Teaching Plan: B.Sc. (Hons.) Mathematics, Semester-8

DSC-20: Field Theory and Galois Extension

Weeks 1 and 2: Fields and prime subfields, Field extensions, Degree of field extensions, Tower theorem.
[2]: Chapter 13 [Section 13.1 up to Theorem 3].
[1]: Chapter 2 [Section 2.5 (page 34, Theorem 2.13, and Corollary 2.14), and Section 2.11].
[1]: Chapter 4 [Sections 4.1, and 4.2].

Weeks 3 and 4: Algebraic and transcendental extensions, Monomorphism of field extensions; Ruler and compass constructions.
[1]: Chapter 4 [Sections 4.3 to 4.5], and Chapter 5.

Week 5: Splitting fields, Extensions of monomorphisms, Uniqueness of splitting field.
[1]: Chapter 6 [Sections 6.1, 6.2, 6.3 (Theorems without proof), and 6.4].

Week 6: Normal Extensions.
[1]: Chapter 7 [Sections 7.1 (Theorem 7.1 without proof, and Corollary 1 to 3), and 7.2].

Weeks 7 and 8: Separability and separable extensions, Monomorphisms and automorphisms of field extension, Galois extensions.
[1]: Chapter 8 [Sections 8.1, 8.2, and 8.3].

Weeks 9 and 10: Automorphism/Galois groups and fixed fields, Galois theory of polynomials, The fundamental theorem of Galois theory.
[1]: Chapter 9.

Weeks 11 and 12: The Discriminant, Cyclotomic polynomials, extensions and its Galois group.
[1]: Chapter 10 [Theorem 10.1].
[1]: Chapter 11 [Sections 11.1, 11.2, 11.3, and 11.4].

Week 13: Solution by radicals.
[1]: Chapter 12 [Section 12.1 (Theorem 12.1 without proof), and Section 12.2].

Weeks 14 and 15: Existence and Uniqueness of finite fields, Simple extensions, and the primitive element theorem.
[1]: Chapter 15 [Section 15.1].
[1]: Chapter 17 [Sections 17.1, and 17.2].

Note. For more related Examples, one can refer to:
Dummit [2]: Chapters 13, and 14; **Gallian:** Chapters 20, 21, and 32.
[Gallian, Joseph. A. (2017). Contemporary Abstract Algebra (9th ed.). Cengage, Indian Reprint 2021].

Essential Readings

1. Garling, D. J. H. (2022). Galois Theory and Its Algebraic Background (2nd ed.). Cambridge University Press.
2. Dummit, David S., and Foote, Richard M. (2011). Abstract Algebra (3rd ed.). Wiley.

DSE-6(i): Advanced Mechanics

Weeks 1 and 2: General force systems, Equilibrium of a system of particles, Reduction of a force systems, Equilibrium of a rigid body, Generalized coordinates and constraints, Work and potential energy.
[2]: Chapter 10 [Sections 10.1 (up to eqn. 10.106), 10.2 (up to eqn. 10.209), 10.3 (up to eqn. 10.303), 10.4 (up to eqn. 10.403), 10.6, 10.7 (up to eqn. 10.712), and Example 1, page 266)].

Weeks 3 and 4: Kinematics of a particle and a rigid body. Moments and products of inertia. Kinetic energy and angular momentum.
[2]: Chapter 11 [Sections 11.1, 11.2 (up to page 280), 11.3 (up to eqn. 11.303), 11.4, and 11.5].

Weeks 5: Motion of a particle and a system, Moving frames of reference, Motion of a rigid body.
[2]: Chapter 12 [Sections 12.1 (up to eqn. 12.105), 12.2 (up to eqn. 12.210), 12.3 (up to eqn. 12.315), and 12.4 (up to eqn. 12.405)].

Weeks 6 and 7: Lagrange's equations for a particle in plane, Classification of dynamical systems, Lagrange's equations for any simple dynamical system, general dynamical system and for impulsive motion.
[2]: Chapter 15 [Sections 15.1, 15.2 (up to page 426, except Lagrange for impulsive force), and 15.3 (up to page 435)].

Weeks 8 and 9: Applications of Lagrange's equations, Hamiltonian and the Canonical equations of motion, The passage from the Hamiltonian to the Lagrangian, Conservative systems.
[2]: Chapter 15 [Sections 15.2, and 15.3].

Week 10: Classification of fluids, Continuum model, Eulerian and Lagrangian approach of description, Differentiation following the fluid motion, Velocity of a fluid particle, Irrotational flow, Velocity potential, Equipotential surfaces, Streamlines and Pathlines.
[1]: Chapter 2 [Sections 2.1 to 2.4, and 2.6].

Week 11: Mass flux density, Conservation of mass leading to the equation of continuity, Boundary surface; Forces in fluid flows.
[1]: Chapter 2 [Sections 2.7 to 2.9].
[1]: Chapter 3 [Sections 3.1, and 3.2].

Week 12: Conservation of linear momentum and its mathematical formulation (Euler's equation of motion), Bernoulli's equation, Axi-symmetric flows and motion of a sphere.
[1]: Chapter 3 [Sections 3.4, 3.5, and 3.9].

Week 13: Two-dimensional flows, Motion of cylinder, Stream function, Complex potential, Line sources and line sinks, Line doublet, Milne-Thomson circle theorem.
[1]: Chapter 5 [Sections 5.1 to 5.8].

Weeks 14 and 15: Viscous flow, Stress components in a real fluid, Stress and strain analysis, Navier-Stokes equations of motion and its applications.
[1]: Chapter 8 [Sections 8.1 to 8.10].

Essential Readings

1. Chorlton, F. (2005). Textbook of Fluid Dynamics. CBS Publishers, Delhi. Reprint 2018.
2. Synge, J. L., and Griffith, B. A. (2017). Principles of Mechanics (3rd ed.). McGraw-Hill Education. Indian Reprint.

DSE-6(ii): Cryptography

Week 1: Overview of Cryptography, Symmetric key and Public-key cryptography, Security attacks, Relation between key length and security, Objectives and applications of cryptography primitives, Types of attacks from cryptanalyst view, Kerckhoff's principle.
[3]: Chapter 1.
[1]: Chapter 1 [Section 1.3].

Weeks 2 to 4: Substitution techniques - Caesar cipher, Monoalphabetic cipher, Hill cipher, Vigenère cipher, One-time pad; Euclidean Algorithm, Modular Arithmetic, Statement of Fermat's, Euler's and Chinese Remainder theorems, Discrete logarithms, Finite fields of the form GF(p) and GF(2^n).
[1]: Chapter 3 [Sections 3.1, and 3.2 (excluding page 95 and 96)].
[1]: Chapter 2 [Sections 2.2, 2.3, 2.5, 2.7, and 2.8].
[1]: Chapter 5 [Sections 5.4, and 5.6 (up to page 159)].

Week 5: Binary and ASCII representation, Pseudo-random bit generation.
[3]: Chapter 4 [Section 4.1], and Chapter 5 [Section 5.1].

Weeks 6 and 7: Introduction to stream and block ciphers, Diffusion and Confusion, The Feistel cipher Structure, Data Encryption Standard (DES).
[1]: Chapter 4 [Sections 4.1 to 4.3].

Weeks 8 and 9: Advanced Encryption Standard (AES) Structure, AES transformation functions, Key expansion, AES Example.
[1]: Chapter 6 [Sections 6.2 to 6.5 (up to page 188)].

