SCHEME OF STUDIES BS MATHEMATICS

Prerequisites: FSc/ICs or Equivalent with minimum 50%

BS-Mathematics-Semester-wise Break up

Semester-I					Semester -II				
Code	**Title**	**Credit**			**Code**	**Title**	**Credit**		
ENG-101	Functional English-I	3	0	3	ENG-102	English-II	3	0	3
PS-101	Introduction to Pakistan Studies	2	0	2	ISS-101	Islamic studies	2	0	2
CS-101	Introduction to Computing	3	0	3	PY-101	Introduction to Psychology	3	0	3
MAT-101	Calculus -I	3	0	3	MAT-102	Calculus-II	3	0	3
CHM-100	General Chemistry	3	0	2	STS-101	Probability and Statistics	3	0	3
PHY-102	Introductory Mechanics	3	0	3	PHY-104	Waves and Optics	3	0	3
	Total Cr. Hrs	17	0	17		Total Cr. Hrs	17	0	17
Semester-III					**Semester -IV**				
Code	**Title**	**Credit**			**Code**	**Title**	**Credit**		
ENG-201	English-III	3	0	3	MAT-203	Discrete Mathematics	3	0	3
MAT-201	Fundamentals of Maths	3	0	3	MAT-204	Intro. To Group and Topology	3	0	3
MAT-202	Calculus-III	3	0	3	MAT-205	Differential Equations and Linear Algebra	3	0	3
STS-102	Basic Statistical Inference	3	0	3	MAT-206	Vector Calculus and Complex Numbers	3	0	3
BY-201	Introductory Biology	3	0	3	CS-III	Software Packages	2 + 1	0	3
EC-201	Basic Economics	3	0	3	MAT-207	Real Analysis	3	0	3
	Total Cr. Hrs	18	0	18		Total Cr. Hrs	18	0	18
Semester-V					**Semester -VI**				
Code	**Title**	**Credit**			**Code**	**Title**	**Credit**		
MAT-301	Linear Algebra	3	0	3	MAT-306	Complex Analysis	3	0	3
MAT-302	Differential Geometry	3	0	3	MAT-307	Analytical Mechanics	3	0	3
MAT-303	Set Topology	3	0	3	MAT-308	Partial Diff. Equations	3	0	3
MAT-304	Ordinary Diff. Equations	3	0	3	MAT-309	Functional Analysis I	3	0	3
MAT-305	Group Theory	3	0	3	MAT-310	Numerical Methods	**3**	**0**	**3**
	Total Cr. Hrs	15	0	15		Total Cr. Hrs	15	0	15
Semester-VII					**Semester-VIII**				
Code	**Title**	**Credit**			**Code**	**Title**	**Credit**		
	Elective I	**3**	**0**	**3**		**Elective VI**	**3**	**0**	**3**
	Elective II	**3**	**0**	**3**		**Elective VII**	**3**	**0**	**3**
	Elective III	**3**	**0**	**3**		**Elective VIII**	**3**	**0**	**3**
	Elective IV	**3**	**0**	**3**		**Elective IX**	**3**	**0**	**3**
	Elective V	**3**	**0**	**3**		**Elective X**	**3**	**0**	**3**
	Total Cr. Hrs	15	0	15		**Total Cr. Hrs**	**15**	**0**	**15**

HOD
Department of Mathematics
University of Baltistan
Skardu

List of Compulsory / Core Courses
BS Mathematics Programme

(a) Compulsory Courses

1. MAT-101 Calculus-I
2. MAT- 102 Calculus-II
3. MAT-201: Fundamentals of Mathematics
4. MAT- 202 Calculus-III
5. MAT- 203: Discrete Mathematics
6. MAT-204 Introduction to Group and Topology
7. MAT-205 Differential Equations and Linear Algebra
8. MAT-206 Vector Calculus and Complex Numbers
9. MAT-207 REAL ANALYSIS
10. MAT-301 LINEAR ALGEBRA
11. MAT-302 DIFFERENTIAL GEOMETRY I
12. MAT-303 SET TOPOLOGY
13. MAT-304 ORDINARY DIFFERENTIAL EQUATIONS
14. MAT-305 GROUP THEORY I
15. MAT-306 COMPLEX ANALYSIS
16. MAT-307 ANALYTICAL MECHANICS
17. MAT-308 PARTIAL DIFFERENTIAL EQUATIONS
18. MAT-309 FUNCTIONAL ANALYSIS I
19. MAT-310 NUMERICAL METHODS

Optional Courses

1. MAT-401 MEASURE AND INTEGRATION
2. MAT-402 OPTIMIZATION THEORY
3. MAT-403 MATHEMATICAL STATISTICS I
4. MAT-404 MATHEMATICAL STATISTICS II
5. MAT-405 NUMERICAL ANALYSIS
6. MAT-406 INTEGRAL EQUATIONS
7. MAT-407 DIFFERENTIAL GEOMETRY II
8. MAT-408 RIEMANNIAN GEOMETRY
9. MAT-409 CONTINUOUS GROUPS
10. MAT-410 THEORY OF MANIFOLDS
11. MAT-411 INTRODUCTION TO COMBINATORICS
12. MAT-412 INTRODUCTION TO ALGEBRAIC GEOMETRY
13. MAT-413 ALGEBRAIC SYSTEMS AND CODING THEORY
14. MAT-414 GROUP ALGORITHMS PROGRAMMING
15. MAT-415 ALGEBRAIC TOPOLOGY
16. MAT-416 ADVANCED TOPLOGY
17. MAT-417 FUNCTIONAL ANALYSIS II

