CALCULUS (DIFFERENTIATION): Partial differentiation- Partial derivatives of first order and higher order- Partial differentiation of implicit functions- Euler's theorem on homogeneous functions - Total derivative - Taylor's series for functions of two variables- Maxima and minima of functions of two variables.

MODULE IV MULTIVARIABLE CALCULUS (MULTIPLE INTEGRALS): Double integration (Cartesian form and Polar form)-constant limits- variable limits- over the region R- Changeof variables in double integrals (Cartesian to polar) - Application of double integral- Area by double integration- Change of Order of Integration- Triple Integration (Cartesian- Spherical and Cylindrical)- constant limits- variable limits- over the region R- Application of triple integral- Volume by triple integration.

MODULE V MULTIVARIABLE CALCULUS (VECTOR CALCULUS): Vector Differential Operator- Gradient - Properties - Directional derivative - Divergence and curl Properties and relations- Solenoidal and Irrotational vector fields - Line integral and Surface integrals - Integral Theorems (excluding Proof) - Green's theorem - Stokes' theorem - Gauss divergence theorem.

Text Books:

1. Bali N.P. and Manish Goyal., "A Text Book of Engineering Mathematics", Laxmi Publications (P) Ltd, 9th Edition, 2014
2. Veerarajan T., "Engineering Mathematics - I & II ", Tata McGraw-Hill, New Delhi, 2014 & 2015.

References:

1. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 43rd Edition, 2014.
2. Dr. M.K. Venkataraman, "Engineering Mathematics – Volume I and Volume II", The National Publishing Company, Chennai, 2008.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, New Delhi, 9thEdition, 2011 Ramana B.V.,

ONLINE / NPTEL Courses:

1. Differential equations for engineers: https://nptel.ac.in/courses/111106100
2. Calculus of Several Real Variables: https://nptel.ac.in/courses/111104125
3. Engineering Mathematics - I: https://nptel.ac.in/courses/111105121
4. Matrix Analysis with Applications: https://nptel.ac.in/courses/111107112

"Higher Engineering Mathematics", Tata McGraw-Hill, New Delhi, 2010

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BTMT 172	Mathematics- II	Sem-2	3L:1T:0P:4C

Course Objectives:

The course aims to:

1. To introduce the concepts of partial differential equations, Laplace transforms, Fourier transforms, and Fourier series as essential mathematical tools for engineering applications.
2. To equip students with the ability to model, analyze, and solve real-world problems in science and engineering using these transform techniques.

	Course Outcomes : By the end of this course, students will be able to:
CO 1	Formulate and solve first-order and higher-order partial differential equations relevant to physical and engineering problems.
CO 2	Apply Laplace transform techniques, including properties and initial/final value theorems, to simplify and solve problems in mathematics and engineering.
CO 3	Compute inverse Laplace transforms using standard methods and apply them to solve linear ordinary differential equations and systems of equations.
CO 4	Utilize Fourier transforms and their properties to analyze and represent functions, including applications of convolution and Parseval's identity.
CO 5	Expand periodic functions into Fourier series, apply half-range expansions, and use Parseval's theorem for harmonic analysis.

Course Contents:

MODULE I PARTIAL DIFFERENTIAL EQUATIONS (12 Hrs)

Formation of partial differential equations, Solutions of standard types of first order partial differential equations, Lagrange s linear equation, Linear partial differential equations of second and higher order with constant coefficients of both homogeneous and non-homogeneous types.

MODULE II LAPLACE TRANSFORM (12 Hrs)

Existence conditions, Transforms of elementary functions , Properties, Transform of unit step function and unitimpulse function , Transforms of derivatives and integrals , Transforms of Periodic Functions , Initial and final value theorems.

MODULE III INVERSE LAPLACE TRANSFORM (12 Hrs)

Inverse Laplace Transforms Properties, Convolution theorem, Application - Solution of ordinary differential equations with constant coefficients - Solution of simultaneous ordinary differential equations.

MODULE IV FOURIER TRANSFORM (12 Hrs)

Fourier Integral theorem (statement only) , Fourier transform and its inverse, Properties: Fourier sine and cosine transforms, Properties, Convolution and Parseval s identity.

MODULE V FOURIER SERIES (12 Hrs)

Dirichlet s conditions , Expansion of periodic functions into Fourier series- Change of interval, Half-range Fourier series, Root mean square value - Parseval s theorem on Fourier coefficients, Harmonic analysis.

Text Books:

1. Grewal B.S, "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 43rd Edition, 2015.
2. Bali N.P and Manish Goyal., "A Text Book of Engineering Mathematics", Laxmi Publications(P) Ltd,2011.

