Rayat Shikshan Sanstha's

YASHAVANTRAO CHAVAN INSTITUTE OF SCIENCE, SATARA

Lead College of

Karmaveer Bhaurao Patil University, Satara

Syllabus For

Bachelor of Science

Part - II

MATHEMATICS

Semester III and IV

(Syllabus to be implemented from Academic Year 2024-25)
(NEP-2020)

Structure of the Course (Level 5.0)

Class	Level	Sem	Major		Minor		VSC	SEC	AEC	VEC	CC	Total
			T	P	T	P						
B.Sc. II	5.0	III	**4** (02 Theory Papers)	**4** (02 Practical Papers)	2	2	2	2	4	2	---	22
		IV	**4** (02 Theory Papers)	**4** (02 Practical Papers)	2	2	2	2	4	---	2	22

VSC- Vocational Skill Courses, SEC- Skill Enhancement Courses, AEC- Ability Enhancement Courses, VEC- Value Education Courses, CC- Co-curricular Courses, T- Theory, P- Practical.

Course Titles

B.Sc. II Semester III

Nature of the Course	Theory/ Practical	Course Code	Name of the Course
Major	Theory	BMT 231	Real Analysis
		BMT 232	Algebra
	Practical	BMP 233	Major Practical III
Minor	Theory	BMT 234	Number Theory
	Practical	BMP 235	Minor Practical III
VSC	Practical	BMP VSC 1	Data Analysis using MATLAB
SEC	Practical	BMP SEC 2	Mathematical Computations using Advanced Excel
VEC	Practical	BMT VEC 2	Environmental Awareness for Mathematics

B.Sc. II Semester IV

Nature of the Course	Theory/ Practical	Course Code	Name of the Course
Major	Theory	BMT 241	Advanced Real Analysis
		BMT 242	Advanced Algebra
	Practical	BMP 243	Major Practical IV
Minor	Theory	BMT 243	Numerical Analysis
	Practical	BMP 244	Minor Practical IV
VSC	Practical	BMP VSC 2	Mathematical Computations using MATLAB
SEC	Practical	BMP SEC 3	Data Visualization using python

B. Sc. II Semester III

BMT 231: Real Analysis

Course Objectives: Student will be able to …

1. understanding fundamental concepts and grasping the foundational principles of real analysis, including sets, functions, sequences, and limits.
2. apply the theoretical knowledge gained to solve real-world problems in various fields, including physics, engineering, and economics.
3. develop problem-solving skills through rigorous exercises and proofs.
4. analyze the properties of real-valued functions, such as boundedness

Credits = 02	**SEMESTER-III** **Real Analysis**	**No. of hours per unit**
UNIT-I	**Sets and Functions**	**(08)**
	1.1 Sets 1.1.1 Operations on sets, Cartesian product of sets, Relation **1.2 Functions** 1.2.1 **Definitions:** Function, Domain, Co-domain, Range, Graph of a function, Direct image and Inverse image of a subset under a function 1.2.2 **Theorem:** If $f: A \to B$ and if $X \subseteq B, Y \subseteq B$ then $f^{-1}(X \cup Y) = f^{-1}(X) \cup f^{-1}(Y)$ 1.2.3 **Theorem:** If $f: A \to B$ and if $X \subseteq B, Y \subseteq B$ then $f^{-1}(X \cap Y) = f^{-1}(X) \cap f^{-1}(Y)$ 1.2.4 **Theorem:** If $f: A \to B$and $X \subseteq A$, $Y \subseteq A$ then $f(X \cup Y) = f(X) \cup f(Y)$ 1.2.5 **Theorem:** If $f: A \to B$ and $X \subseteq A$, $Y \subseteq A$ then $f(X \cap Y) \subseteq f(X) \cap f(Y)$ 1.2.6 **Definitions:** Injective, Surjective and Bijective function (1-1 correspondence), Inverse function. 1.2.7 **Theorem:** Composition of two bijective functions is a bijective function.	
UNIT-II	**Countable Sets**	**(07)**
	2.1 Countable set: 2.1.1 **Definitions:** Finite sets, Infinite sets, Countable Sets, Uncountable Sets. 2.1.2 **Examples of Countable sets:** Set of Natural numbers, Set of	

	Integers, Cartesian product of Countable sets 2.1.3 **Theorem:** Countable union of countable set is countable. 2.1.4 **Theorem:** Set of Rational numbers is countable. 2.1.5 **Theorem:** Any subset of countable set is countable. 2.1.6 **Theorem:** The closed interval [0,1] is uncountable. 2.1.7 **Theorem:** The set of all real numbers is uncountable. 2.1.8 **Theorem:** Every infinite set has a countably infinite subset. 2.1.9 **Examples**	
UNIT-III	**Completeness Property of $\mathbb{R}$**	**(07)**
	3.1 Definitions: Lower bound, Upper bound of a subset of $\mathbb{R}$, Bounded set, Supremum $(l.u.b)$, Infimum $(g.l.b)$. **3.2 Least Upper Bound Axiom [Completeness Property of $\mathbb{R}$]:** **3.3 Theorem (Archimedean Property):** If $x \in \mathbb{R}$ then there exists $n_x \in \mathbb{N}$ such that $x \leq n_x$ 3.3.1 **Corollary:** If $S = \{\frac{1}{n} : n \in \mathbb{N}\}$ then inf $S = 0$ 3.3.2 **Corollary:** If $t > 0$ then there exist $n_t \in \mathbb{N}$ such that $0 < \frac{1}{n_t} < t$ 3.3.3 **Corollary:** If $y > 0$ then there exist $n_y \in \mathbb{N}$ such that $n_y - 1 < y < n_y$ **3.4 Theorem:** There exists a positive real number x such that $x^2 = 2$ 3.4.1 **Corollary:** If x and y are real numbers with $x < y$ then there exist an irrational number z such that $x < z < y$ **3.5 Intervals** 3.5.1 **Characterization Theorem:** If S is a subset of $\mathbb{R}$ that contains at least two points and has the property. If $x, y \in S$ and $x < y$ then the closed interval $[x, y] \subseteq S$ then S is an interval.	
UNIT-IV	**Sequence of Real Numbers**	**(08)**
	4.1 Sequence and Subsequence: 4.1.1 Definition of Sequence and Subsequence 4.1.2 Examples **4.2 Limit of a Sequence** 4.2.1 **Definition** 4.2.2 **Theorem:** If $\{S_n\}_{n=1}^{\infty}$ is a sequence of non-negative numbers and if $\lim_{n\to\infty} S_n = L$ then $L \geq 0$. 4.2.3 Examples **4.3 Convergent Sequence**	

	4.3.1 **Theorem:** Convergent sequence cannot converge to two distinct points. 4.3.2 **Theorem (Without Proof):** If sequence of real numbers $\{S_n\}_{n=1}^{\infty}$ is convergent to L then any subsequence of $\{S_n\}_{n=1}^{\infty}$ is also convergent to L. 4.3.3 Examples	

Course Outcomes: Student should be able to …

1. apply set operations and properties to solve problems involving sets
2. analyze properties of functions such as injectivity, surjectivity, and bijectivity.
3. evaluate problems on properties of convergent sequences, such as monotonicity and boundedness
4. illustrate convergence or divergence of sequences.

References:

1. R. G. Bartle and D. R. Sherbert, **Introduction to Real Analysis**, 4th Edition, Wiley India Pvt. Ltd, 2016.
2. D. Somasundaram and B Choudhary, **First Course in Mathematical Analysis**, 8th Reprint, Narosa Publishing house New, Delhi, 2013.
3. P. K. Jain and S. K. Kaushik, **An Introduction to Real Analysis**, 1st Edition, S. Chand & Company Ltd. New Delhi, 2000.
4. Shanti Narayan and M. D. Raisinghania, **Elements of Real Analysis**, 15th Edition, S. Chand & Company Ltd. New Delhi, 2014.

