Learning Outcome based Curriculum Framework (LOCF)

For

Choice Based Credit System (CBCS)

Syllabus

B.Sc. (Program) in Mathematics

w.e.f. Academic Session 2020-21

Kazi Nazrul University

Asansol, Paschim Bardhaman

West Bengal 713340

Preamble

The LOCF (Learning Outcomes based Curriculum Framework) committee constituted by University Grants Commission (UGC) is pleased to submit its report concerning the syllabi for B.A./B.Sc. (Honours) Mathematics and B.A./B.Sc. with Mathematics as a subject. The committee discussed the framework of syllabi in its meetings and suggests the implementation of these syllabi in the Departments/Schools of Mathematics in Universities/Colleges/Institutes based on following facts:

1. The learning outcomes of each paper are designed so that these may help learners to understand the main objectives of studying the course.
2. This will enable learners to select elective papers depending on the individual inclinations and contemporary requirements.
3. The objectives of LOCF are to mentally prepare the students to learn Mathematics leading to graduate degree with honours in Mathematics or with Mathematics as a subject.
4. These syllabi in Mathematics under CBCS are recommended keeping in view of the wide applications of Mathematics in science, engineering, social science, business and a host of other areas.
5. The study of the syllabi will enable the students to be equipped with the state of the art of the subject and will empower them to get jobs in technological and engineering fields as well as in business, education and healthcare sectors.
6. The LOCF committee in Mathematics has prepared this draft paying suitable attention to objectives and learning outcomes of the papers. These syllabi may be implemented with minor modifications with appropriate justifications keeping in view regional, national and international context and needs.
7. The outcomes of each paper may be modified as per the local requirements.
8. The text books mentioned in references are denotative/demonstrative. The divisions of each paper in units are specified to the context mentioned in courses. These units will help the learners to complete the study of concerned paper in certain periods and prepare them for examinations.
9. The papers are organized considering the credit load in a particular semester. The core papers of general interest are suggested for semesters I to IV. The elective courses and advanced courses are proposed for the B.A./B.Sc. (Hons.) students of semesters V & VI and the elective courses for the students of B.A./B.Sc. semesters V & VI having Mathematics as a subject.
10. The mathematics is a vast subject with immense diversity. Hence it is very difficult for every student to learn each branch of mathematics, even though each paper has its unique importance. ii Under these circumstances, LOCF in Mathematics suggests a number of elective papers along with compulsory papers. A student can select elective papers as per her/his needs and interests.
11. The committee expects that the papers may be taught using various Computer Algebra Systems (CAS) softwares such as Mathematica, MATLAB, Maxima and R to strengthen the conceptual understanding and to widen up the horizon of students' self-experience.
12. The committee of the LOCF in Mathematics expects that the concerned departments/colleges/institutes/universities will encourage their faculty members to include necessary topics in addition to courses suggested by LOCF committee. It is hoped that the needs of all round development in the careers of learners/students will be fulfilled by the recommendations of LOCF in Mathematics.

SEMESTER I

CORE COURSE-1(1)

Course Name: Differential Calculus

Course Code: BSCPMTMC101

Course Type: C	Course Details: CC-**1(1)**		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**……**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Understand limit, continuity, differentiability and partial differentiation.
- Learn Rolle's Theorem, mean value theorems, maxima and minima, indeterminate forms and different applications of calculus.

Limit of functions, Algebra of limits, Continuous functions, Properties of continuous functions, Monotone functions, Inverse function. Differentiability of functions, Successive differentiation, Leibnitz's theorem, Rolle's theorem, Mean value theorem of Lagrange and of Cauchy with geometrical interpretations. Taylor's theorem and Maclaurin's theorem with remainder in Lagrange's and Cauchy's form and application of mean value theorem, Darboux's theorem. Series expansion of $\sin x, \cos x, \log(1+x), (1+x)^n, a^x$ with domain of convergence.

Partial differentiation, Euler's theorem on homogeneous functions.

Determination of maxima and minima, Indeterminate forms.

