B. Sc. (HONS) in MATHEMATICS
Approved Syllabus (by BoS meeting on 09.5.2012)
Department of Mathematics, Faculty of Science, Banaras Hindu University

Semester –I		
Course Code	**Title**	**Credits**
MTB 101	Calculus – I	3
MTB 102	Geometry	3
	Total	**6**
Semester –II		
MTB 201	Calculus – II	3
MTB 202	Statics & Dynamics	3
MTB AM203	Ancillary-I	2
	Total	**8**
Semester –III		
MTB 301	Algebra	3
MTB 302	Differential Equations	3
	Total	**6**
Semester –IV		
MTB 401	Partial Differential Equations	3
MTB 402	Mathematical Methods	3
MTB AM403	Ancillary-II	2
	Total	**8**
Semester -V		
MTB 501	Mathematical Analysis	3
MTB 502	Abstract Algebra	3
MTB 503	Programming in C	3+1P*
MTB 504	Differential Geometry	3
MTB 505	Mechanics	3
MTB 506	Operations Research	3
	ELECTIVE – I (**Any one** of the following courses, each of 3 credits)	3
MTB 507	Combinatorial Mathematics	
MTB 508	Business Mathematics	
MTB 509	Special Theory of Relativity-I	
MTB 510	Computational Mathematics Lab-I	
MTB 511	Probability	
	Total	**22**
Semester –VI		
MTB 601	Set Theory and Metric Spaces	3
MTB 602	Linear Algebra	3
MTB 603	Numerical Analysis	3+1P*
MTB 604	Discrete Mathematics	3
MTB 605	Vector & Tensor Analysis	3
MTB 606	Complex Analysis	3
	ELECTIVE – II (**Any one** of the following courses, each of 3 credits)	3
MTB 607	Number Theory	
MTB 608	Global Differential Geometry	
MTB 609	Special Theory of Relativity-II	
MTB 610	Computational Mathematics Lab-II	
MTB 611	Dynamical Systems	3
	Total	**22**

*Practical based on the concerned paper.

Semester – I

MTB 101 Calculus-I Credits : 3

Differential Calculus: Sequences and series, Notion of convergence, Limit (ε-δ definition), Continuity, Discontinuity, Properties of continuous functions. Intermediate value theorem. Differentiability, Chain rule of differentiation, Successive differentiation and Leibnitz theorem, Rolle's theorem, Mean value theorems, Taylor's and Maclaurin theorems. Asymptotes, Tracing of plane curves.

Integral Calculus: Definite Integral as the limit of sum.

Recommended Books:

1. Gorakh Prasad, Differential Calculus, Pothishala Pvt. Ltd. Allahabad, 2000.
2. Gorakh Prasad, Integral Calculus, Pothishala Pvt. Ltd. Allahabad, 2000.
3. Gabriel Klambauer, Mathematical Analysis, Marcel Dekkar, New York, 1975.
4. Shanti Narayan, Elements of Real Analysis, S. Chand & Company, New Delhi.

MTB 102 Geometry Credits : 3

Polar equations of a conic, Plane and straight line (using vector method). **Sphere:** Plane section of sphere, equations of circle, equation of tangent plane, Angle of intersection of two sphere. **Cone:** cone and plane through its vertex, Intersections of two cones, Right circular cone. **Cylinder**: Enveloping cylinder, Right circular cylinder. Paraboloids, Central Conicoids and their properties.

Recommended Books:

1. R. J. T. Bell, An Elementary Treatise on Co-ordinate geometry of three dimensions, Macmillan India Ltd., New Delhi, 1994.
2. Shanti Narayan, P.K. Mittal, Analytical Solid Geometry, S. Chand & Company, New Delhi, 2008.
3. M.M. Tripathi, Coordinate Geometry: Polar Coordinates Approach, Narosa Publishing House, New Delhi.

Semester – II

MTB 201 Calculus- II Credits : 3

Functions of two Variables: Limit, Continuity, Differentiability. Partial differentiation, Young's theorem, Schwarz's theorem, Change of variables, Euler's, Jacobian, Taylor's theorem. Maxima and minima. Double and triple integrals, Change of order and change of variables in double integrals, Applications to area, volume and surface area. Dirichlet's theorem.

Recommended Books:

1. Shanti Narayan, A Text Book of Vector Calculus, S. Chand & Company, New Delhi.
2. S. C. Mallik, Mathematical Analysis, Wiley Eastern Ltd, New Delhi.
3. Gabriel Klaumber, Mathematical Analysis, Marcel Dekkar, New York 1975.
4. G. B. Thomas, R. L. Finney & M. D. Weir, Calculus and Analytic Geometry, Pearson Education Ltd, 2003.
5. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley, 1999.

