Learning Outcomes Based Curriculum Framework (LOCF)

for

Mathematics

Undergraduate Programme

2023

Department of Mathematics

Cotton University

Panbazar, Guwahati - 781001
Assam

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PART I

1.1 Introduction

Higher education plays a critical role in securing gainful work and/or offering further access to higher education. As a result, improving the quality of higher education should be given top priority in order to enable the next generation of students to acquire the skills, training, and knowledge they need to improve their thinking, comprehension, and application abilities and prepare them to compete, succeed, and excel globally.

The Cotton University envisions all of its programmes in the best interests of its students, and in this effort, it has given all of its Undergraduate courses a new perspective. For all of its Undergraduate programmes, it uses a Learning Outcome-based Curriculum Framework (LOCF).

At the Undergraduate level, the LOCF approach is intended to provide a focused, outcome-based curriculum with an agenda to shape teaching-learning experiences in a more student centric manner. The LOCF strategy has been implemented to enhance students' experiences as they participate in their chosen programme. Students will be prepared for both academics and employment through the Undergraduate Programs.

The syllabus developed for B.Sc. course in Mathematics has the provision of ensuring the integrated personality of the students in terms of providing opportunity for exposure to the students towards Major-minor, Multidisciplinary and value added course with special focus on technical, communication and subject specific skills through practical and other innovative transactional modes to develop their employability skills.

1.2 Learning Outcomes-based Approach to Curriculum Planning and Development

The basic objective of the learning outcome based approach to curriculum planning and development is to focus on demonstrated achievement of outcomes (expressed in terms of knowledge, understanding, skills, attitudes and values) and academic standards expected of graduates of a programme of study. Learning outcomes specify what graduates completing a particular programme of study are expected to know, understand and be able to do at the end of their programme of study.

The expected learning outcomes are used to set the benchmark to formulate the course outcomes, programme specific outcomes, programme outcomes and graduate attributes. These outcomes are essential for curriculum planning and development, and in the design,

delivery and review of academic programmes. They provide general direction and guidance to the teaching-learning process and assessment of student learning levels under a specific programme.

The overall objectives of the learning outcomes-based curriculum framework are to:

- help formulate graduate attributes, qualification descriptors, programme learning outcomes and course learning outcomes that are expected to be demonstrated by the holder of a qualification;
- enable prospective students, parents, employers and others to understand the nature and level of learning outcomes (knowledge, skills, attitudes and values) or attributes a graduate of a programme should be capable of demonstrating on successful completion of the programme of study;
- maintain national standards and international comparability of learning outcomes and academic standards to ensure global competitiveness, and to facilitate student/graduate mobility; and
- provide higher education institutions an important point of reference for designing teaching-learning strategies, assessing student learning levels, and periodic review of programmes and academic standards.

1.3 Key outcomes underpinning curriculum planning and development

The learning outcomes-based curriculum framework is a framework based on the expected learning outcomes and academic standards that are expected to be attained by graduates of a programme of study. The key outcomes that underpin curriculum planning and development include Graduate Attributes, Programme Outcomes, Programme Specific Outcomes, and Course Outcomes.

1.3.1 Graduate Attributes

The disciplinary expertise or technical knowledge that has formed the core of the university courses. They are qualities that also prepare graduates as agents for social good in future. Some of the characteristic attributes that a graduate should demonstrate are as follows:

1. **Disciplinary knowledge**: Capable of demonstrating comprehensive knowledge and understanding of one or more disciplines
2. **Research-related skills**: A sense of inquiry and capability for asking relevant/appropriate questions, problem, synthesizing and articulating
3. **Analytical reasoning**: Ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others
4. **Critical thinking**: Capability to apply analytic thought to a body of knowledge
5. **Problem solving**: Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems

