Proposed Course Structure of Mathematics (UG)

Raja N.L. Khan Women's College (Autonomous)

Curriculum for B.Sc Honours in Mathematics (Choice Based Credit System)

Semester – I

Course Type	Course Details		Teaching Scheme in hour per week			Credit	Marks
			L	T	P		
MTMH-C101	**Group-A**	Calculus	5	1	0	6	75
	Group-B	Geometry					
	Group-C	History of Mathematics					
MTMH - C102	**Group-A**	Classical Algebra	5	1	0	6	75
	Group-B	Abstract Algebra-I					
	Group-C	Linear Algebra-I					
GE-1		TBD				4/5	75
		TBD				2/1	
AECC		English				2	50
			Total Credits = 20				

AECC – Ability Enhancement Compulsory Course:

English / Modern English

Language Interdisciplinary / Generic Elective (GE)

From other department

[Four papers are to be taken and each paper will be of 6 credits]: papers are to be taken from any of the discipline:

Physics/Chemistry/Computer Science/Statistics/Geology/Electronics/Economics/Physiology/Bio-technology

Core Course (CC)

MTMH – C101: Calculus, Geometry & History of Mathematics (Credits 06)

Group-A: Calculus **Marks: 24**

Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b}\sin x, e^{ax+b}\cos x$, $(ax+b)^n \sin x, (ax+b)^n \cos x$, concavity and inflection points, envelopes, asymptotes, curve tracing in cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences.

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int (\sin nx)dx, \int (\cos nx)dx, \int (\tan nx)dx$, $\int (\sec nx)dx$, $\int (\log x)^n dx$, $\int (\sin x)^n (\cos x)^m dx$, parametric equations, parameterizing a curve, arc length of a curve, arc length of parametric curves, area under a curve, area and volume of surface of revolution, techniques of sketching conics.

Group-B: Geometry **Marks: 27**

Reflection properties of conics, rotation of axes and second degree equations, classification of conics using the discriminant, polar equations of conics.

Spheres. Cylindrical surfaces. Central conicoid, paraboloids, plane sections of conicoid, generating lines, classification of quadrics, illustrations of graphing standard quadric surfaces like cone, ellipsoid.

Group C: History of Mathematics **Marks: 09**

Pre historic mathematics, the historical period down to 1000 BC: Contribution of India, Babylon and Egypt. The period from 1000 B.C to 300 B.C: origin of Green mathematics, from Pythagoras to Plato, influence of Plato and Aristotal. The period from 300 B.C to 500 A.M: the school of Alexandria, Euclid, Eratosthenes and Archimedis. The period from 500 AM to 1000 A.M: Contribution of India and China. The orient from 1000 to 1500: India and China. The sixteenth century, the seventh century, Contribution of India, Copernicus, Galileo, Descartes, Pascal, Marquis De, L'Hopitals, Napier, Newton, Wallis, Leibnitz, Keplar, Bernoulli's, The eighteenth century and after: Taylor, Maclurin, Sir William, De-Moivre, Rowan Hamilton, D'Alembert, Lagrange, Laplace, Legendre, Gauss, Jacobi, Weistrass, Dedikind, Cantor, Euler.

Graphical Demonstration (Teaching Aid)

1. Plotting of graphs of function e^{ax+b}, $\log(ax+b)$, $1/(ax+b)$, $\sin(ax+b)$, $\cos(ax+b)$, $|ax+b|$ and to illustrate the effect of a and b on thegraph.
2. Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
3. Sketching parametric curves (E.g. trochoid, cycloid, epicycloids, hypocycloid).
4. Obtaining surface of revolution of curves.
5. Tracing of conics in cartesian coordinates/ polar coordinates.
6. Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, and hyperbolic paraboloid using cartesian coordinates.

Reference Books

- G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
- M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi,2007.
- H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
- R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1989.
- S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India,2004.
- Murray, D., Introductory Course in Differential Equations, Longmans Green andCo.
- G.F. Simmons, Differential Equations, Tata Mcgraw Hill.
- T. Apostol, Calculus, Volumes I andII.
- S. Goldberg, Calculus and mathematical analysis.

MTMH-C102: Algebra **(Credits 06)**

Group-A: Classical Algebra **Marks:23**

Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications.

Theory of equations: Relation between roots and coefficients, transformation of equation, Descartes rule of signs, cubic and biquadratic equation, Ferrari's method, Cardon's method.

Inequality: The inequality involving AM≥ GM≥ HM, Cauchy-Schwartz inequality.

Group-B: Abstract Algebra-I **Marks: 14**

Equivalence relations. Functions, composition of functions, Invertible functions, one to one correspondence and cardinality of a set. Well-ordering property of positive integers, division algorithm, divisibility and Euclidean algorithm. Congruence relation between integers. Principles of Mathematical induction, statement of Fundamental Theorem of Arithmetic.

Group-C: Linear Algebra-I **Marks: 23**

Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence.

Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of R^n, dimension of subspaces of R^n, rank of a matrix, Eigen values, eigen vectors and characteristic equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix.

Reference Books

- Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
- Edgar G. Goodire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
- David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
- K.B. Dutta, Matrix and linearalgebra.
- K. Hoffman, R. Kunze, Linearalgebra.
- W.S. Burnstine and A.W. Panton, Theory ofequations.

