B. Sc. / B. Sc. (Inst)/ BACA
Mathematics Syllabus for Semester System

First Semester

Code	Course	Periods/ Week	Credits
BPM-101	Calculus	4	4
BPM-102	Geometry of Two and Three Dimensions	4	4

Second Semester

Code	Course	Periods/ Week	Credits
BPM-201	Differential Equations	4	4
BPM-202	Algebra and Complex Trigonometry	4	4

Third Semester

Code	Course	Periods/ Week	Credits
BPM-301	Functions of Several Variables	4	4
BPM-302	Group and Rings	4	4

Fourth Semester

Code	Course	Periods/ Week	Credits
BPM-401	Analysis - I	4	4
BPM-402	Numerical Methods	4	4

Fifth Semester

Code	Course	Periods/ Week	Credits
BPM-501	Analysis – II	4	4
BPM-502	Probability and Statistics	4	4

Sixth Semester

Code	Course	Periods/ Week	Credits
BPM-601	Linear Algebra	4	4
BPM-602	Operations Research and Linear Programming	4	4

BPM-101: Calculus

Unit I
Ɛ-δ definition of the limit of a function, Algebra of limits, Continuity, Differentiability, Successive differentiation, Leibnitz theorem, Rolle's Theorem, Mean value theorems, Taylor's and Mclauren's series.

Unit II
Indeterminate forms, Curvature, Cartesian, Polar and parametric formulae for radius of curvature, Partial derivatives, and Euler's theorem on homogeneous functions.

Unit III
Asymptotes, Test of concavity and convexity, Points of inflexion, multiple points, Tracing of curves in Cartesian and polar coordinates.

Unit IV
Reduction formulae, Quadrature, Rectification, Intrinsic equation, Volumes and surfaces of solids of revolution.

Books Recommended:
- Gorakh Prasad: *Differential Calculus*, Pothishalas Pvt Ltd, Allahabad.
- Gorakh Prasad: *Integral Calculus*, Pothishalas Pvt Ltd, Allahabad.
- Shanti Narayan: *Differential Calculus*, S. Chand & Co.
- Shanti Narayan: *Integral Calculus*, S. Chand & Co.
- Khalil Ahmad: *Text Book of Calculus*, World Education Publishers, 2012.

BPM-102: Geometry of Two and Three Dimensions

Unit I
General equation of second degree, Pair of lines, Parabola, Tangent, normal. Pole and polar and their properties, Ellipse, Hyperbola, Tangent, normal, pole and polar, conjugate diameters, Asymptotes, Conjugate hyperbola and rectangular hyperbola.

Unit II
Polar equation of a conics, Polar equation of tangent, normal, polar and asymptotes, General equation of second degree, Tracing of parabola, Ellipse and hyperbola.

Unit III
Review of straight lines and planes, Equation of sphere, Tangent plane, Plane of contact and polar plane, Intersection of two spheres, radical plane, Coaxial spheres, Equation of a cone, Intersection of cone with a plane and a line, Enveloping cone, Right circular cone.

Unit IV
Equation of cylinder, Enveloping and right circular cylinders, Equations of central conicoids, Tangent plane, Normal, Plane of contact and polar plane, Enveloping cone and enveloping cylinder, Equations of paraboloids and its simple properties.

Books Recommended:
- Ram Ballabh: *Textbook of Coordinate Geometry*.
- S. L. Loney: *The elements of coordinate geometry*, Michigan Historical Reprint Series
- P.K. Jain and Khalil Ahmad: *Textbook of Analytical Geometry*, New Age International (P) Ltd. Publishers.

BPM-201: Differential Equations

Unit I
Formation of differential equations, Order and degree of a differential equation, equations of first order and first degree, Homogeneous equations, Linear equations and Bernoulli equations, Exact differential equations, integrating factors, Change of variables.

Unit II
Equations of the first order and higher degree, Equations solvable for *p, y* and *x*, Clairaut's equation, Lagrange's equation, Trajectories.

Unit III
Linear differential equations with constant coefficient, Complementary function and particular integral. Particular integral of the forms $e^{ax}V, e^{ax}$, sinax, cosax, and x^m, Homogeneous linear equations.

Unit IV
Linear differential equations of second order, Complete solution in terms of known integral belonging to the complementary function, Normal form, Change of independent variable, Method of undetermined coefficients, Method of variation of parameters, Simultaneous equations with constant coefficients.

Books Recommended:
- S. L. Ross: *Differential equations*, John Wiley and Sons, 2004.
- Zafar Ahsan: *Text Book of Differential Equations and their Applications*, Prentice Hall of India.
- Khalil Ahmad: *Text Book of Differential Equations*, World Education Publishers, 2012.

