Annexure-1

BABU BANARASI DAS UNIVERSITY, LUCKNOW

Department of Mathematics & Computer Science
School of Basic Sciences

Program Structure

B.Sc. (Hons./Hons. with research) Mathematics and B.Sc. (Hons./Hons. with research) Computer Science

(As per National Education Policy 2020)

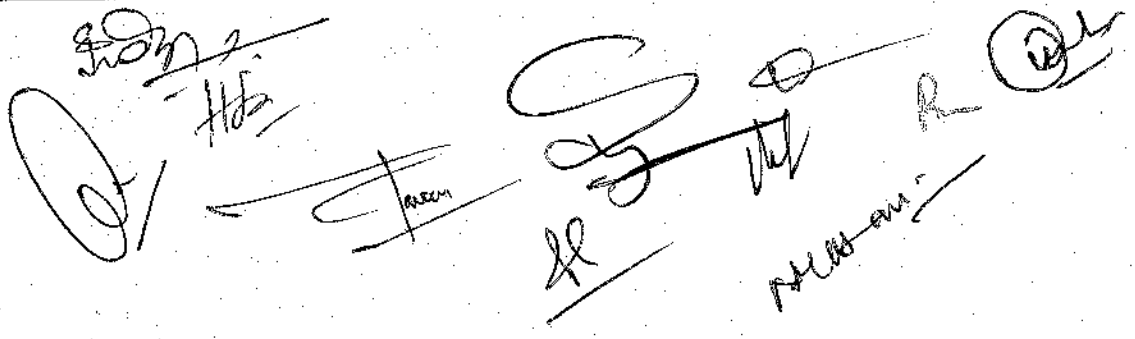
Semester	Major Core Course (DSC) 4 Credits	Major Elective Course (DSE) 4 Cr	Minor Course (GE) 4 Credits	Co-Curricular Course (CC) 3 Credits	Vocational Course (VC) 2 Credits	Apprenticeship/ Internship/ Project/ Community Outreach/ MOOC (AIPCM) 2 Credits	Major Project/ Dissertation/ Academic Project 6 Credits	General Proficiency (GP) / Seminar 1 Credit	Total Credit
I	DSC1 DSC2 DSC3		GE1	CC1	VC1			1	22
II	DSC4 DSC5 DSC6		GE2	CC2	VC2			1	22
III	DSC7 DSC8 DSC9		GE3	CC3	VC3 Or AIPCM			1	22
IV	DSC10 DSC11 DSC12		GE4	CC4	VC4 Or AIPCM			1	22
V	DSC13 DSC14 DSC15	DSE1	GE5		VC5 Or AIPCM				22
VI	DSC16 DSC17 DSC18	DSE2	GE6			Project/ Dissertation 2 Credit			22
VII	DSC19	Three DSE or Two DSE and One GE or One DSE and Two GE					Dissertation/ Academic Project/ Internship		22
VIII	DSC20	Three DSE or Two DSE and One GE or One DSE and Two GE					Dissertation/ Academic Project/ Internship		22

School of Basic Sciences
Program Outcomes (PO) and Program Specific Outcomes (PSO)

Program Outcomes (PO) - B.Sc. (Hons./ Hons. with Research)	
PO1	Scientific Knowledge: Apply the knowledge of mathematics, computer science and various specializations to the solution of complex computational and mathematical problems.
PO2	Persistent learning: Recognize the need to engage in lifelong learning through continuing education and research.
PO3	Problem Analysis: To recognize, define, formulate, review literature and analyze complex mathematical and computational problems reaching substantiated conclusions using principles of mathematics, electronics and computer science.
PO4	Coping with Complex Scientific problems: Maneuvering research methods including programs and experiments and analysis and design of systems.
PO5	Design /Development of Solutions: Design solutions for complex computational and mathematical problems that meet the specified needs with appropriate consideration for the social and environmental consideration.
PO6	Uses of Modern Tools and Techniques: An ability to design, implement, and evaluate a computational and mathematical system using latest tools and methods to meet desired needs within stipulated time boundaries.
PO7	Team Work: Function in multidisciplinary teams by working cooperatively, creatively and responsibly as a member of a team.
PO8	Application of Knowledge: An ability to apply knowledge of mathematics, electronics and computing appropriate to the discipline.
PO9	Handling Multidisciplinary Projects: Demonstrate knowledge and understanding of scientific and computational principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.
PO10	Professional Enhancement: Identifying the need for learners and enhancing the ability to engage in continuous professional development.
PO11	Technological Rationality: Apply current technical concepts and practices in the core information technologies of human machine interaction, information management, applied mathematics, programming, networking, and web systems and technologies.
PO12	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the scientific practice.

Program Specific Outcomes (PSO) of B.Sc. (Hons./ Hons. with Research) in Mathematics	
PSO1	Apply the mathematical complex solutions based on scientific/mathematical principles for the analysis and interpretation of mathematical problems.
PSO2	Inculcate, develop and implement ethical principles and responsibilities of a mathematician to serve the society and have necessary skills and expertise in the field of research and developments through seminar and dissertation.

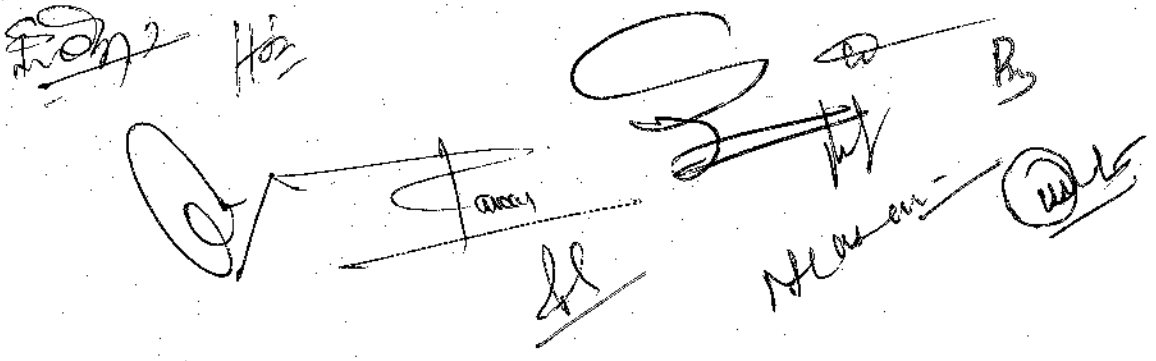
Program Specific Outcomes (PSO) of B.Sc. (Hons./ Hons. with Research) in Computer Science	
PSO1	Ability to understand the fundamentals and principles of computer systems and the sound knowledge about the hardware and software aspects of computer systems.
PSO2	Ability to analyze the problem and design and develop software solutions and understand the structure and software development methodologies and also have necessary skills and expertise in the field of research and developments through seminar and dissertation.