6. **Communication Skills**: Ability to express thoughts and ideas effectively in writing and orally
7. **Information/digital literacy**: Capability to use ICT in a variety of learning situations; demonstrate an ability to access, evaluate, and use a variety of relevant information sources; and use appropriate software for analysis of data.
8. **Self-directed learning**: Ability to work independently, identify appropriate resources required for a project, and manage a project through to completion.
9. **Cooperation/Teamwork**: Ability to work effectively and respectfully with diverse teams
10. **Scientific reasoning**: Ability to analyse, interpret and draw conclusions from quantitative/qualitative data; and critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective
11. **Reflective thinking**: Critical sensibility to lived experiences, with self-awareness and reflexivity of both self and society.
12. **Multicultural competence**: Possess knowledge of the values and beliefs of multiple cultures and a global perspective
13. **Moral and ethical awareness/reasoning**: Ability to embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work
14. **Leadership readiness/qualities**: Capability for mapping out the tasks of a team or an organization, setting direction, formulating an inspiring vision, building a team who can help achieve the vision, motivating and inspiring team members to engage with that vision, and using management skills to guide people to the right destination, smoothly and efficiently.
15. **Lifelong learning**: Ability to acquire knowledge and skills, including 'learning how to learn', that are necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed at personal development, meeting economic, social and cultural objectives, and adapting to changing trades and demands of the work place through knowledge/skill development.

1.3.2 Programme Outcomes (POs) for Undergraduate programme

POs are statements that describe what the students graduating from any of the educational programmes should able to do. They are the indicators of what knowledge, skills and attitudes a graduate should have at the time of graduation.

1. **In-depth knowledge**: Acquire a systematic, extensive and coherent knowledge and understanding of their academic discipline as a whole and its applications, and links to related disciplinary areas/subjects of study; demonstrate a critical understanding of the latest developments in the subject, and an ability to use established techniques of analysis and enquiry within the subject domain.
2. **Understanding Theories**: Apply, assess and debate the major schools of thought and theories, principles and concepts, and emerging issues in the academic discipline.

3. **Analytical and critical thinking**: Demonstrate independent learning, analytical and critical thinking of a wide range of ideas and complex problems and issues.
4. **Critical assessment**: Use knowledge, understanding and skills for the critical assessment of a wide range of ideas and complex problems and issues relating to the chosen field of study.
5. **Research and Innovation**: Demonstrate comprehensive knowledge about current research and innovation, and acquire techniques and skills required for identifying problems and issues to produce a well-researched written work that engages with various sources employing a range of disciplinary techniques and scientific methods applicable.
6. **Interdisciplinary Perspective:** Commitment to intellectual openness and developing understanding beyond subject domains; answering questions, solving problems and addressing contemporary social issues by synthesizing knowledge from multiple disciplines.
7. **Communication Competence:** Demonstrate effective oral and written communicative skills to covey disciplinary knowledge and to communicate the results of studies undertaken in an academic field accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s) of study
8. **Career development**: Demonstrate subject-related knowledge and skills that are relevant to academic, professional, soft skills and employability required for higher education and placements.
9. **Teamwork**: Work in teams with enhanced interpersonal skills and leadership qualities.
10. **Commitment to the society and to the Nation:** Recognize the importance of social, environmental, human and other critical issues faced by humanity at the local, national and international level; appreciate the pluralistic national culture and the importance of national integration.

1.3.3 Programme Specific Outcomes (PSOs) in Mathematics

Programme specific outcomes include subject-specific skills and generic skills, including transferable global skills and competencies, the achievement of which the students of a specific programme of study should be able to demonstrate for the award of the degree. The programme specific outcomes would also focus on knowledge and skills that prepare students for further study, employment. They help ensure comparability of learning levels and academic standards across universities and provide a broad picture of the level of competence of graduates of a given programme of study. The attainment of PSOs for a programme is computed by accumulating PSO attainment in all the courses comprising the programme.

PSO1. Basic Concept: Ability to interpret and analyze various concepts and theories

PSO2. Understanding real life application: An understanding application of various methods and apply in real life problem.

PSO3. Research and Innovation: Use of knowledge to identify a wide range of contemporary problems and issues and acquire research skills to produce a well-researched written work using geographical research tools.

PSO4. Critical thinking: Able to identify critical problems.

