M.Sc. Mathematics (Common for Aided and S.F. Programmes)
Courses Offered

Semester	Subject Code	Title of the Paper	Hours/Week	Credits
I	PM1711	Core I: Algebra - I	6	5
	PM1712	Core II: Analysis - I	6	4
	PM1713	Core III: Probability and Statistics	6	4
	PM1714	Core IV: Ordinary Differential Equations	6	4
	PM1715 PM1716	Elective I: (a) Numerical Analysis (b) Fuzzy sets and Fuzzy logic	6	4
II	PM1721	Core V: Algebra II	6	5
	PM1722	Core VI: Analysis II	6	4
	PM1723	Core VII: Partial Differential Equations	6	4
	PM1724	Core VIII: Graph Theory	6	4
	PM1725 PM1726	Elective II: (a) Classical Dynamics (b) Differential Geometry	6	4
	LST172	Life Skill Training (LST) - I	-	1
III	PM1731	Core IX: Algebra III	6	5
	PM1732	Core X: Topology	6	5
	PM1733	Core XI: Measure Theory and Integration	6	4
	PM1734 PM1735	Elective III: (a) Algebraic Number Theory (b) Stochastic Processes	6	4
	PM17PR	Project	6	4
IV	PM1741	Core XII: Complex Analysis	6	5
	PM1742	Core XIII: Functional Analysis	6	5
	PM1743	Core XIV: Operations Research	6	5
	PM1744	Core XV: Algorithmic Graph Theory	6	4
	PM1745 PM1746	Elective IV: (a) Combinatorics (b) Coding Theory	6	4
	LST174	Life Skill Training (LST) - II	-	1
	STP171	Summer Training Programme	-	1
		TOTAL	**120**	**90**

Semester I
Core I: Algebra I
Sub. Code: PM1711

No. of hours per week	Credits	Total No. of hours	Marks
6	5	90	100

Objectives

1. To study abstract Algebraic systems.
2. To know the richness of higher Mathematics in advanced application systems.

Unit I

Automorphisms and conjugate elements: Inner automorphism - Characteristic subgroups - Conjugate elements - Cauchy's theorem - Similar permutations (Excluding partition of an integer).

Unit II

Sylow's theorems and Direct products: Sylow p-subgroups - Sylow's first theorem - Sylow's second theorem - Sylow's third theorem - Sylow Groups in S_{p^k} - Direct products - Finite abelian groups - Fundamental theorem of finite abelian groups.

Unit III

Rings: Examples - Sub Rings - Sum of two Sub Rings - Characteristic of a Ring -Product of Rings - Ideals - Sum of two Ideals - Product of two Ideals.

Unit IV

Homomorphisms and embedding of Rings: Quotient Rings - Homomorphisms - First theorem of isomorphism - Second theorem of isomorphism - Embedding of Rings - More on Ideals - Maximal Ideals - Prime Ideal.

Unit V

Euclidean and factorization domains: Euclidean Domains - Prime and irreducible elements - Polynomial Rings - Greatest common divisor - Unique Factorization Domains.

Text Book

Vijay K. Khanna., & Bhambri, S. K. (2013). A Course in Abstract Algebra. (Fourth Edition). Vikas Publishing House Pvt. Ltd.

Chapter 4: pages 167 - 197 (Theorems & only the problems 1 - 7, 21, 23, 30);
Chapter 5: Theorems & only the problems 1 - 4, 7 - 10, 15 - 17;
Chapter 7: Theorems & only the problems 1 - 6, 9, 10, 25, 26, 33 - 43;
Chapter 8: Theorems & only the problems 1 - 10, 26 - 33;
Chapter 9: Pages 396 - 465 (only Theorems).

Reference Books

1. Herstein, I. N. (1992). Topics in Algebra. (2^{nd} Edition). New Delhi, Wiley Eastern Ltd.
2. Joseph A.Gallian. (1999). Contemporary Abstract Algebra. (4^{t} Edition). Narosa Publishing House.
3. John B. Fraligh. (1977). A first course in Abstract Algebra. (2^{nd} Edition). Addition Wesley Publishing Company.
4. John R. Durbin. (2005). Modern Algebra. (5^{t} Edition). John wiley & Sons.
5. Rudolf Lidl., & Gunter Pilz. (2009). Applied Abstract Algebra. (2^{nd} Edition). Springer International Edition.

Semester I
Core II: Analysis I
Sub. Code: PM1712

No. of hours per week	Credits	Total No. of hours	Marks
6	4	90	100

Objectives

1. To understand the basic concepts of analysis.
2. To formulate a strong foundation for future studies.

Unit I

Basic topology - Metric spaces - Open and closed sets - Dense sets - Compact sets - Weierstrass theorem - Perfect sets - Cantor set - Connected sets.

Unit II

Convergent sequences - Subsequences - Cauchy sequences - Complete metric space - Upper and lower limits - Some special sequences.

Unit III

Series - Cauchy criterion for convergence of series - series of nonnegative terms - The root and ratio tests - Power series - Summation by parts - Absolute convergence - Addition and multiplication of series - Rearrangements of series.

Unit IV

Continuity - Limits of functions - Continuity and compactness - Continuity and connectedness, discontinuities - Monotonic functions - Infinite limits and limits at infinity.

Unit V

Differentiation - Mean value theorems - The continuity of derivatives - L' Hospital's rule - Taylor's theorem - Differentiation of vector valued functions.

Text Book

Walter Rudin. (1976). Principles of Mathematical Analysis. (3^{rd} Edition). Singapore: McGRAW Hill Book Company.
Chapter 2 : 2.15 - 2.47;
Chapters 3, 4, 5.

Reference Books

1. Charles G. Denlinger. (2011). Elements of Real Analysis. (1^{st} Edition). Jones & Burtlett Learning.
2. Tom M. Apostlal. (2002). Mathematical Analysis. (2^{nd} Edition). New Delhi: Narosa Publishing House.
3. Somasundaram, D., & Choudhary, B.A. (2010). First Course in Mathematical Analysis. (5^{t} Edition). Narosa Publishing House.
4. Mainak Mukherjee. (2011). A Course in Real Analysis. New Delhi: Narosa Publishing house.
5. Richard R. Goldberg. (1970). Methods of Real Analysis. (2^{nd} Edition). Oxford & IBH Publishing Co. Pvt. Ltd.

