Tribhuvan University

Faculty of Humanities and Social Sciences

B. A. Mathematics Courses

Prepared by
Central Department of Mathematics
Tribhuvan University, Kirtipur
2076

Contents

1 Math 421 Calculus

TRIBHUVAN UNIVERSITY
Faculty of Humanities and Social Sciences

Course Title: Calculus (Compulsory) **Full Marks:** 100
Course No.: Math 421 **Pass Marks:** 40
Level: B. A. **Year:** I
Nature of Course: Theory **Periods:** 9 Lecture hours/Week

Course Objectives: This course is designed for the first year of Four Years B. A. Program as a compulsory subject in mathematics. The main aim of this course is to provide knowledge of calculus and use of calculus in different geometrical aspects and vectors. The objective of this course is to acquaint students with the basic concepts, and to build good knowledge base in both differential and integral calculus.

Course Contents:

Unit 1. Functions, Limits and Continuity [15 Lecture Hrs]
Functions and their graphs, Combining functions; Shifting and scaling graphs, Rates of change and Limits, Precise definition of limit, One sided limits, Limits at infinity, Infinite limits, Asymptotes, Continuity.

Unit 2. Differentiation [15 Lecture Hrs]
Tangents and derivatives, Derivative as a function, Differentiation rules, Derivatives as rates of changes, Chain rule, Implicit differentiation, Linearization and differentials, Higher order derivatives , Leibnitz theorem.

Unit 3. Application of Derivatives [15 Lecture Hrs]
Monotonic functions and the first derivative test, Second derivative test, Concavity and Curve Sketching, Indeterminate Forms and L'Hospital's Rule, Mean value theorem (without proof), Taylor's and Maclaurin's theorems(Without proof).

Unit 4. Integrals [15 Lecture Hrs.]
Antiderivatives, Estimating with finite sums, Sigma Notation and Limits of finite sums, Definite integrals and their properties, Fundamental theorem of calculus, Improper integrals, Numerical integrations.

Unit 5. Applications of Definite Integrals [15 Lecture Hrs]
Area between curves, Volumes using cross-sections, Volume using cylindrical shells, Arc length, Area of surfaces of revolution.

Unit 6. Reduction Formulae and Beta and Gamma Function [15 Lecture Hrs]
Reduction formulae for algebraic functions, Reduction formulae for trigonometric functions, Beta functions and their properties, Gamma functions and their properties.

Unit 7. Multiple Integrals [15 Lecture Hrs]
Double and iterated integrals over rectangles, Double integrals over general regions, Area by double integration, Double integrals in polar form, Triple integrals in rectangular coordinates.

Unit 8. Partial Derivatives [15 Lecture Hrs]
Functions of several variables, Limits and continuity, Partial derivatives, The Chain rule, Directional derivatives and gradient vectors, Tangent planes and differentials, Total derivatives, Euler's theorem (Proof required for two variables, but verification only for three variables).

Unit 9. Extreme Values of a Function of Two or More Variables [15 Lecture Hrs]

Criterion for functions to have extreme values, Extreme values and saddle points, Lagrange's multipliers

Unit 10. Vector Calculus [15 Lecture Hrs]

Line integrals, Vector fields, Work, Circulations and flux; Path independence and conservative fields, Green's theorem in the plane, Surface and area, Surface integrals, Stoke's theorem, Divergence theorem.

Text/ Reference Books:

1. M. D. Weir, J. Hass, F. R. Giordano: *Thomas Calculus*, Thirteenth Edition, Pearson.
2. J. Stewart; *Calculus Early Transcendental*, Seventh Edition, Cengage Learning India Private Limited.
3. G. D. Pant and G. S. Shrestha; *Integral Calculus and Differential Equations*, Sunita Prakashan, Kathmandu.
4. M. B. Singh and B.C. Bajracharya ; *A Text Book of Differential Calculus*, Sukunda Pustak Bhandar, Kathmandu.

Evaluation:

There will be a final examination of 70 marks for the period of three hours. The internal examination of 30 marks will be conducted by the department of mathematics of related campus and the marks will be submitted to Tribhuvan University Office of the Controller of Examination, Balkhu. Candidates must pass the internal and the final examinations separately.

Marks allocation for the internal examination:

- Written examinations: 20 marks (1 hour)
- A student or a group of students with presentation: 5 marks
- Assignments with attendance: 5 marks

CENTRAL DEPARTMENT OF MATHEMATICS
TRIBHUVAN UNIVERSITY
KIRTIPUR

2 Math 422 Analytical Geometry and Vectors

TRIBHUVAN UNIVERSITY
Faculty of Humanities and Social Sciences

Course Title: Analytical Geometry and Vectors (Compulsory) **Full Marks:** 100
Course No.: Math 422 **Pass Marks:** 40
Level: B. A. **Year:** I
Nature of Course: Theory **Periods:** 9 Lecture hours/Week

Course Objectives: This course is designed for the first year of Four Years B. A. Program as a compulsory subject in mathematics. The objective of this course is to acquaint students with the basic concepts, and to build good knowledge base in Analytical Geometry of two and three dimensions and Vector Analysis.

Course Contents:

Unit 1. Transformation of Coordinates [10 Lecture Hrs]

Introduction to polar, cylindrical and spherical coordinates, Transformation of coordinates through translation and rotation, Process involving combination of translation and rotation of axes, Invariants in orthogonal transformation.

Unit 2. Ellipse [15 Lecture Hrs]

Introduction to conic sections, Derivation of the equation of ellipse in standard form, Auxiliary circles and eccentric angle, Equations of tangent and normal, Chord of contact, Pole and polar, and their properties, Diameter, conjugate diameters and equi-conjugate diameters.

Unit 3. Hyperbola [15 Lecture Hrs]

Derivation of the equation in standard form, Asymptotes of hyperbola, Relations among the equation of a hyperbola, its asymptotes and the conjugate hyperbola, Equation of a hyperbola referred to the asymptotes as coordinate axes.

Unit 4. General Equation of the Second Degree [15 Lecture Hrs.]

General equation of the second degree and the conic representations by them, Nature of the conic, Center of conic, Equation of the tangent and condition of tangency, Equation of pair of tangents, Director circle, Equation of the normal to a conic, Equation of pole and polar with respect to a conic, Diameter and conjugate diameters, Intersection of conics, Asymptotes to a conic.