Annexure-3

Discipline Specific Core Courses (DSC) for B.Sc. (Hons./ Hons. with Research) in Mathematics										
DSC	Course Code	Course Name	Contact Hours			Marks			Cr	Exam Hrs.
			L	T	P	CIA	ESE	Total		
DSC1	NBSM3101	Algebra	3	1	-	40	60	100	4	3
DSC2	NBSM3102	Elementary Real Analysis	3	1	-	40	60	100	4	3
DSC3	NBSM3103	Calculus	3	1	-	40	60	100	4	3
DSC4	NBSM3201	Theory of Real Functions	3	1	-	40	60	100	4	3
DSC5	NBSM3202	Ordinary Differential Equations	3	1	-	40	60	100	4	3
DSC6	NBSM3203	Geometry and Vector Calculus	3	1	-	40	60	100	4	3
DSC7	NBSM3301	Group Theory	3	1	-	40	60	100	4	3
DSC8	NBSM3302	Multivariate Calculus	3	1	-	40	60	100	4	3
DSC9	NBSM3303	Partial Differential equations	3	1	-	40	60	100	4	3
DSC10	NBSM3401	Ring Theory and Vector Spaces	3	1	-	40	60	100	4	3
DSC11	NBSM3402	Riemann Integration & Series of Functions	3	1	-	40	60	100	4	3
DSC12	NBSM3403	Graph Theory	3	1	-	40	60	100	4	3
DSC13	NBSM3501	Linear Algebra	3	1	-	40	60	100	4	3
DSC14	NBSM3502	Set Theory and Metric Spaces	3	1	-	40	60	100	4	3
DSC15	NBSM3503	Numerical Analysis	3	1	-	40	60	100	4	3
DSC16	NBSM3601	Complex Analysis	3	1	-	40	60	100	4	3
DSC17	NBSM3602	Integral Transform and Fourier Analysis	3	1	-	40	60	100	4	3
DSC18	NBSM3603	Differential Geometry & Tensor Analysis	3	1	-	40	60	100	4	3
DSC19	NBSM3701	Discrete Mathematics	3	1	-	40	60	100	4	3
DSC20	NBSM3801	Ordinary and Partial Differential Equations	3	1	-	40	60	100	4	3

Discipline Specific Elective Courses (DSE) for B.Sc. (Hons./ Hons. with Research) in Mathematics											
DSE	Course Code	Course Name	Contact Hours			Marks			Cr	Exam Hrs.
			L	T	P	CIA	ESE	Total		
DSE1A	NBSME3501	Mathematical Modelling	3	1	-	40	60	100	4	3
DSE1B	NBSME3502	Mechanics	3	1	-	40	60	100	4	3
DSE1C	NBSME3503	Number Theory	3	1	-	40	60	100	4	3
DSE2A	NBSME3601	Boolean Algebra & Automata Theory	3	1	-	40	60	100	4	3
DSE2B	NBSME3602	Analytical Geometry	3	1	-	40	60	100	4	3
DSE2C	NBSME3603	Module Theory	3	1	-	40	60	100	4	3
DSE3A	NBSME3701	Abstract Algebra	3	1	-	40	60	100	4	3
DSE3B	NBSME3702	Topology	3	1	-	40	60	100	4	3
DSE3C	NBSME3703	Real Analysis	3	1		40	60	100	4	3
DSE3D	NBSME3704	Fuzzy Mathematics	3	1	-	40	60	100	4	3
DSE4A	NBSME3801	Advance Algebra	3	1	-	40	60	100	4	3
DSE4B	NBSME3802	Advance Real Analysis	3	1		40	60	100	4	3
DSE4C	NBSME3803	Functional Analysis	3	1		40	60	100	4	3
DSE4D	NBSME3804	Computational Fluid Dynamics	3	1		40	60	100	4	3



Program	**B.Sc. (Hons./ Hons. with Research) Mathematics**				
Year	**1**	**Semester**	**I**		
Course Name	**Algebra**				
Code	**NBSM3101**				
Course Type	**DSC**	**L**	**T**	**P**	**Credit**
Pre-Requisite	**10+2 Mathematics**	**3**	1	-	4
Course Objectives	The objective of the course is to introduce the basic concepts of theory of equations, number theory, group theory, symmetry group of a plane figure, cyclic groups, classification of subgroups of cyclic groups and matrices.				
Course Outcomes:					
CO1	To be able to solve cubic and quartic polynomial equations with special condition on roots and in general.				
CO2	To understand the basic concepts of modular arithmetic and basic properties of congruences.				
CO3	To be able to recognize the algebraic structure, namely groups, and classify subgroups of cyclic groups.				
CO4	To be able to recognize consistent and inconsistent systems of linear equations using matrix method.				

Module	**Course Contents**	**Contact Hrs.**	**Mapped CO**
1	General properties of polynomials and equations. Fundamental theorem of algebra, Relations between the roots and the coefficients ([2] Chapter 3). Newton's method for integral roots, Descartes' rule of signs; De-Moivre's theorem for integer and rational indices and their applications ([2] Chapter 4). The nth roots of unity, Synthetic division method ([2] Chapter 3), Cardan's solution of the cubic, Descartes' solution of the quartic equation; ([3] Chapter 13).	15	CO1
2	Division algorithm in $\mathbb{Z}$, Divisibility and the Euclidean algorithm ([1] Chapter 4), Fundamental theorem of arithmetic, Modular arithmetic and basic properties of congruences ([1] Chapter 4).	15	CO2
3	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, Cyclic groups and properties ([4] Chapter 2).	15	CO3
4	Rank of a matrix, Rank and elementary operations, Row reduction and echelon forms ([2] Chapter 6) System of linear equations, Solution of the matrix equation $AX = B$([2] Chapter 7), Solution sets of linear systems, linear independence, The Characteristic equation and Cayley-Hamilton Theorem ([2] Chapter 8), Eigenvalues and Eigenvectors ([2] Chapter 8).	15	CO4