Semester I
Core III: Probability and Statistics
Sub. Code: PM1713

No. of hours per week	Credits	Total No. of hours	Marks
6	4	90	100

Objectives

1. To upgrade the knowledge in Probability theory.
2. To solve NET / SET related Statistical problems.

Unit I

Conditional probability - Marginal and conditional distributions, Correlation coefficient - Stochastic independence - Necessary and sufficient conditions for stochastic independence.

Unit II

The Binomial, Trinomial and Multinomial distributions - Poisson distribution - Gamma, Chi-square, Normal and Bivariate Normal distributions.

Unit III

Sampling theory - Transformations of variables of discrete and continuous type - Beta distribution, the t and F distributions.

Unit IV

Extension of change of variable technique - Distributions of order statistics - Moment generating function technique - Distributions of $\bar{x}$ and nS^2/σ^2 - Expectations of functions of random variables.

Unit V

Limiting distributions - Stochastic convergence - Limiting moment generating functions - Central limit theorem - Some theorems on limiting distributions.

Text Book

Robert V. Hogg., & Allen T. Craig. (2004). Introduction to Mathematical Statistics. (4^{th} edition). New Delhi, Pearson Education.Chapters 2 to 5.

Reference Books

1. Kapur, J.N., & Saxena, H.C. (2010). Mathematical Statistics. (12^{t} Edition). S. Chand & Co.
2. Kadarkarai Thangam, K., & Subas Chandra Bose, A. (1995). Probability and Statistics. (1^{st} Edition). Jeyalakshmi Publishers.
3. Morris H. DeGroot. (1975). Probability and Statistics. Addison Wesley Publishing Company.
4. Suddhendu Biswass., & Sriwastav, G.L. (2011). Mathematical Statistics. Narosa Publishing House.
5. Murthy, T.S.R. (1995). Probability and Statistics. (1^{st} Edition). I.K. International Publishing House.

Semester I

Core IV: Ordinary Differential Equations

Sub.Code: PM1714

No. of hours per week	Credits	Total No. of hours	Marks
6	4	90	100

Objectives

1. To study mathematical methods for solving differential equations.
2. Solve dynamical problems of practical interest.

Unit I

Second order Linear Equations: The general solution of a homogeneous equation - The use of a known solution to find another - The method of variation of parameters.

Unit II

Power series solutions and special functions: A review of power series - Series solutions of first order equations - Second order linear equations - Ordinary points - Regular singular points.

Unit III

Systems of first order equations: Linear systems - Homogeneous Linear systems with constant coefficients.

Unit IV

The Existence and Uniqueness of solutions: The method of Successive approximations - Picard's theorem - Systems. The second order linear equations.

Unit V

Boundary value problems: Introduction - Sturm Liuville problem - Green's functions - Non existence of solutions.

Text Books

1. George F. Simmons. (1991). Differential equations with Applications and Historical Notes. (2^{nd} Edition). McGraw Hill International Editions.

   Chapter 3 : 14, 15, 16, 19.

   Chapter 5 : 26 to 30

   Chapter 10 : 55, 56

   Chapter 13 : 68 to 70

2. Deo S.G., & Raghavendra V. (1991). Ordinary Differential Equations and stability theory. ($4^{t\square}$ reprint). Tata McGraw - Hill Publishing Company Limited.

   Chapter 7 : 7.1, 7.2, 7.3.

Reference Books

1. Sharma, A.,K. (2010). Advanced Differential Equations. Discovery publishing house.
2. Raisinghania, M. D. (2012). Ordinary and Partial Differential Equations. ($14^{t\square}$ Revised Edition). Ramnagar, New Delhi: S. Chand and company Ltd.
3. Arnold, V. I. (2009). Ordinary Differential Equations. New Delhi: PHI Learning Private limited.

4. John C. Polking., & David Arnold. (2011). Ordinary Differential Equations. (2^{nd} Impression). Dorling Kindersley India Pvt. Ltd.
5. Doshi, J. B. (2009). Differential Equations for Scientists & Engineers. Narosa Publishing House.

Semester I
Elective (a): Numerical Analysis
Sub. Code: PM1715

No. of hours per week	Credits	Total No. of hours	Marks
6	4	90	100

Objectives

1. To study the various behaviour pattern of numbers.
2. To study the various techniques of solving applied scientific problems.

Unit I

Solution of Algebraic and Transcendental Equations - Bisection Method - Method of False Position - Iteration Method - Newton-Raphson Method - Secant Method - Muller's Method.

Unit II

Finite Differences - Forward Differences - Backward Differences - Central Differences - Detection of Errors by use of difference tables - Differences of a polynomial - Newton's formulae for Interpolation - Central Difference Interpolation formulae - Gauss's central difference formulae - Stirling's formulae - Bessel's formulae - Everett's formulae.

Unit III

Numerical Differentiation - Errors in Numerical Differentiation - Numerical Integration - Trapezoidal rule - Simpson's 1/3 rule - Simpson's 3/8 rule - Boole's and Weddle's rule.

Unit IV

Solution of Linear systems - Direct Methods - Gauss elimination - Necessity for Pivoting - Gauss-Jordan method - Modification of the Gauss method to compute the inverse - LU Decomposition method - Solution of Linear systems - Iterative methods.

Unit V

Solution by Taylor's series - Picard's method of successive approximations - Euler's method - Runge - Kutta methods - II order and III order.

Text Book

Sastry, S. S. (2000). Introductory Methods of Numerical analysis. ($5^{t\square}$ Edition). New Delhi, Prentice Hall of India Pvt Ltd.

Chapter 2 : 2.1 to 2.5, 2.7, 2.8.
Chapter 3 : 3.3 (3.3.1 to 3.3.3), 3.4 to 3.6, 3.7 (3.7.1 to 3.7.4).
Chapter 6 : 6.2 (6.2.1), 6.4 (6.4.1 to 6.4.4).
Chapter 7 : 7.5 (7.5.1 to 7.5.4, 7.5.6, 7.6).
Chapter 8 : 8.2 to 8.5.

