Tripura University
(A Central University)

Course Structure of MATHEMATICS (UG Programme)
As per NEP-2020 under Tripura University

MATHEMATICS MINOR

Year	Semester	Paper	Course Content	Credit	Marks
1st	I	MT101M Theory	Foundations and Algebra	4	100 (IA=40 + ESE=60)
	II	MT201M Theory	Linear Algebra and Geometry	4	100 (IA=40 + ESE=60)
2nd	III	MT301M Theory	Calculus	4	100 (IA=40 + ESE=60)
	IV	MT401M Theory	Differential equations and Linear programming problems	4	100 (IA=40 + ESE=60)
3rd	V	MT501M Theory	Real Analysis and Numerical Analysis	4	100 (IA=40 + ESE=60)
	VI	MT601M Theory	Probability, Statistics and Theory of Integration	4	100 (IA=40 + ESE=60)
4th	VII	MT701M Theory	Mechanics, Number theory and Complex Analysis	4	100 (IA=40 + ESE=60)
	VIII	MT801M Theory+ Practical	Python programming with practical	Th -2 P-2	Th-60 (IA=24+ESE=36); P-40 (IA=16+ESE=24)

DETAILED COURSE CONTENT OF MATHEMATICS MINOR

First Year

SEMESTER I

PAPER 1

MT101M: Foundations and Algebra

Total Mark = 100 (IA = 40 + ESE = 60) Credit = 04

Unit-1

Statements, quantifiers, negation, compound statements (conjunction, disjunction, conditional and bi-conditional), contra-positive statement, proofs in Mathematics.

Brief review of sets, finite, countable and arbitrary union and intersection of sets; power set, cartesian product.

Equivalence relations, equivalence classes, partition, fundamental theorem of equivalence relation.

Functions, injection, surjection and bijection; image and pre-image of set under function, composition of functions, invertible functions.

Unit-2

Inequalities involving arithmetic, geometric, and harmonic means, theorem on weighted means, Cauchy-Schwarz inequality, m-th power theorem, Weierstrass inequality and their applications.

Polynomials, The remainder and factor theorems, Synthetic division, Factored form of a polynomial, G.C.D. of polynomials, Fundamental theorem of algebra (statement only), Relations between the roots and the coefficients of polynomial equations, Imaginary roots, Integral and rational roots, irrational roots.

Transformation of equations, reciprocal equations, Descarte's rule of sign. Elementary theorems on the roots of an equations including Cardan'smethod of solution of cubics, Ferrari's method and Descarte's method of solution of quartics.

Unit-3

Binary operations, groupoid, semigroup, monoid, Groups, Abelian groups, Examples of groups: viz matrix groups, general linear and special linear groups, groups of integers modulo n, group of units modulo n, and other examples of groups. Elementary properties of groups, subgroups, necessary and sufficient condition for subgroups, intersection, union and product of subgroups,

centre of agroup, centralizer of an element, subgroup generated by an element.

Unit-4

Cyclic groups, examples and various properties, generators of a cyclic group, Fundamental theorem of finite cyclic groups and it's applications; order of a group and order of an element and their properties,related theorems.

Rings, commutative rings, rings with unity, divisors of zero, integral domains, division rings, fields. Definition,examples, simple properties following from the definition. Subring, subfield, necessary and sufficient conditions for these, examples; characteristic of a ring.

Suggested books:

1. Kumar A, Kumaresan S and Sarma B. K.: A foundation course in Mathematics; Narosa publications
2. Mapa S.K.: Classical Algebra; Levant publications
3. Khan R.M.: Algebra; NCBA
4. Gallian J.A.: Contemporary Abstract Algebra, Narosa Publications.

SEMESTER II

PAPER 2

MT201M: Linear Algebra and Geometry

Total Mark = 100 (IA = 40 + ESE = 60) Credit = 04

Unit-1

Matrices and System of linear equations(homogeneous and non-homogeneous), Matrix operations, Symmetric, skew-symmetric, orthogonal, Hermitian, skew- Hermitian and unitary matrices, Determinant of a square matrix, The inverse of a square matrix (upto order 3). Solution of system of linear equations by matrix method (upto order 3). Transpose of matrices. Elementary

operations and elementary matrices, Reduced Row-Echelon form and its relevance to system of linear systems. The rank of a matrix and its properties, applications of rank of a matrix in checking the consistency of a system of linear equations and solving the system if it is consistent.