MTB 202 Statics & Dynamics Credits : 3

Statics: Analytic condition of equilibrium for coplanar forces. Equation of the resultant force. Virtual work.

Dynamics: Rotation of a vector in a plane. Velocity and acceleration components in Cartesian, polar and intrinsic systems. Central orbit, Kepler's laws of motion, Rectilinear simple harmonic motion. Vertical motion on circular and cycloidal curves. Motion with respect to linearly moving and rotating plane. Coriolis force and centrifugal force.

Recommended Books:

1. R.S. Verma - A Text Book on Statics, Pothishala Pvt. Ltd., Allahabad.

2. S.L. Loney - An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies, Kalyani Publishers, New Delhi.
3. J.L. Synge & B.A. Griffith - Principles of Mechanics, Tata McGraw-Hill, 1959.
4. M. Ray and G. C. Sharma – A Text Book on Dynamics, S. Chand & Company, New Delhi, 2008

MTB AM203 Ancillary-I **Credits : 2**

Elements of Set Theory: Sets, functions and relations (including equivalence relations).
Matrices and Determinants: Matrices, matrix addition and multiplication. Determinants. Elementary row and column operations, Echelon form, rank of a matrix. Inverse of a matrix. Solution of system of linear equations using matrices and determinants.

Recommended Books:

1. D.T. Finkbeiner, *Introduction to Matrices and Linear transformations*, CBS Publishers, New Delhi, 1986
2. Shanti Narayan, *A Text Book of Matrices,* S. Chand & Co., New Delhi, 2004

Semester –III

MTB 301 Algebra-I **Credits : 3**

Matrix Algebra: Hermitian and Skew-Hermitian Matrices, Adjoint of a Matrix, Elementary operations of matrices. Inverse of a matrix. Rank of a matrix. Application of matrices to the system of linear equations, Consistency of the system.
Algebra: Definition of a group with examples and simple properties, Subgroups, Generation of groups, Cyclic groups, Coset decomposition, Lagrange's theorem and its consequences. Homomorphism and Isomorphism. Permutation groups and Cayley's theorem. Normal subgroups, Quotient group, Fundamental theorem of Homomorphism. Isomorphism theorems for groups.

Recommended Books:

1. I. N. Herstein , Topics in Algebra, Wiley Eastern Ltd, New Delhi, 1975.
2. D.T. Finkbeiner, Introduction to Matrices and Linear transformations, CBS Publishers, New Delhi, 1986.
3. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, First Course in Linear Algebra, Wiley Eastern Ltd., New Delhi, 1983.
4. S. Singh and Q. Zameeruddin, Modern Algebra, Vikas Publication House, India.

MTB 302 Differential Equations **Credits : 3**

Ordinary differential equations of first order, initial and boundary conditions, homogeneous equations, linear equations, Exact differential Equation. First order higher degree equations solvable for x, y, p. Singular solution and envelopes.
Linear differential equations with constant coefficients, homogeneous linear differential equations, linear differential equations of second order with variable coefficients.
Series solutions of differential equations. Bessel and Legendre functions, Rodrigue's formula, Generating functions, Recurrence relations.

Recommended Books:

1. Gorakh Prasad, Integral Calculus, Pothishala Private Ltd. Allahabad,2000.
2. S. Balachandra Rao & H.R. Anuradha, Differential Equations with Applications and Programmes, University Press, Hyderabad, 1996.
3. D.A. Murray, Introductory Course in Differential Equations, Orient Longman , 1967.
4. E. A. Codington, An Introduction to Ordinary Differential Equations, Prentice Hall of India, 1961.
5. B. Rai, D.P. Choudhary & H.I. Freedman, Ordinary Differential Equations, Narosa Publications, New Delhi, 2002.

Semester –IV

MTB 401 Partial Differential Equations Credits : 3

Linear partial differential equations of first order and its classifications, Lagrange's method. Non linear PDE of first order: Charpit's method.

Linear partial differential equation of second and higher order of homogeneous and non homogeneous forms with constant coefficients, Linear partial differential equations reducible to equations with constant coefficents. Second order PDE with variable coefficients, Classifications of second order PDE, Reduction to canonical or normal form. Monge's method. Solution of heat and wave equations in one and two dimensions by method of separation of variables.

Recommended Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Son Inc., New York, 1999.
2. Ian N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill Book Company, 1988.
3. S. B. Rao and H. R. Anuradha, Differential Equations, University Press, 1996.
4. W. T. H. Piaggio, Elementary Treatise on Differential Equations and their applications, CBS Publishers, New Delhi, 1985.