18. MAT-418 GROUP THEORY II
19. MAT-419 RINGS AND FIELDS
20. MAT-420 THEORY OF MODULES
21. MAT-421 DECOMPOSITION OF MODULES
22. MAT-451 FLUID MECHANICS I
23. MAT-452 FLUID MECHANICS II
24. MAT-453 ELASTICITY THEORY
25. MAT-454 SPECIAL RELATIVITY
26. MAT-455 GENRAL RELATIVITY
27. MAT-456 ANALYTICAL DYNAMICS
28. MAT-457 ELECTROMAGNETISM
29. MAT-458 INTRODUCTION TO QUANTUM MECHANICS
30. MAT-459 CALCULUS OF VARIATIONS
31. MAT-460 GREEN ENERGY
32. MAT-461 ARIFICAIL INTELLEGECE
33. MAT-462 FUZY MATHEMATICS
34. MAT-463 TEACHING OF MATHEMATICS
35. MAT-464 MACHINE LEARNING
36. MAT-465 COMPUTATIONAL FLUID DYNAMICS (CFD)
37. MAT-466 FINITE ELEMENT METHOD (FEM)
38. MAT-467 FINITE VOLUME METHOD (FVM)
39. MAT-467 BS PROJECT
40. MAT-468 DEEP LEARNING WITH PYTHON
41. MAT-469 LINEAR ALGEBRA AND LEARNING FROM DATA
42. MAT-470 DATA-DRIVEN FOR SCIENCE AND ENGINEERING-I
43. MAT-471 DATA0DRIVEN FOR SCIENCE AND ENGINEERING-II

(b) Minimum requirements for the completion of BS degree in Mathematics is 127 Credit Hour

HOD
Department of Mathematics
University of Baltistan
Skardu

MAT-100 Basic Mathematics (3 Credits)

(Meant for students who have not studied Mathematics at F.Sc. or equivalent level)

Real Numbers: Rational and Irrational, Absolute value, Solving inequalities, Exponents and radicals, Functions: Domain, Range, Compositions, Inverse functions, Polynomials: Linear, Quadratic, Rational functions, Elementary Functions: Algebraic, Logarithmic, Exponential functions, Inverse functions, Plotting of functions, Techniques for solving algebraic equations; Binomial theorem and binomial expansion, Basic trigonometry: Trigonometric functions and formulae, Inverse trigonometric formulae, plotting of trigonometric functions, Equations of line, circles, ellipses, hyperbolas and parabolas, Sequences and Series, Matrices and determinants, Applications to system of linear equations.

MAT-101 Calculus-I (Credit Hours 3)

Prerequisites: Knowledge of Intermediate Calculus

Equations and inequalities: Solving linear and quadratic equations, linear inequalities. Division of polynomials, synthetic division. Roots of a polynomial, rational roots; Viete Relations. Descartes rule of signs. Solutions of equations with absolute value sign. Solution of linear and non-linear inequalities with absolute value sign.

Functions and graphs: Domain and range of a function. Examples: polynomial, rational, piecewise defined functions, absolute value, functions, and evaluation of such functions. Operations with functions: sum, product, quotient and composition. Graphs of functions: linear, quadratic, piecewise defined functions.

Lines and systems of equations: Equation of a straight line, slope and intercept of a line, parallel and perpendicular lines. Systems of linear equations, solution of system of linear equations. Nonlinear systems: at least one quadratic equation.

Limits and continuity: Functions, limit of a function. Graphical approach. Properties of limits. Theorems of limits. Limits of polynomials, rational and transcendental functions. Limits at infinity, infinite limits, one-sided limits. Continuity.

Derivatives: Definition, techniques of differentiation. Derivatives of polynomials and rational, exponential, logarithmic and trigonometric functions. The chain rules. Implicit differentiation. Rates of change in natural and social sciences. Related rates. Linear approximations and differentials. Higher derivatives, Leibnitz's theorem.

Applications of derivatives: Increasing and decreasing functions. Relative extrema and optimization. First derivative test for relative extrema. Convexity and point of inflection. The second derivative test for extrema. Curve sketching. Mean value theorems. Indeterminate forms and L'Hopitals rule. Inverse functions and their derivatives.

Integration: Anti derivatives and integrals. Riemann sums and the definite integral. Properties of Integral. The fundamental theorem of calculus. The substitution rule.

Recommended Books:

1. Thomas, Calculus, 11th Edition. Addison Wesley Publishing Company, 2005 2. H. Anton,
2. Bevens, S. Davis, Calculus, 8th Edition, John Wiley & Sons, Inc. 2005.
3. Hughes-Hallett, Gleason, McCallum, et al, Calculus Single and Multivariable, 3rd Edition. John Wiley & Sons, Inc. 2002.

HOD
Department of Mathematics
University of Baltistan
Skardu

4. Frank A. Jr, Elliott Mendelson, Calculus, Schaum's outlines series, 4th Edition, 1999.
5. C.H. Edward and E.D Penney, Calculus and Analytics Geometry, Prentice Hall, Inc. 1988
6. E. W. Swokowski, Calculus with Analytic Geometry, PWS Publishers, Boston, Massachusetts, 1983.
7. M. Liebeck, A Concise introduction to pure Mathematics, CRC Press, 2011. 8. A. Kaseberg, Intermediate Algebra, Thomson Brooks/cole, 2004.

MAT-102 Calculus II (Credit Hours 3)
Prerequisites: Calculus I

Techniques of integration: Integrals of elementary, hyperbolic, trigonometric, logarithmic and exponential functions. Integration by parts, substitution and partial fractions. Approximate integration. Improper integrals. Gamma functions. Applications of integrals: Area between curves, average value. Volumes. Arc length. Area of a surface of revolution. Applications to Economics, Physics, Engineering and Biology. Infinite series: Sequences and series. Convergence and absolute convergence. Tests for convergence: divergence test, integral test, p- series test, comparison test, limit comparison test, alternating series test, ratio test, root test. Power series. Convergence of power series. Representation of functions as power series. Differentiation and integration of power series. Taylor and McLaurin series. Approximations by Taylor polynomials. Conic section, parameterized curves and polar coordinates: Curves defined by parametric equations. Calculus with parametric curves: tangents, areas, arc length. Polar coordinates. Polar curves, tangents to polar curves. Areas and arc length in polar coordinates.

Recommended Books:

1. Thomas, Calculus, 11th Edition. Addison Wesley Publishing Company, 2005
2. H. Anton, I. Bevens, S. Davis, Calculus, 8th Edition, John Wiley & Sons, Inc. 2005
3. Hughes-Hallett, Gleason, McCallum, et al, Calculus Single and Multivariable, 3 rd Edition. John Wiley & Sons, Inc. 2002.
4. Frank A. Jr, Elliott Mendelson, Calculus, Schaum's outlines series, 4th Edition, 1999
5. C.H. Edward and E.D Penney, Calculus and Analytics Geometry, Prentice Hall, Inc. 1988
6. E. W. Swokowski, Calculus with Analytic Geometry, PWS Publishers, Boston, Massachusetts, 1983.
7. M. Liebeck, A Concise introduction to pure Mathematics, CRC Press, 2011.
8. A. Kaseberg, Intermediate Algebra, Thomson Brooks/COLE, 2004.