Generic Course (GE)

MTM-GE101: Numerical Methods and Differential Calculus-I **Credits 06**

Group-A: Numerical Methods **Marks-34**
Unit 1
Algorithms, convergence, relative errors, absolute errors, round off, truncation.
Unit 2
Transcendental and polynomial equations: Bisection method, Newton's method, secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Rate of convergence of these methods.
Unit 3
System of linear algebraic equations: Gaussian elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. LU decomposition.
Unit 4
Interpolation: Lagrange and Newton's methods, Error bounds, Finite difference operators, Gregory forward and backward difference interpolation. Numerical differentiation: Methods based on interpolations, methods based on finite differences.
Unit 5
Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Simpsons 3/8th rule, Weddle's rule, Boole's Rule. Midpoint rule, Composite trapezoidal rule, composite Simpson's 1/3rd rule, Gauss quadrature formula. The algebraic eigen value problem: Power method. Approximation: Least square polynomial approximation.
Unit 6
Ordinary differential equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four.
Group-B: Differential Calculus-I **Marks-26**
Unit-1
Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$, concavity and inflection points, envelopes, asymptotes, curve tracing in cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences.
Unit-2
Reduction formulae, derivations and illustrations of reduction formulae of the type $\int(\sin nx)dx, \int(\cos nx)dx, \int(\tan nx)dx, \int(\sec nx)dx$, $\int(\log x)^n dx$, $\int(\sin x)^n(\cos x)^m dx$, parametric equations, parameterizing a curve, arc length of a curve, arc length of parametric curves, area under a curve, area and volume of surface of revolution, techniques of sketching conics.

Reference Books

- Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
- C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
- G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
- H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
- John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
- M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi,2007
- M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Ed., New age International Publisher, India, 2007.
- R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1989.
- S. Goldberg, Calculus and mathematicalanalysis.
- S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
- Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishingco.
- T. Apostol, Calculus, Volumes I andII.
- Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.

Proposed Course Structure of Mathematics (UG)

Raja N.L. Khan Women's College (Autonomous)

Curriculum for B.Sc Honours in Mathematics (Choice Based Credit System)

Semester - II

Course Type		Name of the Subject	Teaching Scheme in hour per week			Credit	Marks
			L	T	P		
MTMH-C201	Group A	Group Theory-I	5	1	0	6	75
	Group B	Vector Analysis-I					
MTMH-C202		Real Analysis-I	5	1	0	6	75
MTM-GE201		GE-2				4/5	75
		GE-2				2/1	
AECC- 2		Environmental Studies				4	100
			Total Credits = 22				

L=Lecture, T=Tutorial, P=Practical

AECC- Ability Enhancement Compulsory Course:

Environmental Studies.

Interdisciplinary/Generic Elective (GE)

From other Departments.
[Four papers are to be taken and each paper will be of 6 credits]: papers are to be taken from any of the discipline:

Physics/Chemistry/Computer Science/Statistics/Geology/Electronics/Economics/Physiology/Bio-technology

Core Course

MTMH – C201: Group Theory-I & Vector Analysis-I (Credits 06)

Group A: Group Theory-I **Marks-37**

Symmetries of a square, dihedral groups, definition and examples of groups including permutation groups and quaternion groups (through matrices), elementary properties of groups.

Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups.

Properties of cyclic group, classification of subgroups of cyclic groups. Cyclic notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.

Group-B: Vector Analysis-I **Marks-23**

Triple product, introduction to vector functions, operations with vector-valued function, limits and continuity of vector functions, differentiation and integration of vector functions. Vector equation of straight line and plane, Solution of vector equation, Application of vector in mechanics, Lamis's theorem.

Reference Books:

- John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
- M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
- Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
- D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.
- Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.
- I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
- Maity, K.C. and Ghosh, R.K. Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India).
- M.R. Speigel, Schaum's outline of Vector Analysis.
- Marsden, J., and Tromba, Vector Calculus, McGraw Hill.

MTMH-C202: Real Analysis-I **Credits-06**

Real Analysis-I	**Marks-60**

Review of algebraic and order properties of R, ε-neighborhood of a point in R. Idea of countable sets, uncountable sets and uncountability of R. Bounded above sets, bounded below sets, bounded sets, unbounded sets. Suprema and infima. Completeness property of R and its equivalent properties. The Archimedean property, density of rational (and Irrational) numbers in R, intervals. Limit points of a set, isolated points, open set, closed set, derived set, Illustrations of Bolzano-Weierstrass theorem for sets, compact sets in R, Heine-Borel Theorem.

Sequences, bounded sequence, convergent sequence, limit of a sequence, liminf, limsup. Limit theorems. Monotone sequences, monotone convergence theorem. Subsequences, divergence criteria. Monotone subsequence theorem (statement only), Bolzano Weierstrass theorem for sequences. Cauchy sequence, Cauchy's convergence criterion.

Infinite series, convergence and divergence of infinite series, Cauchy criterion, tests for convergence: comparison test, limit comparison test, D'Alembert,s ratio test, Raabes test, Cauchy's nth root test, integral test. Logarithmic test, Cauchy's condensation test, Gauss's test, Alternating series, Leibniz test, Abel's test, Dirichlet's test. Absolute and conditional convergence.

Reference Books

- R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003.
- Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.
- K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2004.
- Mattuck, Introduction to Analysis, Prentice Hall, 1999.
- S.R. Ghorpade and B.V. Limaye, a Course in Calculus and Real Analysis, Springer, 2006.
- T. Apostol, Mathematical Analysis, Narosa Publishing House
- Courant and John, Introduction to Calculus and Analysis, Vol II, Springer
- W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
- Terence Tao, Analysis II, Hindustan Book Agency, 2006.
- S. Goldberg, Calculus and mathematical analysis.
- Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones& Bartlett, 2010.
- Introduction to Real Analysis, S.K. Mapa

Generic Course (GE)

MTM-GE201 Differential Equations and Differential Calculus-II Credit 06

Group-A: Differential Equation Marks-28

Unit 1

Lipschitz condition and Picard's Theorem (Statement only). General solution of homogeneous equation of second order, Principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

Unit 2

Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients.

Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions.

Unit 3

Equilibrium points, Interpretation of the phase plane, Power series solution of a differential equation about an ordinary point, solution about a regular singular point.

Group-B: Differential Calculus-II Marks-32

Unit 1

Differentiability of a function at a point and in an interval, algebra of differentiable functions. Relative extrema, interior extremum theorem. Rolle's theorem. Mean value theorem, intermediate value property of derivatives, Darboux's theorem.
Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, ln (1 + x), Sinx, Cosx, e^x and $(x+1)^n$.

