FAROOK COLLEGE (AUTONOMOUS)

Farook College PO, Kozhikode-673632

U.G Programme in Mathematics

Under

Choice Based Credit Semester System

SYLLABUS

Core, Complementary & Open Courses

(2022 Admission Onwards)

Prepared By:

Board of Studies in Mathematics

Farook College (Autonomous)

CERTIFICATE

I hereby certify that the documents attached are the bona fide copies of the syllabus of Core Courses offered to B.Sc. Mathematics programme and Complementary & Open Courses offered by the Department of Mathematics to be effective from 2022 admission onwards.

Date: Principal
Place: Farook College

Graduate Attributes (GAs)

Graduate Attributes (GAs) are the qualities and skills expected to be acquired by the students while they pursue a graduate program in Farook College. Graduate Attributes include disciplinary knowledge, communication skills and understanding of interdisciplinary nature of knowledge and societal goals one shall achieve collectively and individually in terms of academic competence and practical experiences. They are achieved by a graduate through productive curricular experiences facilitated by various resources of the college.

1. Disciplinary Knowledge and Competency

The graduates acquire comprehensive knowledge in the subject and competence to demonstrate the same, identify the foundations of the respective discipline and develop essential interdisciplinary awareness.

2. Communication Skills and Digital Literacy

Graduates acquire sufficient communication skills in speech and writing to disseminate knowledge and critically analyze various discourses with the assistance of advanced communication technology in order to prepare themselves for learning, working and living in a digital society.

3. Research and Analytical Skills

Graduates develop a sense of inquiry and capacity to question and problematize different aspects of knowledge and life experiences and cultivate a research aptitude to effect impressive research output.

4. Critical Thinking and Problem-Solving Skills

Graduates maintain the practical experience of critical thinking both in academia and real-life situations, master appropriate skills to analyze various issues and to formulate coherent arguments using scientific approach and develop individual capacity to solve problems in the real and anticipated life.

5. Team Work, Leadership Skills and Professionalism

Graduates can live and work in diverse conditions with members hailing from diverse background towards the fulfilment of the institutional and societal goals, keeping up the spirit of team work and maintaining dynamism and professional behaviour based on

positive leadership qualities, constructive feedback system and productive corrective measures.

6. Scientific Temper and Reflective Thinking

Graduates are expected to nurture a scientific temper to ensure objective and reasoned treatment of problems and experiences and practice reflective thinking for individual and social development.

7. Moral and Ethical Awareness

Graduates are able to embrace moral and ethical values specific to the society and culture and uphold them consistently as responsible members of the society.

8. Employability and Entrepreneurship

Graduates are trained to achieve professional skills required to be employed in their career globally and the potential to formulate innovative ideas and to start up new enterprises.

9. Multicultural Competence

Graduates gain knowledge of values and beliefs of multiple cultures, hold a global perspective and become competent to effectively engage in a multicultural and secular society and interact respectfully with diverse groups.

10. Lifelong Learning

Graduates acquire knowledge and skills for continuous learning in a personalized and self-directed manner, aiming at personal development, meeting social, economic and cultural objectives and adapting to changing trade trends and work culture.

BSc Program Outcomes

On completion of a graduate program in Science, the students will be able to:

- Understand the basic concepts, fundamental principles, and scientific theories associated with various scientific phenomena and internalize their relevance in everyday life.
- Demonstrate and apply fundamental knowledge in the disciplines of Biological/Physical/Mathematical/computational Sciences and their application in research and industry.
- Explore inter-disciplinary areas in the field of basic and applied sciences.
- Conceive the methodology of sciences starting from observation, evidence-based knowledge acquisition, deduction, logical inferences and induction leading to knowledge production.
- Develop scientific temper and apply scientific knowledge in various fields for the betterment of individuals and society as a whole.
- Understand and analyze the problems in the local and global sphere and use the basic knowledge in science to solve real-life situations.
- Acquire the skills in handling scientific instruments, performing laboratory experiments, taking measurements and analyzing the data scientifically.
- Critically evaluate and discuss scientific literature and key methodologies with regard to validity, reliability, and applicability, within the biological and physical sciences.
- Understand the philosophical foundations of science and reciprocal influence of other disciplines such as Humanities, Arts, Social sciences, etc. in the evolution of new scientific theories and inventions.
- Critically evaluate the potential and impact of scientific innovations on the environment and find a sustainable solution to issues pertaining to the environment, public health, and agriculture.
- Develop laboratory skills, computational skills, qualitative and quantitative data handling skills so that students apply their scientific knowledge in real-life situations.

- Acquire Practical, technical, and professional skills to qualify for a broad range of positions in research, industry, consultancy, education and social development.

Programme Specific Outcome of BSc. Mathematics

The programme outcomes of the B.Sc. Mathematics undergraduate course are the summation of the expected course learning outcomes given below.

PO1 Disciplinary knowledge:

(i) Enabling students to develop a positive attitude towards Mathematics as an interesting and valuable subject of study.

(ii) Capability of demonstrating comprehensive knowledge of mathematics and understanding of one or more disciplines which form a part of an undergraduate programme of study.

PO2 Communications skills:

(i) Ability to communicate various concepts of mathematics effectively using examples and their geometrical visualizations.

(ii) Ability to use mathematics as a precise language of communication in other branches of human knowledge.

(iii) Ability to show the importance of mathematics as precursor to various scientific developments since the beginning of the civilization.

PO3 Critical thinking:

(i) Ability to employ critical thinking in understanding the concepts in every area of mathematics.

(ii) A student should get a relational understanding of mathematical concepts and concerned structures, and should be able to follow the patterns involved with mathematical reasoning.

(iii) Know when there is a need for information, to be able to identify, locate, evaluate, and effectively use that information for the issue or problem at hand.

PO4 Analytical reasoning:

Ability to analyze the results and apply them in various problems appearing in different branches of mathematics.

PO5 Problem solving:

(i) Ability to analyze a problem, identify and define the computing requirements, which may be appropriate to its solution.

(ii) Capability to solve problems using concepts of linear algebra and number theory.

(iii) Capability to solve various models such as growth and decay models, radioactive decay model, LCR circuits and population models using techniques of differential equations.

(iii) Ability to solve linear system of equations, linear programming problems and network flow problems.

(iv) Ability to provide new solutions using the domain knowledge of mathematics acquired during this programme.

PO6 Research-related skills:

(i) Capability for inquiring about appropriate questions relating to the concepts in various fields of mathematics.

(ii) Ability to pursue advanced studies and research in pure and applied Mathematical Science.

PO7 Information/digital literacy:

Capability to use appropriate software (Python, Scilab, MATLAB, Tora etc) to solve system of equations, differential equations, numerical methods and linear programming problems.

PO8 Self-directed learning:

Ability to work independently and do in-depth study of various notions of mathematics.

PO9 Lifelong learning:

Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning.

PO10 Application skills:

Ability to apply the acquired knowledge in all aspects especially quantitative models arising in Basic Science, Social Science, Business and Engineering.

PO11 Experimental skills:

Ability to design experiments for appropriate modeling.

PO12 Moral and ethical awareness/reasoning:

Ability to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adopting objective, unbiased and truthful actions in all aspects

Course learning outcomes

Course learning outcomes of each course in B.Sc. Mathematics and B.A./B.Sc. Programme with Mathematics as a complementary course have been enshrined in the beginning of course contents of each course.

CORE COURSES													
Program Outcomes	Basic Logic and Calculus 1	Calculus 2	Theory of Equations and Number Theory	Linear Algebra	Abstract Algebra	Basic Analysis	Numerical Analysis	Linear Programming	Calculus of Multivariable 1	Real Analysis	Complex Analysis	Calculus of Multivariable 2	Differential Equations
Disciplinary Knowledge	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Communication Skills	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Critical Thinking	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Analytical Thinking	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Research related Skills	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Information/ Digital Literacy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Self- directed learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lifelong learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Applicational skills	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Experimental Learning	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓
Employability Options	✓	✓		✓			✓	✓	✓			✓	✓
Ethics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

ELECTIVE COURSES				
Program Outcomes	Graph Theory	Topology of Metric spaces	Mathematical Programming with Python and Latex	Introduction to Geometry
Disciplinary Knowledge	✓	✓	✓	✓
Communication Skills	✓	✓	✓	✓
Critical Thinking	✓	✓	✓	✓
Analytical Thinking	✓	✓	✓	✓
Research related Skills	✓	✓	✓	✓
Information/ Digital Literacy	✓	✓	✓	✓
Self- directed learning	✓	✓	✓	✓
Lifelong learning	✓	✓	✓	✓
Applicational skills	✓	✓	✓	✓
Experimental Learning	✓		✓	✓
Employability Options	✓		✓	
Ethics	✓	✓	✓	✓

OPEN COURSES				
Program Outcomes	Applied Calculus	Discrete Mathematics Basic and Applied Sciences	Linear Mathematical Models	Mathematics for Decision Making
Disciplinary Knowledge	✓	✓	✓	✓
Communication Skills	✓	✓	✓	✓
Critical Thinking	✓	✓	✓	✓
Analytical Thinking	✓	✓	✓	✓
Research related Skills	✓	✓	✓	✓
Information/ Digital Literacy	✓	✓	✓	✓
Self- directed learning	✓	✓	✓	✓
Lifelong learning	✓	✓	✓	✓
Applicational skills	✓	✓	✓	✓
Experimental Learning	✓	✓	✓	✓
Employability Options	✓	✓	✓	✓
Ethics	✓	✓	✓	✓

COMPLEMENTARY COURSES								
Program Outcomes	Mathematics for Physics, Chemistry and Statistics				Mathematics for Computer Science			
	BMT1C01	BMT2C02	BMT3C03	BMT4C04	BMT1C01 (CS)	BMT2C02 (CS)	BMT3C03 (CS)	BMT4C04 (CS)
Disciplinary Knowledge	✓	✓	✓	✓	✓	✓	✓	✓
Communication Skills	✓	✓	✓	✓	✓	✓	✓	✓
Critical Thinking	✓	✓	✓	✓	✓	✓	✓	✓
Analytical Thinking	✓	✓	✓	✓	✓	✓	✓	✓
Research related Skills								
Information/ Digital Literacy	✓	✓	✓	✓	✓	✓	✓	✓
Self- directed learning	✓	✓	✓	✓	✓	✓	✓	✓
Lifelong learning	✓	✓	✓	✓	✓	✓	✓	✓
Applicational skills	✓	✓	✓	✓	✓	✓	✓	✓
Experimental Learning				✓				✓
Employability Options	✓			✓	✓			✓
Ethics	✓	✓	✓	✓	✓	✓	✓	✓

B.Sc. DEGREE PROGRAMME (MATHEMATICS CORE)

COURSE STRTUCTURE

Semester	Course Code	Course Title	Total hours	Hours / Week	Credits	Mark
I	A01	Common Course I – English	72	4	4	100
	A02	Common Course II – English	90	5	3	75
	A07	Common Course III – Language other than English	72	4	4	100
	BMT1B01	Basic Logic and Calculus-1	72	4	4	100
	BST1C01	1st Complementary Course I (Statistics) - Introductory Statistics	72	4	3	75
	BPH1C01	2nd Complementary Course I(Physics)- Properties of Matter and Thermodynamics	36	2	2	75
		2nd Complementary Course Practical V	36	2		
	Audit Course	Environment Studies	-	-	4*	
		Total	**450**	**25**	**20**	**525**
II	A03	Common Course IV – English	72	4	4	100
	A04	Common Course V – English	90	5	3	75
	A08	Common Course VI – Language other than English	72	4	4	100
	BMT2B02	Core Course II – Calculus-2	72	4	4	100
	BST2C02	1st Complementary Course II(Statistics) – Probability Theory	72	4	3	75
	BPH2C02	Complementary Course II: Optics, Laser, Electronics and Communication	36	2	2	75
		Complementary Course V: PHYSICS Practical	36	2		
	Audit Course	Disaster Management			4*	
		Total	**450**	**25**	**20**	**525**
III	A05	Common Course VI – English	90	5	4	100
	A09	Common Course VIII - Language other than English	90	5	4	100
	BMT3B03	Core Course III – Theory of Equations and Number Theory	90	5	4	100

	BST3C03	1st Complementary Course III – (Statistics) - Probability Distributions and Sampling Theory	90	5	3	75
	BPH3C03	Complementary Course III: Mechanics, Relativity, Waves and Oscillations	54	3	2	75
	-	Complementary Course V: PHYSICS Practical	36	2		
	Audit Course	Human Rights/Intellectual Property Rights/Consumer protection			4*	
		Total	**450**	**25**	**17**	**450**
IV	A06	Common Course IX – English	90	5	4	100
	A10	Common Course X - Language other than English	90	5	4	100
	BMT4 B04	Core Course IV – Linear Algebra	90	5	4	100
	BST4C04	1st Complementary Course IV (Statistics) – Statistical Inference and Quality Control	90	5	3	75
	BPH4C04	2nd Complementary Course IV(Physics) - Electricity, Magnetism and Nuclear Physics	54	3	2	75
	BPH4C05L	Complementary Course V: Physics Practical	36	2	4	100
	Audit Course	Gender studies/Gerentology			4*	
		Total	**450**	**25**	**21**	**550**
V	BMT5B05	Abstract Algebra	90	5	4	100
	BMT5B06	Basic Analysis	90	5	4	100
	BMT5B07	Numerical Analysis	72	4	3	75
	BMT5B08	Linear Programming	54	3	3	75
	BMT5B09	Calculus of Multi Variable-1	54	4	3	75
		Project	36	1	*	
		Open Course (Offered by Other Departments)	54	3	3	75
		Total	450	**25**	**20**	**500**
VI	BMT6B10	Real Analysis	90	5	5	100
	BMT6B11	Complex Analysis	90	5	5	100
	BMT6B12	Calculus of Multi variable-2	90	5	4	100
	BMT6B13	Differential Equations	90	5	4	100
	BMT6E0X	Elective	54	3	2	75
	BMT6B14P	Project Viva	36	2	2	75
		Total	450	**25**	**22**	**550**
Total Credits					**120**	**3100**

*Ability Enhancement Courses

Ability Enhancement Courses (Audit Courses) are mandatory for the successful completion of the programme but not counted for the calculation of SGPA or CGPA. There shall be one Audit course each in the first four semesters. These courses are not meant for class room study. The students need to attain only pass (Grade P) for these courses. The students can attain these credits through online courses like NPTEL, SWAYAM, MOOC etc.

Extra Credit Activities

Extra credits are mandatory for the programme. Extra credits will be awarded to students who participate in activities like NCC, NSS and Swatch Bharath. Those students who could not join in any of the above activities have to undergo Farook College Social Service Programme (FCSSP). Extra credits are not counted for SGPA or CGPA.

Syllabus Structure

Core Courses

The following courses are compulsory for B. Sc Mathematics programme.

Sl. No	Code	Name of the Course	Semester	No of contact hours/Week	Credits	Max. Marks			Exam dur.(Hrs)
						Internal	External	Total	
1	BMT1B01	Basic Logic and Calculus-1	1	4	4	20	80	100	2.5
2	BMT2B02	Calculus-2	2	4	4	20	80	100	2.5
3	BMT3B03	Theory of Equations and Number Theory	3	5	4	20	80	100	2.5
4	BMT4B04	Linear Algebra	4	5	4	20	80	100	2.5
5	BMT5B05	Abstract Algebra	5	5	4	20	80	100	2.5
6	BMT5B06	Basic Analysis	5	5	4	20	80	100	2.5
7	BMT5B07	Numerical Analysis	5	4	3	15	60	75	2
8	BMT5B08	Linear Programming	5	3	3	15	60	75	2
9	BMT5B09	Calculus of Multi Variable-1	5	4	3	15	60	75	2
		Project	5	1					
10		Open Course (Offered by Other Departments)	5	3	3	15	60	75	2
11	BMT6B10	Real Analysis	6	5	5	20	80	100	2.5
12	BMT6B11	Complex Analysis	6	5	5	20	80	100	2.5
13	BMT6B12	Calculus of Multi Variable-2	6	5	4	20	80	100	2.5
14	BMT6B13	Differential Equations	6	5	4	20	80	100	2.5
15	BMT6E0X	Elective	6	3	2	15	60	75	2
16	BMT6B14P	Project	6	2	2	15	60	75	
				68	**58**			**1450**	

Elective Courses

One of the following four courses can be offered in the sixth semester as an elective course. (Code BMT6E01, BMT6E02 and BMT6E03, BMT6E04).

Sl. No	Code	Name of the course	Semester	No of contact hours/Week	Credits	Max. Marks			Exam dur. (Hrs)
						Internal	External	Total	
1	BMT6E01	Graph Theory	6	3	2	15	60	75	2
2	BMT6E02	Topology of Metric spaces	6	3	2	15	60	75	2
3	BMT6E03	Mathematical Programming with Python and Latex	6	3	2	15	60	75	2
4	BMT6E04	Introduction to Geometry	6	3	2	15	60	75	2

Open Courses

One of the following four courses can be offered in the fifth semester as an open course for students from other degree programmes (BMT5D01, BMT5D02, BMT5D03 and BMT5D04).

Sl. No	Code	Name of the course	Semester	No of contact hours/Week	Credits	Max. Marks			Unty. exam Dur. (Hrs)
						Internal	External	Total	
1	BMT5D01	Applied Calculus	5	3	3	15	60	75	2
2	BMT5D02	Discrete Mathematics for Basic and Applied Sciences	5	3	3	15	60	75	2
3	BMT5D03	Linear Mathematical Models	5	3	3	15	60	75	2
4	BMT5D04	Mathematics for Decision Making	5	3	3	15	60	75	2

Complementary Courses

Sl. No	Code	Name of the course	Semester	No of contact hours/Week	Credits	Max. Marks			Duration of Examination (Hrs)
						Internal	External	Total	
1	BMT1C01	Mathematics-1	1	4	3	15	60	75	2
2	BMT2C02	Mathematics-2	2	4	3	15	60	75	2
3	BMT3C03	Mathematics-3	3	5	3	15	60	75	2
4	BMT4C04	Mathematics-4	4	5	3	15	60	75	2

Credit and Mark Distribution of B.Sc Mathematics Programme

Sl. No	Course		Credits		Marks	
1	English		22		550	
2	Additional Language		16		400	
3	Core Course	13 Courses	51	55	1225	1375
		1 Elective	2		75	
		Project	2		75	
4	Complementary course I		12		300	
5	Complementary course II		12		400	
6	Open Course		3		75	
Total			120		3100	

Scheme of Evaluation

The evaluation scheme for each course shall contain two parts: internal evaluation and external evaluation.

Internal Evaluation

20% of the total marks in each course are for internal evaluation. The colleges shall send only the marks obtained for internal examination to the university.

Components of Internal Evaluation

Sl No	Components	Marks (For Courses with Max. Marks 75)	Marks (For Courses with Max. Marks 100)
1	Class Room Participation (Attendance)	3	4
2	Assignment	3	4
3	Seminar	3	4
4	Test paper	6	8
Total		15	20

a) Percentage of Class Room Participation (Attendance) in a Semester and Eligible Internal Marks

% of Class Room Participation (Attendance)	Out of 3 (Maximum internal marks is 15)	Out of 4 (Maximum internal marks is 20)
50% ≤ CRP < 75%	1	1
75% ≤ CRP < 85%	2	2
85% and above	3	4

CRP means % of class room participation (Attendance)

b) Percentage of Marks in a Test Paper and Eligible Internal Marks

Range of Marks in test paper (TP)	Out of 6 (Maximum internal marks is 15)	Out of 8 (Maximum internal marks is 20)
Less than 35%	1	1
35%≤*TP* <45%	2	2
45%≤*TP* <55%	3	3
55%≤*TP* <65%	4	4
65%≤*TP* <85%	5	6
85%≤*TP*≤100%	6	8

Evaluation of Project

1. Evaluation of the Project Report shall be done under Mark System.
2. The evaluation of the project will be done at two stages:
    - Internal Assessment (supervising teachers will assess the project and award internal Marks)
    - External evaluation (external examiner)
3. Grade for the project will be awarded to candidates, combining the internal and external marks.
4. The internal to external components is to be taken in the ratio 1: 4.

Assessment of different components may be taken as below.

Internal assessment of Project (15 Marks)

(Supervising Teacher will assess the Project and award internal Marks)

Sl. No.	Components	Internal Marks
1	Originality	3
2	Methodology	3
3	Scheme / Organization of Report	4.5
4	Viva Voce	4.5
Total		15

External Evaluation of Project (60 Marks)

(To be done by the External Examiner)

Sl. No.	Components	External Marks
1	Relevance of the Topic, Statement of Objectives	12
2	Reference/ Bibliography, Presentation, quality of Analysis/ Use of Statistical Tools.	12
3	Findings and recommendations	18
4	Viva-Voce	18
Total		**60**

Pattern of Question Paper for University Examinations

	For Courses with Max. External Marks 80 (2.5 Hrs)		For Courses with Max. External Marks 60 (2 Hrs)	
Section A	Short answer type carries 2 marks each - 15 questions	Ceiling - 25	Short answer type carries 2 marks each-12questions	Ceiling - 20
Section B	Paragraph/Problem type carries 5 marks each - 8 questions	Ceiling - 35	Paragraph/ Problem type carries 5 marks each - 7 questions	Ceiling - 30
Section C	Essay type carries 10 marks (2 out of 4)	2×10 = 20	Essay type carries 10 marks (1 out of 2)	1×10 = 10
Total		**80**		**60**

• Questions are to be evenly distributed over the entire syllabus. At least 20% of questions from each module must be included in each section of the question paper for courses having four modules in the syllabus and 30% for courses having three modules in the syllabus.

CORE COURSES

FIRST SEMESTER

BMT1 B01: BASIC LOGIC & CALCULUS-1

4 hours/week 4 Credits 100 Marks [Int:20+Ext:80]

Aims and Objectives

Logic, the study of principles of techniques and reasoning, is fundamental to every branch of learning. Besides, being the basis of all mathematical reasoning, it is required in the field of computer science for developing programming languages and also to check the correctness of the programmes. Electronic engineers apply logic in the design of computer chips. The first module discusses the fundamentals of logic, its symbols and rules. This enables one to think systematically, to express ideas in precise and concise mathematical terms and also to make valid arguments. How to use logic to arrive at the correct conclusion in the midst of confusing and contradictory statements is also illustrated.