Weeks 10 to 12: Introduction to Public key cryptography, RSA cryptosystem, Diffie Hellman key exchange, Man in the middle attack, Elgamal cryptosystem, Elliptic curve arithmetic, Elliptic curve cryptography, Secret sharing.
[2]: Chapter 6 [Sections 6.1, and 6.3 (up to page 197)].
[1]: Chapter 10 [Sections 10.1,10.2, 10.3, and 10.4].
[3]: Chapter 17 [Sections 17.1, and 17.2].

Weeks 13 and 14: Hash functions, Applications of hash functions – MAC and digital signature, Simple Hash functions, Security requirements of Hash functions, Properties of SHA family of Hash functions; Digital signatures, Elgamal and Schnorr digital signature scheme.
[1]: Chapter 11 [Sections 11.1, 11.2, 11.3 (up to page 348) and Table 11.3 on page 353), and Chapter 13 [Sections 13.1, 13.2, and 13.3].

Week 15: Introduction to Post Quantum cryptography, Linear codes, Generating matrix, Parity check matrix, McEliece Cryptosystem.
[2]: Chapter 9 [Sections 9.1, and 9.3].

Essential Readings

1. Stallings, William (2023). Cryptography and Network Security, Principles and Practice (8th ed.). Pearson Education Limited. Global Edition.
2. Stinson, Douglas R. and Paterson, Maura, B. (2019). Cryptography: Theory and Practice (4th ed.). CRC Press.
3. Trappe, Wade and Washington, Lawrence C. (2020). Introduction to Cryptography with Coding Theory (3rd ed.). Pearson Education International.

DSE-6(iii): Industrial Mathematics

Weeks 1 to 3: Continuous-time linear systems, Laplace transform, Transfer function and analogous systems, State-space models, Block-diagram algebra, Signal flow graph, Order of a system and reduced-order models.
[2]: Chapter 2 [Sections 2.1, and 2.2 (Drawing/Illustration by circuit diagrams optional)].

Weeks 4 and 5: Discrete-time systems, Z-transform and its inverse, Feedback systems, Stability: Routh-Hurwitz criterion, Root locus method, Controllability and Observability.
[2]: Chapter 2 [Sections 2.3, and 2.4].

Weeks 6 and 7: Signal-to-noise ratio, Analog and digital messages, Channel bandwidth and rate of communication, Modulation, Randomness and redundancy.
[3]: Chapter 1 [Sections 1.4, 1.5, and 1.6].

Weeks 8 to 10: Signal energy and power, Period and aperiodic signals, Signal operations, Unit impulse function, Vector representation of signals, Orthogonality, Correlation of signals, Signal representation by orthogonal signal sets.
[3]: Chapter 2 [Sections 2.1 to 2.7].

Week 11: Case Study: Continuous Casting.
[1]: Chapter 2.

Week 12: Case Study: Water Filtration.
[1]: Chapter 3.

Week 13: Case Study: Factory Fires.
[1]: Chapter 5.

Weeks 14 and 15: Case Study: Irrigation
[1]: Chapter 6.

Essential Readings
1. Fulford, Glenn R., and Broadbridge, Philip (2002). Industrial Mathematics: Case Studies. Cambridge University Press.
2. Kheir, Naim A. (Ed.). (1996). Systems Modeling and Computer Simulation, CRC Press.
3. Lathi, B.P., and Ding, Zhi (2019). Modern Digital and Analog Communication Systems (5th ed.). Oxford University Press.

DSE-6(iv): Geometry of Curves and Surfaces

Weeks 1 and 2: Concept of curves, Plane curves, Global theorems on plane curves.
[K]: Chapter 1 [Sections 1.1, 1.2, and 1.3 up to page 16].

Weeks 3 and 4: Total curvature of a plane curve, Space curves, Concepts of curvature for curves, Frenet-Serret's formula for space curves.
[K]: Chapter 1 [Sections 1.3 (Theorem 1.3.2), and 1.4].

Week 5: Global results on space curves.
[K]: Chapter 1 [Section 1.5].

Week 6: Concept of surfaces in the space with examples: Ellipsoid, Hyperboloid of one sheet, Hyperboloid of two sheets, Elliptic paraboloid, Hyperbolic paraboloid, Torus, Surface of revolution.
[K]: Chapter 2 [Section 2.1].

Weeks 7 and 8: Fundamental forms and curvatures with examples.
[K]: Chapter 2 [Sections 2.2, and 2.3].

Weeks 9 and 10: Orthonormal frames, Exterior differential forms in two variables and their uses.
[K]: Chapter 2 [Sections 2.4, 2.5, and 2.6].

Weeks 11 and 12: Riemannian metrics on a surface, Vector fields.
[K]: Chapter 3 [Sections 3.1, 3.2. and 3.3].

Week 13: Covariant derivatives, Concept of geodesic.
[K]: Chapter 3 [Sections 3.4, 3.5. and 3.6 up to page 105].

Week 14: Integration of exterior differential forms.
[K]: Chapter 4 [Section 4.1 up to page 113].

Week 15: The Gauss Bonnet theorem for domains.
[K]: Chapter 4 [Section 4.2].

Essential Reading

[K]. Kobayashi, Shoshichi (2019). Differential Geometry of Curves and Surfaces. Springer Nature Singapore Pte Ltd., corrected publication 2021. ISBN: 978-981-15-1739-6
DOI: **https://doi.org/10.1007/978-981-15-1739-6** (Access provided by University of Delhi).

DSE-6(v): Integral Equations and Calculus of Variations

Weeks 1 and 2: Integral equations, Introduction and relation with linear differential equations; Volterra integral equations and its solutions, Method of resolvent kernel, Method of successive approximations.
[2]: Chapter 1 [Sections 1 to 4].

Weeks 3 and 4: Convolution-type equations, Method of Laplace transform, System of Volterra integral equations, Integro-differential equation, Abel's integral equation and its generalizations.
[2]: Chapter 1 [Sections 5, 6, 8, 10, and 11].

Weeks 5 and 6: Fredholm integral equations and its solutions, Method of resolvent kernels, Method of successive approximations, Integral equations with degenerate kernels.
[2]: Chapter 2 [Sections 12 to 15].

Weeks 7 and 8: Eigenvalues and eigen functions and their properties, Hilbert-Schmidt theorem.
[2]: Chapter 2 [Sections 16, and 17].

Weeks 9 and 10: Nonhomogeneous Fredholm integral equation with symmetric kernel, Fredholm alternative.
[2]: Chapter 2 [Sections 18, and 19].

Weeks 11 and 12: Variational problems, Variation of a functional and its properties, Extremum of functional, Necessary condition for an extremum, Euler's equation and its generalization.
[1]: Chapter 1 [Sections 1 to 5].
[3]: Chapter 3 [Section 3.4].

Weeks 13 to 15: Variational derivative, General variation of a functional and variable end point problem, Sufficient conditions for the extremum of a functional.
[1]: Chapter 1 [Sections 6, and 7], Chapter 2, and Chapter 5 [Section 24].

Note. For more related Examples, one can refer to Logan [3]: Chapters 3 [Sections 3.1-3.3], and 4 [Section 4.4].