Reference Books

1. Balagurusamy, E. (2002). Numerical Methods. New Delhi: Tata McGraw Hill Publishing Company Ltd.
2. Rao, H. S. G. (2011). Numerical Methods. New Delhi: IK International publishing House PVT Ltd.
3. Goel Mittal. (2011). Numerical Anaysis. (21^{st} Edition). Pragati Prakashan Educational Publishers.
4. Vedamurthy, V. N., & N. ch. S. N. Iyengar. (2009). Numerical Methods. New Delhi,Vikas Publising House PVT. LTD.
5. Devi Prasad. (2010). An Introduction to Numerical Anaysis. Narosa Publishing House.

Semester I
Elective (b): Fuzzy Sets and Fuzzy Logic
Sub.Code: PM1716

No. of hours per week	Credits	Total No. of hours	Marks
6	4	90	100

Objectives

1. To understand Fuzzy logic.
2. To apply Fuzzy concepts in other branches of Mathematics.

Unit I

Crisp set - Operations on crisp set - Fuzzy sets - Basic types - Basic concepts -Additional properties of α-Cuts - representation of Fuzzy sets - Extension principle for Fuzzy sets.

Unit II

Operations on Fuzzy sets - Types of operations - Fuzzy complements - Fuzzy intersections: t-Norms - Fuzzy unions: t-Conorms - Combinations of operations - Aggregation operations.

Unit III

Fuzzy arithmetic - Fuzzy numbers - Operations on Fuzzy number - Linguistic variables - Arithmetic operations on intervals - Arithmetic operations on Fuzzy numbers.

Unit IV

Fuzzy relations - Relations on Fuzzy set - Composition of Fuzzy relation - Lattice of Fuzzy numbers - Fuzzy equations - Crisp versus Fuzzy relations - Projections.

Unit V

Binary Fuzzy relations - Binary relations on a single set - Fuzzy equivalence relations - Fuzzy compatibility relations - Fuzzy ordering relations.

Text Book

George J. KlirBo Yuan. (2012). Fuzzy Sets and Fuzzy Logic Theory and Applications. New Delhi: PHI Learning Private Limited.
Chapter 1 : Sections 1.3, 1.4 ; Chapter 2: Sections 2.1 - 2.3;
Chapter 3 : Sections 3.1 - 3.6; Chapter 4: Sections 4.1 - 4.6;
Chapter 5 : Sections 5.1 - 5.7.

Reference Books

1. Hooda, D. S. (2015). Fuzzy Set Theory and Fuzzy Controller. Vivek Raich Narosa Publishing House.
2. Bhargava, A. K. (2013). Fuzzy Set Theory Fuzzy logic and their Application. S. Chand Publishing.
3. Ganesh, M. (2006). Fuzzy sets and Fuzzy logic. Prentice Hall India learning private limited.
4. Shinghal. (2012). Introduction to Fuzzy logic. Prentice Hall India learning private limited.
5. Nanda, S., & Das, N. R. (2015). Fuzzy Mathematical Concepts. Narosa Publishing House Pvt. Ltd.

Semester II

Core V: Algebra II

Sub. Code: PM1721

No. of hours per week	Credits	Total No. of hours	Marks
6	5	90	100

Objectives

1. To understand the concept of Extension fields.
2. To apply the idea of advanced forms of matrices related to linear transformations in real life situations.

Unit I

Vector spaces: Subspaces - Sum of Subspaces - Quotient Spaces - Homomorphisms of Linear Transformations - Linear Span - Linear Dependence and Independence.

Unit II

Linear Transformations: Algebra of linear transformations - Invertible linear transformations - Matrix of a linear transformation - Dual spaces.

Unit III

Eigen values and Eigen vectors: Characteristic polynomials - Characteristic polynomial of a linear operator - Minimal polynomials - Diagonolizable operators - Primary decomposition theorem.

Unit IV

Invariant subspaces - Triangulable linear operator - Cyclic subspaces - T-annihilator - Projection.

Unit V

Fields: Algebraic extensions - Roots of polynomials - Splitting fields.

Text Book

Vijay K. Khanna., & Bhambri, S. K. A. (2013). Course in Abstract Algebra. (4^{t} Edition). Vikas Publishing House Pvt. Ltd.

Chapters 10 : Theorems & only the problems 1 - 5, 7 - 9, 11 - 14, 18 - 22;

Chapter11 : Theorems & only the problems 1 - 7, 16 - 19, 23 - 26;

Chapter 12 : Theorems & only the problems 1 - 10, 15 - 17, 22 - 25, 37 - 39, 47 - 54, 67 - 71;

Chapter 13: Theorems & only the problems 1 - 7 & 11 - 17.

Reference Books

1. Herstein, I. N. (1992). Topics in Algebra. (2^{nd} Edition). New Delhi: Wiley Eastern Ltd.
2. Nathan Jacobson. (1984). Basic Algebra. Hindustan Publishing Corporation.
3. Joseph A. Gallian. (1999). Contemporary Abstract Algebra. (4^{t} Edition). Narosa Publishing House. Reprint.
4. Kenneth Hoffman., & Ray Kunze. (2016). Linear Algebra. (2^{nd} Impression). Pearson India Education Services Pvt. Ltd.
5. John B. Fraligh. (1977). A first course in Abstract Algebra. (2^{nd} Edition). Addition Wesley publishing company.

Semester II

Core VI: Analysis II

Sub.Code: PM1722

No. of hours per week	Credits	Total No. of hours	Marks
6	4	90	100

Objectives

1. To make the students understand the advanced concepts of Analysis.
2. To pursue research in Analysis related subjects.

Unit I

The Riemann Stieltjes integrals - Definition and Existence of the Integral - Properties of the integral - Integration of vector-valued function - Rectifiable curves .

Unit II

Sequences and series of functions - Uniform convergence - Continuity - Integration - Differentiation.

Unit III

Equicontinuous families of functions - Wierstrass theorem - Stone Wierstrass theorem.

Unit IV

Some special functions - Power series - The algebraic completeness of the Complex field - Fourier series - Parseval's theorem.

Unit V

Differentiation - Partial derivatives - The contraction principle - The inverse function theorem.

Text Books

Walter Rudin. (1976). Principles of Mathematical Analysis. (3^{rd} Edition). McGraw Hill International.

Chapters 6, 7

Chapter 8 : 8.1 to 8.5 & 8.8 to 8.16

Chapter 9 : 9.10 to 9.25.