Unit 5. Straight Lines [20 Lecture Hrs]

Review of space and planes, Representation of a line as the intersection of two planes, Line in symmetric form, Line through two points, Reduction of the general form to the symmetrical form, Perpendicular distance of a point from a line, Condition for a line to lie in a plane, General equation of a plane containing a line, Coplanar lines and condition for it, Skew lines, Magnitude and equation of the line of shortest distance between two skew lines.

Unit 6. Spheres [15 Lecture Hrs]

Sphere and equation of a sphere, Representation of sphere by the general equation of the second degree, Sphere through four given points, Plane section of a sphere, Intersection of two spheres, Sphere with a given diameter, Tangent plane to a sphere and condition of tangency.

Unit 7. Cones and Cylinders [15 Lecture Hrs]

Definition and equation of a cone, Condition that the general equation of the second degree to represent a cone, Condition that a cone has three mutually perpendicular generators, Tangent lines and tangent plane, Condition of tangency, Reciprocal cone, Enveloping and right circular cone, Cylinder and enveloping cylinder, Right circular cylinder

Unit 8. Product of Three or More Vectors [15 Lecture Hrs]

Product of three or more vectors, Scalar triple product, Applications and geometrical meanings of scalar triple product, Properties of scalar triple product, Condition of coplanarity of three vectors, Vector triple product, Scalar product of four vectors, Vector product of four vectors, Reciprocal system of vectors.

Unit 9. Differentiation and Integration of Vectors [15 Lecture Hrs]

Vector function of a single variable, Vector function and its expression in terms of unit vectors, Limits and continuity of vector functions, Differentiation of a vector function with respect to a scalar, Partial derivatives of vectors, Higher derivatives of a vector function with respect to a scalar, Differentiation of the product of a scalar and a vector, Differentiation of scalar products and vector products of two and three vectors, Vector Integrations.

Unit 10. Gradient, Curl and Divergence [15 Lecture Hrs]

Point functions, Gradient of a scalar function, Divergence of a vector function, Curl of a vector function and their physical meanings and properties.

Text/ Reference Books:

1. Y. R. Sthapit and B. C. Bajracharya: *A Text Book of Three Dimensional Geometry*, Sukunda Pustak Bhawan, Kathmandu.
2. M. B. Singh and B. C. Bajracharya; *A Text Book of Vector Analysis*, Sukunda Pustak Bhawan, Kathmandu
3. M. R. Joshi; *Analytical Geometry*, Sukunda Pustak Bhawan, Kathmandu.

Evaluation:

There will be a final examination of 70 marks for the period of three hours. The internal examination of 30 marks will be conducted by the department of mathematics of related campus and the marks will be submitted to Tribhuvan University Office of the Controller of Examination, Balkhu. A candidate must pass the internal and the final examinations separately.

Marks allocation for the internal examination:

- Written examinations: 20 marks (1 hour)
- A student or a group of students with presentation: 5 marks
- Assignments with attendance: 5 marks

CENTRAL DEPARTMENT OF MATHEMATICS
TRIBHUVAN UNIVERSITY
KIRTIPUR

3 Math 423 Linear Algebra

TRIBHUVAN UNIVERSITY
Faculty of Humanities and Social Sciences

Course Title: Linear Algebra (Compulsory) **Full Marks:** 100
Course No.: Math 423 **Pass Mark:** 40
Level: B. A. **Year:** II
Nature of Course: Theory **Periods:** 9 Lecture hours/Week

Course Objectives: This course is designed for the second year of Four Years B. A. Program as a compulsory subject in mathematics. The main objectives of this course are to enable the students to acquire in-depth knowledge and develop good theoretical background in linear algebra to carry on higher studies, to sustain interest and joy of linear algebra and its applications in various branches of mathematics, to get associated with teaching, and to be familiar with recent trends in the field of Linear Algebra.

Course Contents:

Unit 1. Matrix Operations [13 Lecture Hrs]

Review of Matrices (Pre- and post-multiplication of matrices, Dot product, Special matrices), Matrix operations (Addition, Scalar multiplication, Subtraction, Matrix multiplication, Transpose) and their properties, Symmetric and skew-symmetric matrices, Trace of a square matrix, Elementary matrices, Vector-matrix product, Left and right inverses of non-square matrices, Solving systems with left and right inverses, Invertible matrices, Computing inverse by using elementary row operations, Similar matrices.

Unit 2. Determinants [13 Lecture Hrs]

Properties of determinants, An algorithm for computing determinants, Algorithm without scaling, Zero determinant, Using determinants to calculate areas and volumes, Direct methods for computing determinants, Computing inverses using determinants, Product of determinants.

Unit 3. System of Linear Equations [13 Lecture Hrs]

Linear equations, System of linear equations, General systems of linear equations, Homogeneous equations, Gaussian elimination, Elementary replacement and scale operations, Row equivalent pairs of matrices, Reduced row echelon form, Row echelon form and applications.

Unit 4. Vectors and Matrices [13 Lecture Hrs.]

n-tuples and vectors, Vector addition, Vector multiplication by scalar, Matrix-vector products, Interpreting linear systems, Row equivalent systems, Consistent and inconsistent systems, Kernel or null space of a matrix, Uniqueness of the reduced row echelon form, Rank of a matrix, General solution of a system, Indexed sets of vectors, Linear dependence and independence.

Unit 5. Vector Spaces and Subspace [18 Lecture Hrs]

Vector spaces, Properties of $\mathbb{R}^n$ as a vector space, Linear combinations of vectors, Span of a set of vectors, Geometric interpretation of vectors, Line passing through origin, Lines in $\mathbb{R}^2$, Lines and planes in $\mathbb{R}^3$, Lines and planes in $\mathbb{R}^n$, Kernels and null subspaces, The row space and column space of a matrix, Basis and dimension of vector spaces, Coordinate vectors, Isomorphism and equivalence relations, Finite-dimensional and infinite-dimensional vector spaces, Dimensions of various subspaces, Coordinate vectors, Changing coordinates.

Unit 6. Linear Transformation [18 Lecture Hrs]

Review of mappings and transformations, Linear transformations, Linear transformation of a set, Use of matrices to define linear maps, Injective and surjective linear transformations, Effects of linear transformations, Effects of transformations on geometrical figures, Algebra of linear mappings, Vector space of linear mappings, Composition of linear mappings, Invertible linear mappings.