The mathematics required for viewing and analyzing the physical world around us is contained in calculus. While Algebra and Geometry provide us very useful tools for expressing the relationship between static quantities, the concepts necessary to explore the relationship between moving/changing objects are provided in calculus. The objectives of the second, third and fourth modules are to introduce students to the fundamental ideas of limit, continuity and differentiability and also to some basic theorems of differential calculus. The second and third modules explain how these ideas can be applied in the problem of sketching of curves and in the solution of some optimization problems of interest in real life.

The fourth module deals with the other branch of calculus viz. integral calculus. Historically, it is motivated by the geometric problem of finding out the area of a planar region. The idea of definite integral is defined with the notion of limit. A major result is the Fundamental Theorem of Calculus, which not only gives a practical way of evaluating the definite integral but establishes the close connection between the two branches of Calculus.

Course Outcome

Successful completion of the course enables the students to

- Reformulate statements from common language to formal logic and apply truth tables and rules of propositions.
- Formulate short proofs of mathematical statements.
- Determine the continuity and differentiability of a function at a point and on a set.
- Understand graphing of functions using qualitative methods.
- Learn definite integral as limit of sums and integration as derivatives.

Syllabus

FIRST SEMESTER

BMT1 B01: BASIC LOGIC & CALCULUS-1

Text: 1	Discrete Mathematics with Applications : Thomas Koshy, *Elsever Academic Press(2004) ISBN:0-12-421180-1*
Text: 2	Calculus: Soo T Tan *Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7*

Module-I	**Text (1)**	**(14 hrs)**

Logic

1.1: Propositions- definition, Boolean (logic) variables, Truth Value, Conjunction, Boolean expression, Disjunction (inclusive and exclusive), Negation, Implication, Converse, Inverse and Contra positive, Biconditional statement, Order of Precedence, Tautology Contradiction and Contingency ['Switching Networks' omitted]

1.2: Logical equivalences- laws of logic ['Equivalent Switching Networks' 'Fuzzy logic' & 'Fuzzy decisions'omitted]

1.3: Quantifiers- universal & existential, predicate logic.

1.4: Arguments- valid and invalid arguments, inference rules.

1.5: Proof Methods – vacuous proof, trivial proof, direct proof, indirect proof-contrapositive & contradiction, proof by cases, Existence proof-constructive & non constructive, counterexample.

Module-II	**Text (2)**	**(18 hrs)**

Limit Continuity and Derivatives

1.1: Intuitive introduction to Limits- A Real-Life Example, Intuitive Definition of a Limit, One-Sided Limits, Using Graphing Utilities to Evaluate Limits.

1.2: Techniques for finding Limits- Computing Limits Using the Laws of Limits, Limits of Polynomial and Rational Functions, Limits of Trigonometric Functions, The Squeeze Theorem.

1.3: Precise Definition of a Limit- $\varepsilon - \delta\, definition$, A Geometric Interpretation, Some illustrative examples.

1.4: Continuous Functions- Continuity at a Number, Continuity at an Endpoint,

Continuity on an Interval, Continuity of Composite Functions, Intermediate Value Theorem.

2.1: Differentiation - definition only.

2.9: Differentials and Linear Approximations- increments, Differentials, Error Estimates, Linear Approximations, Error in Approximating Δy by dy.

Module-III	**Text (2)**	**(17 hrs)**

Applications of the Derivative

3.1: Extrema of Functions - Absolute Extrema of Functions, Relative Extrema of Functions, Fermat's Theorem**,** Finding the Extreme Values of a Continuous Function on a Closed Interval, An Optimization Problem.

3.2: The Mean Value Theorem- Rolle's Theorem, The Mean Value Theorem**,** Some Consequences of the Mean Value Theorem, Determining the Number of Zeros of a Function.

3.3: Increasing and Decreasing Functions- definition, inferring the behaviour of function from sign of derivative, Finding the Relative Extrema of a Function, first derivative test.

3.4: Concavity and Inflection points- Concavity, Inflection Points, The Second Derivative Test, The Roles of $f'$and f''in determining the Shape of a Graph.

3.5: Limits involving Infinity; Asymptotes- Infinite Limits, Vertical Asymptotes, Limits at Infinity, Horizontal Asymptotes, Infinite Limits at Infinity, Precise Definitions.

3.6: Curve Sketching-The Graph of a Function, Guide to Curve Sketching, Slant Asymptotes, Finding Relative Extrema Using a Graphing Utility.

3.7: Optimization Problems – guidelines for finding absolute extrema, Formulating Optimization Problems- application involving several real-life problems.

Module-IV	Text (2)	(15 hrs)

Integration

4.1: Anti derivatives, Indefinite integrals, Basic Rules of Integration, a few basic integration formulas and rules of integration, Differential Equations, Initial Value Problems.

4.3: Area- An Intuitive Look, The Area Problem, Defining the Area of the Region Under the Graph of a Function-technique of approximation ['Sigma Notation' and 'Summation Formulas' Omitted] An Intuitive Look at Area (Continued), Defining the Area of the Region Under the Graph of a Function-precise definition, Area and Distance.

4.4: The Definite Integral- Definition of the Definite Integral, Geometric Interpretation of the Definite Integral, The Definite Integral and Displacement, Properties of the Definite Integral, More General Definition of the Definite Integral.

4.5: The Fundamental Theorem of Calculus- How Are Differentiation and Integration Related? The Mean Value Theorem for Definite Integrals, The Fundamental Theorem of Calculus: Part I, inverse relationship between differentiation and integration, Fundamental Theorem of Calculus: Part 2, Evaluating Definite Integrals Using Substitution, Definite Integrals of Odd and Even Functions, The Definite Integral as a Measure of Net Change.

***List of Practicals (using any software)**

- Plotting graph of functions.
- Evaluating limits by plotting of its graphs.
- Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
- Finding relative and absolute extrema by plotting of its graphs.
- Finding area under a curve and verifying definite integral of a positive function and area under its graph are same.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Kenneth H. Rosen: Discrete Mathematics and Its Applications(7/e) *McGraw-Hill, NY(2007)*
2	Joel Hass, Christopher Heil & Maurice D. Weir : Thomas' Calculus(14/e) *Pearson (2018) ISBN 0134438981*
3	Robert A Adams & Christopher Essex : Calculus *Single Variable (8/e) Pearson Education Canada (2013) ISBN:* 0321877403
4	Jon Rogawski & Colin Adams : Calculus *Early Transcendentals* (3/e) *W. H. Freeman and Company(2015) ISBN: 1319116450*
5	Anton, Bivens & Davis : Calculus *Early Transcendentals* (11/e) *John Wiley & Sons, Inc.(2016) ISBN: 1118883764*
6	James Stewart : Calculus (8/e) *Brooks/Cole Cengage Learning(2016) ISBN: 978- 1-285-74062-1*
7	Jerrold Marsden & Alan Weinstein : Calculus I and II (2/e) *Springer Verlag NY (1985) ISBN 0-387-90974-5 : ISBN 0-387-90975-3*

SECOND SEMESTER

BMT2 B02: CALCULUS-2

4 hours/week 4 Credits 100 Marks [Int:20+Ext:80]

Aims and Objectives

Using the idea of definite integral developed in previous semester, some applications are discussed in the first module. The notion of definite integral not only solves the area problem but is useful in finding out the arc length of a plane curve, volume and surface areas of solids and so on. The integral turns out to be a powerful tool in solving problems in physics, chemistry, biology, engineering, economics and other fields. Some of the applications are included in the syllabus.

In the second module the natural logarithm function is defined and its properties are examined. This allows the student to define its inverse function namely the natural exponential function and also the general exponential function. Exponential functions model a wide variety of phenomenon of interest in science, engineering, mathematics and economics. They arise naturally when we model the growth of a biological population, the spread of a disease, the radioactive decay of atoms, and the study of heat transfer problems and so on. We also consider certain combinations of exponential functions namely hyperbolic functions that also arise very frequently in applications such as the study of shapes of cables hanging under their own weight.

After this, the students are introduced to the idea of improper integrals, their convergence and evaluation. This enables to study a related notion of convergence of a series, which is practically done by applying several different tests such as integral test, comparison test and so on. As a special case, a study on power series- their region of convergence, differentiation and integration etc., is also done.

Course Outcome

Successful completion of the course enables the students to

- Solve problems in a range of mathematical applications using integration.
- Learn the key concepts of transcendental function including logarithmic, exponential, inverse trigonometric and hyperbolic functions.
- Understand the concepts to evaluate the limits of indeterminate forms and the convergence of improper integrals.
- Understand the concepts of sequences and series and determine limits of sequences and convergence of series.
- Define, differentiate and integrate functions represented as power series expansions.

Syllabus

SECOND SEMESTER

BMT2 B02: CALCULUS-2

Text	Calculus: Soo T Tan *Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7*

Module-I	**(12 hrs)**

Applications of Definite Integral

5.1: Areas between Curves- A Real Life Interpretation, The Area Between Two Curves, Integrating with Respect to y adapting to the shape of the region, What Happens When the Curves Intertwine?

5.2: Volume – Solids of revolution, Volume by Disk Method, Region revolved about the x-axis, Region revolved about the y-axis, Volume by the Method of Cross Sections ['Washer Method' omitted].

5.4: Arc Length and Areas of surfaces of revolution- Definition of Arc Length, Length of a Smooth Curve, arc length formula, The Arc Length Function, arc length differentials, Surfaces of Revolution, surface area as surface of revolution.

Module-II	**(21 hrs)**

The Transcendental Functions

6.1: The Natural logarithmic function- *definition*, The Derivative of $ln\ x$, Laws of Logarithms, The Graph of the Natural Logarithmic Function, The Derivatives of Logarithmic Functions, Logarithmic Differentiation, Integration Involving Logarithmic Functions.

6.3: Exponential Functions- The number *e*, Defining the Natural Exponential Function, *properties*, The Laws of Exponents, The Derivatives of Exponential Functions, Integration of the Natural Exponential Function.

6.4: General Exponential and Logarithmic Functions - Exponential Functions with Base *a, laws of exponents*, The Derivatives of a^x and a^u , Graphs of $y= a^x$,integrating a^x, Logarithmic Functions with Base *a, change of base formula*, The Power Rule (General Form), The Derivatives of Logarithmic Functions with Base *a*, The Definition of the Number *e* as a Limit *['Compound Interest' omitted]*

6.5: Inverse trigonometric functions- *definition, graph, inverse properties*, Derivatives of inverse trigonometric functions, Integration involving Inverse Trigonometric Functions.

6.6: Hyperbolic functions- The Graphs of the Hyperbolic Functions, Hyperbolic Identities, Derivatives and Integrals of Hyperbolic Functions, Inverse Hyperbolic Functions, *representation in terms of logarithmic function*, Derivatives of Inverse Hyperbolic Functions, An Application.

6.7: Indeterminate forms and L'Hˆopital rule- *motivation*, The Indeterminate Forms. The Indeterminate Forms $\frac{0}{0}$ and $\frac{\infty}{\infty}$. The Indeterminate Forms $\infty - \infty$ and $0.\infty$. The Indeterminate Forms $0^0, \infty^0$ and 1^∞.

Module-III	**(20 hrs)**

Infinite Sequences and Series

7.6: Improper integrals – *definition*, Infinite Intervals of Integration, Improper Integrals with Infinite Discontinuities, A Comparison Test for Improper Integrals.

9.1: Sequences- *definition, recursive definition*, Limit of a Sequence, *limit laws, squeeze theorem*, Bounded Monotonic Sequences, *definition, monotone convergence theorem (only statement; its proof omitted).*

9.2: Series- *defining the sum, convergence and divergence*, Geometric Series, The Harmonic Series, The Divergence Test, Properties of Convergent Series

9.3: The Integral Test – investigation of convergence, integral test, The *p* Series, *its convergence and divergence*

9.4: The Comparison Test- *test series*, The Comparison Test, The Limit Comparison Test

Module-IV	**(11 hrs)**

9.5: Alternating Series- *definition, the alternating series test, its proof, examples,* Approximating the Sum of an Alternating Series by S_n.

9.6: Absolute Convergence- *definition, conditionally convergent*, The Ratio Test, The Root Test, Summary of Tests for Convergence and Divergence of Series, Rearrangement of Series

9.7: Power Series- *definition*, Interval of Convergence, *radius of convergence*, Differentiation and Integration of Power Series

9.8: Taylor and Maclaurin Series- *definition, Taylor and Maclaurin series of functions,*

Techniques for Finding Taylor Series

***List of Practicals (using any software)**

- Obtaining surface of revolution of curves.
- Plotting of graphs of function $e^{ax+b}, log(ax + b), 1/(ax + b), sin(ax + b), cos(ax + b), |ax + b|$ and to illustrate the effect of a and b on the graph.
- Plotting of graphs of inverse trigonometric and hyperbolic functions.
- Plotting of recursive sequences.
- Study the convergence of sequences through plotting.
- Calculate the sum $1 + 1/2 + 1/3 + 1/4 + \ldots + 1/n$.
- Study the convergence/divergence of infinite series by plotting their sequences of partial sum.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Joel Hass, Christopher Heil & Maurice D. Weir : Thomas' Calculus (14/e) *Pearson(2018) ISBN 0134438981*
2	Robert A Adams & Christopher Essex : Calculus *Single Variable (8/e) Pearson Education Canada (2013) ISBN: 0321877403*
3	Jon Rogawski & Colin Adams : Calculus *Early Transcendentals* (3/e) W. H. Freeman and Company(2015) *ISBN: 1319116450*
4	Anton, Bivens & Davis : Calculus *Early Transcendentals* (11/e) *John Wiley & Sons, Inc.(2016) ISBN: 1118883764*
5	James Stewart : Calculus (8/e) *Brooks/Cole Cengage Learning(2016) ISBN: 978-1-285-74062-1*
6	Jerrold Marsden & Alan Weinstein : Calculus I and II (2/e) *Springer Verlag NY(1985) ISBN 0-387-90974-5 : ISBN 0-387-90975-3*

THIRD SEMESTER

BMT3 B03: THEORY OF EQUATIONS AND NUMBER THEORY

5 hours/week 4 Credits 100 Marks [Int:20+Ext:80]

Aims and Objectives

Theory of equations is an important part of traditional algebra course and it mainly deals with polynomial equations and methods of finding their algebraic solution or solution by radicals. This means we seek a formula for solutions of polynomial equations in terms of coefficients of polynomials that involves only the operations of addition, subtraction, multiplication, division and taking roots. A well knitted formula for the solution of a quadratic polynomial equation is known to us from high school classes and is not difficult to derive. However, there is an increasing difficulty to derive such a formula for polynomial equations of third and fourth degree. One of our tasks in this learning process is to derive formulae for the solutions of third- and fourth-degree polynomial equations given by Carden and Ferrari respectively. In the meantime, we shall find out the relationship between the roots and coefficients of an h degree polynomial and an upper and lower limit for the roots of such a polynomial. This often help us to locate the region of solutions for a general polynomial equation. Methods to find out integral and rational roots of a general h degree polynomial with rational coefficients are also devised. However, all efforts to find out an algebraic solution for general polynomial equations of degree higher than fourth failed or didn't work. This was not because one failed to hit upon the right idea, but rather due to the disturbing fact that there was no such formula.

The classical number theory is introduced and some of the very fundamental results are discussed in other modules. It is hoped that the method of writing a formal proof, using proof methods discussed in the first module, is best taught in a concrete setting, rather than as an abstract exercise in logic. Number theory, unlike other topics such as geometry and analysis, doesn't suffer from too much abstraction and the consequent difficulty in conceptual understanding. Hence, it is an ideal topic for a beginner to illustrate how mathematicians do their normal business. By the end of the course, the students will be able to enjoy and master several techniques of problem solving such as

recursion, induction etc., the importance of pattern recognition in mathematics, the art of conjecturing and a few applications of number theory. Enthusiastic students will have acquired knowledge to read and enjoy on their own a few applications of number theory in the field of art, geometry and coding theory.

Course Outcome

Successful completion of the course enables the students to

- Understand the notion of synthetic division of polynomials.
- Identify the limits of roots of an n^{th} degree polynomial.
- Solve polynomial equations.
- Analyze the sign of a polynomial for small and large values of variable.
- Prove results involving divisibility, greatest common divisor, least common multiple and a few applications.
- Analyze the theory of congruences and solve linear congruent equations.
- Understand methods of solving LDE.
- Solve congruences using Fermat's Theorem, Wilson's Theorem and Euler's Theorem.
- Understand the concept of number theoretic functions- Euler's phi function, tau and sigma function.

Syllabus

THIRD SEMESTER

BMT3 B03: THEORY OF EQUATIONS AND NUMBER THEORY

Text:1	Theory of Equations : J V Uspensky *McGraw Hill Book Company, Inc. (1948) ISBN:07-066735-7*
Text:2	Elementary Number Theory with Applications (2/e): Thomas Koshy, Elsever Academic Press(2007) ISBN:978-0-12-372487-8

Module-I Text:1 (26 hrs)

Theory of Equations

II.3: Division of polynomials, quotient and remainder, method of detached coefficients

II.4: The remainder theorem

II.5: Synthetic Division

III.1: Algebraic equations, roots, maximum number of roots

III.2: Identity theorem

III.3: The Fundamental theorem of Algebra (statement only), factorization to linear factors, multiplicity of roots

III.4: Imaginary roots of equations with real coefficients

III.5: Relations between roots and coefficients Chapter IV

IV.1: Limits of roots

IV.2: Method to find upper limit of positive roots

IV.3: Limit for moduli of roots [only the method to find out upper limit from the auxiliary equation is required; derivation omitted]

IV.4: Integral roots

IV.5: Rational roots

V.1: What is the solution of an equation, algebraic solution or solution by radical

V.2: Carden's formula

V.3: Discussion of solution

V.4: Irreducible case

VI.1: Object of the Chapter

VI.2: The sign of a polynomial for small and large values of variables- locating roots of polynomial between two numbers having values of opposite sign-geometric illustration only-[rigorous reasoning in the starred section omitted]

VI.4: Corollaries- roots of odd and even degree polynomial, number of roots in an interval counted according to their multiplicity

VI.5: Examples

VI.6: An important identity and lemma [derivation not needed]

VI.7: Rolle's theorem [proof omitted], use in separating roots

VI.10: Descarte's rule of signs-only statement and illustrations are required.

Module-II	**Text:2**	**(18hrs)**

1.3: Mathematical induction- well ordering principle, simple applications, weak version of principle of mathematical induction, illustrations, strong version of induction (second principle of MI), illustration

1.4: Recursion- recursive definition of a function, illustrations.

2.1: The division algorithm – statement and proof, div & mod operator, card dealing, ['The two queens puzzle' omitted], pigeonhole principle and division algorithm, divisibility relation, illustration, divisibility properties, union intersection and complement-inclusion-exclusion principle & applications, even and odd integers.

2.5: Prime and Composite Numbers- definitions, infinitude of primes, ['algorithm 2.4' 'The sieve of Eratosthenes omitted], a number theoretic function, prime number theorem (statement only), distribution of primes (upto and including Example 2.25). [rest of the section omitted]

3.1: Greatest Common Divisor- gcd, symbolic definition, relatively prime integers, Duncan's identity, Polya's theorem, infinitude of primes, properties of gcd, linear combination, gcd as linear combination, an alternate definition of gcd, gcd of n positive integers, a linear combination of n positive integers, pairwise relatively prime integers, alternate proof for infinitude of prime.

(Theorem 3.1, Lemma 3, Theorem 3.3 and Theorem 3.3, corollary 3.8 excluded)

Module-III	Text: 2	(20 hrs)

3.2: The Euclidean Algorithm- The Euclidean algorithm [algorithm 3.1, 'A jigsaw puzzle' omitted], Lame's theorem (statement only; proof omitted)

3.3: The Fundamental Theorem of Arithmetic- Euclid's lemma on division of product by a prime, fundamental theorem of arithmetic, Canonical Decomposition, number of trailing zeros, highest power of a prime dividing $n!$, [only statement of Theorem3.14 required; proof omitted] Distribution of Primes Revisited, Dirichlet's Theorem(statement only)

3.4: Least Common Multiple- definition, canonical decomposition to find lcm, relationship between gcd and lcm, relatively prime numbers and their lcm

3.5: Linear Diophantine Equations- Linear Diophantine Equations

(upto example 3.19 & example 3.20 onwards omitted)

4.1: Congruences - congruence modulo m, properties of congruence, characterization of congruence, least residue, ['Friday-the-Thirteenth' omitted], congruence classes, A Complete Set of Residues Modulo m , properties of congruence, use of congruence to find the remainder on division, ['Modular Exponentiation' method omitted], Towers of Powers Modulo m, further properties of congruence and their application to find remainder ['Monkey and Cocunut Puzzle revisited'(example 4.17) omitted] congruences of two numbers with different moduli

4.2: Linear Congruence- solvability, uniqueness of solution, incongruent solutions, Modular Inverses, applications

5.1: Divisibility Tests-Divisibility Test for 10, Divisibility Test for 5, Divisibility Test for 2^i , Divisibility Tests for 3 and 9, Divisibility Test for 11 [rest of the section from Theorem 5.1 onwards omitted]

Module-IV	Text: 2	(16 hrs)

7.1: Wilson's Theorem- self invertible modulo prime, Wilson's theorem and its converse ['Factorial,Multifactorial and Primorial Primes' omitted]

7.2: Fermat's Little Theorem (FLT)- FLT and its applications, [Lagrange's alternate proof of Wilson's theorem omitted], inverse of a modulo p using FLT, application-solution of linear congruences ['Factors of $2^n + 1$'omitted], extension of FLT in various directions ['The Pollard p-1 factoring method' omitted]

7.3: Pseudoprimes- FLT to check compositeness, disproving converse of FLT, pseudoprimes, infinitude of pseudoprime. ['Carmichael Numbers' omitted]

7.4: Euler's Theorem- motivation, Euler's Phi Function φ, Euler's Theorem,

applications, generalisation of Euler's theorem (koshy)

8.1: Euler's Phi Function Revisited- multiplicative functions, fundamental theorem for multiplicative functions, formula for $\varphi(pe)$, [Example 8.3 omitted] multiplicative nature of φ, use in computation, Gauss theorem on sum of $\varphi(d)$ values of divisors d of n.

