Directorate of Distance Learning Education

Scheme of Studies

MASTER OF SCIENCE IN MATHEMATICS

From 2012 and onwards

DEPARTMENT OF MATHEMATICS

GOVERNMENT COLLEGE UNIVERSITY, FAISALABAD

M.Sc Mathematics

SEMESTER- I

Course Code	Course Title	Credit Hours
MTH-551	Real Analysis-I	4(4-0)
MTH-553	Complex Analysis	4(4-0)
MTH-555	Vector and Tensor	4(4-0)
MTH-557	Algebra-I	4(4-0)
MTH-559	Point Set Topology	4(4-0)
Total		20

SEMESTER-II

Course Code	Course Title	Credit Hours
MTH-552	Real Analysis-II	4(4-0)
MTH-554	Algebra-II	4(4-0)
MTH-556	Mechanics	4(4-0)
MTH-558	Functional Analysis	4(4-0)
MTH-560	Differential Geometry	4(4-0)
Total		20

SEMESTER- III

PURE MTHEMATICS

COMPULSORY		
Course Code	**Course Title**	**Credit Hours**
MTH-651	Advanced Group Theory	4(4-0)
MTH-653	Advanced Set Theory	4(4-0)
Optional Paper (3 out of Following)		
MTH-655	Mathematical Statistics- I	4(4-0)
MTH-657	Continuous Groups	4(4-0)
MTH-659	Theory of Modules	4(4-0)
MTH-661	Algebraic Topology	4(4-0)
MTH-663	Advanced Topology	4(4-0)
MTH-665	Numerical Analysis-I	4(4-0)
MTH-667	Linear Algebra	4(4-0)
MTH-669	Rings and Fields	4(4-0)
Total		20

APPLIED MTHEMATICS

COMPULSORY		
Course Code	**Course Title**	**Credit Hours**
MTH-671	Fluid Mechanics-I	4(4-0)
MTH-673	Advanced Mathematical Methods	4(4-0)
Optional papers (2 out of the followings)		
MTH-655	Mathematical Statistics-I	4(4-0)
MTH-675	Special Theory of Relativity	4(4-0)
MTH-677	Operations Research	4(4-0)
MTH-679	Quantum Mechanics	4(4-0)
MTH-681	Soft Ware Engineering	4(4-0)
MTH-665	Numerical Analysis-I	4(4-0)
Total		20

SEMESTER- IV

PURE MTHEMATICS

COMPULSORY		
Course Code	**Course Title**	**Credit Hours**
MTH-652	Measure Theory	4(4-0)
MTH-654	Advanced Functional Analysis	4(4-0)
Optional Paper (2 out of Following)		
MTH-656	Rings and Modules	4(4-0)
MTH-658	Theory of Numbers	4(4-0)
MTH-660	Mathematical Statistics-II	4(4-0)
MTH-662	Numerical Analysis-II	4(4-0)
MTH-664	Theory of Optimization	4(4-0)
MTH-666	Special Functions	4(4-0)
Total		16

APPLIED MTHEMATICS

COMPULSORY		
Course Code	**Course Title**	**Credit Hours**
MTH-668	Fluid Mechanics-II	4(4-0)
MTH-670	Partial Differential Equations	4(4-0)
Optional Paper (2 out of Following)		
MTH-672	Theory of Elasticity	4(4-0)
MTH-674	Electromagnetism	4(4-0)
MTH-660	Mathematical Statistics-II	4(4-0)
MTH-662	Numerical Analysis-II	4(4-0)

MTH-664	Theory of Optimization	4(4-0)
MTH-666	Special Functions	4(4-0)
Total		16

Course Number	Title	Credit Hours	Marks
MATH-711	Real Analysis -I	4(4-0)	80

REAL ANALYSIS-I

Algebraic and ordered properties of Real Numbers, Absolute values, Inequalities (Cauchy's, Minkoski's, Bernoulli's) Properties and concepts of supremum and infimum, Ordered sets, Fields, Field of Real, The extended real number system, Euclidean spaces, Sequences, Subsequences, Cauchy sequence, Series of Numbers and their convergence. The Comparison, Root, Ratio and Integral tests. Absolute and Conditional convergence of infinite series. Limits and Continuity. Properties of continuous functions. Types of discontinuities. Differentiable functions. Mean-value theorems, Continuity of derivatives. Partial Derivatives and Differentiability. Derivative and differentials of Composite functions. The Directional Derivative, the Laplacian in polar cylindrical and Spherical coordinates.

BOOKS RECOMMENDED

1. Bartle R G and Sherbert DR, *Introduction to Real Analysis,* 1999 John Wiley New York.
2. Rudin W. *Principles of Mathematics Analysis,* 1986 McGraw-Hill New York.
3. Brabence RL *Introduction to Real Analysis,* 1997 PWS Publishing Company.
4. Gaughan ED. *Introduction to Analysis (5th Edition)* 1997 Brooks/Cole
5. Kaplan W. *Advance Calculus*1984 Addison-Wesley publishing Company.

Course Number	Title	Credit Hours	Marks
MATH-712	Complex Analysis	4(4-0)	80

COMPLEX ANALYSIS

Analytic functions, Cauchy-Riemann equations. Power series, Radius of convergence. Cauchy's theorem. Cauchy's integral formula and related theorems. Contour integration. Singularities, Branch points. Taylor's and Laurent's series. Analytic continuation. Residues, Residue theorem. Fundamental theorem of Algebra. Application of calculus of residues to infinite products. Conformal transformations and their applications.

BOOKS RECOMMENDED

1. L. Pennisi, L. Gordon, and S. Lasher, *Elements of Complex Variables*, Holt Rinehart and Winston.
2. R.Churchill, *Complex Variables and Application* (1996). McGraw Hill.
3. R.A.Silverman, *Complex Analysis with Applications*, Prentice Hall, Englewood Cliffs, N.Jersey.
4. J. Paliouras, *Complex Variables for Scientists and Engineers* McMillan
5. H.R.Chillingworth, *Complex Variables*, Pergamon Press, Oxford.
6. L.V. Ahlfors, *Complex Analysis* McGraw Hill.
7. M. Iqbal, *Complex Analysis* (1996). Ilmi Kitab Khana.
8. K. Kodaira, *Introduction to Complex Analysis*, Cambridge.
9. S. Lang, *Complex Analysis. 4th Edition*, 2001, Springer.

Course Number	Title	Credit Hours	Marks
MATH-713	Vector and Tensor	4(4-0)	80

VECTOR AND TENSOR

VECTOR ANALYSIS

Curvilinear Coordinates, Scale Factors, Arc length, Area and volume in curvilinear coordinates. Spherical and Cylindrical coordinates, Expansion formulas of Gradient, Divergence and Curl of point in curvilinear coordinate, Relation between orthogonal bases, Curvilinear Coordinates, Spherical and cylindrical coordinates and their applications, Line, Surface and volume integral. Gausses, Green's and Stokes theorem with their application.

CARTESIAN TENSORS

Cartesian Tensor, Law of transformation, from one coordinates system to another coordinates system. Algebra of Tensor, Sum, Difference, Quotient, Inner product, Contraction, Contraction theorem with their application, Symmetric Tensor and Skew Symmetric Tensor, Kronecker Tensor and Levi Civita Tensor, Relation between these Tensors, Isotropic Tensor, First and Second order Differential Operators in Tensor. Application of Tensors in Vector Analysis, Proof of Expansions formulae using tensor formulism.