Unit 7. Eigensystems [13 Lecture Hrs]

Introduction, Eigenvectors, eigenvalues and eigenspaces, Use of determinants in finding eigenvalues of matrices, Eigenvalues of linear transformations, Bases of eigenvectors, Characteristic equation and characteristic polynomial, Diagonalization involving complex numbers, Application: Powers of a matrix

Unit 8. Inner Product Vector Spaces [13 Lecture Hrs]

Inner product spaces and their properties, The norm in an inner product space, Distance function, Mutually orthogonal vectors, Orthogonal projection, Angle between vectors, Orthogonal complements, Orthonormal bases, Subspaces in inner product spaces, The Gram-Schmidt algorithm, Linear least-square solution.

Unit 9. Matrix Factorizations [18 Lecture Hrs]

Hermitian matrices and self-adjoint mappings, Unitary and orthogonal matrices, The Cayley-Hamilton theorem, Quadratic forms, Permutation matrix, LU-factorization, QR-factorization, Partitioned matrices, Solving a system having a 2×2 block matrix, Richardson iterative method, Jacobi iterative method, Gauss-Seidel method.

Unit 10. Applications of Linear Algebra [18 Lecture Hrs]

Algorithm for the reduced row echelon form, Least square approximation, Traffic flow, Graph theory, Cholesky decomposition, Leoneif economic model, Linear ordinary differential equations, Polynomial interpolation, Zeros of polynomial, Rolle's theorem, Descartes rule of signs, Newton's method of approximation.

Text/Reference Books:

1. W. Cheney and D. Kincaid: *Linear Algebra: Theory and Applications*, Jones and Bartlett India Pvt. Ltd.
2. S. H. Friedberg, A. J. Insel and L. E. Spence: *Linear Algebra*, PHI Learning Pvt. Ltd.. New Delhi.
3. T. P. Nepal, T. B. Budhathoki and J. Kafle: *A Textbook of Linear Algebra*, Heritage Publication and Distributors Pvt. Ltd., Kathmandu.
4. R. M. Shrestha and S. Bajracharya: *Linear Algebra, Groups, Rings and Theory of Equations*, Sukunda Pustak Bhawan, Kathmandu.

Evaluation:

There will be a final examination of 70 marks for the period of three hours. The internal examination of 30 marks will be conducted by the department of mathematics of related campus and the marks will be submitted to Tribhuvan University Office of the Controller of Examination, Balkhu. A candidate must pass the internal and the final examinations separately.

Marks allocation for the internal examination:

- Written examinations: 20 marks (1 hour)
- A student or a group of students with presentation: 5 marks
- Assignments with attendance: 5 marks

4 Math 424 Differential Equations

TRIBHUVAN UNIVERSITY
Faculty of Humanities and Social Sciences

Course Title: Differential Equations (Compulsory) **Full Marks:** 100
Course No.: Math 424 **Pass Mark:** 40
Level: B. A. **Year:** II
Nature of Course: Theory **Periods:** 9 Lecture hours/Week

Course Objectives: This course is designed for the second year of Four Years B. A. Program as a compulsory subject in mathematics.The objective of this course is to acquaint students with the basic concepts of differential equations like first order linear and nonlinear differential equations, second order differential equations and higher order linear equations as well as partial differential equations with their wide range of applications in different fields. The course aims at enabling students to build good knowledge base for ordinary and partial differential equations.

Course Contents:

Unit 1. Introduction [13 Lecture Hrs]
Definitions and classification of differential equations, Solutions of differential equations, Some mathematical models, Direction fields.

Unit 2. First Order Linear and Nonlinear Differential Equations [18 Lecture Hrs]
Separable equations, Homogeneous equations, Equations reducible to homogeneous equations, Modeling with first order equations, Difference between the linear and nonlinear equations, Autonomous equations and population dynamics, Exact equations and integrating factors, Existence and uniqueness theorem.

Unit 3. Numerical Methods [13 Lecture Hrs]
Numerical approximations, Euler's method, Improved Euler's method, The Runge-Kutta method, System of first order equations, First order difference equations.

Unit 4. Second Order Linear Equations [18 Lecture Hrs.]
Homogeneous equations with constant coefficients, Solutions of linear homogeneous equation, The Wronskian, Complex roots of the characteristic equation, Repeated roots, Reduction of order, Nonhomogeneous equations, Method of undetermined coefficients, Variation of parameters.

Unit 5. Higher Order Linear Equations [13 Lecture Hrs]
General theory of n^{th} order linear equations, Homogeneous equations with constant coefficients, Method of undetermined coefficients, Method of variation of parameters.

Unit 6. System of First Order Linear Equations [13 Lecture Hrs]
Introduction to system of differential equations, Review of matrices, Linear algebraic equations, Linear independence, Eigenvalues, Eigenvectors, Basic theory of first order linear equations, Homogeneous Linear systems with constant coefficients.

Unit 7. Laplace Transfroms and Their Applications to Differential Equations [13 Lecture Hrs]
Introduction and examples of Laplace transforms, Properties of Laplace transforms, Transform of derivatives, Transforms of integrals, Unit step function, Solution of a linear differential equations with constant coefficients using Laplace transform methods.

Unit 8. Introduction to Partial Differential Equations [18 Lecture Hrs]
Introduction to partial differential equations, Formation and solution of partial differential equations, Easily integrable equations, Linear equations of the first order, Charpit's method

Unit 9. Partial Differential Equations and Fourier Series [18 Lecture Hrs]

Two-point boundary value problems, Fourier series, Fourier convergence theorem, Even and odd functions.

Unit 10. Separation of Variables [13 Lecture Hrs]

Heat conduction in a rod, Other heat conduction problems, Wave equation, Vibration of an elastic string, Laplace's equation

Text/Reference Books:

1. W. Boyce and R. DiPrima: *Elementary Differential Equations and Boundary Value Problems*, 9th Ed., Wiley India
2. Z. Ahsan: *Differential Equations and Their Applications*, Second Edition, PHI Learning Pvt. Ltd.
3. D. J. KC and T. B. Budhathoki: *A Textbook of Differential Equations*, Heritage Publishers & Distributers Pvt. Ltd.
4. J. C. Robinson: *An Introduction to Ordinary Differential Equations*, Cambridge University Press.
5. P. Kattel and J. Kafle: *Differential Equations with Applications*, Sukunda Pustak Bhawan.