Tangents and normals, Curvature, Asymptotes, Singular points, Tracing ofcurves.Parametricrepresentation of curves and tracing of parametric curves, Polar coordinates andtracing of curvesin polar coordinates.

References:

1. H. Anton, I. Birens and S. Davis, *Calculus*, John Wiley and Sons, Inc., 2002.
2. G.B. Thomas and R.L. Finney, *Calculus*, Pearson Education, 2007.
3. Richard R.Goldberg, *Methods of Real Analysis*, Oxford and IBH, 2012.
4. Shanti Naryayn and P. K. Mittal, *Differential Calculus*, S Chand.
5. K.C.Maity and R.K.Ghosh, *Differential Calculus*, Books and Allied (P) Ltd.

SEMESTER II

CORE COURSE-1(2)

Course Name: Differential Equations and Vector Calculus

Course Code: BSCPMTMC201

Course Type: C	Course Details: CC-**1(2)**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**……**	**40**

Course Learning Outcomes:
(After the completion of course, the students will have ability to):

- Learn various methods to find the solutions of ordinary differential equations.
- Understand the central concepts in vector calculus; vector-valued functions; gradient, divergence and curl.

First order exact differential equations. Integrating factors, rules to find an integrating factor. First order higher degree equations solvable for x, y, p. Methods for solving higher-order differential equations. Basic theory of linear differential equations, Wronskian, and its properties. Solving a differential equation by reducing its order.

Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations, Total differential equations.

Definition of vector, Resolution of vectors into components along three directions. Scalar and vector products of two and three vectors. Applications to geometry and mechanics**.**

Continuity and differentiability of vector-valued function of one variable. Velocity and acceleration. Vector-valued functions of two and three variables, Gradient of scalar function, Divergence, Curl and their properties.

References:

1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984.
2. B. Spain, *Vector Analysis*, D.Van Nostrand Company Ltd.
3. L. Brand, *Vector Analysis*, Dover Publications Inc.
4. Shanti Narayan**,** *A Text Book of Vector Analysis*, 19th Edn, S.Chand publishing.
5. M. Spiegel, S.Lipschutz , D. Spellman*, Vector Analysis*, McGraw-Hill.

SEMESTER III

CORE COURSE-1(3)

Course Name: Basics in Algebra

Course Code: BSCPMTMC301

Course Type: C	Course Details: CC-**1(3)**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**……**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Understand the concepts of different types of groups, rings and field.
- Solve a system of non-homogeneous linear equations.
- Understand the concepts of real vector space, sub-space and linear dependence and independence of a finite set of vectors.

Definition and examples of groups, examples of abelian and non-abelian groups, the group Zn of integers under addition modulo n and the group U(n) of units under multiplication modulo n. Cyclic groups from number systems, complex roots of unity, circle group, the general linear group GLn(n,R), groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square, the permutation group Sym (n), Group of quaternions, group of permutation, Normal subgroups: their definition, examples, and characterizations, Quotient groups. Divisor of zeros, Rings, Integral domain, fields.

Solution of non-homogeneous system of three linear equations by matrix inversion method. Elementary row and column operations, rank of a matrix, row reduced echelon form and fully reduced normal form.

Vector spaces over reals, simple examples, Euclidean 3-space E^3, linear dependence and independence of a finite set of vectors, sub-spaces, definition and examples.

References:

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Joseph A Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa, 1999.
4. George E Andrews, *Number Theory*, Hindustan Publishing Corporation, 1984.
5. S. K. Mapa, *Higher Algebra (Abstract and Linear),* Sarat Book House.
6. Promode Kumar Saikia, *Linear Algebra With Applications*, Pearson.
7. U. M. Swamy & A. V. S. N. Murthy, *Algebra: Abstract and Modern*, Pearson.
8. Ghosh & Chakravorty, *Higher Algebra (Classical & Modern),* U. N. Dhur & Sons Pvt. Ltd.