BOOKS RECOMMENDED

1. H. Jeffrey, *Cartesian Tensors*, Cambridge University Press.
2. F. Charlton, *Vector and Tensor Methods*, Ellis Harwood. Publisher, Chichester, U.K. 1997.
3. Schaum Series *Vector and Tensor Analysis Mc Graw Hill Company*.
4. K. L. Mir *Vector and Tensor Analysis* Ilmi Kitab Khana.
5. Dr. Nawzish Ali Shah *Vector and Tensor Analysis*

Course Number	Title	Credit Hours	Marks
MATH-714	Algebra-I	4(4-0)	80

ALGEBRA –I

Groups and subgroups. Generators and relations. Cyclic group, Cosets and Lagrange's theorem. Normalizers and centralizers. Center of a group. Subgroups. Factor groups, Isomorphism theorems and automorphisms. Commutators. Permutation groups and Cayley's theorem, Introduction to Rings, Types of Rings, Integral domains. Field and its characteristic.

BOOKS RECOMMENDED

1. I.D. Macdonald, *The Theory of Groups).* Oxford University Press
2. I.N., Herstein, *Topics in Algebra,* Addison-Wesley.
3. J.B, Fraleigh, *Abstract Algebra.* Addison-Wesley.
4. K.H. Dar, *First Step to Abstract Algebra, (2nd edition 1998).* Feroz Sons, 1998.
5. J.T. Scheik, *Linear Algebra with Applications, 1997,* McGraw Hill.
6. A Majeed, *Theory of groups,* Ilmi Kitab Khana.
7. Q. Mushtaq, *A course in Group Theory, (1993).* University Grants Commission, Islamabad.

Course Number	Title	Credit Hours	Marks
MATH-715	Point set Topology	4(4-0)	80

POINT SET TOPOLOGY

Sets: countable and uncountable sets, Partially and totally ordered sets and lattices with examples. Cardinal numbers, Axiom of choice. Topological spaces; Subspaces and relative topology, Open sets, Closed sets, Neighborhood, Interior, Exterior and limit points, Base and sub base, Product spaces. Continuous and open mappings. Homeomorphism. First and second axioms of countability. Separation axioms, $T_{0,}$ $T_{1,}$ $T_{2,}$ $T_{3,}$ $T_3^{1/2}$, $T_{4,}$ spaces. Regular and normal spaces. Connectedness various characterizations of connectedness, Local connectedness, components. Open covers. Compact spaces and their characterization. Continuity; Uniform continuity and their relationship with compactness in metric spaces. Limit points sequential compactness. Equivalence of different notions of Compactness.

BOOKS RECOMMENDED

1. G.F., Simon's, *Introduction to Topology and Modern Analysis* McGraw Hill.
2. K.R. Munkers, *Topology, A first course* (Prentice Hall, Inc).
3. J. Dugundji: *Topology*; (Prentice Hall, Inc).
4. M. Bashir, *Introduction to Topology*, Jaiza Printers Multan 1999.
5. S.M. Yahya, *Introduction to Piont-set-Topology*, Time Press Karachi.
6. A. Majeed, *Elements of Topology and Functional Analysis* (1996).Ilmi Kitab Khana, Lahore.

Course Number	Title	Credit Hours	Marks
MATH-721	Real Analysis - II	4(4-0)	80

REAL ANALYSIS-II

The Riemann – Stieltjes (R-S) Integrals. Properties of R-S integrals. Functions of bounded variations. Point wise and uniform convergence of sequences and series of functions, Weierstrass M-Test, Uniform convergence and continuity. Uniform Convergence and differentiation, Uniform Convergence and integration. Convergence of improper integrals. Beta and Gamma functions and their properties. Implicit functions, Jacobians, Functional dependence. Taylor's theorem for a function of two variables. Maxmima and minima of functions of two and three variables. Method of Lagrange Mulitiplier.

BOOK RECOMMENDED

1. Bartle RG Sherbert DR, *Introduction to Real Analysis (3rd edition)* 1999, John Wiley New York.
2. Rudin W. *Principles of Mathematics Analysis (3rd edition)* 1986, McGraw-Hill New York.
3. Brabence RL *Introduction to Real Analysis*, 1997, PWS Publishing Company.
4. Gaughan ED. *Introduction to Analysis (5th edition)* 1997, Books/Cole.
5. Kaplan W. *Advance Calculus (3rd edition)* 1984 Addison-Wesley publishing Company.
6. Apostol, Mathematical Analysis 6th Prenteng Addison-wesley Publicating company.

Course Number	Title	Credit Hours	Marks
	Algebra-II	4(4-0)	80

ALGEBRA –II

Review of elementary concepts of vector spaces. Linear dependence and independence of vectors. Vector spaces and subspaces. Quotient spaces. Direct sum of spaces. Linear transformation. Rank and Nullity of linear transformations. Algebra of linear transformations and representation of linear transformations as matrices. Change of bases. Linear functional. Dual spaces and Annihilators. Eigenvectors, eigenvalues and Cayley–Hamilton theorem. Diagonalization of Matrices. Inner product spaces. Bilinear, quadratic and Hermit forms.

BOOKS RECOMMENDED

1. A.M., Tropper, *Linear algebra,* Thomas Nelson & Sons.
2. S. Lang, *Linear Algebra,* Addison-Wesley.
3. K.R. Hoffman, and Kunze, R., *Linear Algebra* Prentice –Hall.
4. I. N., Herstein, *Topics in Algebra,* Addison- Wesley.
5. P.R, Halmos, *Finite Dimensional Vector Spaces,* Von Nostrand.
6. K.H. Dar, *First Step to Abstract Algebra, 2nd Edition 1998.* Feroze Sons Pvt.
7. J.T. Scheick, *Linear Algebra with Applications, 1997.* McGraw Hill.
8. P.M. Chon, *Algebra-I and Algebra-II.*

Course Number	Title	Credit Hours	Marks
MATH-723	Mechanics	4(4-0)	80

MECHANICS

General Motion of a rigid body, Euler's Theorem and Chasles Theorem. Euler's Angles, Moments and Products of Intertia, Intertia Tensor, Euler's Principal Axes and Principal Moments of Inertia , Kinetic Energy and Angular Momentum of a Rigid Body, Momental Ellipsoid and Equimomental Systems, Euler's dynamical Equations and their solution in special cases. Heavy asymmetrical Top, Equilibrium of a Rigid Body, General Conditions of Equilibrium, and Deduction of Conditions in Special Cases.

BOOKS RECOMMENDED

1. Synge & Griffith, *Principles of Mechanics,* McGraw Hill Book Company Inc., New York.
2. D.T. Greenwood, *Principles of Dynamics,* Prentice Hall, Inc.
3. W. Huser, *Introduction to Principles of Mechanics,* Addison Wesley, New York.
4. R.A Becker, *Introduction to Theoretical Mechanics,* McGraw Hill Book Company, Inc., New York.
5. F. Chorlton, *A Text Book of Dynamics.*
6. K .L. Mir, *Theoretical Mechanics* Ilmi Kitab Khana.

Course Number	Title	Credit Hours	Marks
MATH-724	Functional Analysis	4(4-0)	80

FUNCTIONAL ANALYSIS

Definition and examples of Normed spaces. Banach spaces. Convergence in Normed space. Basis of Normed Space. Convex sets. Quotient spaces. Equivalent Norms. Compact Normed space. Characterization of Banach spaces. Linear operators. Bounded linear operators, Various characterizations of bounded (continuous) Linear operators. The space of all bounded Linear operators. Linear Functional and their examples. Dual Space and Reflexive space. Inner product spaces and their examples, The Cauchy-Schwarz inequality. Polarization Identity. Hilbert spaces, Bessel's inequality. Gram-Schmidt orthogonalization Process. Minimizing Vector .Direct Sum of spaces. The Riesz representation theorem. Annihilators and Orthogonal complements. Direct Decomposition.

