B.Sc. (Hons.) Mathematics (Sem I)

Teaching Plan (DSC-1: Algebra):

Weeks 1 to 4: Polynomials, The remainder and factor theorem, Synthetic division, Factored form of a polynomial, Multiple roots, Fundamental theorem of algebra, Relations between the roots and the coefficients of polynomial equations, Upper bounds for the real roots, Results on imaginary, integral and rational roots, Newton's method for integral roots, Descartes' rule of signs.
[2] Chapter II, and Chapter VI (Section 67).

Weeks 5 and 6: Polar representation of complex numbers, De-Moivre's theorem for integer and rational indices and their applications, The *n*th roots of unity, Cardan's solution of the cubic, Descartes' solution of the quartic equation.
[1] Chapter 2 [Sections 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2 (up to Figure 2.8, page 48), and 2.2.3)]
[2] Chapter IV (Sections 42, 43, and 51).

Weeks 7 and 8: Statement of well ordering principle. The division algorithm in $\mathbb{Z}$, Divisibility and the Euclidean algorithm.
[4] Chapter 4 [Sections 4.1 (4.1.1 to 4.1.6), and 4.2 (4.2.1 to 4.2.11)].

Weeks 9 and 10: Fundamental theorem of arithmetic, Modular arithmetic and basic properties of congruences.
[4] Chapter 4 [Sections 4.3 (4.3.7 to 4.3.9), and 4.4].

Weeks 11 to 13: Groups, Basic properties, Symmetries of a square, Dihedral group, Order of a group, Order of an element, Subgroups, Center of a group, Centralizer of an element.
[3] Chapters 1, 2 and 3.

Weeks 14 and 15: Cyclic groups and properties, Generators of a cyclic group, Classification of subgroups of cyclic groups.
[3] Chapter 4.

References:

1. Andreescu, Titu & Andrica, D. (2014). *Complex numbers from A to...Z*. (2nd ed.). Birkhäuser.
2. Dickson, Leonard Eugene (2009). *First Course in the Theory of Equations*. John Wiley & Sons, Inc. The Project Gutenberg eBook: http://www.gutenberg.org/ebooks/29785
3. Gallian, Joseph. A. (2017). *Contemporary Abstract Algebra* (9th ed.). Cengage Learning India Private Limited, Delhi. Indian Reprint 2021.
4. Goodaire, Edgar G., & Parmenter, Michael M. (2006). *Discrete Mathematics with Graph Theory* (3rd ed.). Pearson Education Pvt. Ltd. Indian Reprint 2018.

B.Sc. (Hons.) Mathematics (Sem I)

Teaching Plan (DSC-2: Elementary Real Analysis):

Weeks 1 to 3: Algebraic and order properties of $\mathbb{R}$, Absolute value of a real number, Bounded above and bounded below sets, Supremum and infimum of a nonempty subset of $\mathbb{R}$, The completeness property of $\mathbb{R}$.
[1] Chapter 2 (Sections 2.1 to 2.3).

Week 4: Archimedean property, Density of rational numbers in $\mathbb{R}$.
[1] Chapter 2 [Section 2.4 (except 2.4.2 and 2.4.7)].

Weeks 5 and 6: Sequences and their limits, Convergent sequence, Limit theorems.
[1] Chapter 3 [Sections 3.1 (except 3.1.8 and 3.1.9), and 3.2].

Week 7 and 8: Monotone sequences, Monotone convergence theorem and applications.
[1] Chapter 3 (Section 3.3).

Week 9: Subsequences, Bolzano-Weierstrass theorem, Notion of limit superior and limit inferior for bounded sequence with illustrations.
[1] Chapter 3 [Section 3.4 (with Theorems 3.4.7 and 3.4.11 without proofs)].

Week 10: Cauchy sequences of real numbers and Cauchy's convergence criterion.
[1] Chapter 3 [Section 3.5 (3.5.1 to 3.5.6, except 3.5.6(a))].

Week 11: Convergence and divergence of infinite series, Sequence of partial sums of infinite series, Necessary condition for convergence, Cauchy criterion for convergence of series.
[3] Chapter 8 [Section 8.1 (with Theorem 8.1.10 without proof)].