Essential Readings

1. Gelfand, I. M. and Fomin, S.V. (2000). Calculus of Variations. Dover Publications, Inc.
2. Krasnov, M., Kiselev, A. and Makarenko, G. (1971). Problems and Exercises Integral Equations, Mir Publication Moscow.
3. Logan, J. David (1987). Applied Mathematics: A Contemporary Approach, John Wiley & Sons, Inc. (1997, Second Edition).

DSE-6(vi): Machine Learning: A Mathematical Approach

Week 1: Understanding machine learning. Overview of different tasks: Regression, Classification, and Clustering. Evaluation metrics – Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE).
[1]: Chapter 1 [Sections 1.2.1, 1.2.3, 1.4.1, and 1.4.2].

Weeks 2 and 3: Linear Regression, Cost function, Polynomial Regression, Logistic Regression.
[1]: Chapter 3 [Sections 3.2, 3.3.1, and 3.4].

Weeks 4 and 5: Gradient Descent Algorithm (GDA), Evaluation metrics - accuracy, precision, recall, confusion matrix, ROC curve and AUC, VC dimension, VC bounds (only statement); *k*-fold validation.
[1]: **Chapter 2** [Sections 2.1, and 2.2.3], **Chapter 3** [Section 3.3.2], and **Chapter 4** [Section 4.3].

Week 6: Regularization Techniques – Ridge, Lasso for Linear Regression and Logistic Regression, Bias-variance tradeoff.
[1]: **Chapter 2** [Sections 2.2.2, and 2.3.1], and **Chapter 4** [Sections 4.1, and 4.2].

Week 7 and 8: Cross-entropy and Gini Index, Decision Tree, Regression Tree, Random Forest and Bagging, Tree Pruning.
[2]: Chapter 8 [Sections 8.1.1, 8.1.2, 8.2.1, and 8.2.2].

Week 9 and 10: SVM, Kernel SVM (Gaussian) Similarity Criterion, *k*- Means clustering technique.
[2]: **Chapter 9** [Sections 9.2, and 9.3], and **Chapter 12** [Section 12.4.1].

Week 11: Naive Bayes classifier- Linear Discriminant Analysis (LDA), Quadratic Discriminant Analysis (QDA).
[2]: Chapter 4 [Sections 4.4.1, 4.4.2, and 4.4.3].

Week 12: Dimensionality Reduction, Feature Selection, Principal Component Analysis (PCA).
[2]: Chapter 12 [Section12.2].

Weeks 13 to 15: Artificial neural network (ANN), Activation functions – definition and examples (Sigmoid, ReLU, Tanh), Neurons, layers, Cost function, Information passing, Back propagation algorithm, Optimizers, Learning rate, Statement of Universal Approximation Theorem for continuous functions, Regularization with ANN, Normalization.
[3]: **Chapter 2** [Sections 2.1, and 2.2), **Chapter 3** [Sections 3.1, 3.4, 3.5, and 3.11), **Chapter 5** [Sections 5.1, and 5.3), **Chapter 6** [Sections 6.1, 6.2.1, 6.2.2, and 6.2.3), **Chapter 9** [Proposition 9.3.5], and **Chapter 12** [Exercise 12.13.22].

Essential Readings

1. Abu-Mostafa, Y. S., Magdon-Ismail, M. & Lin, H.-T. (2012), Learning from Data, AML Book.
2. James, Gareth., Witten, D., Hastie, T., Tibshirani, R. and Taylor, J. (2023), An Introduction to Statistical Learning: with Applications in Python, Springer Nature Switzerland.
3. Ovidiu Calin, Springer. (2020). Deep Learning Architectures: A Mathematical Approach, Springer Nature Switzerland.

Teaching Plan: B.A. (Prog.) with Mathematics, Semester-8

DSC-8: Topics in Multivariate Calculus

Week 1: Definition and examples of function of two variables, Limits and continuity of functions of two variables.
[1]: Chapter 11 (Sections 11.1 [Example 1], and 11.2).
Week 2: Partial differentiation and partial derivatives as slope and rate (definitions only), Higher order partial derivatives.
[1]: Chapter 11 (Section 11.3).
Week 3: Tangent planes, Total differential, Differentiability, Chain rule for one independent variable.
[1]: Chapter 11 (Sections 11.4 [except Examples 2 and 3], and 11.5 [up to Example 5]).
Weeks 4 and 5: Extensions of the chain rule to two independent parameters, Directional derivatives, Gradient, Maximal and normal property of the gradient.
[1]: Chapter 11 (Section 11.5 [Examples 6 to 8], and 11.6 [up to Example 7]).
Week 6: Extrema of functions of two variables, Lagrange multipliers method for optimization problems with one constraint.
[1] Chapter 11 (Section 11.7 [up to Example 6], and Section 11.8 [Examples 1 and 2]).
Weeks 7 and 8: Double integration over rectangular regions, and nonrectangular regions, Double integrals in polar coordinates
[1]: Chapter 12 (Sections 12.1 to 12.3).
Week 9: Triple integral over a parallelepiped, and solid regions, Volume by triple integrals.
[1]: Chapter 12 (Section 12.5).
Week 10: Triple integration in cylindrical and spherical coordinates.
[1]: Chapter 12 (Section 12.7 [except Examples 3, and 6]).
Week 11: Jacobians: Change of variables in double and triple integrals.
[1]: Chapter 12 (Section 12.8 [except Example 5]).
Week 12: Line integrals, Applications of line integrals to mass and work, Fundamental theorem for line integrals, Conservative vector fields.
[1]: Chapter 13 (Sections 13.2, and 13.3).
Week 13: Green's theorem, Area as a line integral.
[1]: Chapter 13 (Section 13.4 [up to Example 3]).
Week 14: Surface integrals.
[1]: Chapter 13 (Section 13.5 [up to Example 3]).
Week 15: Stokes' theorem (statement only) and Gauss divergence theorem (statement only).
[1]: Chapter 13 (Sections 13.6 [up to Example 3], and 13.7 [up to Example 3]).

Note. For weeks 9 to 11, please refer to sections 12.4, 12.5, and 12.6 while using the Indian print.

Essential Reading

1. Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). Calculus (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011.

DSE-4(i): Applied Algebra

Weeks 1 to 3: Applications of linear systems: Leontief input-output model in economics, Traffic flow, and diet problem; Applications to computer graphics.
[1]: Chapter 1 (Section 1.6 [Examples 1, and 2], and Section 1.10 [up to Example 1, p. 82]).
[1]: Chapter 2 (Section 2.6 [Examples 1, and 2], and Section 2.7 [up to Example 6, p. 142]).

Weeks 4 and 5: Difference equations and Markov chains, Applications to linear models: Least-squares problems, least-square lines.
[1]: Chapter 4 (Section 4.8 [up to Example 6, p. 252], and Section 4.9).
[1]: Chapter 6 (Section 6.5 [up to Example 3, p. 366, Theorems 13 and 14 without proofs], and Section 6.6 [up to Example 1, p. 372]).

Weeks 6 to 9: Latin squares, Table for a finite group as a Latin square, Latin squares as in design of experiments, Mathematical models for matching jobs, Spelling checker, Network reliability, Street surveillance, Scheduling meetings, Interval graph modeling and Influence model, Pitcher pouring puzzle.
[Lidl, Rudolf and Pilz, Günter]: Chapter 7 (Section 35 [35.1, 35.2, and 35.6]).
[2]: Chapter 1 (Section 1.1, Examples 1 to 6), and Chapter 3 (Section 3.2, Example 3, Page 106).