Evaluation:

There will be a final examination of 70 marks for the period of three hours. The internal examination of 30 marks will be conducted by the department of mathematics of related campus and the marks will be submitted to Tribhuvan University Office of the Controller of Examination, Balkhu. A candidate must pass the internal and the final examinations separately.

Marks allocation for the internal examination:

- Written examinations: 20 marks (1 hour)
- A student or a group of students with presentation: 5 marks
- Assignments with attendance: 5 marks

5 Math 425 Real Analysis

TRIBHUVAN UNIVERSITY
Faculty of Humanities and Social Sciences

Course Title: Real Analysis (Compulsory)
Course No.: Math 425
Level: B. A.
Nature of Course: Theory

Full Marks: 100
Pass Marks: 40
Year: III
Periods: 9 Lecture hours/Week

Course Objectives: This course is designed for the third year of Four Years B. A. Program as a compulsory subject in mathematics. The general objective of this course is to provide basic knowledge and understanding of the mathematical language including symbols, terms, statements, formulae, definitions and logics. Also, the course aims to develop basic knowledge and analytical skill in the emerging areas of real analysis, and to meet prerequisites for higher studies in mathematical analysis.

Course Contents:

Unit 1. Logic, Sets and Functions [13 Lecture Hrs]
Connectives, Quantifiers, Basic laws of logic, Techniques of proof, Sets and set operations, Relations and functions, One-to-one and onto functions, One-to-one correspondence, Images and inverse images, Composition, Inverse functions.

Unit 2. Real Number System [18 Lecture Hrs]
Peano's axioms, Field axioms, Order axioms, Bounded and unbounded sets, Supremum and infimum, Completeness axioms, Archimedean property, Well ordering principle, Rational density theorem, Irrational density theorem, Countable and uncountable sets, Cardinality.

Unit 3. Point Set Topology of the Real Line [18 Lecture Hrs]
Neighbourhood, Interior points and interior of a set, Open and closed sets and their properties, Adherent points and closure of a set, Limit points and derived set, Boundary points and boundary of a set, Bolzano-Weierstrass theorem, Nested interval theorem, Compactness in $\mathbb{R}$.

Unit 4. Sequences of Real Numbers [18 Lecture Hrs.]
Sequences and subsequences, Convergent sequences, Operations on convergent sequences, Monotonic sequences and convergence , Bolzano-Weierstrass theorem for sequences, Nested intervals theorem for sequences, Cauchy sequences, Convergence and divergence criteria.

Unit 5. Series of Real Numbers [13 Lecture Hrs]
Series and sequences, Partial sums, Convergence and divergence, Cauchy's criteria for convergence, Different tests for convergence, Alternating series, Absolute and conditional convergence.

Unit 6. Limit of a Function [13 Lecture Hrs]
Limits, Limit at infinity and infinite limit, Properties of limits, Squeezing theorem, Sequential criterion for limits, One-sided limits.

Unit 7. Continuity of Function [13 Lecture Hrs]
Continuity of functions, Algebra of continuous functions, Types of Discontinuities, Step functions and discontinuities, Continuity and inverse images, Sequential criterion for continuity, Continuity and compactness, Continuous functions on closed and bounded set, Sign preserving property, Bolzano's theorem, Intermediate value theorem, Uniform continuity, Lipschitz condition.

Unit 8. Differentiation [18 Lecture Hrs]
Derivative of a real-valued function of a single real variable, Differentiability at a point and in an interval, Differentiability and continuity, Rules of differentiation, Sequential criterion for derivatives, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, and their

geometric interpretations, Indeterminate forms and L'Hospital's rules, Monotonic functions and differentiation, Taylor's theorem, Maclaurin's theorem, and their applications.

Unit 9. Riemann Integration [13 Lecture Hrs]

Partitions and norm, Refinement of partitions, Upper and lower integrals, Riemann integrable functions and Riemann integrals, Riemann's condition of integrability, Properties of Riemann integrals, Alternative approach: Step function approach to Riemann integration.

Unit 10. Fundamental Theorems of Integral Calculus [13 Lecture Hrs]

Primitive of a function, First mean value theorem for integrals, Generalized first mean value theorem, Fundamental theorem of integrals calculus, Integration by parts, Change of variable in an integral, Second mean value theorem for integrals.

Text/Reference Books:

1. R. G. Bartle and D. R. Sherbert : *Introduction to Real Analysis*, John Wiley and Sons Inc., Singapore.
2. P. M. Bajracharya: *Real Analysis: An Introduction to Proof*, Buddha Academic Publishers & Distributors Pvt.Ltd., Kathmandu, Nepal
3. R. M. Shrestha and N. P. Pahari.: *Fundamentals of Mathematical Analysis*, Sukunda Pustak Bhawan, Kathmandu, Nepal.
4. S. C. Malik and S. Arora: *Mathematical Analysis*, Wiley Eastern Limited, New Delhi.
5. S. L. Gupta and N. Rani: *Fundamental Real Analysis*, Vikas Publishing House, New Delhi.

Evaluation:

There will be a final examination of 70 marks for the period of three hours. The internal examination of 30 marks will be conducted by the department of mathematics of related campus and the marks will be submitted to Tribhuvan University Office of the Controller of Examination, Balkhu. A candidate must pass the internal and the final examinations separately.

Marks allocation for the internal examination:

- Written examinations: 20 marks (1 hour)
- A student or a group of students with presentation: 5 marks
- Assignments with attendance: 5 marks

6 Math 410A Linear Programming & Discrete Mathematics

TRIBHUVAN UNIVERSITY
Faculty of Humanities and Social Sciences

Course Title: Linear Programming and Discrete Mathematics (Elective) **Full Marks:** 100
Course No.: Math 410A **Pass Mark:** 40
Level: B. A. **Year:** III
Nature of Course: Theory **Periods:** 9 Lecture hours/Week

Course Objectives: This course is designed for the third year of Four Years B. A. Program as an elective subject. The course covers basic introduction of linear programming problems, their solution techniques and implementation of the solution techniques to solve real world problems formulated as linear programming problems. After the completion of this course, students will be able to

- know the concept and importance of convexity in optimization.
- formulate instances of real world problems in the form of linear programming problems (LPPs).
- know different techniques for solving LPPs.
- understand the notions of graphs and some algorithms.
- familiarize with some applications.