BPM-202: Algebra and Complex Trigonometry

Unit I
 Relations, Types of relation, Equivalence relations, Partitions. Congruent modulo n. symmetric and skew symmetric matrices. Hermitian and skew Hermitian matrices. Elementary row operations. Elementary matrices and their properties. Singular and non-singular matrices and their properties.

Unit II
Row rank and column rank. Equivalent matrices and their properties. Similar matrices. Equivalence of row and column ranks. Row echelon and reduced row echelon forms of matrix and their properties.

Unit III
 Eigen values and Eigen vectors. Characteristic equation. Cayley Hamilton Theorem and its application in finding the inverse of a matrix. Application of matrices to a system of linear (both homogeneous ad non-homogeneous) equations. Theorem on consistencies of a system of linear equations.

Unit IV
De Moivre's theorem and its application. Circular and Hyperbolic functions. Inverse circular and hyperbolic functions. Expansion of trigonometric functions in terms of power and multiple. Separation of real and imaginary parts of logarithmic, trigonometric and inverse trigonometric functions. Summation of series including $C + iS$ method.

Books Recommended:
- I. N. Hernstein: *Topics in Algebra*, Wiley; 2nd edition (June 20, 1975).
- P.B. Bhattacharya, S. K. Jain and S. R. Nagpaul: *First course in Abstract Algebra*.
- K. B. Dutta: *Matrix ad Linear Algebra*.
- J. Finkbecner: *Matrix theory.*

BPM-301: Functions of Several Variables

Unit I
Functions of several variables, Domain and range, Level curves and level surfaces, Limits and continuity, Partials derivatives, Total differential, Fundamental lemmas, differential of functions of n variables and of vector functions, The Jacobian matrix, derivatives and differentials of composite functions, The general chain rule.

Unit II
Implicit functions, inverse functions, Curvilinear coordinates, Geometrical applications, The directional derivatives, Partial derivatives of higher order, Higher derivatives of composite functions, The Laplacian in polar, Cylindrical and spherical coordinates, Higher derivatives of implicit functions, Maxima and minima of functions of several variables.

Unit III
Vector fields and scalar fields, the gradient field, Divergence and curl of a vector field, Combined operations, Irrotational and solenoidal fields, double, triple and multiple integrals, Change of variable in integrals, Arc length and Surface area.

Unit IV
Line integrals, Integrals with respect to arc length, Basic properties of line integrals, Green's theorem, Simply connected domains, Extension of results to multiply connected domains, Surfaces in space, Orientability, Surface integrals, Divergence theorem and Stoke's theorem, Integrals independent of path.

Books Recommended:

- Wilfred Kaplan: *Advanced Calculus*, Addison- Wesley Publishing Company, 1973.
- E. Swokowski: *Calculus with Analytical Geometry*, Prindle, Weber & Schmidt, 1984.
- E. Kreyszig: Advanced *Engineering Mathematics*, John Wiley and Sons, 1999.
- David Widder: *Advanced Calculus*, Prentice- Hall of India, 1999,
- S.C. Malik and Savita Arora: *Mathematical Analysis*, New Age International (P) Ltd., Publishers, 1996.

BPM-302: Groups and Rings

Unit I
Sets, relations types of relations, equivalence relations, Groups, subgroups and their characterization. Normal subgroups and related theorems. Order of an element of a group. Lagrange's theorem and its corollaries. Factor groups.

Unit II
Group Homomorphism, kernel of a homomorphism, Isomorphism, Natural homomorphism, The homomorphism theorems, The isomorphism theorems, Even and odd permutations, Permutation groups, Alternating groups, Cayley's theorem.

Unit III
Rings and their properties. Integral domain. Field. Subrings. Ideals and their properties. Quotient rings.

Unit IV
Ring homomorphism and its properties. Kernel of a homomorphism. Natural homomorphism. Isomorphism & related theorems. Euclidean rings & their properties. Unique factorization theorem for Euclidean rings.

Books Recommended:
- N. Herstein, *Topics in Algebra*, Wiley Eastern Ltd., New Delhi.
- Surjeet Singh and Qazi Zameeruddin, *Modern Algebra*, Vikas Publishing House Pvt. Ltd., New Delhi.

BPM-401: Analysis – I

Unit I
Bounded and unbounded sets, Infimum and supremum of a set and their properties, Order completeness property of R, Archimedian property of R, Density of rational and irrational numbers in R, Neighbourhood, Open set, Interior of a set, Limit point of a set, Closed set, Derived set, closure of a set, Bolzano- Weierstrass theorem for sets, Countable and uncountable sets.