Weeks 10 and 11: Developing identification numbers, Types of identification numbers, Transmission errors, Check digits, Integer division, Modular arithmetic.
[3]: Chapter 1, and Chapter 2 (Sections 2.2, and 2.3).

Weeks 12 and 13: US postal money orders, Airline ticket identification numbers, The Universal Product Code check digit scheme, ISBN check digit scheme, Creating identification numbers, IBM scheme.
[3] Chapter 2 (Sections 2.4 to 2.7), and Chapter 3 (Sections 3.2, and 3.5).

Weeks 14 and 15: Symmetry, Symmetry and Rigid motions, Verhoeff check digit scheme.
[3] Chapter 4, and Chapter 5 (Section 5.4).

Essential Readings

1. David C. Lay, Steven R. Lay and Judi J. McDonald (2016). Linear Algebra and Its Applications (5th ed.). Pearson.
2. Tucker, Alan (2012). Applied Combinatorics (6th ed.). John Wiley & Sons, Inc.
3. Kirtland, Joseph (2001). Identification Numbers and Check Digit Schemes. Mathematical Association of America.

Suggestive Reading

- Lidl, Rudolf and Pilz, Günter (1998). Applied Abstract Algebra (2nd ed.). Springer. Indian Reprint 2014.

DSE-4(ii): Elements of Partial Differential Equations

Weeks 1 and 2: Review of basic concepts: Origins of first-order PDEs, Lagrange's method for solving linear equations of first order; Integral surfaces passing through a given curve, and surfaces orthogonal to a given system of surfaces.
[3]: Chapter 2 [Sections 1, 2, 4, 5, and 6].

Week 3: Nonlinear PDEs of the first order, and compatible systems of first-order PDEs.
[3]: Chapter 2 [Sections 7, and 9].

Weeks 4 and 5: Charpit's method for solving nonlinear PDEs, special types of first-order PDEs, and solutions satisfying given conditions.
[3]: Chapter 2 [Sections 10, 11, and 12].

Week 6: Jacobi's method for solving nonlinear PDE with three independent variables.
[2]: Chapter XIII [Sections 140-141].
[3]: Chapter 2 [Section 13].

Weeks 7 to 9: Origins of second-order PDEs, and solving linear PDEs with constant coefficients using methods of finding the complementary function and particular integral.
[3]: Chapter 3 [Sections 1, and 4].
[2]: Chapter XIV [Sections 145-151].

Weeks 10 and 11: Monge's method of integrating nonlinear second-order PDE of type $Rr + Ss + Tt = V$ with variable coefficients.
[2]: Chapter XIV [Section 154].
[3]: Chapter 3 [Section 11].

Weeks 12 and 13: Solution of one-dimensional diffusion equation and wave equation by method of separation of variables, d'Alembert's solution of the Cauchy problem for the one-dimensional wave equation.
[3]: Chapter 3 [Section 9, and problem 1, p.125],
[3]: Chapter 6 [Section 4 up to Example 1, and problems 1, 2 (p. 289)], and
[3]: Chapter 5 [Section 2].

Weeks 14 and 15: Solutions of homogeneous one-dimensional wave equations with initial boundary-value problems, and vibration of finite string with fixed ends; Traffic flow model.
[1]: Chapter 7 [Sections 7.3, and 7.5]
[1]: Chapter 13 [Section 13.6].

Essential Readings

1. Myint-U, Tyn & Debnath, Lokenath. (2007). Linear Partial Differential Equations for Scientists and Engineers (4th ed.). Birkhäuser. Indian Reprint.
2. Piaggio, H.T.H. (2004). Differential Equations. CBS Publishers & Distributors, Delhi.
3. Sneddon, Ian N. (2006). Elements of Partial Differential Equations, Dover Publications. Indian Reprint.

DSE-4(iii): Mathematical Statistics

Week 1: Joint Distributed Random Variables: Joint probability mass function for two discrete random variables, Marginal probability mass function, Joint probability density function for two continuous random variables, Marginal probability density function, Independent random variables.
[1]: Chapter 5 [Section 5.1 up to page 285].

Week 2: Expected values, covariance, and correlation.
[1]: Chapter 5 [Section 5.2].

Week 3: Linear combination of random variables and their moment generating functions.
[1]: Chapter 5 [Section 5.3].

Week 4: Conditional distributions and conditional expectation, Laws of total expectation and variance.
[1]: Chapter 5 [Section 5.4].

Week 5: Bivariate Normal Distribution.
[1] Chapter 5 [Section 5.5 up to page 334 (Regression to the Mean)].

Week 6: Distribution of important statistics such as the sample totals, sample means, and sample proportions, Central limit theorem (statement with examples and applications), Law of large numbers.
[1]: Chapter 6 [Section 6.1 (up to Example 6.3), and Section 6.2 (except Example 6.7)].

Week 7: Chi-squared, t, and F distributions; Distributions based on normal random samples.
[1]: Chapter 6 [Section 6.3 (Definitions only), and Section 6.4].

Week 8: Concepts and criteria for point estimation, The methods of moments and MLE.
[1]: Chapter 7 [Section 7.1 (up to the Definition, page 408), and Section 7.2 (up to page 423, except Example 7.20)].

Weeks 9 and 10: Assessing estimators: Accuracy and precision, Unbiased estimation, Consistency and sufficiency, The Neyman factorization theorem, Rao-Blackwell theorem, Fisher Information, The Cramér-Rao inequality (statement only), Efficiency.
[1]: Chapter 7 [Sections 7.3, and 7.4].

Weeks 11 and 12: Interval estimation and basic properties of confidence intervals, One-sample t confidence interval, Confidence intervals for a population proportion and population variance.
[1]: Chapter 8 [Section 8.1 (up to Example 8.4), Section 8.2 (up to Example 8.9), Section 8.3 (up to Example 8.13), and Section 8.4 (up to Example 8.16)].

Weeks 13 and 14: Statistical hypotheses and test procedures, One-sample tests about a population mean and a population proportion, P-values for tests; The simple linear regression model and its estimating parameters.
[1]: Chapter 9 [Sections 9.1, 9.2 (up to page 519), 9.3, and 9.4], Chapter 12 [Sections 12.1, and 12.2].

Week 15: Chi-squared goodness-of-fit tests, Two-way contingency tables.
[1]: Chapter 13 [Section 13.1 (up to Example 13.4), and Section 13.2 (up to Example 13.11)].

Note. *Emphasis should be on problem solving.*

Essential Reading

1. Devore, Jay L., Berk, Kenneth N. & Carlton Matthew A. (2021). Modern Mathematical Statistics with Applications. (3rd ed.). Springer.

DSE-4(iv): Optimization Techniques

Weeks 1 and 2: Transshipment problem.
[2]: Chapter 5 [Section 5.3 brief introduction of transportation problems and its variant as transshipment problems (page 224)]; Chapter 5 [Section 5.5 from previous editions (8th or 9th) of Taha's book].
[Swarup]: Examples [Ex. 1064, 1065, and 1066 (page 290-291)].

Weeks 3 and 4: Shortest-route problem; Dynamic programming, Recursive forward and backward computation.
[2]: Chapter 12 [Sections 12.1, Example 12.1-1 (up to principle of optimality), and 12.2, Example 12.2-1].