Course Contents:

Unit 1. Linearity and Convexity [21 Lecture Hrs]

System of linear equations and inequalities, Matrix representation of system of linear equations and inequalities, Linear dependence and independence, Basic solutions, Lines and hyper planes, Affine and convex sets, Convex cones, Polyhedra, Convex functions, Basic properties of convex functions.

Unit 2. Linear Programming (LP)-Models [11 Lecture Hrs]

Variables and constraints, Cost function, General, Canonical and standard forms of LP models, Slack and surplus variables, The equivalent relation of different LP-forms, Formulation of some instances of real world problems in the form of LP-models.

Unit 3. Solution Methods to LP Problems [11 Lecture Hrs]

Extreme points, Basic feasible solutions, Solution of LP with two variables by graphical method, Introduction to simplex method, Theory of simplex method.

Unit 4. Simplex Method [21 Lecture Hrs]

Geometric motivation of the simplex method, Algebra of the simplex method, Optimality and unboundedness, The simplex method, The simplex method in tableau format, Block pivoting, The simplex tableau.

Unit 5. LP Duality Theory [11 Lecture Hrs]

Alternate formulations of LPs, The dual LP formulation, Complementary slackness conditions, The dual simplex algorithm.

Unit 6. Graphs [11 Lecture Hrs]

Notation and Definitions, Path, Cycles, Connectivity, Eulerian and Hamiltonian Graph.

Unit 7. Trees [11 Lecture Hrs]

Introduction to Trees, Applications of Trees, Tree Traversal, Spanning Trees.

Unit 8. Shortest paths [21 Lecture Hrs]

Shortest paths, Finite metric spaces, Breadth first search and bipartite graphs, The algorithm of Dijkstra.

Unit 9. Spanning Trees [21 Lecture Hrs]

Trees and forests, Incidence matrices, Minimal spanning trees, The algorithms of Prim, Kruskal and Boruvka.

Unit 10. Applications [11 Lecture Hrs]

Models of transportation problem, Assignment problem, Maximal flows in a network, Minimum cost flow problem, Transshipment problem, Diet problem, Traveling salesperson problem, Transportation problem.

Text/Reference Books:

1. M. S. Bazaraa, J. J. Jarvis and H. D.Sherali: *Linear Programming and Network Flows*,John Wiley & Sons, Inc., Hoboken, New Jersey 2010
2. G. Hadley: *Linear Programming*, Narosa, Publishing House.
3. D. Jungnickel: *Graphs, Networks and Algorithms*, Springer.

Evaluation:

There will be a final examination of 70 marks for the period of three hours. The internal examination of 30 marks will be conducted by the department of mathematics of related campus and the marks will be submitted to Tribhuvan University Office of the Controller of Examination, Balkhu. A candidate must pass the internal and the final examinations separately.

Marks allocation for the internal examination:

- Written examinations: 20 marks (1 hour)
- A student or a group of students with presentation: 5 marks
- Assignments with attendance: 5 marks

7 Math 410B Computer Programing

TRIBHUVAN UNIVERSITY
Faculty of Humanities and Social Sciences

Course Title: Computer Programming (Elective) **Full Marks:** 100 (50 Theory + 50 Lab)
Course No.: Math 410B **Pass Mark:** 40 (20 Theory + 20 Lab)
Level: B. A. **Year:** III
Nature of Course: Theory and Practical **Periods:** 9 Lecture hours/Week

Course Objectives: This course is designed for the third year of Four Years B. A. Program as an elective subject. The course aims at providing exposure to mathematical problem-solving through computer programming. With the help of programming in C, it provides basic constructs for most of the high-level programming languages. After the completion of the course, the students will be able to develop logic so that they can write computer programs focusing on the various problems related to mathematics courses.

Course Contents: Theory [75 Lecture Hrs]

Unit 1. Introduction to C Programming [11 Lecture Hrs]

Computer languages,

Introduction to C, Importance of C, Basic structure of a C program, Compilation and execution, The C-character set, C-tokens, Keywords and identifiers, Delimiters, Variables, Declaration of variables, Constants, Data types, Expressions, Statements, Comments, Symbolic constants, Different types of errors, debugging of programs.

Unit 2. C Instructions [21 Lecture Hrs]

Input-Output Statements: Single character input-output, Input data using *scanf*, Writing output data using *printf*, *gets* and *puts* functions; **Operators and Expressions:** Arithmetic operators, Unary operators, Relational operators, Logical operators, Assignment operators, Increment or decrement operators, Conditional operators, Bitwise operators, Comma operator, Precedence of operators, Arithmetic expressions, Type conversion in expressions.

Unit 3. Decision Control Instructions [11 Lecture Hrs]

Branching: The *if* statement, The *if-else* statement, Nested *if-elses*; **Looping:** The *while* statement, The *do-while* statement, The *for* statement, The *switch* statement, The *break* and *continue* statements, The *goto* statement.

Unit 4. Functions and Arrays [11 Lecture Hrs]

Functions: Overview of functions, Defining a function, Library functions, User-defined functions, Accessing a function, Function prototypes, Local and global variables, Passing arguments to a function, Recursion; **Arrays:** Defining an array, Processing an array, One-dimensional array, Multi-dimensional array, Arrays and strings.

Unit 5. Solving Mathematical Problems with C Programming [21 Lecture Hrs]

Searching and sorting, Matrices and matrix operations, Numerical solution of a system of linear equations, Numerical solution of polynomial equations, Numerical solution of non-linear equations, Sequence and series, Approximation by Taylor series expansion, Approximating limits and derivatives, Numerical integration.

Course Contents: Practical (Laboratory Works) [75 Lecture Hrs]

This course requires a lot of programming practices. Each topic must be followed by a practical session. Practical sessions for each unit should be conducted and should include writing programs for mathematical problems as much as possible. The laboratory sessions include the following.

For Unit 1: [12 Lecture Hrs]

Familiarize with computer system; Familiarize with C-programming language, Integrated Development Environment (IDE), Write, compile and run simple C-programs, Write the programs that include the usages of input-output functions with formatting, Write programs using arithmetic expressions and operators, Write programs to illustrate type conversion.