8.2: The Tau and Sigma Function- definition, multiplicative nature of tau(τ) and sigma (σ) functions, formula for $\tau(n)\ and\ \sigma(n)$. ['Application to a Brainteaser' omitted]

***List of Practicals (using any software)**

- Finding roots of quadratic polynomial.
- Writing programming code to find the gcd of two numbers using Euclidean algorithm.
- Writing programming code to find the lcm of two numbers.
- Finding highest power of a prime dividing $n!$.
- Performing divisibility test.
- Checking compositeness of numbers using Fermat's Little Theorem.
- Finding Euler's phi function value of a number.
- Checking solvability of linear congruence.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Dickson L.E: Elementary Theory of Equations John Wiley and Sons,Inc. NY(1914)
2	Turnbull H.W: Theory of Equations(4/e) Oliver and Boyd Ltd. Edinburg(1947)
3	Todhunter I: An Elementary Treatise on the Theory of Equations(3/e) Macmillan and Co. London(1875)
4	William Snow Burnside and Arthur William Panton: The Theory of Equations with An Introduction to Binary Algebraic Forms Dublin University Press Series(1881)
5	David M. Burton : Elementary Number Theory(7/e) McGraw-Hill (2011) ISBN: 978-0-07-338314-9

6	Gareth A. Jones and J. Mary Jones: Elementary Number Theory, Springer Undergraduate Mathematics Series(1998) ISBN: 978-3-540-76197-6
7	Underwood Dudley :Elementary Number Theory(2/e), Dover Publications (2008)ISBN:978-0-486-46931-7
8	James K Strayer: Elementary Number Theory, Waveland Press, inc. (1994), ISBN:978-1-57766-224-2
9	Kenneth H. Rosen: Elementary Number Theory(6/e), Pearson Education(2018)ISBN: 9780134310053.

FOURTH SEMESTER

BMT4 B04: LINEAR ALGEBRA

5 hours/week 4 Credits 100 Marks [Int:20+Ext:80]

Aims and Objectives

An introductory treatment of linear algebra with an aim to present the fundamentals in the clearest possible way is intended here. Linear algebra is the study of linear systems of equations, vector spaces, and linear transformations. Virtually every area of mathematics relies on or extends the tools of linear algebra. Solving systems of linear equations is a basic tool of many mathematical procedures used for solving problems in science and engineering. A number of methods for solving a system of linear equations are discussed. In this process, the student will become competent to perform matrix algebra and also to calculate the inverse and determinant of a matrix. Another advantage is that the student will come to understand the modern view of a matrix as a linear transformation. The discussion necessitates the introduction of central topic of linear algebra namely the concept of a vector space. The familiarity of the students with planar vectors and their algebraic properties under vector addition and scalar multiplication will make them realize that the idea of a general vector space is in fact an abstraction of what they already know. Several examples and general properties of vector spaces are studied. The idea of a subspace, spanning vectors, basis and dimension are discussed and fundamental results in these areas are explored. This enables the student to understand the relationship among the solutions of a given system of linear equations and some important subspaces associated with the coefficient matrix of the system.

After this, some basic matrix transformations in the vector spaces $\mathbb{R}2$ $\mathbb{R}3$, having interest in the field of computer graphics, engineering and physics are studied by specially pinpointing to their geometric effect.

Just like choosing an appropriate coordinate system greatly simplifies a problem at our hand as we usually see in analytic geometry and calculus, a right choice of the basis of the vector space $\mathbb{R}$ greatly simplifies the analysis of a matrix operator on it. With this aim in mind, a study on eigenvalues and eigenvectors of a given matrix (equivalently, that of the corresponding matrix operator) is taken up. Practical method of finding out the eigenvalues from the characteristic equation and the corresponding eigenvectors are also discussed.

A bonus point achieved during this process is a test for the invertibility of a square matrix. As diagonal matrices are the matrices with simplest structure, the idea of

diagonalization of a matrix (and hence the diagonalization of a matrix operator) is introduced and students learn a few fundamental results involving diagonalization and eigenvalues which enable them to check whether diagonalization is possible. They realise that there are matrices that cannot be diagonalized and even learn to check it. Also they are taught a well defined procedure for diagonalizing a given matrix, if this is actually the case. The topic is progressed further to obtain the ultimate goal of spectral decomposition of a symmetric matrix. In this process, students realise that every symmetric matrix is diagonalizable and that this diagonalization can be done in a special way ie., by choosing an orthogonal matrix to perform the diagonalization. This is known as orthogonal diagonalization. Students also learn that only symmetric matrices with real entries can be orthogonally diagonalized and using Gram-Schmidt process a well defined procedure for writing such a diagonalization is also taught. In short, the course gives the students an opportunity to learn the fundamentals of linear algebra by capturing the ideas geometrically, by justifying them algebraically and by preparing them to apply it in several different fields such as data communication, computer graphics, modelling etc.

Course Outcome

Successful completion of the course enables the students to

- Use computational techniques and algebraic skills essential for the study of systems of linear equations and matrix algebra.
- Compute and use determinants.
- Learn vector space and subspace.
- Recognize the concept of the terms span, linear independence, basis and dimension and apply these concepts to various vector spaces and subspaces.
- Analyze vectors in $\mathbb{R}^n$ geometrically and algebraically.
- Understand the relationship among the solutions of a given system of linear equations and some important subspaces associated with the coefficient matrix of the system.
- Familiar with the notion of a linear transformation and its matrix.
- Find the change of basis with respect to two bases of a vector space.
- Find the eigen values and eigen vectors of a square matrix using the characteristic polynomial and will know to diagonalize a matrix when this is possible.

Syllabus

FOURTH SEMESTER

BMT4 B04: LINEAR ALGEBRA

Text	Elementary Linear Algebra: Application Version(11/e) :Howard Anton & Chris Rorres Wiley(2014) ISBN 978-1-118-43441-3

Module-I	**(22 hrs)**

Systems of Linear Equations & Matrices

1.1: Introduction to Systems of Linear Equations- linear equation in variables, linear system of equations in variables, solution, Linear Systems in Two and Three Unknowns, solution by geometric analysis, consistent and inconsistent systems, linear system with no, one, and infinite number of solutions, augmented matrix and elementary row operations.

1.2: Gaussian elimination - Considerations in Solving Linear Systems, Echelon Forms, reduced row echelon form, Elimination Methods, Gauss–Jordan elimination, Gaussian elimination, Homogeneous Linear Systems, Free Variables, Free Variable Theorem for Homogeneous Systems, Gaussian Elimination and Back- Substitution, Some Facts about Echelon Forms.

1.3: Matrices and Matrix operations- Matrix Notation and Terminology, row vector , column vector , square matrix of order *n*, Operations on Matrices , Partitioned Matrices, Matrix Multiplication by Columns and by Rows, Matrix Products as Linear Combinations, linear combination of column vectors, Column-Row Expansion, Matrix Form of a Linear System, Transpose of a Matrix, Trace of a Matrix.

1.4: Inverses and algebraic properties of matrices- Properties of Matrix Addition and Scalar Multiplication, Properties of Matrix Multiplication, Zero Matrices and Properties, Identity Matrices, Inverse of a Matrix, Properties of Inverses, Solution of a Linear System by Matrix Inversion, Powers of a Matrix, Matrix Polynomials, Properties of the Transpose.

1.5: Elementary matrices and a method for finding A^{-1}-row equivalence, elementary matrix, Row Operations by Matrix Multiplication, invertibility of elementary matrices, invertibility and equivalent statements, A Method for Inverting Matrices, Inversion Algorithm, illustrations.

1.6: More on linear systems and invertible matrices - Number of Solutions of a Linear System, Solving Linear Systems by Matrix Inversion, Linear Systems with a Common Coefficient Matrix, Properties of Invertible Matrices, equivalent statements for unique solution of $Ax = b$, determining consistency.

1.7: Diagonal, Triangular and Symmetric matrices-Diagonal Matrices, Inverses and Powers of Diagonal Matrices, Triangular Matrices. Properties of Triangular Matrices, Symmetric Matrices, algebraic properties of symmetric matrices, Invertibility of Symmetric Matrices.

1.8: Matrix transformation- definition, Properties of Matrix Transformations, standard matrix, A Procedure for Finding Standard Matrices.

Module-II	**(18 hrs)**

General Vector Spaces

2.1: Determinants by cofactor expansion- minors, cofactors, cofactor expansion, Definition of a General Determinant, A Useful Technique for Evaluating 2×2 and 3×3 Determinants.

2.2: Evaluating determinants by row reduction- a few basic theorems, elementary row operations and determinant, determinant of elementary matrices, determinant by row reduction.

4.1: Real vector space - Vector Space Axioms, examples, Some Properties of Vectors.

4.2: Subspaces- definition, criteria for a subset to be a subspace, examples, Building Subspaces, linear combination, spanning, Solution Spaces of Homogeneous Systems as subspace, The Linear Transformation Viewpoint, kernel, different set of vectors spanning the subspace.

4.3: Linear Independence- Linear Independence and Dependence, illustrations, A Geometric Interpretation of Linear Independence, Wronskian, linear independence using Wronskian.

Module-III	**(24 hrs)**

4.4: Coordinates and basis-Coordinate Systems in Linear Algebra, Basis for a Vector Space, finite and infinite dimensional vector spaces, illustrations, Coordinates Relative to a Basis, Uniqueness of Basis Representation.

4.5: Dimension- Number of Vectors in a Basis, dimension, Some Fundamental Theorems, dimension of subspaces.

4.6: Change of basis -Coordinate Maps, Change of Basis, Transition Matrices, Invertibility of Transition Matrices, An Efficient Method for Computing Transition Matrices for $\mathbb{R}^n$, Transition to the Standard Basis for $\mathbb{R}^n$.

4.7: Row space, Column space and Null space- vector spaces associated with matrices, consistency of linear system, Bases for Row Spaces, Column Spaces, and Null Spaces, basis from row echelon form, Basis for the Column Space of a Matrix, row equivalent matrices and relationship between basis for column space, Bases Formed from Row and Column Vectors of a Matrix.

4.8: Rank Nullity and Fundamental matrix spaces- equality of dimensions of row and column spaces, Rank and Nullity, Dimension Theorem for Matrices, The Fundamental Spaces of a Matrix, rank of a matrix and its transpose, A Geometric Link Between the Fundamental Spaces, orthogonal complement, invertibility and equivalent statements, Applications of Rank, Overdetermined and Underdetermined Systems.

Module-IV	**(16 hrs)**

4.9: Basic matrix transformations in R^2 and R^3 -Reflection Operators, Projection Operators, Rotation Operators, Rotations in $\mathbb{R}^3$, Dilations and Contractions, Expansions and Compressions, Shears.

4.10: Properties of matrix transformation- Compositions of Matrix Transformations, One-to-One Matrix Transformations, Kernel and Range, fundamental relationship between invertibility of a matrix and its matrix transformation, Inverse of a One-to-One Matrix Operator.

5.1: Eigen values and Eigen Vectors- definition, Computing Eigenvalues and Eigenvectors, characteristic equation, alternative ways of describing eigen values, Finding Eigenvectors and Bases for Eigenspaces, Eigenvalues and Invertibility, Eigenvalues of General Linear Transformations.

5.2: Diagonalization-The Matrix Diagonalization Problem, linear independence of eigen vectors and diagonalizability, Procedure for Diagonalizing a Matrix, Eigenvalues of Powers of a Matrix, Computing Powers of a Matrix, Geometric and Algebraic Multiplicity.

7.1: Orthogonal Matrices- definition, characterisation of orthogonal matrices, properties of orthogonal matrices [rest of the section omitted].

*List of Practicals (using any software)

- Matrix operation (addition, multiplication, inverse, transpose).
- Reorganizing systems of linear equations into matrix form and solve.
- Calculating the eigen values and eigen vectors of a matrix.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Jim DeFranza, Daniel Gagliardi: Introduction to Linear Algebra with Applications *Waveland Press, Inc(2015)ISBN: 1-4786-2777-8*
2	Otto Bretscher: Linear Algebra with Applications(5/e) Pearson Education, Inc (2013) ISBN: 0-321-79697-7
3	Ron Larson, Edwards, David C Falvo : Elementary Linear Algebra(6/e) *Houghton Mifflin Harcourt Publishing Company(2009) ISBN: 0-618-78376-8*
4	David C. Lay, Steven R. Lay, Judi J. McDonald: Linear Algebra and its Application (5/e) *Pearson Education, Inc(2016) ISBN: 0-321-98238-X*
5	Martin Anthony, Michele Harvey: Linear Algebra: Concepts and Methods *Cambridge University Press(2012) ISBN: 978-0-521-27948-2*
6	Jeffrey Holt: Linear Algebra with Applications *W. H. Freeman and Company (2013) ISBN: 0-7167-8667-2*

FIFTH SEMESTER

BMT5 B05: ABSTRACT ALGEBRA

5 hours/week 4 Credits 100 Marks [Int:20+Ext:80]

Aims and Objectives

To provide a first approach to the subject of algebra, which is one of the basic pillars of modern mathematics and to study of certain structures called groups, rings, fields and some related structures. The brilliant mathematician Evariste Galois developed an entire theory that connected the solvability by radicals of a polynomial equation with the permutation group of its roots. The theory now known as Galois theory solves the famous problem of insolvability of quintic. A study on symmetric functions now becomes inevitable. One can now observe the connection emerging between classical algebra and modern algebra. The last three modules are therefore devoted to the discussion on basic ideas and results of abstract algebra. Students understand the abstract notion of a group, learn several examples, are taught to check whether an algebraic system forms a group or not and are introduced to some fundamental results of group theory. The idea of structural similarity, the notion of cyclic group, permutation group, various examples and very fundamental results in the areas are also explored.

Course Outcome

Successful completion of the course enables the students to

- Understand the concept of binary operations by definition and examples.
- Understand the concept of algebraic structures.
- Learn different types of subgroups such as groups, rings, integral domains, fields and fields of quotient of integral domain.
- The students will actively participate in the transition of important concepts such homomorphisms & isomorphisms from discrete mathematics to advanced abstract mathematics.

Syllabus

FIFTH SEMESTER

BMT5 B05: ABSTRACT ALGEBRA

Text	John. B. Fraleigh: A First Course in Abstract Algebra, 7th Ed. Pearson

Module-I (20 hrs)

Binary Operations; Isomorphic binary structures; Groups; Subgroups

(Sections 2, 3, 4 & 5)

Module-II (25 hrs)

Cyclic groups; Groups and permutations; Orbits, Cycles and Alternating Groups

(Sections 6, 8 & 9)

Module-III (15 hrs)

Cosets and Theorem of Lagrange; Homomorphisms

(Sections 10 & 13)

Module-IV (15 hrs)

Rings and Fields; Integral Domains, The Field of Quotients of an Integral Domain

(Sections 18, 19 & 21)

References:

1	Joseph A. Gallian : Contemporary Abstract Algebra(9/e) *Cengage Learning, Boston(2017) ISBN: 978-1-305-65796-0*
2	John B Fraleigh : A First Course in Abstract Algebra(7/e) *Pearson Education LPE(2003) ISBN 978-81-7758-900-9*
3	David Steven Dummit, Richard M. Foote: Abstract Algebra(3/e) *Wiley, (2004) ISBN: 8126532289*
4	Linda Gilbert and Jimmie Gilbert: Elements of Modern Algebra (8/e) *Cengage Learning, Stamford(2015) ISBN: 1-285-46323-4*
5	John R. Durbin : Modern Algebra: An Introduction(6/e) *Wiley(2015) ISBN: 1118117611*
6	Jeffrey Bergen: A Concrete Approach to Abstract Algebra- From the integers to Insolvability of Quintic *Academic Pres [Elsever](2010)ISBN: 978-0-12-374941-3*

FIFTH SEMESTER

BMT5 B06: BASIC ANALYSIS

5 hours/week 4 Credits 100 Marks [Int:20+Ext:80]

Aims and Objectives

In this course, basic ideas and methods of real and complex analysis are taught. Real analysis is a theoretical version of single variable calculus. So many familiar concepts of calculus are reintroduced but at a much deeper and more rigorous level than in a calculus course. At the same time there are concepts and results that are new and not studied in the calculus course but very much needed in more advanced courses. The aim is to provide students with a level of mathematical sophistication that will prepare them for further work in mathematical analysis and other fields of knowledge, and also to develop their ability to analyse and prove statements of mathematics using logical arguments.

Course Outcome

Successful completion of the course enables the students to

- Learn and deduce rigorously many properties of real number system by assuming a few fundamental facts about it as axioms.
- Learn about sequences, their limits, several basic and important theorems involving sequences and their applications.
- Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
- Understand some basic topological properties of real number and complex number system such as the concept of open and closed sets, their properties, their characterization and so on.
- Represent complex numbers algebraically and geometrically and learn complex functions as mappings.

Syllabus

FIFTH SEMESTER

BMT5 B06: BASIC ANALYSIS

Text: 1	Introduction to Real Analysis(4/e) : Robert G Bartle, Donald R Sherbert *John Wiley & Sons(2011) ISBN 978-0-471-43331-6.*
Text: 2	Complex Analysis A First Course with Applications: Dennis Zill & Patric Shanahan *Jones and Bartlett Learning(2015) ISBN:0-7637-1437-2.*

Module-I Text: 1 (20 hrs)

1.3: Finite and Infinite Sets-definition, countable sets, denumerability of $\mathbb{Q}$, union of countable sets, cantor's theorem.

2.1: The Algebraic and Order Properties of $\mathbb{R}$- algebraic properties, basic results, rational and irrational numbers, irrationality of $\sqrt{2}$, Order properties, arithmetic-geometric inequality, Bernoulli's Inequality.

2.2: Absolute Value and the Real Line- definition, basic results, Triangle Inequality, The real line, ε-neighborhood.

2.3: The Completeness Property of $\mathbb{R}$- Suprema and Infima, alternate formulations for the supremum, The Completeness Property.

Module-II Text: 1 (21 hrs)

2.4: Applications of the Supremum Property- The Archimedean Property, various consequences, Existence of $\sqrt{2}$, Density of Rational Numbers in $\mathbb{R}$, The Density Theorem, density of irrationals.

2.5: Intervals-definition, Characterization of Intervals, Nested Intervals, Nested Intervals Property, The Uncountability of $\mathbb{R}$, [binary, decimal and periodic representations omitted] Cantor's Second Proof.

3.1: Sequences and Their Limits- definitions, convergent and divergent sequences, Tails of Sequences, Examples.

3.2: Limit Theorems- sum, difference, product and quotients of sequences, Squeeze Theorem, ratio test for convergence.

3.3: Monotone Sequences-definition, monotone convergence theorem, divergence of harmonic series, calculation of square root, Euler's number.

Module-III	Text: 1	(18 hrs)

3.4: Subsequences and the Bolzano-Weierstrass Theorem- definition, limit of subsequences, divergence criteria using subsequence, The Existence of Monotone Subsequences, monotone subsequence theorem, The Bolzano-Weierstrass Theorem, Limit Superior and Limit Inferior.

3.5: The Cauchy Criterion- Cauchy sequence, Cauchy Convergence Criterion, applications, contractive sequence.

3.6: Properly divergent sequences-definition, examples, properly divergent monotone sequences, ‘‘comparison theorem’’, ‘‘limit comparison theorem’’

11.1: Open and Closed sets in $\mathbb{R}$ - neighborhood, open sets, closed sets, open set properties, closed set properties, Characterization of Closed Sets, cluster point, Characterization of Open Sets, The Cantor Set, properties.

Module-IV	Text: 2	(21 hrs)

1.1: Complex numbers and their properties- definition, arithmetic operations, conjugate, inverses, reciprocal

1.2: Complex Plane- vector representation, modulus, properties, triangle Inequality.

1.3: Polar form of complex numbers- polar representation, principal argument, multiplication and division, argument of product and quotient, integer powers, de Moivre’s formula.

1.4: Powers and roots- roots, principal nth root.

1.5: Sets of points in the complex plane- circles, disks and neighbourhoods, open sets, annulus, domains, regions, bounded sets.

2.1: Complex Functions- definition, real and imaginary parts of complex function, complex exponential function, exponential form of a complex number, Polar Coordinates.

2.2: Complex Functions as mappings- complex mapping, illustrations, Parametric curves in complex planes, common parametric curves, image of parametric curves under complex mapping [The subsection ‘Use of Computers’ omitted].

2.4: Special Power functions- The power function Z^n, The power function $Z^{\frac{1}{n}}$, principal square root function, Inverse Functions, multiple valued functions.