MAT-202 Calculus III (Credit Hours 3)
Prerequisites: Calculus II

Vectors and analytic geometry in space: Coordinate system. Rectangular, cylindrical and spherical coordinates. The dot product, the cross product. Equations of lines and planes. Quadric surfaces. Vector-valued functions: Vector-valued functions and space curves. Derivatives and integrals of vector valued functions. Arc length. Curvature, normal and binormal vectors. Multivariable functions and partial derivatives: Functions of several variables. Limits and Continuity. Partial derivatives, Composition and chain rule. Directional derivatives and the gradient vector. Implicit

HOD
Department of Mathematics
University of Baltistan
Skardu

function theorem for several variables. Maximum and minimum values. Optimization problems. Lagrange Multipliers. Multiple integrals: Double integrals over rectangular domains and iterated integrals. Non-rectangular domains. Double integrals in polar coordinates. Triple integrals in rectangular, cylindrical and spherical coordinates. Applications of double and triple integrals. Change of variables in multiple integrals. Vector calculus: Vector fields. Line integrals. Green's theorem. Curl and divergence. Surface integrals over scalar and vector fields. Divergence theorem. Stokes' theorem.

Recommended Books:

1. Thomas, Calculus, 11th Edition. Addison Wesley Publishing Company, 2005
2. H. Anton, I. Bevens, S. Davis, Calculus, 8th Edition, John Wiley & Sons, Inc. 2005
3. Hughes-Hallett, Gleason, McCallum, et al, Calculus Single and Multivariable, 3 rd Edition. John Wiley & Sons, Inc. 2002.
4. Frank A. Jr, Elliott Mendelson, Calculus, Schaum's outlines series, 4 th Edition, 1999
5. C.H. Edward and E.D Penney, Calculus and Analytics Geometry, Prentice Hall, Inc. 1988
6. E. W. Swokowski, Calculus with Analytic Geometry, PWS Publishers, Boston, Massachusetts, 1983.
7. M. Liebeck, A Concise introduction to pure Mathematics, CRC Press, 2011.
8. A. Kaseberg, Intermediate Algebra, Thomson Brooks/COLE, 2004.
9. J. Stewart, Calculus early transcendentals, 7th Edition, Brooks/COLE, 2008.

MAT-201: Fundamentals of Mathematics (Credit hours: 3)

Contents: Sets, indexed families of sets, Cartesian products of sets, Relations, Equivalence relations, Partially Ordered sets, Functions, Composition of functions, Permutations, Well ordering principle, Number systems, Prime numbers, Congruence, Arithmetic functions, Mathematical induction, Division algorithm, Greatest common divisor, Least common multiples, fundamental theorem of arithmetic, Compound and simple propositions, Truth tables, Quantifiers, Propositional calculus, Methods of proof.

Recommended Books:

1. D. Van Dalen, H.C. Doets and H. Deswart: Sets: Naïve, Axiomatic and Applied, Pergamon Press, (1978)
2. A.W. Goodman and J.S Ratli: Finite Mathematics with Applications, Macmillan Publishing Co.

MAT- 206 Vector Calculus and Complex Numbers (3 Credits)

Vector-Valued Functions and Motion in Space: Vector-Valued Functions and Space Curves, Modeling Projectile Motion, Arc Length and Unit Tangent Vector T, Curvature, Torsion, and the TNB Frame, Planetary Motion and Satellites

Multivariable Functions and Partial Derivatives: Functions of Several Variables, Limits and Continuity, Partial Derivatives, Differentiability, Linearization, and Differentials, Chain Rule, Partial Derivatives with Constrained Variables, Directional Derivatives, Gradient Vectors, and Tangent Planes, Extreme Values and Saddle Points, Lagrange Multipliers, Taylor's Formula

Multiple Integrals: Double Integrals, Areas, Moments, and Centers of Mass, Double Integrals in Polar Form, Triple Integrals in Rectangular Coordinates, Masses and Moments in Three

HOD
Department of Mathematics
University of Baltistan
Skardu

Dimensions, Triple Integrals in cylindrical and Spherical Coordinates, Substitutions in Multiple Integrals

Integration in Vector Fields: Line Integrals, Vector Fields, Work, Circulation, and Flux, Path Independence, Potential Functions, and Conservative Fields, Green's Theorem in the Plane, Surface Area and Surface Integrals, Parameterized Surfaces, Stakes' Theorem, Divergence Theorem and a Unified Theory

Complex Numbers

Sums and Products, Basic Algebraic Properties, Vectors and Moduli, Complex Conjugates, Polar Form, Roots of Complex Numbers, Functions of a Complex Variable, Exponential Function, Logarithmic Function, Branches of Logarithms, Some Identities Involving Logarithms, Complex Exponents, Trigonometric Functions, Hyperbolic Functions, Inverse Trigonometric and Hyperbolic Functions, Analytic Function, Harmonic Functions

Books:

1. Calculus and Analytic Geometry by G.B Thomas and R.L. Finney, 1995
2. Calculus with Analytic Geometry by Ron Larson, 2002
3. Calculus with Analytic Geometry by George Simmon, 1996
4. Introduction to Calculus and Analytic Geometry by Gillett, 2008
5. Complex Variables and its Applications by Brown and Churchill, 8th Edition

MAT- 203: Discrete Mathematics (Credit hours: 3)

Contents: Sets; number systems: decimal, binary, octal and hexadecimal numbers; signed numbers, floating point numbers. Relations and functions: injective, surjective and bijective functions; floor and ceiling functions. Algorithms: pseudo codes; searching algorithm; complexity of algorithms; division algorithm; greatest common divisors and least common multiples; the Euclidean algorithm. Boolean algebra: Huntington postulates; Boolean algebraic theorems; Boolean functions. Logic: logical statements and connectives; truth tables; tautology, absurdity and contingency; logical gates; mathematical reasoning; counting problems. Graphs: types of graphs: simple graphs, multigraphs, pseudo graphs, directed graphs, directed multigraphs; graph terminology; the handshaking theorem; complete graphs; cycles, wheels, n-cubes; bipartite graphs; isomorphism of graphs; connectivity of graphs; paths; Euclidean and Hamiltonian paths; planar graphs; Euler formula; coloring of graphs and applications. Trees: basic definitions; rooted trees; applications of trees; trees and sorting; spanning trees.