Suggested Readings

1. Goodaire, Edgar G., & Parmenter, Michael M. (2006). Discrete Mathematics with Graph

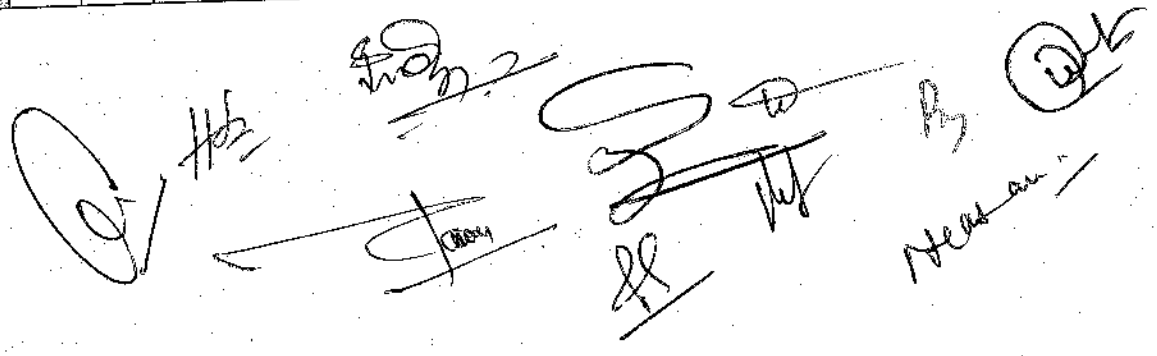
Theory (3rd ed.). Pearson Education Pvt. Ltd. Indian Reprint 2018.
2. MK Singal, Asha Rani Singal, (2020); Algebra (31st Ed) R Chand &Co, New Delhi.
3. Chandrika Prasad, (1963). Text Book on Algebra and Theory of Equations Pothishala Pvt. Ltd.
4. Gallian, Joseph. A. (2017). Contemporary Abstract Algebra (9th ed.). Cengage Learning India Private Limited, Delhi. Indian Reprint 2021.

Online Resources

1. https://nptel.ac.in/courses/111107112
2. https://nptel.ac.in/courses/111105112
3. https://archive.nptel.ac.in/courses/111/101/111101137/
4. https://onlinecourses.swayam2.ac.in/cec21_ma07/preview

Course Articulation Matrix

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1							1					1	2
CO2	1		1					1					1	1
CO3	1	1	1					1					2	1
CO4	1	1	1	1				2					2	2



Program	**B.Sc. (Hons./ Hons. with Research) Mathematics**				
Year	**1**	**Semester**	**1**		
Course Name	**Elementary Real Analysis**				
Code	**NBSM3102**				
Course Type	**DSC**	**L**	**T**	**P**	**Credit**
Pre-Requisite	**10+2 Mathematics**	**3**	**1**	**-**	**4**
Course Objectives	The object of the course is to understanding of real number system and the concepts of convergence and divergence of sequences and series of real numbers.				

Course Outcomes	
CO1	To understand the fundamental properties of the real numbers, including completeness, Archimedean and density property of rational numbers in $\mathbb{R}$
CO2	To understand nested interval property, neighbourhood of a point in $\mathbb{R}$ and learn to define sequences in terms of functions from $\mathbb{N}$ to a subset of $\mathbb{R}$ and find the limit, recognize convergent, divergent and monotonic sequences.
CO3	To recognize sub-sequences, calculate limit superior and inferior of a bounded sequence. Learn to identify infinite series and its convergence.
CO4	To be able to apply the ratio, root, alternating series and limit comparison tests for convergence ardabsolute convergence of an infinite series of real numbers.

Module	**Course Contents**	**Contact Hrs.**	**Mapped CO**
1	Algebraic and order properties of $\mathbb{R}$, Absolute value of a real number, Bounded above and bounded below sets, Supremum and infimum of a non-empty subset of $\mathbb{R}$, The completeness property of $\mathbb{R}$, Archimedean property, Density of rational numbers in $\mathbb{R}$ ([1] Chapter 2).	15	CO1
2	Definition and types of intervals, nested interval property ([1] Chapter 2), Neighbourhood of a point in $\mathbb{R}$, open and closed set in $\mathbb{R}$ ([1] Chapter 11). **Sequences:** Sequences and their limits, Convergent sequence, Limit theorems, Monotone sequences, Monotone convergence theorem ([1] Chapter 3).	15	CO2
3	Subsequences, Bolzano-Weierstrass theorem for sequences. Limit superior and limit inferior for bounded sequence, Cauchy sequence, Cauchy's convergence criterion ([1] Chapter 3). **Infinite Series:** Convergence and divergence of infinite series of real numbers, Necessary condition for convergence ([3] Chapter 8).	15	CO3
4	Cauchy criterion for convergence, Tests for convergence of positive terms series, Integral test, Basic comparison test, Limit comparison test, D'Alembert's ratio test, Cauchy's n^{th} root test, Raabe's test, Alternating series, Leibniz test, Absolute and conditional convergence ([3] Chapter 8).	15	CO4

Suggested Readings

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.

Online Resources

1. https://nptel.ac.in/courses/122104017
2. https://nptel.ac.in/courses/111106142

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1					1					1	1
CO2	1	1	1					2					1	2
CO3	2	2	1					2					1	2
CO4	1	2	1					2					2	2

Program	**B.Sc. (Hons./ Hons. with Research) Mathematics**				
Year	1	**Semester**	**1**		
Course Name	**Calculus**				
Code	**NBSM3103**				
Course Type	**DSC**	**L**	**T**	**P**	**Credit**
Pre-Requisite	**10+2 Mathematics**	**3**	1	-	4
Course Objectives	The objective of the course is to provide the concept of limit, continuity and differentiability and to apply the knowledge to solve problems.				
Course Outcomes					
CO1	To understand continuity and differentiability in terms of limits and graphs of certain functions.				
CO2	To understand the consequences of various mean value theorems for differentipable functions.				
CO3	To understand the concepts of asymptotes and inflexion points in curve tracing.				
CO4	To be able to compute the reduction formulae of standard transcendental functions with applications.				