1.3.4 Course Level Learning Outcome Matrix

1.3.4.1 Course Outcomes(COs) and Programme Outcomes(POs) matrix

Major and Minor Courses

Programme Outcomes (POs)	MTH101C	MTH201C
1.In depth knowledge	✓	✓
2. Understanding Theories	✓	✓
3. Analytical and critical thinking:	✓	✓
4. Critical assessment	✓	✓
5. Research and Innovation	✓	✓
6. Interdisciplinary Perspective		
7.Communication Competence:		
8.Career development	✓	✓
9.Teamwork		
10.Commitment to the society and to the Nation		

1.3.4 Course Level Learning Outcome Matrix

1.3.4.1 Course Outcomes (COs) and Programme Outcomes (POs) matrix

Multidisciplinary and Value Added Course

Programme Outcomes (POs)	Basic Mathematics-I	Basic Mathematics-I	MTH104V
1. In-depth knowledge	✓	✓	✓
2. Specialised knowledge and skills	✓	✓	✓
3. Analytical and critical thinking	✓	✓	✓
4. Research and Innovation	✓	✓	✓
5. Interdisciplinary Perspective	✓	✓	
6. Communication Competence	✓	✓	✓
7. Career development	✓	✓	✓
8. Teamwork			
9. Commitment to the society and the Nation			

1.3.4.2 Course Outcomes (COs) and Programme Learning/Specific Outcomes (PSOs) matrix

Course Level Learning Outcomes Matrix – **Major and Minor Courses**

Programme Specific Outcomes	MTH101C	MTH201C
Basic Concepts	✓	✓
Understanding Landscape	✓	✓
Understand human-environmental concerns		
Cartographic knowledge		✓
Application and Geospatial tools and techniques		
Use of data and statistical tools		
Field knowledge & case study-based analysis		
Applied dimensions	✓	✓
Public policy		

Course Level Learning Outcomes Matrix – **Multidisciplinary and Value Added Course**

Programme Specific Outcomes	Basic Mathematics-I	Basic Mathematics-I	MTH104V
Basic Concepts	✓	✓	✓
Understanding Landscape	✓	✓	✓
Understand human-environmental concerns			
Cartographic knowledge			
Application and Geospatial tools and techniques			
Use of data and statistical tools			
Field knowledge & case study-based analysis			

Applied dimensions	✓	✓	✓
Public policy			

1.4 Teaching-learning process

The department of Geography, Cotton University has student-centric teaching-learning pedagogies to enhance the learning experiences of the students. All classroom lectures are interactive in nature, allowing the students to have meaningful discussions and question and answer sessions. Apart from the physical classes, lectures are also held in online mode where students can have doubt clearing and discussions with the teachers. Most of the teachers use ICT facilities with power-point presentations, e-learning platforms and other innovative e-content platforms for student-centric learning methods.

The Department has adopted participative teaching-learning practices, which includes seminars, presentations and group discussions. These participative teaching-learning practices are included in the curricula of almost all the courses. Apart from these, exposure visits, special lectures by invited experts, workshops, and National/International seminars are held to augment knowledge, encourage innovative ideas and expose the students to global academic and research advancement.

The short-term projects, research projects, assignments and field works, which are the integral components of all the courses, enable the students to solve practical problems. Students are also being engaged in sample surveys, data collection and analysis works of the in-house and external research projects for acquiring experiential learning. The laboratories of the department offer hands-on learning experiences to the students.

UG First Semester (Major & Minor)
Paper Title-Algebra
Paper Code-MTH101C
Credit-(3+1+0)

Course Objectives: The primary objective of this course is to introduce the basic tools of theory of equations, number theory, group theory, symmetry group of a plane figure, basic concepts of cyclic groups, classification of subgroups of cyclic groups.

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

1. Determine number of positive/negative real roots of a real polynomial.
2. Solve cubic and quardatic polynomial equations with special condition on roots and in general.
3. Employ De-Moivre's theorem in a number of applications to solve numerical problems.
4. Use modular arithmetic and basic properties of congruences.
5. Recognize the algebraic structure, namely groups, and classify subgroups of cyclic groups.

Unit – 1 (18 hours)

General properties of polynomials and equations, Fundamental theorem of algebra, Relations between the roots and the coefficients, Upper bounds for the real roots; Theorems on imaginary, integral and rational roots; Newton's method for integral roots, Descartes' rule of signs; De-Moivre's theorem for integer and rational indices and their applications, The nth roots of unity, Cardan's solution of the cubic, Descartes' solution of the quartic equation.