Unit II
Sequence of real numbers, Bounded sequence, limit points of a sequence, limit interior and limit superior, convergent and non-convergent sequences, Cauchy's sequence, Cauchy's general principle of convergence, Algebra of sequences, Theorems on limits of sequences, Subsequences, Monotone sequences, Monotone convergence Theorem.

Unit III
Infinite series and its convergence, Test for convergence of positive term series, Comparison test, Ratio test, Cauchy's root test, Raabe's test, Logarithmic test, Integral test, Alternating series, Leibnitz test, Absolute and conditional convergence.

Unit IV
Continuous and discontinuous functions, Types of discontinuities, Theorems on continuity, Uniform continuity, Relation between continuity and uniform continuity, Derivative of a function, Relation between continuity and differentiability, Increasing and decreasing functions, Darboux theorem, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Taylor's theorem with Cauchy's and Lagrange's form of remainders.

Books Recommended:
- R. G. Bartle and D.R. Sherbert, *Introduction to Real Analysis (3rd Edition),* John Wiley and Sons (Asia) Pvt Ltd., Singapore, 2002.
- S.C. Malik and Savita Arora: *Mathematical Analysis*, New Age International (P) Ltd. 1996.
- K. A. Ross, Elementary Analysis: *The Theory of Calculus*, Under graduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
- Sudhir R Ghorpade and Balmohan V. Limaye, *Course in Calculus and Real Analysis, Undergraduate Text in Math.*, Springer (SIE). Indian reprint, 2004.
- T.M. Apostol: *Mathematical Analysis*, Addison-Wesley Series in Mathematics, 1974.

BPM-402: Numerical Methods

Unit1.
Solution of algebraic and transcendental equations: Bisection method, False position method, Fixed-point iteration method, Newton's method and its convergence, Chebyshev method. Solution of system of non-linear equations by Iteration and Newton-Raphson method.

Unit 2.
Finite difference operators and finite differences; Interpolation and interpolation formulae: Newton's forward and backward difference, Central difference: Sterling's and Bessel's formula, Lagrange's interpolation formula and Newton's divided difference interpolation formula, Hermite interpolation.

Unit 3.
Direct methods to solve system of linear equations: Gauss elimination method, Gauss-Jordan method, LU decomposition; Indirect methods: Gauss-Jacobi and Gauss-Seidal methods. The algebraic eigen value problems by Householder and Power method.

Unit 4.
Numerical differentiation and Numerical integration by Newton cotes formulae, Trapezoidal rule, Simpson's rule, Romberg formula and their error estimation. Numerical solution of ordinary differential equations by Euler's method, Picard's method, Taylor series and Runge-Kutta methods.

Books Recommended:
- B. Bradie, *A Friendly Introduction to Numerical Analysis*, Pearson Education, India, 2007
- M. K. Jain, S. R. K. Iyengar and R. K. Jain, *Numerical Methods for Scientific and Engineering Computation*, New age International Publisher, India, 5th edition, 2007
- M. Pal : *Numerical Analysis for scientific and engineering Computation*
- N. Ahmad, *Fundamental Numerical Analysis with error estimation*

BPM-501: Analysis - II

Unit I
Definition, existence and properties of Riemann integral of a bounded function, Darboux theorem, Condition of integrability, Rieman integrability for continuous functions, bounded functions, monotonic function and functions with finite or infinite number of discontinuities (without proof). The integral as the limit of the sums, Properties of Riemann integral, Fundamental theorem of calculus, First Mean value theorems, Second mean value theorem, Generalised mean value Theorems.

Unit II
Definition of improper integrals, Convergence of improper integrals, Test for convergence of improper integrals Comparison test, Cauchy's test for convergence, Absolute convergence, Abel's Test, Dirichlet's Test, Beta and Gamma functions and their properties and relations.

Unit III
Definition of pointwise and uniform convergence of sequences and series of functions, Cauchy's criterion for uniform convergence, Weierstrass M-test, Uniform convergence and continuity, Uniform convergence and differentiation, Uniform convergence and integration..

Unit IV
Fourier Series, Fourier Series for even and odd functions, Fourier Series on intervals other than $[-\pi, \pi]$. Power series, Radius of convergence, uniform and absolute convergence, Abel's Theorem (without proof), exponential and logarithmic functions.

Books Recommended:
- R. G. Bartle and D.R. Sherbert, *Introduction to Real Analysis* (3rd Edition), John Wiley and Sons (Asia) Pvt Ltd., Singapore, 2002.
- S.C. Malik and Savita Arora*: Mathematical Analysis*, New Age International (P) Ltd. 1996.
- K. A. Ross, Elementary Analysis: *The Theory of Calculus, Under graduate Texts in Mathematics*, Springer (SIE), Indian reprint, 2004.
- Sudhir R Ghorpade and Balmohan V. Limaye, *Course in Calculus and Real Analysis, Undergraduate Text in Math.*, Springer (SIE). Indian reprint, 2004.
- T.M. Apostol: *Mathematical Analysis*, Addison-Wesley Series in Mathematics, 1974.