Recommended Books:

1. S. Susanna: Discrete mathematics with applications, (2000).
2. K. H. Rosen: Discrete mathematics and its applications, (1999).
3. B. Kolman, R. C. Busby and S. Ross: Discrete mathematical structures, (1996).

MAT-204 Introduction to Group and Topology (3 Credits)

Prerequisites: Fundamentals of Mathematics

Definition of Topology, Open Sets, Closed Sets, Intersection of two Topologies, Coarser and Finer Topology, Neighbourhoods, Theorems related to neighbourhoods, Interior, Exterior,

HOD
Department of Mathematics
University of Baltistan
Skardu

Boundary, Limit Points, Closure and related Theorems. Definition of Metric Space, Open Balls, Open Sets, Closed Sets, Theorem related to Open Balls, Open Sets and closed sets.
Definition of a Group, Order of a Group and Order of an element of a Group, Subgroups, Cyclic Groups, Cosets, Partition of a Set, Lagrange Theorem, and Theorems related to order of an element, cyclic Group and Subgroups, Normal Subgroup and related Theorems.
Books:

1. An Introduction to the Theory of Groups By J. J. Rotman, 1994
2. A course on Group Theory by J.S. Rose, 2012
3. Introduction to Topology by B. Mendelson, 1990
4. Introduction to Topology by C.W. Baker, 1996

MAT-205 Differential Equations and Linear Algebra (3 Credits)
Prerequisites: Fundamentals of Mathematics
Linear Algebra:
Matrices, Vectors: Addition and Scalar Multiplication, Matrix Multiplication, Linear Systems of Equations, Gauss Elimination, Linear Independence, Rank of a Matrix, Vector Space, Solutions of Linear Systems: Existence, Uniqueness, Determinants, Cramer's Rule, Inverse of a Matrix, Gauss–Jordan Elimination , Vector Spaces, Inner Product Spaces. Linear Transformations, Matrix Eigenvalue Problem, Determining Eigenvalues and Eigenvectors, Some Applications of Eigenvalue Problems
Ordinary Differential Equations:
First-Order ODEs: Basic Concepts. Modeling, Euler's Method, Separable ODEs, Exact ODEs, Integrating Factors, Linear ODEs, Bernoulli Equation, Orthogonal Trajectories, Existence and Uniqueness of Solutions for Initial Value Problems Second-Order Linear ODEs: Homogeneous Linear ODEs of Second Order, Homogeneous Linear ODEs with Constant Coefficients, Modeling of Free Oscillations of a Mass–Spring System, Euler–Cauchy Equations, Existence and Uniqueness of Solutions, Wronskian, Nonhomogeneous ODEs, Solution by Variation of Parameters,
Book:

1. Advanced Engineering Mathematics by Erwin Kreyszig, Tenth Edition, 2010
2. Advanced Engineering Mathematics by D.G. Zill, 2009
3. Advanced Engineering Mathematics by M. Greenberg, 1998
4. Advanced Engineering Mathematics by K. Strout, 2011

MA-301 REAL ANALYSIS (3 Credits)
Prerequisites: Calculus-I
Algebraic and oder properties of R, Completeness property, Cluster points, Open and Closed sets in R, Sequences, Limit of functions, Limit theorems, Continuous functions and intervals, Boundedness theorems, Maximum-minimum theorem, and intermediate value theorem, Uniform continuity, 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 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 $\int f(x)\sin x\,dx$, 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.

MAT-302 LINEAR ALGEBRA (3 Credits)

Prerequisites: Differential Equations and Linear Algebra

Review of matrices and determinants, Linear spaces, Bases and dimensions, Subspaces, Direct sums of subspaces, Factor spaces, Linear operators, Matrix representation and sums and products of linear operators, The range and null space of 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

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., Topics in Algebra, John-Wiley, 1975.
4. Trooper, A.M., Linear Algebra, Thomas Nelson and Sons, 1969.

MAT 303 DIFFERENTIAL GEOMETRY-I (3 Credits)

Prerequisites: Calculus-I

Historical background; Motivation and applications, Index notation and summation convention, Space curves, The tangent vector field, Parameterization, Arc length, Curvature, Principal normal, Binormal, Torsion, Osculating, Normal and Rectifying planes, 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, Tangent and the Normal planes, Parametric curves, 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, 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:

HOD
Department of Mathematics
University of Baltistan
Skardu

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.

MA-304 SET TOPOLOGY (3 Credits)

Prerequisites: Intro to Group and Topology

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, Derived and perfect sets, Dense sets and separable spaces, Topological bases, Criteria for topological bases, Local bases, First and second countable spaces, Relationship between sparability and second countablity, 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, Completion of metric space, Metrizable spaces. Continuous functions, Various characterizations of continuos functions, Geometric meaning, homeomorphisms, Open and closed continuous functions, Topological properties and homeomorphisms, Separation axioms, T_1 and T_2 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.

MAT-305 ORDINARY DIFFERENTIAL EQUATIONS (3 Credits)

Prerequisites: Differential Equations and Linear Algebra

Definitions and occurrence of differential equations (DEs), Remarks on existence and uniqueness of solution, First order and simple higher order Des, Special equations of 1st order, Elementary applications of 1st order Des, 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 DEs, Bessel,

HOD
Department of Mathematics
University of Baltistan
Skardu

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.

MAT-306 GROUP THEORY- I (3 Credits)

Prerequisites: Intro to Group and Topology

Historical background, Definition pf a group with some examples, Order of an element of a group, Subgroups, Generators and relations, Free groups, Cyclic groups, Finite groups, Cayley's theorem on permutation groups, Cosets and Lagrange's theorem, Normal subgroups, Simplicity, Normalizers, Direct products, Homomorphism, Factor groups, Isomorphism, Automorphism, Isomorphism theorems, Group actions, Stabilizers, Conjugacy classes, Sylow theorems and their applications.