Week 5: Knapsack/fly-away/cargo-loading problems solution through dynamic programming.
[2]: Chapter 12 [Section 12.3.1, Example 12.3-1 (up to page 477)].

Week 6: Integer programming problem. [1]: Chapter 6 [Sections 6.1, and 6.2].
Weeks 7 and 8: Gomory's cutting plane method for integer programming problems.
[1]: Chapter 6 [Section 6.3 (without derivation), Stepwise description, Theorem 6.3.1 (only statement), and Example 6.3.2].
Week 9: Gomory's cutting plane method for mixed integer linear programming problems.
[1]: Chapter 6 [Section 6.4, Example 6.4.1].
Week 10: Branch and bound method.
[1]: Chapter 6 [Section 6.5, Example 6.5.1, and Example 6.5.2].
Week 11: Convex functions and their properties.
[1]: Chapter 7 [Section 7.2 (with examples)].

Week 12: Differentiable convex functions.
[1]: Chapter 7 [Statement of Theorems 7.2.3 to 7.2.6, and Example 7.2.1].

Week 13: Convex programming problems.
[1]: Chapter 7 [Section 7.4, Theorem 7.4.1 (only statement), Def. 7.4.1, and Example 7.4.1, 7.4.2].

Week 14: Generalized convex functions.
[1]: Chapter 12 [Section 12.2 (Definitions 12.2.1, 12.2.2, and 12.2.3 with examples)], and Section 12.3 (Definitions 12.3.1, 12.3.2, and 12.3.3 with examples)].

Week 15: Linear fractional programming problem, Charnes and Cooper transformation, Simplex algorithm to solve linear fractional programming problem.
[1]: Chapter 12 [Sections 12.4, 12.5 (Charnes and Cooper Algorithm, Example 12.5.1, Simplex Algorithm for Linear Fractional Programming, Example 12.5.2, and Exercise 12.10, p. 476 (only simplex method)].

Essential Readings

1. Chandra, Suresh, Jayadeva, and Mehra, Aparna (2009). Numerical Optimization with Applications. Narosa Publishing House Pvt. Ltd. Delhi. Second Reprint 2016.
2. Taha, Hamdy A. (2017). Operations Research: An Introduction (10th ed.). Pearson. PHI.

Suggestive Reading

- Swarup, K., Gupta, P.K., and Mohan, M. (1984). Operations Research. Sultan Chand.

DSE-4(v): Rings and Fields

Weeks 1 to 3: Ring homomorphism, Ideals and the quotient rings, First Fundamental theorem of ring homomorphism, Maximal ideals, Maximal ideals of rings of all real valued continuous functions on closed unit interval, Field of quotients of an integral domain.
[2]: Chapter 3 [Sections 3.3 to 3.6].

Weeks 4 and 5: Euclidean rings, Units in Euclidean rings, Principal ideal rings, Unique factorization theorem, Prime elements and the ideal generated by them, Ring of Gaussian integers.
[2]: Chapter 3 [Sections 3.7, and 3.8 (Theorem 3.8.1)].

Weeks 6 to 8: Polynomial rings in one variable, Division algorithm, Irreducible polynomials and the ideal generated by them, Polynomial rings over the rational field, Gauss' lemma, Eisenstein criterion, Polynomial rings in n variables.
[2]: Chapter 3 [Section 3.9, 3.10, and 3.11 (up to Corollary, p.162)].

Weeks 9 and 10: Extension of Fields: The Fundamental Theorem of Field Theory, Splitting Fields, Zeros of an irreducible polynomial.
[1]: Chapter 20.

Weeks 11 and 12: Characterization of field extensions, Finite extensions, Properties of algebraic extensions.
[1]: Chapter 21, with statement of the Primitive Element Theorem 21.6.

Weeks 13 and 14: Classification of Finite Fields, Structure of Finite Fields, Subfields of a Finite Field.
[1]: Chapter 22.

Week 15: Geometric Constructions: Constructible Numbers, Angle-Trisectors and Circle-Squares.
[1]: Chapter 23.

Essential Readings

1. Gallian, Joseph. A. (2017). Contemporary Abstract Algebra (9th ed.). Cengage Learning India Private Limited, Delhi. Indian Reprint (2021).
2. Herstein. I. N. (1975). Topics in Algebra (2nd ed.). Wiley India. Reprint 2022.

Teaching Plan: B.Sc. (Physical Sciences/Mathematical Sciences), Semester-8

DSC-8: Topics in Multivariate Calculus

Week 1: Definition and examples of function of two variables, Limits and continuity of functions of two variables.
[1]: Chapter 11 (Sections 11.1 [Example 1], and 11.2).
Week 2: Partial differentiation and partial derivatives as slope and rate (definitions only), Higher order partial derivatives.
[1]: Chapter 11 (Section 11.3).
Week 3: Tangent planes, Total differential, Differentiability, Chain rule for one independent variable.
[1]: Chapter 11 (Sections 11.4 [except Examples 2 and 3], and 11.5 [up to Example 5]).
Weeks 4 and 5: Extensions of the chain rule to two independent parameters, Directional derivatives, Gradient, Maximal and normal property of the gradient.
[1]: Chapter 11 (Section 11.5 [Examples 6 to 8], and 11.6 [up to Example 7]).
Week 6: Extrema of functions of two variables, Lagrange multipliers method for optimization problems with one constraint.
[1] Chapter 11 (Section 11.7 [up to Example 6], and Section 11.8 [Examples 1 and 2]).
Weeks 7 and 8: Double integration over rectangular regions, and nonrectangular regions, Double integrals in polar coordinates
[1]: Chapter 12 (Sections 12.1 to 12.3).
Week 9: Triple integral over a parallelepiped, and solid regions, Volume by triple integrals.
[1]: Chapter 12 (Section 12.5).
Week 10: Triple integration in cylindrical and spherical coordinates.
[1]: Chapter 12 (Section 12.7 [except Examples 3, and 6]).
Week 11: Jacobians: Change of variables in double and triple integrals.
[1]: Chapter 12 (Section 12.8 [except Example 5]).
Week 12: Line integrals, Applications of line integrals to mass and work, Fundamental theorem for line integrals, Conservative vector fields.
[1]: Chapter 13 (Sections 13.2, and 13.3).
Week 13: Green's theorem, Area as a line integral.
[1]: Chapter 13 (Section 13.4 [up to Example 3]).
Week 14: Surface integrals.
[1]: Chapter 13 (Section 13.5 [up to Example 3]).
Week 15: Stokes' theorem (statement only) and Gauss divergence theorem (statement only).
[1]: Chapter 13 (Sections 13.6 [up to Example 3], and 13.7 [up to Example 3]).

Note. For weeks 9 to 11, please refer to sections 12.4, 12.5, and 12.6 while using the Indian print.

Essential Reading

1. Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). Calculus (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011.

DSE-6(i): Applied Algebra

Weeks 1 to 3: Applications of linear systems: Leontief input-output model in economics, Traffic flow, and diet problem; Applications to computer graphics.
[1]: Chapter 1 (Section 1.6 [Examples 1, and 2], and Section 1.10 [up to Example 1, p. 82]).
[1]: Chapter 2 (Section 2.6 [Examples 1, and 2], and Section 2.7 [up to Example 6, p. 142]).