MTB 402 Mathematical Methods Credits : 3

Integral Transforms: Laplace Transformation, Laplace Transforms of derivatives and integrals, shifting theorems, Dirac's delta function, differentiation and integration of transforms, convolution theorem. Integral equations, Application of Laplace transform in solution of ordinary differential equations. Fourier series expansion, Half-range expansions, Fourier integrals

Calculus of Variations: Functionals, Deduction of Euler's equations for functionals of first order and higher order for fixed boundaries. Shortest distance between two non-intersecting curves. Isoperimetric problems. Jacobi and Legendre conditions (applications only).

Recommended Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Son Inc., New York, 1999.
2. N. Kumar, An Elementary Course on Variational Problems in Calculus, Narosa Publications, New Delhi.
3. A. S. Gupta, Text Book on Calculus of Variation, Prentice-Hall of India, New Delhi.
4. S. G. Deo, V Lakshmikanthna and V. Raghavendra, Text Book of Ordinary Differential Equations, Tata McGraw-Hill.
5. F. B. Hilderbrand, Advanced Calculus for Applications, PHI, New Delhi, 1997.
6. B. Rai, D. P. Choudhary, H.I. Freedman, Ordinary Differential Equations, Narosa Publishing House, New Delhi, 2002.

MTB A403 Ancillary-II Credits : 2

Calculus: Continuity and derivative of a function. Finding derivatives (of simple functions only). Maxima and minima.

Definite integrals with some simple applications.

Differential equations (simple types only), their solutions and applications.

Recommended Books:

1. Gorakh Prasad, *Differential Calculus,* Pothishala Pvt. Ltd., Allahabad, 2000
2. Gorakh Prasad, *Integral Calculus,* Pothishala Pvt. Ltd., Allahabad, 2000

Semester –V

MTB 501 Mathematical Analysis Credits : 3

Sequences, Theorems on limits of sequences, Monotone convergence theorem, Cauchy's convergence criterion. Infinite series, series of non-negative terms. Comparison test, Ratio

test, Rabbe's, logarithmic test, De Morgan and Bertrand's tests. Alternating series, Leibnitz's theorem, Cauchy's integral test, Dini-Kummer Test, Root test.
Riemann Integral, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, Mean Value theorems of integral calculus.
Improper integrals and their convergence. Comparison test, Abel's and Dirichlet's test, Integral as a function of a parameter and its applications.

Recommended Books:

1. Shanti Narayan, A Course of Mathematical Analysis. S. Chand & Company, New Delhi.
2. T. M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.
3. R. R. Goldberg, Real Analysis, Oxford & IBH Publishing Company, New Delhi, 1970.
4. S. Lang, Undergraduate Analysis, Springer-Verlag, New York, 1983.
5. P. K. Jain and S. K. Kaushik, An Introduction to Real Analysis, S. Chand & Company, New Delhi, 2000
6. W.Rudin, Principles of Mathematical Analysis, McGraw-Hill, .

MTB 502 Algebra-II Credits : 3

Automorphism and inner automorphism, Automorphism groups and their computations. Normalizer and centre, Group actions, stabilizers and orbits. Finite groups, Commutator subgroups. Rings, Integral Domains and Fields. Ideal and quotient Rings. Ring Homomorphism and basic isomorphism theorems. Prime and maximal ideals. Fields of quotients of an integral domain. Principal ideal domains. Polynomial Rings, Division algorithm. Euclidean Rings, The ring Z[i].

Recommended Books:

1. P. B. Bhatacharya, S. K. Jain and S. R. Nagpal, Basic Abstract Algebra (2^{nd} Edition) Cambridge University Press, Indian Edition, 1977.
2. N. Herstain, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
3. N. Jacobson, Basic Algebra, Vol I & II, W.H. Freeman, 1980 (also published by Hindustan Publishing Company).

MTB 503 Programming in C Credits: 3+1P

C fundamentals. Constants, Variables and Data types, Operators and expression, formatted input and output. Decision makings, Branching and Looping. Arrays. User defined functions. Structures. Pointers. File handling. Programming based on above.

Recommended Books:

1. B. W. Kernighan and D. M. Ritchie, The C Programming Language 2^{nd} Edition, (ANSI features) Prentice Hall, 1989.
2. V. Rajaraman, Programming in C, Prentice Hall of India, 1994.
3. Byron S. Gotfried, Theory and Problems of Programming with C, Tata McGraw-Hill, 1998.
4. Henry Mullish & Herbert L. Cooper, Spirit of C: An introduction to Modern Programming, Jaico Publishers, Bombay.
5. E. Balagurusamy, Programming in ANSI C, Tata McGraw Hill New Delhi.

