HAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR
DEPARTMENT OF MATHEMATICS

DETAILED COURSE OUTLINE OF MATHEMATICS M.SC (2 YEARS PROGRAM)

Course Name: Advance Calculus	**Course Code:** Math-511
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites: Knowledge of Intermediate Calculus	

Course Outline:

The real numbers: Algebraic and order properties of R; the completeness property; cluster points; open and closed sets in R. Sequences, the limit of a function, limit theorems. **Continuous functions on intervals:** boundedness theorem, maximum-minimum theorem and the intermediate value theorem; uniform continuity.
The derivative: The mean value theorem; Taylor's theorem.
Functions of several variables: Limit and continuity of functions of two and three variables; partial derivatives; differentiable functions.
Multiple Integrals: Regions in the x-y plane, iterated integrals, double integrals, change in the order of integration, transformation of double integrals.
Line and surface integrals: Jordan curve, regular region, line integral, Green's theorem, independence of the path, surface integrals, Gauss theorem.

Recommended Books:

1. Bartle, R.G. and Sherbert, D.R. Introduction to Real Analysis, John Wiley & Sons 1994.
2. Widder, D.V. Advanced Calculus, Prentice-Hall, 1982.
3. Rudin, W Principles of Real Analysis, McGraw-Hill, 1995.

Course Name: Group Theory	**Course Code:** Math-512
Course Structure: Lectures: 3	**Credit Hours:** 3

Course Outline:

R Groups: Historical background, Definition of a Group with some examples, Order of an element of a group, subgroup, Generators and relations, Free Groups, Cyclic Groups, Finite groups.

Group of permutations: Cayley's Theorem on permutation groups, Cosets and Lagrange's theorem, Normal subgroups, Simplicity, Normalizers, Direct Products.

Homomorphism: Factor Groups, Isomorphisms, Automorphism, Isomorphism Theorems.

Group Acions: Stablizers, Conjugacy classes, Sylow theorems and their applications.

Recommended Books:

1. Shilov, G.E., Linear Algebra, Dover Publication, Inc., New York, 1997.
2. Zill, D.G. and Cullen M.R., Advanced Engineering Mathematics, PWS, publishing company, Boston, 1996.
3. Herstein, I., TopicsinAlgebra, John-Wiley, 1975.
4. Trooper, A.M., Linear Algebra, Thomas Nelson and Sons, 1969.

Course Name: Set Topology	**Course Code: Math-513**
Course Structure: Lectures: 3	**Credit Hours: 03**
Prerequisites:	

Course Outline:

Motivation and introduction, sets and their operations, countable and uncountable sets, cardinal and transfinite numbers. Topological spaces, open and closed sets, interior, closure and boundary of a set, neighborhoods and neighborhood systems, isolated points, some topological theorems, topology in terms of closed sets, limit points, the derived and perfect sets, dense sets and separable spaces, topological bases, criteria for topological bases, local bases, first and second countable spaces, relationship between spar ability and second countability, relative or induced topologies, necessary and sufficient condition for a subset of a subspace to be open in the original space, induced bases. Metric spaces, topology induced by a metric, equivalent topologies, formulation with closed sets, Cauchy sequence, complete metric spaces, characterization of completeness, Cantor's intersection theorem, the completion of metric space, metrizable spaces. Continuous functions, various characterizations of continuous functions, geometric meaning, homeomorphisms, open and closed continuous functions, topological properties and homeomorphisms. Separation axioms, T1 and T2 spaces and their characterization, regular and normal spaces and their characterizations, Urysohn's lemma, Urysohn'n metrizablity theorem (without proof). Compact spaces their characterization and some theorems, construction of compact spaces, compactness in metric spaces, compactness and completeness, local compactness. Connected spaces, characterization and some properties of connected spaces.

Recommended Books:

1. Munkres, J.R., Topology A First Course, Prentice - Hall, Inc. London, 1975.
2. Simon, G.F., Introduction to Topology and Modern Analysis McGraw-Hill, New York, 1963.
3. Pervin, W.J., Foundation of General Topology, Academic Press, London, 2nd, ed., 1965.

Course Name: Real Analysis	**Course Code:** Maths-514
Course Structure: Lectures: 3	**Credit Hours: 03**

Prerequisites:

Course Outline:

The Riemann Integral: Upper and lower sums, definition of a Riemann integral, integrability criterion, classes of integrable functions, properties of the Riemann integral.
Infinite Series: Review of sequences, the geometric series, tests for convergence, conditional and absolute convergence. Regrouping and rearrangement of series. Power series, radius of convergence.
Uniform Convergence: Uniform convergence of a sequence and a series, the M-test, properties of uniformly convergent series. Weierstrass approximation theorem.
Improper Integrals: Classification, tests for convergence, absolute and conditional convergence, convergence of òf(x) sinx dx, the gamma function. Uniform convergence of integrals, the M-text, properties of uniformly convergent integrals.
Fourier Series: Orthogonal functions, Legendre, Hermite and Laguerre polynomials, convergence in the mean. Fourier-Legendre and Fourier-Bessel series, Bessel inequality, Parseval equality. Convergence of the trigonometric Fourier series.

Recommended Books:

1. Bartle, R.G. and Sherbert, D.R., Introduction to Real Analysis, John Wile Sons 1994.
2. Widder, D.V., Advanced Calculus, Prentice Hall 1982.
3. Rudin, W., Principles of Real Analysis, McGraw-Hill 1995.
4. Rabenstein, R.L., Elements of Ordinary Differential Equations, Academic Press, 1984.

Course Name: Complex Analysis	**Course Code:** Math-521
Course Structure: Lecture: 3	**Credit Hours: 03**
Prerequisites:	

Course Outline:

Algebra of complex numbers, analytic functions, C-R equations, harmonic functions, elementary functions, branches of log z, complex exponents.
Integrals: Contours, Cauchy-Goursat theorem, Cauchy integral formula, Morera's theorem, maximum moduli of functions, Liouville's theorem, fundamental theorem of algebra.
Series: Convergence of sequences and series, Taylor series, Laurent series, uniqueness of representation, zeros of analytic function.
Residues and poles: the residue theorem, evaluation of improper integrals, integrals involving trigonometric functions, integration around a branch point.
Mapping by elementary functions: linear functions, the function 1/z, the transformations
w = exp(z) and w = sin(z), successive transformations. Analytic continuation, the argument principle, Rouche's theorem.