***List of Practicals (using any software)**

- Plotting of recursive sequences.
- Study the convergence of sequences through plotting.
- Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Charles G. Denlinger: Elements of Real Analysis *Jones and Bartlett Publishers Sudbury, Massachusetts (2011) ISBN:0-7637-7947-4 [Indian edition: ISBN- 9380853157]*
2	David Alexander Brannan: A First Course in Mathematical Analysis *Cambridge University Press,US(2006) ISBN: 9780521684248*
3	John M. Howie: Real Analysis *Springer Science & Business Media(2012) [Springer Undergraduate Mathematics Series] ISBN: 1447103416*
4	James S. Howland: Basic Real Analysis *Jones and Bartlett Publishers Sudbury, Massachusetts (2010) ISBN:0-7637-7318-2*
5	James Ward Brown, Ruel Vance Churchill: Complex variables and applications(8/e) *McGraw-Hill Higher Education, (2009) ISBN: 0073051942*
6	Alan Jeffrey: Complex Analysis and Applications(2/e) *Chapman and Hall/CRC Taylor Francis Group(2006)ISBN:978-1-58488-553-5*
7	Saminathan Ponnusamy, Herb Silverman: Complex Variables with Applications *Birkhauser Boston(2006) ISBN:0-8176-4457-4*
8	Terence Tao: Analysis I & II (3/e) *TRIM 37 & 38 Springer Science+Business Media Singapore 2016; Hindustan book agency(2015) ISBN 978-981-10-1789-6 (eBook) & ISBN 978-981-10-1804-6 (eBook)*
9	Ajith Kumar & S Kumaresan : A Basic Course in Real Analysis *CRC Press, Taylor & Francis Group(2014) ISBN: 978-1-4822-1638-7 (eBook - PDF)*
10	Hugo D Junghenn : A Course in Real Analysis *CRC Press, Taylor & Francis Group(2015) ISBN: 978-1-4822-1928-9 (eBook - PDF)*

FIFTH SEMESTER

BMT5 B07: NUMERICAL ANALYSIS

4 hours/week 3 Credits 75 Marks [Int:15+Ext:60]

Aims and Objectives

The goal of numerical analysis is to provide techniques and algorithms to find approximate numerical solution to problems in several areas of mathematics where it is impossible or hard to find the actual/closed form solution by analytical methods and also to make an error analysis to ascertain the accuracy of the approximate solution. The subject addresses a variety of questions ranging from the approximation of functions and integrals to the approximate solution of algebraic, transcendental, differential and integral equations, with particular emphasis on the stability, accuracy, efficiency and reliability of numerical algorithms.

Course Outcome

Successful completion of the course enables the students to

- Understand several methods such as bisection method, fixed point iteration method, regula falsi method etc. to find out the approximate numerical solutions of algebraic and transcendental equations with desired accuracy.
- Understand the concept of interpolation and also learn some well-known interpolation techniques.
- Understand a few techniques for numerical differentiation and integration and also realize their merits and demerits.
- Find out numerical approximations to solutions of initial value problems and also to understand the efficiency of various methods.

Syllabus

FIFTH SEMESTER

BMT5 B07: NUMERICAL ANALYSIS

Text	Numerical Analysis (10/e): *Richard L. Burden, J Douglas Faires, Annett M. Burden Brooks Cole Cengage Learning (2016) ISBN:978-1-305-25366-7*

Module-I (28 hrs)

Solutions of Equations in One Variable

Note: Students should be familiar with concepts and definitions such as 'round off error', rate of convergence etc. discussed in sections 1.2 and 1.3

2.1: The Bisection Method

2.2: Fixed-Point Iteration

2.3: Newton's Method and Its Extensions- Newton's Method (Newton-Raphson method), Convergence using Newton's Method, The Secant Method, The Method of False Position

2.4: Error Analysis for Iterative Methods- Order of Convergence, linear and quadratic convergence, Multiple Roots, Modified Newton's method for faster convergence

[Algorithms are omitted]

Interpolation and Polynomial Approximation

3.1: Interpolation and the Lagrange Polynomial- motivation, Lagrange Interpolating Polynomials, error bound

3.3: Divided Differences- k^{th} divided difference, Newton's divided difference formula, Forward Differences, Newton Forward-Difference Formula, Backward Differences, Newton Backward–Difference Formula, Centered Differences, Stirling's formula.

[Algorithms are omitted]

Module-II (18 hrs)

Numerical Differentiation and Integration

4.1: Numerical Differentiation- approximation of first derivative by forward difference

formula, backward difference formula, Three-Point Formulas, Three-Point Endpoint Formula, Three-Point Midpoint Formula [Five-Point Formulas, Five-Point Endpoint Formula, Five-Point Midpoint Formula omitted] Second Derivative Midpoint Formula to approximate second derivative, Round-Off Error Instability.

4.3: Elements of Numerical Integration-numerical quadrature, The Trapezoidal Rule, Simpson's Rule, Measuring Precision, Closed Newton-Cotes Formulas, Simpson's Three-Eighths rule, Open Newton-Cotes Formulas

4.4: Composite Numerical Integration-composite Simpson's rule, composite trapezoidal rule, composite midpoint rule, round off error stability

[Algorithms are omitted]

Module-III	**(18 hrs)**

Initial-Value Problems for Ordinary Differential Equations Introduction

5.1 The Elementary Theory of Initial-Value Problems.

5.2: Euler's Method- derivation using Taylor formula, Error bounds for Euler Method.

5.3: Higher-Order Taylor Methods- local truncation error, Taylor method of order n and order of local truncation error.

5.4: Runge-Kutta Methods- only Mid Point Method, Modified Euler's Method and Runge-Kutta Method of Order Four are required. [derivation of formula omitted in each case].

[Algorithms are omitted]

***List of Practicals (using any software)**

- Bisection Method.
- Newton Raphson Method.
- Fixed-Point Iteration
- Secant Method.
- Regulai Falsi Method.

- Interpolating discrete data to continues data for data interpretation.
- Lagrange interpolation.
- Approximating definite integral by using Simpson's rule and Trapezoidal rule.
- Solving ODE by using Euler's and Runge-Kutta methods.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Kendall E. Atkinson, Weimin Han: Elementary Numerical Analysis(3/e) *John Wiley & Sons(2004) ISBN:0-471-43337-3[Indian Edition by Wiley India ISBN: 978-81-265-0802-0]*
2	James F. Epperson: An Introduction to Numerical Methods and Analysis(2/e) *John Wiley & Sons(2013)ISBN: 978-1-118-36759-9*
3	Timothy Sauer: Numerical Analysis(2/e) *Pearson (2012) ISBN: 0-321-78367-0*
4	S S Sastri : Introductory Methods of Numerical Analysis(5/e) *PHI Learning Pvt. Ltd.(2012) ISBN:978-81-203-4592-8*
5	Ward Cheney,David Kincaid : Numerical Mathematics and Computing (6/e) *Thomson Brooks/Cole(2008) ISBN: 495-11475-8*

FIFTH SEMESTER

BMT5 B08: LINEAR PROGRAMMING

3 hours/week 3 Credits 75 Marks [Int:15+Ext:60]

Aims and Objectives

Linear programming problems are having wide applications in mathematics, statistics, computer science, economics, and in many social and managerial sciences. For mathematicians it is a sort of mathematical modelling process, for statisticians and economists it is useful for planning many economic activities such as transport of raw materials and finished products from one place to another with minimum cost and for military heads it is useful for scheduling the training activities and deployment of army personnel. The emphasis of this course is on nurturing the linear programming skills of students via. the algorithmic solution of small-scale problems, both in the general sense and in the specific applications where these problems naturally occur.

Course Outcome

Successful completion of the course enables the students to

- Formulate real life situations as linear programming models.
- Solve linear programming problems using graphical method, simplex method and dual simplex method.
- Develop and solve transportation and assignment problems using mathematical algorithms.

Syllabus

FIFTH SEMESTER

BMT5 B08: LINEAR PROGRAMMING

Text	Linear Programming and Its Applications: James K. Strayer *Under graduate Texts in Mathematics Springer (1989) ISBN: 978-1-4612-6982-3*

Module-I (20 hrs)

Geometric Linear Programming: Profit Maximization and Cost Minimization, typical motivating examples, mathematical formulation, Canonical Forms for Linear Programming Problems, objective functions, constraint set, feasible solution, optimal solution , Polyhedral Convex Sets, convex set, extreme point, theorems asserting existence of optimal solutions, The Two Examples Revisited, graphical solutions to the problems, A Geometric Method for Linear Programming, the difficulty in the method, Concluding Remarks.

The Simplex Algorithm:- Canonical Slack Forms for Linear Programming Problems; Tucker Tableaus, slack variables, Tucker tableaus, independent variables or non-basic variables, dependent variables or basic variables, .An Example: Profit Maximization, method of solving a typical canonical maximization problem, The Pivot Transformation, The Pivot Transformation for Maximum and Minimum Tableaus, An Example: Cost Minimization, method of solving a typical canonical minimization problem, The Simplex Algorithm for Maximum Basic Feasible Tableaus, The Simplex Algorithm for Maximum Tableaus, Negative Transposition; The Simplex Algorithm for Minimum Tableaus, Cycling, Simplex Algorithm Anti cycling Rules, Concluding Remarks.

Module-II (16 hrs)

Noncanonical Linear Programming Problems: - Unconstrained Variables, Equations of Constraint, Concluding Remarks.

Duality Theory:- Duality in Canonical Tableaus, The Dual Simplex Algorithm, The Dual Simplex Algorithm for Minimum Tableaus, The Dual Simplex Algorithm for Maximum Tableaus, Matrix Formulation of Canonical Tableaus, The Duality Equation, Duality in Noncanonical Tableaus, Concluding Remarks.

Module-III (12 hrs)

Transportation Problems: - The Balanced Transportation Problem, The Vogel Advanced-Start Method (VAM), The Transportation Algorithm, Another Example, Unbalanced Transportation Problems.

Assignment Problems: - The Assignment Problem, The Hungarian Algorithm, Concluding Remarks, The Minimum-Entry Method, The Northwest-Corner Method.

*List of Practicals (using any software)

- Solving linear programming problems.
- Solving transportation models.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

APPLICATIONS:

** The application part is beyond the part of the syllabus. Questions should not be asked from this part.

SOFTWARE: TORA

TORA Package is a computer application software package used for statistical computation and analysis. It is an already written program or suite of programs written for statistical application. It is basically applied for Operations Research (OR) analysis. TORA Optimization Window is a graphical user interface (GUI). This is what makes it unique from other statistical packages that have spreadsheets windows. TORA software offers modules for matrix inversion, solution of simultaneous linear equations, linear programming, transportation models, network models, project planning with CPM and PERT, queuing analysis, and game theory.

References:

1	RobertJ.Vanderbei:LinearProgramming:Foundations and Extensions (2/e) Springer Science+Business Media LLC(2001) ISBN: 978-1-4757-5664-7
2	Frederick S Hiller, Gerald J Lieberman: Introduction to Operation Research(10/e) *McGraw-Hill Education, 2 Penn Plaza, New York(2015)ISBN: 978-0-07-352345-3*
3	Paul R. Thie, G. E. Keough : An Introduction to Linear Programming and Game Theory(3/e) *John Wiley and Sons,Ins.(2008)ISBN: 978-0-470-23286-6*
4	Louis Brickman: Mathematical Introduction to Linear Programming and Game Theory *UTM,Springer Verlag,NY(1989)ISBN:0-387-96931-4*
5	Jiri Matoušek, Bernd Gartner: Understanding and Using Linear Programming *Universitext, Springer-Verlag Berlin Heidelberg (2007)ISBN: 978-3-540-30697-9*

FIFTH SEMESTER

BMT5 B09: CALCULUS OF MULTIVARIABLE-1

4 hours/week 3 Credits 75 Marks [Int:15+Ext:60]

Aims and Objectives

A detailed study of plane and space curves is then taken up. The students get the idea of parametrization of curves, they learn how to calculate the arc length, curvature etc. using parametrization and also the area of surface of revolution of a parametrized plane curve. Students are introduced into other coordinate systems which often simplify the equation of curves and surfaces and the relationship between various coordinate systems are also taught. This enables them to directly calculate the arc length and surface areas of revolution of a curve whose equation is in polar form. At the end of the course, the students will be able to handle vectors in dealing with the problems involving geometry of lines, curves, planes and surfaces in space and have acquired the ability to sketch curves in plane and space given in vector valued form.

This course is also extend the useful ideas and notions such as limit, continuity, derivative and integral seen in the context of function of single variable to function of several variables. The corresponding results will be the higher dimensional analogues of what we learned in the case of single variable functions. The results developed in the course of calculus of multivariable is extremely useful in several areas of science and technology as many functions that arise in real life situations are functions of multivariable.

Course Outcome

Successful completion of the course enables the students to

- Understand the concept of parameterized curve from algebraic, geometric and physical stand points.
- Compute the length and area of surface of revolution of smooth curves.

- Understand the graphs of polar equations and evaluating areas and arc length using polar coordinates.
- Determine the equations of a line, plane and surface in space.
- Introduce the cylindrical, spherical coordinates.
- Describe vector valued functions how to evaluate the limit, continuity, differentiation and integration of a vector valued function.
- Describe the velocity, acceleration of a particle moving in a plane or in space.
- Understand level curves and level surfaces.
- Formulate and work on the idea of limit and continuity for functions of several variables.
- Describe the notion of partial derivatives and their computation and interpretation.
- Understand chain rule for calculating partial derivatives.
- Understand the concepts of directional derivatives of functions of two or three variables and its evaluation, geometrical interpretation and applications.
- Understand the concept of gradient of a scalar function, properties and applications of gradient.

Syllabus

FIFTH SEMESTER

BMT5 B09:CALCULUS OF MULTIVARIABLE-1

Text	Calculus: Soo T Tan *Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7*

Module-I	**(17 hrs)**

10.2: Plane Curves and Parametric Equations- Why We Use Parametric Equations, Sketching Curves Defined by Parametric Equations.

10.3: The Calculus of parametric equations- Tangent Lines to Curves Defined by Parametric Equations, Horizontal and Vertical Tangents, Finding $\frac{d^2y}{dx^2}$ from Parametric Equations, The Length of a Smooth Curve, The Area of a Surface of Revolution.

10.4: Polar coordinate-The Polar Coordinate System, Relationship Between Polar and Rectangular Coordinates, Graphs of Polar Equations, Symmetry, Tangent Lines to Graphs of Polar Equations.

10.5: Areas and Arc Lengths in polar coordinates-Areas in Polar Coordinates, area bounded by polar curves, Area Bounded by Two Graphs, Arc Length in Polar Coordinates, Area of a Surface of Revolution, Points of Intersection of Graphs in Polar Coordinates

Module-II	**(12 hrs)**

11.5: Lines and Planes in Space-Equations of Lines in Space, parametric equation, symmetric equation of a line, Equations of Planes in Space, standard equation, Parallel and Orthogonal Planes, The Angle Between Two Planes, The Distance Between a Point and a Plane

11.6: Surfaces in Space- Traces, Cylinders, Quadric Surfaces, Ellipsoids, Hyperboloids of One Sheet, Hyperboloids of Two Sheets, Cones, Paraboloids, Hyperbolic Paraboloids

11.7: Cylindrical and Spherical Coordinates-The Cylindrical Coordinate System, converting cylindrical to rectangular and vice versa, The Spherical Coordinate System, converting spherical to rectangular and vice versa,

Module-III	(15 hrs)

12.1: Vector Valued functions and Space Curves- definition of vector function, Curves Defined by Vector Functions, [‘Example 7’ omitted] Limits and Continuity.

12.2: Differentiation and Integration of Vector-Valued Function- The Derivative of a Vector Function, Higher-Order Derivatives, Rules of Differentiation, Integration of Vector Functions.

12.3: Arc length and Curvature- Arc Length of a space curve, Smooth Curves, Arc Length Parameter, arc length function, Curvature, formula for finding curvature, Radius of Curvature.

12.4: Velocity and Acceleration- Velocity, Acceleration, and Speed; Motion of a Projectile.

12.5: Tangential and Normal Components of Acceleration- The Unit Normal, principal unit normal vector, Tangential and Normal Components of Acceleration

[The subsections ‘Kepler’s Laws of Planetary Motion’, and ’Derivation of Kepler’s First Law’ omitted]

Module-IV	(20 hrs)

13.1: Functions of two or more variables- Functions of Two Variables, Graphs of Functions of Two Variables, Level Curves, Functions of Three Variables and Level Surfaces

13.2: Limits and continuity-An Intuitive Definition of a Limit, existence and non existence of limit, Continuity of a Function of Two Variables, Continuity on a Set, continuity of polynomial and rational functions, continuity of composite functions, Functions of Three or More Variables, The $\varepsilon - \delta$ Definition of a Limit.

13.3: Partial Derivatives- Partial Derivatives of Functions of Two Variables, geometric interpretation, Computing Partial Derivatives, Implicit Differentiation, Partial Derivatives of Functions of More Than Two Variables, Higher-Order Derivatives, clairaut theorem, harmonic functions

13.4: Differentials- Increments, The Total Differential, interpretation, Error in Approximating Δz by dz [only statement of theorem1 required; proof omitted] Differentiability of a Function of Two Variables, criteria, Differentiability and Continuity, Functions of Three or More Variables

13.5: The Chain rule- The Chain Rule for Functions Involving One Independent Variable, The Chain Rule for Functions Involving Two Independent Variables, The General Chain Rule, Implicit Differentiation

13.6: Directional Derivatives and Gradient vectors - The Directional Derivative, The Gradient of a Function of Two Variables, Properties of the Gradient, Functions of Three Variables

***List of Practicals (using any software)**

- Plotting area bounded by two graphs.
- Sketching parametric curves.
- Tracing of conics in cartesian coordinates/ polar coordinates.
- Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, hyperbolic paraboloid using cartesian coordinates.
- Evaluating limits by plotting of graphs of multi variable functions.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Joel Hass, Christopher Heil & Maurice D. Weir : Thomas' Calculus (14/e) *Pearson(2018) ISBN 0134438981*
2	Robert A Adams & Christopher Essex : Calculus *Single Variable (8/e) Pearson Education Canada (2013) ISBN: 0321877403*
3	Jon Rogawski & Colin Adams : Calculus *Early Transcendentals* (3/e) W. H. Freeman and Company(2015) *ISBN: 1319116450*
4	Anton, Bivens & Davis : Calculus *Early Transcendentals* (11/e) *John Wiley & Sons, Inc.(2016) ISBN: 1118883764*
5	James Stewart : Calculus (8/e) *Brooks/Cole Cengage Learning(2016) ISBN: 978-1-285-74062-1*
6	Jerrold Marsden & Alan Weinstein: Calculus I and II (2/e) *Springer Verlag NY(1985) ISBN 0-387-90974-5 : ISBN 0-387-90975-3*

SIXTH SEMESTER

BMT6 B10: REAL ANALYSIS

5 hours/week 5 Credits 100 Marks [Int:20+Ext:80]

Aims and Objectives

The course is built upon the foundation laid in Basic Analysis course of fifth semester. The course thoroughly exposes one to the rigour and methods of an analysis course. One has to understand definitions and theorems of text and study examples well to acquire skills in various problem-solving techniques. The course will teach one how to combine different definitions, theorems and techniques to solve problems one has never seen before. One shall acquire ability to realise when and how to apply a particular theorem and how to avoid common errors and pitfalls. The course will prepare students to formulate and present the ideas of mathematics and to communicate them elegantly.

Course Outcome

Successful completion of the course enables the students to

- Learn the definition of continuous functions, apply sequential criteria for continuity, and understand several deep and fundamental results of continuous functions on intervals.
- Realize the difference between continuity and uniform continuity and equivalence of these ideas for functions on closed and bounded interval.
- Develop the notion of Riemann integrability of a function using the idea of tagged partitions and calculate the integral value of some functions using the definition.
- Formulate Cauchy criteria for integrability and a few applications of it. In particular they learn to use Cauchy criteria in proving the non-integrability of certain functions.

- Understand two forms of fundamental theorem of calculus and their significance in the practical problem of evaluation of an integral.
- Prove convergence and divergence of sequences of functions and series. Understand the difference between point-wise and uniform convergence of sequences and series of functions.
- Understand the notion of improper integrals, their convergence, principal value and evaluation.
- Learn the properties of and relationship among two important improper integrals namely beta and gamma functions that frequently appear in mathematics, statistics, science and engineering.

Syllabus

SIXTH SEMESTER

BMT6 B10: REAL ANALYSIS

Text: 1	Introduction to Real Analysis(4/e) : Robert G Bartle, Donald R Sherbert John Wiley & Sons(2011) ISBN 978-0-471-43331-6
Text: 2	R.R. Goldberg: Methods of Real Analysis
Text: 3	Narayanan & Manicavachagom Pillay: Calculus, Vol. II

Module-I Text: 1 (18 hrs)

5.1: Continuous Functions- definition, sequential criteria for continuity, discontinuity criteria, examples of continuous and discontinuous functions, Dirichlet and Thomae function.

5.3: Continuous Functions on Intervals- Boundedness Theorem, The Maximum-Minimum Theorem, Location of Roots Theorem, Bolzano's Intermediate Value Theorem, Preservation of Intervals Theorem.

5.4: Uniform Continuity- definition, illustration, Nonuniform Continuity Criteria, Uniform Continuity Theorem, Lipschitz Functions, Uniform Continuity of Lipschitz Functions, converse, The Continuous Extension Theorem, Approximation by step functions & piecewise linear functions, Weierstrass Approximation Theorem (only statement).

Module-II Text: 1 (22 hrs)

7.1: Riemann Integral –Partitions and Tagged Partitions, Riemann sum, Riemann integrability, examples, Some Properties of the Integral, Boundedness Theorem.

7.2: Riemann Integrable Functions-Cauchy Criterion, illustrations, The Squeeze Theorem, Classes of Riemann Integrable Functions, integrability of continuous and monotone functions, The Additivity Theorem.

7.3: The Fundamental Theorem-The Fundamental Theorem (First Form), The Fundamental Theorem (Second Form), Substitution Theorem, Lebesgue's lntegrability Criterion, Composition Theorem, The Product Theorem, Integration by Parts, Taylor's Theorem with the Remainder.

Module-III	Text: 1	(17 hrs)

8.1: Pointwise and Uniform Convergence-definition, illustrations, The Uniform Norm, Cauchy Criterion for Uniform Convergence.

8.2: Interchange of Limits- examples leading to the idea, Interchange of Limit and Continuity, Interchange of Limit and Derivative [only statement of theorem 8.2.3 required; proof omitted] Interchange of Limit and Integral , Bounded convergence theorem(statement only) [8.2.6 Dini's theorem omitted].

9.4: Series of Functions – (A quick review of series of real numbers of section 3.7 without proof) definition, sequence of partial sum, convergence, absolute and uniform convergence, Tests for Uniform Convergence, Weierstrass M-Test (only upto and including 9.4.6).