Unit 2

Functions of several variables, limit and continuity of functions of two or more variables.
Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes.

Reference Books

- Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed., Taylor and Francis group, London and New York, 2009.

- C.H. Edwards and D.E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.
- S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
- Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
- Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
- Boyce and Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley.
- G.F. Simmons, Differential Equations, Tata McGraw-Hill
- G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
- M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi,2007.
- H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
- R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1989.
- T. Apostol, Calculus, Volumes I and II.
- S. Goldberg, Calculus and mathematical analysis.

Proposed Course Structure of Mathematics (UG)

Raja N.L. Khan Women's College (Autonomous)

Curriculum for B.Sc Honours in Mathematics (Choice Based Credit System)

Semester – III

Course Type	Course Details		Teaching Scheme in hours per week			Credits	Marks
			L	T	P		
MTMH-C301	Group A	Ordinary Differential Equations	5	1	0	6	75
	Group B	Applications of Dynamics					
MTMH-C302	Group A	Group Theory-II	5	1	0	6	75
	Group B	Linear Algebra-II					
MTMH-C303		Real Analysis-II	5	1	0	6	75
MTM-GE301		TBD				4/5	75
		TBD				2/1	
MTMH-SEC301		C-Programming/ Object Oriented Programming in C++	1	1	0	2	50
			Total Credits =26				

Core Course (CC)

MTMH C301: Ordinary Differential Equations and Applications to Dynamics
Credits-06

Group A: Ordinary Differential Equations **Marks-36**

Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

Lipschitz condition and Picard's Theorem (Statement only). General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and nonhomogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions.

Equilibrium points, Interpretation of the phase plane
Power series solution of a differential equation about an ordinary point, solution about a regular singular point.

Group B: Applications to Dynamics **Marks-24**

Dynamics of Particle: Motion in Plane (Radial and cross radial, tangential and normal components), Central force. Constrained motion, Varying mass, Planetary motion.

Reference Books

- S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
- Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
- Boyce and Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley.
- G.F. Simmons, Differential Equations, Tata Mc Graw Hill.
- Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed.,Taylor and Francis group, London and New York, 2009.
- C.H. Edwards and D.E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.
- Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
- Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press.

MTMH C302: Group Theory-II & Linear Algebra-II **Credits-06**

Group Theory-II	**Marks-24**
External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups. Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms. First, Second and Third isomorphism theorems. Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties.	
Linear Algebra-II	**Marks-36**
Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces. Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Isomorphisms. Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.	
Reference Books	

- Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Edition., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
- John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
- M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
- Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
- D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.
- Kennath Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice- Hall of India Pvt. Ltd., 1971.
- D.A.R Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.
- S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
- S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2007.
- Gilbert Strange, Linear Algebra and Its Applications, Thomson, 2007.

MTMH C303: Real Analysis-II **Credits-06**

Real Analysis-II	**Marks-60**
Limits of functions (ε - δ approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity. Continuous functions, sequential criterion for	

continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem.

Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, interior extremum theorem. Rolle's theorem. Mean value theorem, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials.

Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, ln (1 + x), 1/(ax + b) and(x+1)n . Application of Taylor's theorem to inequalities.

Functions of several variables, limit and continuity of functions of two or more variables Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems.

Reference Books

- R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003.
- Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.
- K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2004.
- A Mattuck, Introduction to Analysis, Prentice Hall, 1999.
- S.R. Ghorpade and B.V. Limaye, a Course in Calculus and Real Analysis, Springer, 2006.
- T. Apostol, Mathematical Analysis, Narosa Publishing House
- Courant and John, Introduction to Calculus and Analysis, Vol II, Springer
- W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
- Terence Tao, Analysis II, Hindustan Book Agency, 2006.
- S. Goldberg, Calculus and mathematical analysis.
- Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones& Bartlett, 2010.
- E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), Indian reprint, 2005.
- James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001
- G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.

Skill Enhancement Course (SEC)

MTMH SEC301: C-Programming/ Object Oriented Programming in C++

Credits-02

C-Programming/ Object Oriented Programming in C++	**Marks-50**
Character set in. Key words: if, while, do, for, int, char, float, etc. Data type: character, integer, floating point, etc. Variables, Operators: =, == ,!, < > , etc. (arithmetic, assignment, relational, logical, increment, etc.). Expressions: arithmetic and logical expressions. Standard input/output. Use of while, if-else, for, do - while, switch, continue, etc. Arrays, strings, user defined function. Header File. Programming paradigms, characteristics of object oriented programming languages, brief history of C++, structure of C++ program, differences between C and C++, basic C++ operators, Comments, working with variables, enumeration, arrays and pointer. Objects, classes, constructor and destructors, friend function, inline function, encapsulation, data abstraction, inheritance, polymorphism, dynamic binding, operator overloading, method overloading, overloading arithmetic operator and comparison operators.	
Reference Books	
➢ A. R. Venugopal, Rajkumar, and T. Ravishanker, Mastering C++, TMH, 1997. ➢ S. B. Lippman and J. Lajoie, C++ Primer, 3rd Ed., Addison Wesley, 2000. ➢ Bruce Eckel, Thinking in C++, 2nd Ed., President, Mindview Inc., Prentice Hall. ➢ D. Parasons, Object Oriented Programming with C++, BPB Publication. ➢ BjarneStroustrup, The C++ Programming Language, 3rd Ed., Addison Welsley. ➢ E. Balaguruswami, Object Oriented Programming In C++, Tata McGrawHill. ➢ Herbert Scildt, C++, The Complete Reference, Tata McGrawHill.	