.

Recommended Books:

1. Churchill, R.V. Verhey and Brown R., Complex Variables and Applications McGraw-Hill, 1996.
2. Marsden, J.E., Basic Complex Analysis, W.H.Freeman and Co, 1982.
3. Hille, E., Analytic Function Theory, Vols.I and II, Chelsea Publishing Co. New York, 1974.

Course Name: Linear Algebra	**Course Code:** Math-522
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Review of matrices and determinants. Linear spaces. Bases and dimensions. Subspaces. Direct sums of subspaces. Factor spaces. Linear forms. Linear operators. Matrix representation and sums and products of linear operators. The range and null space of linear operators and linear operators. Invariant subspaces. Eigen values and eigen vectors. Transformation to new bases and consecutive transformations. Transformations of the matrix of a linear operator. Canonical form of the matrix of a nilponent operator. Polynomial algebra and canonical form of the matrix of an arbitrary operator. The real Jordan canonical form. Bilinear and quadratic forms and reduction of quadratic form to a canonical form. Adjoint linear operators. Isomorphisms of spaces. Hermitian forms and scalar product in complex spaces. System of differential equations in normal form. Homogeneous linear systems. Solution by diagonalisation. Non-homogeneous linear systems.

1. **Recommended Books:**
2. Shilov, G.E., Linear Algebra, Dover Publication, Inc., New York, 1997.
3. Zill, D.G. and Cullen M.R., Advanced Engineering Mathematics, PWS, publishing company, Boston, 1996.
4. Herstein, I., TopicsinAlgebra, John-Wiley, 1975.
5. Trooper, A.M., Linear Algebra, Thomas Nelson and Sons, 1969.

Course Name: Numerical Methods	**Course Code:** Math-523
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Number Systems and Errors: Loss of significance and error propagation, condition and instability; error estimation; floating point arithmatic; loss of significance and error propagation.
Interpolation by Polynomials: Existence and uniqueness of the interpolating polynomial. Lagrangian interpolation, the divided difference table. Error of the interpolating polynomial; interpolation with equally spaced data, Newton's forward and backward difference formulas, Bessel's interpolation formula.
Solution of non-linear Equations: Bisection method, iterative methods, secant and regula falsi methods; fixed point iteration, convergence criterion for a fixed point iteration, Newton-Raphson method,order of convergence of Newton-Raphson and secant methods.
System of Linear Equations: Gauss elimination methods, triangular factorization, Crout method.
Iterative methods: Jacobi method, Gauss-Seidel method, SOR method, convergence of iterative methods.
Numerical Differentiation: Numerical differentiation formulae based on interpolation polynomials, error estimates.
Numerical Integration: Newton-Cotes formulae; trapezoidal rule, Simpson's formulas, composite rules, Romberg improvement, Richardson extrapolation. Error estimation of integration formulas, Gaussian quadrature.
(Programming will be done in FORTRAN.)

Recommended Books:

1. McCracken, D.D., A guide to Fortran IV programme, Second Edition, John Wiley & Sons, Inc, New York, London, Sydney, Toronto, 1979.
2. Conte, S.D. and Boor, C., Elementary Numerical Analysis, McGraw-Hill 1980.
3. Ahmad, F. and Rana, M.A., Elements of Numerical Analysis, National Book Foundation, Islamabad, 1995.

4. Zurmuhl, R., Numerical Analysis for Engineers and Physicists, Springer-Verlag 1976.

Course Name: Measure And Integration	**Course Code:** Math-524
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Measure Spaces: Definition and examples of algebras and s-algebras, Basic properties of measurable spaces, Definition and examples of measure spaces, Outer measure, Lebesgue measure, Measurable sets, Complete measure spaces.
Measurable Functions: Some equivalent formulations of measurable functions, Examples of measurable functions, Various characterization of measurable functions, Property that holds almost everywhere, Egorov's theorem.
Lebesgue Integrations: Definition of Lebesgue integral, Basic properties of Lebesgue integrals, Comparison between Riemann integration and Lebesgue integration, L2-space, The Riesz-Fischer theorem.

Recommended Books:

1. Royden, H.L., Real Analysis, Macmillan, 1968.
2. Cohn, D.L., Measure Theory, Birkhauser, 1980.
3. Halmos, P.R., Measure Theory, D.Van Nostrand, 1950.

Course Name: Symbolic Computation	**Course Code:** Math-525
Course Structure: Lectures: 1, Practical: 2	**Credit Hours:** 1+2
Prerequisites:	

Course Outline:

Introduction

General introduction and basic use of mathematica, numeric and symbolic computation, the note book, working with data, input and output, built-in functions, front end and the kernel, errors, help

Language of Mathematica

Expressions, values, variables, functions and assignments,, immediate vs delayed, patterns and pattern matching, conditional patterns, predicates and Boolean operations, relational and logical operators, attributes.

Lists

Simple and multidirectional list, List construction and manipulation, testing a list, extracting elements, rearranging list, list component assignments, working with several lists

Programming

Functional programming, Map, Thread, Apply, Inner and Outer, Nest, NestList, Programs as functions, user defined functions, pure functions, module. Procedural programming, loops, flow control. Rule base programming. Dynamic programming. Graphics programming. Writing packages.

Recommended Books:

1. Paul R. Wellin, Richard J. Gaylord, Samuel N. Kamin, *An introduction to programming with Mathematica, third edition*, Cambridge university press New York, 2005.
2. Hartmut F. W. Hoft, Margret Hoft, *Computing with Mathematica, second edition*. Academic Press, 2003.
3. Martha L. Abell, James P.Braselton, *Mathematica By Example, Third Edition*, Academic Press, 2004.