For Unit 2: [12 Lecture Hrs]

Write the programs that include the use of keywords, operators, escape sequence characters, Write programs that illustrate the usages of the basic data types, Write the programs that include the usages of input-output functions with formatting, Write programs to solve some mathematical expressions using arithmetic operators, Write the programs that reflect the usages of different types of operators, Write programs to illustrate type conversion.

For Unit 3: [18 Lecture Hrs]

Write programs using *if-else* statements, Write programs to illustrate looping constructs using *while*, *do-while* and *for*, Write programs to show the use of *break*, *continue* and *goto* statements, Write programs using *switch* statement.

For Unit 4: [15 Lecture Hrs]

Write programs using C-library functions, Write programs using user-defined functions to solve different mathematical problems including the functions having certain return types and recursive functions. Write programs for realizing user defined arrays.

For Unit 5: [18 Lecture Hrs]

Write programs for searching and sorting by using simple algorithms, Write programs using arrays for matrix operations, Write programs to solve system of linear equations, polynomial equations, and non-linear equations, Write programs to generate various sequences, Write programs for approximations using Taylor series, Write programs to evaluate definite integrals.

Text/Reference Books:

1. Y. P. Kanetkar: *Let Us C*. BPB publications, 2004.
2. B. S. Gottefried: *Theory and Problems of Programming with C*, Mc-Graw Hill, New York, 1996
3. E. Balagurusamy: *Programming in ANSI C (4E)*, Tata Mc Graw Hill, 1989.

Evaluation:

There will be a final examination of 70 marks (Theory: 35 marks, Practical: 35 marks) and internal examination(s) of 30 marks. The candidate must pass in theory part and practical (laboratory) part of the final examination respectively and internal (Theory and Practical) examination separately.

The duration of the final examination of the theory part (35 marks) will be of one hour and 30 minutes. The examination for the practical (laboratory) part of 35 marks will be conducted by the concerned department of mathematics along with external examiner(s) and the marks will be submitted to Tribhuvan University Office of the Controller of Examination, Balkhu.

Marks allocation for the final practical examination:

- Laboratory examination: 20 marks
- Quiz (objective type questions): 5 marks
- Lab record file: 5 marks
- Viva-voce: 5 marks

The internal examination of 30 marks will be conducted by the department of mathematics of the related campus and the marks will be submitted to Tribhuvan University Office of the Controller of Examination, Balkhu.

Marks allocation for the internal examination:

- Theory examinations: 10 marks
- Laboratory examination: 10 marks
- Presentations: 3 marks
- Assignments: 2 marks
- Quiz (objective questions): 2 marks
- Viva-voce: 3 marks

There will be internal examination (Theory written exam and Quiz) of 12 marks for the period of one hour.

8 Math 426 Modern Algebra

TRIBHUVAN UNIVERSITY
Faculty of Humanities and Social Sciences

Course Title: Modern Algebra (Compulsory) **Full Marks:** 100
Course No.: Math 426 **Pass Mark:** 40
Level: B. A. **Year:** IV
Nature of Course: Theory **Periods:** 9 Lecture hours/Week

Course Objectives: This course is designed for the fourth year of Four Years B. A. program as a compulsory subject in mathematics. The main objectives of this course are to enable the students to develop in-depth knowledge and good theoretical background in algebra to take up higher studies, to sustain interest and enjoyment of algebra and its applications in various branches of mathematics, to get associated with teaching mathematics with strong contents, and be familiar with recent trends in the field of algebra.

Course Contents:

Unit 1. Groups and Subgroups [13 Lecture Hrs]
Binary operations, Isomorphic binary structures, Groups, Subgroups, Cyclic Groups.

Unit 2. Permutations, Cosets, and Direct Products [18 Lecture Hrs]
Groups of permutations, Orbits, Cycles, Alternating groups, Cosets, Theorem of Lagrange's, Normal subgroups, Direct products

Unit 3. Homomorphism and Factor Groups [18 Lecture Hrs.]
Homomorphisms, Factor groups, Factor group computations.

Unit 4. Group Theory Continued [13 Lecture Hrs]
Center of a group, Simple groups, Isomorphism theorem.

Unit 5. Rings and Fields [13 Lecture Hrs]
Rings, Integral domains, Fermat's and Euler's theorems, Rings of polynomials, Field, The field of quotients of an integral domain, Factorization of polynomials over a field.

Unit 6. Ideals and Factor Rings [18 Lecture Hrs]
Homomorphisms and factor rings, Prime and maximal ideals.

Unit 7. Extension Fields [13 Lecture Hrs]
Introduction to extension fields, Algebraic extensions.

Unit 8. Factorization [13 Lecture Hrs]
Principal ideal domain, Unique factorization domains, Euclidean domains, Gaussian integers.

Unit 9. Theory of Polynomial Equations [18 Lecture Hrs]
Polynomial over an integral domain, Division algorithm, Division of a polynomial, Zeros of a polynomial, Rolles theorem (no proof), Properties of equations, Descartes rule of signs, Relations between roots and coefficients, Application of the relations to the solution of an equation, Symmetric function of roots, Transformation of equations, Transformation in general, Multiple roots, Sum of the power of roots, Reciprocal equations, Binomial equation.

Unit 10. Cubic and Biquadratic Equations [13 Lecture Hrs]
Algebraic solution, Algebraic solution of the cubic, Nature of roots of cubic, Equation of square difference of cubic, Nature of roots from Cardans solution and application to the numerical examples, Solution by symmetric functions of roots, Solution of the biquadratic and the radical.

Text/Reference Books:

1. J. B. Fraleigh: *A First Course in Abstract Algebra*, Seventh Edition, Pearson.

2. T. P. Nepal and T. B. Budhathoki: *A Textbook of Modern Algebra with Theory of Equations*, Heritage Publication and Distributors Pvt. Ltd. Kathmandu.

3. R. M. Shrestha and S. Bajracharya: *Linear Algebra, Groups, Rings & Theory of Equations*, Sukunda Pustak Bhavan, Kathmandu.

4. I. N. Herstein: *Topics in Algebra*, Vikas Publication, India.

5. A. R. Vasishtha: *Modern Algebra*, Krishna Prakashan Mandir, Meerut.

Evaluation:

There will be a final examination of 70 marks for the period of three hours. The internal examination of 30 marks will be conducted by the department of mathematics of related campus and the marks will be submitted to Tribhuvan University Office of the Controller of Examination, Balkhu. A candidate must pass the internal and the final examinations separately.