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Generic Course (GE)

MTM-GE301: Analytical Geometry, Algebra & Vector Algebra **Credit 06**

Group-A: Analytical Geometry **Marks-21**

Two dimensions: Polar equations of straight lines and circles, Polar equation of a conic referred to a focus as pole, equations of chord; tangent and normal. Transformations of rectangular axes: Translation, rotation and their combinations. General equation of second degree in two variables and its reduction to canonical (normal) forms. Classification of conics and their equations in canonical forms. Pairs of straight-lines: Condition that the general equation of second degree may represent two straight lines. Point of intersection of two intersecting straight lines, angle and angle bisectors between two lines given by $ax2 + 2hxy + by2 = 0$. Equations of two straight lines joining the origin to the points in which line meets a conic.

Group-B: Algebra **Marks-30**

Complex Number: Algebra of complex number, Modulus and Amplitude of complex number, De Moivre's theorem and its applications.

Determinants: Properties, co-factors and minors, reduction of determinants, product of two determinants, ad joint and inverse of a determinant, symmetric and skew symmetric determinants.

Matrices of real numbers: Equality of matrices, addition of matrices, multiplication of a matrix by a scalar. Multiplication of matrices-distributive, associative properties. Transpose of matrix-its properties. Square matrices. Symmetric, skew symmetric matrices, scalar matrices, identity matrix, inverse of a non-singular scalar matrix. Orthogonal matrix, rank of a matrix, determination of rank, solution of a system of linear equations with not more than three variables by matrix method (not involving ranks).

Theory of Set: Algebra of sets, Universal set, Empty set, Subsets, Union and Intersection of sets, Partition, Finite Set, Complements, Venn Diagram, Cartesian product of two sets, Mappings, One-to-one and onto mappings, Composition of Mappings.

Group: Definition and examples taken from various branches (examples from number system roots of unity, 2 x 2 real matrices, non-singular real matrices of a fixed order). Elementary properties using the definition of group. Definition and examples of sub groups.

Ring and Field: Definition and examples of ring sub-ring. Integral Domain, Division of zero, every field is an integral domain. Field, sub-field

Group-C: Vector Algebra **Marks-09**

Vector Algebra: Collinear and coplanar vectors, scalar and vector product of two vectors, scalar triple product of three vectors and its geometrical interpretation, simple application to geometry.

Reference Books

- Maity, K.C. and Ghosh, R.K. Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India).
- M.R. Speigel, Schaum's outline of Vector Analysis.
- Marsden, J., and Tromba, Vector Calculus, McGraw Hill.
- Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
- David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
- K.B. Dutta, Matrix and linear algebra.
- K. Hoffman, R. Kunze, Linear algebra.
- W.S. Burnstine and A.W. Panton, Theory of equations.

Proposed Course Structure of Mathematics (UG)

Raja N.L. Khan Women's College (Autonomous)

Curriculum for B.Sc Honours in Mathematics (Choice Based Credit System)

Semester – IV

Course Type	Course Details		Teaching Scheme in hours per week			Credits	Marks
			L	T	P		
MTMH-C401		Numerical Methods	4	0	0	6	75
		Lab	0	0	4		
MTMH-C402		Ring Theory-I	5	1	0	6	75
MTMH-C403	Group A	Vector Analysis-II	5	1	0	6	75
	Group B	Metric Space-I					
MTM-GE401		TBD				4/5	75
		TBD				2/1	
MTMH-SEC401		Graph Theory	1	1	0	2	50
			Total Credits =26				

Core Course (CC)

MTMH C401: Numerical Methods and Labs **Credits-04**

Group A: Numerical Methods **Marks-40**

Algorithms. Convergence. Errors: relative, absolute. Round off. Truncation.

Transcendental and polynomial equations: Bisection method, Newton's method, secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Rate of convergence of these methods.

System of linear algebraic equations: Gaussian elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. LU decomposition

Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation. Numerical differentiation: Methods based on interpolations, methods based on finite differences.

Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's $1/3^{rd}$ rule, Simpsons 3/8th rule, Weddle's rule, Boole's Rule. midpoint rule, Composite trapezoidal rule, composite Simpson's $1/3^{rd}$ rule, Gauss quadrature formula. The algebraic eigen value problem: Power method. Approximation: Least square polynomial approximation.

Ordinary differential equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four.

Reference Books

- Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India,2007.
- M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering
- Computation, 6th Ed., New age International Publisher, India, 2007.
- C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
- Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.
- John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
- Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co.
- Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978.
- Yashavant Kanetkar, Let Us C , BPB Publications.

Group B: Numerical Lab **Marks-20** **Credits-02**

List of practical (using any software)

1. Calculate the sum 1/1 + 1/2 + 1/3 +1/4 + ----------+ 1/N.
2. Enter 100 integers into an array and sort them in an ascending order.

3. Solution of transcendental and algebraic equations by
   i) Bisection method
   ii) Newton Raphson method.
   iii) Secant method.
   iv) Regula Falsi method.
4. Solution of system of linear equations
   i) LU decomposition method
   ii) Gaussian elimination method
   iii) Gauss-Jacobi method
   iv) Gauss-Seidel method
5. Interpolation
   i) Lagrange Interpolation
   ii) Newton Interpolation
6. Numerical Integration
   i) Trapezoidal Rule
   ii) Simpson's one third rule
   iii) Weddle's Rule
   iv) Gauss Quadrature
7. Method of finding Eigen value by Power method
8. Fitting a Polynomial Function
9. Solution of ordinary differential equations
   i) Euler method
   ii) Modified Euler method
   iii) Runge Kutta method

Note: For any of the CAS (Computer aided software) Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.

MTMH C402: Ring Theory-I **Credits-06**

Ring Theory-I	**Marks-60**

Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals.

Ring homomorphisms, properties of ring homomorphisms. Isomorphism theorems I, II and III, field of quotients.

Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, and unique factorization in Z [x]. Divisibility in integral domains, irreducible, primes, unique factorization domains, Euclidean domains.