MTB 504 Differential Geometry Credits : 3

Curves in R^2 and R^3: Basic Definitions and Examples. Arc Length. Curvature and the Frenet-Serret Apparatus. The Fundamental Existence and Uniqueness Theorem for Curves. Non-Unit Speed Curves.

Surfaces in R^3: Basic Definitions and Examples. The First Fundamental Form. Arc length of curves on surfaces. Normal curvature. Geodesic curvature. Gauss and Weingarten

Formulas. Geodesics, Parallel Vector Fields Along a Curve and Parallelism. The Second Fundamental Form and the Weingarten Map, Principal, Gaussian and Mean Curvatures. Isometries of surfaces, Gauss's Theorema Egregium, The Fundamental Theorem of Surfaces, Surfaces of Constant Gaussian Curvature. Exponential map, Gauss Lemma, Geodesic Coordinates. The Gauss-Bonnet Formula and the Gauss-Bonnet Theorem (description only).

Recommended Books:

1. Christian Bär, Elementary Differential Geometry, Cambridge University Press, 2010.
2. M. P. do Carmo, Differential geometry of curves and surfaces, Prentice Hall 1976.
3. A. Gray, Differential Geometry of Curves and Surfaces, CRC Press, 1998.
4. R. S. Millman and G. D. Parkar, Elements of Differential Geometry, Prentice Hall 1977.
5. S. Montiel and A. Ros, Curves and Surfaces, American Mathematical Society, 2005.
6. B. O'Neill, Elementary Differential Geometry, Elsevier 2006
7. John Oprea, Differential Geometry and its applications, Prentice Hall 1997.
8. A. Pressley, Elementary Differential Geometry, Springer 2010.
9. John A. Thorpe, Elementary Topics in Differential Geometry, Springer, 1979.
10. V. A. Toponogov, Differential geometry of curves and surfaces - A concise guide, Birkhauser, 2006.)

MTB 505 Mechanics Credits : 3

Satatics: Analytic conditions of equilibrium in 3-dimension. Poinsot's central axis. Stable and unstable equilibrium.
Dynamics: Moment of inertia, Equimomental systems, Principle axes. D'Alemdert's principle for motion of rigid body-linear and rotation for finite and impulsive forces. Conservation of momentum and energy. Compound pendulum. Reaction of axis of rotation. Kinetic energy and angular momentum for motion in two dimensions.

Recommended Books:

1. S. L. Loney, An Elementary Treatise on Statics, Kalyani Publishers, New Delhi.
2. S. L. Loney, An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies, Kalyani Publishers, New Delhi.
3. J. L. Synge and B. A. Griffith, Principles of Mechanics, McGraw-Hill, 1959.
4. N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw-Hill, 1991.

MTB 506 Operations Research Credits : 3

Linear Programming problem, Convexity, Simplex and Revised Simplex algorithm, Duality theory, Dual simplex. Transportation, Assignment and Traveling Salesman problems. Portfolio Theory, Principle of Optimality and its applications.

Recommended Books:

1. G. Hadley, Linear Programming, Narosa Publishing House, 1995.
2. S. I. Gass, Linear Programming: Methods and Applications (4^{th} edition) McGraw-Hill, New York, 1975.
3. Kanti Swaroop, P.K. Gupta and Man Mohan, Operations Research, Sultan Chand & Sons, New Delhi, 1998.
4. Hamdy A. Taha, Operations Research, Prentice-Hall of India, 1997.

ELECTIVE -I (**Any one** of the following **3 credit** courses: MTB 507 - MTB 511)

MTB 507 Combinatorial Mathematics

Introduction to basic ideas. Selection and Binomial Coefficients: Permutations, Ordered selections, Unordered selections, Remarks on Binomial theorem.
Pairing problems: Pairing within a set, Pairing between sets, an optimal assignment problem, Gale's optimal assignment problem.
Recurrence: Fibonacci type relations, using generating functions, Miscellaneous methods.

Inclusion-Exclusion principle: The Principle, Rook polynomials.
Block Diagram and Error- correction Codes: Block designs, Square block designs, Hadanard Configurations, Error Correcting Codes. Steiner Systems. Golay's Perfect code.