Course Name: Differential Geometry -I	**Course Code:** Math-631
Course Structure: Lectures: 3	**Credit Hours:** 03
Prerequisites:	
Historical background; Motivation and applications. Index notation and **Course Outline:** Summation convention; Space curves; The tangent vector field; Reparametrization; Arc length; Curvature; Principal normal; Binormal; Torsion; The osculating, the normal and the rectifying planes; The Frenet-Serret Theorem;	

Spherical images; Sphere curves; Spherical contacts; Fundamental theorem of space curves; Line integrals and Green's theorem; Local surface theory; Coordinate transformations; The tangent and the normal planes; Parametric curves; The first fundamental form and the metric tensor; Normal and geodesic curvatures; Gauss's formulae; Christoffel symbols of first and second kinds; Parallel vector fields along a curve and parallelism; The second fundamental form and the Weingarten map; Principal, Gaussian, Mean and Normal curvatures; Dupin indicatrices; Conjugate and asymptotic directions; Isometries and the fundamental theorem of surfaces.

Recommended Books:

1. Millman,R.S and Parker., G.D. Elements of Differential Geometry, Prentice-Hall Inc., New Jersey, 1977.
2. Struik, D.J., Lectures on Classical Differential Geometry, Addison-Wesley Publishing Company, Inc., Massachusetts, 1977.
3. Do Carmo, M.P., Differential Geometry of Curves and Surfaces, Prentice-Hall, Inc., Englewood, New Jersey, 1985.
4. Neil, B.O., Elementary Differential Geometry, Academic Press, 1966.
5. Goetz, A., Introduction to Differential Geometry, Addison-Wesley, 1970.
6. Charlton, F., Vector and Tensor Methods, Ellis Horwood, 1976.
7. F. Chorlton, *Vector and Tensor Methods*, Ellis Horwood Publisher, U.K., 1977.

Course Name: Functional Analysis	**Course Code:**Math-632
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Banach Spaces: Definition and examples of normed spaces, Banach spaces, Characterization of Banach spaces.
Bounded Linear Transformations: Bounded linear operators, Functionals and their examples, Various characterizations of bounded (continuous) linear operators, The space of all bounded linear operators, The open mapping and closed graph theorems, The dual (conjugate) spaces, Reflexive spaces.
Hahn-Banach Theorem: Hahn-Banach theorem (without proof), Some important consequences of the Hahn-Banach theorem.
Hilbert Spaces: Inner product spaces and their examples, The Cauchy-Schwarz inequality, Hilbert spaces, Orthogonal complements, The projection theorem, The Riesz representation theorem.

Recommended Books:

1. Kreyszig, E., Introductory Functional Analysis with Applications, John Wiley, 1978.
2. Maddox, J., Elements of Functional Analysis, Cambridge, 1970.
3. Simmon, G.F., Introduction to Topology and Modern Analysis, McGraw-Hill, N.Y.1983.
4. Rudin, W., Functional Analysis, McGraw-Hill, N.Y., 1983.

Course Name: Mathematical Statistics-I	**Course Code:** Math-633
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

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

Course Name: Ordinary Differential Equations	**Course Code:** Math-634
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Definitions and occurrence of differential equations (d.e.), remarks on existence and uniqueness of solution. First order and simple higher order d.e; special equations of 1st order. Elementary applications of 1st order d.e. Theory of linear differential equations. Linear equations with constant coefficients. Methods of undetermined coefficients and variation of parameters. S-L boundary value problems; self adjoint operators. Fourier series. Series solution of d.e. The Bessel modified Bessel Legendres, Hermite, Hypergeometric, Lauguere equations and their solutions. Orthogonal polynomials. Green function for ordinary differential equations.

Recommended Books:

1. Morris, M and Brown, O.E., Differential Equations, Englewood Cliffs, Prentice-Hall, 1964.
2. Spiegel, M.R., Applied Differential Equations, Prentice-Hall, 1967.
3. Chorlton, F., Ordinary Differential and Difference Groups, Van Nostrand, 1965.
4. Brand, L., Differential and Difference Equations, John-Wiley, 1966.
5. Zill, D.G and Cullen, M.R., Advanced Engineering Mathematics PWS, Publishing Co. 1992.
6. Rainville, E.D. and Bedient, P.E., Elementary Differential Equations, MaCmillian Company, New York, 1963.

Course Name: Differential Geometry-II	**Course Code:** Math-641
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Definition and examples of manifolds; Differential maps; Submanifolds; Tangents; Coordinate vector fields; Tangent spaces; Dual spaces; Multilinear functions; Algebra of tensors; Vector fields; Tensor fields; Integral curves; Flows; Lie derivatives; Brackets; Differential forms; Introduction to integration theory on manifolds; Riemannian and semi-Riemannian metrics; Flat spaces; Affine connextions; Parallel translations; Covariant differentiation of tensor fields; Curvature and torsion tensors; Connexion of a semi-Riemannian tensor; Killing equations and Killing vector fields; Geodesics; Sectional curvature.

Recommended Books:

1. Bishop, R.L. and Goldberg, S.I., Tensor Analysis on Manifolds, Dover Publications, Inc. N.Y., 1980.
2. do Carmo, M.P., Riemannian Geometry, Birkhauser, Boston, 1992.
3. Lovelock, D. and Rund, H. Tensors., Differential Forms and Variational Principles, John-Willey, 1975.
4. Langwitz, D., Differential and Riemannian Geometry, Academic Press, 1970.
5. Abraham, R., Marsden, J.E. and Ratiu, T., Manifolds, Tensor Analysis and Applications, Addison-Wesley, 1983.

