(DRAFT) REVISED SYLLABUS

FOR

M. Sc. (MATHEMATICS)

UNDER

CHOICE BASED CREDIT SYSTEM (CBCS)

M. Sc. (MATHEMATICS)

Proposed Course Structure under CBCS

Abbreviations: **T** = Contact hours (Theory), **P** = Contact hours (Practical),
CR = Credits, **C** = Core for Math Students, **O** = Open Choice for all.
MTHC = Mathematics Core, **MTHO** = Mathematics Open Choice,
1st of the last three digits correspond to semester**, last two** digits correspond to course serial number.

Semester	*Course Code*	*Course Name Short Form*	*Max. Marks*	T	P	CR	C	O
1st Semester			**450**	**216**	**Nil**	**18**	**18**	**00**
	MTHC101	Analysis-I	100	48	Nil	4	C	
	MTHC102	Linear Algebra	100	48	Nil	4	C	
	MTHC103	Ord. Diff. Eq.	100	48	Nil	4	C	
	MTHC104	Classcl. Mech.	100	48	Nil	4	C	
	MTHC105	Application of Mathematics in Environmental studies	50	24	Nil	2	C	
2nd Semester			**450**	**208**	**16**	**18**	**18**	**02**
	MTHC201	Algebra	100	48	Nil	4	C	
	MTHC202	Analysis-II	100	48	Nil	4	C	
	MTHC203	Part. Diff. Eq	100	48	Nil	4	C	
	MTHC204	Topology	100	48	Nil	4	C	
	MTHO205	Fortran Programmng.	50	16	16	2		O
3rd Semester			**450**	**192**	**48**	**18**	**8**	**10**
	MTHO301	Prog. in C and Appl.	100	48	Nil	4		O
	MTHO302	Comp. Pract.	50	Nil	48	2		O
	MTHC303	Complex Funct.Theory	100	48	Nil	4	C	
	MTHO304	Elem. NumbTh.	100	48	Nil	4		O
	MTHC3XY	Optional	100	48	Nil	4	C	
4th Semester			**450**	**192**	**48**	**18**	**18**	**00**
	MTHC4 XY	Numer. Anal.	100	48	Nil	4	CO	
	MTHC4 XY	Comp. Num. Anal. Pract.	50	Nil	48	2	CO	
	MTHC4 XY	Optional	100	48	Nil	4	CO	
	MTHC4 XY	Optional	100	48	Nil	4	CO	
	MTHC4 XY	Optional	100	48	Nil	4	CO	

***Note:- MTHC3XY will correspond to the Course Code of the optional papers being offered in the third semester*.**

***MTHC4XY will correspond to the Course Code of the optional papers being offered in the forth semester*.**

CORE (COMPULSORY) AND OPEN CHOICE CORSES

M THC101. Analysis-I (CORE, 4 Credits)
MTHC102. Linear Algebra (CORE, 4 Credits)
MTHC1O3. Ordinary Differential Equations (CORE, 4 Credits)
MTHC104. Classical Mechanics (CORE, 4 Credits)
MTHC105. Application of Mathematics in Environmental Studies (CORE, 2 Credits)

MTHC201. Algebra (CORE, 4 Credits)
MTHC202. Analysis-II (CORE, 4 Credits)
MTHC203. Partial Differential Equations (CORE, 4 Credits)
MTHC204. Topology (CORE, 4 Credits)
MTHO205. Fortran Programming (OPEN CHOICE, 2 Credits)

MTHO301. Programming in C and Applications (OPEN CHOICE, 4 Credits)
MTHO302. Computer Practical (OPEN CHOICE, 2 Credits)
MTHC303. Complex Function Theory (CORE, 4 Credits)
MTHO304. Elementary Number Theory (OPEN CHOICE, 4 Credits)

MTHC401. Numerical Analysis (CORE, 4 Credits)
MTHC402. Computer Oriented Numerical Analysis (Practical) (CORE, 2 Credits)

OPTIONAL COURSES:

Third Semester:

MTHC305. Differential Geometry (CORE, 4 Credits)
MTHC306. Theory of Field Extensions (CORE, 4 Credits)
MTHC307. Fluid Mechanics (CORE, 4 Credits)
MTHC308. Tensor Analysis and Riemannian Geometry (CORE, 4 Credits)

Fourth Semester:

MTHC401. Theory of Relativity (CORE, 4 Credits)
MTHC402. Functional Analysis (CORE, 4 Credits)
MTHC403. Mathematical Methods (CORE, 4 Credits)
MTHC404. Ring Theory (CORE, 4 Credits)
MTHC405. *p*-adic Analysis (CORE, 4 Credits)
MTHC406. Relativistic Cosmology (CORE, 4 Credits)
MTHC407. Algebraic Topology (CORE, 4 Credits)
MTHC408. Algebraic Geometry (CORE, 4 Credits)
MTHC409. Dynamical Oceanography (CORE, 4 Credits)
MTHC410. Commutative Algebra (CORE, 4 Credits)
MTHC411. Non-linear Dynamical Systems (CORE, 4 Credits)
MTHC412. Discrete Mathematics (CORE, 4 Credits)
MTHC413. Operations Research (CORE, 4 Credits)

Note for the paper setter to be forwarded along with the syllabus of the paper

1. Note for the paper setter:

Two questions are to be set from each unit. Five questions are to be attempted choosing one from each unit.

Recommendation:

1) Whenever feasible questions may be divided into two parts. Part (a) will follow the traditional pattern, while part (b) will be devoted to true/false type questions.

2) If the last recommendation is followed uniformly for all questions in the paper, the following note should precede the question paper.

2. Note for examinees:

Part (a) of each question carries nine marks. In part (b) – which carries six marks – you have to determine whether the assertions made there are true or false choosing any two out of three. You have to justify the answer by a proof or a concrete counter example. This justification would normally extend from four to six lines.

DETAILS OF SYLLABI

MTHC101: Analysis-I

- **[T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C**= Core for Math Students = **Yes**, **O**= Open Choice for all = **No**].

UNIT I

Brief review of sets, relations and functions. Finite and infinite sets, countable and uncountable sets, Schröder-Bernstein theorem, Ordered fields, least upper bound property, the field of real numbers, Archimedean property, density of rational numbers, existence of n^{th} root of positive real numbers, exponential and logarithm, the extended real number system, the complex field.

UNIT II

Numerical sequences and their convergence, bounded sequences, Cauchy sequences, construction of real numbers using Cauchy sequences; series of complex numbers, convergence of series, series of nonnegative terms, the number e, the root and ratio tests, limit supremum and limit infimum, power series, summation by parts, absolute convergence, addition and multiplication of series, rearrangements (statement only).

UNIT III

Euclidean spaces, metric spaces, open and closed sets, limit points, interior points, compact spaces; statements only of the following: nested interval theorem, Heine-Borel theorem, and Bolzano-Weierstrass' threorem.

UNIT IV

Limits of functions, continuous functions, continuity and compactness, uniform continuity, connected sets, connected subsets of real numbers, continuity and connectedness, intermediate value theorem; discontinuities and their classifications, monotonic functions, infinite limits and limits at infinity.

UNIT-V

Differentiation of real-valued functions and its elementary properties; mean value theorem; Taylor's theorem; differentiation of vector-valued functions; elementary properties of Riemann integral (brief review); integration of vector-valued functions.

Textbooks:

1. Naïve Set Theory (3rd edition) – P. R. Halmos, D. Van Nostrand Co., Inc, Princeton, New Jersey, 2002.
2. Principles of Mathematical Analysis (5th edition) – W. Rudin, McGraw Hill Kogakusha Ltd., 2004.
3. An Introduction To The Theory of Groups (4th edition) – J. J. Rotman, Allyn and Bacon, Inc., Boston, 2002.

Reference books:

1. Mathematical Analysis (5th edition) – T. Apostol, Addison-Wesley; Publishing Company, 2001.
2. Introduction to Real Analysis (3rd edition) – R. G. Bartle and D. R. Sherbert, John Wiley & Sons, Inc., New York, 2000.
3. A First Course in Abstract Algebra (4th edition) – J. B. Fraleigh, Narosa Publishing House, New Delhi, 2002.

4. Contemporary Abstract Algebra (4th edition) – J. A. Gallian, Narosa Publishing House, New Delhi, 1999.
5. Basic Real Analysis – H.H. Sohrab, Birkhäuser (2003).