SEMESTER IV

CORE COURSE-1(4)

Course Name: Introduction to Real Analysis

Course Code: BSCPMTMC401

Course Type: C	Course Details: CC-**1(4)**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**…….**	**40**

Course Learning Outcomes:
(After the completion of course, the students will have ability to):

- Understand about sets in R, sequences, series of functions and infinite series.

Finite and infinite sets, examples of countable and uncountable sets.Real line, bounded sets,suprema and infima, completeness property of R, Archimedean property of R, intervals. Conceptof cluster points and statement of Bolzano-Weierstrass theorem.

Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences. Cauchy's theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence (monotone convergence theorem without proof).
Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, comparison test, convergence of p-series, Root test, Ratio test, alternating series, Leibnitz's test(Tests of Convergence without proof). Definition and examples of absolute and
conditional convergence.

Sequences and series of functions, Pointwise and uniform convergence. M_n-test, M-test, Statements of the results about uniform convergence and integrability and differentiability of functions, Power series and radius of convergence.

References:

1. T. M. Apostol, *Calculus* (Vol. I), John Wiley and Sons (Asia) P. Ltd., 2002.
2. R.G. Bartle and D. R Sherbert, *Introduction to Real Analysis,* John Wiley and Sons.
3. E. Fischer, *Intermediate Real Analysis*, Springer Verlag, 1983.
4. K.A. Ross, *Elementary Analysis- The Theory of Calculus Series*- Undergraduate Texts In Mathematics, Springer Verlag, 2003.
5. Richard R.Goldberg, *Methods of Real Analysis*, Oxford and IBH, 2012.

SEMESTER V

DESCIPLINE SPECIFIC ELECTIVE(DSE-1(1))

(Choose any one from the following)

Course Name: Mechanics

Course Code: BSCPMTMDSE501

Course Type: D**SE**	Course Details: D**SEC-1(1)**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**……..**	**40**

Course Learning Outcomes:
(After the completion of course, the students will have ability to):

- Understand the basic concepts of mechanics with examples and applications of real world problems.

Rectilinear motion, Motion under repulsive force (i) proportional to distance (ii) inversely proportional to square of the distance, Motion under attractive force inversely proportional to square of the distance, Motion under gravitational acceleration.

Simple harmonic motion, Damped oscillation, Forced and Damped oscillation,Elastic string and spiral string, Hook's law, Particle attached to a horizontal elastic string, Particle attached to a vertical elastic string.

Projectiles motion in vacuum and in a medium with resistance varying linearly as velocity. Motion under forces varying as distance from a fixed point.

Central orbit. Kepler's laws of motion. Motion under inverse square law.

References:

1. S. L. Loney, An Elementary Treatise On the Dynamics of a Particle and a Rigid Body, Cambridge University Press.
2. J. L. Synge and B. A. Griffith, Principles of Mechanics, McGraw-Hill.
3. A. S. Ramsey, Dynamics (Part I & II), Cambridge University Press.
4. F. Chorlton, A Text Book of Dynamics, E. Horwood.

Course Name: Numerical Analysis

Course Code: BSCPMTMDSE502

Course Type: D**SE**	Course Details: D**SEC-1(1)**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**…….**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Understand the problem solving skills using numerical methods,
- Handle large system of equations, non-linearity and and that are often impossible to solve analytically,
- Solve differential equations by numerical methods.

Approximate numbers, significant figures, rounding off numbers. Errors - absolute, relative and percentage. General formula for errors. Errors in arithmetic operations.

Ordinary and divided differences. Newton's forward and backward interpolation formulae. Newton's divided difference formula. Lagrange interpolation formula. Errors in interpolation formulae. Problems related to interpolations.

Numerical integration - Newton- Cotes' formula. Trapezoidal rule and Simpson's 1/3 rule - their inherent error and geometrical significance.

Solution of first order ODE. - Picard's method and Euler's method.

Solution for real roots of algebraic and transcendental equations - Regula Falsi Method , Fixed point iteration method and Newton - Raphson Method - their convergences (statement only).