Reference Books

1. Charles G. Denlinger. (2011). Elements of Real Analysis. (1^{st} Edition). New Delhi: Jones & Burtlett Learning.

2. Tom M. Apostlal. (2002). Mathematical Analysis. (2^{nd} Edition). New Delhi: Narosa Publishing House.
3. Mittal. (2012). Real Analysis. (7^{t} Edition). Pundir Pragati Prakashan Educational Publishers.
4. Mainak Mukherjee. (2011). A Course in Real Analysis. New Delhi: Narosa Publishing house.
5. Bali, N.P. (2016). Real Analysis. (1^{st} Edition). New Delhi: Firewall media.

Semester II

Core VII: Partial Differential Equations

Sub. Code: PM1723

No. of hours per week	Credits	Total No. of hours	Marks
6	4	90	100

Objectives

1. To formulate and solve different forms of partial differential equations.
2. To solve the related application oriented problems.

Unit I

Non linear Partial Differential Equations of order one - complete integral, particular integral, singular integral - Compatible system of First Order Equations - Charpit's Method.

Unit II

Special methods of solutions applicable to certain standard forms - Standard form I, II, IIII, IV - Jacobi's method for solving non linear first Order Partial Differential Equations in Two independent variables - Cauchy's method of Characteristics for solving non linear first Order Partial Differential Equations.

Unit III

Homogeneous and Non Homogeneous Linear Partial Differential Equations with constant coefficients - Solution of Homogeneous and Non Homogeneous Linear Partial Differential Equations with constant coefficients - Method of finding Complementary Function of Linear Homogeneous Partial Differential Equations with constant coefficients - Particular Integral of Homogeneous Partial Differential Equations - General method of finding Particular Integral of Linear Homogeneous Partial Differential Equations.

Unit IV

Non Homogeneous Linear Partial Differential Equations with constant coefficients - Reducible and Irreducible Linear Differential operators - Reducible and Irreducible Linear Differential Equations with constant coefficients - Determination of Complementary Function of Reducible Non Homogeneous Linear Partial Differential Equations with constant coefficients - General Solution of Non Homogeneous Linear Partial Differential Equations with constant coefficients - Determination of Particular Integral of Non Homogeneous Linear Partial Differential Equations with constant coefficients.

Unit V

Boundary Value Problem - Solution by Separation of variables - Solution of One dimensional Wave Equation - Solution of Two dimensional Wave Equation - Vibration of Circular Membrane - Solution of One Dimensional Heat Equation - Solution of Two Dimensional Laplace's Equation - Solution of two dimensional heat equation.

Text Books

1.Raisinghania, M. D. (2012). Ordinary and Partial Differential Equations. ($14^{t\square}$ Revised Edition). New Delhi: S. Chand and company Ltd.
Chapter 3 : 3.1, 3.4 to 3.8B.
Chapter 3 : 3.9, 3.10 to 3.18, 3.22, 3.23.
Chapter 4 : 4.1 to 4.6, 4.12, 4.13.
Chapter 5 : 5.1 to 5.3, 5.5, 5.10 to 5.13.
2. Sharma, A. K. (2010). Advanced Differential Equations. Dicovery Publishing House.
Chapter 12: 12.1 to 12.8.

Reference Books

1. Amaranath, T. An Elementary Course in Partial Differential Equations. (2^{nd} Edition). New Delhi: Narosa Publishing House.
2. Ian Sneddon. (1957). Elements of Partial Differential Equations. International Edition.
3. Kevorkian, J. (2006). Partial Differential Equations. Springer International Edition.
4. Sharma, I. N., & Kehar Singh. (2009). Partial Differential Equations for Engineers and Scientists. (Second Edition). Narosa Publishing House PVT. LTD.
5. Lawrence C. Evans. (2009). Partial Differential Equations. (1^{st} Indian Edition). Rhode Island, American Mathematical Society Providence.

Semester II

Core VIII: Graph Theory

Sub. Code: PM1724

No. of hours per week	Credits	Total No. of hours	Marks
6	4	90	100

Objectives

1. To introduce the important notions of graph theory.
2. To develop the skill of solving application oriented problems.

Unit I

Connectivity: Cut vertices - Blocks - Connectivity - edge connectivity - Geodetic Sets.

Unit II

Digraphs: Strong Digraphs - The First Theorem of Digraph Theory - Eulerian digraph - Tournaments.

Unit III

Matchings and Factorization: Matchings - Gallai Identities - Factorization - Petersen's Theorem - Hamiltonian Factorization - Decompositions and Graceful Labelings -Steiner triple system.

Unit IV

Planarity: Planar Graphs - The Euler Identity - Kuratowski's Theorem, Coloring : Vertex Coloring - Brook's Theorem - Edge Coloring - The Heawood Map Coloring Theorem - The Five Color Theorem.

Unit V

Ramsey Numbers: The Ramsey Number of Graphs - Turan's Theorem, Distance: The center of a graph - Distant Vertices.

Text Book

Gary Chartrand., & Ping Zhang. (2006). Introduction to Graph Theory. McGraw Hill Education (India).
Chapter 5 : 5.1 - 5.3 and 5.5
Chapter 7 : 7.1and 7.2
Chapter 8 : 8.1 - 8.3
Chapter 9 : 9.1
Chapter 10 : 10.2 - 10.4
Chapter 11 : 11.1and 11.2
Chapter 12 : 12.1and 12.2

Reference Books

1. Bondy, J. A., & Murty, U. S. R. (1976). Graph Theory with Applications. (1^{st} Edition). Macmillan Press Ltd.
2. Douglas B.West. (2003). Introduction to Graph Theory. (2^{nd} Edition). Pearson Education services.
3. Frank Harary. (2001). Graph Theory. Narosa Publishing House.
4. Balakrishnan, R., & Ranganathan, K. (2013). A Text Book of Graph Theory. Springer International Edition.
5. Reinhard Diestel. (2006). Graph Theory. (2^{nd} Edition). Springer International Edition.

Semester II

Elective II (a): Classical Dynamics

Sub. Code: PM1725

No. of hours per week	Credits	Total No. of hours	Marks
6	4	90	100

Objectives

1. To gain deep insight into concepts of Dynamics.
2. To do significant contemporary research .

Unit I

The Mechanical System - Generalized coordinates - Constraints - Virtual work and D' Alembert's Principle - Energy and Momentum.