Weeks 12 and 13: Tests for convergence of positive term series: Statement of the integral test and convergence of *p*-series, Basic comparison test, Limit comparison test, Ratio, root and Raabe's tests.
[3] Chapter 8 [Section 8.2 (with Theorems 8.2.3, 8.2.13, 8.2.16, 8.2.18, and 8.2.20 without proofs)].

Weeks 14 and 15: Alternating series, Leibniz test, Absolute and conditional convergence.
[2] Chapter 6 [Section 6.2 (with Theorem 6.2.9 without proof)].

References:

1. Bartle, Robert G., & Sherbert, Donald R. (2011). *Introduction to Real Analysis* (4th ed.). John Wiley & Sons. Wiley India Edition 2015.
2. Bilodeau, Gerald G., Thie, Paul R., & Keough, G. E. (2010). *An Introduction to Analysis* (2nd ed.). Jones and Bartlett India Pvt. Ltd. Student Edition. Reprinted 2015.
3. Denlinger, Charles G. (2011). *Elements of Real Analysis*. Jones and Bartlett India Pvt. Ltd. Student Edition. Reprinted 2015.

B.Sc. (Hons.) Mathematics (Sem I)

Teaching Plan (DSC-3: Probability and Statistics):

Weeks 1 and 2: Descriptive statistics: Populations, Samples, Stem-and-leaf displays, Dotplots, Histograms, Qualitative data, Measures of location, Measures of variability, Boxplots. [1] Chapter 1.

Weeks 3 and 4: Sample spaces and events, Probability axioms and properties, Conditional probability, Bayes' theorem and independent events. [1] Chapter 2.

Weeks 5 and 6: Discrete random variables and probability distributions, Expected values; Probability distributions with their mean and variance: Binomial, geometric, hypergeometric, negative binomial, Poisson, and Poisson distribution as a limit. [1] Chapter 3.

Weeks 7 and 8: Continuous random variables, Probability density functions, Uniform distribution, Cumulative distribution functions and expected values. [1] Chapter 4 (Sections 4.1 and 4.2).

Weeks 9 and 10: Normal and standard normal distributions with their percentiles, Approximating the binomial distribution; Exponential distribution, Lognormal distribution.
[1] Chapter 4 [Sections 4.3, 4.4 (up to Example 4.22 page 172), and 4.5 (Definition page 179 to Example 4.27)].

Weeks 11 and 12: Sampling distribution and standard error of the sample mean, Central Limit Theorem and applications. [1] Chapter 5 (Section 5.4).

Weeks 13 to 15: Scatterplot of bivariate data, Regression line using principle of least squares (statement with normal equations), Predicted values and the residuals, Error sum of squares, Coefficient of determination, The sample correlation coefficient and properties.
[1] Chapter 12 [Sections 12.1 (up to Example 12.2), 12.2, and 12.5 (up to page number 529)].

Reference:

1. Devore, Jay L. (2016). *Probability and Statistics for Engineering and the Sciences* (9th ed.). Cengage Learning India Private Limited. Delhi. Indian Reprint 2020.

Practical component - Software labs using Microsoft Excel or any other spreadsheet.

1. Presentation and analysis of data (univariate and bivariate) by frequency tables, descriptive statistics, stem-and-leaf plots, dotplots, histograms, boxplots, comparative boxplots, and probability plots ([1] Section 4.6).
2. Fitting of binomial, Poisson and normal distributions.
3. Illustrating the Central Limit Theorem through Excel.
4. Fitting of regression line using the principle of least squares.
5. Computation of sample correlation coefficient.

B.A. (Prog.) with Mathematics as Major (Sem I)

Teaching Plan: (DSC-1: Elements of Discrete Mathematics)

Week 1: Sets, Propositions and logical operations.
[2] Chapter 1 (Section 1.1), and Chapter 2 (Section 2.1).

Week 2: Conditional statements, Mathematical induction.
[2] Chapter 2 (Sections 2.2, and 2.4).