Weeks 4 and 5: Difference equations and Markov chains, Applications to linear models: Least-squares problems, least-square lines.
[1]: Chapter 4 (Section 4.8 [up to Example 6, p. 252], and Section 4.9).
[1]: Chapter 6 (Section 6.5 [up to Example 3, p. 366, Theorems 13 and 14 without proofs], and Section 6.6 [up to Example 1, p. 372]).

Weeks 6 to 9: Latin squares, Table for a finite group as a Latin square, Latin squares as in design of experiments, Mathematical models for matching jobs, Spelling checker, Network reliability, Street surveillance, Scheduling meetings, Interval graph modeling and Influence model, Pitcher pouring puzzle.
[Lidl, Rudolf and Pilz, Günter]: Chapter 7 (Section 35 [35.1, 35.2, and 35.6]).
[2]: Chapter 1 (Section 1.1, Examples 1 to 6), and Chapter 3 (Section 3.2, Example 3, Page 106).

Weeks 10 and 11: Developing identification numbers, Types of identification numbers, Transmission errors, Check digits, Integer division, Modular arithmetic.
[3]: Chapter 1, and Chapter 2 (Sections 2.2, and 2.3).

Weeks 12 and 13: US postal money orders, Airline ticket identification numbers, The Universal Product Code check digit scheme, ISBN check digit scheme, Creating identification numbers, IBM scheme.
[3] Chapter 2 (Sections 2.4 to 2.7), and Chapter 3 (Sections 3.2, and 3.5).

Weeks 14 and 15: Symmetry, Symmetry and Rigid motions, Verhoeff check digit scheme.
[3] Chapter 4, and Chapter 5 (Section 5.4).

Essential Readings

1. David C. Lay, Steven R. Lay and Judi J. McDonald (2016). Linear Algebra and Its Applications (5th ed.). Pearson.
2. Tucker, Alan (2012). Applied Combinatorics (6th ed.). John Wiley & Sons, Inc.
3. Kirtland, Joseph (2001). Identification Numbers and Check Digit Schemes. Mathematical Association of America.

Suggestive Reading

- Lidl, Rudolf and Pilz, Günter (1998). Applied Abstract Algebra (2nd ed.). Springer. Indian Reprint 2014.

DSE-6(ii): Elements of Partial Differential Equations

Weeks 1 and 2: Review of basic concepts: Origins of first-order PDEs, Lagrange's method for solving linear equations of first order; Integral surfaces passing through a given curve, and surfaces orthogonal to a given system of surfaces.
[3]: Chapter 2 [Sections 1, 2, 4, 5, and 6].

Week 3: Nonlinear PDEs of the first order, and compatible systems of first-order PDEs.
[3]: Chapter 2 [Sections 7, and 9].

Weeks 4 and 5: Charpit's method for solving nonlinear PDEs, special types of first-order PDEs, and solutions satisfying given conditions.
[3]: Chapter 2 [Sections 10, 11, and 12].

Week 6: Jacobi's method for solving nonlinear PDE with three independent variables.
[2]: Chapter XIII [Sections 140-141].
[3]: Chapter 2 [Section 13].

Weeks 7 to 9: Origins of second-order PDEs, and solving linear PDEs with constant coefficients using methods of finding the complementary function and particular integral.
[3]: Chapter 3 [Sections 1, and 4].
[2]: Chapter XIV [Sections 145-151].

Weeks 10 and 11: Monge's method of integrating nonlinear second-order PDE of type $Rr + Ss + Tt = V$ with variable coefficients.
[2]: Chapter XIV [Section 154].
[3]: Chapter 3 [Section 11].

Weeks 12 and 13: Solution of one-dimensional diffusion equation and wave equation by method of separation of variables, d'Alembert's solution of the Cauchy problem for the one-dimensional wave equation.
[3]: Chapter 3 [Section 9, and problem 1, p.125],
[3]: Chapter 6 [Section 4 up to Example 1, and problems 1, 2 (p. 289)], and
[3]: Chapter 5 [Section 2].

Weeks 14 and 15: Solutions of homogeneous one-dimensional wave equations with initial boundary-value problems, and vibration of finite string with fixed ends; Traffic flow model.
[1]: Chapter 7 [Sections 7.3, and 7.5]
[1]: Chapter 13 [Section 13.6].

Essential Readings

1. Myint-U, Tyn & Debnath, Lokenath. (2007). Linear Partial Differential Equations for Scientists and Engineers (4th ed.). Birkhäuser. Indian Reprint.
2. Piaggio, H.T.H. (2004). Differential Equations. CBS Publishers & Distributors, Delhi.
3. Sneddon, Ian N. (2006). Elements of Partial Differential Equations, Dover Publications. Indian Reprint.

DSE-6(iii): Mathematical Statistics

Week 1: Joint Distributed Random Variables: Joint probability mass function for two discrete random variables, Marginal probability mass function, Joint probability density function for two continuous random variables, Marginal probability density function, Independent random variables.
[1]: Chapter 5 [Section 5.1 up to page 285].

Week 2: Expected values, covariance, and correlation.
[1]: Chapter 5 [Section 5.2].

Week 3: Linear combination of random variables and their moment generating functions.
[1]: Chapter 5 [Section 5.3].

Week 4: Conditional distributions and conditional expectation, Laws of total expectation and variance.
[1]: Chapter 5 [Section 5.4].

Week 5: Bivariate Normal Distribution.
[1] Chapter 5 [Section 5.5 up to page 334 (Regression to the Mean)].

Week 6: Distribution of important statistics such as the sample totals, sample means, and sample proportions, Central limit theorem (statement with examples and applications), Law of large numbers.
[1]: Chapter 6 [Section 6.1 (up to Example 6.3), and Section 6.2 (except Example 6.7)].

Week 7: Chi-squared, t, and F distributions; Distributions based on normal random samples.
[1]: Chapter 6 [Section 6.3 (Definitions only), and Section 6.4].

Week 8: Concepts and criteria for point estimation, The methods of moments and MLE.
[1]: Chapter 7 [Section 7.1 (up to the Definition, page 408), and Section 7.2 (up to page 423, except Example 7.20)].

Weeks 9 and 10: Assessing estimators: Accuracy and precision, Unbiased estimation, Consistency and sufficiency, The Neyman factorization theorem, Rao-Blackwell theorem, Fisher Information, The Cramér-Rao inequality (statement only), Efficiency.
[1]: Chapter 7 [Sections 7.3, and 7.4].

Weeks 11 and 12: Interval estimation and basic properties of confidence intervals, One-sample t confidence interval, Confidence intervals for a population proportion and population variance.
[1]: Chapter 8 [Section 8.1 (up to Example 8.4), Section 8.2 (up to Example 8.9), Section 8.3 (up to Example 8.13), and Section 8.4 (up to Example 8.16)].

Weeks 13 and 14: Statistical hypotheses and test procedures, One-sample tests about a population mean and a population proportion, P-values for tests; The simple linear regression model and its estimating parameters.
[1]: Chapter 9 [Sections 9.1, 9.2 (up to page 519), 9.3, and 9.4], Chapter 12 [Sections 12.1, and 12.2].

Week 15: Chi-squared goodness-of-fit tests, Two-way contingency tables.
[1]: Chapter 13 [Section 13.1 (up to Example 13.4), and Section 13.2 (up to Example 13.11)].