Module	**Course Contents**	**Contact Hrs.**	**Mapped CO**
1	$\varepsilon - \delta$ definition of a limit, Infinite limits, Continuity and types of discontinuities ([1] Chapter 2); Differentiability of a function ([1] Chapter 3), Successive differentiation: Calculation of the nth derivatives, Leibnitz theorem ([1] Chapter 5). Partial differentiation, Euler's theorem on homogeneous functions ([1] Chapter 12).	15	CO1
2	Rolle's theorem, Mean value theorems, Taylor's and Maclaurin's series expansions of one variable ([1] Chapter 7). Indeterminate forms ([1] Chapter 16).	15	CO2
3	Asymptotes ([1] Chapter 9), Curvature, Concavity and inflexion points ([1] Chapter 10), Singular points, Tangents at the origin and nature of singular points, Curve tracing ([1] Chapter 11).	15	CO3
4	Integration of irrational algebraic functions and transcendental functions, Reduction formulae for $\int \sin^n x\,dx$, $\int \cos^n x\,dx$, $\int \sin^m x \cos^n x\,dx$, $\int x^n \sin mx\,dx$, $\int x^n \cos mx\,dx$ and $\int x^n (\log x)^m\,dx$ ([2] Chapter 3&4). Definite integral as a limit of sum ([2] Chapter 5),	15	CO4

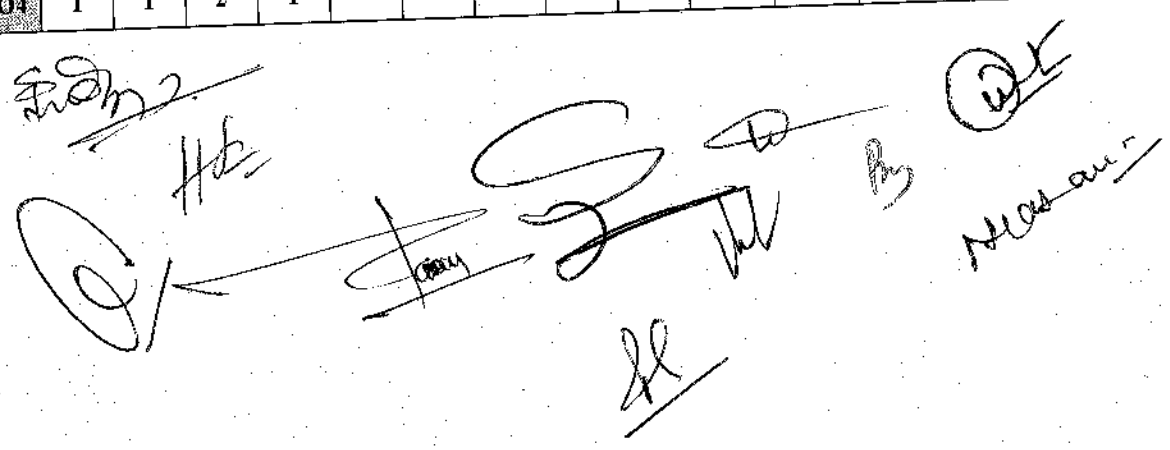
Suggested Readings

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

Online Resources

1. https://archive.nptel.ac.in/courses/111/106/111106146/
2.https://vidyamitra.inflibnet.ac.in/index.php/search?subject%5B%5D=&course%5B%5D=Calculus&domain%5B%5D=Physical+%26+Basic+Sciences

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1				2			1		2	1
CO2	2	2	2	1				2			2		2	2
CO3	1	2	1	1				1			1		1	1
CO4	1	1	2	1				2					1	1



Program	B.Sc. (Hons./ Hons. with Research) Mathematics				
Year	I	Semester	2		
Course Name	Theory of Real Functions				
Code	NBSM3201				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	10+2 Mathematics	3	1	-	4
Course Objectives	The objective of the course is to provide a knowledge and the key concepts of calculus, namely, limits, continuity, differentiability and their applications.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to					
CO1	To be able to calculate the limit and examine the continuity of a function at a point.				
CO2	To understand the concept of differentiability and chain rule of differentiability.				
CO3	To understand the concept behind various mean value theorems for differentiable functions.				
CO4	To be able to find expansions for algebraic & transcendental function with the help of Taylor's & Maclaurin's theorem.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Limits of functions, limit theorems ([1]: Chapter 4). Continuous functions, algebra of continuous functions, continuous functions on interval, Boundedness theorem, Maximum- minimum theorem, location of roots theorem, Bolzano intermediate value theorem, preservation of intervals theorem, uniform continuity, non-uniform continuity criteria, uniform continuity theorem. ([1]: Chapter 5).	15	CO1
2	Differentiability of a function at a point and in an interval, The Chain Rule, Caratheodory's theorem, algebra of differentiable functions, Interior extremum theorem. ([1]: Chapter 6).	15	CO2
3	Rolle's theorem, First mean value theorem. Intermediate value property for derivatives, Darboux's theorem, Cauchy's mean value theorem, Application of mean value theorems([1]: Chapter 6).	15	CO3
4	Taylor's theorem with Lagrange's and Cauchy's form of remainders, Taylor series, Maclaurin series, Expansions of exponential, Logarithmic and Trigonometric functions. ([1]: Chapter 6).	15	CO4

Suggested Readings

1. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis (4th Edition), John Wileyand Sons (Asia) Pvt. Ltd., Singapore, 2010.
2. K. A. Ross, Elementary Analysis, The Theory of Calculus, Undergraduate Texts in

Mathematics, Springer (SIE), Indian reprint, 2004.
3. A. Mattuck, Introduction to Analysis, Prentice Hall, 1999.
4. S. R. Ghorpade and B.V. Limaye, A Course in Calculus and Real Analysis, Springer, 2006.

Online Resources

1. https://vidyamitra.inflibnet.ac.in/index.php/search?subject%5B%5D=&course%5B%5D=A+basic+course+in+real+analysis&domain%5B%5D=Physical+%26+Basic+Sciences

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	1				3	2				2	2
CO2	2	2	2	1				3	2				2	2
CO3	2	3	2	1				2	2				2	1
CO4	2	3	2	1				2	2				2	1

Program	**B.Sc. (Hons./ Hons. with Research) Mathematics**				
Year	1	**Semester**	2		
Course Name	**Ordinary Differential Equations**				
Code	**NBSM3202**				
Course Type	**DSC**	**L**	**T**	**P**	**Credit**
Pre-Requisite	**10+2 Mathematics**	**3**	1	-	4
Course Objectives	The objective of this course is to introduce the students to understand and solve of Differential Equations, create various Mathematical models and their applications in everyday life.				

Course Outcomes	
CO1	To understand the genesis of ordinary differential equations of first order and first degree.
CO2	To learn various techniques of getting exact solutions of linear differential equations of Second and higher order.
CO3	To develop the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.
CO4	To formulate mathematical models in the form of ordinary differential equations to suggest possible solutions of the day to day problems arising in physical, chemical and biological disciplines.