Week 3: Relations and equivalence relation, Equivalence classes, Partial order relation, Partially ordered set.
[1] Chapter 1 (Section 1.1, up to the Definition of POSET).
[2] Chapter 4 (Sections 4.2 (up to Example 16), 4.4, and 4.5).

Weeks 4 and 5: Hasse diagrams, Chain, Maximal and minimal elements, Least and greatest elements, Least upper bound, greatest lower bound in POSETS, Zorn's lemma, Functions and bijective functions.
[1] Chapter 1 (Sections 1.1 to 1.4).
[2] Chapter 5 (Section 5.1).

Week 6 and 7: Functions between POSETS, Order isomorphism, Lattice as a POSET, Lattice as an algebra and their equivalence.
[1] Chapter 1 (Sections 1.5 to 1.10, and 1.12 to 1.14).
[2] Chapter 6 (Section 6.1).

Week 8: Bounded lattice, Sublattice, Interval in a lattice.
[1] Chapter 1 (Sections 1.11, 1.15, and 1.16).

Week 9: Products and homomorphism of lattices, Isomorphism of lattices.
[1] Chapter 1 (Sections 1.17 to 1.20).

Week 10: Distributive lattices, Complemented lattice, Partition and pentagonal lattice.
[1] Chapter 1 (Sections 2.1 to 2.10).

Weeks 11 and 12: Boolean algebra, De Morgan's laws, Boolean expressions, Truth tables, Logic diagrams. [1] Chapter 1 (Sections 3.1 to 3.6); [2] Chapter 6 (Section 6.5).

Week 13: Boolean functions, Disjunctive normal forms (as join of meets), Minimal forms of Boolean polynomials.
[1] Chapter 1 (Sections 4.13, and 4.15 to 4.17).

Week 14: Quine Mc-Cluskey method, Karnaugh maps.
[1] Chapter 1 (Sections 6.1 to 6.5); [2] Chapter 6 (Section 6.6).

Week 15: Switching circuits, Applications of switching circuits.
[1] Chapter 2 (Sections 7, and 8).

References:

1. Rudolf Lidl, & Gunter Pilz (2004). *Applied Abstract Algebra* (2nd ed.). Undergraduate text in Mathematics, Springer (SIE), Indian Reprint.
2. Bernard Kolman, Robert C. Busby, & Sharon Cutler Ross (2009). *Discrete Mathematical Structures* (6^{th} ed.). Pearson education Inc., Indian reprint.

B.A. (Prog.) with Mathematics as Major (Sem I)
Teaching Plan (DSC-2: Topics in Calculus):

Weeks 1 and 2: Limit of a function, definition of a limit, Infinite limits, Continuity and types of discontinuities.
[1] Chapter 2.

Weeks 3 and 4: Differentiability of a function, Successive differentiation: Calculation of the *n*th derivatives, Leibnitz theorem.
[1] Chapter 3 (Sections 3.1, and 3.2), and Chapter 5.

Week 5: Partial differentiation, Euler's theorem on homogeneous functions.
[1] Chapter 12 [Section 12.2 (12.21 without proof, exclude 12.22 and 12.23), and Section 12.3].

Weeks 6 and 7: Rolle's theorem, Mean value theorems and applications to monotonic functions and inequalities.
[1] Chapter 7 (Sections 7.4 to 7.6).

Weeks 8 and 9: Taylor's theorem with Lagrange's and Cauchy's form of remainders, Definition and examples of convergent sequences and series, Taylor's series, Maclaurin's series expansions of e^x, $\sin x$, $\cos x$, $\log(1+x)$ and $(1+x)^m$.
[1] Chapter 6 (Brief introduction of convergence from the Sections 6.1 and 6.2).
[1] Chapter 7 (Sections 7.7, and 7.8).

Week 10: Indeterminate forms.
[1] Chapter 16.

Week 11: Asymptotes (parallel to axes and oblique).
[1] Chapter 9 (Sections 9.1 to 9.4).

Weeks 12 and 13: Concavity and inflexion points, Singular points (cusp, node and conjugate), Tangents at the origin and nature of singular points, Curve tracing (cartesian and polar equations).
[1] Chapter 10 (Section 10.7).
[1] Chapter 11. Use only statement for nature of double points in the Section 11.4.