Recommended Book:

1. Ian Anderson, A First course in Combinatorial Mathematics, Springer, 1989.

MTB 508 Business Mathematics

Financial Management: Financial Management. Goals of Financial Management and main decisions of financial management. Time Value of Money: Interest rate and discount rate. Present value and future value-discrete case as well as continuous compounding case. Annuities and its kinds.
Meaning of return. Return as Internal Rate of Return (IRR). Numerical Methods like Newton Raphson Method to calculate IRR. Measurement of returns under uncertainty situations. Meaning of risk. Difference between risk and uncertainty. Types of risks. Measurements of risk. Calculation of security and Portfolio Risk and Return-Markowitz Model. Sharpe's Single Index Model Systematic Risk and Unsystematic Risk.Taylor series and Bond Valuation. Calculation of Duration and Convexity of bonds.
Mathematics in Insurance: Insurance Fundamentals - Insurance defined. Meaning of loss. Chances of loss, peril, hazard, and proximate cause in insurance. Costs and benefits of insurance to the society and branches of insurance-life insurance and various types of general insurance. Insurable loss exposures-feature of a loss that is ideal for insurance. Life Insurance Mathematics. Construction of Mortality Tables. Computation of Premium of Life Insurance for a fixed duration and for the whole life.

Recommended Books:

1 Aswath Damodaran, Corporate Finance - Theory and Practice. John Wiley & Sons. Inc.
2. John C. Hull, Options, Futures, and Other Derivatives, Prentice-Hall of India Private Limited.
3. Sheldon M. Ross, An Introduction to Mathematical Finance, Cambridge University Press.
4. Mark S. Dorfman, Introduction to Risk Management and Insurance, Prentice Hall, Englwood Cliffs, New Jersey.
5. C. D. Daykin, T. Pentikäinen and M Pesonen, Practical Risk Theory for Actuaries, Chapman & Hall.

MTB 509 Special Theory of Relativity-I

Review of Newtonian mechanics: Inertial frames. Speed of light and Gallilean relativity. Michelson-Morley experiment. Lorentz-Fitzgerold contraction hypothesis. Relative character of space and time. Postulates of special theory of relativity. Lorentz transformation equations and its geometrical interpretation. Group properties of Lorentz transformations.
Relativistic kinematics: Composition of parallel velocities. Length contraction. Time dilation. Transformation equations for components of velocity and acceleration of a particle and Lorentz contraction factor.
Geometrical representation of space-time: Four dimensional Minkowskian space-time of special relativity. Time-like, light-like and space-like intervals. Null cone, Proper time. World line of a particle. Four vectors and tensors in Minkowiskian space-time.

Recommended Books:

1. C. Moller, The Theory of Relativity, Oxford Clarendon Press, 1952.
2. P. G. Bergmann, Introduction to the Theory of Relativity, Prentice Hall of India, 1969.
3. J. L. Anderson, Principles of Relativity Physics, Academic Press, 1967.
4. W. Rindler, Essential Relativity, Van Nostrand Reinhold Company, 1969.
5. V. A. Ugarov, Special Theory of Relativity, Mir Publishers, 1979.
6. R. Resnick, Introduction to Special Relativity, Wiley Eastern Pvt. Ltd. 1972.
7. J. L. Synge, Relativity: The Special Theory, North-Holland Publishing Company, 1956.
8. W. G. Dixon, Special Relativity: The Foundation of Macroscopic Physics, Cambridge University Press, 1982.

MTB 510 Computational Mathematics Lab-I

The student is expected to familiarize with popular software's for numerical computation. Real life problems requiring knowledge of numerical algorithms for linear and nonlinear algebraic equations, Eigen value problems/ writing computer program in a programming language. To this end software's like MATLAB, MATHEMATICA, MAPLES can be adopted with the following course outline.

1. Plotting of functions.
2. Matrix operations, vector and matrix manipulations, Matrix Computation and its applications.
3. Data analysis and curve fitting.
4. Solution of equations.
5. 2-D Graphics and 3-D Graphics - general purpose graphics functions, colour maps and colour controls.
6. Examples : Number theory,

References :

1. MATLAB - High performance numeric computation and visualization software: User's Guide.
2. MATHEMATICA - Stephen Wolfram, Cambridge.

MTB 511 Probability

Notion of probability: Random experiment, sample space, axiom of probability, elementary properties of probability, equally likely outcome problems.

Random Variables: Concept, cumulative distribution function, discrete and continuous random variables, expectations, mean, variance, moment generating function.

Discrete random variables: Bernoulli random variable, binomial random variable, geometric random variable, Poisson random variable.

Continuous random variables: Uniform random variable, exponential random variable, Gamma random variable, normal random variable.