Module-IV	Text: 2 &3	(23 hrs)

Improper Riemann Integrals

Improper Integrals, Improper integrals of the first kind, Improper integrals of the second kind, Cauchy Principal value, Improper Integrals of the third kind.
(Sections 7.9, 7.10 of text 2)

Beta and Gamma Functions

Beta functions, Gamma Functions, Relation between Beta and Gamma functions.
(Chapter IX, Sections 2.1, 2.2, 2.3, 3, 4, 5 of text 3)

***List of Practical (using any software)**

- Find Riemann Integral by using Riemann sum.
- Plotting of recursive sequences of functions.
- Study the convergence of sequences of functions through plotting.
- Study the convergence/divergence of infinite series of functions by plotting their sequences of partial sum.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Charles G. Denlinger: Elements of Real Analysis *Jones and Bartlett Publishers Sudbury, Massachusetts (2011) ISBN:0-7637-7947-4 [Indian edition: ISBN- 9380853157]*
2	David Alexander Brannan: A First Course in Mathematical Analysis *Cambridge University Press,US(2006) ISBN: 9780521684248*
3	John M. Howie: Real Analysis *Springer Science & Business Media(2012)[Springer Undergraduate Mathematics Series] ISBN: 1447103416*
4	James S. Howland: Basic Real Analysis *Jones and Bartlett Publishers Sudbury, Massachusetts (2010) ISBN:0-7637-7318-2*
5	Terence Tao: Analysis I & II (3/e) *TRIM 37 & 38 Springer Science+Business Media Singapore 2016; Hindustan book agency(2015) ISBN 978-981-10-1789-6 (eBook) & ISBN 978-981-10-1804-6 (eBook)*
6	Richard R Goldberg: Methods of Real Analysis *Oxford and IBH Publishing Co.Pvt.Ltd. NewDelhi(1970)*
7	Saminathan Ponnusamy: Foundations of Mathematical Analysis *Birkhauser(2012) ISBN 978-0-8176-8291-0*
8	William F Trench: Introduction to Real Analysis *ISBN 0-13-045786-8*
9	Ajith Kumar & S Kumaresan : A Basic Course in Real Analysis *CRC Press, Taylor & Francis Group(2014) ISBN: 978-1-4822-1638-7 (eBook - PDF)*
10	Hugo D Junghenn : A Course in Real Analysis *CRC Press, Taylor & Francis Group(2015) ISBN: 978-1-4822-1928-9 (eBook - PDF)*

SIXTH SEMESTER

BMT6 B11: COMPLEX ANALYSIS

5 hours/week 5 Credits 100 Marks [Int:20+Ext:80]

Aims and Objectives

The course is aimed to provide a thorough understanding of complex function theory. It is intended to develop the topics in a fashion analogous to the calculus of real functions. At the same time differences in both theories are clearly emphasised. When real numbers are replaced by complex numbers in the definition of derivative of a function, the resulting complex differentiable functions (more precisely analytic functions) turn out to have many remarkable properties not possessed by their real analogues. These functions have numerous applications in several areas of mathematics such as differential equations, number theory etc. and also in science and engineering. The focus of the course is on the study of analytic functions and their basic behaviour with respect to the theory of complex calculus.

Course Outcome

Successful completion of the course enables the students to

- Distinguish the concepts of differentiability and analyticity of Complex functions.
- Identify the relation between harmonic functions and analytic functions.
- Understand the elementary functions and identities of Complex analysis analogous to calculus of real valued functions.
- Understand complex integral, its properties and evaluation.
- Explain a few fundamental results on contour integration theory such as Cauchy's Theorem, Cauchy- Goursat Theorem and their applications.
- Apply Cauchy 's Integral formulas and derive Liouville's Theorem, Morera's theorem and power series expansion of analytic functions.
- Apply Residue Theorem to evaluate contour integrals.

Syllabus

SIXTH SEMESTER

BMT6 B11: COMPLEX ANALYSIS

Text	Complex Analysis A First Course with Applications: Dennis Zill & Patric Shanahan Jones and Bartlett Learning (2015) ISBN:0-7637-1437-2

Module-I (21 hrs)

Complex Functions and Mappings

2.6: Limit and Continuity- Limit of a complex function, condition for non-existence of limit, real and imaginary parts of limit, properties of complex limits, continuity, discontinuity of principal square root function, properties of continuous functions, continuity of polynomial and rational functions, Bounded Functions, Branches, Branch Cuts and Points.

Analytic Functions

3.2: Differentiability and Analyticity – Derivative of a complex Function, rules of differentiation, function that is nowhere differentiable, Analytic functions, entire functions, singular points, Analyticity of sum product and quotient, L'Hospital rule.

3.3: Cauchy Riemann Equations- Necessary condition for analyticity, Criterion for non-analyticity, sufficient condition for analyticity, sufficient condition for differentiability, Cauchy Riemann equations in polar coordinates.

3.4: Harmonic Functions- definition, analyticity and harmonic nature, harmonic conjugate functions, finding harmonic conjugate.

Elementary Functions

4.1: Exponential and logarithmic functions-Complex Exponential Function, its derivative, analyticity, modulus argument and conjugate, algebraic properties, periodicity, exponential mapping and its properties, Complex Logarithmic Function, logarithmic identities, principal value of a complex logarithm, *Ln z* as inverse function, derivative, logarithmic mapping, properties, other branches.

4.3: Trigonometric and Hyperbolic functions- Complex Trigonometric Functions, identities, periodicity of *sine and cosine*, Trigonometric equations and their solution, Modulus, zeroes analyticity, [subsection 'Trigonometric Mapping' omitted], Complex Hyperbolic Functions, relation to sine and cosine.

Module-II	(21 hrs)

Integration in the Complex plane

5.1: Real Integrals- Definite Integral, simple, smooth, closed curves, Line integrals in the plane, Method of Evaluation-curves defined parametrically and curves given as functions, Orientation of a Curve.

5.2: Complex Integral-contours, definition of complex integral, complex valued function of a real variable, evaluation of contour integral, properties of contour integral, ML-inequality.

5.3: Cauchy-Goursat Theorem- simply and multiply connected regions, Cauchy theorem, Cauchy-Goursat theorem for simply connected domain (without proof), Multiply Connected Domains, principe of deformation of contours, Cauchy-Goursat theorem for multiply connected domains, illustrations.

5.4: Independence of Path- definition, analyticity and path independence, anti-derivative, Fundamental theorem for contour integrals, Some Conclusions, Existence of anti-derivative.

5.5: Cauchy's Integral Formulas & their Consequences- Cauchy's Two Integral Formulas, illustration of their use, Some Consequences of the Integral Formulas- cauchy's inequality, Liouville theorem, Morera's theorem, Maximum modulus theorem.

Module-III	(18 hrs)

Series

6.1: Sequences and Series- definition, criteria for convergence, Geometric series, necessary condition for convergence, test for divergence, absolute and conditional convergence, Ratio test, root test, Power Series, circle of convergence, radius of convergence, Arithmetic of Power Series.

6.2: Taylor Series- differentiation and integration of power series, term by term differentiation and integration, Taylor Series, Maclaurian series , illustrations.

6.3: Laurent's Series- isolated singularities, Laurent's Theorem [proof omitted], illustrations.

Module-IV	(20 hrs)

Residues

6.4: Zeros and Poles- classification of isolated singular points, removable singularity, pole, essential singularity, order of zeros and poles.

6.5: Residues and Residue Theorem- residue, method of evaluation of residue at poles, (Cauchy's) Residue Theorem, illustrations.

6.6: Some Consequences of Residue theorem-
6.6.1: Evaluation of Real Trigonometric Integrals

***List of Practicals (using any software)**

- Plotting of complex functions on the complex plane.
- Study the convergence of sequences of complex numbers through plotting.
- Study the convergence/divergence of infinite series of complex numbers by plotting their sequences of partial sum.
- Plotting the region of convergence of series.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	James Ward Brown, Ruel Vance Churchill: Complex variables and applications (8/e), McGrawHill Higher Education, (2009) ISBN: 0073051942
2	Alan Jeffrey: Complex Analysis and Applications (2/e), Chapman and Hall/CRC Taylor Francis Group (2006), ISBN:978-1-58488-553-5
3	Saminathan Ponnusamy, Herb Silverman: Complex Variables with Applications Birkhauser Boston(2006) ISBN:0-8176-4457-4
4	John H. Mathews & Russell W. Howell : Complex Analysis for Mathematics and Engineering (6/e)
5	H A Priestly: Introduction to Complex Analysis (2/e), Oxford University Press, (2003), ISBN: 0-19-852562-1
6	Jerrold E Marsden, Michael J Hoffman: Basic Complex Analysis (3/e) W.H Freeman, N.Y. (1999) ISBN:0-7167-2877-X

SIXTH SEMESTER

BMT6 B12: CALCULUS OF MULTI VARIABLE-2

5 hours/week 4 Credits 100 Marks [Int:20+Ext:80]

Aims and Objectives

The intention of the course is to extend the immensely useful ideas and notions such as limit, continuity, derivative and integral seen in the context of function of single variable to function of several variables. The corresponding results will be the higher dimensional analogues of what we learned in the case of single variable functions. The results we develop in the course of calculus of multivariable is extremely useful in several areas of science and technology as many functions that arise in real life situations are functions of multivariable.

Course Outcome

Successful completion of the course enables the students to

- Learn the geometrical interpretation of the gradient.
- Understand how we use the gradient to get various local information about the function including tangent planes and normal lines.
- Develop various techniques such as second derivative tests to find relative and extreme of multi variable functions.
- Develop Lagrange's multiplier methods to find absolute extreme of a multivariable function.
- Define the double integrals and triple integrals as a limit of Riemann sum and to see their interpretations as average value, volume under graphs, volume of a solid, area of a region, total mass from density.
- Demonstrate the ability to think critically by setting up and solving application problems involving double and triple integrals.
- Learn iterated integrals and Fubini's theorem.

- Evaluate the double integrals in polar coordinates and triple integrals in cylindrical coordinates and spherical coordinates.
- Understand the idea of vector fields, curl and divergence of a vector field and their evaluation.
- Understand path independence and conservative field.
- Evaluate the line integral and surface integral.
- Study the major theorems: Greens theorem, Divergence theorem and Stokes theorem.

Syllabus

SIXTH SEMESTER

BMT6 B12: CALCULUS OF MULTI VARIABLE-2

Text	Calculus: Soo T Tan *Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7*

Module-I (20 hrs)

13.7: Tangent Planes and Normal Lines- Geometric Interpretation of the Gradient, Tangent Planes and Normal Lines, Using the Tangent Plane of f to approximate the Surface $z = f(x, y)$

13.8: Extrema of Functions of two variables - Relative and Absolute Extrema, Critical Points—Candidates for Relative Extrema, The Second Derivative Test for Relative Extrema, Finding the Absolute Extremum Values of a Continuous Function on a Closed Set

13.9: Lagrange Multipliers- Constrained Maxima and Minima, The Method of Lagrange Multipliers, Lagrange theorem, Optimizing a Function Subject to Two Constraints

14.1: Double integrals- An Introductory Example, Volume of a Solid between a Surface and a Rectangle, The Double Integral over a Rectangular Region, Double Integrals over General Regions, Properties of Double Integrals

14.2: Iterated Integrals-Iterated Integrals over Rectangular Regions, Fubini's Theorem for Rectangular Regions, Iterated Integrals over Nonrectangular Regions, y- simple and x- simple regions, advantage of changing the order of integration.

Module-II (20 hrs)

14.3: Double integrals in polar coordinates- Polar Rectangles, Double Integrals over Polar Rectangles, Double Integrals over General Regions, r-simple region, method of evaluation

14.5: Surface Area- Area of a Surface $z = f(x, y)$, Area of Surfaces with Equations $y = g(x, z)$ and $x = h(y, z)$.

14.6: Triple integrals- Triple Integrals Over a Rectangular Box, definition, method of evaluation as iterated integrals, Triple Integrals Over General Bounded Regions in Space, Evaluating Triple Integrals Over General Regions, evaluation technique.

14.7: Triple Integrals in cylindrical and spherical coordinates- evaluation of integrals in Cylindrical Coordinates, Spherical Coordinates

14.8: Change of variables in multiple integrals- Transformations, Change of Variables in Double Integrals [only the method is required; derivation omitted], illustrations, Change of Variables in Triple Integrals

Module-III (20 hrs)

15.1: Vector Fields- V.F. in two- and three-dimensional space, Conservative Vector Fields

15.2: Divergence and Curl- Divergence- idea and definition, Curl- idea and definition

15.3: Line Integrals- Line integral w.r.t. arc length-motivation, basic idea and definition, Line Integrals with Respect to Coordinate Variables, orientation of curve Line Integrals in Space, Line Integrals of Vector Fields

15.4: Independence of Path and Conservative Vector Fields-path independence through example, definition, fundamental theorem for line integral, Line Integrals Along Closed Paths, work done by conservative vector field, Independence of Path and Conservative Vector Fields, Determining Whether a Vector Field Is Conservative, test for conservative vector field Finding a Potential Function, Conservation of Energy

Module-IV (20 hrs)

15.5: Green's Theorem- Green's Theorem for Simple Regions, proof of theorem for simple regions, finding area using line integral, Green's Theorem for More General Regions, Vector Form of Green's Theorem

15.6: Parametric Surfaces-Why We Use Parametric Surfaces, Finding Parametric Representations of Surfaces, Tangent Planes to Parametric Surfaces, Area of a Parametric Surface [derivation of formula omitted]

15.7: Surface Integrals-Surface Integrals of Scalar Fields, evaluation of surface integral

for surfaces that are graphs, [derivation of formula omitted; only method required] Parametric Surfaces, evaluation of surface integral for parametric surface, Oriented Surfaces, Surface Integrals of Vector Fields-definition, flux integral, evaluation of surface integral for graph [method only], Parametric Surfaces, evaluation of surface integral of a vector field for parametric surface [method only].

15.8: The Divergence Theorem-divergence theorem for simple solid regions (statement only), illustrations, Interpretation of Divergence

15.9: Stokes Theorem-generalization of Green's theorem –Stokes Theorem, illustrations, Interpretation of Curl.

***List of Practicals (using any software)**

- Plotting tangent planes and normal lines of a surface.
- Finding relative and absolute extrema by plotting of its graphs.
- Plotting volume of a solid between a surface and a rectangle.
- Sketching parametric curves.
- Tracing of conics in cartesian coordinates/ polar coordinates.
- Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, hyperbolic paraboloid using cartesian coordinates.
- Evaluating limits by plotting of graphs of multi variable functions.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	JoelHass, Christopher Heil & Maurice D. Weir : Thomas' Calculus(14/e) *Pearson(2018) ISBN 0134438981*
2	Robert A Adams & Christopher Essex : Calculus: *A complete Course (8/e) Pearson Education Canada (2013) ISBN: 032187742X*
3	Jon Rogawski: Multivariable Calculus *Early Transcendentals* (2/e) W. H. Freeman and Company(2012) *ISBN: 1-4292-3187-4*
4	Anton, Bivens & Davis : Calculus *Early Transcendentals* (10/e) John Wiley & Sons, Inc.(2012) ISBN: 978-0-470-64769-1
5	James Stewart : Calculus (8/e) *Brooks/Cole Cengage Learning(2016) ISBN: 978-1-285-74062-1*
6	Jerrold E. Marsden & Anthony Tromba :Vector Calculus (6/e) *W. H. Freeman and Company, New York(2012) ISBN: 978-1-4292-1508-4*
7	Arnold Ostebee & Paul Zorn: Multivariable Calculus (2/e) *W. H. Freeman Custom Publishing, N.Y.(2008)ISBN: 978-1-4292-3033-9*

SIXTH SEMESTER

BMT6 B13: DIFFERENTIAL EQUATIONS

5 hours/week 4 Credits 100 Marks [Int:20+Ext:80]

Aims and Objectives

Differential equations model the physical world around us. Many of the laws or principles governing natural phenomenon are statements or relations involving rate at which one quantity changes with respect to another. The mathematical formulation of such relations (modelling) often results in an equation involving derivative (differential equations). The course is intended to find out ways and means for solving differential equations and the topic has wide range of applications in physics, chemistry, biology, medicine, economics and engineering.

Course Outcome

Successful completion of the course enables the students to

- Identify a number of areas where the modelling process results in a differential equation.
- Learn what an ODE is, what it means by its solution, how to classify DEs, what it means by an IVP and so on.
- Learn to solve DEs that are in linear, separable and in exact forms and also to analyze the solution.
- Realize the basic differences between linear and nonlinear DEs and also basic results that guarantees a solution in each case.
- Learn a method to approximate the solution successively of a first order IVP.
- Familiar with the theory and method of solving a second order linear homogeneous and nonhomogeneous equation with constant coefficients.

- Determine the Laplace Transform and Inverse Laplace Transform of a function
- Learn the linearity and shifting theorems.
- Acquire the knowledge of solving a differential equation using Laplace method which is especially suitable to deal with problems arising in engineering field.
- Understand periodic functions and their Fourier series expansion
- Learn the technique of solving partial differential equations using the method of separation of variables.

Syllabus

SIXTH SEMESTER

BMT6 B13: DIFFERENTIAL EQUATIONS

Text	Elementary Differential Equations and Boundary Value Problems (11/e): William E Boyce, Richard C Diprima And Douglas B Meade *John Wiley & Sons(2017) ISBN: 1119169879.*

Pre-Requisites

1.1: Some Basic Mathematical Models; Direction Fields

1.2: Solutions of some Differential equations

1.3: Classification of Differential Equations

Module-I (22 hrs)

2.1: Linear Differential Equations; Method of Integrating Factors

2.2: Separable Differential Equations

2.3: Modelling with First Order Differential Equations

2.4: Differences Between Linear and Nonlinear Differential Equations

2.6: Exact Differential Equations and Integrating Factors

2.8: The Existence and Uniqueness Theorem *(proof omitted)*

Module-II (23 hrs)

3.1: Homogeneous Differential Equations with Constant Coefficients

3.2: Solutions of Linear Homogeneous Equations; the Wronskian

3.3: Complex Roots of the Characteristic Equation

3.4: Repeated Roots; Reduction of Order

3.5: Nonhomogeneous Equations; Method of Undetermined Coefficients

3.6: Variation of Parameters

Module-III (15 hrs)

6.1: Definition of the Laplace Transform

6.2: Solution of Initial Value Problems

6.3: Step Functions

6.5: Impulse Functions

6.6: The Convolution Integral

Module-IV (20 hrs)

10.1: Two-Point Boundary Value Problems

10.2: Fourier Series

10.3: The Fourier Convergence Theorem

10.4: Even and Odd Functions

10.5: Separation of Variables; Heat Conduction in a Rod

10.7: The Wave Equation: Vibrations of an Elastic String

*List of Practicals (using any software)

- Plotting the solutions of some famous model like Population model, Predatory-prey, Epidemic model of influenza models, etc.
- Plotting of first and second order solutions of ordinary differential equations.
- Plotting the solutions of heat and wave equations.
- Finding the Laplace transforms of some functions.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Dennis G Zill &Michael R Cullen: Differential Equations with Boundary Value Problems(7/e):*Brooks/Cole Cengage Learning(2009)ISBN: 0-495-10836-7*
2	R Kent Nagle, Edward B. Saff & Arthur David Snider: Fundamentals of Differential Equations(8/e) *Addison-Wesley(2012) ISBN: 0-321-74773-9*
3	C. Henry Edwards &David E. Penney: Elementary Differential Equations (6/e) *Pearson Education, Inc. New Jersey (2008) ISBN 0-13-239730-7*
4	John Polking, Albert Boggess & David Arnold : Differential Equations with Boundary Value Problems(2/e) *Pearson Education, Inc New Jersey(2006) ISBN 0-13-186236-7*
5	Henry J. Ricardo: A Modern Introduction to Differential Equations(2/e*) Elsevier Academic Press(2009)ISBN: 978-0-12-374746-4*
6	James C Robinson: An Introduction to Ordinary Differential Equations *Cambridge University Press (2004)ISBN: 0-521-53391-0*

ELECTIVE COURSES

SIXTH SEMESTER (Elective)

BMT6 E01: GRAPH THEORY

3 hours/week 2 Credits 75 Marks [Int:15+Ext:60]

Aims and Objectives

Graph theory has been applied to several areas of physics, chemistry, communication science, biology, electrical engineering, operations research, psychology, linguistics, among others fields, to solve problems that can be modelled as discrete objects called graphs.

Course Outcome

Successful completion of the course enables the students to

- Understand and apply the fundamental concepts in graph theory.
- Apply graph theory-based tools in solving practical problems.
- Improve the proof writing skills.
- Analyze properties of graphs.
- Understand trees and their properties.
- Distinguish between Eulerian and Hamiltonian graphs.
- Analyze planar graphs.

Syllabus

SIXTH SEMESTER (Elective)

BMT6 E01: GRAPH THEORY

Text	A First Look at Graph Theory: John Clark & Derek Allan Holton, *Allied Publishers, First Indian Reprint 1995.*

Module-I (16 hrs)

1.1 Definition of a graph

1.2 Graphs as models

1.3 More definitions

1.4 Vertex degrees

1.5 Sub graphs

1.6 Paths and Cycles

1.7 Matrix representation of a graph [up to Theorem 1.6; proof of Theorem 1.5 is omitted]

Module-II (16 hrs)

2.1 Definitions and Simple Properties

2.2 Bridges [Proof of Theorem 2.6 and Theorem 2.9 are omitted]

2.3 Spanning Trees

2.6 Cut Vertices and Connectivity [Proof of Theorem 2.21omitted]

Module-III (16 hrs)

3.1 Euler Tour [up to Theorem 3.2, proof of Theorem 3.2 omitted]

3.3: Hamiltonian Graphs [Proof of Theorem 3.6 omitted]

5.1: Plane and Planar graphs [Proof of Theorem 5.1 omitted]

5.2 Euler's Formula [Proofs of Theorems 5.3 and Theorem 5.6 omitted]

*List of Practicals (using any software)

- Drawing of graphs using Techard.
- Constructing spanning trees.
- Find the number of spanning trees in a graph.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1.	R.J. Wilson: Introduction to Graph Theory, 4th ed., LPE, Pearson Education
2.	J.A. Bondy& U.S.R. Murty : Graph Theory with Applications
3.	J. Clark & D.A. Holton: A First Look at Graph Theory, Allied Publishers
4.	N. Deo: Graph Theory with Application to Engineering and Computer Science, PHI.