RECOMMENDED BOOKS

1. E. Kreyszig, *Introductory Analysis with Applications*, John Wilsy, 1978.
2. J Maddox,.Elements of *Functional Analysis*, Cambridge ,1970.
3. G.F. Simmon, *Introduction to Topology and Modern Analysis*, McGraw-Hill-N. Y,1983.
4. W. Rudin, *Functional Analysis*, McGraw-Hill. N.Y.1983.
5. A. Majeed, *Elements of Topology and Functional Analysis* Ilmi Kitab Khana Lahore.

Course Number	Title	Credit Hours	Marks
MATH-725	Differential Geometry	4(4-0)	80

DIFFERENTIAL GEOMERTRY

The moving trihedron, Arc length parameter representations; The osculating plane, The osculating circle analysis and the osculating sphere; Curvature and torsion of unit speed and non unit speed curves, Serret-Frenet formulae. Helices, Spherical indicatericies, Evolutes. The theory of surfaces: Simple surface and coordinate patches. The tangent plane and the normal planes, the first fundamental form and the metric, Coordinate transformations. Surface curves: the angle between two curves on a surface; Normal curvature Analysis and geodesic curvature, The second fundamental form, Christoffel symbols. Gauss theorem. Mean and Gauss Ian curvatures, Principal curvatures, Asymptotic and principal direction, Euler's theorem, Dupin's indicatericies. The Gauss-Weingarten, Guass-Codazzi equations.

BOOKS RECOMMENDED

1. R. Millman, and G. Parker. *Elements of differential Geometry* Prentice Hall Inc.
2. B., O' Neill. *Elementary Differential Geometry*.
3. D.J. Struik. *Lectures on Classical Differential Geometry* Addison- Wesley.
4. A. Goetz, *Introduction to Differential Geometry* Addison- Wesley.
5. F. Chorlton. *Vector and Tensor Methods* Ellis Harwood.

Course Number	Title	Credit Hours	Marks
MATH-731-P	Advanced Group Theory	4(4-0)	80

ADVANCED GROUP THEORY

Introduction to Sets and Structures. Examples of groups. Finite groups. Subgroups. Permutations and cyclic groups. Isomorphism's and Homomorphism with separate reference to Abelian groups. Cosets, Normal groups, Factor groups and Simple groups. Series of groups. The Sylow theorems. Groups actions, Free groups and group presentations, Geometric, Analytic and dynamical applications. A brief introduction to continuous groups and group representations.

RECOMMENDED BOOKS

1. J.B. Fraleigh, *A First Course in Algebra*, Addison-Wesley 1982.
2. M. Hamermesh, *Group Theory*, Addisosn-Wesley 1972.
3. I.N. Herstein, *Topics in Algebra*, John Wiley 1975.

Course Number	Title	Credit Hours	Marks
MATH-732-P	Advanced Set Theory	4(4-0)	80

ADVANCED SET THEORY

Equivalent sets, Countable and uncountable sets, The concept of cardinal number, Addition and multiplication of cardinals, Cartesian products as sets of function, Addition and multiplication of ordinals. Partially ordered sets axiom of choice, statement of lemma.

LEBESGUE MEASURE

Introduction, outer measure, Measurable sets and Lebesgue measure. A non-measurable set. Measurable function, the Lebesgue Integral and the Riemann integral, the Lebesgue integral of a bounded function over a set of finite measure, The integral of a non-negative function. The general Lebesgue integral. Convergence in measure.

BOOKS RECOMMENDED

1. Frankal, *Abstract Set Theory*, North-Holland Publishing Company Amsterdam.
2. Patrick Suppes, *Axiomatic Set Theory*, Dover Publications, Inc., New York.
3. P.R. Halmos, *Naïve Set Theory*, New York, Van Nostrand.
4. B.Rotman & G.T. Kneebone, *The Theory of Sets and Transfinite Numbers*, Old bourne London.
5. P.R. Halmos, *Measure Theory*, Von Nostrand, New York.
6. W. Rudin, *Real and Complex Analysis*, Mcgraw Hill, New York.
7. R.G. Bartle, *Theory of Integration*.
8. H.L. Royden, *Real Analysis*.

Course Number	Title	Credit Hours	Marks
MATH-733-P	Mathematical Statistics –I	4(4-0)	80

MATHEMATICAL STATISTICS-I

Interpretations of Probability. Experiments and events, Definition of probability, Finite sample spaces. Counting methods. The probability of a union of events. Independent events. Definition of conditional probability. Baye's' theorem. Random variables and Discrete Distributions. Continuous distributions. Probability function and probability density function. The distribution function, Bivariate distributions, Marginal distributions. Conditional distributions. Multivariate distributions. Functions of random variables. The expectation of a random variable. Properties of expectations. Variance, Moments. The mean and the median. Covariance and correlation. Conditional expectation. The sample mean and associated inequalities. The multivariate normal distribution.

RECOMMENDED BOOKS

1. A.M. Mood, Graybill, F.A, Boes, D.C. *Introduction to the Theory of Statistics, 3rd Edition*,(McGraw-Hill Book Company New York, 1974).
2. M. H Degroot,. *Probability and Statistics, (2nd edition),* Addison-Wesley Publishing Company, USA, 1986.
3. K.V. Mardia, Kent, J.T. Bibby, J.M. *Multivariate Analysis*. Academic Press New York,1979.

Course Number	Title	Credit Hours	Marks
MATH-734-P	Continuous Groups	4(4-0)	80

CONTINUOUS GROUPS

Continuous Groups; Gl(n,r),Gl(n,c),So(p,q),Sp(2n); generalities on Continuous Groups; Groups of isometrics; Introduction to Lie groups with special emphasis on matrix Lie groups; Relationship of isometrics and Lie group; Theorem of Cartan; Correspondence of continuous groups with Lie algebras; Classification of groups of low dimensions; Homogeneous spaces and orbit types; Curvature of invariant metrics on Lie groups and homogeneous spaces.

RECOMMENDED BOOKS

1. Bredon,G.E, *Introduction to compact Transformation groups* Academic Press,- 1972).
2. Eisenhart, L.P. *Continuous Groups of Transformations* (Priceton U.P.1933).
3. Pontrjagin ,L. S., *Topological groups*.(Princeton University Press, 1939).
4. Hussain Taqdir. *Introduction to Topological Groups*.(W.B.Saunder's-Company,1966).
5. Miller Willard, Jr., *Symmetry groups and their application*;(Academic Press-New York and London 1972).

Course Number	Title	Credit Hours	Marks
MATH-735-P	Theory of Modules	4(4-0)	80

THEORY OF MODULES

Definition and examples, Sub modules, Homeomorphisms and quotient modules. Direct sums of modules. Finitely generated modules, Torsion Modules, Free modules. Basis, Rank and endomorphism of free modules. Matrices over Rings and their connections with the basis of free modules. A Module. A Module as the direct sum of a free and a torsion module. Exact sequences and elementary notions of homological algebra. Noetherian and modules, Radicals, Semi simple rings and modules.