Conditional probability and conditional expectations, Baye's theorem, independence, computing expectation by conditioning; some applications - a list model, a random graph, Polya's urn model.

Bivariate random variables: Joint distribution, joint and conditional distributions, the correlation coefficient.

Functions of random variables: Sum of random variables, the law of large numbers and central limit theorem, the approximation of distributions.

Uncertainty, information and entropy, conditional entropy, solution of certain logical problems by calculating information.

Recommended Books:

1 S. M. Ross, Introduction to Probability Models (Sixth edition) Academic Press, 1997.
2. I. Blake, An Introduction to Applied Probability, John Wiley & Sons, 1979.
3. J. Pitman, Probability, Narosa, 1993.
4. A. M. Yagolam and I.M. Yagolam, Probability and Information, Hindustan Publishing Corporation, Delhi, 1983.

Semester –VI

MTB 601 Set Theory and Metric Spaces Credits : 3

Set Theory: Countable and uncountable sets, cardinal numbers, Schroeder-Berstiein theorem, partially ordered sets, Zorn's lemma, Axiom of choice.

Metric spaces: Introduction. Neighbourhood, limit points, interior points, open and closed set, closure and interior, boundary points. Subspace of a metric space, Completeness. Cantor's intersection theorem. Construction of real numbers as the completion of the incomplete metric space of rationals.

Dense subsets. Separable metric spaces. Continuous functions. Uniform continuity, Isometry and homeomorphism. Equivalent metrics.

Recommended Books:

1. P.R. Halmos, Naïve Set Theory, Springer, 1974.
2. E. T. Copson, Metric Spaces, Cambridge University Press, 1968.
3. P. K. Jain and K. Ahmad, Metric Spaces, Narosa Publishing House, New Delhi, 1996.

MTB 602 Linear Algebra Credits : 3

Vector spaces, subspaces and linear spans, linear dependence and independence. Quotient vector space. Finite dimensional vector spaces. Linear transformations and their matrix representations. Algebra of linear transformations, the rank and nullity theorem. Change of basis. Dual spaces, bidual space and natural isomorphism. Eigen values, eigen vectors, and eigenspaces. Diagonalization, Cayley -Hamilton theorem.
Inner product spaces, Cauchy-Schwarz inequality, orthogonal vectors. Orthonormal basis, Bessel's inequality, Gram-Schmidt orthogonalization process.

Recommended Books:

1. N. Herstain, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. K. Hoffman and R. Kunze, Linear Algebra, Prentice-Hall of India, New Delhi, 1971.
3. N. Jacobson, Basic Algebra, Vols I & II, W.H. Freeman, 1980 (also published by Hindustan Publishing Company).
4. K. B. Dutta, Matrix and Linear Algebra, Prentice Hall of India, New Delhi, 2000.

MTB 603 Numerical Analysis Credits : 3+1P

Errors and their computations; Numerical solutions of algebraic equations: Bisection, Regula-Falsi, Newton-Raphson, Rate of convergence of iterative methods; Roots of Polinomials: Birge-Vieta method; System of linear equations: Gauss elimination method, Gauss-Jordan method, Jacobi iterative method, Gauss-Seidal iterative method. Eigen value computation: Power method, Jacobi's method. Finite differences; Interpolation: Newton's forward and backward interpolation, Lagrange's interpolation, Newton's divided difference interpolation; Numerical differentiation. Numerical Quadrature: Newton's cotes quadrature formula, Trapezoidal rule, Simpson's one-third and three-eighth rules, Weddle's rule; Errors in quadrature formulae. Numerical solution to ordinary differential equations of first order: Picard's method, Euler's method, Modified Euler's method, Taylor's method, Runge-Kutta second and fourth order, Implicit Runge-Kutta second order; Predictor Corrector methods: Milne- Simpson method, Adams-Bashforth method.

Practical based on above methods using 'C' Language.

Recommended Books:

1. M. K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International, New Delhi, Sixth edition.
2. C. F. Gerald, P. O. Wheatley, Applied Numerical Analysis, Pearson Education, 2009.
3. S. D. Conte, C de Boor, Elementary Numerical Analysis, McGraw-Hill, 1980.
4. C. E. Froberg, Introduction to Numerical Analysis, (Second Edition), Addition-Wesley, 1979.
5. Melvin J. Maron, Numerical Analysis A Practical Approach, Macmillan Publishing Company Inc., New York, 1982.
6. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI Learning Private Limited, New Delhi, 2010.