Unit-2

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear dependence and independence, basis and dimension. Sums, direct sums of subspaces.

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation. Algebra of linear transformations, isomorphisms, isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.

Eigen spaces of a linear operator, Characteristic polynomial, minimal polynomial for a linear operator. Cayley-Hamilton theorem.

Unit-3

Transformation of rectangular axes, translation, rotation and their combinations, theory of invariants. General equation of second degree in two variables, reduction into canonical form, lengths and position of the axes.

Pair of straight lines: Condition that the general equation of second degree in two variables may represent a pair of straight lines. Point of intersection of two intersecting straight lines, angle between two lines given by $ax^2+2hxy+by^2=0$, equation of bisectors of the anglebetween the pair of straight lines, equation of two lines joining the origin to the point in which two curves meet.

Polar coordinates, polar equation of straight lines, circles and conic referred to a focus as pole, equation of chord, tangent and normal.

Unit-4

Planes: Distance of a point from a plane, Angle between two planes, pair of planes, Bisectors of angles between two planes; Straight lines: Equations of straight lines, Distance of a point from a straight line, Distance between two straight lines, Distance between a straight line and a plane; Spheres: Different forms, Intersection of two spheres, Orthogonal intersection, section of a sphere by a plane, great circle, sphere through a given circle, Tangents and normal, Radical plane, Radical line, Coaxial system of spheres, Pole, Polar and Conjugacy.

Classification of quadric surfaces, Cone, Cylinder, Central conicoids, Tangent plane, Normal, Polar planes, and Polar lines.

Suggested books:

1. Mapa S.K.: Higher Algebra (Abstract and Linear); Levant publications
2. Khan R.M.: Algebra; NCBA
3. Sengupta S.B.: Coordinate geometry and vector analysis
4. Khan R.M.: Analytical geometry of two and three dimensions and vector analysis; NCBA
5. Loney S.L.: The elements of coordinate geometry; Arihant publications.
6. Fenn R: Geometry; Springer publications.

SECOND YEAR

SEMESTER III

PAPER 3

MT301M: Calculus

Total Mark = 100 (IA = 40 + ESE = 60) Credit = 04

Unit-1

Limits of functions (epsilon − δ approach), continuity, examples of continuous functions, intermediate value theorem, Differentiability and its geometrical interpretation, higher order derivatives, Leibniz rule and its applications. Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem and their geometrical interpretations, Darboux's theorem. Indeterminate forms, L'Hospital's rule.

Unit-2

Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's seriesexpansions of exponential and trigonometric functions.

Convexity and point of inflexion; Tangent and Normal; Curvature of plane curves; Asymptotes; Envelopes; Singular points.

Unit-3

Functions of several variables, limit and continuity of functions of two variables, repeated limits, partial differentiation, chain rule, change of variables, total derivative, equality of mixed partial derivatives, Euler's theorem for homogeneous functions of two and three variables, converse of Euler's theorem, Jacobian, functional dependence.

Criteria for Maxima/ Minima/ Saddle points, method of Lagrange multipliers, constrained optimization problems.

Unit-4

Double integration over rectangular and nonrectangular regions, Double integrals in polar coordinates, Triple integral over a parallelepiped and solid regions, Volume by triple integrals, Line integrals, Green's theorem, Area as a line integral, Surface integrals, Stokes' theorem, The Gauss divergence theorem.

Suggested books:

1. Maity and Ghosh: Analysis (Differential Calculus); Central publications.
2. Shanti Narayan and Mittal P.K.: Differential Calculus, S. Chand publications.
3. Pundir S.K.: Mathematical Analysis; CBS publishers.
4. Klymchuk S: Counterexamples in Calculus; Mathematical Association of America.
5. Marsden, Tromba and Weinstein: Basic Multivariable Calculus; Springer.