BPM-502: Probability and Statistics

Unit I:
Sample space and events, algebra of events, axiomatic approaches, conditional probability, basic laws of total probability and compound probability, Byes' theorem, Independence.

Unit- II:
Discrete and continuous random variables, mathematical expectation, variance, moment about a point, central moment, moment generating function, Binomial, Poisson, Normal and Rectangular distributions.

Unit III:
Two-dimensional random variables, joint distribution functions, marginal distributions, covariance, linear regression and correlation, rank correlation, least square method of fitting regression lines.

Unit IV:

Sampling, random sampling, large sample tests of means and proportion. *t*-student, χ^2 (chi square) and *F* distributions (without derivation) and testing of hypothesis based on them.

Books recommended:
- Irwin Miller and Marylees Miller**,** *John E. Freund's Mathematical Statistics with Applications*, Pearson Education.
- Robert V. Hogg, Allen Craig Deceased and Joseph W. McKean, *Introduction to Mathematical Statistics,* Pearson Education
- Sheldon M. Ross, *Introduction to probability and statistics for engineers and scientists*, Elsevier Academic Press.
- J. N. Kapur and H.C. Saxena, *Mathematical Statistics*, S. Chand.

BPM-601: Linear Algebra

Unit I
Definition, examples and basic properties of a vector space, Subspaces, Linear independence, Linear combinations and span, Basis and dimension, Sum and intersection of subspaces, Direct sum of subspaces.

Unit II
Definition, examples and properties of linear transformations, Rank and kernel, The rank and nullity of a matrix, Rank-Nullity Theorem and its consequences, The matrix representation of a linear transformation, Change of basis.

Unit III
Scalar product in R^n and C^n. Complex matrices and Orthogonality in C^n. Inner product spaces, Orthogonality in inner product spaces, Normed linear spaces, Inner product on complex vector spaces, Orthogonal complements, Orthogonal sets and the Gram-Schmidt process.

Unit IV
Eigenvalues and eigen vectors, Characteristic equation and polynomial, Eigenvectors and eigenvalues of linear transformations and matrices, The Caley-Hamilton theorem, Similar matrices and diagonalization,

Books recommended:
- David C. Lay: Linear algebra and its applications (3rd Edition), Pearson Education Asia, Indian Reprint, 2007,
- Geory Nakos and David Joyner: Linear algebra with Applications, Brooks/ Cole Publishing Company, International Thomson Publishing, Asia, Singapore, 1998,
- Stephen H, Friedberg, Arnold J, Insel and L,E,Space- Linear Algebra, 4th edition, PHI , New Delhi, 2004,
- I. V. Krishnamurty, V.P. Mainra, J.L. Arora- An introduction to Linear Algebra, EWP, New Delhi, 2002,

BPM-602: Operations Research and Linear Programming

Unit I:
Operations Research (OR) and its Scope, Modeling in OR, Scientific Method in Operations Research, Linear Programming: Definition, mathematical formulation, standard form, Solution space, solution – feasible, basic feasible, optimal, infeasible, multiple, redundancy, degeneracy, Solution of LP Problems - Graphical Method, Simplex Method.

Unit- II:
Duality in LP, Dual Simplex Method, Economic interpretation of Dual, Transportation Problem, Basic feasible solution using different methods (North-West corner, Least Cost, Vogel's Approximation Method), Optimality Methods, Unbalanced transportation problem, Degeneracy in transportation problems, Assignment Problem, Hungarian Method for Assignment Problem.

Unit III:
Elementary inventory models, Replacement models, Group replacement problem, Sequencing theory, m machines and n jobs problem, Graphical method for sequence problem.

Unit IV:
Game Theory, pure and mixed strategies, Saddle point, Two-Persons-Zero-Sum Game, Game with mixed strategies, Dominance rule, Graphical Method, Inter - relation between the theory of games and linear programming, Solution of game using Simplex method.

Books Recommended:
- J. K. Sharma, *Operations Research – Theory and Application*, Macmillian Pub.
- J. K. Sharma, *Operations Research – Problems and Solutions*, Macmillian Pub.
- G. Hadly, *Linear Programming*, Narosa Publishing House
- A. H. Taha, *Operations Research – An Introduction*. Prentice Hall
- Hillier and Lieberman, *Introduction to Operations Research*, McGraw Hill.