BOOKS RECOMMENDED

1. Blyth, T.S., *Module theory*, Oxford University Press, 1977.
2. Hartley, B. and Hawkes, T.O. *Rings, Modules and Linear Algebra*, Chapman and Hall, 1980.
3. Herstein, I.N. *Topics in Algebra*, John Wiley and Sons, 1975.
4. Adamson, J. *Rings and Modules*.

Course Number	Title	Credit Hours	Marks
MATH-736-P	Algebraic Topology	4(4-0)	80

ALGEBRAIC TOPOLOGY

Path wise connectedness; Notion of homotopy, Homotopy classes. Path homotopy. Path homotopy classes; Fundamental groups, Covering maps. Covering spaces. Litting properties of covering spaces, Fundamental group of a circle.

RECOMMENDED BOOKS

1. Kosniowski, C.*A first course in Algebraic Topology* (Cambridge University Press)
2. Greenberg, M.J, *Algebraic Topology*. A first Course (Benjamin. 1976).
3. Wallace,A. H. *Algebraic Topology*. Gemology and Comology.(Benjamin,1968).

Course Number	Title	Credit Hours	Marks
MATH-737-P	Advanced Topology	4(4-00	80

ADVANCED TOPOLOGY

Compactness in metric spaces, Limit point, Compactness, Sequential compactness and their various characterizations, Equivalence of different notions of compactness. Connectedness, various characterizations of connectedness, Connectedness and T()spaces, Local connectedness, Path-connectedness, Components. Homotopic maps, Homotopic paths, Loop spaces, Fundamental groups, Covering spaces, the lifting theorem, Fundamental groups of the circle () etc.Chain complex, Notion of homology.

RECOMMENDED BOOKS

1. Greenberg, M.J. *Algebraic Topology, A first Course*, The Benjamin/Commings Publishing Company,1967.
2. Wallace, A.H. *Algebraic Topology*, Homology and eohomology. W.A. Benjamin, Inc New York, 1968.
3. Gemignani, M.C., *Elementary Topology*, Addison-Wesley Publishing Company, 1972.

Course Number	Title	Credit Hours	Marks
MATH-738-P	Numerical Analysis-I	4(4-0)	80

NUMERICAL ANALYSIS- I

Introduction, Computation error and error analysis, Study of various Iterative methods to solve non-linear equations with analysis of error, Convergence and stability of Bisection, False position , Secant, Newton- Rephson and Fixed point methods, Acceleration of convergence by Aitken method, Solution of system of linear equations by LU decomposition method, Cases of failure, Iterative methods, (Jacobi, Gauss Seidel, SOR, SUR) and their convergence analysis , Ill conditioned systems and Condition number, Interpolation: Review of simple interpolation for equally spaced data, Interpolation by Gauss forward/ backward methods, Bessel and Stirling method with error analysis, Lagrange Interpolation and Newton divided differences formula with error analysis, Interpolation by Spline functions (up to Cubic spline), methods of Least squares, Numerical differentiation, Numerical integration for equally spaced data (Newton cotes formula and its special cases e.g. Trapezoidal Rule and Simpson's rules) and for unequally spaced data(using Lagrange and divided differences formula of interpolation), Gaussian quadrature using a system of orthogonal polynomials (Legendre and Laguere polynomials).

BOOKS RECOMMENDED

1. C. Gerald, Applied *Numerical Analysis*, Addison-Wesley Publishing Company, 1978.
2. A. Balfour & W.T. Beveridge, *Basic Numerical Analysis with Fortran*, Heinemann Educational Books Ltd. (1977).
3. Shan and Kuo, *Computer Applications of Numerical Methods* (Addison – Wesley) National Book Foundation, (1972), Islamabad.
4. R. L. Burden and J. D. Faires, Brooks /Cole Publishing Company, New York.

Course Number	Title	Credit Hours	Marks
MATH-739-P	Linear Algebra	4(4-0)	80

LINEAR ALGEBRA

Review of elementary concepts of Vector spaces. Linear dependence and Independence of vectors. Vector spaces and subspaces. Quotient spaces. Direct sum of spaces. Linear transformation. Rank and Nullity of linear transformations. Algebra of linear transformations and representation of linear transformations as matrices. Change of bases. Linear functional. Dual spaces and Annihilators. Eigenvectors, Eigenvalues and Cayley–Hamilton theorem. Digitalization of matrices. Inner product spaces. Bilinear, Quadratic and Hermit Ian forms.

BOOKS RECOMMENDED

1. K.H. Dar, *First Step to Abstract Algebra*, (2^{nd} Edition 1998). Feroze Sons Pvt.
2. J.T. Scheick, *Linear Algebra with Applications*, 1997. McGraw Hill.
3. K.R. Hoffman, and Kunze, R., *Linear Algebra* Prentice –Hall.
4. A.M., Tropper, *Linear algebra*, Thomas Nelson & Sons.
5. S. Lang, *Linear Algebra*, Addison-Wesley.
6. I. N., Herstein, *Topics in Algebra*, Addison- Wesley.
7. P.R, Halmos, *Finite Dimensional Vector Spaces*, Von Nostrand.
8. P.M. Chon, *Algebra-I and Algebra-II*.

Course Number	Title	Credit Hours	Marks
MATH-740-P	Rings & Fields	4(4-0)	80

RINGS AND FIELDS

Definitions and basic concepts, homeomorphisms, homomorphism theorems. Polynomial rings. Unique factorization domain, factorization theory. Euclidean domain, arithmetic in Euclidean domains, Extension fields, Algebraic and transcendental elements, simple extension, Introduction to Galois theory.

RECOMMENDED BOOKS

1. Hartley, B. and Hawkes, T.O. *Rings, Modules and Linear Algebra*, Chapman and Hall, 1980.
2. Herstein, I.N. *Topics in Algebra*, John Wiley and Sons, 1975.
3. Blyth, T.S., *Module theory*, Oxford University Press, 1977.
4. Adamson, J. *Rings and Modules*.

Course Number	Title	Credit Hours	Marks
MATH-731-A	Fluid Mechanics- I	4(4-0)	80

FLUID MECHANICS -I

Real fluids and ideal fluids, Velocity of a fluid at a point, Streamlines and path lines, Steady ad unsteady flows, Velocity potential, Vorticity vector, Local and particle rates of change, Equation of continuity. Acceleration of a fluid, Conditions at a rigid boundary, General Analysis of fluid motion Euler's equations of motion, Bernoulli's equations steady motion under conservative body forces, Some potential theorems, impulsive motion. Sources, Sinks and doublets, Images in rigid infinite plane and solid spheres, Axi-symmetric flows, Stokes's stream function.

Stream function, Complex potential for two-dimensional, Irrational, Incompressible flow, Complex velocity spotential for uniform stream. Line sources and line sinks, Line doublets image systems, Miline-Thomson circle theorem, Blasius's Theorem.

BOOKS RECOMMENDED

1. Chorlton, F., *Text Book of fluid Dynamics* D. Van No strand Co. Ltd.1967.
2. Thomson, M., *Theoretical Hydrodynamics,* Macmillan Press, 1979.
3. Jaunzemics, W., *Continuum Mechanic,* Macmillan Company, 1967.
4. Landau, L.D, and Lifshitz, E.M., *Fluid Mechanics,* Pergamon Press, 1966.
5. Batchelor, G.K., *An Introduction to Fluid Dynamics,* Cambridge University Press, 1969.
6. Brvce R. Munson and Donald F. Young, *Fundamentals of Fluid Mechanics,* Department of Engineering Science and Mechanics, Department of Mechanics Engineering Lowa State university Amos Lowa USA.