Unit II

Derivation of Lagrange's equations - Problems using Lagrange's equation - Integrals of the motion.

Unit III

Hamilton's Principle - Hamilton's Equations - Legendre transformation - Other Variational Principles - Modified Hamilton's Principle - Principle of least action - Examples.

Unit IV

Hamilton's Principal function - The canonical integral - Pfaffian differential forms - The Hamilton - Jacobi equation - Jacobi's theorem - Conservative systems and ignorable coordinates - Examples.

Unit V

Canonical Transformations - Differential forms and generating functions - Special transformations - Lagrange and Poisson brackets.

Text Book

Greenwood G. T. (1979). Classical Dynamics. Prentice Hall.
Chapter 1: 1.1 - 1.5; Chapter 2: 2.1 - 2.3; Chapter 4:4.1 - 4.3
Chapter 5: 5.1, 5.2; Chapter 6: 6.1 - 6.3

Reference Books

1. Goldstein, H. (1994). Classical Mechanics. (2^{nd} Edition). Narosa Publishing.
2. Synge, J. L., & Griffith, B. A. (1959). Principle of Mechanics. McGraw Hill.
3. Rutherford, D. E. (2000). Classical Mechanics. New York: Oliver Boyd.
4. Chorlton, F. (1969). Text book of Dynamics. Van Nostrand.
5. Javier E. Hasbun. (2009). Classical Mechanics. Jones and Bartlett Publishers.

Semester II
Elective II (b): Differential Geometry
Sub. Code: PM1726

No. of hours per week	Credits	Total No. of hours	Marks
6	4	90	100

Objectives

1. To study coordinate free geometry.
2. Apply the theory in Tensors and theory of relativity.

Unit I

Theory of space curves - Arc length - Tangent, normal, principal normal, Curvature, torsion.

Unit II

Contact between curves and surfaces - Osculating circle and osculating sphere - Locus of centres of spherical curvature - tangent surfaces, involutes, evolutes - intrinsic equation of space curves - fundamental theorem for space curves - helices.

Unit III

The first fundamental form and local intrinsic properties of a surface - introduction - Definition of a surface - Curves on surfaces - General surfaces of revolution - Helicoids - Metric on a surface - Direction coefficients on a surface.

Unit IV

Families of curves - Orthogonal trajectories - Double family of curves - Isometric correspondence - Intrinsic properties - Geodesics on a surface - Introduction and its differential equations - Canonical geodesic equations.

Unit V

The second fundamental forms - Principal and lines of curvature - The Dupin'sindicatrix - Developable surfaces - Developable associated with space curves and curves on surfaces.

Text Book

Willmore, T. J. (1959). An introduction to Differential Geometry. (1^{st} Edition). Oxford Press.
Chapter 1 (except section 5); Chapter 2 : Sections 1 to 11; Chapter 3 : Sections 1 to 5.

Reference Books

1. Somasundaram, D. (2010). Differential geometry - A First Course. Narosa Publishing House.
2. Auslander, L., Harper., & Row. (1965). Differential Geometry. J London Mathematical Society
3. Khanna, M. L. (1975 - 76). Differential geometry. Jai prakash Nath & Co.
4. Gupta., & Malik Pundir. (2012). Differential Geometry. Pragathi Prakashan.
5. Martin M. Lipschutz. (1969). Differential geometry - Theory and Problems. McGraw - Hill Book Company.

SEMESTER III

Core IX: Algebra - III

Sub. Code: PM1731

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To learn in depth the concepts of Galois Theory, theory of modules and lattices.

2. To pursue research in pure Mathematics.

Unit I

The Elements of Galois Theory - Galois Groups over the Rationals.

Unit II

Finite fields - Wedderburn's theorem. (First proof only).

Unit III

A Theorem of Frobenius - Integral Quaternions and the four square Theorem.

Unit IV

Modules-Definitions - Direct Sums - Free Modules - Vector Spaces - Quotient Modules - Homomorphisms - Simple Modules -Modules over PID's.

Unit V

Partially ordered set and Lattices - Distributivity and Modularity, Boolean Algebra.

Text books

1. Herstein, I.N. (2007). Topics in Algebra. (2^{nd} Edition). New Delhi: Wiley Eastern Ltd. Chapter 5 : 5.6, 5.7; Chapter 7: 7.1, 7.2,7.3,7.4
2. Musili, C. (2006). Rings and Modules. (2^{nd} Revised Edition). Narosa Publishing House. Chapters 5.
3. Nathan Jacobson. (1984). Basic Algebra - I. (Indian Edition). Hindustan Publishing Corporation.

   Chapter 8: 8.1,8.2,8.5.

Reference Books

1. Joseph A.Gallian. (1999). Contemporary Abstract Algebra. (4^{t} Edition). Narosa Publishing House.

2. Nathan Jacobson. (1984). Basic Algebra. (Indian Edition). Hindustan Publishing Corporation.
3. Joseph Rotsman. (2010). Galois Theory. (2^{nd} Edition). Springer International Edition.
4. John R. Durbin. (2005). Modern Algebra. (5^{t} Edition). John wiley & Sons.
5. Rudolf Lidland Gunter Pilz. (2009). Applied Abstract Algebra. (2^{nd} Edition). Springer International edition.

SEMESTER III
Core X: Topology
Sub. Code: PM1732

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To distinguish spaces by means of simple topological invariants.
2. To lay the foundation for higher studies in Geometry and Algebraic Topology.

Unit I

Topological spaces - basis for a topology - The order topology - The product topology on $X \times Y$- The subspace topology - Closed sets and Limit points - Hausdorff spaces.

Unit II

Continuous function - Homeomorphism - Constructing Continuous functions - The product topology - Comparison of the box and product topologies.

Unit III

Connected spaces - Product of connected spaces - Components and local connectedness - Compact spaces.

Unit IV

Local compactness - One point compactification - The countability axioms - First countable - Second countable - Lindelof space - Separable - The separation axioms.

Unit V

Normal spaces - The Urysohn Lemma - Completely regular Space - The Tietze Extension Theorem.

Text Book

James R. Munkres. (2002). Topology. (2^{nd} Edition). Pearson Education Inc.
Sections : 12 - 19, 23, 25, 26, 29 - 33, 35.