SIXTH SEMESTER (Elective)

BMT6 E02: TOPOLOGY OF METRIC SPACES

3 hours/week 2 Credits 75 Marks [Int:15+Ext:60]

Aims and Objectives

The aim of this course is to give theoretical foundation for key concepts appearing in Analysis: open sets, closed sets, connected sets, continuous maps. This will be done in the context of metric and topological spaces. After this course student will be able to perform simple theoretical analysis involving sets in metric and topological spaces and maps between these spaces. Be able to apply these concepts to other areas of mathematics.

Course Outcome

Successful completion of the course enables the students to

- Learn the notion of metric space and construct the topology by using the metric.
- Understand the notion of distance and related concepts.
- Learn boundary points and related concepts.
- Understand open/ closed balls, open/ closed sets and dense subsets.
- Understand the concept of convergence of sequences and Cauchy sequences.
- Understand the concept of boundedness, uniform and pointwise convergence.

Syllabus

SIXTH SEMESTER (Elective)

BMT6 E02: TOPOLOGY OF METRIC SPACES

Text	Metric Spaces: *Mícheál Ó Searcóid Undergraduate Mathematics Series Springer-Verlag London Limited (2007) ISBN: 1-84628-369-8*

Module-I	**(18 hrs)**

Metrics

1.1: Metric Spaces

1.3: Metric Subspaces and Metric Super spaces

1.4: Isometries

1.6: Metrics on Products

1.7: Metrics and Norms on Linear Spaces- [example1.7.8 omitted]

Distance

2.1: Diameter

2.2: Distances from Points to Sets

2.3: Inequalities for Distances

2.4: Distances to Unions and Intersections

2.5: Isolated Points

2.6: Accumulation Points

2.7: Distances from Sets to Sets

Boundary

3.1: Boundary Points

3.2: Sets with Empty Boundary

3.3: Boundary Inclusion

3.6: Closure and Interior

3.7: Inclusion of Closures and Interiors

Module-II	(15 hrs)

Open, Closed and Dense subsets

4.1: Open and Closed Subsets

4.2: Dense Subsets

4.3: Topologies

4.4: Topologies on Subspaces and Superspaces

4.5: Topologies on Product Spaces

Balls

5.1: Open and Closed Balls

5.2: Using Balls

Module-III	(15 hrs)

Convergence

6.1: Definition of Convergence for Sequences

6.2: Limits

6.4: Convergence in Subspaces and Superspaces

6.6: Convergence Criteria for Interior and Closure

6.7: Convergence of Subsequences

6.8: Cauchy Sequences

Bounds

7.1: Bounded Sets

7.4: Spaces of Bounded Functions

7.6: Convergence and Boundedness

7.7: Uniform and Pointwise Convergence

References:

1	E.T.Copson: Metric Spaces *Cambridge University Press(1968)ISBN:0 52135732 2*
2	Irving Kaplansky: Set Theory and Metric Spaces *Allyn and Bacon,Inc. Boston(1972)*
3	S. Kumaresan: Topology of Metric Spaces *Alpha Science International Ltd.(2005) ISBN: 1-84265-250-8*
4	Wilson A Sutherland: Introduction to Metric and Topological Spaces(2/e) *Oxford University Press(2009)ISBN:978-0-19-956308-1*
5	Mohamed A. Khamsi and William A. Kirk: An Introduction to Metric Spaces and Fixed Point Theory *John Wiley & Sons, Inc(2001) ISBN 0-471-41825-0*

SIXTH SEMESTER (Elective)

BMT6 E03: MATHEMATICAL PROGRAMMING WITH PYTHON AND LATEX

3 hours/week 2 Credits 75 Marks [Int:15+Ext:60]

Aims and Objectives

This course helps the students to understand basis of Python programming, apply Python programming in plotting mathematical functions, apply Python programming in numerical analysis, understands typesetting using Latex and apply Latex in writing equations.

Course Outcome

Successful completion of the course enables the students to

- Understand one of the most popular and robust general purpose programming language Python.
- Understand how scientific programming can be performed using Python.
- Learn different data types, keywords, packages and modules in python.
- Visualize mathematics concepts and get the ability to demonstrate mathematical ideas through graphics.
- Understand Applications of Python Programming.
- Understand the basic commands to prepare an input file in LATEX.
- Able to change the type style of a document.
- Able to create commands and environments for specific purposes.
- The students will be able to typeset documents which involve accents of foreign languages, mathematical symbols, long tables pictures etc according to international standards.

Syllabus

SIXTH SEMESTER (Elective)

BMT6 E03: MATHEMATICAL PROGRAMMING WITH PYTHON AND LATEX

3 hours/week 2 Credits 75 Marks [Int:15+Ext:60]

Text	Python for Education - Learning Maths and Physics using Python: Ajith Kumar B.P *Inter University Accelerator Centre 2010*

Course Contents

The course has Theory Part (*external evaluation*) and Practical Part (*only for internal evaluation*). A student has to maintain a practical record of the work. *Practical should be carried out in a GNU/Linux computer system.*

Theory

Module-I	**(15 hrs)**

Basics of Python Programming

Programming in Python: Two modes of using Python, Interpreter Variables and Data Types, Operators and their Precedence, Python Strings, Slicing, Python Lists, Mutable and Immutable Types, Input from the Keyboard, Iteration: while and for loops, Python Syntax, Colon & Indentation, Syntax of 'for loops', Conditional Execution: if, elif and else, Modify loops : break and continue, Line joining, Functions, Scope of variables, Optional and Named Arguments, More onStrings and Lists, split and join, Manipulating Lists, Copying Lists, Python Modules and Packages, Different ways to import, Packages, File Input/Output, The pickle module, Formatted Printing, Exception Handling

Module-II	**(20 hrs)**

Applications of Python Programming

Turtle Graphics:

Arrays and Matrices: The NumPy Module, Vectorized Functions.

(sec. 2.1 to 2.19, 3.1 to 3.2)

Data visualization: The Matplotlib Module, Plotting mathematical functions, Famous Curves, Power Series, Fourier Series, 2D plot using colors, Meshgrids, 3D Plots, Mayavi, 3D visualization.

(sec. 4.1 to 4.6, 4.8 to 4.10)

Module-III	(13 hrs)

Latex

Type setting using LATEX: Document classes, Modifying Text, Dividing the document, Environments, Typesetting Equations, Arrays and matrices, Floating bodies, Inserting Images, Example, Application (sec. 5.1 to 5.8)

Practical

A practical examination, based on following topics, should be conducted for the internal assessment only.

Part A: Plotting

1. Cartesian plot of polynomials showing all zeros
2. Cartesian plot of quotient of polynomials
3. Cartesian plot of functions showing asymptotes
4. Parametric plot of curves
5. Polar plot of curves
6. Plot Pi chart
7. Plot 3D curves
8. Plot 3D surfaces

Part B: LATEX

1. General documentation
2. Tables
3. Writing equations

Mark distribution for practical examination as test paper (Total 6 Marks)

Part A: 4 marks

Part B: 2 marks

Practical Record as Assignment: 3 marks

References:	
1	Saha, Amit: Doing Math with Python: Use Programming to Explore
	Algebra, Statistics, Calculus, and More*!. No Starch Press, 2015*.
2	Nunez-Iglesias, Juan, Stefan van der Walt, and Harriet Dashnow:
	"Elegant SciPy: The Art of Scientific Python." (2017).
3	Stewart, John M.: Python for scientists. *Cambridge University Press, 2017.*
4	Kinder, Jesse M., and Philip Nelson: A student's guide to Python for
	physical modeling. *Princeton University Press, 2018*.
5	McGreggor, Duncan :. Mastering matplotlib. *Packt Publishing Ltd, 2015*
6	Lamport, Leslie. LaTeX: A Document Preparation System(2/e) *Pearson*
	Education India, 1994.
7	Hahn, Jane: LATEX for Everyone. *Prentice Hall PTR, 1993*

SIXTH SEMESTER (Elective)

BMT6 E04: INTRODUCTION TO GEOMETRY

3 hours/week 2 Credits 75 Marks [Int:15+Ext:60]

Aims and Objectives

Geometry is used in various daily life applications such as art, architecture, engineering, robotics, astronomy, sculptures, space, nature, sports, machines, cars, and much more. Geometry is a main branch of mathematics concerned with the properties and relations of points, lines, surfaces, solids, and higher dimensional analogues. This course is intended to learn about the basic elements of geometry, including how to use inductive reasoning, Model and solve geometric situations using algebraic properties and affine geometry provides the basis for Euclidean structure. Students will enable to understand about transformations and how to use transformations in real life situations._The aim of the course also includes to provide students with an introduction to axiomatic system Projective geometry. Projective Geometry examines those properties of geometric figures that remain unchanged by a central projection.

Course Outcome

Successful completion of the course enables the students to

- Understand the basic facts about conics.
- Understand the concept of geometry and transformations, affine transformations and their properties.
- Understand the basis results of the projective geometry.

Syllabus

SIXTH SEMESTER (Elective)

BMT6 E04: INTRODUCTION TO GEOMETRY

Text	Geometry(2/e): David A Brannan, Mathew F Espen, Jeremy J Gray Cambridge University Press(2012) ISBN: 978-1-107-64783-1

Module-I (10 hrs)

Conics

1.1.1: Conic Sections

1.1.3: Focus-Directrix Definition of the Non-Degenerate Conics- definition**,** parabola in standard form, ellipse in standard form, hyperbola in standard form, Rectangular Hyperbola, Polar Equation of a Conic.

1.1.4: Focal Distance Properties of Ellipse and Hyperbola-Sum of Focal Distances of Ellipse, Difference of Focal Distances of Hyperbola.

1.2: Properties of Conics- Tangents, equation of tangents to ellipse, hyperbola, and parabola, polar of a point w.r.t. unit circle, normal, Reflections, The Reflection Law, Reflection Property of the Ellipse, Reflection Property of the Hyperbola, Reflection Property of the Parabola, Conics as envelopes of tangent families.

1.3: Recognizing Conics- equation of conic in general form, identifying a conic.

Module-II (20 hrs)

Affine Geometry

2.1: Geometry and Transformations - What is Euclidean Geometry? Isometry, Euclidean properties, Euclidean transformation, Euclidean-Congruence.

2.2: Affine Transformations and Parallel Projections- Affine Transformations, Basic Properties of Affine Transformations, Parallel Projections, Basic Properties of Parallel Projections, Affine Geometry, Midpoint Theorem, Conjugate Diameters Theorem, Affine Transformations and Parallel Projections, affine transformations as composite of two parallel projections.

2.3: Properties of Affine Transformations-Images of Sets Under Affine Transformations,

The Fundamental Theorem of Affine Geometry, Proofs of the Basic Properties of Affine Transformations.

2.4: Using the Fundamental Theorem of Affine Geometry-The Median Theorem, Ceva's Theorem, converse, Menelaus' Theorem, converse [subsection "2.4.4. Barycentric Coordinates" omitted].

2.5: Affine Transformations and Conics-Classifying Non-Degenerate Conics in Affine Geometry, A few affine properties, Applying Affine Geometry to Conics.

Module-III	**(18 hrs)**

Projective Geometry: Lines

3.1: Perspective- Perspective in Art, Mathematical Perspective, Desargues' Theorem.

3.2: The Projective Plane $\mathbb{RP}^2$ -Projective Points, Projective Lines, Embedding Planes, An equivalent definition of Projective Geometry.

3.3: Projective Transformations- The Group of Projective Transformations, Some Properties of Projective Transformations, Fundamental Theorem of Projective Geometry, [The subsection "3.3.4. Geometrical Interpretation of Projective Transformations" omitted].

3.4: Using the Fundamental Theorem of Projective Geometry- Desargues' Theorem and Pappus' Theorem [The subsection "3.4.2. Duality "omitted].

3.5: Cross-Ratio-Another Projective Property, properties of cross ratio, Unique Fourth Point Theorem, Pappus' Theorem, Cross-Ratio on Embedding Planes, An Application of Cross-Ratio.

*List of Practicals (using any software)

- Sketching parabola, ellipse, hyperbola and rectangular hyperbola using Cartesian coordinates.
- Tracing of conics in Cartesian coordinates/ Polar coordinates.
- Plotting tangent planes.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	George A Jennings: Modern Geometry with Applications Universitext, Springer (1994) ISBN:0-387-94222-X
2	Walter Meyer: Geometry and its Application(2/e) Elsever, Academic Press (2006)ISBN:0-12-369427-0
3	Judith N Cederberg : A Course in Modern Geometries(2/e) UTM,Springer (2001) ISBN: 978-1-4419-3193-1
4	J Ryan: Euclidean and Non Euclidean Geometry-An Analytic Approach Cambridge University Press, International Student Edition (2009) ISBN:978-0-5 21-12707-3
5	David C Kay: College Geometry: A Unified Approach CRC Press Tayloe and Francic Group(2011) ISBN: 978-1-4398-1912-8 (Ebook-PDF)
6	James R Smart: Modern Geometries(5/e) Brooks/Cole Publishing Co.,(1998) ISBN:0-534-35188-3
7	Michele Audin: Geometry Universitext, Springer(2003)ISBN:3-540-43498-4

OPEN COURSES

FIFTH SEMESTER (OPEN COURSE)
(For students not having Mathematics as Core Course)

BMT5 D01 APPLIED CALCULUS

3 hours/week **3 credits** **75marks Int:15+Ext:60]**

Aims and Objectives

Calculus is the study of how things change. It provides a framework for modelling systems in which there is change, and a way to deduce the predictions of such models. It provides a way to construct relatively simple quantitative models of change, and to deduce their consequences.

Course Outcome

Successful completion of the course enables the students to

- Identify the independent and dependent variables of a function and compute its domain and range.
- Evaluate functions given by formulas at given points.
- Plot the graphs of straight lines and conics.
- Compute limits.
- Check continuity.
- Compute derivatives and write down the equation of the tangent line.
- Determine whether the function is increasing or decreasing using derivatives.
- Compute velocity and acceleration.
- Compute marginal cost/revenue/profit of production.
- Compute differential and use it to approximate the error occurred.
- Perform implicit differentiation.
- Compute convexity, concavity and points of inflection.
- Sketch curves.
- Determine extreme values.
- Determine the level of elasticity and use it for predicting the behaviour of revenue/cost/profit.

- Combine the techniques of model building with optimization techniques.
- Use exponential/logarithmic function to compute compound interest, radioactive decay etc.
- Compute the area under a curve, average value of a function using integration
- Integrate using substitution
- Estimate the future and present value of an income flow
- Compute the survival and renewal functions.
- Compute antiderivative.
- Determine population density.
- Find the area and volume of surface of revolution.

Syllabus

FIFTH SEMESTER (OPEN COURSE)
(For students not having Mathematics as Core Course)

BMT5 D01 APPLIED CALCULUS

Text	Calculus: For Business, Economics, and the Social and Life Sciences BRIEF (10/e): Laurence D. Hoffmann, Gerald L. Bradley *McGraw-Hill (2010) ISBN: 978–0–07–353231–8*

Module I 16 hrs

Functions, Graphs, and Limits
1.1: Functions
1.2: The Graph of a Function
1.3: Linear Functions
1.4: Functional Models
1.5: Limits
1.6: One sided limits and continuity

Differentiation: Basic Concepts
2.1: The Derivative
2.2: Techniques of Differentiation
2.3: Product and quotient rules: Higher order derivatives [proof of product and quotient rules omitted]
2.4: The Chain rule [proof of general power rule omitted]

Module II 18 hrs

2.5: Marginal Analysis and Applications using increments
2.6: Implicit Differentiation and Related Rates

Additional Applications of Derivative
3.1: Increasing and Decreasing Functions; Relative Extrema,
3.2: Concavity and Points of Inflection
3.4: Optimization; Elasticity of Demand
3.5: Additional Applied Optimization

Module III	14 hrs

Integration

5.1: Antidifferentiation: The Indefinite Integral

5.2: Integration by Substitution

5.3: The Definite Integral and the Fundamental Theorem of Calculus [only statement of FTC required; Justification given at the end of the section omitted]

References:

1	Soo T Tan: Applied Calculus for the Managerial, Life, and social sciences(8/e) *Cengage Learning(2011) ISBN: 978-0-495-55969-6*
2	Ron Larson : Brief Calculus *An Applied Approach(8/e) Houghton Mifflin Company(2009)ISBN: 978-0-618-95847-4*
3	Stefan Waner, Steven R. Costenoble: Finite Mathematics and Applied Calculus(5/e) *Brooks/Cole Cengage Learning(2011) ISBN: 978-1-4390-4925-9*
4	Frank C. Wilson, Scott Adamson: Applied Calculus *Houghton Mifflin Harcourt Publishing Company(2009)*
5	Geoffrey C. Berresford, Andrew M. Rockett: Applied Calculus(7/e) *Cengage Learning(2016)ISBN: 978-1-305-08531-2*

FIFTH SEMESTER (OPEN COURSE)
(For students not having Mathematics as Core Course)

BMT5 D02: DISCRETE MATHEMATICS FOR BASIC AND APPLIED SCIENCES

3 hours/week **3 credits** **75marks [Int:15+Ext:60]**

Aims and Objectives

The first module of the course discusses the fundamentals of logic, its symbols and rules. This enables one to think systematically, to express ideas in precise and concise mathematical terms and also to make valid arguments. How to use logic to arrive at the correct conclusion in the midst of confusing and contradictory statements is also illustrated. The second module aims to introduce the notion of algebraic structure in Mathematics consisting of one or more sets together with one or more operations which enable members of the sets to be combined in some way. What is important about a particular algebraic structure is that many of its properties are predictable from the characteristics of the operation or operations involved. This means that we can classify algebraic structures into families whose members have many features in common. Identification of a given algebraic structure as belonging to a particular family of structures allows us to conclude that it has the properties characteristic of all members of the family. The strong similarity between the algebra of sets and that of propositions and the laws common to these two systems leads to the introduction of an algebraic structure known as a Boolean algebra such that the properties which are shared by these systems are common to all Boolean algebras. The idea of a Boolean algebra was first developed by George Boole in the middle of the nineteenth century. The course aims to introduce Boolean algebra as a significant component of abstract algebra and to familiarize important applications in the analysis of electronic circuits and electronic control systems. Third module deals with Graph theory which is a branch of Mathematics whose origin traces back to 17th century with the solution of Konigsberg Bridge problem by Leonhard Euler. The course aims to

provide an introduction to Graph theory and to outline a handful of its applications in various fields.

Course Outcome

Successful completion of the course enables the students to

- Identify correct and incorrect arguments.
- Understand the criteria for the evaluation of arguments.
- Understand the scientific way of decision making using the laws of logic.
- Understand the concept of algebraic structures in Mathematics.
- Identify a given algebraic structure as belonging to a particular family of structures and to state the characteristic properties of the members of the family.
- Understand the concept of groups and derive basic theorems on groups.
- Define the concept of Boolean algebra as an algebraic structure and list its properties.
- Understand the applications of Boolean algebra in switching circuits.
- Define a Graph and identify different classes of graphs.
- Understand various applications of Graph theory.

Syllabus

FIFTH SEMESTER (OPEN COURSE)
(For stude not having Mathematics as Core Course)

BMT5 D02: DISCRETE MATHEMATICS FOR BASIC AND APPLIED SCIENCES

Text	Discrete Mathematics; Proofs, Structures and Applications (3/e): *Rowan Garnier & John Taylor* *CRC Press, Taylor & Francis Group (2009) ISBN:978-1-4398-1280-8(hardback)/ 978-1-4398-1281-5 (eBook - PDF)*

Module I 14 hrs

Logic

1.1: Propositions and Truth Values

1.2: Logical Connectives and Truth Tables- Disjunction, Conditional Propositions, Bi conditional Propositions

1.3: Tautologies and Contradictions

1.4: Logical Equivalence and Logical Implication- More about conditionals

1.5: The Algebra of Propositions- The Duality Principle, Substitution Rule

1.6: Arguments

1.7: Formal Proof of the Validity of Arguments

1.8: Predicate Logic- The Universal Quantifier, The Existential Quantifier, Two-Place Predicates, Negation of Quantified Propositional Functions

1.9: Arguments in Predicate Logic- Universal Specification (US), Universal Generalization (UG), Existential Specification (ES), Existential Generalization (EG)

Module II 16 hrs

Algebraic Structures

8.1: Binary Operations and Their Properties

8.2: Algebraic Structures- Semigroups

8.3: More about Groups

8.4: Some Families of Groups- Cyclic Groups, Dihedral Groups, Groups of Permutations

8.5: Substructures

8.6: Morphisms

Boolean Algebra

10.1: Introduction

10.2: Properties of Boolean Algebras

10.3: Boolean Functions
10.4: Switching Circuits
10.5: Logic Networks
10.6: Minimization of Boolean Expressions

Module III 18 hrs

Graph Theory
11.1: Definitions and Examples
11.2: Paths and Cycles
11.3: Isomorphism of Graphs
11.4: Trees
11.5: Planar Graphs [proof of Euler formula omitted]
11.6: Directed Graph

Applications of Graph Theory
12.2: Rooted Trees
12.3: Sorting
12.4: Searching Strategies

References:

1	Edward R. Scheinerman: Mathematics A Discrete Introduction(3/e) Brooks/Cole, Cengage earning(2013)ISBN: 978-0-8400-4942-1
2	Gary Haggard, John Schlipf, Sue Whitesides: Discrete Mathematics for Computer Science Thomson Brooks/Cole(2006)ISBN:0-534-49601-x
3	DPAcharjya,Sreekumar:FundamentalApproachtoDiscrete Mathematics New Age International Publishers(2005) ISBN: 978-81-224-2304-4
4	Gary Chartrand, Ping Zhang: Discrete Mathematics Waveland Press, Inc(2011)ISBN: 978-1-57766-730-8
5	Tom Jenkyns, Ben Stephenson: Fundamentals of Discrete Math for Computer Science A Problem-Solving Primer Springer-Verlag London (2013) ISBN: 978-1-4471-4068-9.
6	Faron Moller, Georg Struth: Modelling Computing Systems Mathematics for Computer Science Springer-Verlag London (2013) ISBN 978-1-84800-321-

FIFTH SEMESTER (OPEN COURSE)
(For students not having Mathematics as Core Course)

BMT5 D03 LINEAR MATHEMATICAL MODELS

3 hours/week **3 credits75marks [Int:15+Ext:60]**

Aims and Objectives

The aim of this course is to explain the basic concepts of linear functions, solve system of linear equations using various methods, solve linear programming problems geometrically. And to solve LP problems more effectively using Simplex algorithm and also explain duality theory. On successful completion of this course, the students will be able to Understand the idea of slope of the lines, understand to find solution of Linear Systems by the Echelon Method and Gauss Jordan method. Gets an idea of matrices, understand how to add, subtract and multiplication of matrices and understand how find the inverse of a matrix. Understand the methods of solving linear programming problems geometrically and understands the drawbacks of geometric methods and to solve LP problems more effectively using Simplex method. Understand duality theory, a theory that establishes relationships between linear programming problems of maximization and minimization.