Course Number	Title	Credit Hours	Marks
MATH-732-A	Mathematical Physics	4(4-0)	80

MATHEMATICAL PHYSICS

Theory of Sturm-Liouville Problems. Linear homogeneous differential equations of order n. Fundamental set of solutions. Linearly dependent and independent solutions. Wronskian Determinant. Adjoint and self-adjoint Equations. Self-adjoint operator. Symmetric operator. Lagrange's identity. Green's identity. Eigenvalue problem. Eigenfunctions and eigenvalues. Self-adjoint eigenvalue problem..

Orthogonality of eigenfunctions. Real eigenvalues. Regular, Periodic and singular Sturm-liouvill systems. Orthogonal Sets of functions. Expansion of functions in terms of eigenfunctions.

Power Series, Solutions of Legendre's Equation, Legendre's polynomials Generating function; Rodrigue's formula, Recurrsion relations. Orthogonality and normality of Legendre's Polynomials, Legendre's Series. Bessel's equation, Bessel's Functions, Generating function, Recurring relations, Orthogonality of Bassel's function, Bessel's series Green's function methods applied to ODEs. Green's function in one and two dimensions.

Integral Equations. Formulation and classification of integral equations. Degenerate Kernels. Methods of successive approximations.

BOOKS RECOMMENDED

1. I. Stakgold, *Boundary Value Problems of Mathematical Physics, Vol. I, II. Macmillan.*
2. Lal Din Baig *Methods of Mathematical Physics 2000*.
3. H.Sagan, *Boundary and Eigenvalue problems in Mathematical Physics*.
4. E.L Butkov, *Mathematical Physics*, Addison-Wesley
5. G. Arfken, *Mathematical Methods for Physics*, Academic Press.
6. R.P kanwal, *Linear Integral Equations*.
7. My-Tung & Debnath, Partail *Differential Equations*

Course Number	Title	Credit Hours	Marks
MATH-733-A	Mathematical Statistics -I	4(4-0)	80

MATHEMATICAL STATISTICS -I

Interpretations of Probability, Experiments and events, Definition of probability, Finite sample spaces. Counting methods, The probability of a union of events. Independent events. Definition of conditional probability. Baye's' theorem. Random variables and discrete distributions. Continuous distributions. Probability function and probability density function. The distribution function. Bivariate distributions. Marginal distributions. Conditional distributions. Multivariate distributions. Functions of random variables. The expectation of a random variable. Properties of expectations. Variance, Moments. The mean and the median. Covariance and Correlation. Conditional expectation. The sample mean and associated inequalities. The multivariate normal distribution.

Recommended Books

1. A.M. Mood, F.A Graybill, D.C. Boes, *Introduction to the Theory of Statistics, 3rd Edition, (*McGraw-Hill Book Company New York, 1974).
2. M. H. Degroot, *Probability and Statistics, (2nd edition)* .Addison-Wesley Publishing Company, USA, 1986.
3. K.V. Mardia, Kent, J.T. Bibby, J.M. *Multivariate Analysis.Academic* Press New York,1979.

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Course Number	Title	Credit Hours	Marks
MATH-734-A	Special Theory of Relativity	4(4-0)	80

SPECIAL THEORY OF RELATIVITY

Historical background and fundamental concepts of Special Theory of Relativity. Lorentz transformations (for motion along axis). Length contraction. Time dilation and simultaneity. Velocity addition formulae. 3-dimensional Lorentz transformations. Introduction to 4-vector formalism. Lorentz transformations in the 4 vector formalism. The Lorentz and Poincare groups. Introduction to classical Mechanics. Minkowski spacetime and null cone. 4-velocity, 4 acceleration 4-momentum and 4-force. Application of Special Relativity to Doppler shift and Compton Effect. Particle scattering. Binding energy, Particle production and decay. Electromagnetism in Relativity. Electric current. Maxwell's equations and electromagnetic waves. The 4-vector formulation of Maxwell's equations. Special Relativity with small acceleration.

BOOKS RECOMMENDED

1. A. Qadir, *Relativity: An Introduction to the Special Theory,* World Scientific, 1989.
2. R. D' Inverno, *Isntroduction Einstein's Relativity,* Oxford University Press. 1992.
3. H. Goldstein, *Classical Mechanics,* Addison Wesley, New York, 1962.
4. J.D. Jackson, *Classical Relativity,* Springer-Verlag, 1977.
5. J.G. Taylor, *Special Theory of Relativity*

Course Number	Title	Credit Hours	Marks
MATH-735-A	Operations Research	4(4-0)	80

OPERATIONS RESEARCH

LINEAR PROGRAMMING

Mathematical modeling. Formulation and graphical solution. Analytical solution. Simplex method. Two- phase and M-technique for Linear programs.
Duality. Duality simplex method. Sensitivity Analysis.

TRANSPORTATION PROBLEMS

Definition. Various methods including North –West Corner method. Least – cost method and Vogel's approximation. The Assignment model. Application to Networks. Shortest- Route Algorithm for acyclic and cyclic networks. Maximal-flow problems.

INTEGER PROGRAMMING

Definition and formulation- Cutting-Plane Algorithm and Branch-and Bound method,Application. The mixed Algorithm, Zero-one polynomial programming.

BOOKS RECOMMENDED

1. Hamdy A Taha *An Introduction to Operations Research* Macmillan Publishing Company Inc, New York, 1987.
2. S Kalavathy *Operations Research* Vikas Publishing House (P) Ltd.
3. F. S Hiller and G. J Liebraman, *Operational Research* CBS Publisher and distributors, New Delhi, 1974.
4. C. M Harvey, *Operation Research,* North Holland, New Delhi
5. Prof. Sr. Saeed Akhtar Bhatti *Operations Research: An Introduction*
6. Krajewsky and Ritzman *Operations Management Strategy and Analysis*.

Course Number	Title	Credit Hours	Marks
MATH-736-A	Quantum Mechanics	4(4-0)	80

QUANTUM MECHANICS

Basic postulates of Quantum mechanics. State vector. Formal properties of quantum mechanical operators. Eigenvalues and Eigenstates, Simple harmonics oscillator, Schrodinger representation. Heisenberg equation of motion Schrodinger equation. Potential step, Potential hydrogen atom. Matrix representation of angular momentum an spin. Time independent perturbation theory, Degeneracy. The Stark effect. Introduction to relativistic Quantum Mechanics.

RECOMMENDED BOOKS

1. Fayyazuddin and Riazuddin, *Quantum Mechanics* (World Scientific 1990).
2. Merzbache, E. *Quantum Mechanics,* John Wiley (2^{nd} edition) 1970.
3. Liboff, R.L *Introductory Quantum Mechanics,* Oxford University Press.

Course Number	Title	Credit Hours	Marks
MATH-737-A	Soft Ware Engineering	4(4-0)	80

SOFT WARE ENGINEERING

Introduction to Software. Designing phases of Software, Different Phase used in Software Development Process. Applying UML (Unified Modeling Language) & Patterns. Software Types, Different kinds of Development Cycles. Iterative , Water Fall, Big Bang Techniques. Software Testing, Black Box Testing, White Box Testing. Concepts of Object Oriented Programming. Difference Between Structured Programming & Object Oriented Programming. Advancements of OOPS.