Module	**Course Contents**	**Contact Hrs.**	**Mapped CO**
1	Basic concepts and genesis of ordinary differential equations, Order and degree of a differential equation ([2] Chapter 1, Part I), Differential equations of first order and first degree, Equations in which variables are separable, Homogeneous equations, Linear differential equations and equations reducible to linear form, Exact differential equations, Integrating factor ([2] Chapter 2, Part I), First order higher degree equations solvable for x, y and p. Clairaut's form and singular solutions ([2] Chapter 4, Part I).	15	CO1
2	Second Order Linear Differential Equations: Solutions of homogeneous linear ordinary differential equations of second order with constant coefficients ([1] Chapter 2), Euler-Cauchy's linear differential equations, Legendre's linear differential equations. Transformations of the equation by changing the dependent/independent variable, Method of variation of parameters ([2] Chapter 10, Part I), Reduction of order ([1] Chapter 2). Higher Order Linear Differential Equations: Linearly dependent and linearly independent solutions on an interval, Wronskian and its properties.	15	CO2
3	Power series method ([2] Chapter 7, Part II), Frobenius method ([2] Chapter 8, Part II), Legendre's equation, Legendre polynomials, Rodrigue's formula, Orthogonality of Legendre polynomials ([2] Chapter 9, Part II), Bessel's equation, Bessel	15	CO3

	functions and their properties, Recurrence relations ([2] Chapter 11, Part II).		
4	Application of first order differential equations to acceleration-velocity model ([5] Chapter 2), Growth and Decay model ([4] Chapter 2). Introduction to compartmental models ([4] Chapter 2), Lake pollution model (with case study of Lake Burley Griffin) ([4] Chapter 2), Drug Assimilation models ([4] Chapter 2), population models (with limited growth, exponential growth) Epidemic models ([5] Chapter 2 or [4] Chapter 3).	15	CO4

Suggested Readings

1. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley.
2. M. D. Raisinghania, Advanced Differential Equations, Eighteenth Edition 2013, S. Chand.
3. H. I. Freedman (1980). Deterministic Mathematical Models in Population Ecology. Marcel Dekker Inc.
4. Barnes, Belinda &Fulford, Glenn R. (2015). Mathematical Modelling with Case Studies, Using Maple and MATLAB (3rd ed.). CRC Press, Taylor & Francis Group.
5. Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). Differential Equation and Boundary Value Problems: Computing and Modeling(5th ed.). Pearson Education

Online Resources

1. https://archive.nptel.ac.in/courses/111/106/111106100/

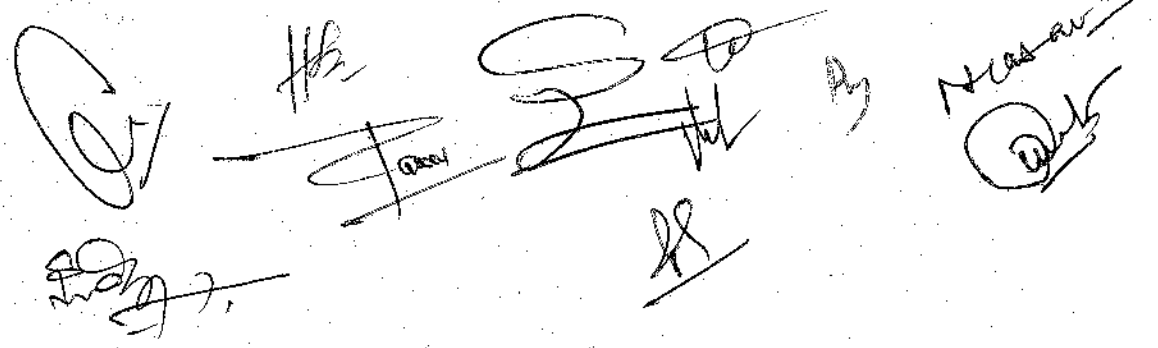
Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1		2			1					1	2
CO2	1	2	2		3			3					2	3
CO3	2	2	1		2			1					2	2
CO4	2	3	2	1	3			2					3	3

Program	**B.Sc. (Hons./ Hons. with Research) Mathematics**				
Year	1	**Semester**	2		
Course Name	**Geometry and Vector Calculus**				
Code	**NBSM3203**				
Course Type	**DSC**	**L**	**T**	**P**	**Credit**
Pre-Requisite	**10+2 Mathematics**	**3**	1	-	4
Course Objectives	The objective of the course is to introduce the basic tools of vector calculus and geometric properties of different conic sections which are helpful in understanding their applications in Planetary motion and real-world problems.				
Course Outcomes					
CO1	To understand the geometrical terminology and have a detailed clear cut idea of planes and straight lines.				
CO2	To be able to explain the geometrical and theoretical concept of Sphere with its properties.				
CO3	To be able to explain the concept of three dimensional spaces				
CO4	To understand the calculus of vector valued functions and apply the knowledge to solve various problem.				

Module	**Course Contents**	**Contact Hrs.**	**Mapped CO**
1	Planes: Distance of a point from a plane, Angle between two planes, pair of planes, Bisectors of angles between two planes, Straight lines: Equations of straight lines, Distance of a point from a straight line, Distance between two straight lines, Distance between a straight line and a plane, ([4] Chapter III).	15	CO1
2	Spheres: Different forms, Intersection of two spheres, Orthogonal intersection, Tangents and normal, Radical plane, Radical line, Coaxial system of spheres, Pole, Polar and Conjugacy ([4] Chapter V).	15	CO2
3	Space curves, Algebraic curves, Ruled surfaces, Some standard surfaces, Classification of quadric surfaces, Cone, Cylinder, Central conicoids. Tangent plane, Normal, Polar planes and Polar lines. ([4] Chapter VI,VII).	15	CO3
4	Vector valued functions and their graphs, Limits and continuity of vector functions, Differentiation and integration of vector functions, Projectile motion, Unit tangent, Normal and binormal vectors, Curvature and Torsion ([5] Chapter 13)	15	CO4

Suggested Readings

1. Leonard Eugene Dickson (2009). First Course in the Theory of Equations. The Project Gutenberg E Book (http://www.gutenberg.org/ebooks/29785).
2. Edgar G. Goodaire& Michael M. Parmenter (2015). Discrete Mathematics with Graph Theory (3rd edition).Pearson Education Pvt. Ltd. India.