B. Sc. II Semester III

BMT 232: Algebra

Course Objectives: Student should be able to …

1. define matrices and understand their basic properties and operations, including addition, multiplication, and scalar multiplication.
2. understand divisibility of integers and understand properties of divisibility, including prime numbers, divisibility tests, and the Fundamental Theorem of Arithmetic.
3. explore properties of relations and their representations using matrices, graphs, and tables.
4. acquire the knowledge of symmetry groups, permutation groups.

Credits = 02	**SEMESTER-III** **Algebra**	**No. of hours per unit**
UNIT-I	**Divisibility in Integers**	**(07)**
	1.1 Definition: Divisibility in integers **1.2 The Well Ordering Principle (Statement Only)** **1.3 Properties of Divisibility** 1.3.1 Definition of divisor and Multiple 1.3.2 **Theorem:** Let a, b, c, d be integers. Then i) If a | b then a | bx ii) If a | b and a | c then a | bx+cy ; $\forall$ x, y $\in$ I iii) If a | b and b | c then a | c iv) If m $\neq$ 0 is in $\mathbb{Z}$ and a | b $\Rightarrow$ am | bm v) If a | b and c | d then ac | bd vi) If ab | bc then a | c; (b$\neq$ 0) **1.4 Theorem: Division Algorithm (Without Proof)** **1.5 Greatest common divisor and least common multiple** 1.5.1 **Definitions:** Greatest common divisor and least common multiple 1.5.2 **Theorem:** Let a and b be two integers at least one of them not zero. Then there exist a unique greatest common divisor d of a and b. Moreover, d can be written as $d = am + bn$ for integers m and n. 1.5.3 **The Euclidean Algorithm and Examples.** 1.5.4 Definition: Relatively Prime 1.5.6 **Euclid's lemma:** For a prime number p , if $p \mid ab$ then either $p \mid a$ or $p \mid b$. 1.6 **Unique Factorization Theorem or Fundamentals Theorem of Arithmetic.**	

UNIT-II	**Relation**	**(08)**
	2.1 Relation 2.1.1 **Definitions:** Cartesian Product, Relation, Binary Relation, Inverse Relation. 2.1.2 Examples on 2.1.1. **2.2 Pictorial Representation of Relation** 2.2.1 Co-ordinate Diagram 2.2.2 Arrow Diagram 2.2.3 Matrix Representation 2.2.4. Directed Graph 2.2.5 Examples on 2.2.1 to 2.2.4 **2.3 Compositions of Relations** 2.3.1 **Definition:** Composition of Relations 2.3.2 **Theorem:** Let A, B, C and D be sets. Let R: A$\longrightarrow$ B, S: B$\longrightarrow$ C, T: C$\longrightarrow$ D be Relation then $R \circ (S \circ T) = (R \circ S) \circ T$. **2.4 Types of Relations** 2.4.1 **Definitions:** Reflexive, Symmetric, Antisymmetric and transitive. 2.4.2 Examples on 2.4.1 2.4.3 **Theorem:** Let R be relation on set A. Then R^{∞} is the smallest transitive relation on A that contain R. **2.5 Equivalence relation and partitions** 2.5.1 **Theorem:** Let R be an equivalence relation on setA. Then quotient set A/R forms a partition of A. 2.5.2 **Theorem:** Let $\{A_i\}, i \in I$ be partition of a setA. Then there exists an equivalence Relation R on the set A such that quotient set A / R is the given partition $\{A_i\}, i \in I$ on A. **2.6 Partial order relation** 2.6.1 **Definition**: Partial order relation. 2.6.2 Examples on 2.6.1	
UNIT-III	**Congruence Relations**	**(07)**
	3.1 Definition and examples **3.1.1 Theorem:** Let $n > 1$ be a fixed positive integer and a be any integer then $a \equiv a \pmod{n}$. **3.1.2 Theorem:** Let $n > 1$ be a fixed positive integer and a, b be any integers and if $a \equiv b \pmod{n}$ then $b \equiv a \pmod{n}$. **3.1.3 Theorem:** Let $n > 1$ be a fixed positive integer and a, b, c be any integers and if $a \equiv b \pmod{n}$ and $b \equiv c \pmod{n}$ then $a \equiv c \pmod{n}$. **3.1.4 Theorem:** Let $n > 1$ be a fixed positive integer and a, b, c, d be any integers and if $a \equiv b (mod n)$ and $c \equiv$	

	$d \pmod n$ then $i)\ a + c \equiv b + d \pmod n$ and $ii)\ ac \equiv bd \pmod n$ **3.1.5 Theorem:** Let $n > 1$ be a fixed positive integer and a, b be any integers and if $a \equiv b \pmod n$ then $i)\ a + c \equiv b + c \pmod n$ and $ii)\ ac \equiv bc \pmod n$. **3.1.6 Theorem:** Let $n > 1$ be a fixed positive integer and a, b be any integers and if $a \equiv b \pmod n$ then $a^k \equiv b^k \pmod n$, for any positive integer k. **3.1.7 Theorem:** If $ca \equiv cb (mod\ n)$ then $a \equiv b \left(mod\ \frac{n}{d}\right)$; where $d = \gcd(a, b)$. **3.2** Divisibility test **3.3** Linear congruence and examples **3.4** Chinese Remainder Theorem and examples **3.5** Fermat's theorem and examples	
UNIT-IV	**Groups**	**(08)**
	4.1 Binary operation on a set 4.1.1 **Definition**: Binary operation on a set with illustration **4.2 Semigroup** 4.2.1 **Definition:** Semigroup with illustration **4.3 Monoid** **4.3.1 Definition:** Monoid with illustration **4.4 Group** 4.4.1 **Definition:** Group, Abelian Group, Finite Group, Infinite Group, Order of a group 4.4.2 Examples on 4.4.1 **4.5 Properties of Groups** 4.5.1 **Theorem:** If $< G,* >$ is a group, then a) Identity element in G is unique b) Every a in G has unique inverse in G. c)For every a in G, $(a^{-1})^{-1} = a$ d) For all a, b $\in$ G, $(a * b)^{-1} = b^{-1} * a^{-1}$ 4.5.2 **Theorem:** If a, b, c are elements in a group G, then i) $a * b = a * c$ implies $b = c$ (Left Cancellation Law) ii) $b * a = c * a$ implies $b = c$ (Right Cancellation Law) 4.5.3 **Theorem:** If G is a group and a, b$\in$ G, then the equations $a * x = b$ and $y * a = b$ have unique solutions $x = a^{-1} * b$ and $y = b^{-1} * a$ respectively. 4.5.4 **Definition:** Order of element with illustration, Properties (Without Proof) **4.6 Permutation** 4.6.1 **Definition with Illustration** 4.6.2 **Cyclic Permutation**	

	4.6.3 **Transposition, Disjoint Permutations, Even and Odd Permutations**	

Course Outcomes: Student will be able to …

1. use the properties of these operations such as associativity and distributivity.
2. apply concepts to solve problems in number theory, cryptography, and other mathematical fields.
3. analyze divisibility concepts to solve problems related to modular arithmetic, Diophantine equations, and cryptography.
4. evaluate the concepts of groups in group theory applies to various mathematical structures.

References:

1. Shantinarayan, **A Text Book of Matrices**, 11th Edition, S. Chand Co., Pvt. Ltd. Raminagar, New Delhi, 2005.
2. David. M. Burton, **Elementary Number Theory**, 7th Edition, McGraw Hill Education, 2017.
3. Seymour Hipschutz, Marehipson**, Schaum's Outline**, **Discrete Mathematics**, 3rd Edition, Tata MaGraw-Hill Publishing Company Ltd., New Delhi, July 2017 (Unit 3).
4. V. K. Khanna and S. K. Bhambri, **A course in abstract Algebra**, 5th Edition, Vikas Publishing House Private Limited, New Delhi, 2016 (Unit 4).