RECOMMENDED BOOKS:

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

MAT-307 COMPLEX ANALYSIS (3 Credits)

Prerequisites: Real Analysis

Algebra of complex numbers, Analytic functions, C-R equations, Harmonic functions, Elementary functions, Branches of log z, Complex exponents, Contours, Cauchy-Goursat theorem, Cauchy integral formula, Morera's theorem, Maximum moduli of functions, Liouville's theorem, Fundamental theorem of algebra, Convergence of sequences and series, Taylor series, Laurent series, Power series, Residues and poles, Residues theorems, Zeros of analytic function, Zeros and poles, Evaluation of improper integrals, Integrals involving trigonometric functions, Integration around a branch point, Definite integrals involving sine and cosine, Argument principle, Rouche theorem, Inverse Laplace transform, Mapping of complex functions, Conformal mapping, Analytic continuation

RECOMMENDED BOOKS:

1. Brown, J. W. and Churchill, R.V., *Complex Variables and Applications*, McGraw-Hill, 2009.
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.

HOD
Department of Mathematics
University of Baltistan
Skardu

MAT-308 ANALYTICAL MECHANICS (3 Credits)

Kinematics of particle and rigid body in three dimensions; 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, .

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.
5. Beer, F. P. and Johnston, E. R., *Mechanics for Engineers*, Vols.I&II, McGraw-Hill, N.Y, 1975.

MAT-309 PARTIAL DIFFERENTIAL EQUATIONS (3 Credits)

Prerequisites: Ordinary Differential Equations

Review of ordinary differential equation in more than one variable partial differential equations (PDEs) of the first order., Nonlinear PDEs of first order, Applications of 1st order PDEs, Partial differential equations of second order**,** Mathematical modeling of heat, Laplace and wave equations, Classification of 2nd order PDEs, Boundary and initial conditions, Reduction to canonical form and the solution of 2nd order PDEs, Technique of separation of variable for the solution of PDEs with special emphasis on Heat, Laplace and wave equations. Laplace transform, Fourier transform and Hankel transform for the solution of PDEs 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.

HOD
Department of Mathematics
University of Baltistan
Skardu

MAT-310 FUNCTIONAL ANALYSIS I (3 Credits)

Prerequisites: Real Analysis

Definition and examples of normed spaces, Banach spaces, Characterization of Banach spaces, Bounded linear operators, Functionals and their examples, Various characterizations of bounded (continuous) linear operators, Space of all bounded linear operators, Open mapping and closed graph theorems, Dual (conjugate) spaces, Reflexive spaces, Hahn-Banach theorem (without proof), Some important consequences of the Hahn-Banach theorem., Inner product spaces and their examples, Cauchy-Schwarz inequality, Hilbert spaces, Orthogonal complements, Projection theorem, 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.

MAT-401: NUMERICAL METHODS (3 Credits)

Prerequisites: Real Analysis

Introduction, Computer arithmetic (brinary, octal and hexadecimal system), Errors and their types, Floating point arithmetic, Nonlinear equations, Introduction, Direct and indirect methods, Intermediate value theorem (secant method, regular-falsi method and Newton-Raphson method), Iterative methods based on second degree equation, Rate of convergence (iterative methods based on first and second degree equations), General iterative methods (first, second and higher order methods), Acceleration of the convergence, Methods for multiple roots, System of nonlinear equations, Polynomial equations, System of linear algebraic equation: Introduction, Direct methods (Gauss elimination methods with partial and complete pivoting, Gauss-Jordon elimination methods), Triangularization methods (Doolittle's, Crout's and Cholesky methods), Partition methods, Indirect methods (Jacobi iteration methods, Gauss Seidel iteration methods, Successive over relaxation method), Convergence of iterative methods, Optimal relaxation parameter for SOR method, Solution of tridiagonal systems, Interpolation, Introduction, finite difference operators (forward, backward, central difference, shift, average, and differential) and their relation, Differences of a polynomial, Factorial polynomial, Error propagation in difference table, Summation of series, Newton's formulae for interpolation, Interpolation with unequally spaced data (Lagrange's formula and its error, Hemite's interpolation-formula, Divided difference and their properties, Newton's general interpolation formula)

RECOMMENDED BOOKS:

1. Jain, M.K., Iyengar, S.R.K., and Jain, R.K., Nuemrical Methods for Scientific and Engineering Computation, 5th ed., New Age Int. Pub., 2009.
2. Sewell, G., The Numerical Solution of Ordinary and Partial Differential Equations, John Wiley and sons Inc. New Jersey, 2005.
3. Burden, R.L. and Faires, J.D., Numerical Analysis, Thomas Brooks/Cols, 8th ed., 2005.
4. Gerald, C.F., Applied numerical analysis, Addison Wesely, 1984.
5. Conte, S.D. and C. Boor, De., Elementary Numerical Analysis, McGraw-Hill, 1980.

MAT-402 MEASURE AND INTEGRATION (3 Credits)

Definition and examples of algebras and σ-algebras, Basic properties of measurable spaces, Definition and examples of measure spaces, Outer measure, Lebesgue measure, Measurable sets, Complete measure spaces, Some equivalent formulations of measurable functions, Examples of measurable functions, Various characterization of measurable functions, Property that holds almost everywhere, Egorov's theorem, Definition of Lebesgue integral, Basic properties of Lebesgue integrals, Comparison between Riemann integration and Lebesgue integration, L^2-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.

MAT-403 OPTIMIZATION THEORY (3 Credits)

Introduction to optimization, Relative and absolute extrema, Convex, concave and unimodal functions, Constraints, Mathematical programming, Optimisation of one, two and several variables functions and necessary and sufficient conditions for their optima, Optimisation 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 optimisation by Gradient method, Convex and concave programming, Calculus of variation and Euler Lagrange equations. Functionals depending on several independent variables, Variational problems in parametric form, Generalised 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.

MAT-404 MATHEMATICAL STATISTICS-I (3 Credits)

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,

HOD
Department of Mathematics
University of Baltistan
Skardu

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.

MAT-405 MATHEMATICAL STATISTICS-II (3 Credits)

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, 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 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*, 2nd edition, McGraw-Hill Book Company New York 1986.
2. Degroot, M. H., *Probability and Statistics*, 2nd edition, Addison-Wesley Publishing Company, USA 1986.

MAT-406 NUMERICAL ANALYSIS (3 credits)

Pre-requisite is Numerical methods (MAT-401)

MATLAB: Introduction to the basic environment, MATLAB Desktop, Syntax, Variables, Strings, Expressions, Basic program writing in MATLAB, Symbolic mathematics, Array operations, Solving systems of linear equations, LU factorization, Differentiation, Integration, Solution of simple initial and boundary value problems, Numerical integration, Two and three dimensional plots in MATLAB.