Reference Books

- Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Edition., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
- John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
- M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
- Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
- D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.
- Kennath Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice- Hall of India Pvt. Ltd., 1971.
- D.A.R Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.
- S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
- S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2007.
- Gilbert Strange, Linear Algebra and Its Applications, Thomson, 2007.

MTMH C403: Vector Analysis-II & Metric Space –I Credits-06

Group A: Vector Analysis-II **Marks-37**

Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates. Change of variables in double integrals and triple integrals.

Definition of vector field, divergence and curl. Line integrals, applications of line integrals: mass and work. Fundamental theorem for line integrals, conservative vector fields, independence of path.

Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem.

Group B: Metric Space – I **Marks-23**

Definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, subspaces, dense sets, separable spaces.

Sequences in metric spaces, Cauchy sequences. Complete metric spaces, Cantor's theorem.

Reference Books

- Marsden, J., and Tromba, Vector Calculus, McGraw Hill.
- M.R. Speigel, Schaum's outline of Vector Analysis.
- S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House,2011.
- Maity, K.C. and Ghosh, R.K. Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India).
- G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 2004.
- Satish Shirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.

Skill Enhancement Course (SEC)

MTMH SEC401: Graph Theory **Credits-02**

Graph Theory	**Marks-50**

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bipartite graphs isomorphism of graphs.

Eulerian circuits, Eulerian graph, semi-Eulerian graph, theorems, Hamiltonian cycles, theorems Representation of a graph by matrix, the adjacency matrix, incidence matrix, weighted graph,

Tree and their properties, shortest path, Dijkstra's algorithm, Travelling salesman's problem, spanning tree, Warshall algorithm.

Reference Books

- B.A. Davey and H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.
- Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.
- Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

Generic Course (GE)

MTM-GE401: Differential Calculus III, Integral Calculus, Differential Equations and Probability and Statistics

Credit 06

Group-A: Differential Calculus	**Marks-20**
Algebra of limits and continuity (no proof), Definition and acquaintance (no proof required) with the properties of continuous function on closed intervals, Derivatives- its geometric and physical interpretation, rule of differentiation (a revision of previous knowledge only), Differential and its geometrical interpretation. Successive derivatives, Leibnitz theorem: increasing and decreasing function, sign of the derivatives, statement of Rolle's theorem and its geometrical interpretation, Lagrange's Mean value theorems and its geometrical interpretation, Cauchy's mean value theorem. Intermediate forms, L'Hospital's rule, maxima and minima (Differentiations and acquaintance with rules of finding extreme, emphasis on solving problems only).	
Group-B: Integral Calculus	**Marks-09**
Indefinite integration: Standard form, Methods by substitution and integration by parts (Revision of previous knowledge), Integration of rational function and trigonometric function, Definite integral as the limit sum, Geometrical interpretation of definite integrals of bounded continuous functions, Fundamental theorem of integral calculus, Properties of definite integral and their applications.	
Group-C: Differential Equations	**Marks-12**
First order linear and non-linear differential equations, Applications in simple geometrical problems, Second order linear differential equations with constant coefficients.	
Group-D: Probability and Statistics	**Marks-19**
Unit 1	
Random experiments, Statistical regularity and idea of probability as long run mutually exclusive and exhaustive events, union, intersection and complement, classical definition of probability, axiomatic approach of probability theory (detailed treatment not required), theorems on union of a number of events, conditional probability, theorem of total probability and Bayes' theorem, independent event and independent trails, random variable and its probability distribution (Binomial, Poisson, Normal, Uniform, Exponential Distribution), expectation and variance.	
Unit 2	
Qualitative and quantitative characters, Discrete variable and continuous variable, frequency distribution and its graphical representation, measure of central tendency (mean, median and mode), measures of dispersion (range, mean, deviation and standard deviation), correlation and regression.	

Reference Books

- T. Apostol, Calculus, Volumes I and II.
- S. Goldberg, Calculus and mathematical analysis.
- G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
- Gupta, Ground work of Mathematical Probability and Statistics, Academic publishers.
- Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
- Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006.
- Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.
- Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007.
- S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
- Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
- Boyce and Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley.

Proposed Course Structure of Mathematics (UG)

Raja N.L. Khan Women's College (Autonomous)

Curriculum for B.Sc Honours in Mathematics (Choice Based Credit System)

Semester - V

Course Type	Course Details		Teaching Scheme in hour per week			Credits	Marks
			L	T	P		
MTMH-C501		Real Analysis-III	5	1	0	6	75
MTMH-C502	Group A	Partial Differential Equations	5	1	0	6	75
	Group B	Metric Space-II					
MTMH-DSE501		Linear Programming Problem Or Point Set Topology Or Theory of Equations				6	75
MTMH-DSE502		Probability and Statistics Or Boolean Algebra and Automata Theory Or Portfolio Optimization				6	75
			Total Credits=24				

Course Core (CC)

MTMH C501: Real Analysis – III **Credits 06**

Real Analysis – III	**Marks-60**

Riemann integration: inequalities of upper and lower sums, Darbaux integration, Darbaux theorem, Riemann conditions of integrability, Riemann sum and definition of Riemann integral through Riemann sums, equivalence of two definitions. Riemann integrability of monotone and continuous functions, properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorem of Integral Calculus.

Improper integrals. Convergence of Beta and Gamma functions.

Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.

Fourier series: Definition of Fourier coefficients and series, Reimann Lebesgue lemma, Bessel's inequality, Parseval's identity, Dirichlet's condition. Examples of Fourier expansions and summation results for series.

Power series, radius of convergence, Cauchy Hadamard theorem. Differentiation and integration of power series; Abel's theorem; Weierstrass approximation theorem.

Reference Books

- K.A. Ross, Elementary Analysis, The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
- R.G. Bartle D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
- Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011.
- S. Goldberg, Calculus and mathematical analysis.
- Santi Narayan, Integral calculus.