MTB 604 Discrete Mathematics Credits : 3

Logic: Propositional and predicate logic. Inference.
Lattices as partially ordered sets and as algebraic systems. Duality, Distributive, complemented and complete lattices. Boolean algebras and their basic properties. Boolean functions and expressions. Application of Boolean algebra to switching circuits(using AND, OR and NOT gates)
Graphs and Planar Graphs: Graphs, Multi-graphs, Weighted Graphs, Directed graphs. Paths and circuits. Matrix representation of graphs. Eulerian paths and circuits. Planar graphs. Euler's formula. Trees and spanning trees.

Recommended Books:

1. C. L. Liu, Elements of Discrete Mathematics, (Second Edition), McGraw Hill, International Edition, 1986.
2. J. P. Tremblay and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw-Hill Book Co., 199
3. S. Wiitala, Discrete Mathematics: A Unified Approach, McGraw-Hill Book Co.
4. N. Deo, Graph Theory with Applications to Computer Science, Prentice-Hall of India,

MTB 605 Vector and Tensor Analysis Credits : 3

Differential operators: The concept of Gradient, Divergence and Curl.
Vector Integration: Line, surface and volume integrals.
Integral Theorems: Green's theorem in the plane, Gauss divergence theorems, Stokes' theorem, Green's formulas and application of these theorems/formulas.
Curvilinear Coordinates: Curvilinear and orthogonal curvilinear coordinate systems and unit vectors. Arc lengths. Volume elements. Gradient, Divergence and Curl in curvilinear coordinate systems. Some special orthogonal curvilinear coordinate systems
Tensor Analysis: Contravariant and covariant tensors, mixed tensors, coordinate transformation and physical laws. Contraction, symmetric and skew symmetric tensors. metric tensor, length, angle between two curves. Christoffel symbols. Transformation laws of Christoffel symbols. Geodesics. Gradient, Divergence and Curl in tensor form, Derivation.

Recommended Books:

1. David C. Kay, Tensor Analysis, Schaum's Outline Series, McGraw Hill 1988.
2. R. S, Mishra, A Course in Tensors with Applications to Reimannian Geometry, Pothishala Pvt. Ltd, Allahabad.
3. M. R. Spiegel, Vector Analysis, Schaum's Outline Series, McGraw Hill 1959.

MTB 606 Complex Analysis Credits : 3

Complex numbers, their representation and the algebra of complex numbers.
The complex plane and open set, domain and region in a complex plane. Stereographic projection.
Complex functions and their limits, continuity, differentiability and analyticity. The C-R equations and sufficient conditions for differentiability and analyticity.
Harmonic functions. The exponential and trigonometric functions.
Complex integration: Line integration, path independence, Green's theorem, anti-derivative theorem, Cauchy-Goursat theorem, Cauchy's integral formula, Cauchy's inequality, derivative of analytic functions, Liouville theorem, fundamental theorem of algebra, maximum modulus theorem.
Sequences, series and their convergence, power series, radius of convergence, Taylor and Laurent series.

Recommended Books:

1. J.E. Brown, R.V. Churchill, *Complex Variables & Applications,* McGraw-Hill, 2004.
2. J.B. Conway, *Functions of Complex Variables*, Springer-Verlag,
3. W. Rudin, *Real & Complex Analysis,* Tata-McGraw-Hill,
4. T.W. Gamwlin, *Complex Analysis,* Springer-Verlag, 2001.
5. L.V. Ahlfors, *Complex Analysis,* McGraw-Hill,
6. E.C. Titchmarsh, *The Theory of Functions,* Oxford Univ. Press,

ELECTIVE -II Credits : 3
(Any one of the following 3 credit courses: MTB 607 - MTB 611)

MTB 607 Number Theory

Primes and factorization. Division algorithm. Congruence and modular arithmetic. Chinese

remainder theorem. Euler phi function. Primtive roots of unity. Quardratic law of reciprocity, application. Arithmetical functions. Mobius inversion formula. The Diophantine equations $x^2 + y^2 = z^2$, $x^4 + y^4 = z^4$. Farey sequences.

Recommended Books:

1 David M. Burton, Elementary Number Theory, Wm. C. Brown Publishers, Dubuque, Iowa 1989.
2 K. Ireland, and M. Rosen, A Classical Introduction to Modern Number Theory, GTM Vol. 84, Springer-Verlag, 1972.
3 G. A. Jones, and J. M. Jones, Elementary Number Theory, Springer-Verlag, 1998.
4 W. Sierpinski, Elementary Theory of Numbers, North-Holland, Ireland, 1988.
5 Niven, S.H. Zuckerman, and L.H. Montgomery, An Introduction to the Theory of Numbers, John Wiley, 1991.
6 H. B. Mann, Addition Theorems, Krieger, 1976.
7 Melvyn B. Nathanson, Additive Number Theory: Inverse Problems and the Geometry of Sumsets, Springer-Verlag, 1996.