SEMESTER IV

PAPER 4

MT401M: Differential equations and Linear programming problems

Total Mark = 100 (IA = 40 + ESE = 60) Credit = 04

Unit-1

Significance of ordinary differential equation. Geometrical and physical consideration. Formation of differential equation by elimination of arbitrary constant. Meaning of the solution of ordinary differential equation. Concept of linear and non-linear differential equations. Order and degree of an ordinary differential equation, Equations of first order and first degree : Statement of existence theorem. Separable, Homogeneous and Exact equation. Condition of exactness, Integrating factor. Rules of finding integrating factor, (statement of relevant results only),Equations reducible to first order linear equations.

Equations of first order but not of first degree, Clairaut's equation. Singular solution, Applications : Geometric applications, Orthogonal trajectories. Higher order linear equations with constant coefficients : Complementary function, Particular Integral, Symbolic operator D.

Method of undetermined co-efficients, Method of variation of parameters. Euler's homogeneous equation and Reduction to an equation of constant coefficients.

Unit-2

Exact differential equations of higher order, method of solution, Non-linear exact equations, linear equations of some special forms, Second order linear equations with variable coefficients, Reduction of order when one solution the homogeneous part is known. Complete solution. Method of variation of parameters.

Reduction to Normal form. Change of independent variable. Operational Factors. Simple eigenvalue problems. Simultaneous linear differential equations.

Unit-3

Formulation**,** Canonical and standard forms, Graphical method; Convex and polyhedral sets, Hyperplanes, Extreme points; Basic solutions, Basic Feasible Solutions, Reduction of feasible solution to basic feasible solution, Correspondence between basic feasible solutions and extreme points; Slack and surplus variables, Standard form of an LPP.

Optimality criterion, Improving a basic feasible solution, Unboundedness, Unique and alternate optimal solutions; Simplex algorithm and its tableau format; Artificial variables, Two-phase method, Big-*M* method.

Unit-4

Formulation of the dual problem, primal-dual relationships, Duality theorems, Complimentary slackness theorem, Economic interpretation of the dual, Dual-simplex method.

Applications:

*Transportation Problem***:** Definition and formulation, Methods of finding initial basic feasible solutions: Northwest-corner rule, Row minima, Column minima, matrix minima, Least- cost method, Vogel approximation method; Unbalanced transportation problems, Optimality tests for transportation problems and MODI method for obtaining optimal solution, degeneracy in transportation problems;

*Assignment Problem***:** Mathematical formulation and Hungarian method.

Suggested books:

1. Ross S.L.: Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
2. Ahsan Z: Differential Equations & their applications, Prentice Hall of India.
3. Raisinghania M.D.: Ordinary Differential Equations; S.Chand and Sons.
4. Raisinghania M.D.: Advanced Differential Equations; S. Chand and Sons.
5. Paul R. Thie & Gerard E. Keough (2014). *An Introduction to Linear Programming and Game Theory* (3rd edition). Wiley India Pvt. Ltd.
6. Frederick S. Hillier & Gerald J. Lieberman (2015). *Introduction to Operations Research* (10th edition). McGraw-Hill Education.
7. J.G. Chakraborty and P.R.Ghosh; Linear Programming and Game theory; MoulikLibrary.
8. P.M.Karak; Linear Programming and theory of games; New Central Book Agency

THIRD YEAR

SEMESTER V

PAPER 5

MT501M: Real Analysis and Numerical Analysis

Total Mark = 100 (IA = 40 + ESE = 60) Credit = 04

Unit-1

Review of algebraic and order properties of R, neighborhood of a point in R, idea of countable sets, uncountable sets and uncountability of R. Bounded above sets, bounded below sets, bounded sets, unbounded sets, supremum (l.u.b) and infimum (g.l.b), the completeness property of R, the Archimedean property, density of rational (and irrational) numbers in R, intervals in R. Limit points of a set, isolated points, derived sets, open and closed sets, closure of a set, Bolzano-Weierstrass theorem for sets.

Unit-2

Sequences, bounded sequence, convergent sequence, limit of a sequence, limit theorems,monotone sequences, monotone convergence theorem.

Subsequences, divergence criteria, monotone subsequence theorem (statement only), Bolzano Weierstrass theorem for sequences, Cauchy sequence, Cauchy's convergence criterion

Infinite series, convergence and divergence of infinite series, Cauchy criterion, tests for convergence: comparison test, limit comparison test, ratio test, Cauchy's nth root test, integral test, alternating series, Leibniz test, absolute and conditional convergence.