MTMH C502: Partial Differential Equations & Metric Space – II **Credits 06**

Group A: Partial Differential Equation	**Marks-42**

Partial differential equations – Basic concepts and definitions. Mathematical problems. First- order equations: classification, construction and geometrical interpretation. Method of characteristics for obtaining general solution of quasi linear equations. Canonical forms of first-order linear equations. Method of separation of variables for solving first order partial differential equations.

Derivation of heat equation, wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order linear equations to canonical forms.

The Cauchy problem, Cauchy-Kowalewskaya theorem, Cauchy problem of an infinite string. Initial boundary value problems. Semi-infinite string with a fixed end, semi-infinite string with a free end. Equations with non-homogeneous boundary conditions. Non- homogeneous wave equation. Method of separation of variables, solving the vibrating string problem. Solving the heat conduction problem

Group B: Metric Space – II **Marks-18**

Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Connectedness, connected subsets of R, Continuous functions on Connected sets.

Compactness: Sequential compactness, Heine-Borel property, totally bounded spaces, finite intersection property, and continuous functions on compact sets. Homeomorphism. Contraction mappings. Banach fixed point theorem and its application to ordinary differential equation.

Reference Books

- Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, 4th edition, Springer, Indian reprint, 2006.
- S.L. Ross, Differential equations, 3rd Ed., John Wiley and Sons, India, 2004.
- Martha L Abell, James P Braselton, Differential equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
- Sneddon, I. N., Elements of Partial Differential Equations, McGraw Hill.
- Miller, F. H., Partial Differential Equations, John Wiley and Sons.
- S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House,2011.
- G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 2004.
- Satish Shirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.

Discipline Specific Elective (DSE)

MTMH DSE501: Linear Programming Problem **Credits 06**

Linear Programming Problem **Marks-60**

Introduction to linear programming problem. Theory of simplex method, graphical solution, convex sets, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method. Big-M method and their comparison.

Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual. Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem. Travelling salesmen problem.

Game theory: formulation of two persons zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.

Reference Books

- Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
- F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
- Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.
- G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

Or

MTMH DSE 501: Point Set Topology **Credits 06**

Point Set Topology **Marks-60**

Countable and Uncountable Sets, Schroeder-Bernstein Theorem, Cantor's Theorem. Cardinal numbers and cardinal arithmetic. Continuum Hypothesis, Zorns Lemma, Axiom of Choice. Well-ordered sets, Hausdorff's maximal principle. Ordinal numbers.

Topological spaces, basis and Subbasis for a topology, subspace topology, interior points, limit points, derived set, boundary of a set, closed sets, closure and interior of a set. Continuous functions, open maps, closed maps and homeomorphisms. Product topology, quotient topology, metric topology, Baire category theorem.

Connected and path connected spaces, connected sets in R, components and path components, local connectedness. Compact spaces, compact sets in R. Compactness in metric spaces. Totally bounded spaces, Ascoli-Arzela theorem, the Lebesgue number lemma. Local compactness.

Reference Books

- Munkres, J.R., Topology, A First Course, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
- Dugundji, J., Topology, Allyn and Bacon, 1966.
- Simmons, G.F., Introduction to Topology and Modern Analysis, McGraw Hill, 1963.
- Kelley, J.L., General Topology, Van Nostrand Reinhold Co., New York,1995.
- Hocking, J., Young, G., Topology, Addison-Wesley Reading, 1961.
- Steen, L., Seebach, J., Counter Examples in Topology, Holt, Reinhart and Winston, New York, 1970.
- Abhijit Dasgupta, Set Theory, Birkhäuser.

Or

MTMH DSE 501: Theory of Equations **Credits 06**

Theory of Equations	**Marks-60**

General properties of polynomials, Graphical representation of a polynomial, maximum and minimum values of a polynomials, General properties of equations, Descarte's rule of signs positive and negative rule, Relation between the roots and the coefficients of equations.

Symmetric functions. Applications of symmetric function of the roots. Transformation of equations. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic. Properties of the derived functions.

Symmetric functions of the roots, Newton's theorem on the sums of powers of roots, homogeneous products, limits of the roots of equations.

Separation of the roots of equations, Strums theorem. Applications of Strum's theorem, conditions for reality of the roots of an equation. Solution of numerical equations.

Reference Books

- W.S. Burnside and A.W. Panton, The Theory of Equations, Dublin University Press, 1954.
- C. C. MacDuffee, Theory of Equations, John Wiley & Sons Inc., 1954.

MTMH DSE 502: Probability & Statistics **Credits 06**

Probability & Statistics	**Marks-60**

Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential.

Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables.

Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers. Central limit theorem for independent and identically distributed random variables with finite variance, Markov chains, Chapman-Kolmogorov equations, classification of states.

Random Samples, Sampling Distributions, Estimation of parameters, Testing of hypothesis.

Reference Books

- Gupta, Ground work of Mathematical Probability and Statistics, Academic publishers.
- Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.

- Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006.
- Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.
- Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007.

Or

MTMH DSE 502: Boolean Algebra and Automata Theory **Credits 06**

Boolean Algebra and Automata Theory	**Marks-60**

Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, lattices as ordered sets, lattices as algebraic structures, sublattices, products and homomorphisms.

Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal and maximal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, Logic gates, switching circuits and applications of switching circuits.

Introduction: Alphabets, strings, and languages. Finite automata and regular languages: deterministic and non-deterministic finite automata, regular expressions, regular languages and their relationship with finite automata, pumping lemma and closure properties of regular languages.

Context free grammars and pushdown automata: Context free grammars (CFG), parse trees, ambiguities in grammars and languages, pushdown automaton (PDA) and the language accepted by PDA, deterministic PDA, Non- deterministic PDA, properties of context free languages; normal forms, pumping lemma, closure properties, decision properties.

Turing Machines: Turing machine as a model of computation, programming with a Turing machine, variants of Turing machine and their equivalence.

Undecidability: Recursively enumerable and recursive languages, undecidable problems about Turing machines: halting problem. Post correspondence problem, and undecidability problems about CFGs.