Note. *Emphasis should be on problem solving.*

Essential Reading

1. Devore, Jay L., Berk, Kenneth N. & Carlton Matthew A. (2021). Modern Mathematical Statistics with Applications. (3rd ed.). Springer.

DSE-6(iv): Optimization Techniques

Weeks 1 and 2: Transshipment problem.
[2]: Chapter 5 [Section 5.3 brief introduction of transportation problems and its variant as transshipment problems (page 224)]; Chapter 5 [Section 5.5 from previous editions (8th or 9th) of Taha's book].
[Swarup]: Examples [Ex. 1064, 1065, and 1066 (page 290-291)].

Weeks 3 and 4: Shortest-route problem; Dynamic programming, Recursive forward and backward computation.
[2]: Chapter 12 [Sections 12.1, Example 12.1-1 (up to principle of optimality), and 12.2, Example 12.2-1].

Week 5: Knapsack/fly-away/cargo-loading problems solution through dynamic programming.
[2]: Chapter 12 [Section 12.3.1, Example 12.3-1 (up to page 477)].

Week 6: Integer programming problem. [1]: Chapter 6 [Sections 6.1, and 6.2].
Weeks 7 and 8: Gomory's cutting plane method for integer programming problems.
[1]: Chapter 6 [Section 6.3 (without derivation), Stepwise description, Theorem 6.3.1 (only statement), and Example 6.3.2].
Week 9: Gomory's cutting plane method for mixed integer linear programming problems.
[1]: Chapter 6 [Section 6.4, Example 6.4.1].
Week 10: Branch and bound method.
[1]: Chapter 6 [Section 6.5, Example 6.5.1, and Example 6.5.2].
Week 11: Convex functions and their properties.
[1]: Chapter 7 [Section 7.2 (with examples)].

Week 12: Differentiable convex functions.
[1]: Chapter 7 [Statement of Theorems 7.2.3 to 7.2.6, and Example 7.2.1].

Week 13: Convex programming problems.
[1]: Chapter 7 [Section 7.4, Theorem 7.4.1 (only statement), Def. 7.4.1, and Example 7.4.1, 7.4.2].

Week 14: Generalized convex functions.
[1]: Chapter 12 [Section 12.2 (Definitions 12.2.1, 12.2.2, and 12.2.3 with examples)], and Section 12.3 (Definitions 12.3.1, 12.3.2, and 12.3.3 with examples)].

Week 15: Linear fractional programming problem, Charnes and Cooper transformation, Simplex algorithm to solve linear fractional programming problem.
[1]: Chapter 12 [Sections 12.4, 12.5 (Charnes and Cooper Algorithm, Example 12.5.1, Simplex Algorithm for Linear Fractional Programming, Example 12.5.2, and Exercise 12.10, p. 476 (only simplex method)].

Essential Readings

1. Chandra, Suresh, Jayadeva, and Mehra, Aparna (2009). Numerical Optimization with Applications. Narosa Publishing House Pvt. Ltd. Delhi. Second Reprint 2016.
2. Taha, Hamdy A. (2017). Operations Research: An Introduction (10th ed.). Pearson. PHI.

Suggestive Reading

- Swarup, K., Gupta, P.K., and Mohan, M. (1984). Operations Research. Sultan Chand.

DSE-6(v): Rings and Fields

Weeks 1 to 3: Ring homomorphism, Ideals and the quotient rings, First Fundamental theorem of ring homomorphism, Maximal ideals, Maximal ideals of rings of all real valued continuous functions on closed unit interval, Field of quotients of an integral domain.
[2]: Chapter 3 [Sections 3.3 to 3.6].

Weeks 4 and 5: Euclidean rings, Units in Euclidean rings, Principal ideal rings, Unique factorization theorem, Prime elements and the ideal generated by them, Ring of Gaussian integers.
[2]: Chapter 3 [Sections 3.7, and 3.8 (Theorem 3.8.1)].

Weeks 6 to 8: Polynomial rings in one variable, Division algorithm, Irreducible polynomials and the ideal generated by them, Polynomial rings over the rational field, Gauss' lemma, Eisenstein criterion, Polynomial rings in n variables.
[2]: Chapter 3 [Section 3.9, 3.10, and 3.11 (up to Corollary, p.162)].

Weeks 9 and 10: Extension of Fields: The Fundamental Theorem of Field Theory, Splitting Fields, Zeros of an irreducible polynomial.
[1]: Chapter 20.

Weeks 11 and 12: Characterization of field extensions, Finite extensions, Properties of algebraic extensions.
[1]: Chapter 21, with statement of the Primitive Element Theorem 21.6.

Weeks 13 and 14: Classification of Finite Fields, Structure of Finite Fields, Subfields of a Finite Field.
[1]: Chapter 22.

Week 15: Geometric Constructions: Constructible Numbers, Angle-Trisectors and Circle-Squares.
[1]: Chapter 23.

Essential Readings

1. Gallian, Joseph. A. (2017). Contemporary Abstract Algebra (9th ed.). Cengage Learning India Private Limited, Delhi. Indian Reprint (2021).
2. Herstein. I. N. (1975). Topics in Algebra (2nd ed.). Wiley India. Reprint 2022.

Teaching Plan for Generic Electives (GE), Semester-8

GE-8(i): Rings and Fields

Weeks 1 to 3: Ring homomorphism, Ideals and the quotient rings, First Fundamental theorem of ring homomorphism, Maximal ideals, Maximal ideals of rings of all real valued continuous functions on closed unit interval, Field of quotients of an integral domain.
[2]: Chapter 3 [Sections 3.3 to 3.6].

Weeks 4 and 5: Euclidean rings, Units in Euclidean rings, Principal ideal rings, Unique factorization theorem, Prime elements and the ideal generated by them, Ring of Gaussian integers.
[2]: Chapter 3 [Sections 3.7, and 3.8 (Theorem 3.8.1)].

Weeks 6 to 8: Polynomial rings in one variable, Division algorithm, Irreducible polynomials and the ideal generated by them, Polynomial rings over the rational field, Gauss' lemma, Eisenstein criterion, Polynomial rings in n variables.
[2]: Chapter 3 [Section 3.9, 3.10, and 3.11 (up to Corollary, p.162)].

Weeks 9 and 10: Extension of Fields: The Fundamental Theorem of Field Theory, Splitting Fields, Zeros of an irreducible polynomial.
[1]: Chapter 20.

Weeks 11 and 12: Characterization of field extensions, Finite extensions, Properties of algebraic extensions.
[1]: Chapter 21, with statement of the Primitive Element Theorem 21.6.

Weeks 13 and 14: Classification of Finite Fields, Structure of Finite Fields, Subfields of a Finite Field.
[1]: Chapter 22.

Week 15: Geometric Constructions: Constructible Numbers, Angle-Trisectors and Circle-Squares.
[1]: Chapter 23.

Essential Readings

1. Gallian, Joseph. A. (2017). Contemporary Abstract Algebra (9th ed.). Cengage Learning India Private Limited, Delhi. Indian Reprint (2021).
2. Herstein. I. N. (1975). Topics in Algebra (2nd ed.). Wiley India. Reprint 2022.

GE-8(ii): Elements of Partial Differential Equations

Weeks 1 and 2: Review of basic concepts: Origins of first-order PDEs, Lagrange's method for solving linear equations of first order; Integral surfaces passing through a given curve, and surfaces orthogonal to a given system of surfaces.
[3]: Chapter 2 [Sections 1, 2, 4, 5, and 6].