MTHC102: LINEAR ALGEBRA

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**,
C= Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT-I

Vector spaces, linear independence; linear transformations, matrix representation of a linear transformation; isomorphism between the algebra of linear transformations and that of matrices;

UNIT-II

Similarity of matrices and linear transformations; trace of matrices and linear transformations, characteristic roots and characteristic vectors, characteristic polynomials, relation between characteristic polynomial and minimal polynomial; Cayley-Hamilton theorem (statement and illustrations only); diagonalizability, necessary and sufficient condition for diagonalizability;

UNIT-III

Projections and their relation with direct sum decomposition of vector spaces; invariant subspaces; primary decomposition theorem, cyclic subspaces; companion matrices; a proof of Cayley-Hamilton theorem; triangulability; canonical forms of nilpotent transformations; Jordan canonical forms; rational canonical forms.

UNIT-IV

Inner product spaces, properties of inner products and norms, Cauchy-Schwarz inequality; orthogonality and orthogonal complements, orthonormal basis, Gram-Schmidt process; adjoint of a linear transformation; Hermitian, unitary and normal transformations and their diagonalizations.

UNIT-V

Forms on inner product spaces and their matrix representations; bilinear forms; Hermitian forms; symmetric bilinear forms; orthogonal diagonalization of real quadratic forms.

Textbooks:

1. Linear Algebra (2nd edition) – K. Hoffman and R. Kunze, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
2. First Course in Linear Algebra – P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, Wiley Eastern Ltd., New Delhi, 2000.

Reference books:

1. Topics in Algebra (4th edition) – I. N. Herstein, Wiley Eastern Limited, New Delhi, 2003.
2. Linear Algebra – G. E. Shilov, Prentice Hall, 1998.
3. Finite Dimensional Vector Spaces – P. R. Halmos, Van Nostrand Inc., 1965.
4. Introduction to Matrices and Linear Transformations (3rd edition) – D. T. Finkbeiner, D.B. Taraporevala, Bombay, 1990.
5. Linear Algebra, A Geometric Approach – S. Kumaresan, Prentice-Hall of India Pvt. Ltd., New Delhi, 2001.

MTHC103: ORDINARY DIFFERENTIAL EQUATIONS

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Linear equations with constant coefficients; the second and higher order homogeneous equation; initial value problems for second order equations; existence theorem; uniqueness theorem; linear dependence and independence of solutions; the Wronskian and linear independence; a formula for the Wronskian; the non-homogeneous equation of order two.

UNIT II

Linear equations with variable coefficients, initial value problems for the homogeneous equations; existence theorem; uniqueness theorem; solutions of homogeneous equations; the theorem on n linearly independent solutions; the Wronskian and linear independence;

UNIT III

Existence and uniqueness of solutions – introduction; equations with variable separated; exact equations, Lipschitz condition; non-local existence of solutions; uniqueness of solutions; existence and uniqueness theorem for first order equations; statement of existence and uniqueness theorem for the solutions of ordinary differential equation of order n.

UNIT IV

Initial value problems for the homogeneous equations; solutions of homogeneous equations; Wronskian and linear independence; non-homogeneous equations; homogeneous equations with analytic coefficients; Legendre equation, justification of power series method; Legendre polynomials and Rodrigues' formulae.

UNIT V

Linear equations with regular singular points – introduction; Euler equation; second order equations with regular singular points – example and the general case, convergence proof, exceptional cases; Bessel equation; regular singular points at infinity.

Textbooks:

1. An Introduction to Ordinary Differential Equations – E. A. Coddington, Prentice-Hall of India Private Ltd., New Delhi, 2001 .
2. Spherical Harmonics – T. M. Mac Robert, Pergamon Press, 1967.

Reference books:

1. Elementary Differential Equations (3rd Edition) – W. T. Martain and E. Relssner, Addison Wesley Publishing Company, inc., 1995.
2. Theory of Ordinary Differential Equations – E. A. Codington and N. Levinson, Tata McGraw hill Publishing co. Ltd. New Delhi, 1999.
3. Differential Equations, Dynamical Systems and an Introduction to Chaos – M.W. Hirsch, S. Smale, and R.L. Devaney, Elsevier (2004).

MTHC104: CLASSICAL MECHANICS

[T = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Generalized coordinates; holonomic & non-holonomic systems; D'Alembert's principle; Lagrange's equations; calculus of variations.

UNIT II

Hamilton's principle, Lagrange's equations from Hamilton's principle, extension of Hamilton's principle to non-conservative and non-holonomic systems, conservation theorems and symmetry properties.

UNIT III

Eulerian angles; Euler's theorem on the motion of a rigid body; infinitesimal rotations; rate of change of a vector; coriolis force; Euler's equations of motion; force free motion of a rigid body; heavy symmetrical top with one point fixed.

UNIT IV

Hamilton's equations of motion, conservation theorems and physical significance of Hamiltonian, Hamilton's equations from variational principle, principle of least action.

UNIT V

Equations of canonical transformation; integral invariants of Poincare'; Lagrange and Poisson brackets as canonical invariants, equations of motion in Poisson bracket notation; infinitesimal contact transformations; constants of motion and symmetry properties.

Textbook:

1. Classical Mechanics (3^{rd} edition) – H. Goldstein, Addison Wesley Publications, Massachusetts, 2002.

Reference books:

1. Classical Mechanics **–** C. R. Mondal, Prentice-Hall of India, 2001.
2. Classical Mechanics **–** T. W. B. Kibble, Orient Longman, London, 1985.
3. Mechanics **–** L. D. Landau and E. M. Lipshitz, Pergamon Press, Oxford, 1976.
4. Lectures on Mechanics **–** J. E. Marsden, Cambridge University Press, 1992.

MTHC105: APPLICATION OF MATHEMATICS IN ENVIRONMENTAL STUDIES

[T = Contact hours (Theory) = **24**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **2**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT 1

Linear Equations, matrix form, row reduction; row rank and column rank, row equivalence, row reduced echelon matrices, various methods to find solutions of a system of linear equations, linear inequalities.

UNIT II

Introduction to ecology and environment; linear programming problem – introduction, graphical solution method, some exceptional cases; general linear programming problem, duality, simplex method; problems related to ecology and environment.

Textbook:

1. Linear Algebra (2^{nd} edition) – K. Hoffman and R. Kunze, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
2. Introduction to Matrices and Linear Transformations (3^{rd} edition) – D. T. Finkbeiner, D.B. Taraporevala, Bombay, 1990.
3. Operations Research (for Group B) – K. Swarup, P. K. Gupt and Man Mohan, Sultan Chand & Sons, New Delhi, 2000.

Reference books:

4. Applied Operation Research: A Survey (for Group B) **–** G. E. Whitehouse and B. L. Wechsler, John Wiley & Sons, 1975.
5. Ecology: The Experimental Analysis of Distribution and Abundance (2^{nd} edition) (for Group B) **–** C. J. Krebs, Harper and Row Publishers, 1978.

MTHC201: ALGEBRA

[T = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**,
C = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

A brief review of groups, their elementary properties and examples, subgroups, cyclic groups, homomorphism of groups and Lagrange's theorem; permutation groups, permutations as products of cycles, even and odd permutations, normal subgroups, quotient groups; isomorphism theorems, correspondence theorem;

UNIT II

Group action; Cayley's theorem, group of symmetries, dihedral groups and their elementary properties; orbit decomposition; counting formula; class equation, consequences for p-groups; Sylow's theorems (proofs using group actions)

UNIT III

Applications of Sylow's theorems, conjugacy classes in S_n and A_n, simplicity of A_n. Direct product; structure theorem for finite abelian groups; invariants of a finite abelian group (Statements only)

UNIT IV

Basic properties and examples of ring, domain, division ring and field; direct products of rings; characteristic of a domain; field of fractions of an integral domain; ring homomorphisms (always unitary); ideals; factor rings; prime and maximal ideals, principal ideal domain; Euclidean domain; unique factorization domain.

UNIT V

A brief review of polynomial rings over a field; reducible and irreducible polynomials, Gauss' theorem for reducibility of $f(x) \in \mathbf{Z}[x]$; Eisenstein's criterion for irreducibility of $f(x) \in \mathbf{Z}[x]$ over $\mathbf{Q}$, roots of polynomials; finite fields of orders 4, 8, 9 and 27 using irreducible polynomials over $\mathbf{Z}_2$ and $\mathbf{Z}_3$.

Textbooks:

4. Basic Abstract Algebra (3^{rd} edition) – P.B. Bhattacharya, S. K. Jain and S. R. Nagpal, Cambridge University Press, 2000.