References:

1. Veerarajan T, "Transforms and Partial Differential Equations", Tata McGraw-Hill, New Delhi, 2012.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, New Delhi, 9th Edition,2011.
3. Ramana B.V., "Higher Engineering Mathematics", Tata McGraw-Hill, New Delhi, 2010.

ONLINE / NPTEL Courses:

1. Laplace Transform: https://nptel.ac.in/courses/111106139
2. Partial Differential Equations: https://nptel.ac.in/courses/111101153
3. Advanced Engineering Mathematics: https://nptel.ac.in/courses/111107119

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BTMT 173	Subject Title APPLIED LINEAR ALGEBRA – SEM 2	L T P C 3 0 0 3

Learning Objectives:

1. To provide a strong foundation in linear algebra concepts such as vector spaces, linear transformations, orthogonality, and eigenvalue problems, and their applications.
2. To equip students with direct and iterative numerical methods for solving systems of equations and eigenvalue problems arising in science and engineering.

	Course Outcomes : By the end of this course, students will be able to:
CO 1	Explain and apply the fundamental concepts of vector spaces, subspaces, linear dependence/independence, basis, and dimension.
CO 2	Analyze linear transformations, their matrix representations, and apply diagonalization techniques to solve systems of differential equations.
CO 3	Utilize inner product spaces, orthogonality, and Gram-Schmidt orthogonalization to construct orthonormal bases and perform least-square approximations.
CO 4	Solve systems of linear equations using direct methods (Gauss elimination, Gauss-Jordan, LU/Cholesky decomposition) and iterative methods (Jacobi, Gauss-Seidel, SOR).
CO 5	Implement and analyze numerical methods for eigenvalue problems, including Power method, Jacobi's rotation method, QR decomposition, and Singular Value Decomposition (SVD).

Components of Teaching Type: *Classroom Based Teaching*

Unit I: Vector spaces

Vector spaces – Subspaces – Linear combinations and linear system of equations. Linear independence and Linear dependence – Basis and Dimension

Unit II: Linear Transformations

Linear Transformation – Null space, Range space - Dimension theorem - Matrix representations of Linear Transformations. Eigenvalues and Eigenvectors of a linear transformation – Diagonalization of linear transformations – Application of diagonalization in a linear system of differential equations.

Unit III: Orthogonal vectors

Inner Product Spaces –Norms - Orthogonal vectors – Gram Schmidt orthogonalization process – Least Square Approximations

Unit IV: Linear system of equations

Solution of linear system of equations – Direct method: Gauss elimination method – Pivoting – Gauss Jordan method -LU decomposition method – Cholesky decomposition method Iterative methods: Gauss-Jacobi and Gauss-Seidel – SOR Method

Unit V: Eigenvalue problems

Eigenvalue Problems: Power method – Inverse Power method - Jacobi's rotation method Generalized Inverses QR decomposition - Singular Value Decomposition method

Text and Reference Books:

1. **Stephen H. Friedberg, Insel A.J. and Spence L.E., "Linear Algebra", 4th. Edition, Prentice - Hall of India, New Delhi, 2003.**
2. M.K.Jain, S.R.K.Iyengar, R.K.Jain, "Numerical Methods for Scientific and Engineering Computation", New Age International (P) Limited, New Delhi, 2003.
3. Strang G., "Linear Algebra and its Applications", Thomson (Brooks/Cole), New Delhi, 2005.
4. Kumaresan. S., "Linear Algebra – A Geometric Approach", PHI, New Delhi, 2010.
5. Faires J.D. and Burden R., "Numerical Methods", Brooks/Cole (Thomson Publications), New Delhi, 2002.

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BTMT 271	Subject Title DISCRETE MATHEMATICS SEM-3	L T P C 3 1 0 4

Course Objectives:

The course aims to:

1. To introduce the fundamental structures of discrete mathematics (sets, relations, functions, logic, algebraic structures, graphs, trees, Boolean algebra, recurrence relations) that are essential for computer science and engineering.
2. To develop the ability to apply discrete mathematical concepts and proof techniques in modeling, analyzing, and solving computational and real-world problems.

	Course Outcomes : By the end of this course, students will be able to:
CO 1	Apply set theory, relations, functions, and proof techniques such as induction, contradiction, and counterexamples to establish mathematical properties.
CO 2	Demonstrate understanding of algebraic structures such as groups, rings, and fields, and apply them to modular arithmetic and related problems.
CO 3	Analyze partially ordered sets, lattices, and Boolean algebras, and use Boolean simplifications and Karnaugh maps in designing digital circuits.
CO 4	Construct logical arguments using propositional and predicate logic, and evaluate validity through truth tables and inference rules.
CO 5	Represent and analyze trees, graphs, recurrence relations, and combinatorial structures, and apply them in solving computational and algorithmic problems.