RECOMMENDED BOOKS

1. Applying UML & Patterns By Grasp
2. Practitioner’s approach towards Software Engineering by Pressman
3. Applying UML & Patterns by Craig Larman

Course Number	Title	Credit Hours	Marks
MATH-738-A	Numerical Analysis-I	4(4-0)	80

NUMERICAL ANALYSIS-I

Introduction, Computation error and error analysis, study of various Iterative methods to solve non-linear equations with analysis of error, Convergence and stability of Bisection, False position , Secant, Newton- Rephson and Fixed point methods, Acceleration of convergence by Aitken method, solution of system of linear equations by LU decomposition method, Cases of failure, Iterative methods, (Jacobi, Gauss Seidel, SOR, SUR) and their convergence analysis , Ill conditioned systems and Condition number, Interpolation: Review of simple interpolation for equally spaced data, Interpolation by Gauss forward / backward methods, Bessel and Stirling method with error analysis, Lagrange Interpolation and Newton divided differences formula with error analysis, Interpolation by spline functions (up to cubic spline), methods of least squares, Numerical differentiation, Numerical integration for equally spaced data (Newton cotes formula and its special cases e.g. Trapezoidal Rule and Simpson's rules) and for unequally spaced data, (using Lagrange and divided differences formula of interpolation), Gaussian quadrature using a system of orthogonal polynomials (Legendre and Laguere polynomials).

BOOKS RECOMMENDED

1. Johnson L., and Dean, R.; *Numerical Analysis*, Addison Wesley.
2. James, M.L., Smith, G.M. & Woford, J.C., *Applied Numerical Methods for Digital Computation*, Harper and Row, Publications.
3. Ralston, A & Philips, R.A. *First Course in Numerical Analysis*, McGraw Hill.
4. Froeberg , C.E. *Introduction to Numerical Analysis*, Addison Wesley.
5. Scarborough , J.B., *Numerical Mathematical Analysis* , John Hopkins Press.
6. M. Iqbal, *Numerical Analysis* , National Book Foundation.
7. J.H. Wilkinson, *Eigenvalue Problems*, Oxford University Press.
8. Aitkinson , *Elementary Numerical Analysis*.

Course Number	Title	Credit Hours	Marks
MATH-741- P	Measure Theory	4(4-0)	80

LEBESGUE MEASURE

Introduction, outer measure, Measurable sets and Lebesgue measure. A non-measurable set. Measurable function, the Lebesgue Integral and the Riemann integral, the Lebesgue integral of a bounded function over a set of finite measure, The integral of a non-negative function. The general Lebesgue integral. Convergence in measure.

BOOKS RECOMMENDED

1. P.R. Halmos, *Naïve Set Theory*, New York, Van Nostrand.
2. B.Rotman & G.T. Kneebone, *The Theory of Sets and Transfinite Numbers*, Old bourne London.

Course Number	Title	Credit Hours	Marks
MATH-742- P	Advanced Functional Analysis	4(4-0)	80

Course Number	Title	Credit Hours	Marks
MATH-743- P	Rings and Modules	4(4-0)	80

RINGS & MODULES

Definition and examples, Submodules, Homomorphisms and Quotient modules. Direct sums of modules. Finitely generated modules, Torsion Modules, Free modules. Basis, rank and endomorphism of free modules. Matrices over Rings and their connections with the basis of free modules. A Module. A Module as the direct sum of a free and a torsion module. Exact sequences and elementary notions of homological algebra. Noetherian and modules, Radicals, Semi simple rings and modules.

BOOKS RECOMMENDED

1. Blyth, T.S., *Module theory*, Oxford University Press, 1977.
2. Hartley, B. and Hawkes, T.O. *Rings, Modules and Linear Algebra*, Chapman and Hall, 1980.
3. R. B. J. E. Allenly, Rings Fields and Groups, An Introduction to Abstract Algebra, Edward Arnold, 1985.
4. Herstein, I.N. *Topics in Algebra*, John Wiley and Sons, 1975.
5. Lal Din Baig *Methods of Mathematical Physics 2000*.
6. Adamson, J. *Rings and Modules*.

Course Number	Title	Credit Hours	Marks
MATH-744- P	Theory of Numbers	4(4-0)	80

THEORY OF NUMBERS

Algebraic Numbers and integers, Units and Primes in R(v). Ideals. Arithmetic of Ideals congruences. The norm of a Ideal. Prime Ideals. Units of Algebraic number field.

APPLICATION TO RATIONAL NUMBER THEORY

Equivalence and class number. Cyclotomic field K Fermat's equation. Kummer's theorem, the q equation $X^2 + 2=Y^{3,}$ pure cubic fields. Distribution of Primes and Riemann Zets function, the prime number theorem.

BOOKS RECOMMENDED

1. W.J. Leveque, *Topics in Number Theory, Vol. I and II* Addison-Wesley Publishing Co, 1956.
2. Shailesh Shirali, C. S Yogananda, Number theory Universities press.
3. Steven Miller Ramin Takloo-Bighash, An Introduction to modern Number Theory Publishing Princeton
4. Neville Robbins, Beginning Number Theory (2^{nd} edition), Jones and Bartlett.

Course Number	Title	Credit Hours	Marks
MATH-745- P	Mathematical Statistics- II	4(4-0)	80

MATHEMATICAL STATISTICS- II

Statistical inference. Maximum likelihood estimators. Properties of maximum likelihood estimators. Sufficient statistics. Jointly sufficient statistics. Minimal sufficient sufficient statistics. The sampling distribution of a statistic. The Chi square distribution. Joint distribution of the sample mean and sample variance. The t distribution. Confidence intervals. Unbiased estimators. Fisher information. Testing simple hypotheses. Uniformly most powerful tests. The t test. The F distribution. Comparing the means of two normal distributions. Tests of goodness of fit. Contingency tables. Equivalence of confidence sets and tests. Kolmogorov- Smirnov tests. The Wilcoxon Signed-ranks tests. The Wilcoxon-Mann-Whitney Ranks test.

RECOMMENDED BOOKS

1. Mood, A.M. Graybill, F.A . Boes, D.C. *Introduction to the Theory of Statistics, (2nd edition),* McGraw-Hill Book Company New York ,1986.
2. Degroot, M.H. *Probability and Statistics, (2nd edition)* Addison Wesley Company New York 1986.
3. Walpole-Myers. Myers. Ye *Probability and Statistics* (7th edition)
4. K. V. Mardia, Kent, J. T. Bibby, J. M. *Multivariate Analysis* Academic Press New York 1979.
5. Allen. T Craig, Robert V. Hogg, *Introduction to Mathematical Statistics* 5th edition publish by Pearson education Singapore (Pvt) Ltd

Course Number	Title	Credit Hours	Marks
MATH-746-P	Numerical Analysis-II	4(4-0)	80

NUMERICAL ANALYSIS-II

Methods of least squares, Numerical Integration for equally spaced data, Newton cotes formula and its special cases e.g. Trapezoidal Rule Simson's Rules, Gaussian quadrature using a system of orthogonal, Polynomials (Legender and Laguere Ploynomials, Numerical Differentiation, Difference Equations, Differential Equations, Euler's Method, Improved Euler's Methods. Mid point Formula, Heun's Method,

BOOKS RECOMMENDED

1. Johnson L., and Dean, R.; *Numerical Analysis*, Addison Wesley.
2. James, M.L., Smith, G.M. & Woford, J.C., *Applied Numerical Methods for Digital Computation*, Harper and Row, Publications.
3. Ralston, A & Philips, R.A. *First Course in Numerical Analysis*, McGraw Hill.
4. Froeberg , C.E. *Introduction to Numerical Analysis*, Addison Wesley.
5. Scarborough , J.B., *Numerical Mathematical Analysis* , John Hopkins Press.
6. M. Iqbal, *Numerical Analysis* , National Book Foundation.
7. J.H. Wilkinson, *Eigenvalue Problems*, Oxford University Press.
8. Aitkinson , *Elementary Numerical Analysis*.