Course Name: Analytical Mechanics	**Course Code:** Math-642
Course Structure: Lectures: 3	**Credit Hours:** 3

Prerequisites:
Course Outline: **Review of basic principles:** Kinematics of particle and rigid body in three dimension; Euler's theorem. Work, Power, Energy, Conservative field of force. Motion in a resisting medium. Variable mass problem. Moving coordinate systems, Rate of change of a vector, Motion relative to the rotating Earth. The motion of a system of particles, Conservation laws. Generalized coordinates, Lagrange's equations, Hamilton's equations, Simple applications. Motion of a rigid body, Moments and products of inertia, Angular momentum, kinetic energy about a fixed point; Principal axes; Momental ellipsoid; Equimomental systems. Gyroscopic motion, Euler's dynamical equations, Properties of a rigid body motion under no forces. Review of material.
Recommended Books: 1. Chorlton, F., Principles of Mechanics, McGraw Hill, N.Y 1983. 2. Symon, K.R., Mechanics, Addison Wesley, 1964. 3. Goldstein, H., Classical Mechanics, Addison Wesley, 2nd Edition, 1980. 4. Synge, J. I. and Griffith, B. A., Principles of Mechanics, McGraw-Hill, N.Y. 1986. 1. Beer, F. P. and Johnston, E. R., Mechanics for Engineers, Vols.I&II, McGraw-Hill, N.Y, 1975

Course Name: Mathematical Statistics-II	**Course Code:** Math-643
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites: Real Analysis-I	
Course Outline: Statistical inference. Maximum likelihood estimators. Properties of maximum likelihood estimators. Sufficient statistics. Jointly sufficient statistics. Minimal sufficient statistics. The sampling distribution of a statistic. The chi square distribution. Joint distribution of the sample mean and sample variance. Tha**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 test. The Wilcoxon-Mann-Whitney Ranks test.	
Recommended Books: 1. Mood, A.M., Graybill, F.A., Boes, D.C., Introduction to the Theory of Statistics, 2^{nd} edition, McGraw-Hill Book Company New York 1986. 2. Degroot, M. H., Probability and Statistics, 2nd edition, Addison-Wesley Publishing Company, USA 1986.	

Course Name: Partial Differential Equations	**Course Code:** Math-644
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Review of ordinary differential equation in more than one variable. Partial differential equations (p.d.e) of the first order. Nonlinear p.d.e. of first order Applications of 1st order partial differential equations.

Partial differential equations of second order: Mathematical modeling of heat, Laplace and wave equations. Classification of 2nd order p.d.e. Boundary and initial conditions. Reduction to canonical form and the solution of 2nd order p.d.e. Technique of separation of variable for the solution of p.d.e with special emphasis on Heat, Laplace and wave equations. Laplace, Fourier and Hankel transforms for the solution of p.d.e and their application to boundary value problems.

Recommended Books:

1. Sneddon, I.N., Elements of Partial Differential Equations, McGraw-Hill Book Company, 1987.
2. Dennemyer, R., Introduction to Partial Differential Equations and Boundary Value Problems, McGraw-Hill Book Company, 1968.
3. Humi, M and Miller, W.B., Boundary Value Problems and Partial Differential Equations, PWS-Kent Publishing Company, Boston, 1992.
4. Chester, C.R., Techniques in Partial Differential Equations, McGraw-Hill Book Company, 1971.
5. Haberman, R., Elementary Applied Partial Differential Equations, Prentice Hall, Inc.New Jersey, 1983.
6. Zauderer, E., Partial Differential Equations of Applied Mathematics, John Wiley & Sons, Englewood Cliff, New York, 1983.

Course Name: Optimization Theory	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Specific Objectives of course:

The subject of optimization can be studied as a branch of pure mathematics and has application in nearly all the branches of science and technology. Therefore this course aims to equip students from those aspects of optimization methods which are of importance in real life problem solving.

Course Outline:

Basic Results:

Definition, Condition for unconstrained variables, Equality constraints, General consideration and necessary conditions of Inequality constraints. Convexity, abnormal point and sufficient conditions for Inequality. Sadle point condition and Duality. **Unconstrained Optimization:** Line search Methods, General search methods, Gradient Methods, Newton and Quasi Newton Methods. **Linear Programming:** Solution of LP Problem, Duality. **Constrained Optimization:** General Properties of the solution, Projection Methods, Quadratic Programming, Application of projection methods to nonlinear constraints..
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 Name: Numerical anlysis	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	
Course Outline: Osculating polynomials, Differentiation and integration in multidimension. Ordinary differential equations: Predictor methods, Modified Eulers method, Truncation error and stability, The Taylor series method, Runge-Kutta methods. Differential equations of higher order: System of differential equations; Runge-Kutta methods, shooting methods, finite difference methods. Partial differential equations: Elliptic hyperbolic and parabolic equations; Explicit and implicit finite difference methods, stability, convergence and consistency analysis, The method of characteristic. Eigen value problems; Estimation of eigen values and corresponding error bounds, Gerschgorin’s theorem and its applications Schur’s theorem, Power method, Shift of origin, Deflation method for the subdominant eigen values.	
Recommended Books:	

1. Conte, S.D., and De Boor., Elementary Numerical Analysis, McGraw-Hill 1972.
2. Gerald, C.F., Applied Numerical Analysis, Addison Wesely, 1984.
3. Froberg, C.E., Introduction to Numerical Analysis, Addison Wesely, 1972.
4. Gourlay, A.R. and Watson, G.A., Compitational Methods for Matrix Eigene Problems. John Wiley & Sons 1973.
5. Smith G.D., Numerical Solution of Partial Differential Equations, Oxford University Press.
6. Mitchel A.R. and Griffiths D.F., The Finite Difference Methods in Partial Differential Equations, John Wiley and Sons 1980.

Course Name: Integral Equations	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Integal equation formulation of boundary value problems, classification of integral equations, method of successive approximation, Hilbert-Schmidt theory, Schmidt's solution of non- homogeneous integral equations, Fredholm theory, case of multiple roots of characteristic equation, degenerate kernels. Introduction to Wiener-Hopf technique.

Recommended Books:

1. Lovitt, W.V., Linear integral equations, Dover Publications 1950.
2. Smith, F., Integral equations, Cambridge University Press.
3. Tricomi, F.G., Integral equations, Interscience, 1957.
4. B. Noble., Methods based on the Wiener-Hopf technique, Pergamon Press, 1958.
5. Abdul J. Jerri., Introduction to integral equations with applications, Marcel Dekker Inc. New York, 1985.