Unit I: Set Theory : Introduction, Combination of sets, Multisets, Ordered pairs. Proofs of some general identities on sets. Relations: Definition, Operations on relations, Properties of relations, Composite Relations, Equality of relations, Recursive definition of relation, Order of relations. Functions: Definition, Classification of functions, Operations on functions, Recursively defined functions, Growth of Functions, Natural Numbers: Introduction, Mathematical Induction, Variants of Induction, and Induction with Nonzero Base cases. Proof Methods, Proof by counter – example, Proof by contradiction.

Unit II: Algebraic Structures

Definition, Groups, Subgroups and order, Cyclic Groups, Cosets, Lagrange's theorem, Normal Subgroups, Permutation and Symmetric groups, Group Homomorphisms, Definition and elementary properties of Rings and Fields, Integers Modulo n.

Unit III: Partial order sets

Definition, Partial order sets, Combination of partial order sets, Hasse diagram. Lattices: Definition, Properties of lattices – Bounded, Complemented, Modular and Complete lattice. Boolean Algebra: Introduction, Axioms and Theorems of Boolean algebra, Algebraic manipulation of Boolean expressions. Simplification of Boolean Functions, Karnaugh maps, Logic gates, Digital circuits and Boolean algebra.

Unit IV: Propositional Logic

Proposition, well-formed formula, Truth tables, Tautology, Satisfiability, Contradiction, Algebra of proposition, Theory of Inference Predicate Logic: First order predicate, well-formed formula of predicate, quantifiers, Inference theory of predicate logic.

Unit V: Trees

Definition, Binary tree, Binary tree traversal, Binary search tree. Graphs: Definition and terminology, Representation of graphs, Multigraphs, Bipartite graphs, Planar graphs, Isomorphism and Homeomorphism of graphs, Euler and Hamiltonian paths, Graph coloring Recurrence Relation & Generating function: Recursive definition of functions, Recursive algorithms, Method of solving recurrences. Combinatory, Introduction, Counting Techniques, Pigeonhole Principle.

Text Books:

1. Elements of Discrete Mathematics – Liu and Mohapatra, McGraw Hill Publications, 2017
2. Discrete Mathematical Structures – B. Kolman, R.C. Busby, and S.C. Ross, PHI Publications, Third edition, 2016
3. Discrete Mathematical Structures with Application to Computer Science – Jean Paul Trembley and R Manohar, McGraw-Hill Publications, 2017
4. Discrete and Combinatorial Mathematics – R.P. Grimaldi, Addison Wesley, 2006
5. Discrete Mathematics and Its Applications, Kenneth H. Rosen, McGraw-Hill 8th edi, 2021

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BTMT 272	NUMERICAL TECHNIQUES	Sem-3	2L:0T:2P:3C

Course Objectives:

The course aims to:

1. To provide fundamental knowledge of numerical techniques for solving interpolation, integration, linear and nonlinear equations, differential equations, and eigenvalue problems.
2. To develop computational skills for implementing numerical algorithms, analyzing their accuracy and convergence, and applying software tools to real-world engineering problems.

	Course Outcomes By the end of this course, students will be able to:
CO 1	Apply interpolation and numerical integration techniques with error analysis to approximate functions and evaluate definite integrals.
CO 2	Solve systems of linear equations using direct and iterative methods (Gaussian elimination, Gauss-Seidel, LU/Cholesky factorization) and assess numerical stability.
CO 3	Implement and compare root-finding methods (bisection, secant, Newton-Raphson) for nonlinear equations and systems, with emphasis on convergence behavior.
CO 4	Apply Euler, Runge-Kutta, and multistep methods for solving ODEs, and finite difference methods for PDEs, analyzing their accuracy and convergence.
CO 5	Solve eigenvalue problems using iterative methods and employ software packages to implement numerical algorithms for engineering applications.

Course Contents:

MODULE I Interpolation **9 Hours**

Interpolation by polynomials, error of the interpolating polynomial, piecewiselinear and cubic spline interpolation.

MODULE II Numerical Integration **9 Hours**

Numerical integration, Simpson rule, composite rules, error formulae, Gaussquadrature.

MODULE III System of Linear Equations **9 Hours**

Solution of a system of linear equations, implementation of Gaussian elimination and Gauss- Seidel methods, partial pivoting, row echelon form, LU factorization, Cholesky's method, ill- conditioning, norms.