B.Sc. Part-II SEMESTER III

BMP 233: Major Practical III

Course Objective: Student should be able to…

1. understand divisibility of integers and understand properties of divisibility, including prime numbers, divisibility tests, and the Fundamental Theorem of Arithmetic.
2. explore properties of relations and their representations using matrices, graphs, and tables.
3. learn how to use programming constructs such as loops and conditional statements effectively to solve problems and implement algorithms.
4. gain practical experience in developing applications and software solutions using the C-programming language.

Group A

Sr. No.	Name of Practical	No. of hours per practical
1.	Hermitian and Skew-Hermitian matrices	4
2.	Rank of matrix	4
3.	Solution of System of m linear homogeneous equations in n unknowns	4
4.	Solution of System of m linear non homogeneous equations in n unknowns	4
5.	Eigen values and Eigen vectors of matrix	4
6.	Inverse of Matrix by Cayley Hamilton Method	4
7.	Properties of divisibility	4
8.	Euclidean Algorithm	4
9.	Pictorial Representation of Relation	4
10.	Examples on equivalence relation	4
11.	Examples on partial order relation	4
12.	Examples on Fermat's theorem	4
13.	Examples on Group & Order of an element	4
14.	Gamma function	4
15.	Beta function	4

Group B

Sr. No.	Name of Practical	No. of hours per practical
1.	C-Introduction-I	4
2.	C-Introduction-II	4
3.	printf- output function in C-language	4
4.	scanf- input function in C-Language	4
5.	Complete Structure of C-program	4
6.	C-program for area of square, rectangle, triangle, circle.	4
7.	C-program for volume of cuboid, cube, sphere, cylinder.	4
8.	Some other simple C-programs	4
9.	If Statement	4
10.	If else Statement	4
11.	Nested if else and switch statement	4
12.	For loop	4
13.	While loop	4
14.	Do while loop	4
15.	Go to statement	4

Course Outcomes: Student will be able to…

1. analyze divisibility concepts to solve problems related to modular arithmetic, Diophantine equations, and cryptography.
2. evaluate the concepts of groups in group theory applies to various mathematical structures.
3. demonstrate a thorough understanding of basic programming concepts such as variables, data types, operators, and control structures in the C-language.
4. create skills in debugging and troubleshooting C programs by identifying and fixing errors such as syntax errors, logic errors, and runtime errors.

References:

1. David. M. Burton, **Elementarary Number Theory**, 7th Edition, McGraw Hill Education, 2017.
2. Seymour Hipschutz, Marehipson, **Schaum's Outline, Discrete Mathematics**, 3rd Edition, Tata MaGraw-Hill Publishing Company Ltd., New Delhi**,** July 2017.
3. R.B. Kulkarni, U.H. Naik, J.D. Yadhav, S.P. Thorat, A.A. Basade, H.V. Patil, H.T. Dinde, **A Hand Book of Computational Mathematics Laboratory**, 1st Edition, Shivaji University Mathematics Society, 2005.
4. B. P. Demidovich & I. A. Maron, **Computational Mathematics**, (translated by George Yankosky), 3rd Reprint, Mir Publishers, Moscow, 1981.

B. Sc. II Semester IV

BMT 241: Advanced Real Analysis

Course Objectives: Student should be able to…

1. develop a deep comprehension of limits of functions and sequences, continuity, and their properties.
2. determine convergence or divergence of sequences and series.
3. apply sequences and series concepts to solve real-world problems in various fields, including physics, engineering, economics, and probability.
4. acquire the knowledge of convergence tests for sequences and series, such as the Ratio Test, Root Test, Comparison Test, Alternating Series Test.

Credits = 02	**SEMESTER-IV** **Advanced Real Analysis**	**No. of hours per unit**
UNIT-I	**Operations on Convergent sequences**	**(08)**
	1.1 Operation on Convergent sequence: 1.1.1 **Theorem:** If $\{s_n\}_{n=1}^{\infty}$ and $\{t_n\}_{n=1}^{\infty}$ are sequences of real numbers, if $\lim_{n\to\infty} s_n = L$ and $\lim_{n\to\infty} t_n = M$ then $\lim_{n\to\infty}(s_n + t_n) = L + M$. 1.1.2 **Theorem:** If $\{s_n\}_{n=1}^{\infty}$ and $\{t_n\}_{n=1}^{\infty}$ are sequences of real numbers, if $\lim_{n\to\infty} s_n = L$ and $\lim_{n\to\infty} t_n = M$ then $\lim_{n\to\infty}(s_n - t_n) = L - M$. 1.1.3 **Theorem:** If $\{s_n\}_{n=1}^{\infty}$ is a sequence of real numbers, f $c \in \mathbb{R}$ and if $\lim_{n\to\infty} s_n = L$ then $\lim_{n\to\infty} cs_n = cL$. 1.1.4 **Theorem:** If $0 < x < 1$ then the sequence $\{x^n\}$ converges to 0. 1.1.5 **Lemma:** If sequence of real numbers $\{S_n\}_{n=1}^{\infty}$ is convergent to L then $\{{s_n}^2\}_{n=1}^{\infty}$ converges to L^2. 1.1.6 **Theorem :** If $\{s_n\}_{n=1}^{\infty}$ and $\{t_n\}_{n=1}^{\infty}$ are sequences of real numbers, if $\lim_{n\to\infty} s_n = L$ and $\lim_{n\to\infty} t_n = M$ then $\lim_{n\to\infty}(s_n . t_n) = LM$. 1.1.7 **Theorem:** If $\{s_n\}_{n=1}^{\infty}$ and $\{t_n\}_{n=1}^{\infty}$ are sequences of real numbers, if $\lim_{n\to\infty} s_n = L$ and $\lim_{n\to\infty} t_n = M$ then $\lim_{n\to\infty}(s_n / t_n) = L/M$.	
UNIT-II	**Monotone Sequences and Cauchy Sequences**	**(06)**
	2.1 Monotone Sequence 2.1.1 **Definition and Examples** 2.1.2 **Theorem:** A non-decreasing sequence which is bounded above is convergent. 2.1.3 **Theorem:** A non-increasing sequence which is bounded below is	

	convergent. 2.1.4 **Corollary:** The sequence $\{(1+\frac{1}{n})^n\}$ is convergent. 2.1.5 **Theorem (Without Proof):** A non-decreasing sequence which is not bounded above diverges to infinity. 2.1.6 **Theorem (Without Proof):** A non-increasing sequence which is not bounded below diverges to infinity. 2.1.7 **Theorem:** A bounded sequence of real numbers has convergent subsequence. **2.2 Cauchy Sequence** 2.2.1 **Definition and Examples** 2.2.2 **Theorem:** If sequence of real numbers $\{s_n\}_{n=1}^{\infty}$ converges then $\{s_n\}_{n=1}^{\infty}$ is Cauchy sequence. 2.2.3 **Theorem:** If $\{s_n\}_{n=1}^{\infty}$is the Cauchy sequence of real numbers then $\{s_n\}_{n=1}^{\infty}$is bounded. 2.2.4 **Theorem:** If $\{s_n\}_{n=1}^{\infty}$is the Cauchy sequence of real numbers then $\{s_n\}_{n=1}^{\infty}$is convergent.	
UNIT-III	**Limit Superior and Inferior of Sequences**	**(06)**
	3.1 Definitions and Examples **3.1.1 Theorem:** If $\{S_n\}_{n=1}^{\infty}$ is convergent sequence of real numbers then $\lim_{n\to\infty} sup\, s_n = \lim_{n\to\infty} S_n$. **3.1.2 Theorem:** If $\{S_n\}_{n=1}^{\infty}$ is convergent sequence of real numbers then $\lim_{n\to\infty} inf\, S_n = \lim_{n\to\infty} S_n$. **3.1.3 Theorem:** If $\{S_n\}_{n=1}^{\infty}$ is convergent sequence of real numbers and if $\lim_{n\to\infty} sup\, S_n = \lim_{n\to\infty} inf\, S_n = L$ where $L \in \mathbb{R}$ then $\{S_n\}_{n=1}^{\infty}$ is convergent and $\lim_{n\to\infty} S_n = L$. **3.1.4 Theorem:** If $\{s_n\}_{n=1}^{\infty}$ and $\{t_n\}_{n=1}^{\infty}$ are bounded sequences of real numbers and if $s_n \le t_n$ then $i)\ \lim_{n\to\infty} sup\, s_n \le \lim_{n\to\infty} sup\, t_n$ $ii)\ \lim_{n\to\infty} inf\, s_n \le \lim_{n\to\infty} inf\, t_n$. **3.1.5 Theorem:** If $\{s_n\}_{n=1}^{\infty}$ and $\{t_n\}_{n=1}^{\infty}$ are bounded sequences of real numbers then $i)\ \lim_{n\to\infty} sup\,(s_n+t_n) \le \lim_{n\to\infty} sup\, s_n + \lim_{n\to\infty} sup\, t_n$ $ii)\ \lim_{n\to\infty} inf\,(s_n+t_n) \ge \lim_{n\to\infty} inf\, s_n + \lim_{n\to\infty} inf\, t_n$.	
UNIT-IV	**Series of Real Numbers**	**(10)**
	4.1 Convergent and Divergent Series: 4.1.1 **Definitions:** Convergent Series, Divergent Series and Examples	