Week 14 and 15: Reduction formulae for $\int \sin^n x\,dx, \int \cos^n x\,dx,$ and $\int \sin^m x \cos^n x\,dx$ and their applications. [2] Chapter 4 (Sections 4.1, 4.11, 4.12, and 4.13).

References:

1. Prasad, Gorakh (2016). *Differential Calculus* (19th ed.). Pothishala Pvt. Ltd. Allahabad.
2. Prasad, Gorakh (2015). *Integral Calculus*. Pothishala Pvt. Ltd. Allahabad.

B.A/ B.Sc. (Prog.) with Mathematics as Non-Major (Sem I)
Teaching Plan (DSC: Topics in Calculus):

Weeks 1 and 2: Limit of a function, definition of a limit, Infinite limits, Continuity and types of discontinuities.
[1] Chapter 2.

Weeks 3 and 4: Differentiability of a function, Successive differentiation: Calculation of the *n*th derivatives, Leibnitz theorem.
[1] Chapter 3 (Sections 3.1, and 3.2), and Chapter 5.

Week 5: Partial differentiation, Euler's theorem on homogeneous functions.
[1] Chapter 12 [Section 12.2 (12.21 without proof, exclude 12.22 and 12.23), and Section 12.3].

Weeks 6 and 7: Rolle's theorem, Mean value theorems and applications to monotonic functions and inequalities.
[1] Chapter 7 (Sections 7.4 to 7.6).

Weeks 8 and 9: Taylor's theorem with Lagrange's and Cauchy's form of remainders, Definition and examples of convergent sequences and series, Taylor's, Maclaurin's series expansions of e^x, $\sin x$, $\cos x$, $\log(1+x)$ and $(1+x)^m$.
[1] Chapter 6 (Brief introduction of convergence from the Sections 6.1 and 6.2).
[1] Chapter 7 (Sections 7.7, and 7.8).

Week 10: Indeterminate forms.
[1] Chapter 16.

Week 11: Asymptotes (parallel to axes and oblique).
[1] Chapter 9 (Sections 9.1 to 9.4).

Weeks 12 and 13: Concavity and inflexion points, Singular points (cusp, node and conjugate), Tangents at the origin and nature of singular points, Curve tracing (cartesian and polar equations).
[1] Chapter 10 (Section 10.7).
[1] Chapter 11. Use only statement for nature of double points in the Section 11.4.

Weeks 14 and 15: Reduction formulae for $\int \sin^n x\,dx, \int \cos^n x\,dx,$ and $\int \sin^m x \cos^n x\,dx$ and their applications. [2] Chapter 4 (Sections 4.1, 4.11, 4.12, and 4.13).

References:

1. Prasad, Gorakh (2016). *Differential Calculus* (19th ed.). Pothishala Pvt. Ltd. Allahabad.
2. Prasad, Gorakh (2015). *Integral Calculus*. Pothishala Pvt. Ltd. Allahabad.

GENERIC ELECTIVE for other than B.Sc. (Hons.) Mathematics

Teaching Plan (GE-1(i): Fundamentals of Calculus):

Weeks 1 and 2: Limits and continuity, Types of discontinuities.
[1] Chapter 1 (Theorems without proofs).
[2] Chapter 2 (Section 2.7).

Week 3: Differentiability of functions.
[1] Chapter 2 (Section 2.2).
[2] Chapter 3 (Section 3.2).

Week 4: Successive differentiation, Leibnitz theorem.
[2] Chapter 5.

Week 5: Partial differentiation, Euler's theorem on homogeneous functions.
[2] Chapter 12 [Section 12.2 (12.21 without proof, exclude 12.22 and 12.23), and Section 12.3].

Weeks 6 and 7: Rolle's theorem, Mean value theorems and applications to monotonic functions and inequalities.
[2] Chapter 7 (Sections 7.4 to 7.6).