Unit – 2 (12 hours)

Division algorithm in $\mathbb{Z}$, Divisibility and the Euclidean algorithm, Fundamental theorem of arithmetic, Modular arithmetic and basic properties of congruences.

Unit – 3 (18 hours)

Groups, Basic properties, Symmetries of a square, Dihedral group, Order of a group, Order of an element, Subgroups, Center of a group, Centralizer of an element, Cyclic groups and properties, Generators of a cyclic group, Classification of subgroups of cyclic groups.

Books Recommended

1. Andreescu, Titu & Andrica, D. (2014). Complex numbers from A to...Z. (2nd ed.). Birkhäuser.
2. Dickson, Leonard Eugene (2009). First Course in the Theory of Equations. John Wiley & Sons, Inc. The Project Gutenberg eBook: http://www.gutenberg.org/ebooks/29785
3. Gallian, Joseph. A. (2017). Contemporary Abstract Algebra (9th ed.). Cengage Learning India Private Limited, Delhi. Indian Reprint 2021.

4. Goodaire, Edgar G., & Parmenter, Michael M. (2006). Discrete Mathematics with Graph Theory (3rd ed.). Pearson Education Pvt. Ltd. Indian Reprint 2018.

Books for Reference

1. Burnside, W.S., & Panton, A.W. (1979), The Theory of Equations, Vol. 1. Eleventh Edition, (Fourth Indian Reprint. S. Chand & Co. New Delhi), Dover Publications, Inc.
2. Burton, David M. (2011). Elementary Number Theory (7th ed.). McGraw-Hill Education Pvt. Ltd. Indian Reprint.
3. Rotman, Joseph J. (1995). An Introduction to The Theory of Groups (4th ed.). Springer-Verlag, New York.

(Multidisciplinary)

UG First Semester

Paper Title : Basic Mathematics-I

(Credit 2+1+0)

Course Objectives:

The primary objective of this course is to introduce the concept of set, operations with set, mapping, relations, algebraic system, matrix, determinants, truth table etc.

Course Learning Outcome:

This course will enable the students:

1. Understand and apply different operations on set.
2. Understand apply concepts of relations and mappings.
3. Solve system of linear equations by applying concept of matrix.
4. Apply the concept of divisors, primes, gcd, congruence.
5. Understand the statements involving the connecting words- difference among contradiction, converse and contrapositive.

Unit-I (06 hours)

Sets, equal sets, subsets, universal set, union and intersection of sets, Venn diagrams, operations with sets, the product sets, mapping, one-to-one mapping, onto mapping

Unit-II (06 hours)

Relations, properties of binary relations, equivalence relations, equivalence class, ordering in sets, operations, types of binary operations, well defined operations, algebraic system

Unit-III (10 hours)

Matrix, different types of matrices, operations, properties, Invertible matrices, determinants, adjoint of matrix, solution of system of linear equations,

Unit-IV (04 hours)

Divisors, primes, gcd, congruence, an application to the calender

Unit-V (06 hours)

Statements, Connecting words/ phrases "if and only if, "implies", "and/or", "implied by", "and", "or", "there exists" and their use through variety of examples related to real life and Mathematics. Validating the statements involving the connecting words- difference among contradiction, converse and contrapositive. Truth table.

Books Recommended

1. Frank Ayres, L. R. Jaising, Theory and problems of abstract algebra, Mcgraw Hill
2. M. K. Sen and B. C. Chakraborty, Introduction to discrete mathematics, Books and allied ltd
3. Burton, David M. (2011). Elementary Number Theory (7th ed.). McGraw-Hill Education Pvt. Ltd. Indian Reprint.

UG First Semester

Value Added Course

Paper Title: Vedic Mathematics

Paper Code:

Credit (2+0+0)

Course Objectives:

Foster the love for mathematics by creating a positive attitude through Vedic and Ancient Indian Mathematics, Help students appreciate ancient Indian Mathematics and its contribution to the world, Enhance computational proficiency by involving procedures in Linear and Matrix Algebra, Improve geometrical thinking by understanding the basic tenets of geometry such as construction of line segments, angles, triangles and circles as used in Ancient IndiaDevelop conceptual knowledge of mathematical concepts, Appreciate the need of conceptual knowledge over procedural processes

Learning Outcomes:

After completion of the course, students shall be able to

- think critically
- Find mathematical solution of algebraic expressions
- Solve system of linear equations and matrices faster and with ease.
- Appreciate the Mathematical advancements of Ancient India.