4.1.2 If $\sum_{n=1}^{\infty} a_n$ is convergent series then $\lim_{n\to\infty} a_n = 0$.

4.2 Cauchy's General Principal for convergence (Statement only):

A necessary and sufficient condition for the convergence of an infinite series $\sum_{n=1}^{\infty} u_n$ is that the sequence of its partial sum $\{s_n\}$ is convergent.

4.3 Series of Nonnegative real numbers:

4.3.1 **Definition and Examples**

4.3.2 **Theorem:** A positive term series converges if and only if its sequence of partial sum is bounded above.

Theorem: A positive term series $\sum_{n=1}^{\infty} \frac{1}{n^p}$ is convergent if and only if $p > 1$.

4.4 Tests for convergence:

4.4.1 **Comparison Test (First Type):**

If $\sum u_n$ and $\sum v_n$ are two positive term series and $k \neq 0$, a fixed positive real number (independent of n) and there exists a positive integer m such that $u_n \leq k v_n$ for every $n \geq m$ then

$a)$ $\sum u_n$ is convergent if $\sum v_n$ is convergent and

$b)$ $\sum v_n$ is divergent if $\sum u_n$ is divergent

4.4.2**Comparison Test (Second Type):**

If $\sum u_n$ and $\sum v_n$ are two positive term series and there exist positive number m, such that $(u_n/u_{n+1}) \geq (v_n/v_{n+1})$ for every $n \geq m$ then

$a)$ $\sum u_n$ is convergent if $\sum v_n$ is convergent and

$b)$ $\sum v_n$ is divergent if $\sum u_n$ is divergent

4.4.3 $\boldsymbol{p}$ **− Series Test:** The series $\sum_{n=1}^{\infty} \frac{1}{n^p}$ is convergent if $p > 1$ and divergent if $p \leq 1$.

4.4.4 **Root Test:** Consider the series $\sum_{n=1}^{\infty} a_n$ .Then

$a)$ If $\lim sup|a_n|^{1/n} < 1$ then the series convergent absolutely

$b)$ If $\lim sup|a_n|^{1/n} > 1$ then the series diverges

$c)$ If $\lim sup|a_n|^{1/n} = 1$, this test gives no information

4.5 Alternating Series:

4.5.1 **Leibnitz Test:** If the alternating series

$u_1 - u_2 + u_3 - u_4 + \ \dots$, $(u_n > 0$ for every $n)$ is such that

$i)$ $u_{n+1} \leq u_n$, for every n and

$ii)$ $\lim u_n = 0$ then the series converges

4.6 Examples

4.7 Absolute and Conditional Convergence:

	4.7.1 Definition and Examples 4.7.2 Theorem: Every Absolutely convergent series is convergent **4.8 Examples**	

Course Outcomes: Student will be able to…

1. use the conditions under which each convergence test is applicable and effective.
2. apply sequences and series concepts to solve real-world problems in areas such as engineering, physics, finance, and statistics.
3. analyze the behavior of sequences using limits, including convergence and divergence.
4. evaluate the convergence behavior of series involving factorials, exponentials, and logarithms.

References:

1. R. G. Bartle and D. R. Sherbert, **Introduction to Real Analysis**, 4th Edition, Wiley India Pvt. Ltd, 2016.
2. D. Somasundaram and B Choudhary, **First Course in Mathematical Analysis**, 8th Reprint, Narosa publishing house New, Delhi, 2013.
3. P. K. Jain and S. K. Kaushik, **An Introduction to Real Analysis**, 1st Edition, S. Chand & Company Ltd. New Delhi, 2000.
4. Shanti Narayan and M. D. Raisinghania, **Elements of Real Analysis**, 15th Edition, S. Chand &Company Ltd. New Delhi, 2014.

B.Sc. II Semester IV

BMT 242 Advanced Algebra

Course Objectives: Student should be able to…

1. define subgroups and understand their basic properties.
2. explore the structure of finite and infinite cyclic groups.
3. identify normal subgroups and determine if a given subgroup is normal.
4. understand how concepts of subgroups, cyclic groups, and normal subgroups are interconnected and foundational to the study of group theory.

<table>
<tr><th>Credits = 02</th><th>SEMESTER-IV
Advanced Algebra</th><th>No. of hours per unit</th></tr>
<tr><td>UNIT-I</td><td>Subgroups</td><td>(08)</td></tr>
<tr><td></td><td>1.1 Subgroups
1.1.1 Definition: Subgroups with illustrations
1.2 Theorems on subgroup
1.2.1 Theorem: A non-empty subset H of a group G is a subgroup of G If and only if a, b $\in$ H $\Rightarrow$ ab $\in$ H
a$\in H$ $\Rightarrow$ $a^{-1} \in H$
1.2.2 Theorem: A non-empty subset of a group G is a subgroup of G if and only if a, b $\in$ H $\Rightarrow ab^{-1} \in H$
1.2.3 Theorem: A non-empty finite subset H of a group G is a subgroup of G if and only if H is Closed under multiplication.
1.3 Centre of a Group
1.3.1 Definition: Centre of a Group, Normalizer of an element with illustration.
1.3.2 Theorem: Centre of group G is subgroup of group G.
1.3.3 Theorem: Normalizer of an element group G is subgroup of group G.
1.4 Cosets
1.4.1 Definition: Coset and examples
1.4.2 Theorem: Let H be a subgroup of G then
$i)\ Ha = H \iff a \in H\ and\ aH = H \iff a \in H$
$ii)\ Ha = Hb \iff ab^{-1} \in H$ and $aH = bH \iff a^{-1}b \in H$
$iii)\ Ha(aH)$ is a subgroup of G iff$a \in H$
1.4.3 Theorem: $Ha = \{x \in G\ |x \equiv a\ mod\ H\} = cl(a)$for any a in G
1.4 Lagrange's Theorem
1.4.1 Theorem: If G is a finite group and H is a subgroup of G then $o(H)$divides $o(G)$.
1.5 Index of a subgroup</td><td></td></tr>
</table>