Marks allocation for the internal examination:

- Written examinations: 20 marks (1 hour)
- A student or a group of students with presentation: 5 marks
- Assignments with attendance: 5 marks

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9 Math 427 Mathematical Analysis

TRIBHUVAN UNIVERSITY
Faculty of Humanities and Social Sciences

Course Title: Mathematical Analysis (Compulsory) **Full Marks:** 100
Course No.: Math 427 **Pass Mark:** 40
Level: B. A. **Year:** IV
Nature of Course: Theory **Periods:** 9 Lecture hours/Week

Course Objectives: This course is designed for the fourth year of Four years B. A. Program as a compulsory subject in mathematics. The main aim of this course is to provide advanced knowledge of mathematical analysis. The general objectives of this course are

- to develop theoretical knowledge and analytical skills in the emerging areas of mathematics.
- to raise interest of students in the field of analytical world so that they can take up any course easily in modern mathematics.
- to acquire and develop skills in the use and understanding of mathematical language, especially in mathematical symbols, terms, statements, formulae, definitions and logic.
- to construct solutions, proofs, examples and counter examples with own independent efforts.
- to prepare a sound base for higher studies in pure and applied mathematics.

Course Contents:

Unit 1. Euclidean Spaces and Metric Spaces [18 Lecture Hrs]
Set $\mathbb{R}^n$, Algebraic and metric structure of $\mathbb{R}^n$ and their properties, Point set topology in $\mathbb{R}^n$, Bolzano-Weierstrass theorem (without proof for $n > 1$), Cantor intersection theorem, Metric spaces, Point set topology in metric spaces.

Unit 2. Covering Theorems and Compactness [13 Lecture Hrs]
Lindelöf covering theorem, Heine-Borel covering theorem, Compactness in $\mathbb{R}^n$, Compactness in metric spaces.

Unit 3. Limits and Continuity [18 Lecture Hrs]
Convergent sequences in a metric space, Cauchy sequence, Complete metric spaces, Sequences and Compactness, Bolzano-Weierstrass theorem for sequences, Limit of a function and properties, Continuous functions and properties, Continuity and inverse images, Functions continuous on compact sets, Bolzano's theorem and intermediate value theorem, Uniform continuity, Uniform continuity and compact sets.

Unit 4. Functions of Bounded Variation [13 Lecture Hrs.]
Properties of monotonic functions, functions of bounded variation, Total variation, Additive property of total variation, Total variation on $[a, x]$ as a function of x, Functions of bounded variation expressed as the difference of increasing functions, Continuous function of bounded variation.

Unit 5. Riemann-Stieltjes Integration [18 Lecture Hrs]
Riemann-Stieltjes integrals, Linear properties, Integration by parts, Change of variable, Reduction to a Riemann integral, Increasing integrators, Upper and lower integrals, Riemann's condition, Comparison theorems, Necessary and sufficient conditions for existence of Riemann-Stieltjes integrals, Mean value theorem, Integral as a function of the interval, Second fundamental theorem, Second mean value theorem.

Unit 6. Multivariable Differentiation [13 Lecture Hrs]

Linear operator and its matrix representation, Partial Derivatives, Directional derivatives, Total derivatives, Jacobian matrix, Mean value theorem, Higher order partial derivatives, Equality of mixed partial derivatives.

Unit 7. Sequences and Series of Functions [13 Lecture Hrs]

Sequences of Functions: Point-wise convergence, Uniform convergence, Criterion for non-uniform convergence, Cauchy condition for uniform convergence, Uniform convergence and continuity.
Series of Functions: Uniform convergence of series of functions, Cauchy condition, Weierstrass M-test, Dirichlet's test, and Abel's test for uniform convergence.

Unit 8. Improper Integrals [18 Lecture Hrs]

Classification of improper integrals, Convergence and divergence of improper integrals, Application of fundamental theorem of calculus, Simple properties, Conditions and tests for convergence, Absolute convergence, Abel's test and Dirichlet's test.

Unit 9. Complex Numbers [13 Lecture Hrs]

Algebraic and Geometric properties of complex numbers, Polar coordinates and Euler's formula, Products and quotients in exponential form, Roots of complex numbers, Regions in the complex plane, Complex functions, Complex functions as mappings.

Unit 10. Analytic Functions [13 Lecture Hrs]

Limits and continuity, Differentiability, Cauchy-Riemann equations, Sufficient conditions for differentiability, Analytic functions, Harmonic functions.

Text/Reference Books:

1. T. M. Apostol: *Mathematical Analysis*, 2nd edition, Narosa Publishing House, India.
2. D. V. Widder: *Advanced Calculus*, 2nd edition, Dover Publications.
3. J. W. Brown and R. V. Churchill: *Complex Variables and Applications*, 8th edition, McGraw-Hill. Inc.
4. N. P. Pahari: *A Textbook of Mathematical Analysis*, Sukunda Pustak Bhawan, Kathmandu.
5. S. Ponnusamy: *Foundations of Mathematical Analysis*, Springer.

Evaluation:

There will be a final examination of 70 marks for the period of three hours. The internal examination of 30 marks will be conducted by the department of mathematics of related campus and the marks will be submitted to Tribhuvan University Office of the Controller of Examination, Balkhu. A candidate must pass the internal and the final examinations separately.

Marks allocation for the internal examination:

- Written examinations: 20 marks (1 hour)
- A student or a group of students with presentation: 5 marks
- Assignments with attendance: 5 marks

10 Math 428 Project Work

TRIBHUVAN UNIVERSITY
Faculty of Humanities and Social Sciences

Course Title: Project Work (Elective) **Full Marks:** 100
Course No.: Math 428 **Pass Marks:** 40
Level: B. A. **Year:** IV
Nature of Course: Theory (Project writing)

Course Objectives: This course is designed for the fourth year of Four Years B. A. program as an elective subject in mathematics for the interested students who meet the prescribed criteria. This course offers students to learn basics of mathematical research. After the completion of this course, students will be able to

- deeply investigate and study mathematical theory and problems through various levels.
- present their findings effectively and systematically.
- determine an area of interest.
- improve their technical skills.
- learn to balance collaborative and individual work.
- understand the research process.
- develop skills in the interpretation of results.
- analyze data.
- integrate theory and practice.