Eigenvalues problems: Eigenvalues and eigenvectors, Bounds on eigenvalues (Gerschgorin's theorem and its applications), Schur's theorem, Power method, Shift of origin, Deflation method for the subdominant eigenvalues,

Numerical differentiation and integration: Brief introduction of finite differences, Numerical differentiation formula based on interpolation polynomials, Maximum and minimum values of tabulated functions, Newton-Cotes integration formula, Numerical integration formula based on interpolation polynomials, Trapezoidal rule, Simpson's 1/3 and 3/8 formula, Romberg integration,

HOD
Department of Mathematics
University of Baltistan
Skardu

Errors in integration formulae, Double integrals having constant limit (Trapezoidal and Simpson's rule and their errors.)

Numerical solution of ordinary differential equations: Introduction of difference equations, Solution of homogeneous and nonhomogeneous difference equations, Ordinary differential equations, Buler method, Improved and modified Euler methods, Local truncation error, Order of a method, Solution by Taylor series, Picard's method of successive approximations, Runge-Kutta methods up to 4^{th} order, Predictor corrector methods (Milne's method and Adams-Bashforth method), Boundary value problems (shooting method and finite difference method)

RECOMMENDED BOOKS:

1. Jain, M.K., Iyengar, S.R.K., and Jain, R.K., *Nuemrical Methods for Scientific and Engineering Computation*, 5^{th} ed., New Age Int. Pub., 2009.
2. Sewell, G., *The Numerical Solution of Ordinary and Partial Differential Equations*, John Wiley and Sons Inc. New Jersey, 2005.
3. Kiusalans, J., *Numerical methods in engineering with MATLAB*, Cambridge Uni. Press New York, 2005.
4. Burden, R.L. and Faires, J.D., *Numerical Analysis*, Thomas Brooks/Cols, 8^{th} ed., 2005.
5. Gerald, C.F., *Applied numerical analysis*, Addison Wesely, 1984.
6. Conte, S.D. and C. Boor, De., *Elementary Numerical Analysis*, McGraw-Hill, 1980.

MAT-407 INTEGRAL EQUATIONS (3 Credits)

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. 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, 1987.
5. Abdul J. Jerri., *Introduction to integral equations with applications,* Marcel Dekker Inc. New York, 1985.

MAT-408 DIFFERENTIAL GEOMETRY-II (3 Credits)

Prerequisites: Differential Geometry-I

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

HOD
Department of Mathematics
University of Baltistan
Skardu

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.

MAT-409 RIEMANNIAN GEOMETRY (3 Credits)

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.

MAT-410 CONTINUOUS GROUPS (3 Credits)

Continuous Groups, Gl(n,$\mathbb{R}$), Gl(n,$\mathbb{C}$), 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,* Princeton 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.

HOD
Department of Mathematics
University of Baltistan
Skardu

MAT-411 THEORY OF MANIFOLDS (3 Credits)

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.

MAT-412 INTRODUCTION TO COMBINATORICS (3 Credits)

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

MAT-413 INTRODUCTION TO ALGEBRAIC GEOMETRY (3 Credits)

Algebraic varieties, Affine algebraic varieities, Hibert basis theorem, Decomposition of variety into irreducible components, Hibert's Nulttstellensatz, The Spectrum of a ring, Projective variety and the homogeneous spectrum., Functions and morphisms, Some properties of Zariski topology, Rings and modules of fractions and their properties, Coordinate ring and polynomial functions, Polynomial maps, Regular and rational functions, Morphisms, Rational maps. The Krull dimension of topological spaces and rings, Prime ideal chain and integral extensions, The

HOD
Department of Mathematics
University of Baltistan
Skardu

dimension of affine algebras and affine algebraic varieties, The dimension of projective varieties, The product of varieties, On dimension, Tangent space and smoothness, Completeness

RECOMMENDED BOOKS:

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

MAT-414 ALGEBRAIC SYSTEMS AND CODING THEORY (3 Credits)

Abelian groups, Commutative rings with identity, fields, Ideals, Polynomial 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, Basis, Linear transformations. Eigenvalues, Eigenvectors, Eigen spaces, Characteristics 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, 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. John B Fraleigh, J.B., *A First Course in Abstract Algebra*, 5th edition, Addison-Wesley, 1994.
2. Laatsch, R., *An Introduction to Abstract Algebra*, McGraw-Hill, 1968.
3. Larsen, M.D., *Introduction to Modern Algebraic Concepts*, Addison-Wesley, 1969.
4. Budden, F. J., *The Fascination of Groups*, Cambridge University Press, 1972.
5. Broida, J.G. and Williamson, S. G., *A comprehensive Introduction to Linear Algebra*, Addison-Wesley, 1989.
6. Raymond, H., *A first course in coding theory*, Oxford University Press, 1986,
7. McEliece, R. J.., *The theory of information and coding*, Cambridge University Press, 2002.
8. Steven, R., *Introduction to coding and information theory*, New York: Springer, 1997.
9. Assmus, E. F., *Designs and their codes*, Cambridge University Press, 1992.
10. Hamming, R. W., *Coding and information theory*, Englewood Cliffs N.J: Prentice-Hall, 1986.

MAT-415 GROUP ALGORITHMS PROGRAMMING (3 Credits)

Algorithms and their Analysis, Basic concepts and their 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

HOD
Department of Mathematics
University of Baltistan
Skardu

its application in sorting, Amortized analysis, Worst-case analysis, Average case analysis., Graph algorithms, Basic search techniques, Algorithmic binary trees and its application, breadth-first search, Depth-first search, Planner graphs, Graph colouring, Minimum spanning trees, Single source shortest paths, Algorithms for parallel computers, Matrix operations, Polynomials and the FFT, Number-Theoretic algorithms, NP-completeness, Approximations algorithms, Encyption/Decryption algorithms

RECOMMENDED BOOKS:

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

MAT-416 ALGEBRAIC TOPOLOGY (3 Credits)

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, $\pi_1(S^n)$.

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.

MAT-417 ADVANCED TOPOLOGY (3 Credits)

Prerequisites: Topology

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 T_2-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 Cohomoloy*, Benjamin, Inc., New York, 1968.
3. Gemignani, M.C., *Elementry Topology*, Addison-Wesley Publishing Company, 1972.