MTB 608 Global Differential Geometry

Global Theory of Plane Curves: The Rotation Index of a Plane Curve, Convex Curves, The Isoperimetric Inequality, Mukhopadhyay Theorem (The Four-Vertex Theorem).

Global Theory of Space Curves: Fenchel's Theorem, The Fary-Milnor Theorem, Total Torsion.

Global Theory of Surfaces: Simple curvature results. The Gauss-Bonnet Formula. Gauss-Bonnet Theorem and Euler characteristic. Theorems of Jacobi and Hadmard.

Recommended Books:

1. M. P. do Carmo, Differential geometry of curves and surfaces, Prentice Hall 1976.
2. W. Klingenberg, A Course in Differential Geometry, Springer Verlag, 1978.
3. R. S. Millman and G. D. Parkar, Elements of Differential Geometry, Prentice Hall 1977.
4. S. Montiel and A. Ros Curves and Surfaces, American Mathematical Society, 2005.
5. B. O'Neill, Elementary Differential Geometry, Elsevier 2006.
6. A. Pressley, Elementary Differential Geometry, Springer 2010.)

MTB 609 Special Theory of Relativity-II

Relativistic mechanics - Variation of mass with velocity. Equivalence of mass and energy. Transformation equations for mass momentum and energy. Energy-momentum four vector. Relativistic force and Transformation equations for its components. Relativistic Lagrangian and Hamiltonian. Relativistic equations of motion of a particle. Energy momentum tensor of a continuous material distribution.

Electromagnetism - Maxwell's equations in vacuo. Transformation equations for the densities of electric charge and current. Propagation of electric and magnetic field strengths. Transformation equations for electromagnetic four potential vector. Transformation equations for electric and magnetic field strengths. Gauge transformation. Lorentz invariance of Maxwell's equations. Maxwell's equations in tensor form. Lorentz force on a charged particle. Energy momentum tensor of an electromagnetic field.

Recommended Books:

1. C. Moller, The Theory of Relativity, Oxford Clarendon Press, 1952.
2. P. G. Bergmann, Introduction to the Theory of Relativity, Prentice Hall of India, 1969.
3. J. L. Anderson, Principles of Relativity Physics, Academic Press, 1967.
4. W. Rindler, Essential Relativity, Van Nostrand Reinhold Company, 1969.
5. V. A. Ugarov, Special Theory of Relativity, Mir Publishers, 1979.
6. R. Resnick, Introduction to Special Relativity, Wiley Eastern Pvt. Ltd. 1972.
7. J. L. Synge, Relativity: The Special Theory, North-Holland Publishing Company,

1956.
8. W. G. Dixon, Special Relativity: The Foundation of Macroscopic Physics, Cambridge University Press, 1982.

MTB 610 Computational Mathematics Lab-II

The student is expected to get familiarized with popular software's for numerical computation and optimization. Numerical algorithms for linear and nonlinear algebraic equations, Eigen value problems, Finite difference methods. Differentiation; Integration Ordinary differential equations etc. should be attempted.. The objective of such a laboratory is to equip students to model and simulate systems using optimization modelling languages/programming languages. To this end software's like MATLAB, LINDO, MATHEMATICA, MAPLES can be adopted with the following course outline.

1. Numerical integration.
2. Nonlinear Equations and Optimization functions.
3. Differential equations.
4. Sparse Matrices - Iterative methods for sparse linear equations, Eigen values of sparse matrices, Game of life.
5. Linear Programming, Integer Programming and Quadratic Programming - Modelling and Simulation Techniques.

References

1. MATLAB - High performance numeric computation and visualization software : User's Guide.
2. MATHEMATICA - Stephen Wolfram, Cambridge.
3. Optimization Modelling with LINDO : Linus Scharge.

MTB 611 Dynamical Systems

Linear dynamical systems: preliminary concepts, autonomous and non-autonomous systems, diagonalization, fundamental theorem of linear systems, Jordan canonical forms, stability, stable, unstable and center subspaces, nonhomogeneous linear systems.
Non-linear dynamical systems: solutions to initial value problem, existence and uniqueness of solutions, linearization, phase space, classification of critical points.

References

1. Lawrence Perko, Differential equations and dynamical systems, Springer-Verlag, 2001.
2. F. Verhulst, Non-linear Differential Equations and Dynamical Systems, Springer, 1990.