Course Outcome

Successful completion of the course enables the students to

- Understand the idea of slope of the lines, understand to find the solution of Linear Systems by the Echelon Method and Gauss Jordan method.
- Get an idea of matrix operations and understand how to find the inverse of a matrix.
- Understand the methods of solving linear programming problems geometrically and understands the drawbacks of geometric methods and to solve LP problems more effectively using Simplex method.

- Understand duality theory, a theory that establishes relationships between linear programming problems of maximization and minimization.
- Students learn about different types of real-life mathematical models and their analysis.

Syllabus

FIFTH SEMESTER (OPEN COURSE)
(For students not having Mathematics as Core Course)

BMT5D03 LINEAR MATHEMATICAL MODELS

Text	Finite Mathematics and Calculus with Applications (9/e) *Margaret L. Lial, Raymond N. Greenwell & Nathan P. Ritchey* Pearson Education, Inc(2012) ISBN: 0-321-74908-1

Module I 18 hrs

Linear Functions
1.1: Slopes and Equations of Lines
1.2: Linear Functions and Applications
1.3: The Least Squares Line

Systems of Linear Equations and Matrices
2.1: Solution of Linear Systems by the Echelon Method
2.2: Solution of Linear Systems by the Gauss-Jordan Method
2.3: Addition and Subtraction of Matrices
2.4: Multiplication of Matrices
2.5: Matrix Inverses

Module II 12 hrs

Linear Programming: The Graphical Method
3.1: Graphing Linear Inequalities
3.2: Solving Linear Programming Problems Graphically
3.3: Applications of Linear Programming

Module III 18 hrs

Linear Programming: The Simplex Method
4.1: Slack Variables and the Pivot
4.2: Maximization Problems
4.3: Minimization Problems; Duality

*List of Practicals (using any software)

- Solving linear programming problems.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Soo T Tan: Finite Mathematics For the Managerial, Life, and social sciences(11/e) *Cengage Learning(2015) ISBN: 1-285-46465-6*
2	Ronald J. Harshbarger, James J. Reynolds: Mathematical Applications for the Management, Life, and Social Sciences (9/e) *Brooks/Cole Cengage Learning(2009) ISBN: 978-0-547-14509-9*
3	Stefan Waner, Steven R. Costenoble: Finite Mathematics and Applied Calculus(5/e) *Brooks/Cole Cengage Learning(2011) ISBN: 978-1-4390-4925-9*
4	Michael Sullivan: Finite Mathematics An Applied Approach(11/e) *John Wiley & Sons, Inc(2011)ISBN: 978-0470-45827-3*
5	Howard L. Rolf: Finite Mathematics *Enhanced Edition*(7/e) *Brooks/Cole, Cengage Learning(2011) ISBN:978-0-538-49732-9*
6	Seymour Lipschutz, John J. Schiller, R. Alu Srinivasan: Beginning Finite Mathematics *Schaum's Outline Series, McGraw-Hill(2005)*

FIFTH SEMESTER (OPEN COURSE)
(For students not having Mathematics as Core Course)

BMT5 D04 MATHEMATICS FOR DECISION MAKING

3 hours/week **3 credits** **75marks [Int:15+Ext:60]**

Aims and Objectives

Statistics is the science of learning from data. Various mathematical techniques involved in it enables to gather, analyze and draw inferences from the data around us, thereby enabling to make solid decisions. The profound statistical techniques help in evaluating and interpreting both qualitative and quantitative forms of data. In the given scope of the course, various probability concepts and probability distributions are introduced to get a wider understanding on the application of statistics in decision making. The objective of this course is to prepare the students for the core modules in statistical modeling and analysis. The first module introduces the student to data, describing data and descriptive and graphical summaries of data. In the later modules, the student is also introduced to probability concepts and basic probability distributions which are vital for statistical analyses.

Course Outcome

Successful completion of the course enables the students to

- Understand the classifications of data. Student is also introduced to various data collection techniques.
- Learn to visualize various types of data with the use of frequency charts and appropriate graphs.
- Understand concepts like measures of central tendency, measures of variation and measures of position.
- Get a clear understanding of basic probability concepts. Student learns conditional probability, addition rule and other basic theories in probability.

- Learn various probability distributions of discrete and continuous variables.
- Learn about the normal distribution, which is an important continuous probability distribution in inferential statistics.
- Understand the standard normal distribution and learns the conversion of normal variable to standard normal variable.

Syllabus

FIFTH SEMESTER (OPEN COURSE)
(For students not having Mathematics as Core Course)

BMT5 D04 MATHEMATICS FOR DECISION MAKING

Text	Elementary Statistics: Picturing the World (6/e) *Ron Larson & Betsy Farber* *Pearson Education, Inc (2015) ISBN: 978-0-321-91121-6*

Module I 14 hrs

Introduction to Statistics

1.1: An Overview of Statistics
1.2: Data Classification
1.3: Data Collection and Experimental Design

Descriptive Statistics

2.1: Frequency Distributions and their Graphs
2.2: More Graphs and Displays
2.3: Measures of Central Tendency
2.4: Measures of Variation
2.5: Measures of Position

Module II 12 hrs

Probability

3.1: Basic Concepts of Probability and Counting
3.2: Conditional Probability and the Multiplication Rule
3.3: The Addition Rule
3.4: Additional topics in probability and counting

Module III 22 hrs

Discrete Probability Distribution

4.1: Probability Distributions
4.2: Binomial Distributions
4.3: More Discrete Probability Distributions

Normal Probability Distribution

5.1: Introduction to Normal distributions and Standard Normal Distributions

5.2: Normal Distributions: Finding Probabilities

5.3: Normal Distributions: Finding Values

References:

1	Mario F. Triola: Elementary Statistics(13/e) : *Pearson Education, Inc(2018) ISBN: 9780134462455*
2	Neil A. Weiss: Elementary Statistics(8/e) *Pearson Education, Inc(2012) ISBN: 978-0-321-69123-1*
3	Nancy Pfenning: Elementary Statistics: Looking at Big Picture *Brooks/Cole Cengage Learning(2011) ISBN: 978-0-495-01652-6*
4	Frederick J Gravetter, Larry B. Wallnau: Statistics for the Behavioral Sciences (10/e) *Cengage Learning(2017) ISBN: 978-1-305-50491-2*
5	Seymour Lipschutz, John J. Schiller, R. Alu Srinivasan: Beginning Finite Mathematics *Schaum's Outline Series, McGraw-Hill(2005)*
6	Michael Sullivan: Finite Mathematics An Applied Approach(11/e) *John Wiley & Sons, Inc(2011)ISBN: 978-0470-45827-3*

COMPLEMENTARY COURSES

FIRST SEMESTER
(For Physics, Chemistry and Statistics students)

BMT1 C01: MATHEMATICS-1

4 hours/week **3 Credits** **75 Marks[Int.15 + Ext. 60]**

Text (1)	George B. Thomas Jr. and Ross L. Finney: Calculus, LPE, Ninth edition, Pearson Education.

Aims and Objectives

This course deals with the two branches of calculus, differential calculus and integral calculus and their applications. Calculus is a tool for analyzing the physical world around us. The concepts necessary to explore the relationship between moving objects are provided in calculus. The idea of the definite integral is defined with the notion of the limit. The first three modules are based on differential calculus and its applications, and the fourth module is based on integral calculus and its applications. The Fundamental Theorem of Calculus establishes the connection between the two branches of calculus.

Course Outcome

Successful completion of the course enables the students to learn

- The fundamental ideas of limit, continuity, and differentiability.
- Increasing and decreasing functions, local maxima, minima, concavity, inflection points and drawing graphs using these ideas.
- To find the solution of maximum-minimum problems using the idea of derivatives.
- The Mean Value Theorem for derivatives and L'Hospital rule.
- Mean value Theorem for integrals and Fundamental Theorem of Calculus.
- Applications of definite integrals (arc length, area, volume and area of surface of revolution).

Syllabus

FIRST SEMESTER
(For Physics, Chemistry and Statistics students)

BMT1 C01: MATHEMATICS-1

Module I 10 hrs

Limits and Continuity

Rates of change and limits, Rules for finding limits, Extensions of the limit concepts, Continuity, Tangent Lines

(Sections 1.1 (from limits of function values onwards), 1.2, 1.4 (omit precise definitions of one-sided limits onwards), 1.5, 1.6)

Module II 12 hrs

Derivatives

Derivative of a function, Differentiation Rules, Rates of change, The Chain Rule, Implicit Differentiation and rational exponents

(Section 2.1, 2.2, 2.3, 2.5, 2.6)

Module III 24 hrs

Application of Derivatives and L'Hopital's Rule

Application of derivatives: Related rates of change, Extreme values of a function. The mean value theorem, First derivative test, Graphing with y' and y". Limits as $x \to \pm\infty$. Asymptotes and Dominant Terms. L'Hopital's Rule.

(Section 2.7, 3.1, 3.2, 3.3, 3.4, 3.5 and see section 6.6)

Module IV 22 hrs

Integration and its Applications

Integration: Properties of definite integrals, areas and the Mean value theorem. The Fundamental theorem. (Section 4.6, 4.7).

Application of Integrals: Areas between curves, Finding Volumes by slicing, Volumes of Solids of Revolution (Disk method only), Lengths of plane curves. Areas of surfaces of revolution.

(Section 5.1, 5.2, 5.3, 5.5, 5.6)

***List of Practicals (using any software)**

- Plotting graph of functions.
- Evaluating limits by plotting of its graphs.
- Finding relative and absolute extrema by plotting of its graphs.
- Finding area under a curve and verifying definite integral of a positive function and area under its graph are same.
- Obtaining surface of revolution of curves.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Soo T Tan: Calculus *Brooks/Cole, Cengage Learning(2010)ISBN 0-534-46579-X*
2	Gilbert Strang: Calculus *Wellesley Cambridge Press(1991)ISBN:0-9614088-2-0*
3	Ron Larson. Bruce Edwards: Calculus(11/e) *Cengage Learning(2018) ISBN: 978-1-337-27534-7*
4	Robert A Adams & Christopher Essex : Calculus *Single Variable (8/e) Pearson Education Canada (2013) ISBN:* 0321877403
5	Joel Hass, Christopher Heil & Maurice D. Weir : Thomas' Calculus(14/e) *Pearson (2018) ISBN 0134438981*
6	Jon Rogawski & Colin Adams : Calculus *Early Transcendentals* (3/e) *W. H. Freeman and Company(2015) ISBN: 1319116450*
7	Murray R. Spiegel, Advanced Calculus, Schaum's Outline Series.
8	Jerrold Marsden & Alan Weinstein: Calculus I (2/e) Springer-Verlag New York Inc(1985) ISBN 0-387-90974-5
9	Jerrold Marsden & Alan Weinstein: Calculus II (2/e) Springer-Verlag New York Inc(1985) ISBN 0-387-90975-3

SECOND SEMESTER
(For Physics, Chemistry and Statistics students)

BMT2 C02: MATHEMATICS-2

4 hours/week **3 Credits** **75 Marks [Int.15 + Ext. 60]**

Aims and Objectives

In this course, polar coordinates are introduced in the first module. Polar coordinates often simplify the equation of curves and surfaces. Polar coordinates are used in navigation as the destination or direction of travel can be given as an angle and distance from the object being considered. The relationship between the Cartesian and polar coordinates is specified. Hyperbolic and inverse hyperbolic functions are introduced. Hyperbolic functions are defined in terms of exponential functions. Further applications of integral calculus are demonstrated. In the second module, the rank of a matrix and the linear systems are introduced. A study of eigen values and eigen vectors is taken up. The third and fourth module deal with the definition of limits and convergence in the context of sequences and series of real numbers.

Course Outcome

Successful completion of the course enables the students to

- Find the derivatives and anti-derivatives of hyperbolic and inverse hyperbolic functions.
- Represent points in polar coordinates and their graphing.
- Find the area and arc length of polar curves.
- Find the rank and inverse of a matrix using elementary row transformations.
- Solve a system of linear equations using matrix theory.
- Find the characteristic roots values and the corresponding characteristic vectors of a matrix.
- Verify Cayley Hamilton Theorem and understand its applications.
- Find the limit of sequences, convergence and divergence of series.
- Represent a function as Power Series, Taylor Series and Maclaurin Series.

Syllabus

SECOND SEMESTER
(For Physics, Chemistry and Statistics students)

BMT2 C02: MATHEMATICS-2

Text (1)	George B Thomas, Jr and Ross L Finney: CALCULUS, LPE, Ninth edition, Pearson Education.
Text (2)	Frank Ayres JR: Matrices, Schaum's Outline Series, TMH Edition.

Module I Text (1) 20 hrs

Hyperbolic Functions and Polar coordinates

Hyperbolic Functions- Definitions and Identities, Derivatives and Integrals, Inverse Hyperbolic Functions, Derivatives and Integrals.

Polar coordinates, Graphing in Polar Coordinates, Polar equations for conic sections, Integration in Polar coordinates.

(Section 6.10, 9.6, 9.7, 9.8, 9.9 of the Text 1)

Module II Text (2) 18 hrs

Matrices

Rank of a Matrix, Non-Singular and Singular matrices, Elementary Transformations, Inverse of an elementary Transformations, Row Canonical form, Normal form. Systems of Linear equations: Homogeneous and Non Homogenoeus Equations, Characteristic equation of a matrix; Characteristic roots and characteristic vectors. Cayley Hamilton Theorem (statement only) and simple applications (relevant sections of Text 2).

Module III Text(1) 8 hrs

Sequences

Limit of Sequences of Numbers, Theorems for calculating limits of sequences (Excluding Picard's Method)

(Sections 8.1, 8.2 of Text 1)

Module IV Text(1) 22 hrs

Infinite series

Infinite series, The ratio and root test for series of nonnegative terms, Power Series, Taylor and Maclaurin Series.

(Sections 8.3, 8.6, 8.8, 8.9 of the Text 1)

*List of Practicals (using any software)

- Plotting of graphs of hyperbolic functions.
- Matrix operation (addition, multiplication, inverse, transpose).
- Reorganizing systems of linear equations into matrix form and solve.
- Calculating the eigen values and eigen vectors of a matrix.
- Plotting of recursive sequences.
- Study the convergence of sequences through plotting.
- Calculate the sum $1 + 1/2 + 1/3 + 1/4 + \ldots + 1/n$.
- Study the convergence/divergence of infinite series by plotting their sequences of partial sum.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Soo T Tan: Calculus *Brooks/Cole, Cengage Learning(2010)ISBN 0-534-46579-X*
2	Gilbert Strang: Calculus *Wellesley Cambridge Press(1991)ISBN:0-9614088-2-0*
3	Ron Larson. Bruce Edwards: Calculus(11/e) *Cengage Learning(2018) ISBN: 978-1-337-27534-7*
4	Robert A Adams & Christopher Essex: Calculus *Single Variable (8/e) Pearson Education Canada (2013) ISBN: 0321877403*
5	Joel Hass, Christopher Heil & Maurice D. Weir : Thomas' Calculus(14/e) *Pearson (2018) ISBN 0134438981*
6	Glyn James: Advanced Modern Engineering Mathematics(4/e) *Pearson Education Limited(2011) ISBN: 978-0-273-71923-6*
7	Murray R. Spiegel, Advanced Calculus, Schaum's Outline Series
8	Erwin Kreyszig: Advanced Engineering Mathematics, Eighth Edition, Wiley, India.

THIRD SEMESTER
(For Physics, Chemistry and Statistics students)

BMT3 C03: MATHEMATICS-3

5 hours/week **3 Credits** **75 Marks[Int.15 + Ext. 60]**

Aims and Objectives

This course comprises the study of numerical integration, functions of several variables, vector-valued functions and complex numbers. The first module deals with the approximation of the value of definite integral by using numerical integration. The ideas of limit, continuity of functions of several variables and the notion of partial derivatives. The second and third module analyse the limit, continuity, derivatives and integrals of vector-valued functions. Also, the concepts of the gradient of a scalar function, curl, and divergence of a vector field are discussed. Line integral, double integral, and triple integral of vector-valued functions are dealt with and the methods of evaluation are given using several examples. In fourth module, complex numbers are introduced in a fashion similar to the calculus of real functions. The study of analytic functions and their behaviour with respect to the theory of complex calculus is the main focus. The students are enabled to understand the difference between the differentiability and analyticity of a complex function and the necessary and sufficient conditions for analyticity.

Course Outcome

Successful completion of the course enables the students to

- Approximate the integral using the trapezoidal rule and Simpson's rule.
- Find limits, continuity and differentiability of functions of several variables.
- Work on the idea of limit, continuity, and derivative of vector-valued functions.
- Use partial derivatives to find the tangent plane and normal line to a point on a surface.
- Understand the concept of gradient and directional derivative and their geometrical

interpretation.

- Learn curl and divergence of a vector field and their applications.
- Understand line integral, double integral, surface integral, and triple integral.
- Learn the three important theorems: Green's theorem, Gauss's theorem, and Stokes's theorem.
- Perform basic mathematical operations with complex numbers in cartesian and polar forms.
- Determine continuity, differentiability, analyticity of a complex function.
- Relate harmonic functions and analytic functions.

Syllabus

THIRD SEMESTER
(For Physics, Chemistry and Statistics students)

BMT3 C03: MATHEMATICS-3

Text (1)	George B Thomas, Jr and Ross L Finney: CALCULUS, LPE, Ninth edition, Pearson Education.
Text (2)	Erwin Kreyszig: Advanced Engineering Mathematics, Eighth Edition, Wiley, India.

Module I Text (1) 16 hrs

Numerical Integration and Functions of Several Variables

Numerical Integration: Trapezoidal Rule, Simpson's Rule. (Section 4.9 of Text 1).

Functions of Several Variables, Limits and Continuity, Partial Derivatives, differentiability, Chain rule (Sections 12.1, 12.2, 12.3, 12.4, 12.5 of the Text 1))

Module II Text (2) 22 hrs

Vector Differential Calculus

A quick Review of vector algebra, Inner product and vector product in $\mathbb{R}^2$ and $\mathbb{R}^3$.

Vector and scalar functions and Fields, Derivatives, Curves, Tangents, Arc Length, Gradient of a scalar field; Directional Derivative, Divergence of a vector field, Curl of a Vector Field. (Sections 8.1, 8.2, 8.3, 8.4, 8.5, 8.9, 8.10, 8.11 of Text (2))

Module III Text (2) 24 hrs

Vector Integral Calculus

Line Integrals, Independence of path, Green's Theorem in the Plane (without proof), surfaces for Surface Integrals, Surface Integrals, Triple Integrals, Divergence theorem of Gauss and Stoke's theorem (without proofs).

(Sections 9.1, 9.2, 9.4, 9.5, 9.6, 9.7, 9.9, 9.10 of Text (2))

Module IV Text (2) 16 hrs

Complex Analysis

A Quick Review: Complex Numbers, Complex Plane, Polar Form of Complex Numbers, Powers and Roots. Derivatives, Analytic functions, Cauchy-Riemann Equations, Laplace's Equation (All proofs omitted)

(Section 12.1, 12.2, 12.3, 12.4, 13.1, 13.2, 13.3, 13.4 (statements only) of the Text (2))

***List of Practicals (using any software)**

- Approximating definite integral by using Simpson's rule and Trapezoidal rule.
- Evaluating limits by plotting of graphs of multi variable functions.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Soo T Tan: Calculus *Brooks/Cole, Cengage Learning(2010)ISBN 0-534-46579-X*
2	Gilbert Strang: Calculus *Wellesley Cambridge Press(1991)ISBN:0-9614088-2-0*
3	Ron Larson. Bruce Edwards: Calculus(11/e) *Cengage Learning(2018) ISBN: 978-1-337-27534-7*
4	Robert A Adams & Christopher Essex : Calculus *several Variable (7/e) Pearson Education Canada (2010) ISBN:* 978-0-321-54929-7
5	Jerrold Marsden & Anthony Tromba : Vector Calculus (6/e) *W. H. Freeman and Company ISBN 978-1-4292-1508-4*
6	Peter V O'Neil: Advanced Engineering Mathematics(7/e) *Cengage Learning(2012)ISBN: 978-1-111-42741-2*
7	Erwin Kreyszig : Advanced Engineering Mathematics(10/e) John Wiley & Sons(2011) ISBN: 978-0-470-45836-5
8	Glyn James: Advanced Modern Engineering Mathematics(4/e) Pearson Education Limited(2011) ISBN: 978-0-273-71923-6

FOURTH SEMESTER
(For Physics, Chemistry and Statistics students)

BMT4 C04: MATHEMATICS-4

5 hours/week **3 Credits** **75 Marks[Int.15 + Ext. 60]**

Aims, Objectives and Outcomes

In this course, students learn the different methods of solving ordinary and partial differential equations. The importance of differential equations lies in the fact that even the simplest equations correspond to useful physical models. The reason for solving a differential equation is to learn about the underlying physical process. The Laplace method and Fourier series which are valuable tools in finding the solutions of ordinary and partial differential equations.