Unit-3

Approximate numbers, significant figures, errors: relative, absolute and percentage. rounding off, truncation. Definition and properties of finite difference operators, shift operator

Interpolation: Newton's forward, backward formulae, Lagrange's formula. related problems. Differentiation formula based on Newton forward and backward formula

Numerical integration : General quadrature formula - Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule.

Unit-4

Numerical solution of ordinary differential equations : Taylor series method, Picard's method, Euler's method, modified Euler's method.

Transcendental and polynomial equations : bisection method, regula-falsi method, secant method, Newton-Raphson method, iteration method, rates of convergence of these methods, related problems.

System of linear algebraic equations: Gaussian Elimination and Gauss -Jordan methods including matrix inversion, Gauss- Seidel method and their convergence, related problems.

Suggested books:

1. Bartle R.G.and Sherbert D.R., Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Kumar A and Kumaresan S: A basic course in Real Analysis, CRC Press.
3. Goldberg R.R.: Real Analysis.
4. Mukherjee Kalyan: Numerical Analysis; NCBA.

5. Mollah S.A.; Numerical Analysis and Computational procedures; Books and Allied Pvt. Ltd.

6. Scarborough J.B.; Numerical mathematical analysis; Oxford University Press.

7. Rao G.S. ; Numerical Analysis; New Age International.

8. Chakraborty and Ghosh; Numerical Analysis; U.N. Dhur and sons.

SEMESTER VI

PAPER 6

MT601M: Probability, Statistics and Theory of Integration

Total Mark = 100 (IA = 40 + ESE = 60) Credit = 04

Unit-1

Brief review of Measures of Central Tendency. Measures of Dispersion: Definition, properties (without proof) and calculation of Range, Quartile Deviation, Mean Deviation, Standard Deviation and coefficient of variation. Definition and calculation of moments, skewness and kurtosis.

Correlation and Regression: Concept of bivariate frequency distribution, marginal frequency distribution and conditional frequency distribution. Pearson's correlation coefficient: Definition, properties and calculation. Regression: Definition and different properties, fitting of regression lines by method of least squares. Curve fitting: Second degree polynomial and exponential.

Unit-2

Probability :Different terminology regarding probability, Classical definition, Statistical definition and Axiomatic definition of probability. Addition theorem and multiplication theorem of probability.

Probability Distribution: One dimensional random variable and two dimensional random variable (Definition only), univariate and bivariate probability distribution, cumulative distribution function: definition and properties. Mathematical expectation, addition andmultiplication theorem of expectation, moment generating function and characteristic function. Marginal and conditional probability distribution. Regression curve.

Uniform, Bernoulli, Binomial, Poisson and Normal distribution.

Unit-3

Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions; Riemann integrability of monotone and continuous functions

Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorems of Calculus, Mean value theorems, Riemann integrability of composition of Riemann integrablefunctions.

Unit-4

Reduction formulae, derivations and illustrations of reduction formulae of the type sinnx, cosnx, tannx, secnx, log x , sinmxcosnx etc. Working knowledge of Beta and Gamma integrals (assuming their convergence and other properties),

Improper integrals and their convergence, Beta and Gamma functions, related problems.

Suggested books:

1. S.C. Gupta and V.K. Kapoor: *Fundamentals of Mathematical Statistics*, Sultan Chand andSons.
2. Sheldon Ross: *Introduction to Probability Models*, 9th Ed., Academic Press, IndianReprint, 2007.
3. Medhi, J.: *Statistical Methods: An introductory Text*, (New Age International (P) Ltd, 2000).
4. Mapa S.K.: Real Analysis; Levant Publications
5. Maity and Ghosh: Analysis (Integral Calculus); NCBA
6. Bartle R.G. and Sherbert D.R.: Introduction to Real Analysis, 3rd Ed., John Wiley andSons (Asia) Pvt. Ltd., Singapore, 2002.

FOURTH YEAR

SEMESTER VII

PAPER - 7

MT701M: Mechanics, Number theory and Complex Analysis

Total Mark = 100 (IA = 40 + ESE = 60) Credit = 04

Unit-1

Expression for velocity and acceleration of particle moving in a straight line and in a planecurve.

Rectilinear motion of a particle under attractive force.