5. Basic Algebra I (3rd edition) – N. Jacobson, Hindustan Publishing corporation, New Delhi, 2002.
6. Contemporary Abstract Algebra (4th edition) – J. A. Gallian, Narosa Publishing House, New Delhi, 1999.

Reference books:

3. Topics in Algebra (4th edition) – I. N. Herstein, Wiley Eastern Limited, New Delhi, 2003.
4. A First Course in Abstract Algebra (4th edition) – J. B. Fraleigh, Narosa Publishing House, New Delhi, 2002.
5. Abstract Algebra – D.S. Dummit, R.M. Foote, John Wiley&Sons (2003)

MTHC202: ANALYSIS-II

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT-I

Sequences of functions, pointwise and uniform convergence; uniform convergence and continuity; uniform convergence and integration; uniform convergence and differentiation; nowhere differentiable functions; Statement of Stone-Weierstrass' theorem for a real and complex-valued functions on an interval.

UNIT-II

Directional derivatives; derivatives of functions of several variables and their interrelationship; chain rule; mean value theorem; higher order partial derivatives; equality of mixed partial derivatives, Schwarz lemma; Taylor's theorem.

UNIT-III

Injective mapping theorem, surjective mapping theorem, inverse function theorem and implicit function theorem of functions of two and three (for analogy) variables; extremum problems with and without constraints of functions of two and three (for analogy) variables.

UNIT-IV

σ rings of sets, additive, countably additive, regular set functions, outer measures on power set of reals, measurable spaces, Lebesgue measure, measurable functions and their properties.

UNIT-V

Lebesgue integral, Lebesgue integrable functions, properties of integrals, Lebesgue's monotone convergence theorem, Fatou's lemma, Lebesgue's dominated convergence theorem, integration of complex valued functions, functions of class L^2 , Fourier series, Riesz-Fischer theorem.

Textbooks:

1. Principles of Mathematical Analysis (5th edition) – W. Rudin, McGraw Hill Kogakusha Ltd., 2004.
2. Mathematical Analysis (5th edition) – T. Apostol, Addison-Wesley; Publishing Company, 2001.
3. The Elements of Real Analysis (3rd edition) – R. G. Bartle, Wiley International Edition, 1994.

Reference books:

1. Advanced Calculus (4th Edition) – R.C. Buck & E.F. Buck, McGraw Hill Book Company, 1999.
2. Introduction to Topology and Modern Analysis (4th edition) – G. F. Simmons, McGraw Hill Kogakusha Ltd., 2000.
3. Introduction to Real Analysis (3rd edition) – R. G. Bartle and D. R. Sherbert, John Wiley & Sons, Inc., New York, 2000.

MTHC203: PARTIAL DIFFERENTIAL EQUATIONS

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Definition of PDE, origin of first-order PDE; determination of integral surfaces of linear first order partial differential equations passing through a given curve; surfaces orthogonal to given system of surfaces; non-linear PDE of first order, Cauchy's method of characteristic; compatible system of first order PDE; Charpit's method of solution, solutions satisfying given conditions, Jacobi's method of solution.

UNIT II

Origin of second order PDE, linear second order PDE with constant coefficients, linear second order PDE with variable coefficients; characteristic curves of the second order PDE; Monge's method of solution of non-linear PDE of second order.

UNIT III

Separation of variables in a PDE; Laplace's equation, elementary solutions of Laplace's equations; families of equipotential surfaces.

UNIT IV

Wave equation, the occurrence of wave equations, elementary solutions of one-dimensional wave equation; vibrating membranes, three dimensional problems.

UNIT V

Diffusion equation, resolution of boundary value problems for diffusion equation, elementary solutions of diffusion equation, separation of variables.

Text Book:

1. Elements of Partial Differential Equation (3rd edition) – I. N. Sneddon, McGraw Hill Book Company, 1998.

Reference Book:

2. Partial Differential Equations (2nd edition) – E. T. Copson, Cambridge University Press, 1995.

MTHC204: TOPOLOGY

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Definition and examples of topological spaces; basis and sub basis; order relations, dictionary order, order topology; subspace topology; Kuratowski's closure axioms.

UNIT II

Continuity and related concepts; product topology; quotient topology; a brief introduction to minimal uncountable well ordered set S_Ω; countability axioms; Lindelof spaces and separable spaces.

UNIT III

Connected spaces, generation of connected sets; component, path component; local connectedness, local path-connectedness.

UNIT IV

Compact spaces; limit point compact and sequentially compact spaces; locally compact spaces; one point compactification; finite product of compact spaces, statement of Tychonoff's theorem.

UNIT V

Separation axioms; Urysohn's lemma; Tietze's extension theorem; statement of Urysohn's metrization theorem.

Textbooks:

1. Topology, a first course – J. R. Munkres, Prentice-Hall of India Ltd., New Delhi, 2000.
2. General Topology – J. L. Kelley, Springer Verlag, New York, 1990.
3. An introduction to general topology (2nd edition) – K. D. Joshi, Wiley Eastern Ltd., New Delhi, 2002.

Reference books:

1. General Topology – J. Dugundji, Universal Book Stall, New Delhi, 1990.
2. Foundations of General Topology – W. J. Pervin, Academic Press, New York, 1964.
3. General Topology – S. Willard, Addison-Wesley Publishing Company, Massachusetts, 1970.
4. Basic Topology – M.A. Armstrong, Springer International Ed. 2005.

MTHO205: FORTRAN PROGRAMMING

[**T** = Contact hours (Theory) = **16**, **P** = Contact hours (Practical) = **16**, **CR** = Credits = **2**, **C** = Core for Math Students = **No**, **O** = Open Choice for all = **Yes**].

UNIT I

Working of a digital computer; machine language on a small hypothetical computer; decimal, binary, octal and hexadecimal representation of numbers and mutual conversions; remarks about logic gates and machine language in binary system; high level language, character sets for FORTRAN; constants and variables (including complex and double precision) in FORTRAN; arithmetic expressions in FORTRAN; arithmetic statements in FORTRAN; built-in functions and libraries in FORTRAN; input and output statements in FORTRAN; comment statements; data types; TYPE declarations; statement labels; elementary programs in FORTRAN.

Logical IF statements in FORTRAN; GOTO, nested logical IF, arithmetic IF, computed GOTO and assigned GOTO statements in FORTRAN; DO loops, nested DO loops.

UNIT II

Subscripted variables and arrays in FORTRAN; single and multiple subscripts, dimension statements, assigned DO type notations for input/output of arrays, DO loops with subscripts in FORTRAN;; format specifications in FORTRAN.

Statement functions, functions subprogram, subroutine subprogram, COMMON statements, use of procedure names and arguments in FORTRAN; character manipulation, execution time format declaration, EQUIVALENCE declarations in FORTRAN. File processing commands.

Textbooks:

1. Computer Programming in FORTRAN 77 – V. Rajaraman, Prentice-Hall of India Pvt. Ltd., 2005.
2. Computer Applications of Mathematics and Statistics – A. K. Chattapadhyay and T. Chattapadhyay, Asian Books Pvt. Ltd., New Delhi, 2005.

Reference books:

1. Computer Programming in FORTRAN IV – V. K. Gupta, Pragati Prakashan, 2004.
2. Computer Programming for FORTRAN 77 – Ramkumar, Tata McGraw Hill, 2002.
3. Primes and Programming – An Introduction to Number Theory with Programming – P. Goblin, Cambridge University Press, 1993.

MTHO301: PROGRAMMING IN C AND APPLICATIONS

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**,
C = Core for Math Students = **No**, **O** = Open Choice for all = **Yes**].

UNIT I

Character sets for C; constants and variables in C; arithmetic expressions in C; assignment and multiple assignments and mode of statements in C; built-in functions and libraries in C; input and output statements in C; comment statements; data types; TYPE declarations; statement labels; elementary programs in C.

UNIT II

Logical IF statements in C; switch, break, continue GOTO statements in C; WHILE, FOR, DO WHILE loops in C.

UNIT III

Subscripted variables and arrays in C; array variables, syntax rules, use of multiple subscripts in arrays, reading and writing multi-dimensional arrays, for loops, for arrays in C; format specifications in C.

UNIT IV

Some algorithms and programs on theory of matrices and numbers like Sieve method for primality test, generation of twin primes, solution of congruence using complete residue system, addition, subtraction and multiplication of matrices. transpose, determinant .