Course Name: Riemann Geometry	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Geodesics and their length minimizing properties; Jacobi fields; Equation of geodesic deviation; Geodesic completeness (Theorem of Hopf-Rinow); Curvature and its influence on topology (Theorem of Cartan-Myers and Hadamard); Geometry of submanifolds; Second fundamental form; Curvature and convexity; Minimal surfaces, Mean curvature of minimal surfaces; Calculus of differential forms and integration on manifolds; Theorem of Stokes; Elementary applications of differential forms to algebraic topology.

Recommended Books:

1. Do Carmo, M.P., Riemannian Geometry, Birkhauser, 1992.
2. Gallot. S.; Lafontaine, J., Riemannian Geometry, Springer-Verlag, 1990.
3. Bott, R. and Tu, M., Differential forms in algebraic topology, Springer-Verlag, 1987

Course Name: Continuous Groups	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Continuous Groups; Gl(n,R), Gl(n,C), So(p,q), Sp(2n); generalities on continuous groups; groups of isometries, classification of two and three dimensional Euclidean space accoding to their isometries; introduction to Lie groups with special emphasis on matrix Lie groups; relationship of isometries and Lie group; theorem of Cartan; correspondence of continuous groupswith 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. Husain 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 Name: Group Algorithm Analysis	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Algorithms and its Analysis – Basic concepts and its applications.
Mathematical Foundations: Growth of functions, Asymptotic functions, Summations, Recurrences, Counting and probability.

Divide-and-Conquer algorithms; General method and its analysis, Binary search and its analysis, Merge sort and its analysis, Quick sort and its analysis, Insertion sort and its analysis.

Advanced Design and Analysis Techniques: Dynamic Programming, Greedy algorithms and its applications in scheduling, Generating functions and its application in Recurrences, Permutation Algorithms and its application in sorting, Amortized analysis, Worst-case analysis, Average case analysis.

Graph algorithms: Basic search techniques, Algorithmic binary tees and its application, breadth-first search, Depth-first search, Planner graphs, Graph colouring, Minimum Spanning Trees, Single source shortest paths.

Special Topics:

Algorithms for parallel computers. Matrix Operations. Polynomials and the FFT. Number-Theoretic algorithms. NP-completeness. Approximations algorithms. Encyption/Decryption algorithms.

Recommended Books:

- Thomas H. Cormen and Charles E, Leiserson, Introduction to Algorithms, MIT Press, McGraw-Hill (2nd Edition) 1990.
- H. Sedgwick Analysis of Algorithms, Addison Wesley, (1st Edition) 1995.
- K. Rosen., Discrete Mathematics and its Applications, McGraw Hill, (5th Edition) 1999.

Course Name: Basics in Programming	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Introduction To Problem Solving Using Computers, Levels of Programming Languages, Role of Compilers and Interpreters.

C++ Programming Basics, Input/Output Statement, Operators and their Precedence.

Decision Statements: If Statement, Switch Statement.

Loops: For Loop, While Loop, Do Loop, Other Control Statements.

Arrays and Strings: Fundamentals and Usage, string Functions.

Function: Simple Functions, Kinds of Arguments, Pointers and Arrays, Pointers and strings, Pointers and Functions, Inline Functions Variable and Storage Classes.

Structures: Accessing Members of Structures, Structures Within Structure, Arrays of Structures, Enumerated Data Types.

Files: Text Files, Binary Files.

Objects and Classes: Constructors and Destructors, Objects as Function arguments, Overloading. Inheritance, Virtual Functions, Friend Functions.

Recommended Books:

- gary J. Bronson, Program development and Design using C++, Brooks and Cole Publishing Company: 2000, 2nd Edition.
- Nell Dale, Chip Weems, Mark Headington, Programming and Program Solving with C++, Jones and Bartlett Publisher: 1997, 3rd Edition.
- Robert Lafore, Objects Oriented Programming using C++. Techmedia, New Delli: 2001, 4th Edition.

Course Name: Advance Topology	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Compactness in metric spaces, limit point compactness, Sequential compactness and their various characteriztions, equivalence of different notions of compactness.
Connectedness, various characterizations of connectedness, connectedness and T2-spaces, local connectedness, path-connectedness, components.
Homotopic maps, homotopic paths, loop spaces, fundamental groups, covering spaces, the lifting theorem, fundamental groups of the circle, torus etc.
Chain complexes, 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., Elementry Topology, Addison-Wesley Publishing Company, 1972.

Course Name: Advance functional analysis	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

The Hahn-Banach theorem, principle of uniform boundedness, open mapping theorem, closed graph theorem, Weak topologies and the Banach-Alouglu theorem, extreme points and the Klein-Milman theorem.
The dual and bidual spaces, reflexive spaces, compact operators, Spectrum and eigenvalues of an operator, elementary spectral theory.

Recommended Books:

1. Kreyszing, E., Introductory Functional Analysis and Applications, John Wiley, 1973.
2. Taylor, A.E., and Lay, D.C., Introduction of Functional Analysis, John Wiley, 1979.
3. Heuser, H.G., Functional Analysis, John Wiley, 1982.
4. Groetsch, C.W., Elements of Applicable Functional Analysis, Marcel Dekker, 1980

Course Name: Fluid Mechanics-I	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Real fluids and ideal fluids, velocity of a fluid at a point, streamlines and pathlines, steady and unsteady flows, veclocity 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 equation 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, irrotational, incompressible flow, complex velocity potential for uniform stream. Line sources and line sinks, line doublets and line vortices, image systems, Miline-Thomson circle theroem, Blasius' theorem, the use of conformal transformation and the Schwarz-Christoffel transformation in solving problems, vortex rows.
Kelvin' s minimum energy theorem, Uniqueness theorem, fluid streaming past a circular cylinder, irrotational motion produced by a vortex filament.
The Helmholtz vorticity equation, Karman's vortex-street.