Course Number	Title	Credit Hours	Marks
MATH-747- P	Theory of Optimization	4(4-0)	80

THEORY OF OPTIMIZATION

Introduction to optimization. Relative and absolute extreme. Convex. Concave and unimodal functions. Constants. Mathematical programming problems. Optimization of one, two and several variables functions and necessary and sufficient conditions for their optima.

OPTIMIZATION BY EQUALITY CONSTRAINTS

Direct substitution method and Lagrange multiplier method, necessary and sufficient conditions for an equality-constrained optimum with bounded independent variables. Inequality constraints and Lagrange multipliers. Kuhn-Tucker Theorem. Multidimensional optimization by Gradient method. Convex and concave programming, Calculus of variation and Euler Language equations, Functions depending on several independent variables. Variational problems in parametric form. Generalized mathematical formulation of dynamics programming. Non-Linear continuous models, Dynamics programming and Variational calculus. Control theory.

RECOMMENDED BOOKS

1. Gotfried B.S and Weisman, J. *Introduction to Optimization Theory* (Prentice-Inc. New Jersey,1973).
2. Elsgolts. L. *Differential Equations and the Calculus of Variations* (Mir Publishers- Moscow,1970).
3. Wismer D.A and Chattergy R. *Introduction to Nonlinear Optimization* (North - Holland, New York,1978).
4. Intriligator M.D. *Mathematical Optimization and Economic Theory*(Prentice-Hall, Inc, New Jersey,1971).

Course Number	Title	Credit Hours	Marks
MATH-748- P	Special Functions	4(4-0)	80

SPECIAL FUNCTIONS

Sturm-Liouville theory of DEs, Basic properties of a SL System, Orthogonality, Reality and uniqueness, Sturm's comparison theorem, completeness of Eigenfunctions Via Rayleigh quotient, Bessel functions, Legendre Polynomial and their Generating functions and properties, Hermite equation and functions and their properties, Laguerre Equation and functions and their properties, chibeicif function, Hypergeomtric Differential Equations and Functions, Gamma and Beta Functions

RECOMMENDED BOOKS

1. G.B. Arfken And H. J. Weber, *Mathematical Methods for Physicists*, CUP New York.
2. B. G. Korenev, *Bessel Functions and their Applications*
3. R. E. Attar, *Special Functions and Orthogonal Polynomials*
4. G. N. Watson, *A Treatise on the Theory of Bessel Functions*

Course Number	Title	Credit Hours	Marks
MATH-749-P	Project	4(4-0)	80

The Project of M.Sc. Mathematics will be offered as an optional paper to not more than 50 % of the class strength and only to those who obtain at least 65 % marks on the basis of their performance in I & II Semesters.

Course Number	Title	Credit Hours	Marks
MATH-741-A	Fluid Mechanics -II	4(4-0)	80

FLUID MECHANICS -II

Vortex motion, Line Vortex, Vortex row Image System, Kelvin's minimum energy theorem, Uniqueness theorem, Fluid streaming past a circular cylinder, Irrational motion produced by a vortex filament. The Helmholtz vorticity equation, Karman's vortex-street.

Constitutive equations; Navier- Stoke's equations; Exact solution of Navier-Stoke's equations; Steady unidirectional flow; Poiseuille flow; Couette flow; Unsteady undirectional flow, Sudden motion of a plane boundary in a fluid at rest; Flow due to an oscillatory boundary; Equations of motion relative to a rotating system; Ekman flow; Dynamical similarity of turbulent motion.

BOOKS RECOMMENDED

1. L.D. Landan & E. M. Lifshitz, *Fluid Mechanics,* Pergamon Press, 1966.
2. Batchelor, G.K. *An Introduction to Fluid Dynamics,* Cambridge University Press, 1969.
3. Walter Jaunzemis, *Continuum Mechanics,* McMillan Company, 1967.
4. Milne-Thomas, *Theoretical Hydrodynamics,* McMillan Company, 1967.
5. D. J Tritton, Physical Fluid Dynamics 2nd edition Oxford

Course Number	Title	Credit Hours	Marks
MATH-742- A	Partial Differential Equations	4(4-0)	80

PARTIAL DIFFERENTIAL EQUATIONS

Basic Concepts and Definitions, Formation and Classification of partial differential equations (PDEs). Partial differential equations of the first order. Nonlinear PDEs of first order. Applications of first order PDEs. Partial differential equations of second order: Mathematical formation of heat, Laplace and wave equations. Classification of second order PDEs. Boundary and initial conditions. Characteristics. Method of Characteristics. Reduction to various Canonical (Normal) forms. And the general solutions of PDEs. Methods of separation of variables (Product Method) for solving PDEs like elliptic, parabolic and hyperbolic equations. The Cauchy Problem. Cauchy's Problem for hyperbolic system in two independent variables with application to wave equations. Laplace, Fourier and Hankel transform for the solution of PDEs and their application to boundary value problems.

RECOMMENDED BOOKS

1. E.I. Butkov, *Mathematical Physics,* Addison-Wesley.
2. H. Sagan, *Boundary and Eigenvalue Problems in Mathematical Physics.*
3. My-Tung & Debnath, *Partial Differential Equations.*
4. G. Arken, *Mathematical Methods for Physics,* Academic Press.
5. I. Stakgold, *Boundary Value Problems of Mathematical Physics, Vol. I, II Macmillan.*
6. Sneddon, I.N., *Elements of Partial Differential Equations,* McGraw-Hill Book Company, 1987.
7. Dennemyer, R., *Introduction to Partial Differential Equations and Boundary Value Problems*, MeGraw-Hill Book Company,1968.
8. Himi, M And Millerl, W.B., *Boundary Value Problems and Partial Differential equations* PWS-Kent Publishing Company, Boston, 1992.

9. Chester, C. R., *Techniques in Partial Differential equations* MeGraw-Hill Book Company, 1971.

10. Haberman, R., *Elementary Applied Partial Differential Equations*, Prentice Hall, Inc. New Jersey, 1983.

11. Zauderer E., *Partial differential Equations of Applied Mathematics*, John Wiley & Sons, Englewood Cliff, New York, 1983

12. J. D. Logan, *Partial Differential Equations*, *Second Edition*, Springer-Verlag, 2004

Course Number	Title	Credit Hours	Marks
MATH-743- A	Theory of Elasticity	4(4-0)	80

THEORY OF ELASTICITY

Cartesian tensors, Analysis of stress and strain, Generalized Hooke's law; crystalline structure, Point groups of crystals, Reduction in the number of elastic moduli due to crystal symmetry; Equations of equilibrium; Boundary conditions, ompatibility equations; Plane stress and plane strain problems; Two dimensional problems in rectangular and polar co-ordinates; torsion of rods and beams.

RECOMMENDED BOOKS

1. S. P. Timoshenko And J.N. Goodier, *Theory of Elasticity, 3rd edition*, McGraw Hill Book Company, 1970, 1987.
2. A. P. Boresi And K. P. Chong, *Elasticity iri Engineering Mechanics, 2nd edition*, John Wiley & Sons, 2000.
3. A.C. Ugural And S.K. Fenster, *Advanced Strength and Applied Elasticity, 2nd edition* Elsevier Science Publishing Co., Inc., 1987.
4. Adel S. Saada, Elasticity: *Theory and Applications, Second Edition*, Krieger Publishing, Malabar, Florida, 1993.
5. Abdel-Rahman Ragab & Salah Eldin Bayoumi, *Engineering Solid Mechanics: Fundamentals and Applications*, CRC Press, Boca Raton, Florida, 1999.