	1.5.1 **Definition:** Index of subgroup H in G with illustration **1.6Theorem:** For subgroups H and K of G, HK is a subgroup of G if and only if HK=KH	
UNIT-II	**Cyclic groups**	**(07)**
	2.1 Cyclic groups 2.1.1 **Definition:** Cyclic group, generator of a cyclic group 2.1.2 Examples on 2.1.1 **2.2 Theorems on Cyclic Groups** 2.2.1 **Theorem:** Order of a cyclic group is equal to the order of its generator. 2.2.2 **Theorem:** A subgroup of cyclic group is cyclic. 2.2.3 **Theorem:** Every cyclic group is abelian. 2.2.4 **Theorem:** If G is finite group, then order of any element of G divides order of G. 2.2.5 **Theorem:** An infinite cyclic group has precisely two generators. **2.3 Euler ϕ function** 2.3.1 **Definition:** Euler's $\emptyset$ function 2.3.2 **Theorem:** Number of generators of a finite cyclic group of order n is $\emptyset(n)$. **2.4 Euler and Fermat's Theorem** 2.4.1 **Euler's Theorem:** Let $a, n (n \geq 1)$ be any integers such that $\gcd(a, n) = 1$ then $a^{\emptyset(n)} \equiv 1(mod n)$ 2.4.2 **Fermat's Theorem:** For any integer a and prime p $a^p \equiv a(mod p)$ 2.4.3 Examples on 2.4.1 and 2.4.3	
UNIT-III	**Normal groups**	**(08)**
	3.1 Normal groups 3.1.1 Definitions: Normal subgroups, Simple group 3.1.2 Examples **3.2 Results on Normal Groups** 3.2.1 **Theorem:** A subgroup H of group G is normal in G if and only if $g^{-1}Hg = H, g \in G$. 3.2.2 **Theorem:** A subgroup H of group G is normal in G if and only if $g^{-1}hg \in H$ for all $h \in H, g \in G$. 3.2.3 **Theorem:** A subgroup H of group G is normal in G if and only if the product of two right (left) cosets of H in G is again a right (left) coset of H in G. **3.3 Quotient groups** 3.3.1 **Definition: Quotient groups with illustration.** 3.3.2 **Theorem:** If G is finite group and N is normal subgroup of G then $o\left(\frac{G}{N}\right) = \frac{o(G)}{o(N)}$.	

	3.3.2 **Theorem:** Every quotient group of cyclic groups is cyclic.	
UNIT-IV	**Homomorphism, Permutation Group**	**(07)**
	4.1 Homomorphism 4.1.1 Definitions: Homomorphism, Epimorphism, Monomorphism, Endomorphism and Automorphism. 4.1.2 Examples on 4.4.1 4.1.3 **Theorem:** If $f: G \to G'$ is homomorphism then (i) $f(e) = e'$ (ii) $f(x^{-1}) = [f(x)]^{-1}$ (iii) $f(x^n) = [f(x)]^n$, nis an integer. **4.2 Kernel of Homomorphism** 4.2.1 **Definition:** Kernel of Homomorphism with illustration 4.2.2 **Theorem:** If $f: G \to G'$ is homomorphism then kerf is a normal subgroup of G. 4.2.3 **Theorem:** A homomorphism $f: G \to G'$ is one-one if and only if kerf = {e}. **4.3 Isomorphism Theorems** 4.3.1 **Fundamental Theorem of group Homomorphism:** If $f: G \to G'$ is an onto homomorphism with $K = \ker f$ then $\frac{G}{K} \cong G'$. 4.3.2 **Second theorem of Isomorphism :(Statement only)** Let H and K be two subgroups of group G , where H is normal in G, then $\frac{HK}{H} \cong \frac{K}{H \cap K}$. 4.3.3 **Third theorem of Isomorphism (Statement only):** Let H and K be two normal subgroups of group G, such that $H \subseteq K$ then $\frac{G}{K} \cong \frac{G/H}{K/H}$. **4.4 Permutation Group** 4.4.1 **Cayley Theorem:** Every group G is isomorphic to a permutation group. 4.4.2 **Theorem:** Set of even permutations is a normal subgroup of S_n Alternating group.	

Course Outcomes: Student will be able to…

1. recognize the significance of subgroups in the study of group theory.
2. apply cyclic groups to solve problems in various mathematical contexts, such as number theory and cryptography.
3. analyze the group homomorphisms and determine their kernel and image.
4. evaluate groundwork for further studies in abstract algebra, group theory, and algebraic structures.

References:

1. V. K. Khanna and S. K. Bhambri, **A course in abstract Algebra**, 3rd Edition, Vikas Publishing house Private Limited, New Delhi, 2008 (Unit 1,2,3,4).
2. J. B. Fraleigh, **A first course in Abstract Algebra**, 10th Reprint, Narosa Publishing House New Delhi, 2003.
3. A. R. Vasishtha, **Modern Algebra**, 2023rd Edition, Krishna Prakashan, Meerut, 2023.
4. I.N. Herstein, **Topics in Algebra**, 2nd Edition, Wiley India Pvt. Ltd, 2006.

B.Sc. Part-II SEMESTER IV

BMP 243: Major Practical IV

Course Objective: Student should be able to …

1. define subgroups and understand their basic properties.
2. determine convergence or divergence of sequences and series.
3. understand the concept of modular programming and learn how to create and use functions and libraries to organize and structure code effectively.
4. learn best practices and coding standards for writing clean, readable, and maintainable C-code.

Group A

Sr. No.	**Name of Practical**	**No. of hours per practical**
1.	Examples on subgroups	4
2.	Examples on Cyclic Group	4
3.	Euler's Phi function and Fermat's theorem	4
4.	Examples on Normal Subgroup	4
5.	Examples on quotient group	4
6.	Permutation Group	4
7.	Homomorphism of Groups	4
8.	Operations on convergent sequences of real numbers	4
9.	Monotone sequences	4
10.	Limit superior of sequence of real numbers	4
11.	Limit inferior of sequence of real numbers	4
12.	Comparison test and	4
13.	Cauchy's n^{th} Root test	4
14.	D'Alembert Ratio test	4
15.	Examples on P-test	4

Group B

Sr. No.	Name of Practical	No. of hours per practical
1.	Break statement	4
2.	Continue statement	4
3.	One-Dimensional Array	4
4.	Two-Dimensional Array	4
5.	Function	4
6.	Trapezoidal Rule and its Program	4
7.	Simpson's $(1/3)^{rd}$ rule and its program	4
8.	Simpson's $(3/8)^{th}$ rule and its program	4
9.	Gauss Elimination Method and its program	4
10.	Gauss Jordan Method and its program	4
11.	Gauss-Seidel Method and its program	4
12.	Euler's Method and its program	4
13.	Euler's Modified Method and its program	4
14.	Runge-Kutta second order Method and its program	4
15.	Runge-Kutta fourth order Method and its program	4

Course Outcomes: Student will be able to …

1. identify the conditions under which each convergence test is applicable and effective.
2. apply cyclic groups to solve problems in various mathematical contexts, such as number theory and cryptography.
3. enhance their problem-solving skills by solving a variety of programming problems and implementing algorithms in C.
4. create work on programming projects individually or in teams, applying C programming skills to develop real-world applications or software solutions.

References:

1. V. K. Khanna and S. K. Bhambri, **A course in abstract Algebra**, 3rd Edition, Vikas Publishing house Private Limited, New Delhi, 2008.
2. Shanti Narayan and M. D. Raisinghania, **Elements of Real Analysis**, 15th Revised Edition, S. Chand & Company Ltd. New Delhi, 2014.
3. R.B. Kulkarni, U.H. Naik, J.D. Yadhav, S.P. Thorat, A.A. Basade, H.V. Patil, H.T. Dinde, **A Hand Book of Computational Mathematics Laboratory**, 1st Edition, Shivaji University Mathematics Society,2005.
4. B. P. Demidovich & I. A. Maron, **Computational Mathematics,** (translated by George Yankosky), 3rd Reprint, Mir Publishers, Moscow, 1981.

B. Sc. II Semester III

BMT 234: Differential Equations

Course Objectives: Student should be able to …

1. learn techniques for solving ordinary differential equations (ODEs).
2. grasp the fundamental concepts of differential equations, including what they are, how they are classified, and their significance in modeling real-world phenomena.
3. using computational tools such as MATLAB, Python, or other software to solve differential equations numerically and visualize solutions.
4. study differential equations, such as separation of variables, homogeneous differential equations, integrating factors etc.