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UNIT V

Function definition, function prototypes, arguments, call by value, call by reference, pointers, character arrays, automatic variables in C; external variables and scopes in C; some applications of C; operations with strings and sorting; file processing commands.

Textbooks:

1. Computer Programming in C – V. Rajaraman, Prentice-Hall of India Pvt. Ltd., 2005.

2. Computer Applications of Mathematics and Statistics – A. K. Chattapadhyay and T. Chattapadhyay, Asian Books Pvt. Ltd., New Delhi, 2005.

Reference books:

3. The C Programming Language – B. W. Kernighan and D. M. Ritchie, Prentice Hall, India, 1995.
4. Primes and Programming – An Introduction to Number Theory with Programming – P. Goblin, Cambridge University Press, 1993.

MTHO302: COMPUTER PROGRAMING (PRACTICAL)

[**T** = Contact hours (Theory) = **Nil**, **P** = Contact hours (Practical) = **48**, **CR** = Credits = **2**, **C** = Core for Math Students = **No**, **O** = Open Choice for all = **Yes**].

The following programs are to be practised:

1. Determination of roots of quadratic equations, $Ax^2+Bx+C=0$,
2. Arranging given set of numbers in increasing/decreasing order, calculation of Mean,
3. Evaluation of sum of power series eg. e^x, sin x, cos x, log (1 + x).
4. Calculation of GCD/LCM of two integers.
5. Evaluation of factorial of a positive integer and evaluation of binomial coefficients.
6. Evaluation of factorial of binomial coefficients mod 2.
7. Sieve method for primality test.
8. Generation of twin primes.
9. Solution of congruence using complete residue system.
10. Evaluation Legendre polynomial from recurrence relation.
11. Addition, subtraction and multiplication of matrices.
12. Transpose, determinant.
13. Inversion of real or complex matrices.
14. Searching a pattern in a given text and replacing every occurrence of it with another given string.
15. Writing a given number in words using function.
16. Arranging a set of names in alphabetical order.
17. Operations with strings and sorting.

MTHC303: COMPLEX FUNCTION THEORY

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Brief survey of formal power series, radius of convergence of power series, exponential, cosine and sine, logarithm functions introduced as power series, their elementary properties.

UNIT II

Integration of complex-valued functions and differential 1-forms along a piecewise differentiable path, primitive , local primitive and primitive along a path of a differential 1-form, homotopic pats, simply connected domains, index of a closed path, holomorphic functions, Cauchy's theorem and its corollaries.

UNIT III

Cauchy’s integral formula, Taylor’s expansion of holomorphic functions, Cauchy's estimate; Liouville's theorem; fundamental theorem of algebra; zeros of an analytic function and related results; maximum modulus theorem; Schwarz’ lemma.

UNIT IV

Laurents’s expansion of a holomorphic function in an annulus, singularitiesof a function, removable singularities, poles and essential singularities; extended plane nd stereographic projection, residues, calculus of residues; evaluation of definite integrals; argument principle; Rouche's Theorem.

UNIT V

Complex form of equations of straight lines, half planes, circles, etc., analytic (holomorphic) function as mappings; conformal maps; Mobius transformation; cross ratio; symmetry and orientation principle; examples of images of regions under elementary analytic function.

Textbooks:

1. Functions of one complex variable – J. B. Conway, Springer International Student edition, Narosa Publishing House, New Delhi, 2000.
2. Elementary Theory of Analytic Functions of one or several complex variables – H. Cartan, Courier Dover Publications, New York, 1995.

Reference books:

1. Complex Analysis (2nd Edition) – L. V. Ahlfors, McGraw-Hill International Student Edition, 1990.
2. Complex Variables and applications – R. V. Churchill, McGraw-Hill, 1996.
3. An Introduction to the Theory of functions of a complex Variable – E. T. Copson, Oxford university press, 1995.
4. An Introduction To Complex Analysis – A. R. Shastri, Macmillan India Ltd., 2003.
5. Complex Variables and Applications – S. Ponnusamy, and H. Silverman, Birhkäuser, 2006.

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MTHO304: ELEMENTARY NUMBER THEORY

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**,
C = Core for Math Students = **No**, **O** = Open Choice for all = **Yes**].

UNIT I

Divisibility; Euclidean algorithm; primes; congruences; Fermat’s theorem, Euler’s theorem and Wilson’s theorem; Fermat’s quotients and their elementary consequences; solutions of congruences; Chinese remainder theorem; Euler’s phi-function.

UNIT II

Congruence modulo powers of prime; power residues; primitive roots and their existence; quadratic residues; Legendre symbol, Gauss’ lemma about Legendre symbol; quadratic reciprocity law; proofs of various formulations; Jacobi symbol.

UNIT III

Greatest integer function; arithmetic functions, multiplicative arithmetic functions (elementary ones); Mobius inversion formula; convolution of arithmetic functions, group properties of arithmetic functions; recurrence functions; Fibonacci numbers and their elementary properties.

UNIT IV

Diophantine equations – solutions of $ax + by = c$, $x^2 + y^2 = z^2$, $x^4 + y^4 = z^2$; properties of Pythagorean triples; sums of two , four and five squares; assorted examples of diophantine equations.

UNIT V

Simple continued fractions, finite and infinite continued fractions, uniqueness, representation of rational and irrational numbers as simple continued fractions, rational approximation to irrational numbers, Hurwitz theorem, basic facts of periodic continued fractions and their illustrations (without proofs); Pell's equation.

Textbooks:

1. An Introduction to the Theory of Numbers (6^{th} edition) – I. Niven, H. S. Zuckerman and H. L. Montegomery, John Wiley and sons, Inc., New York, 2003.
2. Elementary Number Theory (4^{th} edition) – D. M. Burton, Universal Book Stall, New Delhi, 2002.

Reference books:

1. History of the Theory of Numbers (Vol. II, Diophantine Analysis) – L. E. Dickson, Chelsea Publishing Company, New York, 1971.
2. An Introduction to the Theory of Numbers (6^{th} edition) – G. H. Hardy and E. M. Wright, The English Language Society and Oxford University Press, 1998.
3. An Introduction to the Theory of Numbers (3^{rd} edition) – I. Niven and H. S. Zuckerman, Wiley Eastern Ltd., New Delhi, 1993.

MTHC401: NUMERICAL ANALYSIS

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**,
C = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

A brief introduction to algebraic and transcendental equations and their roots; direct and iterative methods for determination of roots of these equations; initial approximations; bisection method, secant method, Regula-Falsi method, Newton-Raphson method for determination of roots of algebraic and transcendental equations; error analysis, rate of convergence and algorithm for each of these methods.

UNIT II

A brief introduction to systems of linear algebraic equations and their solutions, eigenvalue problem and its solution; direct and iterative methods; forward and backward substitution method; Cramer's rule; Gauss elimination method; Gauss-Jordan elimination method; Gauss-Jacobi iteration method; Gauss-Seidel iteration method; power method for eigenvalue problem; iterative method for matrix inversion; error analysis, rate of convergence and algorithm for each of these methods.

UNIT III

Lagrange and Newton interpolation; Lagrange interpolating polynomial and Newton divided differences interpolating polynomial; linear interpolation; Newton's divided difference interpolation and its generalizations; finite difference operators; relation between differences and derivatives; Gregory-Newton forward and backward difference interpolation; truncation error bounds and algorithm for each of these interpolations.

UNIT IV

Differentiation and integration; numerical differentiation; methods based on linear and quadratic interpolation with error of approximation; methods based on finite differences; optimum choice of step length; numerical integration; methods based on interpolation; determination of the error term; trapezoidal rule; Simpson's rule; error of integration; algorithms for numerical differentiation and integration.

UNIT V

Ordinary differential equations and their numerical solutions; initial value problems; error estimates; Euler-Richardson method, Runge-Kutta methods and Predictor-Corrector method; error analysis and algorithm for each of these methods; partial differential equations; finite-difference method with error analysis and algorithm.

Textbooks:

1. Numerical Methods for scientific and Engineering computation – M. K. Jain, S. R. K. Iyenger and R. K. Jain, New Age international publishers, New Delhi, 2003.
2. Fundamental of Computer Numerical Analysis – M. Friedman and A. Kandel, CRC Press, Boca Raton, 1993.
3. Applied Numerical Analysis (5th edition) – C. F. Gerald and P. O. Wheatley, Addison-Wesley, New York, 1998.