Recommended Books:

1. Chorlton, F., Textbook of fluid Dynamics, D. Van Nostrand Co. Ltd. 1967.
2. Thomson, M., Theoretical Hydrodynamics, Macmillan Press, 1979.
3. Jaunzemics, W., Continuum Mechanic, Machmillan Company, 1967.
4. Landau, L.D., and Lifshitz, E.M., Fluid Mehanics, Pergamon Press, 1966.
5. Batchelor, G.K., An Introduction to Fluid Dynamics, Cambridge University Press, 1969.

Course Name: Analytical Dynamics	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Constraints, generalized co-ordinates, generalized forces, general equation of dynamics, Lagrange's equations, conservation laws, ignorable co-ordinates, Explicit form of Lagranges equation in terms of tensors. Hamilton's principle, principle of least action, Hamilton's equations of motion, Hamilton-Jacobi Method. Poisson Brackets (P.B's); Poisson's theorem; Solution of mechanical problems by algebraic technique based on (P.B's). Small oscilations and normal modes, vibrations of straings, transverse vibrations, normal modes, forced vibrations and damping, reflection and transmission at a discontinuity, Iongitudinal vibrations, Rayleigh's principle.

Recommended Books:

1. Chorlton, F., Textbook of dynamics, Van Nostrand, 1963.
2. Chester, W., Mechanics, George Allen and Unwin Ltd., London 1979.

3. Goldstein, H., Classical Mechanics, Cambridge, Mass Addison-Wesley, 1980. (latest edition).
4. G. Meirovitch. L., Methods of Analytical Dynamics, McGraw-Hill, 1970.

Course Name: Introductry Quantum Mechanics	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Basic postulates of quantum mechanics. State vectors. Formal properties of quantum mechanical operators. Eigenvalues and eigenstates, simple harmonic oscillator. Schrodinger representation. Heisenberg equation of motion Schrodinger equation. Potential step, potential barrier, potential well. Orbital angular momentum. Motion in a centrally symmetric field. Hydrogen atom. Matrix representation of angular momentum and 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. Merzbacher, E., Quantum Mechanics, John Wiley 2nd Ed. 1970.
3. Liboff, R.L., Introductory Quantum Mechanics, Addision-Wesley 2nd Ed. 1991.
4. Dirac, P.M.A., Principles of Quantum Mechanics, (Latest Edition), Oxford University Press.

Course Name: Theory of Manifolds	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Manifolds and smooth maps; Derivatives and Tangents; The inverse function theorem and Immersions; Submersions; Transversality, homotopy and stability; Embedding manifolds in Euclidean space; Manifolds with boundary; One manifolds and some consequences; Exterior algebra; Differential forms; Partition of unity; Integration on manifolds; Exterior derivative; Cohomology with forms; Stoke's theorem; Integration and mappings; The Gauss-Bonnet theorem; Lie groups as examples of manifolds; Their Lie algebras; Examples of matrix Lie groups and their Lie algebras.

Recommended Books:

1. Guillemin, V. and Pollock, A., Differential Topology, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1974.

2. Boecker, T. and Dieck, T., Representations of Compact Lie groups, Springer Verlag, 1985.
3. Bredon, G.E., Introduction to Compact Transformation Groups, Academic Press, 1972.

Course Name: Galois THeory	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Basics:

Integral domains and Fields, Homorphisms and ideals, Quotient Rings, Polynomial rings in one indeterminate over Fields, Prime ideals and Maximal ideals, irreducible Polynomials.

Field Extensions:

Algebraic and Transcendental field extensions, Simple Extensions, Composite Extensions, Splitting Fields, The Degree of and Extension, Ruler and Compass Constructions. Normality and Separability.

Finite Field Extensions:

Circle Division, The Galois Group, Toots of Unity, Solvability by Radicals, Galois Extensions, The Fundamental Theorem of Galois Theory, Galois's Great Theorem, Algebraically Closed Fields.

Recommended Books:

1. Joseph Rotman, "Galois Theory", Springer-Veriog, New York, Inc. (2005)
2. Lan Steward, "Galois Theory", Chapman & Hall, New York (2004)
3. David S. Dummit and Richard M. Foote, "Abstract Algebra", John Wiley & Sons, Inc, New York (2002).

Course Name: Number Theory	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Divisibility: Divisors, Bezeout's identity, LCM, Linear Diophantine equations,

Prime Numbers: Prime numbers and prime-power factorizations, Distribution of primes, Primality-testing and factorization. **Congruences:**Modular arithmetic, Linear congruences, An extension of chineses Remainder Theorem, The Arithmetic's of Zp. Solving conruences mod (pe). Euler's Function: Units, Euler's function. **The Group of Units:** The group Un, Primitive roots, The group Un, n is power of odd prime and n is power of 2. **Quadratic Residues:**Quadratic congruences, The group of quadratic residues, The Legendre symbol, Quadratic reciprocity. **Arithmetic Functions:** Definition and examples, perfect numbers, The Modius Inversion formula. **The Reimann Zeta Function:** Random integers, Dirichlet series, Euler products, Sums of two Squares, The Gaussian integers, sums of three Squares, Sums of four Squares, **Fermat's Last Theorem:** The problem, Pythagorean Theorem, Pythagorean triples, The case n=4, Odd prime exponents.
Recommended Books: 1. Gareth A. Jones and J. Mary Jones, "Elementary Number Theory", Springer-Variog, London Limited (1998). 2. Melvyn B. Nathanson, "Methods in Number Theory", Springer-Verlog, New York, Inc. (2000). 3. A.N. Parshin and I.R. Shafarevich, "Number Theory I, Fundamental Problems, Ideas and Theories", Springer-Veriag, Berlin Heidelberg, (1995) University Press.