Credits = 02	**SEMESTER-III** **Differential Equations**	**No. of hours per unit**
UNIT-I	**Differential Equations**	**(08)**
	1.1 Definition 1.2 Order and Degree of Differential Equations 1.3 Formation of Differential Equations 1.4 Solution of Differential Equations 1.4.1 General Solution 1.4.2 Particular Solution	
UNIT-II	**First-Order and First-Degree Differential Equations**	**(07)**
	2.1 Definition 2.2 Methods for Solving First Order and First-Degree Differential Equations 2.2.1 Variable Separable Method 2.2.1.1 Equation Reducible to Variable Separable Method 2.2.3 Homogeneous Differential Equations 2.2.3.1 Equation Reducible to Homogeneous Differential Equations 2.4 Exact Differential Equations	
UNIT-III	**Linear Differential Equation of First Order**	**(08)**
	3.1 Definition 3.2 Integrating Factors 3.3 General Solution of Linear Differential Equations 3.4 Equation Reducible to Linear Differential Equations	
UNIT-IV	**Application of Differential Equations**	**(07)**

	4.1 Population Growth and Growth of Bacteria 4.1.1 Examples 4.2 Radio Active Decay 4.2.1 Examples 4.3 Surface Area 4.3.1 Examples 4.4 Newton's Law of Cooling 4.4.1 Examples	

Course Outcomes: Student will be able to …

1. use fundamental theoretical concepts related to differential equations.
2. apply differential equations in various fields such as physics, engineering, biology, chemistry, economics, and other sciences.
3. analyzing and interpreting solutions to differential equations, including understanding the behavior of solutions over time and in different conditions.
4. create mathematical ideas, solutions, and interpretations both orally and in writing.

References:

1. R. L. Ghosh and K. C. Maity, **An Introduction to Differential Equations**¸ 7th Edition, Book and Allied (P) Ltd., 2000.
2. Sharma and Gupta, **Differential Equation,** 49th Edition, Krishna Prakashan media Co., January 2014.
3. Shepley L. Ross, **Differential Equations,** 3rd Edition, John Wiley and Sons Inc., 1984.
4. Martin Braun, **Differential Equations and Their Applications: An Introduction to Applied Mathematics,** 4th Edition, Springer-Verlag, New York Inc., 1993.

B.Sc. Part-II SEMESTER III

BMP 235: Minor Practical III

Course Objective: Student should be able to …

1. gain solid understanding of what differential equations are and their significance in modeling various phenomena in practical contexts
2. acquire proficiency in solving differential equations using analytical and numerical techniques.
3. learn to interpret solutions of differential equations in the context of the problem.
4. gain skills and knowledge that are applicable to careers in fields such as engineering, science, finance, and data analysis.

Sr. No.	**Name of Practical**	**No. of hours per practical**
1.	Order and Degree of Differential Equations	3
2.	Formation of Differential Equations	3
3.	Solution of Differential Equations	3
4.	Variable Separable Method	3
5.	Equations Reducible to Variable Separable Method	3
6.	Homogeneous Differential Equations	3
7.	Equation Reducible to Homogeneous Differential Equations	3
8.	Exact Differential Equations	3
9.	Examples on Integrating Factors- I $\left(\text{I. F.} = \frac{1}{Mx+Ny}\right)$	3
10.	Examples on Integrating Factors- II $\left(\text{I. F.} = \frac{1}{Mx-Ny}\right)$	3
11.	Examples on Integrating Factors- III $\left(\text{I. F.} = \frac{\frac{\partial M}{\partial y}-\frac{\partial N}{\partial x}}{N}\right)$	3
12.	Examples on Integrating Factors- IV $\left(\text{I. F.} = \frac{\frac{\partial N}{\partial x}-\frac{\partial M}{\partial y}}{M}\right)$	3
13.	Linear Differential Equations	3
14.	Equation Reducible to Linear Differential Equations	3
15.	Bernoulli’s Differential Equations	3
16.	Orthogonal Trajectories: Cartesian Coordinates	3
17.	Orthogonal Trajectories: Polar Coordinates	3
18.	Population Growth and Growth of Bacteria	3
19.	Radio Active Decay	3
20.	Surface Area and Newton’s Law of Cooling	3

Course Outcomes: Student will be able to …

1. identify how differential equations which are serve as a powerful tool for bridging mathematical theory with applications in various fields.
2. apply differential equations to models and real-world problems in fields such as physics, engineering, biology, economics, and environmental science.
3. analyze complex practical problems, identify key mathematical concepts and techniques.
4. create mathematical ideas, solutions, and interpretations effectively.

References:

1. Martin Braun, **Differential Equations and Their Applications: An Introduction to Applied Mathematics,** 4th Edition, Springer-Verlag, New York Inc., 1993.
2. Prof. Chaitanya Kumar, Dr. Bhavneet Kaur, Dr. Geetan Manchanda, **A Textbook on Differential Equations and Applications,** Sultan Chand and Sons, January, 2023.
3. Sharma and Gupta, **Differential Equation,** 49th Edition, Krishna Prakashan media Co., January 2014.
4. M. D. Raisinghania, **Ordinary and Partial Differential Equations,** 18th Edition, S. Chand Publication, New Delhi, 2008.

B. Sc. II Semester IV

BMT 244: Numerical Analysis

Course Objectives: Student should be able to …

1. understand numerical techniques for solving linear systems of equations, eigenvalue problems.
2. learn various numerical methods used for solving mathematical problems, including root finding, interpolation, numerical integration, differential equations, and optimization.
3. study the convergence properties and stability conditions of numerical methods, including convergence rates, order of convergence.
4. acquire critical thinking and problem-solving skills by analyzing and solving challenging numerical problems.

Credits = 02	**SEMESTER-III** **Numerical Analysis**	**No. of hours per unit**
UNIT-I	**Root Finding Methods and System of Equations:**	**(08)**
	Bisection Method, Secant Method, Newton-Raphson Method, Gauss Elimination Method, Gauss Jordan Method, Gauss Seidel Method.	
UNIT-II	**Eigenvalues, Eigenvectors and Interpolation**	**(07)**
	Eigenvalues, Eigenvectors, Power Method, Newton's Forward Interpolation, Newton's Backward Interpolation, Lagrange Interpolation, Divided Difference Interpolation.	
UNIT-III	**Integration**	**(07)**
	Trapezoidal Rule and examples, Simpson's $\left(\frac{1}{3}\right)^{rd}$ Rule and examples, Simpson's $\left(\frac{3}{8}\right)^{th}$ Rule and examples.	
UNIT-IV	**Ordinary Differential Equations**	**(08)**
	Euler Method, Modified Euler Method, Runge-Kutta of Second and Fourth Order Method, Examples.	

Course Outcomes: Student should be able to …

1. utilize various numerical methods used for solving mathematical problems, including root finding, interpolation, numerical integration, differential equations, and optimization.
2. apply numerical techniques to solve real-world problems in various fields such as engineering, physics, finance, and data analysis, and evaluate the effectiveness and limitations of different numerical approaches.
3. analyze numerical techniques involving in large scale matrices.
4. evaluate various numerical methods to finding roots, interpolation, numerical integration and differentiation.

References:

1. Devi Prasad**, An Introduction to Numerical Analysis,** 3rd Edition**,** Narosa Publishing House, 2008.

2. S. S. Sastry**, Introduction Methods of Numerical Analysis,** 5th Edition, Prentice Hall of India**,** 2012.

3. J. H. Mathews, **Numerical Methods for Mathematics, Science and Engineering**, 2nd Edition, Prentice Hall of India, 1973.