References:

1. F. B. Hildebrand, Introduction to Numerical Analysis, McGraw-Hill.
2. C. F. Gerald and P. O. WheatleyApplied Numerical Analysis, Pearson.
3. J. B. Scarborough, Numerical Mathematical Analysis, Oxford and IBH Publishing.
4. Nayak, P.K., Numerical Analysis: Theory & Applications, Asian Books Pvt. Ltd.
5. B. Dasgupta, Applied Mathematical Methods, Pearson.
6. A. Gupta and S. C. Bose , Introduction to Numerical Analysis, Academic Press

SEMESTER VI

DISCIPLINE SPECIFIC ELECTIVE(DSE-1(2))

(Choose any one from the following)

Course Name: Linear Programming Problems

Course Code: BSCPMTMDSE601

Course Type: D**SE**	Course Details: D**SEC-1(2)**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**……**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Analyze and solve linear programming models of real life situations.
- Provide graphical solution of linear programming problems with two variables, and illustrate the concept of convex set and extreme points.
- Solve linear programming problems using simplex method.
- Learn techniques to solve transportation and assignment problems.

Motivation of Linear Programming problem. Statement of L.P.P., Formulation of L.P.P., Slack and Surplus variables. L.P.P. is matrix form. Convex set, Hyperplane, Extreme points, convex Polyhedron, Basic solutions and Basic Feasible Solutions (B.F.S.). Degenerate and Non-degenerate B.F.S.

Fundamental Theorem of L.P.P. (Statement only) Reduction of a feasible solution to a B.F.S. Standard form of an L.P.P. Solution by graphical method (for two variables). Simplex method, Simplex algorithm, Artificial variable technique (Big M method).

Duality in L.P.P.: Concept of duality, Fundamental properties of duality, Fundamental theorems of duality, Duality & Simplex method.

Transportation Problem (T.P.): Mathematical formulation, Existence of feasible solution, Loops and their properties, Initial basic feasible solutions (different methods, like North West corner, Row minima, Column minima, Matrix minima & Vogel's Approximation method), Optimal solutions, Degeneracy in T.P., Unbalanced T.P.

References:

1. G. Hadley, Linear Programming, Addison – Wesley.
2. R. Bronson and G. Naadimuthu, Schaum's Outline of Operations Research, Schaum's Outline.
3. J.G. Chakravorty and P.R. Ghosh, Linear Programming and Game Theory, Moulik Library.
4. J. K. Sharma, Operations Research – Theory and Applications, Macmillan.
5. H. A. Taha, Operations Research – An Introduction, Prentice-Hall

Course Name: Probability & Statistics

Course Code: BSCPMTMDSE602

Course Type: D**SE**	Course Details: D**SEC-1(2)**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**…….**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Understand the basic concepts on probability and statistics.
- Understand the various probability distributions and their applications, mathematical expectation, moments.

Elements of probability Theory: Random experiment, Outcome, Event, Mutually Exclusive Events,Equally likely and Exhaustive. Classical definition of probability, Theorems of Total Probability, Conditionalprobability and Statistical Independence. Shortcoming of the classicaldefinition. Axiomatic approach problems, Random Variable and its Expectation, Theorems on mathematicalexpectation. Joint distribution of two random variables.
Theoretical Probability Distribution Discrete and Continuous (p.m.f., p.d.f.) Binomial, Poisson and Normaldistributions and their properties.

Mathematical expectation, Moments, Measures of skewness and kurtosis, Moment generating function, Characteristic function.

Theory of estimation, point estimation, unbiasedness, minimum variance, consistency, efficiency, maximum likelihood method; Interval estimation –confidence interval, approximate confidence interval.

Bivariate Frequency Distribution. Scatter Diagram, Correlation co-efficient- definition and properties. Regressionlines.

References:

1. S. Ross – First Course in Probability, Pearson Education.
2. R. V. Hogg, J. W.Mekenard and A.T. Craig, Introduction to Mathematical Statistics, Pearson Education.
3. A.Gupta, Groundwork of Mathematical Probability & Statistics, Academic publishers.
4. Banerjee, De & Sen, Mathematical Probability, U. N. Dhur & Sons Pvt. Ltd.