Course Outcome

Successful completion of the course enables the students to

- Learn the major classifications of differential equations.
- Learn the conditions for the existence of solution of first and second order initial value problems.
- Learn to solve the first order differential equations that are of linear, separable, exact, and Bernoulli's forms.
- Find the orthogonal trajectories of family of curves.
- Familiar with the theory and method of solving second order linear homogeneous and non-homogeneous equations with constant coefficients.
- Learn the method of reduction of order to find a second solution of linear second order equation by reducing to linear first order equation.
- Learn the method of solution of Euler Cauchy equations.
- Determine the Laplace Transform and Inverse Laplace Transform of a function
- Learn the linearity and shifting theorems.

- Acquire the knowledge of solving a differential equation using the Laplace method.
- Understand periodic functions and their Fourier series expansion.
- Learn the basic concepts of partial differential equations.

Syllabus

FOURTH SEMESTER
(For Physics, Chemistry and Statistics students)

BMT4 C04: MATHEMATICS-4

Text	Erwin Kreyszig: Advanced Engineering Mathematics, Eighth Edition, Wiley, India.

Module I **18 hrs**

Ordinary Differential Equations

Basic concepts and ideas, Geometrical meaning of y' = f (x, y), Direction Fields, Separable Differential Equations. Exact Differential Equations; Integrating Factors, Linear Differential Equations; Bernoulli Equation, Orthogonal Trajectories of Curves.

(Sections 1.1, 1.2, 1.3, 1.5, 1.6, 1.8)

Module II **20 hrs**

Linear Differential equations of Second and Higher order

Linear Differential equations of Second and Higher order: Differential Operators, Euler-Cauchy Equation, Wronskian, Nonhomogeneous Equations, Solutions by Undetermined Coefficients, Solution by variation of Parameters.

(Sections 2.1, 2.2, 2.3, 2.4, 2.6, 2.7, 2.8, 2.9, 2.10).

Module III **22 hrs**

Laplace Transforms

Laplace Transforms: Laplace Transform, Inverse Transform, Linearity, Shifting, Transforms of Derivatives of Integrals, Differential Equations. Unit step Function, Second Shifting Theorem, Dirac Delta Function, Differentiation and integration of Transforms, Convolution, Integral Equations, Partial Fractions, Differential Equations.

(Sections 5.1, 5.2, 5.3, 5.4, 5.5, 5.6).

Module IV 16 hrs

Fourier Series and Partial differential Equations

Fourier Series: Periodic Functions, Trigonometric Series, Fourier Series, Even and Odd functions, Half-range Expansions.

(Sections 10.1, 10.2, 10.4 – Excluding Proofs)

Partial differential Equations: Basic Concepts. (Sections 11.1).

*List of Practicals (using any software)

- Plotting of first and second order solutions of ordinary differential equations.
- Finding the Laplace transforms of some functions.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References

1	Peter V O'Neil: Advanced Engineering Mathematics(7/e) *Cengage Learning(2012)ISBN: 978-1-111-42741-2*
2	Erwin Kreyszig : Advanced Engineering Mathematics(10/e) *John Wiley & Sons(2011) ISBN: 978-0-470-45836-5*
3	Alan Jeffrey: Advanced Engineering Mathematics *Harcourt/Academic Press(2002) ISBN: 0-12-382592-X*
4	Glyn James: Advanced Modern Engineering Mathematics(4/e) Pearson Education Limited (2011) ISBN: 978-0-273-71923-6
5	Dennis G Zill: Advanced Engineering Mathematics(6/e) Jones & Bartlett Learning, LLC(2018)ISBN: 978-1-284-10590-2

FIRST SEMESTER
(For Computer Science students)

BMT1 C01(CS): MATHEMATICS-1

4 hours/week **3 Credits** **75 Marks[Int.15 + Ext. 60]**

Aims and Objectives

The first module deal with the concept of sets and relations. Also learn about Venn diagrams, Cartesian product of sets and definitions of various types of relations and examples. Logic, the study of principles of techniques and reasoning, is fundamental to every branch of learning. Besides, being the basis of all mathematical reasoning, it is required in the field of computer science for developing programming languages and also to check the correctness of the programmes. Electronic engineers apply logic in the design of computer chips. The second module discusses the fundamentals of logic, its symbols and rules. This enables one to think systematically, to express ideas in precise and concise mathematical terms and also to make valid arguments.

The mathematics required for viewing and analysing the physical world around us is contained in calculus. While Algebra and Geometry provide us very useful tools for expressing the relationship between static quantities, the concepts necessary to explore the relationship between moving/changing objects are provided in calculus. The objectives of the third and fourth modules are to introduce students to the fundamental ideas of limit, continuity and differentiability and also to some basic theorems of differential calculus. The fourth module explain how these ideas can be applied in the problem of sketching of curves.

Course Outcome

Successful completion of the course enables the students to

- Learn the basic concepts in set theory.
- Learn the cartesian product- definition and examples.

- Define relations on a set, various types of relations, equivalence relation.
- Understand the concept of equivalence classes and partitions of a set.
- Learn about the logical statements, sentential connectives, implications.
- Discuss the negation of a statement, statements with quantifiers and its negation.
- The fundamental ideas of limit, continuity, and differentiability.
- Increasing and decreasing functions, local maxima, minima, concavity, inflection points and drawing graphs using these ideas.
- To find the solution of maximum-minimum problems using the idea of derivatives.
- The Mean Value Theorem for derivatives and L'Hospital rule.

Syllabus

FIRST SEMESTER
(For Computer Science students)

BMT1 C01 (CS): MATHEMATICS-1

Text (1)	S. Lipschutz: Set Theory and related topics (Second Edition), Schaum Outline Series, Tata McGraw-Hill Publishing Company, New Delhi.
Text (2)	George B. Thomas Jr. and Ross L. Finney: Calculus, LPE, Ninth edition, Pearson Education.
Text (3)	Discrete Mathematics and its Applications: Thomas Koshy, Elsever Academic Press (2004)

Module I Text (1) 15 hrs

Set theory and Relations

Set theory: Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and the counting principle. Empty set, properties of empty set, set operations, Difference and Symmetric difference, Algebra of sets, Duality, Classes of sets, Power sets.

(Sections 1.6, 1.7 & 1.9 of Text (1)).

Relations: Product set, Relations (Directed graph of relations on set is omitted). Composition of relations, Types of relations, Partitions, Equivalence relations with examples.

(Chapter 3 of Text 1 excluding 3.7).

Module II Text (3) 10 hrs

Logics

Propositions- definition, Boolean (logic) variables, Truth Value, Conjunction, Boolean expression, Disjunction (inclusive and exclusive), Negation, Implication, Converse, Inverse and Contra positive, Biconditional statement, Order of Precedence, Tautology Contradiction and Contingency [Switching Networks 'omitted]

Logical equivalences- laws of logic [Equivalent Switching Networks 'Fuzzy logic& Fuzzy decisions' omitted]

Quantifiers- universal & existential, predicate logic.

(As in sections 1.1, 1.2 & 1.3 of Text 3).

Module III Text (2) 22 hrs

Limits and Continuity and Derivatives

Limits and Continuity: Rates of change and limits, Rules for finding limits, Extensions of the limit concepts, Continuity, Tangent Lines

(Sections 1.1 (from limits of function values onwards), 1.2, 1.4 (omit precise definitions of one-sided limits onwards), 1.5, 1.6 of Text (2))

Derivatives: Derivative of a function, Differentiation Rules, Rates of change, The Chain Rule, Implicit Differentiation and rational exponents. (Section 2.1, 2.2, 2.3, 2.5, 2.6 of Text 2)

Module IV Text (2) 24 hrs

Application of Derivatives and L'Hopital's Rule

Application of derivatives: Related rates of change, Extreme values of a function. The mean value theorem, First derivative test, Graphing with y' and y". Limits as $x \to \pm\infty$. Asymptotes and Dominant Terms, L'Hopital's Rule. (Section 2.7, 3.1, 3.2, 3.3, 3.4, 3.5 and see section 6.6 of Text 2).

***List of Practicals (using any software)**

- Plotting graph of functions.
- Evaluating limits by plotting of its graphs.
- Finding relative and absolute extrema by plotting of its graphs.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Soo T Tan: Calculus *Brooks/Cole, Cengage Learning (2010) ISBN 0-534-46579-X*
2	Gilbert Strang: Calculus *Wellesley Cambridge Press (1991) ISBN:0-9614088-2-0*
3	Ron Larson. Bruce Edwards: Calculus(11/e) *Cengage Learning (2018) ISBN: 978-1-337-27534-7*
4	Steven R Lay, Analysis with an introduction to proof, 5th edition, Pearson, 2014
5	Ajith Kumar et al, A foundation course in Mathematics, Narosa, India, 2018
6	Kenneth H Rosen, Discrete Mathematics and it's Applications, 6th edition, Tata Mc Grawhill

SECOND SEMESTER
(For Computer Science students)

BMT2 C02(CS): MATHEMATICS-2

4 hours/week **3 Credits** **75 Marks[Int.15 + Ext. 60]**

Aims and Objectives

The first two modules are based on integral calculus and its applications. The Fundamental Theorem of Calculus establishes the connection between the two branches of calculus. In this course, polar coordinates are introduced in the third module. Polar coordinates often simplify the equation of curves and surfaces. Polar coordinates are used in navigation as the destination or direction of travel can be given as an angle and distance from the object being considered. The relationship between the Cartesian and polar coordinates is specified. Hyperbolic and inverse hyperbolic functions are introduced. Hyperbolic functions are defined in terms of exponential functions. Further applications of integral calculus are demonstrated.

Course Outcome

Successful completion of the course enables the students to

- Mean value Theorem for integrals and Fundamental Theorem of Calculus.
- Applications of definite integrals (arc length, area, volume and area of surface of revolution).
- Find the derivatives and anti-derivatives of hyperbolic and inverse hyperbolic functions.
- Represent points in polar coordinates and their graphing.
- Find the area and arc length of polar curves.
- Find the limit of sequences, convergence and divergence of series.
- Represent a function as Power Series, Taylor Series and Maclaurin Series.

Syllabus

SECOND SEMESTER
(For Computer Science students)

BMT2 C02 (CS): MATHEMATICS-2

Text	George B Thomas, Jr and Ross L Finney: CALCULUS, LPE, Ninth edition, Pearson Education.

Module I Text (1) 22 hrs

Integration

Integration: Properties of definite integrals, areas and the Mean value theorem. The Fundamental theorem (Omit Proof) (Section 4.6, 4.7).

Application of Integrals

Application of Integrals: Areas between curves, Finding Volumes by slicing, Volumes of Solids of Revolution (Disk method only), Lengths of plane curves. Areas of surfaces of revolution. (Section 5.1, 5.2, 5.3, 5.5, 5.6)

Module II Text (1) 20 hrs

Hyperbolic Functions and Polar coordinates

Hyperbolic Functions- Definitions and Identities, Derivatives and Integrals, Inverse Hyperbolic Functions, Derivatives and Integrals.

Polar coordinates, Graphing in Polar Coordinates, Polar equations for conic sections, Integration in Polar coordinates. (Section 6.10, 9.6, 9.7, 9.8, 9.9)

Module III Text (1) 14 hrs

Sequences

Limit of Sequences of Numbers, Theorems for calculating limits of sequences (Excluding Picard's Method) (Sections 8.1, 8.2)

Module IV Text (1) 14 hrs

Infinite Series

Infinite series, The ratio and root test for series of nonnegative terms, Power Series, Taylor and Maclaurin Series. (Sections 8.3, 8.6, 8.8, 8.9)

*List of Practicals (using any software)

- Finding area under a curve and verifying definite integral of a positive function and area under its graph are same.
- Obtaining surface of revolution of curves.
- Plotting of graphs of hyperbolic functions.
- Plotting of recursive sequences.
- Study the convergence of sequences through plotting.
- Calculate the sum $1 + 1/2 + 1/3 + 1/4 + \ldots + 1/n$.
- Study the convergence/divergence of infinite series by plotting their sequences of partial sum.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Soo T Tan: Calculus *Brooks/Cole, Cengage Learning(2010)ISBN 0-534-46579-X*
2	Gilbert Strang: Calculus *Wellesley Cambridge Press(1991)ISBN:0-9614088-2-0*
3	Ron Larson. Bruce Edwards: Calculus(11/e) *Cengage Learning(2018) ISBN: 978-1-337-27534-7*
4	Robert A Adams & Christopher Essex : Calculus *Single Variable (8/e) Pearson Education Canada (2013) ISBN:* 0321877403
5	Joel Hass, Christopher Heil & Maurice D. Weir : Thomas' Calculus(14/e) *Pearson (2018) ISBN 0134438981*
6	Peter V O'Neil: Advanced Engineering Mathematics(7/e) *Cengage Learning(2012)ISBN: 978-1-111-42741-2*
7	Erwin Kreyszig : Advanced Engineering Mathematics(10/e) *John Wiley & Sons(2011) ISBN: 978-0-470-45836-5*
	Glyn James: Advanced Modern Engineering Mathematics(4/e) *Pearson Education Limited(2011) ISBN: 978-0-273-71923-6*

THIRD SEMESTER
(For Computer Science students)

BMT3 C03 (CS): MATHEMATICS-3

5 hours/week **3 Credits** **75 Marks[Int.15 + Ext. 60]**

Aims and Objectives

This course comprises the study of matrices, vector-valued functions and complex numbers. In the first module, matrices, eigen values and eigen vectors are introduced. Also the ideas of limit, continuity, derivatives, and integrals of vector-valued functions are introduced. The concepts of the gradient of a scalar function, curl, and divergence of a vector field is discussed. Line integral, double integral, and triple integral of vector-valued functions are dealt with and the methods of evaluation are given using several examples. Complex numbers are introduced in a fashion similar to the calculus of real functions. The study of analytic functions and their behaviour with respect to the theory of complex calculus is the main focus. The students are enabled to understand the difference between the differentiability and analyticity of a complex function and the necessary and sufficient conditions for analyticity.

Course Outcome

Successful completion of the course enables the students to

- Find the rank and inverse of a matrix using elementary row transformations.
- Solve a system of linear equations using matrix theory.
- Find the characteristic roots and the corresponding characteristic vectors of a matrix.
- Verify Cayley Hamilton Theorem and understand its applications.
- Find limits, continuity and differentiability of functions of several variables.
- Work on the idea of limit, continuity, and derivative of vector-valued functions.
- Use partial derivatives to find the tangent plane and normal line to a point on a surface.

- Understand the concept of gradient and directional derivative and their geometrical interpretation.
- Learn curl and divergence of a vector field and their applications.
- Perform basic mathematical operations with complex numbers in cartesian and polar forms.
- Determine continuity, differentiability, analyticity of a complex function.
- Relate harmonic functions and analytic functions.

Syllabus

THIRD SEMESTER
(For Computer Science students)

BMT3 C03 (CS): MATHEMATICS-3

Text (1)	George B Thomas, Jr and Ross L Finney: CALCULUS, LPE, Ninth edition, Pearson Education.
Text (2)	Frank Ayres JR: Matrices, Schaum's Outline Series, TMH Edition
Text (3)	Erwin Kreyszig: Advanced Engineering Mathematics, Eighth Edition, Wiley, India.

Module I Text (2) 18 hrs

Matrices

Rank of a Matrix, Non-Singular and Singular matrices, Elementary Transformations, Inverse of an elementary Transformations, Row Canonical form, Normal form. Systems of Linear equations: Homogeneous and Non-Homogeneous Equations, Characteristic equation of a matrix; Characteristic roots and characteristic vectors. Cayley Hamilton Theorem (statement only) and simple applications (relevant sections of Text 2).

Module II Text (1) 15 hrs

Functions of Several Variables

Functions of Several Variables, Limits and Continuity, Partial Derivatives, differentiability, Chain rule (Sections 12.1, 12.2, 12.3, 12.4, 12.5 of the Text 1)

Module III Text (3) 24 hrs

Vector Differential Calculus

A quick Review of vector algebra, Inner product and vector product in $\mathbb{R}^2$ and $\mathbb{R}^3$.

Vector and scalar functions and Fields, Derivatives, Curves, Tangents, Arc Length, Gradient of a scalar field; Directional Derivative, Divergence of a vector field, Curl of a Vector Field. (Sections 8.1, 8.2, 8.3, 8.4, 8.5, 8.9, 8.10, 8.11 of Text 3)

Module IV Text (3) 16 hrs

Complex Analysis

A Quick Review: Complex Numbers, Complex Plane, Polar Form of Complex Numbers, Powers and Roots. Derivatives, Analytic functions, Cauchy-Riemann Equations, Laplace's Equation (All proofs omitted)

(Section 12.1, 12.2, 12.3, 12.4, 13.1, 13.2, 13.3, 13.4 (statements only) of the Text 3).

***List of Practicals (using any software)**

- Matrix operation (addition, multiplication, inverse, transpose).
- Reorganizing systems of linear equations into matrix form and solve.
- Calculating the eigen values and eigen vectors of a matrix.
- Evaluating limits by plotting of graphs of multi variable functions.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Soo T Tan: Calculus *Brooks/Cole, Cengage Learning(2010)ISBN 0-534-46579-X*
2	Gilbert Strang: Calculus *Wellesley Cambridge Press(1991)ISBN:0-9614088-2-0*
3	Ron Larson. Bruce Edwards: Calculus(11/e) *Cengage Learning(2018) ISBN: 978-1-337-27534-7*
4	Robert A Adams & Christopher Essex : Calculus *several Variable (7/e) Pearson Education Canada (2010) ISBN:* 978-0-321-54929-7
5	Jerrold Marsden & Anthony Tromba : Vector Calculus (6/e) *W. H. Freeman and Company ISBN 978-1-4292-1508-4*
6	Peter V O'Neil: Advanced Engineering Mathematics(7/e) *Cengage Learning(2012)ISBN: 978-1-111-42741-2*
7	Erwin Kreyszig : Advanced Engineering Mathematics(10/e) John Wiley & Sons(2011) ISBN: 978-0-470-45836-5
8	Dennis G Zill: Advanced Engineering Mathematics(6/e) Jones & Bartlett Learning, LLC (2018) ISBN: 978-1-284-10590-2

FOURTH SEMESTER
(For Computer Science students)

BMT4 C04 (CS): MATHEMATICS-4

5 hours/week **3 Credits** **75 Marks[Int.15 + Ext. 60]**

Aims and Objectives

In this course, students learn the different methods of solving ordinary and partial differential equations. The importance of differential equations lies in the fact that even the simplest equations correspond to useful physical models. The reason for solving a differential equation is to learn about the underlying physical process. The Laplace method and Fourier series which are valuable tools in finding the solutions of ordinary and partial differential equations.

Course Outcome

Successful completion of the course enables the students to

- Learn the major classifications of differential equations.
- Learn the conditions for the existence of solution of first and second order initial value problems.
- Learn to solve the first order differential equations that are of linear, separable, exact, and Bernoulli's forms.
- Find the orthogonal trajectories of family of curves.
- Familiar with the theory and method of solving second order linear homogeneous and non-homogeneous equations with constant coefficients.
- Learn the method of reduction of order to find a second solution of linear second order equation by reducing to linear first order equation.
- Learn the method of solution of Euler Cauchy equations.
- Determine the Laplace Transform and inverse Laplace Transform of a function.
- Learn the linearity and shifting theorems.

- Acquire the knowledge of solving a differential equation using the Laplace method.
- Understand periodic functions and their Fourier series expansion.
- Approximate the integral using the Trapezoidal rule and Simpson’s rule.
- Learn the basic concepts of partial differential equations.

Syllabus

FOURTH SEMESTER
(For Computer Science students)

BMT4 C04 (CS): MATHEMATICS-4

Text	Erwin Kreyszig: Advanced Engineering Mathematics, Eighth Edition, Wiley, India.

Module I 20 hrs

Ordinary Differential Equations

Basic concepts and ideas, Geometrical meaning of y' = f (x, y), Direction Fields, Separable Differential Equations. Exact Differential Equations; Integrating Factors, Linear Differential Equations; Bernoulli Equation, Orthogonal Trajectories of Curves.
(Sections 1.1, 1.2, 1.3, 1.5, 1.6, 1.8)

Module II 20 hrs

Linear Differential equations of Second and Higher order

Linear Differential equations of Second and Higher order: Differential Operators, Euler-Cauchy Equation, Wronskian, Nonhomogeneous Equations, Solutions by Undetermined Coefficients, Solution by variation of Parameters.
(Sections 2.1, 2.2, 2.3, 2.4, 2.6, 2.7, 2.8, 2.9, 2.10).

Module III 24 hrs

Laplace Transforms and Fourier Series

Laplace Transforms: Laplace Transform, Inverse Transform, Linearity, Shifting, Transforms of Derivatives of Integrals, Differential Equations. Unit step Function, Second Shifting Theorem.
(Sections 5.1, 5.2, 5.3 – excluding Proofs).

Fourier Series: Periodic Functions, Trigonometric Series, Fourier Series, Even and Odd functions, Half-range Expansions.

(Sections 10.1, 10.2, 10.4 – Excluding Proofs)

Module IV 8 hrs

Numerical Integration and Partial Differential Equations

Numerical Integration: Trapezoidal Rule, Simpson's Rule. (Section 4.9).

Partial differential Equations: Basic Concepts. (Section 11.1).

*List of Practicals (using any software)

- Plotting of first and second order solutions of ordinary differential equations.
- Finding the Laplace transforms of some functions.
- Approximating definite integral by using Simpson's rule and Trapezoidal rule.

* Practical shall be conducted during extra hours. Questions should not be asked from this part.

References:

1	Peter V O'Neil: Advanced Engineering Mathematics(7/e) *Cengage Learning (2012) ISBN: 978-1-111-42741-2*
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4	Glyn James: Advanced Modern Engineering Mathematics(4/e) Pearson Education Limited (2011) ISBN: 978-0-273-71923-6
5	Dennis G Zill: Advanced Engineering Mathematics(6/e) Jones & Bartlett Learning, LLC (2018) ISBN: 978-1-284-10590