4. K. Sankara Rao**, Numerical Methods for Scientists and Engineers,** 4th Edition, Prentice Hall of India, 2018.

5. Bhupendra Singh**, Numerical Analysis,** 6th Edition, Pragati Prakashan, 2017.

B.Sc. Part-II SEMESTER IV

BMP 245: Practical IV

Course Objective: Students will be able to …

1. learn appropriate numerical methods and determine the solutions to given non-linear equations.
2. study numerical methods and determine approximate solutions to given linear equations.
3. understand the use of interpolation methods to find intermediate values in given graphical and / or tabulated data.
4. develop critical thinking and problem-solving skills by analyzing and solving challenging numerical problems, evaluating the strengths and weaknesses of different numerical approaches.

Practical No.	Name of Practical	No. of hours per practical
1.	Bisection method	3
2.	Secant method	3
3.	Newton-Raphson method	3
4.	Gauss elimination method	3
5.	Gauss-Jordan method	3
6.	Jacobi iteration method	3
7.	Gauss-Seidel method	3
8.	Euler Method	3
9.	Modified Euler method	3
10.	Eigen values and Eigen vectors	3
11.	Power method	3
12.	Newton's forward interpolation	3
13.	Newton's backward interpolation	3
14.	Lagrange interpolation	3
15.	Divided difference interpolation	3
16.	Trapezoidal rule	3
17.	Simpson's $\left(\frac{1}{3}\right)^{rd}$ rule	3
18.	Simpson's $\left(\frac{3}{8}\right)^{th}$ rule	3
19.	Second order Runge-Kutta method	3
20.	Fourth order Runge-Kutta method	3

Course Outcomes: Students should be able to …

1. identify optimization problems using numerical optimization methods, analyze optimization results, and interpret findings in the context of practical applications.
2. apply numerical techniques to solve real-world problems in various fields such as engineering, physics, finance, and data analysis.
3. analyze and quantify errors in numerical computations, including round-off errors, truncation errors.
4. create skills in solving ordinary and partial differential equations using numerical methods, including finite difference methods.

References:

1. Devi Prasad**, An Introduction to Numerical Analysis,** 3rd Edition**,** Narosa Publishing House, 2008.
2. S. S. Sastry**, Introduction Methods of Numerical Analysis,** 5th Edition, Prentice Hall of India**,** 2012.
3. J. H. Mathews, **Numerical Methods for Mathematics, Science and Engineering**, 2nd Edition, Prentice Hall of International, 1992.
4. K. Sankara Rao**, Numerical Methods for Scientists and Engineers,** 4th Edition, Prentice Hall of International, 2018.
5. Bhupendra Singh**, Numerical Analysis,** 6th Edition, Pragati Prakashan, 2017.

B.Sc. II Semester III

BMP VSC 1: Data Analysis Using MATLAB

Course Objectives: Student should be able to …
1. understands the basics of MATLAB.
2. perform mathematical operations efficiently using MATLAB's array-based approach.
3. apply conditional statements for data selection and manipulation.
4. design algorithms using loops and conditionals to solve complex problems in MATLAB.

Credits=2	**Semester III** **BMP VSC 1: Data Analysis using MATLAB**	**No. of lectures**
1	Introduction to MATLAB: A Beginner's Guide	3
2	MATLAB Commands	3
3	Basic Operations and Functions	3
4	Vectors and Matrices	3
5	Creating and Manipulating Arrays	3
6	Accessing Data in Arrays	3
7	Mathematical operations with arrays	3
8	Conditional data selection	3
9	Tables of data	3
10	Organizing tabular data	3
11	Data types	3
12	Preprocessing data	3
13	Data analysis tasks in MATLAB: Smoothing data	3
14	Data analysis tasks in MATLAB: Linear Correlation	3
15	Data analysis tasks in MATLAB: Fitting polynomials	3
16	Decision Branching	3
17	For Loops	3
18	While Loops	3
19	Increasing Automation with Functions	3
20	Troubleshooting code	3

Course Outcomes: Student will be able to …
1. recognize different data types and structures in MATLAB.
2. utilize conditional data selection techniques to extract relevant information.
3. analyze data in MATLAB through tasks such as smoothing, linear correlation, and polynomial fitting.
4. create MATLAB scripts and functions to solve computational problems.

References:

1. A. Stormy, **MATLAB: A Practical Introduction to Programming and Problem Solving**, 5th Edition, Butterworth-Heinemann, July, 2017.
2. R. J. Bansal, A. K. Goel and M. K. Sharma, **MATLAB and its applications in Engineering**, 1st Edition, Pearsons Publication, 2016.
3. A. Gilat, **MATLAB: An Introduction with Applications,** 4th Edition, Wiley Publication, 2012.
4. P. Patankar and S. Kulkarni, **MATLAB and Simulink In-Depth: Model-based Design with Simulink and Stateflow, User Interface, Scripting, Simulation, Visualization and Debugging**, 1st Edition, BPB Publications, 2022.

B.Sc. II Semester IV

BMP VSC 2: Mathematical Computations by Using MATLAB

Course Objectives: Student should be able to…

1. recall the syntax and commands for visualizing data in 2D and 3D using MATLAB.
2. apply algebraic manipulation and simplification techniques to solve mathematical problems.
3. evaluate the accuracy and reliability of curve fitting models in representing datasets.
4. create customized visualizations to effectively communicate data insights.

Credits=2	**Semester IV** **BMP VSC 2: Mathematical Computations by using MATLAB**	**No. of lectures**
1	Visualizing data in 2D	3
2	Visualizing data in 3D	3
3	Curve fitting	3
4	Visualizing data: Types of Visualizations, Scatter plot, Histogram, Scatter plot with Histogram, Box Plot	3
5	Descriptive Statistics: Descriptive Statistics, Measures of Center, Measures of Spread, Measures of Shape, Calculate Multiple Statistics for Grouped Variables	3
6	Normal Distribution, Hypothesis testing	3
7	Solving an unconstrained optimization problem in MATLAB	3
8	Solving a constrained optimization problem in MATLAB	3
9	Mathematical expression with symbolic variable	3
10	Algebraic Manipulation and Simplification	3
11	Working with Units of Measurement	3
12	Finding Derivatives and integrals	3
13	Approximating Functions using Taylor Polynomials	3
14	Root of a function and root finding problems	3
15	Bisection method	3
16	MATLAB function $fzero$ to find roots.	3
17	MATLAB function *fsolve* to solve systems of nonlinear equations.	3
18	Solving ordinary differential equations numerically	3
19	System of ordinary differential equations	3
20	System of higher order ordinary differential equations	3

Course Outcomes: Student will be able to…

1. recognize the principles behind curve fitting and how it is used to model data in MATLAB.
2. analyze optimization problems and determine appropriate solution methods based on problem constraints.
3. evaluate the solutions of differential equations and systems of equations in terms of accuracy and relevance.
4. create solutions for ordinary and higher-order differential equations systems using MATLAB.

References:

1. A. Stormy, **MATLAB: A Practical Introduction to Programming and Problem Solving**, 5th Edition, Butterworth-Heinemann, July, 2017.
2. R. J. Bansal, A. K. Goel and M. K. Sharma, **MATLAB and its applications in Engineering**, 1st Edition, Pearsons Publication, 2016.
3. A. Gilat, **MATLAB: An Introduction with Applications,** 4th Edition, Wiley Publication, 2012.
4. P. Patankar and S. Kulkarni, **MATLAB and Simulink In-Depth: Model-based Design with Simulink and Stateflow, User Interface, Scripting, Simulation, Visualization and Debugging**, 1st Edition, BPB Publications, 2022.

B.Sc. II Semester III
BMP SEC 2: Mathematical Computations Using Advanced Excel

Course Objectives: Student should be able to…

1. learn basic mathematical operations in Excel.
2. explore mathematical data using advanced Excel tools.
3. analyze complex mathematical models in Excel.
4. emphasize mathematical concepts and Excel functionality to solve practical problems.