Week 3: Nonlinear PDEs of the first order, and compatible systems of first-order PDEs.
[3]: Chapter 2 [Sections 7, and 9].

Weeks 4 and 5: Charpit's method for solving nonlinear PDEs, special types of first-order PDEs, and solutions satisfying given conditions.
[3]: Chapter 2 [Sections 10, 11, and 12].

Week 6: Jacobi's method for solving nonlinear PDE with three independent variables.
[2]: Chapter XIII [Sections 140-141].
[3]: Chapter 2 [Section 13].

Weeks 7 to 9: Origins of second-order PDEs, and solving linear PDEs with constant coefficients using methods of finding the complementary function and particular integral.
[3]: Chapter 3 [Sections 1, and 4].
[2]: Chapter XIV [Sections 145-151].

Weeks 10 and 11: Monge's method of integrating nonlinear second-order PDE of type $Rr + Ss + Tt = V$ with variable coefficients.
[2]: Chapter XIV [Section 154].
[3]: Chapter 3 [Section 11].

Weeks 12 and 13: Solution of one-dimensional diffusion equation and wave equation by method of separation of variables, d'Alembert's solution of the Cauchy problem for the one-dimensional wave equation.
[3]: Chapter 3 [Section 9, and problem 1, p.125],
[3]: Chapter 6 [Section 4 up to Example 1, and problems 1, 2 (p. 289)], and
[3]: Chapter 5 [Section 2].

Weeks 14 and 15: Solutions of homogeneous one-dimensional wave equations with initial boundary-value problems, and vibration of finite string with fixed ends; Traffic flow model.
[1]: Chapter 7 [Sections 7.3, and 7.5]
[1]: Chapter 13 [Section 13.6].

Essential Readings

1. Myint-U, Tyn & Debnath, Lokenath. (2007). Linear Partial Differential Equations for Scientists and Engineers (4th ed.). Birkhäuser. Indian Reprint.
2. Piaggio, H.T.H. (2004). Differential Equations. CBS Publishers & Distributors, Delhi.
3. Sneddon, Ian N. (2006). Elements of Partial Differential Equations, Dover Publications. Indian Reprint.

GE-8(iii): Elements of Complex Analysis

Week 1: Basic properties of complex numbers and their exponential form; Limits, continuity, and partial derivatives of functions of two variables.
[1]: Chapter 1 [overview of basic concepts from sections 1 to 8].
[Straus]: Chapter 11 [review of the definitions and examples from sections 11.2, and 11.3].
Strauss, M. J., Bradley, G. L., & Smith, K. J. (2007). Calculus (3rd ed.). Dorling Kindersley (India) Pvt. Ltd.

Week 2: Limits, continuity, and partial derivatives of functions of a complex variable.
[1]: Chapter 2 [Sections 15, 18, and 19].

Weeks 3 and 4: Cauchy-Riemann equations and examples, Sufficient conditions for differentiability, Analytic functions and their examples.
[1]: Chapter 2 [Sections 21, 22, 23 (Theorem, p.66 without proof), 25, and 26].

Week 5: Exponential, logarithmic, and trigonometric functions.
[1]: Chapter 3 [Sections 30, 31, and 37].

Week 6: Derivatives of functions, Definite integrals of functions, Contours.
[1]: Chapter 4 [Sections 41, 42, and 43].

Week 7: Contour integrals and examples, Upper bounds for moduli of contour integrals.
[1]: Chapter 4 [Sections 44, 45, and 47].

Weeks 8 to 10: Antiderivatives, Statement of Cauchy-Goursat theorem, Cauchy integral formula and its extension, Cauchy’s inequality, Liouville's theorem and the fundamental theorem of algebra.
[1]: Chapter 4 [Sections 48, 50, 54, 55, 57, and 58].

Weeks 11 to 13: Convergence of sequences and series of complex numbers, Taylor, and Laurent series with examples.
[1]: Chapter 5 [Sections 60 to 66, and 68].

Week 14: Isolated singular points, Residues, Cauchy's residue theorem.
[1]: Chapter 6 [Sections 74 to 76].

Week 15: Types of isolated singular points, Residues at poles and its examples.
[1]: Chapter 6 [Sections 79 to 81].

Essential Reading

1. Brown, James Ward, & Churchill, Ruel V. (2014). Complex Variables and Applications (9th ed.). McGraw-Hill Education. Indian Reprint.

GE-8(iv): Optimization Techniques

Weeks 1 and 2: Transshipment problem.
[2]: Chapter 5 [Section 5.3 brief introduction of transportation problems and its variant as transshipment problems (page 224)]; Chapter 5 [Section 5.5 from previous editions (8th or 9th) of Taha's book].
[Swarup]: Examples [Ex. 1064, 1065, and 1066 (page 290-291)].

Weeks 3 and 4: Shortest-route problem; Dynamic programming, Recursive forward and backward computation.
[2]: Chapter 12 [Sections 12.1, Example 12.1-1 (up to principle of optimality), and 12.2, Example 12.2-1].

Week 5: Knapsack/fly-away/cargo-loading problems solution through dynamic programming.
[2]: Chapter 12 [Section 12.3.1, Example 12.3-1 (up to page 477)].

Week 6: Integer programming problem. [1]: Chapter 6 [Sections 6.1, and 6.2].

Weeks 7 and 8: Gomory's cutting plane method for integer programming problems.
[1]: Chapter 6 [Section 6.3 (without derivation), Stepwise description, Theorem 6.3.1 (only statement), and Example 6.3.2].

Week 9: Gomory's cutting plane method for mixed integer linear programming problems.
[1]: Chapter 6 [Section 6.4, Example 6.4.1].

Week 10: Branch and bound method.
[1]: Chapter 6 [Section 6.5, Example 6.5.1, and Example 6.5.2].

Week 11: Convex functions and their properties.
[1]: Chapter 7 [Section 7.2 (with examples)].

Week 12: Differentiable convex functions.
[1]: Chapter 7 [Statement of Theorems 7.2.3 to 7.2.6, and Example 7.2.1].

Week 13: Convex programming problems.
[1]: Chapter 7 [Section 7.4, Theorem 7.4.1 (only statement), Def. 7.4.1, and Example 7.4.1, 7.4.2].

Week 14: Generalized convex functions.
[1]: Chapter 12 [Section 12.2 (Definitions 12.2.1, 12.2.2, and 12.2.3 with examples)], and Section 12.3 (Definitions 12.3.1, 12.3.2, and 12.3.3 with examples)].

Week 15: Linear fractional programming problem, Charnes and Cooper transformation, Simplex algorithm to solve linear fractional programming problem.
[1]: Chapter 12 [Sections 12.4, 12.5 (Charnes and Cooper Algorithm, Example 12.5.1, Simplex Algorithm for Linear Fractional Programming, Example 12.5.2, and Exercise 12.10, p. 476 (only simplex method)].

Essential Readings

1. Chandra, Suresh, Jayadeva, and Mehra, Aparna (2009). Numerical Optimization with Applications. Narosa Publishing House Pvt. Ltd. Delhi. Second Reprint 2016.
2. Taha, Hamdy A. (2017). Operations Research: An Introduction (10th ed.). Pearson. PHI.

Suggestive Reading

- Swarup, K., Gupta, P.K., and Mohan, M. (1984). Operations Research. Sultan Chand.