Course Name: Rings and fields	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	
Course Outline: Difinitions and basic concepts, homomorphisms, homomorphism theorems, polynamical rings, unique factorization domain, factorization theory, Euclidean domains, arithemtic in Eclidean domains, extension fields, algebraic and transeendental elements, simple extension, introduction to Galois theory.	
Recommended Books:	

1. Fraleigh, J.A., A First Course in Abstract Algebra, Addision Wesley Publishing Company, 1982.
2. Herstein, I.N., Topies in Algebra, John Wiley & Sons 1975.
3. Lang, S., Algebra, Addison Wesley, 1965.
4. Hartley, B., and Hawkes, T.O., Ring, Modules and Linear Algebra, Chapman and Hall, 1980

Course Name: Theory of Modules	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Elementary notions and examples, Modules, submodules, quotient modules, finitely generated and cyclic modules, exact sequences and elementary notions of homological algebra, Noetherian and Artinian rings and modules, radicals, semisimple rings and modules.

Recommended Books:

1. Adamson, J., Rings and modules. 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.

Course Name: Introduction to Algebraic Geometry	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Algebraic varieties: Affine algebraic varieities, Hibert basis Theorem, Decomposition of variety into irreducible components, Hibert's Nulttstellensatz, The Sectrum of a Ring, Projective variety and the homogeneous Spectrum.

Functions and Morphisms: Some properties of Zariski topology, Rings and modules of franctions and their properties, Coordinate ring and polynomial functions, Polynomial maps, Regular and rational functions, Morphisms, Rational maps.

Dimension: The Krull dimension of Topological Spaces and Rings, Prime Ideal Chain and Integral Extensions, The Dimension of Affine Algebras and Affine Algebraic Varieties, The Dimension of Projective Varieties.

Applications: The product of varieties, On dimension, Tangent space and smoothness, Completeness.

Recommended Books:

1. O. Zariski and P. Samual, Commutative Algebra, Vol. 1, Van Nostrand, Princeton, N. J., 1958.
2. M.F. Atiyah and I. G. Macdonald, Introduction to Commutative Algebra, Addison Wesley Pub. Co., 1969.
3. I.R. Shafarevich, Basic Algebraic Geometry, Springer Verlag, 1974.
4. R. Hartshorne, Algebraic Geometry, Springer Verlag, 1977.
5. E, Kunz, Introduction to Commutative Algebra and Algebraic Geometry, Boston; Basel; Stuttgrat: Birkhauser, 1985

Course Name: Introduction to Algebraic System	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

An introduction to the use of abstract methods in mathematics, using algebraic systems that play an important role in many applications of mathematics.

Abelian groups, Commutative rings with identity, fields, Ideals, Polynonial rings, Principal Ideal domains, arithmetic of integers mod n and finite fields. Vector spaces over arbitraty fields, Examples of Algebra of Polynomial rings over an arbitrary field, subspaces, bass, linear transformations. Eigenvalues, eigenvectors, eigenspaces, Characteristies, Polynomial, Minimal Polynomial, Linear Transformation as a matrix operator, geometric and algebraic multiplicity and diagonalisation. Groups: subgroups, cosets, Lagrange's theorem, homomorphisms.
Applications to coding theory will be chosen from: linear codes, encoding and decoding, the dual code, the parity check matrix, syndrome decoding, Hamming codes, perfect codes, cyclic codes, BCH codes.

Recommended Books:

1. Any book labeled "Abstract Algebra" or "An Introduction to Abstract Algebra". Call numbers are AQ 162 and QA266. In addition.
2. John B Fraleigh A First Course in Abstract Algebra, 5th edition, Addison-Wesley, 1994, AQ266.F7.

3. Richard Laatsch
An Introduction to Abstract Algebra, McGraw-Hill, 1968, QA266..L3
4. Max D Larsen
Introduction to Modern Algebraic Concepts, Addison-Wesley, 1969, QA266.L.36
5. F.J. Budden
The Fascination of Groups, Cambridge University Press, 1972, QA 171. B83.
6. Joel G Broida and S Gill Williamson
A comprehensive Introduction to Linear Algebra, Addison-Wesley, 1989, AQ 184. B75 1989.
7. Hill, Raymond, 1942
A first course in coding theory, Oxford [Oxford shire]: Clarendon Press; New York:
Oxford University Press, 1986, QA268.H55 1986.
8. McEliece, Robert J
The theory of information and coding, Cambridge, U.K; New York: Cambridge University Press, 2002, Q360.M25 2002.
9. Roman, Steven
Introduction to coding and information theory, New York: Springer, c1997 QA268. R66, 1997
10. Assmus, E.F
Designs and their codes, Cambridge: Cambridge University Press, 1992, QA268. A88, 1992
11. Hamming R. W. (Richard Wesley), 1915-
Coding and information theory / Richard W. Hamming, Englewood Cliffs N.J: Prentice-hall, c1986, QA268. H35 1986.

Some electronic references are:

Numbers, Groups and Codes, J.F Humphreys & M. Y. Prest.
http://www-math.cudenver.edu/-wcherowi/courses/m5410/m5410cd1.htm1
http://www.mdstud.chalmers.se/-md7sharo/coding/main/node2.htm1
http://web.syr.edu/-rrosenqu/ecc/linear/linear2.htm
http://k9.dv8.org/-tim/syndrome.pdf
http://www.math.nus.edu.sg/-ma3218/bkch4.pdf
http://www.math.nus.edu.sg/-ma3218/
http://www.mathreference.com/grp,intro.html
http://www.math.csusb.edu/notes/advanced/algebra/gp/gp.html
http://akbar.marlboro.edu/-mahoney/groups/dog_school/inded.html
http.//www.maths.adelaide.edu.au/pure/pscott/groups/gpf/
http://www.maths.lancs.ac.uk/dept/coursenotes/m22ri199/master/master.html
http://www.ping.be/-ping1339/vect.htm
http://distance-ed.math.tamu.edu/Math640/chapter3/nodel.html

http://www.ping.be/math/mathindex.htm http://www.maths.nottingham.ac.uk/personal/jff/G12VSP

Course Name: Algebraic Topology	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	
Course Outline: Pathwise connectedness; Notion of homotopy, Homotopy classes, Path homotopy, Path homotopy classes; Fundamental groups, Covering maps, Covering spaces, Lifting properties of covering spaces, Fundamental group of a circle, p1 (Sn).	
Recommended Books: 1. Kosniowski, C., A first course in algebraic topology, Cambridge University Press, 1980. 2. Greenberg, M.J., Algebraic topology, A first course, Benjamin/Commings, 1967. 3. Wallace, A.H., Algebraic Topology, Homology and Cohomology, Benjamine, 1968.	