Simple Harmonic Motion, damped vibrations, forced vibration, damped forced oscillations Tangent and normal acceleration. Velocity and acceleration along radial and transverse directions.

Unit-2

Central orbits, central forces, motion of a particle under central force. Differential equation inpolar and pedal coordinates, velocity under central force. Apse, apsidal distance and apsidal angle. Motion in resisting medium. Areal velocity, Characteristics of central orbits, Kepler's laws of planetary motion.

Unit-3

The division algorithm, The greatest common divisor (g.c.d.) of two integers a and b. Relatively prime integers. The equation ax+ by = c has integral solution iff (a,b) divides c. (a , b, c are integers). Prime numbers. Euclid's first theorem: If some prime p divides ab, then p divides either a or b. Euclid's second theorem: There are infinitely many prime integers. Unique factorization theorem. Statement Chinese Remainder Theorem and simple problems. Euler ϕ function.

Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Fermat's Little theorem, Wilson's theorem.

Unit-4

Polar representation of complex numbers, De Moivre's theorem for rational indices, related problems, expansions of sin $n\theta$, cos$n\theta$, sinθ, cosθ, trigonometric, exponential and logarithmic functions of complex arguments, Gregory's series.

Algebra of complex numbers, polar representation of complex numbers, geometrical interpretation of argument and modulus of complex numbers , complex equations of straight lines, circles. Limits, continuity of functions of complex variable, regions in the complex plane.

Derivatives, differentiation formulae, Cauchy-Riemann equations, sufficient conditions for differentiability, analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function.

Suggested books:

1. Datta N. and Jana R.N.: Dynamics of a Particle.
2. Chakraborty and Ghosh: Dynamics of Particle and Rigid bodies; U N Dhur and Sons.
3. Loney, S. L., Elements of Statics & Dynamics, Part I (Maxford Books, 2003).
4. Rao, S. Engineering Mechanics - Statics and Dynamics (Pearson Education, 2008).
5. Elementary Number Theory, David. M. Burton, MacGrawHill.
6. Malik S.B.: Basic Number Theory.
7. Ponnusamy S.: Foundations of Complex Analysis, Narosa Publishers.
8. Spiegel M.R.: Complex Analysis; McGraw Hill Publications.

SEMESTER VIII

PAPER 8

MT801M: Python programming with practical

Group A (Theory)

Total Mark = 60 (IA = 24 + ESE = 36); Credit = 02

Unit-1

Introduction to Python Programming: Features, basic syntax, Writing and executing simple program, Basic Data Types such as numbers, strings, etc Declaring variables, Performing assignments, arithmetic operations, Simple input-output

Sequence Control – Precedence of operators, Type conversion Conditional Statements: if, if-else, nested if –else

Looping: for, while, nested loops.

Unit-2

Control statements: Terminating loops, skipping specific conditionsString Manipulation: declaring strings, string functions Manipulating Collections Lists, Tuples

Dictionaries – Concept of dictionary, techniques to create, update & delete dictionary items. Functions: Defining a function, calling a function, Advantages of functions, types of functions, function parameters, Formal parameters, Actual parameters, anonymous functions, global and local variables

Group B (Practical)

Total Mark = 40 (IA = 16 + ESE = 24); Credit = 02

Unit-1

1. Ascending / Descending order. Finding Largest / smallest.

2. Sum of finite series.

3. Sum of Convergent series.

4. Checking whether a number is prime or not. Generation of prime numbers.

5. Solution of Quadratic equation

6. Mean, variance, correlation coefficient, equation of regression lines.

7. Operations on integers, matrices,

8. Drawing graphs of functions,

9. Generating diagrams of surface areas and volumes under surfaces of revolution.

Unit-2

1. Newton's forward interpolation formula.

2. Newton's Backward interpolation formula.

3. Lagrange interpolation formula.

4. Bisection method.

5. Newton-Raphson method.

6. Regula Falsi method.

7. Trapezoidal Rule.

8. Simpson's 1/3 rule.

Suggested books:

1. Yashavant Kanetkar, Aditya Kanetkar: Let Us Python, 5th Edition, BPB Publications.
2. M. Lutz: Learning Python, 5th Edition, O'Reilly Media(2013).

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