Unit I: (4 hours) Vedic maths-High speed addition and subtraction, Vedic maths-History of vedic maths and its features, Vedic maths formulae- *Sutras* and *upsutras,* addition in vedic maths-without carrying, dot method, subtraction in vedic maths- *nikhilam, navatashcaramam dashatah* (all from 9 last from 10), fraction-addition and subtraction

Unit II: (4 hours) Vedic maths- miracle multiplication and excellent division, multiplication in vedic maths, base methods (any two number up to three digits), multiplication by urdhva tiryak sutra, miracle multiplication- any three-digit number by series of 1's and 9's, division by urdhva tiryak sutra (Vinculum method)

Unit III: (4 hours) Vedic maths- lightening squares and rapid cubes, square of any two-digit numbers: base method, square of numbers ending in 5: ekadhikena purvena sutra, easy square roots: dwandwa yoga (dulpex) sutra, square root of 2: *baudhayana shulbasutra*, cubing yavadunam sutra

Unit IV: (4 hours) Vedic maths- enlighten algebra and geometry: factoring quadratic equations: *anurupyena, adyamadyenantyamantya sutra*, concept of baudhayana (Pythogoras) theorem, circling a square: *baudhayana shulbasutra*, concept of pi: *baudhayana shulbasutra*, concept of angle (θ), 0^0, 30^0, 45^0, 60^0 and 90^0: *baudhayana* number

Unit V: (4 hours) Contribution of Indian Mathematicians- Varahmihir, Brahmagupta, Srinivasa Ramanujan, Neelkanth Somayya, Bharti Krishna Tirtha

Unit VI: (4 hours) Easy Solution of linear equations- Introduction of simple equation, Solutions of simple equations, Solutions of linear equations in two variables, Practical application of linear equations in two variables

Unit VII: (4 hours) High Speed Matrix Algebra- Introduction and history of Matrices and Determinants, Matrices and Determinants of third order, Inverse of Matrices

Unit VIII: (4 hours) Vedic Geometry- Different forms of straight lines, The Triangle, The Cyclic Quadrilateral, Squares, and the Circle, Geometrical constructions (such as *Altars*), Transformation of simple shapes,
Kalpa Sutras-*Srautha Sutras* and *Sulbha Sutras*

Essential Readings:

1. Vedic Mathematics, Swami Bharati Krishna Trithaji, *Motilal Banarsidas, New Delhi*.
2. The Essential of Vedic Mathematics, Rajesh Kumar Thakur, *Rupa Publications, New Delhi*
3. Vedic Mathematics For All Ages, Vandana Singhal, *Motilal Banarsidas Publishers.*
4. Learn Vedic Speed Mathematics systematically, Chaitanya A. Patil, 2018

Suggested Readings

1. A Modern Introduction to Ancient Indian Mathematics, T S Bhanumurthy, *Wiley Eastern Limited, New Delhi*
2. Magical World of Mathematics, VG Unkalkar, *Vandana publishers, Bangalore*
3. Vedic Mathematics - Modern Research Methods, Tiwari P., *Cumpus Books International*

UG Second Semester (Major & Minor)
Paper Title- Elementary Real Analysis
Paper Code-MTH201C
Credit-(3+1+0)

Course Objectives : The course will develop a deep and rigorous understanding of real line $\mathbb{R}$ with algebraic, order and completeness properties to prove the results about convergence and divergence of sequences and series of real numbers.

Course Learning Outcomes : This course will enable the students to:
1. Understand the fundamental properties of the real numbers, including completeness and Archimedean, and density property of rational numbers in $\mathbb{R}$.
2. Learn to define sequences in terms of functions from $\mathbb{N}$ to a subset of $\mathbb{R}$ and find the limit.
3. Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate the limit superior and limit inferior of a bounded sequence.
4. Apply limit comparison, ratio, root, and alternating series tests for convergence and absolute convergence of infinite series of real numbers.