Course Number	Title	Credit Hours	Marks
MATH-744- A	Electromagnetism	4(4-0)	80

ELECTROMEGNETISM

Electrostatics and the solution of electrostatics problems in vacuum and in media, Electrostatic energy, Electro currents, The magnetic field of steady currents. Magnetic properties of matter. Magnetic energy, Electromagnetic Introduction, Maxwell's equations, Boundary Value Potential Problems in two dimensions, Electromagnetic Waves, Radiation, Motion of electric charges.

RECOMMENDED BOOKS

1. Reitz, J. R. & Milford, F. J., *Foundation of Electromagnetic Theory,* Addison-Wesley 1969.
2. Panofsky, K.H. and Philips, M., *Classical Electricity and Magnetism,* Addison Wesley, 1962.
3. Corson, D. and Lerrain, P., *Introduction to Electromagnetic Fields and Waves, Freeman, 1962.*
4. Jackson, D.W., *Classical Electrodynamics, John-Wiley.*
5. Ferraro, V.C.A., *Electromagnetic Theory*, the Athlone Press, 1968.

Course Number	Title	Credit Hours	Marks
MATH-745- A	Mathematical Statistics- II	4(4-0)	80

MATHEMATICAL STATISTICS- II

Statistical inference. Maximum likelihood estimators. Properties of maximum likelihood estimators. Sufficient statistics. Jointly sufficient statistics. Minimal sufficient sufficient statistics. The sampling distribution of a statistic. The chi square distribution. Joint distribution of the sample mean and sample variance. The t distribution. Confidence intervals. Unbiased estimators. Fisher information. Testing simple hypotheses. Uniformly most powerful tests. The t test. The F distribution. Comparing the means of two normal distributions. Tests of goodness of fit. Contingency tables. Equivalence of confidence sets and tests. Kolmogorov- Smirnov tests. The Wilcoxon Signed-ranks tests. The Wilcoxon-Mann-Whitney Ranks test.

RECOMMENDED BOOKS

1. Mood, A.M. Graybill, F.A . Boes, D.C. *Introduction to the Theory of Statistics,2nd Edition,* (McGraw-Hill Book Company New York ,1986).
2. Degroot, M.H. *Probability and Statistics, 2nd Edition* (Addison Wesley Company New York 1986).

Course Number	Title	Credit Hours	Marks
MATH-746-A	Numerical Analysis-II	4(4-0)	80

NUMERICAL ANALYSIS-II

Methods of least squares, Numerical Integration for equally spaced data, Newton cotes formula and its special cases e.g. Trapezoidal Rule Simson's Rules, Gaussian quadrature using a system of orthogonal, polynomials (Legender and Laguere Ploynomials, Numerical Differentiation, Difference Equations, Differential Equations, Euler's Method, Improved Euler's Methods. Mid point Formula, Heun's Method,

BOOKS RECOMMENDED

1. Johnson L., and Dean, R.; *Numerical Analysis*, Addison Wesley.
2. James, M.L., Smith, G.M. & Woford, J.C., *Applied Numerical Methods for Digital Computation*, Harper and Row, Publications.
3. Ralston, A & Philips, R.A. *First Course in Numerical Analysis*, McGraw Hill.
4. Froeberg , C.E. *Introduction to Numerical Analysis*, Addison Wesley.
5. Scarborough , J.B., *Numerical Mathematical Analysis* , John Hopkins Press.
6. M. Iqbal, *Numerical Analysis* , National Book Foundation.
7. J.H. Wilkinson, *Eigenvalue Problems*, Oxford University Press.
8. Aitkinson , *Elementary Numerical Analysis*.

Course Number	Title	Credit Hours	Marks
MATH-747-A	Theory of Optimization	4(4-0)	80

OPTIMIZATION THEORY

Introduction to optimization. Relative and absolute extreme. Convex. Concave and unimodal functions. Constants. Mathematical programming problems. Optimization of one, two and several variables functions and necessary and sufficient conditions for their optima.

OPTIMIZATION BY EQUALITY CONSTRAINTS

Direct substitution method and Lagrange multiplier method, necessary and sufficient conditions for an equality-constrained optimum with bounded independent variables. Inequality constraints and Lagrange multipliers. Kuhn-Tucker Theorem. Multidimensional optimization by Gradient method. Convex and concave programming, Calculus of variation and Eulre Language equations, Functions depending on several independent variables. Variational problems in parametric form. Generalized mathematical formulation of dynamics programming. Non-Linear continuous models Dynamics programming and Variational calculus. Control theory.

RECOMMENDED BOOKS

1. Gotfried B.S and Weisman, J. *Introduction to Optimization Theory* (Prentice-Inc. New Jersey,1973).
2. Elsgolts. L. Differential Equations and the Calculus of Variations (Mir Publishers-Moscow,1970).
3. Wismer D.A and Chattergy R. *Introduction to Nonlinear Optimization* (North - Holland, New York,1978).
4. Intriligator M.D. *Mathematical Optimization and Economic Theory*(Prentice-Hall, Inc, New Jersey,1971).

Course Number	Title	Credit Hours	Marks
MATH-748- A	Special Functions	4(4-0)	80

SPECIAL FUNCTIONS

Sturm-Liouville theory of DEs, Basic properties of a SL System, Orthogonality, Reality and uniqueness, Sturm's comparison theorem, completeness of Eigenfunctions Via Rayleigh quotient, Bessel functions, Legendre Polynomial and their Generating functions and properties, Hermite equation and functions and their properties, Laguerre Equation and functions and their properties, chibeicif function, Hypergeomtric Differential Equations and Functions, Gamma and Beta Functions

RECOMMENDED BOOKS

1. G.B. Arfken And H. J. Weber, *Mathematical Methods for Physicists*, CUP New York.
2. B. G. Korenev, *Bessel Functions and their Applications*
3. R. E. Attar, *Special Functions and Orthogonal Polynomials*
4. G. N. Watson, *A Treatise on the Theory of Bessel Functions*

Course Number	Title	Credit Hours	Marks
MATH-749-A	Project	4(4-0)	80

The Project of M.Sc. Mathematics will be offered as an optional paper to not more than 50 % of the class strength and only to those who obtain at least 65 % marks on the basis of their performance in I & II Semesters.

Course Number	Title	Credit Hours	Marks
MATH-750-A	C++	4(4-0)	80

PROGRAMMING LANGUAGE C++.

Object Oriented Programming using C++. Declaring Variable, Designing Functions, Designing Classes, Using Built in Functions and Libraries.

Introduction I:- History of C++, writing C++ Program, structure, preprocessor, Header file, Main function, Increment operators++, data types, Declaration of the variable, Initialization of the variable, Arithmetic operators, arithmetic Expression, order of precedence of operation.

Introduction 2:- Basis input / output, cout<< object, the escape sequence, the end line, setw manipulator, Assignment operator, the cin>> operator. Compound assignment, increment and decrement operator, the comment statement, the conditional statement, loops statement, arrays, structures, functions part I and part II, pointers, inheritance, and polymorphism part I and II, Files graphics, bit wise operators.

RECOMMENDED BOOKS

1. Object Oriented Programming Using C++ by Robert Lafore 3rd Edition.
2. Aikman Series. C.M Aslam T A Qurashi. Urdu bazaar Lahore.