Course Name: Advance Group Theory	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	
Course Outline: Actions of Groups, Permutation representation, Equivalence of actions, Regular representation, Cosets spaces, Linear groups and vector spaces. Affine group and affine spaces, Transitivity and orbits, Partition of G-spaces into orbits, Orbits as conjugacy class Computation of orbits, The classification of transitive G-spaces Catalogue of all transitive G-spaces up to G-isomorphism, One-one correspondence between the right coset of Ga and the G-orbit, G-isomorphism between coset spaces and conjugation in G. Simplicity of A5, Frobenius-Burnside lemma, Examples of morphisms, G-invariance, Relationship between morphisms and congruences, Order preserving one-one correspondences between congruences on Ω and subrroups H of G that contain the stabilizer Gα. The alternating groups, Linear groups, Projective groups, Mobius groups, Orthogonal groups, unitary groups, Cauchy's theorem, P-groups, Sylow P-subgroups, Sylow theorems, Simplicity of An when n $\geq$ 5..	
Recommended Books:	

1. J.S. Rose, A Course on Group Theory, Cambridge University Press, 1978.
2. H. Wielandt, Finite Permutation Groups. Academic Press, 1964.
3. J.B. Fraleigh, A Course in Algebra, Addison-Wesley 1982

Course Name: Elasticity Theory	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

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, compatibility equations; plane stress and plane strain problems; two dimensional problems in rectangular and polar co-ordinates; torsion of rods and beams.

Recommended Books:

1. Sokolinikoff., Mathematical theory of Elasticity, McGraw-Hill, New York.
2. Dieulesaint, E. and Royer, D., Elastic Waves in Solids, John Wiley and Sons, New York, 1980.
3. Funk, Y.C., Foundations of Solid Mechanics, Prentice-Hall, Englewood Cliffs, 1965.

Course Name: Special Relitivity	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Course Outline:

Historical background and fundamental concepts of Special theory of Relativity. Lorentz transformations (for motion along one 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-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.

Recommended Books:

1. Qadir, A. Relativity, An Introduction to the Special Theory, World Scientific, 1989.
2. D' Inverno. R., Introducing Einstein's Relativity, Oxford University Press, 1992.
3. Goldstein, H., Classical Mechanics, Addison Wesley, New York, 1962.
4. Jackson, J.D., Classical Electrodynamics, John Wiley, New York, 1962.
5. Rindler, W., Essential Relativity, Springer-Verlag, 1977.

Course Name: General Relativity	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

<u>Course Outline:</u>

The Einstein field equations. The principles of general relativity. The stress-energy momentum tensor. The vacuum Einstein equations and the Schwarzschild solution. The three classical tests of general relativity. The homogeneous sphere and the interior Schwarzschild solution. Birkhoff's theorem. The Reissner-Nordstrom solution and the generalised Birkhoff's theorem. The Kerr and Kerr-Newman solution. Essential and coordinate singularities. Event horizon and black holes. Eddington-Finkelstein. Kruskal-Szekres coordinates. Penrose diagrams for Schwarzschild, Reissner-Nordstrom solutions.

<u>Recommended Books:</u>

1. Wald, R.M., Introduction to General Relativity, University of Chicago Press, Chicago,1984.
2. Adler, R., Bazine, M., and Schiffer, M., Introduction to General Relativity, McGraw- Hill Inc., 1965.
3. Rindler, W., Essential Relativity, Springer Verlag 1977.

Course Name: Introduction to combinatrics	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

<u>Course Outline:</u>

To basic counting principles, Permutations, Combinations. The injective and bijective principles, Arrangements and selections with repetitions. Graphs in Combinatorics.

The Binomial theorem, combinatorial identities. Properties of binomial coefficients, Multinomial coefficients, The multinomial theorem.

The Pigeonhole principle, Examples, Ramsay numbers, The principle of inclusion and exclusion, Generalization. Integer solutions. Surjective mapping, Stirling numbers of the second kind, The Sieve of Eratostheries, Euler φ-function, The Probleme des Manages.

Ordinary Generating Functions, Modelling problems. Partition of integers, Exponential generating functions.

Linear homogeneous recurrence relations, Algebraic solutions of linear recurrence relations and constant functions, The method of generating functions, A non-linear recurrence relation and Catalpa numbers

Recommended Books:

1. A Tucker, Applied Combinatorics, John Wiley & Sons, New York, 2nd Edition, 1985.
2. C.C. Chen and K.M.Koh, Principles and Techniques in Combinatorics, World Scientific Pub. Co. Pte. Ltd, Singapore. 1992.
3. V.K.Balakrishnan, Theory and Problems of Combunatorics, Schaum's Outline Series, MeGraw-Hill International Edition, Singapore, 1995.
4. C.L.Liu, Introduction to Combinatorial Mathematics, McGraw-Hill, New York, 1968.
5. J.H.van Ling & R.M. Wilson, A course on Combinatorics, 2nd Edition, Cambridge University Press, Cambridge, 2001.

Course Name: Fluid Mechanics-II	**Course Code:**
Course Structure: Lectures: 3	**Credit Hours:** 3
Prerequisites:	

Constitutive equations; Navier-Stoke's equations; Exact solutions of Navier-

Course Outline:

Stoke's equations; Steady unidirectional low; Poiseuille flow; Couette flow; Unsteady unidirectional low; 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 and the Reynold's number; Flow over a flat plate (Blasius' solution); Reynold's equations of turbulent motion.

Recommended Books:

1. L.D. Landau and E.M. Lifshitz., Fluid Mechanics, Pergamon Press, 1966.
2. Batchelor, G.K. , An Introduction to Fluid Dynamics, Cambidge University Press,1969.
3. Walter Jaunzemis, Continuum Mechanics, MacMillan Company, 1967.

4. Milne-Thomson, Theoretical Hydrodynamics, MacMillan Company, 1967.