Unit – 1 (12 hours)

Algebraic and order properties of $\mathbb{R}$, Absolute value of a real number, Bounded above and bounded below sets, Supremum and infimum of a non-empty subset of $\mathbb{R}$, The completeness property of $\mathbb{R}$, Archimedean property, Density of rational numbers in $\mathbb{R}$.

Unit – 2 (20 hours)

Sequences and their limits, Convergent sequence, Limit theorems, Monotone sequences, Monotone convergence theorem, Subsequences, Bolzano-Weierstrass theorem for sequences, Limit superior and limit inferior for bounded sequence, Cauchy sequence, Cauchy's convergence criterion.

Unit – 3 (16 hours)

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

Books Recommended

1. Bartle, Robert G., & Sherbert, Donald R. (2011). Introduction to Real Analysis (4th ed.). John Wiley & Sons. Wiley India Edition 2015.
2. Bilodeau, Gerald G., Thie, Paul R., & Keough, G. E. (2010). An Introduction to Analysis (2nd ed.). Jones and Bartlett India Pvt. Ltd. Student Edition. Reprinted 2015.
3. Denlinger, Charles G. (2011). Elements of Real Analysis. Jones and Bartlett India Pvt. Ltd. Student Edition. Reprinted 2015.

Books for Reference

1. Aliprantis C. D., & Burkinshaw, O. (1998). Principles of Real Analysis (3rd ed.). Academic Press.
2. Ross, Kenneth A. (2013). Elementary Analysis: The Theory of Calculus (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian reprint.
3. Thomson, B. S., Bruckner, A. M., & Bruckner, J. B. (2001). Elementary Real Analysis. Prentice Hall.

(Multidisciplinary)

UG Second Semester

Paper Title: Basic Mathematics-II

Course Objectives:

The primary objective of this course is introduce basic idea of derivative, its geometric interpretation, its application on different types of functions, idea of continuity and some related important theorems. Also introduce basic concepts of integration, definite integrals as a limit of a

sum, Fundamental Theorem of Calculus and its applications. Introduce related terminology of linear programming (L.P.) problems, mathematical formulation of L.P. problems and solution for problems in two variables.

Course Learning Outcome:

This course will enable the students:

1. Apply concept of derivative on many real life problems.
2. Apply the concept of of integration to find area and on other real life problems.
3. Solve linear programming problems with two variables using graphical method.

UNIT-I (10 hours)

Derivative introduced as rate of change both as that of distance function and geometrically, intuitive idea of limit, Definitions of derivative, relate it to slope of tangent of the curve, derivative of sum, difference, product and quotient of functions. Derivatives of polynomial and trigonometric functions.Continuity and differentiability, derivative of composite functions, chain rule, derivatives of inverse trigonometric functions, derivative of implicit function. Concept of exponential and logarithmic functions and their derivatives. Logarithmic differentiation. Derivative of functions expressed in parametric forms. Second order derivatives. Rolle's and Lagrange's Mean Value Theorems (without proof) and their geometric interpretations.

UNIT-II (06 hours)

Applications of derivatives : Rate of change, increasing/ decreasing functions, tangents and normals, approximation, maxima and minima. Simple problems (that illustrate basic principles and understanding of the subject as well as real-life situations).

UNIT-III (10 hours)

Integration as inverse process of differentiation. Integration of a variety of functions by substitution, by partial fractions and by parts, only simple integrals. Definite integrals as a limit of a sum. Fundamental Theorem of Calculus (without proof). Basic properties of definite integrals and evaluation of definite integrals. Applications in finding the area under simple curves.

UNIT-IV (06 hours)

Introduction, related terminology such as constraints, objective function, optimization, different types of linear programming (L.P.) problems, mathematical formulation of L.P. problems, graphical method of solution for problems in two variables, feasible and infeasible regions, feasible and infeasible solutions, optimal feasible solutions.

Books Recommended

1. Shanti Narayan and P K Mittal (2018). Differential Calculus. 15th Ed (Revised)., S Chand

Publication, New Delhi
2. Shanti Narayan and P K Mittal (2016). Integral Calculus. 11th Ed (Revised), S Chand Publication, New Delhi
3. K. Swarup, P.K. Gupta and M.Mohan, Operations Research(Ninth Edition) , Sultan Chand & Sons, New Delhi, 2002