Reference Books

1. Gupta, K. P. (2013). Topology. (21^{st} Edition). Pragati Prakashan Publishers.
2. Kelley, J. L. (2009). General Topology. (3^{rd} Indian reprint). Springer - Verlag.
3. George F. Simmons. (2004). Introduction to Topology and Modern Analysis. (2^{nd} Indian reprint). McGraw Hill.
4. Willard, S. (1970). General Topology. Addison - Wesley Publishing Co Inc.
5. Joshi, K. D. (1983). Introduction to General Topology. Wiley Eastern Ltd.

SEMESTER III

Core XI: Measure Theory and Integration

Sub. Code: PM1733

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To generalize the concept of integration using measures.
2. To develop the concept of analysis in abstract situations.

Unit I

Lebesgue Measure - Introduction, outer measure - Measurable sets and Lebesgue measure - Measurable functions - Littlewood's three principles (no proof for first two).

Unit II

The Lebesgue integral - The Riemann Integral - The Lebesgue integral of a bounded function over a set of finite measure - The integral of a non-negative function - The general Lebesgue integral .

Unit III

Differentiation and integration - Differentiation of monotone functions - Functions of bounded variation - Differentiation of an integral - Absolute continuity.

Unit IV

Measure and integration - Measure spaces - Measurable functions - Integration - general convergence theorems - Signed measures.

Unit V

The L^P spaces - Measure and outer measure - Outer measure and measurability - The extension theorem.

Text Book

Royden, H. L. (2004). Real Analysis. (3^{rd} Edition). Prentice Hall of India.
Chapters : 3, 4, 5, 11 (except 3.4, 4.5, 5.5, 11.6)
Chapter : 12 (sections 1 and 2)

Reference Books

1. De Barra, G. (2009). Measure Theory and Integration. New Age International (P) Limited Publishers.
2. Jain, P. K., Gupta, V. P., & Pankaj Jain. (2015). Lebesgue Measure and Integration. (2^{nd} Edition). New Age International Publishing.
3. Inder K. Rana. (2014). An Introduction to Measure and Integration. (2^{nd} Edition). Narosa Publishing House.
4. Jain P. K., & Pankaj Jain. (2014). General Measure and Integration. (1^{st} Edition). New Age International Publishers.
5. Chandrasekhar Rao, K. (2009). Topology. Narosa Publishing House.

SEMESTER III

Elective III (a): Algebraic Number Theory

Sub.Code: PM1734

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To gain deep knowledge about Number theory
2. To study the relation between Number theory and Abstract Algebra.

Unit I

Quadratic Reciprocity and Quadratic Forms: Quadratic Residues - Quadratic Reciprocity - The Jacobi Symbol.

Unit II

Binary Quadratic Forms - Equivalence and Reduction of Binary Quadratic Forms - Sum of Two Squares.

Unit III

Some Diophantine Equations - Pythagorean Triangles - Algebraic Numbers: Polynomials - Algebraic Numbers.

Unit IV

Algebraic Number Fields - Algebraic Integers - Quadratic Fields - Units in Quadratic Fields - Primes in Quadratic Fields.

Unit V

Partition Function - Ferrers Graphs - Formal Power Series - Eulers Identity - Eulers Formula.

Text Book

Ivan Niven., Herbert S. Zuckerman., & Hugh L. Montgomery. (2006). An Introduction to the Theory of Numbers. (5^{t} Edition). John - Wiley & Sons.
Chapter 3 : 3.1 - 3.6; Chapter 5 : 5.3;
Chapter 9 : 9.1 - 9.7; Chapter 10 : 10.1 - 10.4

Reference Books

1. Hardy, G. H., & Wright E. M. (1975). An Introduction to the Theory Of Number. (4^{th} Edition). Oxford at the Clarendon Press.
2. Kenneth Ireland., & Michael Rosen. (1990). A classical Introduction to Modern Number Theory. (2^{nd} Edition). Springer International Edition.
3. Graham Everest., & Thomas Ward. (2008). An Introduction to Number Theory. Springer International Edition.
4. John Stillwell. (2008). Elements of Number Theory. Springer International Edition.
5. Tom. M. Apostol. (1998). Introduction to Analytic Number Theory. Narosa Publishing House.

SEMESTER III
Elective III (b): Stochastic Processes
Sub. Code: PM1735

No. of Hours per Week	Credit	Total No. of Hours	Marks
6	4	90	100

Objectives

1.To understand the stochastic models.

2. To relate the models studied to real life probabilistic situations.

Unit I

Stochastic processes - Specification of Stochastic processes - Stationary processes - Markov chain - Transition probabilities - Random walk - Higher transition probabilities.

Unit II

Classification of states and chains - Transient and recurrent states - Stability of a Markov system.

Unit III

Markov process with discrete state space - Poisson process-Generalizations of Poisson process - Poisson Cluster process - Pure birth process - Yule-Furry process - Birth Immigration Process - Birth and death process.

Unit IV

Renewal processes - Renewal process in Discrete time - Renewal process in continuous time - Renewal equation-Renewal theorems - Residual and current life times.

Unit V

Stochastic processes in queuing - Queuing processes - Steady state behaviour of M/M/1 queuing model-Non-Markovian queuing models-Queues with Poisson input- M/G/1 and GI/M/1 queuing models.

Text Book

Medhi, J. (1994). Stochastic Processes.(Second Edition).New Age International Publishers. New Delhi.

Chapter 2: Sections 2.1,2.2,2.3; Chapter 3: Sections 3.1,3.2,3.4,3.6.

Chapter 4: Sections 4.1, 4.3 (except 4.3.5 - 4.3.7), 4.4.

Chapter 6: Sections 6.1.1- 6.1.3, 6.2 (except example 2(b)), 6.3, 6.5 (except 6.5.2), 6.7.

Chapter 10: Sections 10.1(except 10.1.4), 10.2 (except 10.2.3.1),10.7 (except examples 7(a),7(b) & sections 10.7.3,10.7.4), 10.8 (except example 8(a)).

Reference Books

1.Narayan Bhat, U. (1972). Elements of Applied Stochastic Processes. (Second Edition). John Wiley & Sons. New York.

2.Prabhu, N.V. (1970). Stochastic Processes. Mac Millon. New York.

3.Bhat, B.R. (2010). Stochastic Models Analysis and Applications. New Age International (P) Limited Publishers.