Reference books:

1. Introduction to Numerical Analysis (2nd edition) – K. E. Atkinson, John Wiley, 1989.
2. Elementary Numerical Analysis: An Algorithmic Approach (3rd edition) – S. D. Conte and C. de Boor, McGraw Hill, New York, 1980.
3. Numerical Mathematical Analysis – J. B. Scarborough, Oxford & IBH Publishing Co., 2001.
4. Computer Oriented Numerical Analysis – V. Rajaraman, Prentice-Hall of India Pvt. Ltd., 2002.

MTHC402: Computer Oriented Numerical Analysis (Practical)

[**T** = Contact hours (Theory) = **Nil**, **P** = Contact hours (Practical) = **48**, **CR** = Credits = **2**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

The following programs are to be practised:

1. Solving simple/algebraic/transcendental equations; Newton's method (real roots only),
2. Solutions of system of linear equations, using Gauss' elimination method.
3. Solutions of system of linear equations, using Gauss-Siedel Iterative method.
4. Matrix inversion using Gauss' elimination method.
5. Matrix inversion using Gauss-Jordan method.
6. Power method for finding largest Eigen value.
7. Interpolation using Lagrange's formula.
8. Interpolation using Newton's divided difference formula.
9. Numerical differentiation using Newton's formula.
10. Numerical differentiation using Lagrange's formula.
11. Numerical integration using trapezoidal rule.
12. Numerical integration using Simpson's rules.
13. Improving the numerical integral using Richardson's Extrapolation.

14. Numerical solutions of ordinary differential equations (initial value problems) using Euler-Richardson method.
15. Numerical solutions of ordinary differential equations (initial value problems) using Runge-Kutta methods.
16. Numerical solutions of ordinary differential equations (initial value problems) using Predictor-Corrector method.

OPTIONAL PAPERS

MTHC305: DIFFERENTIAL GEOMETRY

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Vectors; tangent vectors; tangent spaces; tangent vector fields; derivative mappings; translations; affine transformations and rigid motions (isometries); exterior derivatives.

UNIT II

Space curves; arc length; tangent vectors and vector fields on a curve; curvature and torsion; Serret-Frenet formulas; osculating plane; osculating circle; osculating sphere; fundamental theorem of local theory of space curves (existence and uniqueness theorems).

UNIT III

Surfaces and their (local) parametrization on coordinate systems; change of parameters; parametrized surfaces; curves on surfaces; tangent and normal vectors; tangent and normal vector fields on a surface; first, second and third fundamental forms of a surface at a point; Gauss mapping.

UNIT IV

Normal sections and normal curvature of a surface at a point; Meusnier’s theorem; elliptic, hyperbolic, parabolic and planar points; Dupin indicatrix; principal directions; principal curvatures of a surface at a point; Mean curvature and Gaussian curvature of a surface at a point.

UNIT V

Line of curvature; asymptotic curves; conjugate directions; fundamental equations of the local theory of surfaces; statement of Bonnet’s fundamental theorem of local theory of surfaces.

Textbook:

1. A first course in Differential Geometry – Chun-Chin Hsiung, Willey-Interscience Publications, John Wiley & Sons, 1981.

Reference books:

1. A treatise on the differential geometry of curves and surfaces – P. Eissenhart, Dover Publications, Inc., New York, 1960.
2. Differential Geometry of three dimensions – C. R. Weatherburn, The English Language Book Society and Cambridge University Press, 1964.
3. An Introduction to differential geometry – T. S. Willmore, Oxford, Clarendon Press, 1979.
4. A course in differential geometry – W. Klingenberg, Graduate Texts in Mathematics 51, Springer-Verlag, 1978.
5. Elementary differential Geometry – A. Pressley, Springer International Edition, 2005.

MTHC306: THEORY OF FIELD EXTENSIONS

[T = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**,
C = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Extension fields, finite extensions; algebraic and transcendental elements, adjunction of algebraic elements, Kronecker theorem, algebraic extensions, splitting fields – existence and uniqueness; extension of base field isomorphism to splitting fields;

UNIT II

Simple and multiple roots of polynomials, criterion for simple roots, separable and inseparable polynomials; perfect fields; separable and inseparable extensions, finite fields; prime fields and their relation to splitting fields; Frobenius endomorphisms; roots of unity and cyclotomic polynomials.

UNIT III

Algebraically closed fields and algebraic closures, primitive element theorem; normal extensions; automorphism groups and fixed fields; Galois pairing; determination of Galois groups, fundamental theorem of Galois theory, abelian and cyclic extensions.

UNIT IV

Normal and subnormal series, composition series, Jordan-Holder theorem (statement only); solvable groups; nilpotent groups.

UNIT V

Sovability by radicals; solvability of algebraic equations; symmetric functions; ruler and compass constructions, fundamental theorem of algebra.

Textbooks:

1. Basic Abstract Algebra (3rd edition) – P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, Cambridge University Press, 2000.
2. Basic Algebra I (3rd edition) – N. Jacobson, Hindustan Publishing corporation, New Delhi, 2002.
3. Galois Theory – T. I. F. R. Mathematical pamphlets, No. 3, 1965

Reference books:

1. Topics in Algebra (4th edition) – I. N. Herstein, Wiley Eastern Limited, New Delhi, 2003.
2. A First Course in Abstract Algebra (4th edition) – J. B. Fraleigh, Narosa Publishing House, New Delhi, 2002.
7. Contemporary Abstract Algebra (5th edition) – J. A. Gallian, University of Minnesota, Duluth, 2004.

MTHC307: FLUID MECHANICS

[T = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**,
C = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Lagrangian and Eulerian methods of description; Governing equations of fluid motion; stream line; velocity potential, path line, velocity and circulation; equations of continuity in Lagrangian and Eulerian methods; equivalence of the two forms of equations of continuity; Boundary surface; acceleration; Euler's equations of motion; integrals of Euler's equations of motion, Lagrange's equations of motion; Cauchy's integrals; equation of energy.

UNIT II

Motion in two dimensions; stream function; complex potential; source; sink and doublet; image, images in two dimensions, images of a source with regard to a plane, a circle and a sphere; image of a doublet; circle theorem; theorem of Blasius.

UNIT III

Vortex Motion, Helmholtz properties of vortices, velocity in a vortex field, motion of a circular vortex, infinite rows of vortices, Ka'rma'n vortex street.

UNIT IV

Viscous fluid, Stokes-Navier equations; diffusion of vorticity, dissipation of energy; steady motion of a viscous fluid between two parallel planes; steady flow through cylindrical pipes; Reynolds' number.

UNIT V

Waves motion in a gas; speed of sound; equation of motion of a gas; subsonic, sonic and supersonic flows of a gas; isentropic gas flow; flow through a nozzle; shock formation; elementary analysis of normal and oblique shock waves.

Textbooks:

1. A treatise of Hydromechanics (3^{rd} edition) – W. H. Besant, A. S. Ramsey and G. Bell, 1997.
2. Ideal and Incompressible Fluid Dynamics – M. E. O'Neill and F. Chorlton, John Wiley publications, 1986.

Reference books:

1. Theoretical Hydrodynamics – L. M. Milne-Thomson, Macmillan Publishing co., 1985.
2. Text Book of Fluid Dynamics – F. Chorlton, Van Nostrand Reinhold Co., London, 1990.

MTHC308: TENSOR ANALYSIS AND RIEMANNIAN GEOMETRY

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Idea of differentiable manifolds with n dimensions; space of n dimensions, subspaces; transformation of coordinates; scalar; contravariant (tangent) and covariant (cotangent) vectors; scalar product of two vectors; tensor space of rank more than one contravariant and covaniant tensors; symmetric and skew-symmetric tensors; addition and multiplication of tensors; contraction; composition of tensors; quotient law; reciprocal symmetric tensors of the second order.

UNIT II

Riemannian space; fundamental tensor; length of a curve; magnitude of a vector; associated covariant and contravariant vectors; inclination of two vectors, orthogonal vectors; coordinate hypersurfaces; coordinate curves; field of normals to a hypersurface; principal directions for a symmetric covariant tensor of the second order; Euclidean space of n dimensions.

UNIT III

Levi-Civita tensors; Christoffell symbols and second derivatives; need for covariant derivative; parallel transformations; covariant derivative of a contravariant and covariant vector; curl of a vector and its derivative; covariant differentation of a tensor; divergence of a vector.

UNIT IV

Gaussian curvature; Riemann curvature tensor; geodesics; differential equations of geodesics; geodesic coordinates; geodesic deviation; Riemannian coordinates; geodesic in Euclidean space; straight lines.