Credits=2	Semester III BMP SEC 2: Mathematical Computation using Advanced Excel	No. of lectures
1	Perform mathematical analysis on dataset using excel functions. (SUM, AVERAGE, MEDIAN, MODE etc.)	3
2	Crete pivot tables to summarize and analyze data effectively.	3
3	Absolute and Relative referencing.	3
4	Perform simple Mathematical functions.	3
5	Perform logical operations.	3
6	Decision making using IF, SUMIF, COUNTIF etc.	3
7	Text functions and Look up functions.	3
8	Crete various types of graphs including line graphs, bar charts, pie charts.	3
9	Explore various chart formatting options such as data labels and titles, colors, fonts and styles.	3
10	Use of trend lines to identify and visualize trends within data sets.	3
11	Use of chart templates and annotations to highlights specific data points.	3
12	Combine different chart types.	3
13	Learn to create dynamic charts using Excel named ranges, and data validation for interactive data visualization.	3
14	Explore the creation of Histogram to visualize relationship between two continuous variables.	3
15	Create heat maps to visualize the density or intensity of data across different categories or dimensions using color gradients.	3
16	Crete data models and relationships between multiple data set.	3
17	Use power query to clean, transform and shape data before visualizations.	3

18	Explore power pivot to create advanced calculations and measure.	3
19	Explore 3D mapping capabilities in Excel for visualizing geographical data.	3
20	Perform matrix calculations such as addition, subtraction, multiplication and inversion using Excel's array function.	3

Course Outcomes: Student will be able to…

1. demonstrate proficiency in performing mathematical operations in Excel.
2. utilize Excel functions like AVERAGE, MEDIAN, and MODE to analyze numerical data sets, interpret the results, and draw conclusions.
3. create and manipulate formulas and functions, including nested functions and array formulas, to develop sophisticated mathematical models for various real-world applications.
4. integrate their understanding of mathematical principles with advanced Excel features.

References:

1. Ritu Arora, **Mastering Advanced Excel**, BPB Publication, 2023
2. Alan Murray, **Advanced Excel Success: A Practical Guide to Mastering Excel**, 1st Edition, Apress, 2020.
3. L. Winston Wayne, **Microsoft Excel 2019: Data Analysis & Business Model**, PHI Learning Pvt. Ltd., 2019.
4. Naveen Mishra, **Excel with Microsoft Excel: Comprehensive & Easy Guide to Learn Advanced MS Excel**, Penman Books, 2019.
5. Jordan Goldmeier, **Advanced Excel Essentials**, 1st Edition, Apress, 2014.

B.Sc. II Semester IV

BMP SEC 3: Data Visualization using Python

Course Objectives: Student should be able to…

1. learn about Python libraries like Matplotlib, Seaborn etc.
2. explore the principles behind effective data visualization techniques using Python.
3. analyze datasets and identify patterns and trends through visual exploration.
4. develop advanced data visualization projects using Python.

Credits=2	**Semester IV** **BMP SEC 3: Data Visualization using Python**	**No. of lectures**
1	Introduction to various Data Visualization tools in Python.	3
2	Basic Visualization in Python.	3
3	Introduction to Matplotlib and Installation.	3
4	Connecting to Data and preparing data for visualization in Matplotlib.	3
5	Line Chart: To display trends over time.	3
6	Bar Chart: To compare categories or groups.	3
7	Histogram: Visualizing distribution of continuous data.	3
8	Scatter Plot: Showing relationships between two variables.	3
9	Pie Chart: Representing proportions of a whole.	3
10	Box Plot: Displaying the distribution of data along a five-number summary.	3
11	Heatmap: Visualizing data density or correlations.	3
12	Violin Plot: Combining the features of a box plot and a kernel density plot.	3
13	Bubble Chart: Displaying data points with varying sizes.	3
14	Treemap: Representing hierarchical data using nested rectangles.	3
15	Stacked Area Chart: Showing trends over time for multiple categories.	3
16	Parallel Coordinates: Visualizing high-dimensional data.	3
17	Network Graph: Displaying relationships between entities.	3
18	Choropleth Map: Representing data values on a map.	3
19	Word Cloud: Visualizing text data by displaying frequently occurring words.	3
20	Explore 3D mapping in Python.	3

Course Outcomes: Student will be able to…

1. demonstrate appropriate chart types, color schemes, and labeling for different types of datasets.
2. apply Python code to generate histograms, scatter plots, line charts, and other visualization types using relevant libraries.
3. illustrate insights from data, such as detecting correlations, outliers, and distributions.
4. implement comprehensive data visualization projects, incorporating multiple visualization techniques to effectively communicate insights from complex datasets.

References:

1. Bharti Motwani, **Data Analytics using Python**, Wiley, 2020.
2. Swapnil Saurav, **Learn and Practice Data Visualization using Python**, 1st Edition, Eka Publishers, 2020.
3. Kalilur Rahman, **Python Data Visualization Essentials Guide**, BPB Online, 2021.
4. Seema Acharya, **Reimagining Data Visualization Using Python**, Wiley, 2022.
5. Dr. Abhinav, **Data Visualization using Python Programming- - A Technical Guide for Beginners, Researchers and Data Analyst**, Shashwat Publication, 2023.

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Lead College of Karmaveer Bhaurao Patil University, Satara

Department of Mathematics

SEMESTER III

BMT VEC 2: Environmental Awareness for Mathematics

Course Objectives: Student should be able to…

1. gain an awareness of the environmental issues and challenges that can arises in the practice of science & technology.
2. explore the environmental laws and ethics.
3. understanding the interconnectedness of the *SDGs* and their relevance to Mathematics.
4. emphasize the role of mathematics to address environmental issues.

Credits=2	**SEMESTER-III** **BMT VEC 2: Environmental Awareness for Mathematics**	**No. of lectures per unit**
UNIT I	**Environmental Issues**	**(08)**
	Pollution (Air, Water and Land), Fresh-water overuse, Natural disasters, Fuel and Energy shortage due to overuse, Increase in wasteland, Biodiversity loss, Global warming and climate change, role of mathematics in resolving environmental issues.	
UNIT II	**Environmental laws and ethics**	**(07)**
	Environmental Protection Act, Wildlife Protection Act, Forest Conservation Act, Prevention and Control of Pollution Act (Air, Water and Land), from unsustainable to sustainable development, Responsibilities of an Environmentally aware citizen.	
UNIT III	**Sustainable Development Goals**	**(07)**
	Overview of the Sustainable Development Goals, Sustainable Development Goals in India, Global Indicator Framework, National Indicator Framework and Guidelines.	
UNIT IV	**Role of Mathematics in meeting Sustainable Development Goals**	**(08)**
	Data Analysis and Environmental Modeling, Application of mathematical tools and techniques to maximize resource efficiency, minimize waste and improve distribution of resources, Calculation of Carbon Foot printing (CC), Mathematical Ecology.	

Course Outcomes: Student will be able to…

1. analyze about environmental challenges such as pollution, climate change, biodiversity loss and resource depletion.
2. evaluate the effectiveness of environmental laws and policies.
3. estimate data and results of Sustainable Development Goal*s* using mathematical reasoning.
4. apply mathematical tools and techniques to study and address environmental issues and meeting *SDGs*.

Reference Books:

1. Danial D. Chiras, **Environmental Science,** Jones & Bartlett Publishers, 2016.
2. P. Leelakrishnan, **Environmental Law in India**, LexisNexis, 2020.
3. R. Rajagopalan, **Environmental Studies: From Crisis to Sustainable Development**, Oxford University Press, 2018.
4. P. D. Kaushik & Ajit Kumar, **Understanding Sustainable Development Goals (SDGs): Concept, Implementation, Challenges and Opportunities**, Springer, 2019.
5. Tony Norton, Eleanor H. Norton & Nicholas A. Booker, **Mathematics and the Sustainable Development Goals: Solving Complex Problems**, Springer, 2020.