Reference Books

- B A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.
- Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory,
- (2nd Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint 2003.
- Rudolf Lidl and Günter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
- J. E. Hopcroft, R. Motwani and J. D. Ullman, Introduction to Automata Theory, Languages, and Computation, 2nd Ed., Addison-Wesley, 2001.
- H.R. Lewis, C.H. Papadimitriou, C. Papadimitriou, Elements of the Theory of Computation, 2nd Ed., Prentice-Hall, NJ, 1997.

- J.A. Anderson, Automata Theory with Modern Applications, Cambridge University Press, 2006.

Or

MTMH DSE 502: Portfolio Optimization **Credits 06**

Portfolio Optimization	**Marks-60**
Financial markets. Investment objectives. Measures of return and risk. Types of risks. Risk free assets. Mutual funds. Portfolio of assets. Expected risk and return of portfolio. Diversification. Mean-variance portfolio optimization- the Markowitz model and the two-fund theorem, risk-free assets and one fund theorem, efficient frontier. Portfolios with short sales. Capital market theory. Capital assets pricing model- the capital market line, beta of an asset, beta of a portfolio, security market line. Index tracking optimization models. Portfolio performance evaluation measures.	

Reference Books

- F. K. Reilly, Keith C. Brown, Investment Analysis and Portfolio Management, 10th Ed., South-Western Publishers, 2011.
- H.M. Markowitz, Mean-Variance Analysis in Portfolio Choice and Capital Markets, Blackwell, New York, 1987.
- M.J. Best, Portfolio Optimization, Chapman and Hall, CRC Press, 2010.
- D.G. Luenberger, Investment Science, 2nd Ed., Oxford University Press, 2013.

Proposed Course Structure of Mathematics (UG)

Raja N.L. Khan Women's College (Autonomous)

Curriculum for B.Sc Honours in Mathematics (Choice Based Credit System)

Semester - VI

Course Type	Course Details		Teaching Scheme in hour per week			Credits	Marks
			L	T	P		
MTMH-C601		Group Theory-III	5	1	0	6	75
MTMH-C602	Group A	Linear Algebra-III	5	1	0	6	75
	Group B	Complex Analysis					
MTMH-DSE601		Mechanics Or Number Theory Or Industrial Mathematics				6	75
MTMH-DSE602		Mathematical Modeling Or Differential Geometry Or Bio Mathematics				6	75
			Total Credits=24				

Course Core (CC)

MTMH C601: Group Theory-III **Credits 06**

Group Theory-III	**Marks-60**
Properties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental theorem of finite abelian groups. Group actions, stabilizers and kernels, permutation representation associated with a given group action. Applications of group actions. Generalized Cayley's theorem. Index theorem. Groups acting on themselves by conjugation, class equation and consequences, conjugacy in Sn, p-groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity of An for $n \geq 5$, non-simplicity tests.	
Reference Books	
➢ John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002. ➢ M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011. ➢ Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999. ➢ D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra. ➢ Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995. ➢ I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975. ➢ David S. Dummit and Richard M. Foote, Abstract Algebra, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004. ➢ J.R. Durbin, Modern Algebra, John Wiley & Sons, New York Inc., 2000. ➢ D. A. R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.	

MTMH C602: Linear Algebra-III & Complex Analysis **Credits 06**

Group A: Linear Algebra-III	**Marks-30**
Eigen spaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator, canonical forms. Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator. Least squares approximation, minimal solutions to systems of linear equations. Normal and self-adjoint operators. Orthogonal projections and Spectral theorem.	

Group B: Complex Analysis	**Marks-30**
Limits, limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. Analytic functions, examples of analytic functions, exponential function, logarithmic function, trigonometric function, derivatives of functions, and definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy- Goursat theorem, Cauchy integral formula. Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series	

Reference Books

- James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.
- Joseph Bak and Donald J. Newman, Complex Analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.
- S. Ponnusamy, Foundations of complex analysis.
- E.M.Stein and R. Shakrachi, Complex Analysis, Princeton University Press.
- Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Edition., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
- Kennath Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice- Hall of India Pvt. Ltd., 1971.
- S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
- S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2007.
- Gilbert Strange, Linear Algebra and Its Applications, Thomson, 2007.

Discipline Specific Elective (DSE)

MTMH DSE601: Mechanics **Credits 06**

Mechanics	**Marks-60**
Co-planar forces, Astatic equilibrium, Centre of gravity for different bodies, Friction: Equilibrium of a particle on a rough curve, Virtual work, Forces in three dimensions, Stable and unstable equilibrium. Equations of motion referred to a set of rotating axes, Motion of a projectile in a resisting medium. Stability of nearly circular orbits. Motion under the inverse square law. Slightly disturbed orbits.	

Motion of artificial satellites. Motion of a particle in three dimensions. Motion on a smooth sphere, cone, and on any surface of revolution.

Degrees of freedom. Moments and products of inertia. Momental Ellipsoid. Principal axes. D'Alembert's Principle, Motion about a fixed axis, Compound pendulum. Motion of a rigid body in two dimensions under finite and impulsive forces (Finite and varying mass). Conservation of momentum and energy

Reference Books

- I.H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, (4th Ed.), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.
- R.C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
- Chorlton, F., Textbook of Dynamics.
- Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies,Loney Press.
- Loney, S. L., Elements of Staticsand Dynamics I and II.
- Ghosh, M. C, Analytical Statics.
- Verma, R. S., A Textbook on Statics, Pothishala, 1962.
- Matiur Rahman, Md., Statics.
- Ramsey, A. S., Dynamics (Part I).

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Or

MTMH DSE 601: Number Theory **Credits 06**

Number Theory **Marks-60**

Linear diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues. Chinese remainder theorem, Fermat's little theorem, Wilson's theorem.

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function.

Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli. Public key encryption, RSA encryption and decryption, the equation $x2 + y2 = z2$, Fermat's Last theorem.

Reference Books

- David M. Burton, Elementary Number Theory, 6th Ed., Tata McGraw-Hill, Indian reprint, 2007.
- Neville Robinns, Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2007.

Or

MTMH DSE 601: Industrial Mathematics **Credits 06**

Industrial Mathematics	**Marks-60**

Medical Imaging and Inverse Problems. The content is based on Mathematics of X-ray and CT scan based on the knowledge of calculus, elementary differential equations, complex numbers and matrices.

Introduction to Inverse problems: Why should we teach Inverse Problems? Illustration of Inverse problems through problems taught in Pre-Calculus, Calculus, Matrices and differential equations. Geological anomalies in Earth's interior from measurements at its surface (Inverse problems for Natural disaster) and Tomography.

X-ray: Introduction, X-ray behavior and Beers Law (The fundamental question of image construction) Lines in the place.

Radon Transform: Definition and Examples, Linearity, Phantom (Shepp - Logan Phantom-Mathematical phantoms).

Back Projection: Definition, properties and examples.

CT Scan: Revision of properties of Fourier and inverse Fourier transforms and applications of their properties in image reconstruction. Algorithms of CT scan machine. Algebraic reconstruction techniques abbreviated as ART with application to CT scan.

Reference Books

- Timothy G. Feeman, The Mathematics of Medical Imaging, A Beginners Guide, Springer Under graduate Text in Mathematics and Technology, Springer, 2010.
- C.W. Groetsch, Inverse Problems, Activities for Undergraduates, The Mathematical Association of America, 1999.
- Andreas Kirsch, An Introduction to the Mathematical Theory of Inverse Problems, 2nd Ed., Springer, 2011.

MTMH DSE 602: Mathematical Modeling **Credits 06**

Mathematical Modeling	**Marks-60**
Power series solution of Bessel's equation and Legendre's equation, Laplace transform and inverse transform, application to initial value problem up to second order. Monte Carlo simulation modeling: simulating deterministic behavior (area under a curve, volume under a surface), generating random numbers: middle square method, linear congruence, queuing models: harbor system, morning rush hour, Overview of optimization modeling. Linear programming model: geometric solution algebraic solution, simplex method, sensitivity analysis.	
Reference Books	
➢ TynMyint-U and Lokenath Debnath, Linear Partial Differential Equation for Scientists and Engineers, Springer, Indian reprint, 2006. ➢ Frank R. Giordano, Maurice D. Weir and William P. Fox, A First Course in Mathematical Modeling, Thomson Learning, London and New York, 2003.	
Graphical demonstration as Teaching aid using any software	
1. Plotting of Legendre polynomial for n = 1 to 5 in the interval [0,1]. Verifying graphically that all the roots of Pn(x) lie in the interval [0,1]. **2.** Automatic computation of coefficients in the series solution near ordinary points. **3.** Plotting of the Bessel's function of first kind of order 0 to 3. **4.** Automating the Frobenius Series Method. **5.** Random number generation and then use it for one of the following (a) Simulate area under a curve (b) Simulate volume under a surface. **6.** Programming of either one of the queuing model (a) Single server queue (e.g. Harbor system) (b) Multiple server queue (e.g. Rush hour). **7.** Programming of the Simplex method for 2/3 variables.	

Or

MTMH DSE 602: Differential Geometry **Credits 06**

Differential Geometry	**Marks-60**
Theory of space curves: Space curves. Planer curves, curvature, torsion and Serret-Frenet formula. osculating circles, osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves. Theory of surfaces: Parametric curves on surfaces. Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Euler's theorem.	

Rodrigue's formula. Conjugate and asymptotic lines.

Developables: Developable associated with space curves and curves on surfaces. Minimal surfaces. Geodesics: Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem.

Reference Books

- T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.
- B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.
- C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press2003.
- D.J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1988.
- S. Lang, Fundamentals of Differential Geometry, Springer, 1999.
- B. Spain, Tensor Calculus: A Concise Course, Dover Publications, 2003

Or

MTMH DSE 602: Bio Mathematics **Credits 06**

Bio Mathematics **Marks-60**

Mathematical biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, bacterial growth in a chemostat, harvesting a single natural population, Prey predator systems and LotkaVolterra equations, populations in competitions, epidemic models (SI, SIR, SIRS, SIC)

Activator-inhibitor system, insect outbreak model: Spruce Budworm. Numerical solution of the models and its graphical representation. Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria. Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario. Spatial models: One species model with diffusion. Two species model with diffusion, conditions for diffusive instability, spreading colonies of microorganisms, Blood flow in circulatory system, travelling wave solutions, spread of genes in a population.

Discrete models: Overview of difference equations, steady state solution and linear stability analysis. Introduction to discrete models, linear models, growth models, decay models, drug delivery problem, discrete prey-predator models, density dependent growth models with harvesting, host-parasitoid systems (Nicholson-Bailey model), numerical solution of the models and its graphical representation. case studies. Optimal exploitation models, models in genetics, stage structure models, age structure models.

Reference Books

- L.E. Keshet, Mathematical Models in Biology, SIAM, 1988.

- J. D. Murray, Mathematical Biology, Springer, 1993.
- Y.C. Fung, Biomechanics, Springer-Verlag, 1990.
- F. Brauer, P.V.D. Driessche and J. Wu, Mathematical Epidemiology, Springer, 2008.
- M. Kot, Elements of Mathematical Ecology, Cambridge University Press, 2001.

Graphical demonstration as Teaching aid using any software

1. Growth model (exponential case only).
2. Decay model (exponential case only).
3. Lake pollution model (with constant/seasonal flow and pollution concentration).
4. Case of single cold pill and a course of cold pills.
5. Limited growth of population (with and without harvesting).
6. Predator-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
7. Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers).
8. Battle model (basic battle model, jungle warfare, long range weapons).