Weeks 8 and 9: Taylor's theorem with Lagrange's and Cauchy's forms of remainders, Definition and examples of convergent sequences and series, Taylor's series, Maclaurin's series expansion of $e^x, \sin x, \cos x, \log(1+x)$, and $(1+x)^m$.
[2] Chapter 6 (Brief introduction of convergence from the Sections 6.1 and 6.2).
[2] Chapter 7 (Sections 7.7 and 7.8).

Week 10: Indeterminate forms.
[1] Chapter 6 (Section 6.5).
[2] Chapter 16 (Examples and Exercises).

Weeks 11 and 12: Concavity and inflexion points, Asymptotes (parallel to axes and oblique).
[1] Chapter 3 [Section 3.1 (3.1.3 to 3.1.5)].
[2] Chapter 9 (Sections 9.1 to 9.4).

Weeks 13 to 15: Relative extrema, Tracing graphs of polynomial and rational functions.
[1] Chapter 3 (Sections 3.2 and 3.3), and Chapter 10 (Section 10.2).

References:

1. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). *Calculus* (10th ed.). Wiley India Pvt. Ltd. New Delhi. International Student Version. Indian Reprint 2016.
2. Prasad, Gorakh (2016). *Differential Calculus* (19th ed.). Pothishala Pvt. Ltd. Allahabad.

GENERIC ELECTIVE for other than B.Sc. (Hons.) Mathematics

Teaching Plan (GE-1(ii): Theory of Equations and Symmetries):

Weeks 1 and 2: General properties of polynomials and equations; Statement of the Fundamental theorem of algebra and its consequences.
[1] Chapter I (Sections 8, 9 and 10); Chapter II (Sections 12 to 17).
[2] Chapter II (Sections 13 to 19)

Weeks 3 and 4: Theorems on imaginary, integral and rational roots; Descartes' rule of signs for positive and negative roots.
[1] Chapter II (Sections 18 to 22).
[2] Chapter II (Sections 21, 24, 25 and 27), and Chapter VI [Section 67]
(Proofs of theorems in the Chapters II and VI are omitted).

Weeks 5 and 6: Relations between the roots and coefficients of equations, Applications to solution of equations when an additional relation among the roots is given.
[1] Chapter III (Sections 23 and 24).
[2] Chapter II (Sections 20).

Weeks 7 and 8: De Moivre's theorem for rational indices, the *n*th roots of unity and symmetries of the solutions; Transformation of equations (multiplication, reciprocal, increase/diminish in the roots by a given quantity), Removal of terms.
[1] Chapter III (Section 26); Chapter IV (Sections 29 to 34).
[2] Chapter I (Sections 7 to 10).

Weeks 9 and 10: Cardon's method of solving cubic and Descartes' method of solving biquadratic equations.
[1] Chapter VI (Sections 56 and 64).
[2] Chapter IV (Sections 42, 43, 51 and 52).

Weeks 11 and 12: Elementary symmetric functions and symmetric functions of the roots of an equation; Newton's theorem on sums of the like powers of the roots.
[2] Chapter IX (Sections 103 to 106, methods only).
[1] Chapter VIII (Section 77, method only).

Weeks 13 to 15: Computation of symmetric functions such as:

$\sum\alpha^2\beta,\ \sum\alpha^2\beta^2, \sum\alpha^2\beta\gamma, \sum\frac{1}{\alpha^2\beta\gamma}, \sum\alpha^{-3}, \sum(\beta+\gamma-\alpha)^2,\ \sum\frac{\alpha^2+\beta\gamma}{\beta+\gamma},\ldots$ of polynomial equations;

Transformation of equations by symmetric functions and in general.
[1] Chapter III (Sections 27 and 28); Chapter IV (Sections 39, 41 and 44).
[2] Chapter IX (Section 109, methods only).

References:

1. Burnside, W.S., & Panton, A.W. (1979). *The Theory of Equations* (11th ed.). Vol. 1. Dover Publications, Inc. (4th Indian reprint. S. Chand & Co. New Delhi).
2. Dickson, Leonard Eugene (2009). *First Course in the Theory of Equations*. John Wiley & Sons, Inc. The Project Gutenberg eBook: http://www.gutenberg.org/ebooks/29785