Guidelines: It is expected that a standard project in mathematics should be organized, properly documented, carefully edited, logical, imaginative, and accurate. Some suggestive guidelines are listed below.

1. Students are required to identify the mathematical problems of their field of interest in the project work through literature review and the problem should be addressed by them.
2. A student or a group of students can carry out project work only if a faculty agrees to supervise student(s) to carry out research activities.
3. The nature of a project work in mathematics can be theoretical, computational or applied type. In any of the cases, students are supposed to critically review literature of the area and identify the problem specifically.
4. Students are required to prepare a proposal of the project and submit it to the department within the first three months of the commencement of the fourth year. The general format of the proposal should like this:
   (a) Background/Introduction
   (b) Literature Review
   (c) Motivation/ Objectives
   (d) Methodology
   (e) Anticipated Outcomes
   (f) References
   (Format will be provided in the detailed syllabus)

5. The format of the project work will be provided in the detailed syllabus.
6. The eligibility criteria for the students, supervisors, co-supervisors will be provided in the detailed syllabus.
7. Additional fee for the project and remuneration for the supervisor will be decided by the concerned university campus in coordination with the Dean's office.

Reference Books:

1. C. R. Kothari: *Research Methodology; Methods and Techniques*, Second Edition, New Age International Publishers.
2. S. B. Mishra and S. Alok: *Handbook of Research Methodology*, Educreation Publishing.

Evaluation: The project work submitted to the research committee after the approval of the supervisor will be reviewed. After the approval of subject committee, student(s) present the project work. The evaluation scheme is outlined below.

- Introduction of the Topic: 10%
- Presentation: 15%
- Organization: 10%
- Figures/plots/tables: 5%
- Content: 60%

The breakdown of the marks for the content (60%) is:

1. Originality and Creativity: 15%
2. Literature Review: 10%
3. In-depth Research: 15%
4. Analysis and Logical Argument/Presentation: 15%
5. Conclusion / Findings: 5%

The final presentation/viva examination should be held within a couple of months of the fourth year final examination and the marks will be submitted to Tribhuvan University Office of the Controller of Examination, Balkhu.

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11 Math 429 Mathematical Economics

TRIBHUVAN UNIVERSITY
Faculty of Humanities and Social Sciences

Course Title: Mathematical Economics (Elective) **Full Marks:** 100
Course No.: Math 429 **Pass Mark:** 40
Level: B. A. **Year:** IV
Nature of Course: Theory **Periods:** 9 Lecture hours/Week

Course Objectives: This course is designed for the interested students of the fourth year of Four Years B. A. Program as an elective subject in mathematics. It aims to introduce mathematical modes of real-life problems related to economics that exist in the society and industry. After the completion of this course, the students will be able to understand mathematical modeling techniques of different economic problems and apply mathematical tools to solve them. The focus has been given to the equilibrium, cooperative-static and dynamic analysis, and optimization techniques.

Course Contents:

Unit 1. Economic Models and Equilibrium Analysis [18 Lecture Hrs]
Nature of mathematical economics, Economic models, Equilibrium analysis, Market equilibrium, Linear, non-linear and general models, Solution by elimination of variables, algebraic method and graphical method, General equation system, Applications to national-income analysis, Finite Markov chains, Applications to market and income models, Limitations of static analysis.

Unit 2. Application of Derivatives in Economics [13 Lecture Hrs]
Concept and use of derivatives in comparative statics, Modeling of marginal and average revenue functions, Relationships between the cost functions, Gradient vector of the production function, Applications to comparative static analysis, Geometric interpretations in economic terms.

Unit 3. Total Differentials and Implicit Functions [13 Lecture Hrs]
Meaning of total differentials and implicit functions in economic terms, Comparative statics of general function models, National income model and its extension, Application to economical problems, Limitations of comparative statics.

Unit 4. Optimality Conditions [13 Lecture Hrs]
Equilibrium analysis, Meaning of optimum and extreme values, Relative and absolute optimality, First, second and higher derivative tests, Necessary and sufficient conditions, Conditions for profit maximization, Marginal revenue curve, Geometric interpretations.

Unit 5. Exponential and Logarithmic Functions [13 Lecture Hrs]
Economic applications, Computation of interest, The growth function and its variants, Optimal timing.

Unit 6. Optimization Methods [18 Lecture Hrs]
Differential versions, First and second order conditions, Extreme values of functions of two variables, First and second order conditions, Quadratic forms and objective functions with more than two variables, Conditions to convexity and concavity, Their geometry.

Unit 7. Constrained Optimization [18 Lecture Hrs]
Optimization with equality constraints, Effects of a constraint, Stationary values, Lagrange-multiplier method and an interpretation, Total differential approach, Second order total differentials, Second order conditions, The Bordered Hessian, Multivariable and multiconstraints.

Unit 8. Economic Applications [13 Lecture Hrs]
Utility maximization and consumer demand, First order and second order conditions, Homogeneous functions, Linear homogeneity, Cobb-Douglas production function, Economic interpretations.

Unit 9. Nonlinear Programming [18 Lecture Hrs]

Effect of non-negativity restrictions and inequality constraints, Nonlinear utility function maximization, KKT-conditions, The inequalities at boundary points, Meaning of constraint qualifications, Sufficient conditions to NLP.

Unit 10. Dynamic Analysis [13 Lecture Hrs]

Dynamics and integration, The growth model, Dynamics of market price, The qualitative-graphic approach, The time path, The market model with price expectations.

Text/Reference Books:

1. A. C. Chiang, K. Wainwright: *Fundamental Methods of Mathematical Economics*, McGraw Hill Publishers.

2. M. Hoy, J. Livernois, C. McKenna, R. Rees, T. Stengos: *Mathematics for Economics*, Third edition, PHI Learning Private Limited.

Evaluation:

There will be a final examination of 70 marks for the period of three hours. The internal examination of 30 marks will be conducted by the department of mathematics of related campus and the marks will be submitted to Tribhuvan University Office of the Controller of Examination, Balkhu. A candidate must pass the internal and the final examinations separately.

Marks allocation for the internal examination:

- Written examinations: 20 marks (1 hour)
- A student or a group of students with presentation: 5 marks
- Assignments with attendance: 5 marks