UNIT V

Parallel transport along an extended curve; curvature tensor; Bianchi identities; Ricci tensor; scalar curvature; Killing vector field; space-time symmetries (homogeneity and isotropy); space time of constant curvature; conformal transformations.

Textbooks:

1. An Introduction to Riemannian Geometry and Tensor Calculus – C. E. Weatherburn, Cambridge university Press, 1986.
2. General Relativity and Cosmology – J. V. Narlikar, The Mac-Millan Company of India Ltd., 1978.

Reference books:

1. Aspects of Gravitational Interactions – S. K. Srivastava & K. P. Sinha, Nova Science publications Inc., Commack, NY, 1998.
2. Tensor Analysis – I. S. Sokolnikoff, John Wiley & Sons, Inc., 1964.

MTHC401:THEORY OF RELATIVITY

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**,
C = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT-I

The special theory of relativity: inertial frames of reference; postulates of the special theory of relativity; Lorentz transformations; length contraction; time dilation; variation of mass; composition of velocities; relativistic mechanics; world events, world regions and light cone; Minkowski space-time; equivalence of mass and energy.

UNIT II

Energy-momentum tensors: the action principle; the electromagnetic theory; energy-momentum tensors (general); energy-momentum tensors (special cases); conservation laws.

UNIT III

General Theory of Relativity: introduction; principle of covariance; principle of equivalence; derivation of Einstein's equation; Newtonian approximation of Einstein's equations.

UNIT IV

Solution of Einstein's equation and tests of general relativity: Schwarzschild solution; particle and photon orbits in Schwarzschild space-time; gravitational red shift; planetary motion; bending of light; radar echo delay.

UNIT V

Brans-Dicke theory: scalar tensor theory and higher derivative gravity; Kaluza-Klein theory.

Textbooks:

1. The Theory of Relativity (2^{nd} edition) – R.K. Pathria, Hindustan Publishing co. Delhi, 1994.
2. General Relativity & Cosmology (2^{nd} edition) – J.V. Narlikar, Macmillan co. of India Limited, 1988.

Reference books:

1. Aspects of Gravitational Interactions – S. K. Srivastava and K. P. Sinha, Nova Science Publishers Inc. Commack, New York , 1998.
2. Essential Relativity – W. Rindler, Springer-Verlag, 1977.
3. General Relativity – R.M. Wald, University of Chicago Press, 1984.

MTHC402: FUNCTIONAL ANALYSIS

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**,
C = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Classical Banach spaces, L^p spaces; Holder's inequality, Minkowski's inequality; convergence and completeness; Riesz-Fischer theorem, bounded linear functional on L^p spaces, Riesz representation theorem.

UNIT II

General Banach spaces – definition and examples; continuous linear transformations between normed linear spaces; Hahn-Banach theorem and its consequences.

UNIT III

Embedding of a normed linear space in its second conjugate space; strong and weak topologies; open mapping theorem; closed graph theorem; uniform boundedness theorem; conjugate of an operator.

UNIT IV

Hilbert's space, examples and simple properties, orthogonal complements, orthonormal set, Bessel's inequalities, complete orthonormal sets, Gram-Schmidt orthogonalization process, self adjoint operators.

UNIT V

Normal and unitary operators, projections, spectrum of an operator, spectral theorem for a normal operator on a finite dimensional Hilbert space.

Textbooks:

1. Real Analysis (4^{th} edition) – H. L. Royden, Macmillan Publishing co. inc, New York, 1999.
2. Introduction to Topology and Modern Analysis (4^{th} edition) – G. F. Simmons, Tata McGraw -Hill Ltd., 2004.

Reference books:

1. Functional Analysis – W. Rudin, Tata McGraw hill Book Company, 1974
2. Functional Analysis – B. V. Limaye, Willy Eastern Ltd., 1991.
3. First course in Functional Analysis – C.Goffman and G. Pedrick, Prentice-Hall of India Pvt. Ltd, New Delhi, 1974.

MTHC403: MATHEMATICAL METHODS

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Laplace transforms, properties of Laplace transform, inversion formula convolution, application to ordinary and partial differential equations; Fourier transform, properties of Fourier transform, inversion formula, convolution, Parseval's equality; Fourier transform of generalized functions, application of transforms to heat wave and Laplace equation.

UNIT II

Formulation of integral equations, integral equations of Fredholm and Volterra type, solution by successive substitution and successive approximation; integral equations with degenerate kernels.

UNIT III

Integral equations of convolution type and their solutions by Laplace transform, Fredholm's theorems; integral equations with symmetric kernel; eigenvalues and eigenfunctions of integral equations and their simple properties.

UNIT IV

Generalized functions; Minusinkski's operational calculus of one variable (algebra of addition and convolution of functions, ordered pairs of functions, convolution quotients of a function with a nonzero function), Dirac delta function.

UNIT V

Eigenvalue problem; ordinary differential equations of the Sturm-Liouville type; eigenvalues and eigenfunctions; expansion theorem; extrema properties of the eigenvalues of linear differential operators, formulation of the eigenvalue problem of a differential operator as a problem of integral equation.

Textbooks:

1. Laplace Transform Theory – M. G. Smith, Van Nostrand Inc., 2000.
2. Generalized Functions and Partial Differential Equations – G. E. Shilov, Bernard Seckler, Gordon and Breach, 1999.
3. Integral Equations – David Porter and David S. G. Stirling, Cambridge University Press, 1993.

Reference books:

1. The Use of Integral Transforms – I. N. Sneddon, Tata McGraw Hill, New Delhi, 1974.
2. Fourier Transforms – R. R. Goldberg, Cambridge University Press, 1970.
3. Lectures on integral equations – H. Widom, Van Nostrand, 1969.

MTHC404: RING THEORY

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Basic concepts of rings, modules, operations on ideals and sub-modules; matrix rings, polynomial rings; direct products of rings; fields and division rings; idempotent and nilpotent elements in a ring.

UNIT II

Isomorphism theorems; exact sequences; the group of homomorphisms and its properties relative to exact sequences.

UNIT III

Direct sums and direct products of modules, external and internal direct sums, direct summands; Zorn's lemma, every vector space has a basis; free modules and projective modules; torsion free and torsion modules over commutative domains; exact sequences and projectivity.

UNIT IV

Injective modules, injectivity and divisibility over domains; exact sequences and injectivity; Baer's theorem and its elementary applications; simple modules, semisimple modules (as per Bourbaki); Schur's lemma.

UNIT V

Equivalent conditions for semisimple modules; Wedderburn structure theorem (only statement); characterization of semisimple rings via projective and injective modules.

Textbooks:

1. Elementary Rings and Modules – I. T. Adamson, Oliver and Boyd, Edinburgh, 1995.
2. Notes on Homological Algebra – J. J. Rotman, Van nostrand, 1990.
3. Basic Algebra II (3rd edition) – N. Jacobson, Hindustan Publishing Corporation, New Delhi, 2002.

Reference books:

4. Algebra, Second Edition – S. Lang, Addison-Wesley, Massachusetts, 1984.
5. Algebra, Vol. 2: Rings – I. S. Luthar and I.B.S. Passi, Narosa Publishing House, New Delhi, 1999.

MTHC405: *p*-ADIC ANALYSIS

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**,
C = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Norm on a field; Archimedean and non-Archimedean norm; *p*-adic norm on rationals; metric induced by a norm; isosceles triangle principle; equivalent norm; Ostrowski's theorem.

UNIT II

Completion $\mathbb{Q}_p$ of $\mathbb{Q}$ with respect to the *p*-adic norm; *p*-adic numbers and *p*-adic integers; standard expansion of *p*-adic numbers; arithmetic in $\mathbb{Q}_p$; Hensel's lemma; sequence and series in $\mathbb{Q}_p$, exponential and logarithmic series in $\mathbb{Q}_p$.

UNIT III

Topology on $\mathbb{Q}_p$; existence of nontrivial locally constant functions; Teichmuller functions and expansions; compactness and sequential compactness of $\mathbb{Z}_p$; continuous functions from $\mathbb{Z}_p$ to $\mathbb{Q}_p$.

UNIT IV

A brief introduction to Mahler expansion and Mahler coefficients of a continuous function from $\mathbb{Z}_p$ to $\mathbb{Q}_p$; *p*-adic interpolation; *p*-adic gamma function and its elementary properties; Gauss multiplication formula; Mahler's expansion of gamma function; the 2-adic gamma function.