MA-418 FUNCTIONAL ANALYSIS II (3 Credits)

Prerequisites: Functional Analysis-I

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

HOD
Department of Mathematics
University of Baltistan
Skardu

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.

MAT-419 GROUP-THEORY II

Prerequisites: Group Theory

Action of a group on a set G-spaces, G-morphism, The symmetric and alternating groups, orbits, stablisars of a group, The relation of stabliser and orbits, The formulae for counting orbits, Transitivity, Linear groups and their types, Graphical representation of group.

RECOMMENDED BOOKS:

1. Rose, J. S., *A Course on Group Theory*, Cambridge University Press, 1978.
2. Magnus, W., Karrass, A., and Solitar., *Combinatorial Group Theory*, Dover publication, 1966.
3. Husain, T., *Introduction to Topological Groups*, W.B. Saunder's Company-Philadelphia and London, 1966.

MAT-420 RINGS AND FIELDS (3 Credits)

Difinitions and basic concepts, Homomorphisms, Homomorphism theorems, Polynomial rings, Unique factorization domain, Factorization theory, Euclidean domains, Arithmetic in Euclidean domains, Extension fields, Algebraic and transcendental 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.

MAT-421 THEORY OF MODULES (3 Credits)

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

HOD
Department of Mathematics
University of Baltistan
Skardu

MAT-422 DECOMPOSITION OF MODULES (3 credits)

Rings and modules, Decomposition of modules, Decomposition theorem, The primary decomposition theorem, The primary decomposition, Abelian groups as $\mathbb{Z}$-modules, Abelian groups, Sylow's theorem, Linear transformation and matries, Invariants and the Jordan canonical form, the rational canonical form theorem - (linear transformation version), The Jordan canonical form theorem, Conjugacy classes in general linear groups

RECOMMENDED BOOKS:

1. Blyth, T., *Module Theory*, Oxford University Press, Oxford, 1977.
2. Hartley, B. and Hawkes, T., *Rings, Modules and Linear Algebra*, Chapman, and Hall, 1980.

MAT-451 FLUID MECHANICS-I (3 Credits)

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' 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.

MA-452: FLUID MECHANICS-II (3 Credits)

Prerequisites: Fluid Mechanics-I

Constitutive equations, Navier-Stokes' equations, Exact solutions of Navier-Stokes' 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. Landau, L.D., and Lifshitz, E.M., *Fluid Mehanics*, Pergamon Press, 1966.

HOD
Department of Mathematics
University of Baltistan
Skardu

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.

MA-453: ELASTICITY THEORY (3 Credits)

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.

MA-454: SPECIAL RELATIVITY (3 credits)

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.

MAT-455: GENERAL RELATIVITY (3 Credits)

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

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RECOMMENDED BOOKS:

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.

MAT-456: ANALYTICAL DYNAMICS (3 Credits)

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, Longitudinal 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.
4. G. Meirovitch. L., *Methods of Analytical Dynamics*, McGraw-Hill, 1970.

MAT-457: ELECTROMAGNETISM (3 Credits)

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

RECOMMENDED BOOKS:

1. Reitz, J.R. and Milford, F.J., *Foundation of Electromagnetic Theory*, Addision-Wesley, 1969.
2. Panofsky, K.H. and Philips, M., *Classical Electricity and Magnetism*, Addision-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.

MAT-458: INTRODUCTORY QUANTUM MECHANICS (3 Credits)

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

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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.
3. Dirac, P.M.A., *Principles of Quantum Mechanics*, (Latest Edition), Oxford University Press.

MAT-459 CALCULUS OF VARIATIONS (3 Credits)

Basics of functional variations, General statement of the external problems, Maxima and minima, weak local minima and maxima, well-posed end point conditions, Existence and uniqueness of solutions, Simple Eulerian maximization problems, Euler-Lagrange conditions, First integrals of the Euler-Lagrange equations, Canonical formalism of the Euler-Lagrange conditions, Action integrals and their functional variations, Hamilton conditions, Inverse problems in variational calculus, Isoperimetric problems, Constrained surfaces of least curvature, Broken externals, Weierstrass-Erdmann conditions, Multidimensional cases and higher order necessary conditions, Lagrange problem and the Euler-Lagrange theorem in multidimensions, Applications to the Branchistochrone, Minimum surface of revolution, Geodesics, Geometrical optics, Fermat principle, Hamilton equations of motion, Eigenvalue and eigenfunction problems, Ritz variational principle, Strum-Liouville problems, Membrane vibrations, Schrodinger equation and energy minimization, Existence of minima of Dirichlet integral.

RECOMMENDED BOOKS:

1. Weinstock, R., Calculus of Variations, Dover Publications, New York 1974.
2. Biss, G.A., Calculus of Variations, Mathematical Association of America, Washington D.C. 1944.
3. Gelfand, I.M., Fomin, S.V., Calculus of Variations, Dover Publications, New York 2000.
4. Ban Brunt, B., The Calculus of Variations, Springer-Verlag, New York 2004.
5. Logan, J.D., Invariant Variational Principles, Academic Press, New York 1977.
6. Fox, C., An Introduction to the Calculus of Variations, Dover Publications, New York 1987.
7. Bolza, O., Lectures on the Calculus of Variations (3rd Edition), American Mathematical Society, Rhode Island 2000.
8. Jost, J., Li-Jost, X., Calculus of Variations, Cambridge University Press, Cambridge 1999.

CS-III Software Packages C.Hrs. (2 + 1)

Prerequisites: Intro to Computing

MATLAB, Mathematica, Python, NSYS, OpenFOAM, Multiphysics COMSOL, Latex

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MAT-461 Artificial Intelligence C.Hrs. (2 + 1)

What is AI, why to learn AI, Application of AI, Branches of AI, AI agents and environment, The concept of rationality, The nature of environment. The structure of agents, AI and python -how do they relate,What is python, why choose python for building AI application, installation of python, matplotlib, NumPy, Pandas, forms of learning, classification and regression using supervised learning.

Recommended Books

1 Artificial Intelligence, A Modern Approach by Stuart J. Russell and Peter Norvig
2 Artificial Intelligence by Prateek Joshi.
3 Deep learning with Python by Francois Chollet.