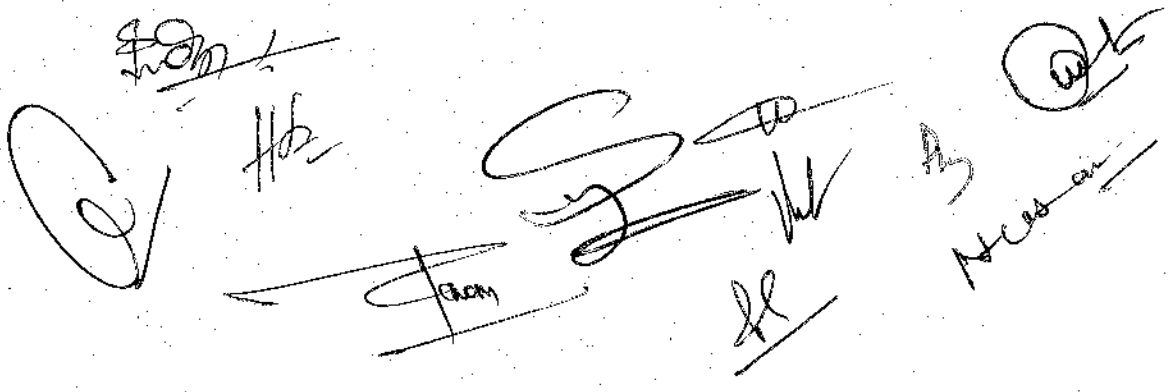


3. David C. Lay, Steven R. Lay & Judi J. McDonald (2016). Linear Algebra and its Applications (5th edition).Pearson Education Pvt. Ltd. India.
4. Robert J. T. Bill (1994). An Elementary Treatise on Coordinate Geometry of Three Dimensions. Macmillan India Ltd.
5. Thomas, Jr. George B., Weir, Maurice D., & Hass, Joel (2014). Thomas' Calculus
6. (13thed.)Pearson Education, Delhi. Indian Reprint 2017.
7. B. C. Das, B. N. Mukherjee. Differential Calculus (55th Edition), U.N.Dhur& Sons Private Ltd., Kolkata (2015)

Online Resources

1. https://nptel.ac.in/courses/111104095
2. https://archive.nptel.ac.in/courses/111/105/111105122/

Course Articulation Matrix													
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1					1					1	2
CO2	1	1	1	1					1				1	1
CO3	1	1	1	1					1				1	1
CO4	1	2	1	1	1			1	1				2	2



Annexure-6

Minor Course (GE) for B.Sc. (Hons./ Hons. with Research) in Mathematics

GE	Course Code	Course Name	Contact Hours			Marks			Cr	Exam Hrs.
			L	T	P	CIA	ESE	Total		
GE1 A	NBSC3102	Programming using C	3	-	-	40	60	100	3	3
	NBSC3151	Programming using C Lab	-	-	2	40	60	100	1	3
GE1 B	NBBA5102	Business Environment	3	1	-	40	60	100	4	3
GE1 C	NBSE1101	Descriptive Statistic	3	1	-	40	60	100	4	3
GE2 A	NBSC3201	Data Structure using C	3	-	-	40	60	100	3	3
	NBSC3251	Data Structure using C Lab			2	40	60	100	1	3
GE2 B	NBBA5203	Business Organisation	3	1	-	40	60	100	4	3
GE2 C	NBSE1201	Probability & Distribution	3	1	-	40	60	100	4	3
GE3 A	NBSC3301	Java Programing	3	-	-	40	60	100	3	3
	NBSC3351	Java Programing Lab	-	-	2	40	60	100	1	3
GE3 B	NBBA5302	Rural Management	3	1	-	40	60	100	4	3
GE3 C	NBSE1301	Statistical Inference	3	1	-	40	60	100	4	3
GE4 A	NBSC3401	Database Management System	3	-	-	40	60	100	3	3
	NBSC3451	Database Management System (Lab)	-	-	2	40	60	100	1	3
GE4 B	NBBA5402	Human Resource Management and Development	3	1	-	40	60	100	4	3
GE4 C	NBSE1401	Survey Sampling	3	1	-	40	60	100	4	3
GE5 A	NBSC3501	Web Technologies	3	1	-	40	60	100	4	3
	NBSC3551	Web Technologies (Lab)	-	-	2	40	60	100	1	3
GE5 B	NBBA5501	Business policy and strategic	3	1	-	40	60	100	4	3
GE5 C	NBSE1501	Analysis of Variance & Design of Experiment.	3	1	-	40	60	100	4	3
GE6 A	NBSC3603	Soft Computing	3	1	-	40	60	100	4	3
GE6 B	NBBA5602	Entrepreneurship & Small business Management	3	1	-	40	60	100	4	3
GE6 C	NBSE1601	Operations Research	3	1	-	40	60	100	4	3
GE7 A	NBSCE3701	Big Data Analysis	3	1	-	40	60	100	4	3
GE7 B	NBBA5703	Income tax Law & Practice	3	1	-	40	60	100	4	3
GE7 C	NBSE1701	Optimization Techniques	3	1	-	40	60	100	4	3
GE8 A	NBSCE3801	Augmented & Virtual Reality	3	1	-	40	60	100	4	3
GE8 B	NBBA5801	Banking & Insurance	3	1	-	40	60	100	4	3
GE8 C	NBSE1801	Applied Statistics	3	1	-	40	60	100	4	3

Program	B.Sc. (Hons./ Hons. with Research) Computer Science				
Year	1	Semester	I		
Course Name	Programming using C				
Code	NBSC3102				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic knowledge of computer and its operations	3	-	-	3
Course Objectives	The course is designed to provide complete knowledge of C language. Students will be able to develop logics which will help them to create programs, applications in C. Also by learning the basic programming constructs they can easily switch over to any other language in future				
Course Outcomes					
CO1	To learn and develop simple algorithms to solve various types of problems and develop problem solving skills coupled with Top-Down design principles.				
CO2	To learn the strategies of writing efficient and well-structured computer programs and develop the skills for formulating Iterative solutions to various problems.				
CO3	To learn various types of Operators and Functions in C programming and learn the concept of single and multi-dimensional Arrays & various Searching and Sorting techniques.				
CO4	To enhance the learning of C programming by using Pointers & various types of Dynamic Memory Allocation functions.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Introduction to Programming Languages**: Concept of Assembler, Compiler, Interpreter ([1] Chapter 1).The Role of Programming Languages, HLL, LLL, Programming Paradigms, Programming Environments. ([1] Chapter 1).Programming Basics: Structure of C Program, Writing and Executing the first C program, Syntax and Logical Errors in Compilation, Object and Executable Code. Components of C language: Standard I/O in C, Fundamental Data Types, Variables and Memory Locations, Storage Classes ([1] Chapter 1,2).	15	CO1
2	**Arithmetic expressions & Conditional Branching:** Arithmetic Expressions and Precedence, Operators and Expression using Numeric and Relational Operators, Mixed-mode Operations, Type Conversion, Logical Operators, Bit-wise Operators, Assignment Operators, Operator Precedence and Associativity. **Conditional Branching**: Applying if-else and Switch-case Statements, Nesting If-Else([1] Chapter 6).**Loops & Functions**: Iteration and Loops, While, Do-while and for Loops, Multiple Loop Variables, Break and Continue Statements ([1] Chapter 6). **Functions:** Introduction,	15	CO2