UNIT V

Vector space norm and their equivalence; extension of *p*-adic norm from $\mathbb{Q}_p$ to its algebraic closure $\overline{\mathbb{Q}}_p$; incompleteness of $\overline{\mathbb{Q}}_p$; completion Ω of $\overline{\mathbb{Q}}_p$; Krasner's lemma; proof of Ω being algebraically closed.

Textbooks:

1. *p*-adic Number, *p*-adic Analysis, and Zeta-Functions – Neal Koblitz, Graduate Text in Mathematics, vol 58, Springer-Verlag.
2. An Introduction to *p*-adic Number and *p*-adic Analysis – A. J. Baker, Lecture Notes, University of Glasgow.
3. A Course in *p*-adic Analysis – A. M. Robert, Graduate Text in Mathematics, vol. 1998, Springer.

Reference book:

1. Introduction to *p*-adic analytic Number Theory – M. Ram Murty, Lecture notes, Harishchandra Research Institute, Allahabad,2001.

MTHC406: RELATIVISTIC COSMOLOGY

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**,
C = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Gravitational collapse of a homogeneous dust ball; observational background for cosmology; Weyl's postulates; cosmological principle; Hubble's law; angular size; flux of radiation; surface brightness.

UNIT II

Cosmological field equations for Friedmann models (dust and radiation models); cosmologies with nonzero cosmological constant; cosmic microwave radiation background; Newtonian cosmology.

UNIT III

Perfect cosmological principle; creation of matter; creation field; C-field cosmology; observable parameters of the steady state theory; event horizon.

UNIT IV

Mach's principle, Brans-Dicke theory, Hoyle-Narlikar theory, variation of gravitational constant, Dirac cosmology, white holes.

UNIT V

Big-bang nucleosynthesis; horizon and flatness problems of the early universe; inflation as remedy to these problems, dark energy; dark matter and present cosmic acceleration.

Text Book:

1. General Relativity and Cosmology – J. V. Narlikar, Mcmillan Co of India Ltd., 1978.

Reference books:

1. Gravitation and Cosmology: Principles and Applications – S. Weinberg, John Wiley and sons, 1972.
2. Cosmology and Particle Physics – R. D. Teureiro and M. Quiros, World Scientific, 1988.
3. An Introduction to Cosmology – J. V. Narlikar, Mcmillan Co of India Ltd., 1983.
4. General Relativity – R.M. Wald, University of Chicago Press, 1984.

MTHC407: ALGEBRAIC TOPOLOGY

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**,
C = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Homotopy of paths, fundamental group of a topological space, fundamental group functor, homotopy of maps of topological spaces; homotopy equivalence; contractible and simply connected spaces; fundamental group of $\mathbb{S}^1$, $\mathbb{S}^1$ x $\mathbb{S}^1$ etc.; degree of maps of $\mathbb{S}^1$.

UNIT II

Calculation of fundamental groups of $\mathbb{S}^n$ (n > 1) using Van Kampen's theorem (special case); fundamental group of a topological group; Brouwer's fixed point theorem; fundamental theorem of algebra; vector fields, Frobenius theorem on eigenvalues of 3 x 3 matrices.

UNIT III

Covering spaces, unique lifting theorem, path-lifting theorem, covering homotopy theorem, applications; criterion of lifting of maps in terms of fundamental groups; universal coverings and its existence; special cases of manifolds and topological groups.

UNIT IV

Simplicial and singular homology, reduced homology, Eilenberg-Steenrod axioms (without proof), relation between Π_1 and H_1; relative homology.

UNIT V

Calculations of homology of $\mathbb{S}^n$; Brouwer's fixed point theorem for $f : \mathbb{E}^n \to \mathbb{E}^n$ (n > 2) and its applications to spheres and vector fields; Meyer-Vietoris sequence and its application.

Textbooks:

1. Topology, a first course – J. R. Munkres, Prentice-Hall of India Ltd., New Delhi, 2000.
2. Algebraic topology, a first course (2nd edition) – M. J. Greenberg and J. R. Harper, Addison-Wesley Publishing co., 1997.
3. Algebraic Topology – A. Hatcher, Cambridge University Press, 2002.

Reference books:

1. Algebraic Topology (2nd edition) – E. H. Spanier, Springer-Verlag, New York, 2000.
2. An Introduction to Algebraic Topology – J. J. Rotman, Graduate Text in Mathematics, No. 119, Springer, New york, 2004.
3. Algebraic topology, a first course (2nd edition) – W. Fulton, Graduate Text in Mathematics, No. 153, Springer, New york, 1995.
4. Foundations of Algebraic Topology (2nd edition) – S. Eilenberg and N. E. Steenrod, Princeton University Press, 1995.

MTHC408: ALGEBRAIC GEOMETRY

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Introduction; affine varieties, Hilbert’s Nullstellensatz, polynomial function and maps; rational functions and maps.

UNIT II

Projective space; projective varieties; rational functions and morphisms; smooth points and dimension, smooth and singular points, algebraic characterizations of the dimension of a variety.

UNIT III

Plane cubic curves, plane curves, intersection multiplicity, classification of smooth cubics, the group structure of an elliptic curve.

UNIT IV

Cubic surfaces, the existence of lines on a cubic, configuration of the 27 lines, rationality of cubics.

UNIT V

Introduction to the theory of curves, divisors on curves, the degree of a principal divisor, Bezout's theorem, linear system on curves, projective embeddings of curves.

Textbook:

1. Elementary Algebraic Geometry – K. Hulek (translated by H. Verrill), Student Mathematical Library, vol 20, American Mathematical Society, 2003.

Reference books:

1. Algebraic Geometry – R. Hartshorne, Springer-Verlag, 1977.
2. Algebraic Geometry: A First Course – J. Harris, Springer-Verlag, 1992.
3. Elliptic Curves – Notes on NBHM Instructional conference held at TIFR, Mumbai, 1991.

MTHC409: DYNAMICAL OCEANOGRAPHY

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Thermodynamics of equilibrium state; Gibbs' relation; Gibbs-Duhem relation; sea water as a two-component solution; conditions of equilibrium of sea-water; conditions for the absence of convection – Vaisala frequency.

UNIT II

Thermodynamics of irreversible processes; equations of conservation of mass; equations of motion; equations of conservation of energy.

UNIT III

Wave motion in the ocean, basic equations; separation of variables; analysis of the simplest cases.

UNIT IV

Equations of the theory of ocean currents and their properties; equations of evolution of potential vorticity; Boussinesq's approximations; averaging of basis equations; the basis equations in spherical coordinates; coefficients of turbulent exchange; boundary conditions; quasi-static approximation; geostrophic motion.

UNIT V

Ekman theory; wind driven currents in a homogeneous ocean; pure drift current, the basis equations of Ekman theory; vertical structure of the flow-Ekman boundary layers; certain very simple solutions; western boundary current.

Textbooks:

1. Fundamentals of Ocean Dynamics – V. M. Kamenkovich, Elsivier, 1997.
2. Waves in the Ocean – P. H. Leblond and B. A. Mysak, Elsivier, 1987.
3. Thermodynamics and Introduction to Thermo statistics (Second Edition) – Herbert B. Callen, John Willey, 1985.

Reference books:

1. The Theory of Rotating Fluids – H. P. Greenspan, Cambridge University Press, First Edition, 1968.
2. Geo-physical Fluid Dynamics – J. Pedlosky, first edition, Springer-Verlag, 1979.

MTHC410: COMMUTATIVE ALGEBRA

[T = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**,
C = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

Preliminaries on rings and ideals; local and semilocal rings; nilradical and Jacobson radical; operations on ideals; extension and contraction ideals; modules and module homomorphisms; submodules and quotient modules; operations on submodules; annihilator of a module; generators for a module, finitely generated modules; Nakayama's lemma; exact sequences.

UNIT II

Existence and uniqueness of tensor product of two modules; tensor product of n modules; restriction and extension of scalars; exactness properties of tensor products; flat modules.

UNIT III

Multiplicatively closed subsets; saturated subsets; ring of fractions of a ring; localization of a ring; module of fractions and its properties; extended and contracted ideals in a ring of fractions; total ring of fractions of a ring.

UNIT IV

Primary ideals; *p*-primary ideals; primary decomposition, minimal primary decomposition, uniqueness theorems; primary submodules of a module.

UNIT V

Chain conditions, ascending chain conditions on modules; maximal condition; Noetherian modules; descending chain condition; minimal condition; Artinian modules, their properties; Noetherian rings; Hilbert basis theorem; Artinian rings; structure theorem for Artinian rings.