4.Veerarajan, T. (2006). Probability, Statistics and Random Processes. Tata McGraw - Hill Publishing Company Limited.

5.Salil Kumar Chaudhri., & Ashis K. Chakraborthy. (2009). Statistical Methods. Asian Books Private Ltd.

SEMESTER IV

Core XII: Complex Analysis

Sub. Code: PM1741

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To impart knowledge on complex functions.

2. To facilitate the study of advanced mathematics.

Unit I

Complex Functions - Introduction to the Concept of Analytic Function - Analytic functions, Polynomials, Rational functions, Elementary Theory of Power Series - Sequences, Series, Uniform Convergence.

Unit II

Power series - Abel's theorem, Abel's limit theorem, The Exponential and Trigonometric functions - The periodicity.

Unit III

Analytic functions as mappings - conformality - Arcs and closed curves, Analytic Functions in Regions, Conformal Mapping, Length and Area, Linear transformations - The linear group, The Cross Ratio, Symmetry.

Unit IV

Complex Integration - Fundamental theorems - Line Integrals, Rectifiable Arcs, Line Integrals as Functions of Arcs, Cauchy's Theorem for a Rectangle, Cauchy's Theorem in a Disk, Cauchy's integral formula - The Index of a Point with Respect to a Closed Curve, The Integral Formula, Higher Derivatives, Local Properties of Analytic Functions - Removable singularties and Taylor's theorem, Zeros and poles.

Unit V

The local mapping, The maximum principle, The General Form of Cauchy's Theorem - Chains and Cycles, Simple Connectivity, Homology, The General Statement of Cauchy's Theorem (statement only), The Calculus of Residues - The Residue Theorem, The Argument Principle, Evaluation of Definite Integrals.

Text Book

Ahlfors. (1979). Complex Analysis. (3^{rd} Edition). Tata McGraw Hill. New York.

Chapter 2: sections 1.2 - 1.4, 2.1 - 2.5, 3.1 - 3.3

Chapter 3: sections 2.1 - 2.4, 3.1- 3.3

Chapter 4: sections 1.1 - 1.5, 2.1 - 2.3, 3.1 - 3.4, 4.1 - 4.4, 5.1 - 5.3

Reference Books

1. Karunakaran, V. (2002). Complex Analysis. Narosa Publishing House.
2. Shanthi Narayanan., & Mittal, P.K. (2011). Theory of Functions of a Complex Variable. S.Chand & Co Publication.
3. Ponnusamy, S. (2011). Foundations of Complex Analysis. (2^{nd} Edition). Narosa Publishing House.
4. Theodore W. Gamelin. (2008). Complex Analysis. Springer International Edition.
5. Kapoor, A. K. (2011). Complex Variables. (Reprint Edition). World Scientific Publishing Co. Pvt. Ltd.

SEMESTER IV

Core XIII: Functional Analysis

Sub. Code: PM1742

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To study the three structure theorems of Functional Analysis and to introduce Hilbert Spaces and Operator theory.

2. To enable the students to pursue research.

Unit I

Banach spaces - Definition and examples - Continuous linear transformations - The Hahn Banach theorem.

Unit II

The natural imbedding of N into N** - The open mapping theorem - The conjugate of an operator.

Unit III

Hilbert spaces - Definition and properties - Orthogonal complements - Orthonormal sets - The conjugate space.

Unit IV

Adjoint of an operator, self adjoint operators - Normal and unitary operators - Projections.

Unit V

Matrices - Determinants - Spectral theory - Spectrum of an operator - The spectral theorem.

Text Book

Simmons, G. F. (1963). Introduction to Topology and Modern Analysis.
Tata McGraw Hill.
Sections : 46 to 62

Reference Books

1. Soma Sundaram, D. (2014). A first course in Functional Analysis. Narosa Publishing House Pvt. Ltd.
2. Chandra Sekhara Rao, K. (2002). Functional Analysis. Narosa Publishing House.

3. Thamban Nair, M. (2002). Functional Analysis. A First Course. Prentice Hall of India.
4. Erwin Kreyzig. (2006). Introductory Functional Analysis with Applications. John Wiley and Sons Publication.
5. Casper Goffman., & George Pedrick. (1974). First course in Functional Analysis. Prentice/ Hall of India Private Limited.

SEMESTER IV
Core XIV: Operations Research
Sub. Code: PM1743

No. of Hours per Week	Credit	Total No. of Hours	Marks
6	5	90	100

Objectives

1. To learn optimizing objective functions.
2. To solve life oriented decision making problems.

Unit I

Elements of the DP Model - The Capital Budgeting Example - More on the definition of the state - Examples of DP Models and computations - Solution of Linear Programming by Dynamic programming - Game theory.

Unit II

Arrow (Network) Diagram Representations - Critical Path Calculations - Construction of the Time Chart and Resource Leveling - Probability and Cost Considerations in Project Scheduling .

Unit III

A Generalised Inventory model - Types of Inventory Models - Deterministic Models - Single Item Static Model - Single Item Static - Model with Price Breaks - Multiple - Item static Model with Storage Limitations - Single - Item .

Unit IV

Basic Elements of the Queueing Model - Roles of Poisson and Exponential Distributions - Queue with Combined Arrivals and Departure - Queueing Models of Type : (M/M/1): (GD/∞/∞) , (M/M/1): (GD/N/∞) .

Unit V

Queueing Models of Types : (M/G/1): (GD/∞/∞) - The Pollaczek - Khintchine Formula, (M/M/C) : (GD/∞/∞) - (M/M/∞) : (GD/∞/∞) Self service Model, (M/M/R) : (GD/K/K) R < K - Machine Service -Tandem or series queues .

Text Book

Handy .A. Taha. (1989). Operations Research - An Introduction. (3^{rd} Edition). MacMillan Publishing Co. Inc.
Chapter 9 : Section 9.1 - 9.3, 9.5; Chapter 11 : Section 11.4 ;
Chapter 12 : Section 12.1 - 12.4; Chapter 13 : Section 13.1 - 13.3 (except 13.3.5);
Chapter 15 : Section 15.1, 15.2 (only 15.2.1, 15.2.2), 15.3 (15.3.1, 15.3.2, 15.3.3, 15.3.4, 15. 3.6, 15.3.7), 15.5 - (only15.5.1).