	Types of Functions, Functions with Array, Passing Parameters to Functions, Call by value, Call by Reference([1] Chapter 7).		
3	**Arrays and Structures:** Array Notation and Representation, Manipulating Array Elements, Arrays Using Multi-Dimensional, Character Arrays and Strings, Structure, Union, Enumerated Data Types, Array of Structures, Passing Arrays to Functions ([1] Chapter 9).Basic Algorithms: Searching & Basic Sorting Algorithms (Bubble and Selection).	15	CO3
4	**Pointers & File Handling:** Pointers: Pointers &Memory Allocation in C, Pointer to Pointer, Pointers to Structures, Problems with Pointers, Passing Pointers as Function Arguments, Using Arrays with Pointers, Passing Arrays to Functions. **Static and Dynamic Memory Allocation**: use of malloc(), calloc() and free() functions, Storage of Variables In Static and Dynamic Memory Allocation ([1] Chapter 10). **File handling:** Creating Files, various File handling modes, File I/O functions, Standard C Pre-processors, defining and calling Macros([1] Chapter 1-2).	15	CO4

Suggested Readings

1. Schaum's Outline of Programming with C by Byron Gottfried, McGraw-Hill
2. The C programming by Kernighan Brain W. and Ritchie Dennis M, PearsonEducation.
3. Computer Basics and C Programming by V.Rajaraman, PHI Learning Pvt. Limited, 2015.
4. Computer Concepts and Programming in C, R.S. Salaria, Khanna Publishing House.

Online Resources

1. https://nptel.ac.in/courses/106104128
2. https://nptel.ac.in/courses/106105151

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1	1				1					1	1
CO2	1		1	1				1					1	2
CO3	1	1	1					1					1	1
CO4	1	1	1					1					1	1

Program	**B.Sc. (Hons./ Hons. with Research) Computer Science**				
Year	**1**	**Semester**		**I**	
Course Name	**Programming using C Lab**				
Code	**NBSC3152**				
Course Type	**DSC**	**L**	**T**	**P**	**Credit**
Pre-Requisite	**Basic knowledge of computer and its operations**	-	-	2	1
Course Objectives	The course is designed to provide Practical knowledge of C language. Students will be able to develop C language programs on various mathematical and computational problems which will help them to create applications in C.				
Course Outcomes					
CO1	To learn the basic terminology of C language, Structure of C program and writing user friendly programs.				
CO2	To learn the various kind of operators, data types, character sets which will help to create basic program of c language.				
CO3	To develop logical C language program using array loops, functions, structure and union.				
CO4	To create programs using concept of pointers, dynamic memory allocation and file handling.				

1. WAP to print the sum and product of digits of an Integer.
2. WAP to reverse a number.
3. WAP to compute the Sum of the first n terms of the following series S 1+1/2+1/3+1/4+...
4. WAP to compute the Sum of the first n terms of the following series S =1-2+3-4+5.....
5. Write a function that checks whether a given string is Palindrome or not.
6. Write a function to find whether a given no. is Prime or not. Use the same to generate the Prime numbers less than 100.
7. WAP to compute the factors of a given number.
8. Write a macro that Swap two numbers.
9. WAP to perform following actions on an Array entered by the User:
   i) Print the Even-valued elements.
   ii) Print the Odd-valued elements.
   iii) Calculate and print the Sum and Average of the elements of Array.
   iv) Print the Maximum and Minimum elements of Array.
   v) Remove the duplicates from the Array.
   vi) Print the Array in Reverse Order.

   The Program should present a Menu to the User and ask for one of the Options.
   The Menu should also include options to re-enter Array and to quit the Program.
10. WAP that prints a table indicating the number of occurrences of each alphabet in the text entered as Command line Arguments.
11. Write a program that Swap two numbers using Pointers.
12. Write a program in which a Function is passed address of two variables and then alter its contents.

13. Write a program which takes the radius of a circle as input from the user, passes it to another function that computes the area and the circumference of the circle and displays the value of area and circumference from the main() function.
14. Write a program to find Sum of n elements entered by the user. To write thisprogram, Allocate memory dynamically using malloc() /calloc() functions or new Operator.

15. Write a Menu driven program to perform following Operations on strings:
    a) Show address of each character in String.
    b) Concatenate two strings without using strcat() function.
    c) Concatenate two strings using strcat() function.
    d) Compare two Strings.
    e) Calculate length of the string (use Pointers).
    f) Convert all Lowercase characters to Uppercase.
    g) Convert all Uppercasecharacters to Lowercase.
    h) Calculate number of Vowels.
    i) Reverse the String
16. Given two ordered Arrays of Integers, Write a program to merge the two-Arrays to get an ordered Array.
17. WAP to display Fibonacci series:
(i)Using Recursion.
(ii) Using Iteration.
18. WAP to calculate Factorial of a number:
(i)Using Recursion.
(ii) Using Iteration.
19. Create a Structure Student containing fields for Roll No., Name, Class, Year and Total Marks.Create 10 such Students and store them in a file.
20. Copy the contents of one text file to another file, after removing all Whitespaces.
21. Write a function that reverses the elements of an Array in place. The function must accept only one Pointer value and return void.
22. Write a program that will read 10 integers from user and store them in an array. Implement array using pointers. The program will print the array elements in ascending and descending order.
23. Write a Program to create a file & store information.
24. Write a C Program to illustrate reading of data from a File.
25. Write a C Program delete a specific Line from a text File.