MODULE IV Non-linear Equation **9 Hours**

Solution of a nonlinear equation, bisection and secant methods. Newton-Raphson method, rateof convergence, solution of a system of nonlinear equations.

MODULE V Numerical solution of Ordinary Differential Equations

Euler and Runge-Kutta methods, multistep methods, predictor-corrector methods, order of convergence, finite difference methods, numerical solutions of elliptic, parabolic, and hyperbolic partial differential equations. Eigenvalue problem, power method, QR method, Gershgorin‟s theorem. Exposure to software packages.

Text Books:

1. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering,2012, New Age International Ltd., 6th Edition.
2. R.L. Burden and J. D. Faires, Numerical Analysis, , 2012, 4th Edition, Brooks Cole.

Reference Books:

1.E. Kreyszig, Advanced engineering mathematics (8th Edition), John Wiley (1999).
2.Reena Garg, Advanced Engineering Mathematics, Khanna Book Publishing (2022).
3.R. Agor, Elements of Mathematical Analysis, Khanna Publishing House, 2015.

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BTMT 273	Mathematics – III	Sem-3	3L:1T:0P:4C

Course Objectives:

The course aims to:

1. To provide fundamental knowledge of probability, statistics, partial differential equations, and numerical methods required for engineering applications.
2. To develop problem-solving skills using analytical and computational techniques for modeling and solving real-world problems.

	Course Outcomes : By the end of this course, students will be able to:
CO 1	Apply concepts of probability, random variables, and standard distributions to model uncertain events.
CO 2	Analyze and interpret data using statistical measures, correlation, regression, curve fitting, and hypothesis testing.
CO 3	Solve engineering problems involving wave, heat, and diffusion equations using methods of partial differential equations and special functions.
CO 4	Implement numerical methods for integration, systems of linear and nonlinear equations, and analyze convergence and stability.
CO 5	Apply numerical techniques for solving ODEs and PDEs, including eigenvalue problems, and evaluate their accuracy using computational tools.

Unit – I: Probability **(12 hrs)**

Sample space and Events, Axioms of Probability, Conventional Probability, Bayes' Theorem, Independent Events, Random Variables, Discrete and Continuous Random Variables – Probability Mass Function – Probability Density Function – Cumulative Distribution Function – Expectation and Variance, Standard probability Distribution – Bernoulli, Binomial, Poisson, Geomtric and Normal Distributions.

Unit – II: Statistics and applications **(12 hrs)**

Measures of Central Tendency – Mean- Median-Mode; Measure of Dispersion – Range – Variance- Standard Deviation; Moments, Skewness and Kurtosis, Correlation and Regression – Rank Correlation

Curve Fitting by the Method of Least Square, Fitting of Straight lines, Second degree parabolas and more general curves. Test of Significance: Large sample test for single proportion, Difference of proportions, Single Mean, Difference of Means and Difference of Standard Deviations

Unit -III - Application of PDEs **(16 hrs)**

Second-order linear PDE and their classification, Initial and boundary conditions, D'A lembert's solution of the wave equation; Duhamel's principle for one dimensional wave equation. Heat diffusion and vibration problems, Separation of variables method to simple problems in Cartesian coordinates. The Laplacian in plane, cylindrical and spherical polar coordinates, solutions with Bessel functions and Legendre functions. One dimensional diffusion equation and its solution by separation of variables.

Unit IV - Numerical Methods **(10 hrs)**

Numerical integration, Simpson rule, composite rules, error formulae, Solution of a system of linear equations, implementation of Gaussian elimination and Gauss- Seidel methods, Cholesky's method, Solution of a nonlinear equation, bisection and secant methods. Newton-Raphson method, rate of convergence, solution of a system of nonlinear equations.

Unit V - Numerical solution to ODE **(10 hrs)**

Euler and Runge-Kutta methods, multistep methods, predictor-corrector methods, order of convergence, finite difference methods, numerical solutions of elliptic, parabolic, and hyperbolic partial differential equations. Eigenvalue problem, power method, QR method

Text Book:

1. Reena Garg, Engineering Mathematics, Khanna Book Publishing Company, 2022.
2. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering, 2012, New Age International Ltd., 6th Edition.
3. R.L. Burden and J. D. Faires, Numerical Analysis, 2012, 4th Edition, Brooks Cole.

Reference Books:

1. Reena Garg, Advanced Engineering Mathematics, Khanna Book Publishing Company, 2021.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
3. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
4. R. Agor, Elements of Mathematical Analysis, Khanna Publishing House, 2015.

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