Reference Books

1. Er . Prem Kumar Gupta., & Dr. Hira, D.S. (2014). Operations Research. (7th Edition). S. Chand and company private ltd.
2. Sharma, J.K. (2009). Operations Research : Theory and Applications. (4th Edition). Macmillian Publishers India ltd.
3. Panneerselvam, R. (2009). Operations Research. (2nd Edition). PHI Learning private ltd.
4. Prem Kumar Gupta., Dr. Hira, D. S., & AartiKamboj. (2012). Introduction to Operations Research. S. Chand and Company ltd.
5. Naidu, N. V. R., Rajendra, G., & Krishna Rao, T. (2011). Operations Research. (Kindle Edition). IK . International Publishing house private ltd.

SEMESTER IV

Core XV: Algorithmic Graph Theory

Sub. Code: PM1744

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To instill knowledge about algorithms

2. To write innovative algorithms for graph theoretical problems.

Unit I

The Role of Algorithms in Computing - Algorithms, Algorithm as a Technology. Getting Started - Insertion Sort, Analyzing Algorithms.

Unit II

Elementary Graph Algorithms - Representation of Graphs, Breadth-first Search, Depth-first Search.

Unit III

Minimum Spanning Trees - Growing a Minimum Spanning Tree, The algorithms of Kruskal and Prim.

Unit IV

Single Source Shortest Paths - The Bellman-Ford Algorithm, Single-source Shortest Paths in Directed acyclic Graphs, Dijkstra's Algorithm.

Unit V

All-Pairs Shortest Paths - Shortest Paths and Matrix Multiplication, The Floyd-Warshall Algorithm.

Text Book

Thomas H. Cormen., Charles E. Leiserson., Ronald L. Rivest., & Clifford Stein. (2010). Introduction to Algorithms. (3^{rd} Edition). PHI Learning Pvt. Limited.

Chapter I : 1.1 - 1.2 and 2.1 - 2.2

Chapter VI : 22.1 - 22.3, 23.1 - 23.2, 24.1 - 24.3 and 25.1 - 25.2.

Reference Books

1. Gary Chartrand., & Ortrud R. Oellermann. (1993). Applied and Algorithmic Graph Theory. (International Editions). McGraw-Hill.
2. Bondy, J. A., & Murty, U. S. R. (1976). Graph Theory with Application. Macmillan.
3. Murugan, M. (2003). Graph Theory and Algorithms. Muthali Publishing House.
4. Hu, T. C. (1982). Combinatorial Algorithms. Addison-Wesley Publishing Company.
5. Alan Gibbons. (1985). Algorithmic Graph Theory. Cambridge University.

SEMESTER IV

Elective IV (a): Combinatorics

Sub. Code: PM1745

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To do an advanced study of permutations and combinations.

2. Solve related real life problems.

Unit I

Permutations and combinations - The Rules of sum and product - Permutations - Combinations - Distribution of Distinct Objects.

Unit II

Generating Functions - Generating Functions for Combinations - Enumerators for Permutations.

Unit III

Recurrence Relations - Linear Recurrence Relations with Constant Coefficients - Solution by the Technique of Generating Functions.

Unit IV

The Principle of Inclusion and Exclusion - The General Formula - Derangements - Permutations with Restrictions on Relative Positions - The Rook Polynomials.

Unit V

Polya's Theory of Counting - Equivalence Classes under a Permutation Group - Equivalence classes of Function - Weights and Inventories of Functions - Polya's Fundamental Theorem.

Text Book

Liu, C.L. (1988). Combinatorial Mathematics. McGraw Hill.

Chapters 1: 1.1to 1.5; Chapter 2: 2.1 to 2.3; Chapter 3: 3.1 to 3.3

Chapter 4: 4.1 to 4.6; Chapter 5: 5.3 to 5.6

Reference Books

1. Anderson. (1974). Combinatorial Mathematics. Elarendon Press.
2. Balaji, G. (2010). Discrete Mathematics. (3^{rd} Edition).G. Balaji Publishers.
3. Robert J. Mceliece., Robert B. Ash., & Carol Ash. (1989). Introduction to Discrete Mathematics. Mcgraw-Hill International Editions.
4. Laszlo Lovasz. (1979). Combinatorial problems and Exercises. North - Holland publishing company.
5. Alan Tucker. (1984). Applied Combinatorics. (2^{nd} Edition). John Wiley & sons.

SEMESTER IV

Elective IV (b): Coding Theory

Sub. Code: PM1746

No. of Hours per Week	Credits	Total No. of Hours	Marks
6	4	90	100

Objectives

1. To learn the different procedures of coding and decoding.

2. To avail job opportunities in a number of detective agencies.

Unit I

Mathematical Background: Algebra - Krawtchouk Polynomials - Combinatorial theory - Shannon's Theorem: Introduction - Shannon's Theorem.

Unit II

Linear codes: Block codes - Linear codes - Hamming codes - Majority logic decoding - Weight Enumerators - The Lee metric.

Unit III

Some good codes: Hadamard codes and generalizations - The binary Golay code - The ternary Golay code - Constructing codes from other codes - Reed-Muller code - Kerdock codes.

Unit IV

Bound on codes: The Gilbert bound - Upper bounds - Cyclic codes: Definitions - Generator matrix and check polynomial - Zeros of a cyclic code.

Unit V

The idempotent of a cyclic code - Other Representations of cyclic codes - BCH codes - Decoding BCH codes - Binary cyclic codes of length 2n (n odd).

Text Book

Van Lint, J. H. (2000). Introduction to Coding Theory. (3^{rd} Edition).S pringer.

Chapters 1 (except 1.4), 2 (Sections 2.1 and 2.2 only), 3, 4, 5 (except 5.3), and Chapter 6 (except 6.8, 6.9 and 6.11).

Reference Books

1. Borda, M. (2011). Fundamentals in information theory and coding. Springer.
2. Raymond Hill. (1986). A First Course in Coding Theory. Clarendon Press. Oxford.
3. Vera Pless. (1998). Introduction to the Theory of Error - Correcting Codes. (3rd Edition). John Wiley and Sons Inc.
4. Cary Huffman, W., & Vera Pless. (2003). Fundamentals of Error - Correcting codes. Cambridge University Press.
5. Stefan M. Moser., & Po-Ning Chen. (2012). A Student's Guide to Coding and Information Theory. Cambridge University press.