Semester III

SKILL ENHANCEMENT COURSE (SEC-1)

Course Name: Sets and Mathematical Logic

Course Code: BSCPMTMSE301

Course Type: **SE**	Course Details: **SEC-1**			L-T-P: **4-0-0**	
Credit: **4**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		.....	**10**	**.....**	**40**

Course Learning Outcomes:
(After the completion of course, the students will have ability to):

- Understand about different propositions of logic, truth table, logical operators, various operations and relations related to sets.

Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.

Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinitesets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set.

Difference and Symmetric difference of two sets. Set identities, generalized union and intersections. Relation: Product set. Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation. Partial ordering relations, n- ary relations.

References:

1. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998.
2. P.R. Halmos, Naive Set Theory, Springer, 1974.
3. E. Kamke, Theory of Sets, Dover Publishers, 1950.

Semester IV

SKILL ENHANCEMENT COURSE (SEC-2)

Course Name: Boolean Algebra

Course Code: BSCPMTMSE401

Course Type: **SE**	Course Details: **SEC-2**			L-T-P: **4-0-0**	
Credit: **4**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**…….**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Understand Boolean algebra and Boolean functions, logic gates,switching circuitsand their applications.
- Apply a number of proof techniques to theorems in language design.

Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, maximal and minimal elements, lattices as ordered sets, complete lattices, lattices as algebraic structures, sublattices, products and homomorphisms. Definition, examples and properties of modular and distributivelattices, Boolean algebras.

Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, switching circuits and minimization of switching circuits using Boolean algebra.

References:

1. B A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge,1990.
2. Rudolf Lidl and G¨unter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

Semester V

SKILL ENHANCEMENT COURSE (SEC-3)

Course Name: Number Theory

Course Code: BSCPMTMSE501

Course Type: **SE**	Course Details: **SEC-3**			L-T-P: **4-0-0**	
Credit: **4**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**……**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Learn Lame's theorem, linear Diophantine equation, congruences, Goldbach conjecture, Euler's phi-function.

Division algorithm, Lame'e theorem, Linear Diophantine equation, fundamental theorem of arithmetic, prime counting function, statement of prime number theorem, Goldbach conjecture, binary and decimal representation of integers, linear congruences, complete set of residues.

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobious inversion formula, the greatest integer function, Euler's phi-function.

References:

1. David M. Burton, Elementary number Theory, Tata McGraw-Hill.
2. N. Robinns, Beginning Number Theory, Narosa Publishing House.

Semester VI

SKILL ENHANCEMENT COURSE (SEC-4)

Course Name: Graph Theory

Course Code: BSCPMTMSE601

Course Type: **SE**	Course Details: **SEC-4**			L-T-P: **4-0-0**	
Credit: **4**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**……**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Appreciate the definition and basics of graphs along with types and their examples.
- Understand the Eulerian circuits, Eulerian graphs, Hamiltonian cycles, representation of a graph by matrix.
- Relate the graph theory to the real-world problems.

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bipartite graphs isomorphism of graphs.

Eulerian circuits, Eulerian graph, semi-Eulerian graph and theorems, Hamiltonian cycles and theorems.Representation of a graph by a matrix, the adjacency matrix, incidence matrix, weighted graph,

Travelling salesman's problem, shortest path, Tree and their properties, spanning tree, Dijkstra's algorithm, Warshall algorithm.

References:

1. J. Clark and D. A. Holton: A First Look at Graph Theory, Allied Publishers Ltd., 1995.
2. D. S. Malik, M. K. Sen and S. Ghosh: Introduction to Graph Theory, Cengage Learning Asia.
3. Nar Sing Deo : *Graph Theory,* Prentice-Hall, 1974.
4. J. A. Bondy and U.S.R. Murty: Graph Theory with Applications, Macmillan, 1976.
5. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.

***