Textbook:

1. Introduction to Commutative Algebra – M. F. Atiyah and I. G. Macdonald, AddisonWesley, 2000.

Reference books:

1. Undergraduate Commutative Algebra – M. Reid, London Math. Soc. Student Texts, No. 29, 1995.
2. Algebra (Volume 2: Rings) – I. S. Luther and I. B. S. Passi, Narosa Publishing House, New Delhi, 1999.
3. Algebra (Volume 3: Modules) – I. S. Luther and I. B. S. Passi, Narosa Publishing House, New Delhi, 1999.
4. Algebra – S. Lang, Addison-Wesley Publishing Company, London, 2000.

MTHC411: NON-LINEAR DYNAMICAL SYSTEMS

[T = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT I

First order continuous autonomous systems – some terminology, classification of fixed points of autonomous systems, attractors and repellors, natural boundaries, case study: population growth.

UNIT II

Second order continuous autonomous systems – autonomous second order systems, constant cofficient equations, phase curves and fixed points, classification of fixed points of linear systems, analyzing non-linear systems, case studies: lead absorption in the body, interacting species.

UNIT III

Discrete Systems – examples of discrete systems, some terminology, linear discrete systems, non-linear discrete systems, quadratic maps.

UNIT IV

Bifurcations in one-dimensional flows – introduction, saddle-node bifurcation, transcritical bifurcation, Pitchfork bifurcation.

UNIT V

Bifurcation in two-dimensional flows – saddle-node, transcritical, and Pitchfork bifurcations, Hopf bifurcations.

Textbooks:

1. Introduction to Non-Linear Systems – J.Berry and Arnold, Great Britain 1996.
2. Non Linear Dynamics and Chaos – S. H. Strogatz, Addision- Wesley Publishing Company, USA, 1994.

Reference books:

1. Introduction to Applied Non-Linear Dynamical systems and Chaos (Vol-2)– S. Wiggins, TAM, Springer-Verlag, NewYork, 1990.
2. Differential Equations, Dynamical Sysstems and an Introduction to Chaos – M.W. Hirsch, S. Smale, and R.L. Devaney, Elsevier (2004).

MTHC412: DISCRETE MATHEMATICS

[T = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**].

UNIT-I

Sets and classes, Relations and functions, Equivalence relations and equivalence classes, Principle of mathematics induction, Recursive definitions, Posets, Chains and well-ordered sets, Axiom of choice, Cardinal and ordinal numbers, Cantor's lemma, Set theoretic paradoxes.

UNIT-II

Propositional Calculus: Well-formed formulas, Tautologies, Equivalence, Normal forms, Truth of algebraic systems, Calculus of predicates.

UNIT-III

Principles of addition and multiplication, Arrangements, Permutation and combinations, Multinomial theorem, Partitions and allocations, Pigeonhole principle, Inclusion-exclusion principle, Generating functions, Recurrent relations.

UNIT-IV

Graphs and digraphs, Eulerian cycle and Hamiltonian cycle, adjacency and incidence matrices, vertex colouring, planarity and duality, trees, spanning trees, minimum spanning trees.

UNIT-V

Applications of graph theory to transport networks, matching theory and graphical algorithms, spectra of graphs, graph colorings, Ramsey theory.

Textbooks:

1. J.P. Tremblay and R.P. Manohar , *Discrete Mathematics with Applications to Computer Science,* McGraw Hill , 1989.
2. V. K. Balakrishnan, *Introductory Discrete Mathematics*, Dover, 1996
3. F. Harary, *Graph Theory*, Narosa, 1995
4. Bela Bollobas, *Graph Theory: An Introductory Course*, GTM, Springer Verlag, 1990

MTHC413: OPERATIONS RESEARCH

[**T** = Contact hours (Theory) = **48**, **P** = Contact hours (Practical) = **Nil**, **CR** = Credits = **4**, **C** = Core for Math Students = **Yes**, **O** = Open Choice for all = **No**]

UNIT I

(Linear Programming Problem)

Introduction- Nature and Features of Operations Research (O.R)- Convex set-Polyhedral Convex Set-Linear Programming (L.P)-Mathematical Formulation of the Problem- Graphical Solution Method-Some Exceptional Cases-General Linear Programming Problem (General L.P.P) – Slack and Surplus Variables-Reformulation of the General L.P.P.- Simplex Method- Matrix Notation-Duality (Statement only of Property without Proof)- Initial Simplex Tableau- Pivot-Calculating the new Simplex Tableau-Terminal Simplex Tableau- Algorithm of the Simplex Method.

UNIT II

(Markov Analysis**)**

Introduction- Probability Vectors-Stochastic Matrices – Regular Stochastic Matrices- Fixed Points of Square Matrices- Relationships between Fixed Points and

Regular Stochastic Matrices- Markov Processes- State Transition Matrix-Transition Diagram-Brand Switching Analysis-Construction of State Transition Matrices—n-step Transition Probabilities- Stationary Distribution of Regular Markov Changes- Steady State (Equilibrium) Conditions- Markov Analysis Algorithm.

UNIT III

(Games and Strategies)

Introduction- Two- person Zero-sum games-Pay-off Matrix – some basic terms-the Maximum –Minimal Principle-Theorem on Maximum and Minimal Values of the Game-Saddle Point and Value of the Game-Rule for determining a Saddle Point-Games without Saddle Points-Mixed Strategies-Graphic solution of 2 x n and m x 2 games- Dominance Property- General rule for Dominance-Modified Dominance Property.

UNIT IV

(Inventory Control)

Introduction- The Inventory Decisions- Costs Associated with Inventories-Factors affecting Inventory Control- Economic Order Quantity (EOQ) – Deterministic Inventory Problems with no Shortages- Case 1: The fundamental EOQ problem; Characteristics and Corollary. Case 2: EOQ Problem with Several Production Runs of Unequal Length. Case 3: EOQ Problem with Finite Replenishment (Production); Characteristics- Deterministic Inventory Problems with Shortages Case 1: EOQ Problem with Instantaneous Production and Variable Order Cycle Time; Characteristics. Case 2: EOQ Problem with Instantaneous Production of Fixed Order Cycle. Case 3: EOQ Problem with Finite Replenishment (Production); Characteristics.

UNIT V

(Replacement Problem and System Reliability)

Introduction- Replacement of Equipment/Asset that deteriorates gradually-Replacement Policy when value of money does not change with time. Case 1: when t is a continuous variable. Case 2: when t is a discrete variable- Replacement Policy when value of money changes with time and its Corollary- Selection of the best equipment amongst two- Replacement of equipment that fails suddenly- Reliability and System Failure Rates- Definition of Reliability- Failure Rates- Bath-tub-shaped Failure Rate-Instantaneous Failure Rate- Mean Time Between Failure (MTBF)- Estimation of Reliability-Reliability Improvement.

Text Book:

1. Operations Research by Kanti Swarup, P.K. Gupta and Man Mohan, Published by Sultan Chand & Sons, New Delhi-110002, Ninth Edition (2002).

Reference Books:

2. Operations Research- by Friderick S. Hillier and Gerald J. Lieberman, Published by Holden-Day Inc, San Fransisco, USA. Second Edition (1974)
3. Operation Research – An Introduction by Hamdy A. Taha. Published by Prentice-Hall of India Pvt. Ltd., New Delhi- 110001, Sixth Edition (2002).

पूर्वोत्तर पर्वतीय विश्वविद्यालय
पू॰ प॰ विवि॰ परिसर, शिलांग-७९३०२२ (मेघालय)

North-Eastern Hill University

NEHU Campus, Shillong - 793 022 (Meghalaya)

Phone:
Grams: NEHU

NO 395
Date: 16.2.2009.

To
The Controller of Exams.,
NEHU, Shillong.

Sir,

I am sending here with the time table and a copy of the course structure and the Syllabus of Mathematics (under CBCS) commencing from February, 19th , 2009, for your necessary action.

Day/time	9.30-1030
Tuesday	FORTRAN Programming
Wednesday	FORTRAN Programming
Thursday	FORTRAN Programming

Thanking you,

Yours sincerely,

(H.K. Mukerjee)
Head, Dept. of Mathematics,
NEHU, Shillong.

Copy to:
1. The Dean School of Physical Sciences, NEHU, Shillong.
2. The System Analyst; VSAT (Please correct the web page entry by inserting the enclosed syllabus ~~by~~ the one already in the web page which is the older syllabus). replacing.