MAT-464 Machine Learning CHrs. (2 + 1)

Introduction to machine learning, Regression, Linear Regression with One Variable, Linear Regression with Multiple Variables, Logistic Regression, learning decision trees, Introduction to Neural Networks, Types of activation function, Unsupervised learning (Clustering and Retrieval), Dimensionality reduction, Gaussian Mixture Model, Density Estimation with Gaussian Mixture Models, Classification with Support Vector Machines, Learning probabilistic models.

Recommended Books:

1. Mathematics for Machine Learning by Marc Peter Deisenroth, Aldo Faisal
2. Matrix Analysis (2nd ed.). Roger A. Horn, Charles R. Johnson. Cambridge University Press, 2013.
3. Introduction to Probability (2nd ed.). Dimitri P. Bertsekas, John N. Tsitsiklis. Athena Scientific, 2008.
4. The Elements of Statistical Learning (2nd ed.). Trevor Hastie, Robert Toshigami, Jerome Friedman. Springer, 2008.

MAT-462 Fuzzy Mathematics CHrs: **03**

Introduction to fuzzy logic, Crispness and fuzziness, Fuzzy subsets and examples, Level subsets, Support and cardinality of fuzzy sets, Set theoretic and algebraic Operations on fuzzy sets, relations and function on fuzzy sets, Types and extensions of fuzzy sets, T-norms and S-norms, Fuzzy Measures and Measures of Fuzziness, Fuzzy Numbers, Algebraic Operations with Fuzzy Numbers, Multisets Applications of fuzzy set theory.

Recommended Books:

1. H. J. Zimmermann, Fuzzy Set Theory-and Its Applications, Fourth Edition by by Springer Seience+Business Media New York 2001.

2. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall PTR 1995.

3. Tamalika Chaira, Fuzzy Set and Its Extension, John Wiley & Sons, Inc. 2019.

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MAT-465 Computational Fluid Dynamics (CFD) C.Hrs. 03

Introduction, Conservation laws for fluid motion and boundary conditions, Turbulence and its modeling, the finite volume for diffusion problem, the finite volume for convection-diffusion problems, Solution algorithms for pressure-velocity coupling in steady flows, solution of a discretized equations, The finite volume for unsteady flows, implementation of boundary conditions, Errors and uncertainty in CFD modelling, Methods for dealing with complex geometry.

Recommended Books

1. Tu, J., Yeoh, G. H., and Liu, C., Computational Fluid Dynamics, A Practical Approach, Butterworth & Heiemann.
2. Patankar. S. V. Numerical heat transfer and fluid flow, Hemisphere.
3. Malalasekra, W. and Versteeg, H., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Prentice Hall.
4. Anderson, J., Computational Fluid Dynamics, McGraw Hill Book Co.

MAT-466 Finite Element Methods C.Hrs. 03

Introduction, The Finite Element Method concepts and its history, Discretization, Relationship to the Finite-Difference Method, Advantages and Disadvantages of the Finite Element Method, Mathematical preliminaries, The Direct Approach, Variational and weighted Residual formulation, Steady state thermal and fluid flow analysis, Numerical integration: Gaussian quadrature, Reduced integration, The Patch test, Finite element error analysis, Error estimates, Convergence and accuracy of solutions, Infinite and singularity elements, Time Dependant problems, Semi-discrete FEM, Time approximations, Computer implementation, Freefem++ OpenFOAM, COMSOL Multiphysics, ANSYS

Recommended Books

1. O. C. Zienkewicz, R. L. Taylor. The Finite Element Method
2. F. L. Stasa, Applied Finite Element Analysis for Engineers, Int'l Thomson Pub.
3. S. S. Rao. Finite Element Method in Engineering, 3rd ed., Pergamon Press.
4. I. M. Smith, Programming the Finite Element Method. John Wiley & Sons.

MAT-467 Finite Volume Method C.Hrs. 03

Introduction, Review of vector calculus, Mathematical description of physical phenomenon, Discretization process, Finite Volume Method, Finite Volume mesh, Finite volume mesh, discretization of diffusion term, discretization of convective term, Gradient computation, solving the system of algebraic equations, Fluid flow computation, Turbulence modeling and boundary conditions.

Recommended Books

1. Mokalled, F., L. Mangani, and M. Darwish. "The Finite Volume Method on Computational Fluid Dynamics." (2016).
2. Eymard, Robert, Thierry Gallouët, and Raphaèle Herbin. "Finite volume methods." Handbook of numerical analysis 7 (2000): 713-1018.

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MAT-469 Deep Learning with Python Cr. Hrs. (2 + 1)

Fundamentals of deep learning, what is deep learning, before we begin: the mathematical building blocks of neural networks, Getting started with neural networks, Fundamentals of machine learning,

Deep learning in practice, Deep learning for computer vision, Deep learning for text and sequences, Advanced deep-learning best practices, Generative deep learning, and Conclusions.

Recommended Book

Deep learning with Python

Author: Francois Chollet

MAT-470 Linear Algebra and Learning from Data Cr. Hrs. (2 + 1)

Highlights of Linear Algebra, Computations with Large Matrices**,** Low Rank and Compressed Sensing, Special Matrices, Probability and Statistics**,** Optimization, Learning from Data,

Recommended Book

Linear Algebra and Learning from Data Author: Gilber Strang

MAT-471 Data-Driven for Science and Engineering-I Cr. Hrs. (2 + 1)

Part I Dimensionality Reduction and Transforms Singular value decomposition, Fourier and Wavelet Transforms, Sparsity and Compressed Sensing,

Part II Machine Learning and Data Analysis: Regression and Model Selection, Clustering and Classification, Neural Networks and Deep Learning

Recommended Book

Data-driven Science and Engineering

Authors Steven L. Brunton J. Nathan Kutz Edition: Second

MAT-472 Data-Driven for Science and Engineering-II Cr. Hrs. (2 + 1)

Part III Dynamics and Control: Data-Driven Dynamical Systems, Linear Control Theory, Balanced Models for Control,

Part IV Advanced Data-Driven Modelling and Control: Data-Driven Control, Reinforcement Learning, Reduced-Order Models (ROMs), Interpolation for Parametric Reduced-Order Models, Physics-Informed Machine Learning

Recommended Book

Data-driven Science and Engineering

Authors Steven L. Brunton, J. Nathan Kutz Edition: Second

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