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1	1	2	1		2	1	3	1		1		1	1
CO2	1	1	3	1		2	2	3	1		1		1	2
CO3	1	1	2	1		3	1	3	2		1		1	1
CO4	1	1	3	1		3	2	3	2		1		2	1

Program	**B.Sc. (Hons./ Hons. with Research) Computer Science**				
Year	**1**	**Semester**			**II**
Course Name	**Data Structures using C**				
Code	**BSC3201**				
Course Type	**DSC**	**L**	**T**	**P**	**Credit**
Pre-Requisite	**Basic knowledge of computer and its operations**	**3**		**-**	3
Course Objectives	Allow to assess how the choice of data structures and algorithm design methods impacts the performance of programs. To solve problems using data structures such as linear lists, stacks, queues, binary trees, binary search trees, and graphs and writing programs for these solutions.				
Course Outcomes					
CO1	To be familiar with fundamental Data Structures and with the manner in which these Data Structures can best be implemented, become accustomed to the description of Algorithms in both functional and procedural styles.				
CO2	To have knowledge of Complexity of basic Operations like Insert, Delete, Search on these Data Structures. Ability to choose a Data Structure to suitably model any data used in Computer Applications.				
CO3	To design programs using various Data Structures including Hash tables, Binary and general Search Trees, Heaps, Graphs etc.				
CO4	Ability to assess efficiency trade-offs among different Data Structure implementations. Implement and know the applications of Algorithms for Sorting, Pattern-matching etc.				

Module	**Course Contents**	**Contact Hrs.**	**Mapped CO**
1	**Basic concepts:** Algorithm Specification-Introduction, Recursive Algorithms, Data Abstraction Performance analysis ([1] Chapter 1).Linear and Non Linear Data Structures. **Linked Lists:** Creating and Traversing linked-lists, Circularly Linked Lists: Operations for Circularly Linked Lists, Doubly Linked Lists-operations ([1] Chapter 4).Representation of Single, Two Dimensional Arrays, Sparse Matrices-Array and Linked Representations.([2] Chapter 4).	15	CO1
2	**Stack:** Operations, Array and Linked Implementations, Applications- Infix to Postfix Conversion, Postfix Expression Evaluation, Recursion implementation. **Queue:** Definition and Operations, Array and Linked implementations, Circular Queues-Insertion and Deletion Operations, Deque(Double Ended Queue) Priority Queue- Implementation ([2] Chapter 6).	15	CO2

3	**Trees:** Representation of Trees, Binary Trees, Properties of Binary Trees, Binary Tree Representations- Array and Linked Representations, Binary Tree Traversals, Threaded Binary Trees, Heap-Definition, Insertion, Deletion. Search Trees: Binary Search Trees, AVL Trees- Definition, creation and traversing. ([2] Chapter 7).	15	CO3
4	**Graphs:** Graph ADT, Graph Representations: Adjacency Matrix, Incidence Matrix, Graph Traversals ([2] Chapter 8).Sorting Methods, Comparison of Sorting Methods. **Hashing:** Introduction, Hash Tables, Hash Functions, Overflow Handling ([2] Chapter 9).	15	CO4

Suggested Readings

1. Fundamentals of Data structures in C, 2nd Edition, E. Horowitz, S. Sahni and Susan Anderson-Freed, Universities Press.
2. Lipschutz, Schaum's outline series Data structures Tata McGraw-Hi
3. Data structures and Algorithm Analysis in C, 2nd edition, M. A. Weiss, Pearson.
4. .Data structures using C and S. Tanenbaum, Y. Langsam, and M. J. Augenstein.

Online Resources

1. https://nptel.ac.in/courses/106103069
2. https://nptel.ac.in/courses/106102064

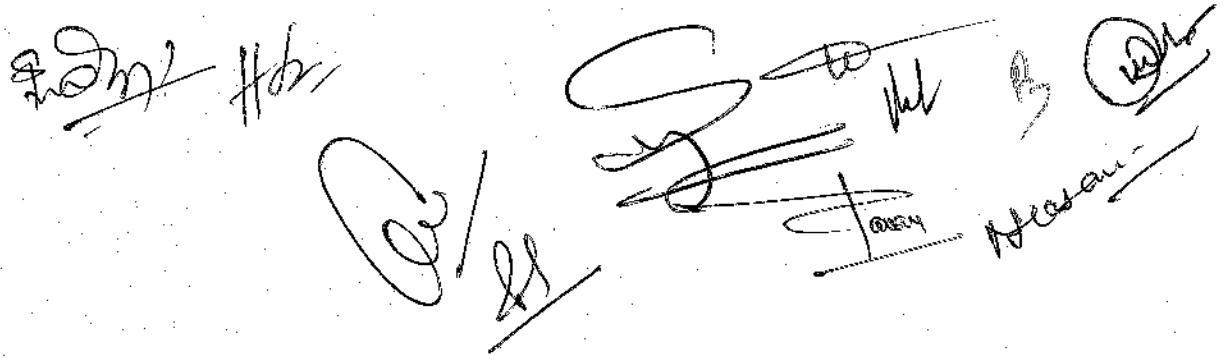
PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	1	1						1					1	1
CO 2	1			1				1					1	1
CO 3	1	1	1			2		1					1	1
CO 4	1	1	1	1		1		1					1	1

Program	B.Sc. (Hons./ Hons. with Research) Computer Science				
Year	1	Semester		Second	
Course Name	Data Structures using C Lab				
Code	NBSC3251				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic knowledge of computer and its operations	-	-	2	1
Course Objectives	To solve problems using data structures such as linear lists, stacks, queues, binary trees, binary search trees, and graphs and writing programs for these solutions.				
Course Outcomes					
CO1	Student will be able to develop programs using various kinds of data structure like array and linked list				
CO2	To develop and implement programs of stack and queue data structure using array and linked list.				
CO3	Student will be able to develop logic using heterogeneous data structure like tree BST, AVL tree etc.				
CO4	Student will be able to create and implement various algorithms using graph theory.				

1. Write a program to perform Insertion and Deletion operations in an Array.
2. Write a program to multiply two 2D Matrices.
3. Write a program to Display non-zero elements from Sparse Matrix.
4. WAP to convert the Sparse Matrix into non-zero form and vice-versa.
5. Write a program to Search an element from a list. Give user the option to perform Linear or Binary search.
6. WAP using templates to Sort a list of elements. Give user the option to perform sorting using Insertion Sort, Bubble sort or Selection sort.
7. Write a program to create Queue and perform Insertion and Deletion operations.
8. Write a program to create Deque and perform Insertion and Deletion operations.
9. Write a program to create Priority Queue and perform Insertion and Deletion operations.
10. Implement Linked List using templates. Include functions for Insertion, Deletion and search of a number, Reverse the list and concatenate two Linked Lists.
11. Implement Doubly Linked-List using templates. Include functions for Insertion, Deletion and search of a number, reverse the list.
12. Implement Circular Linked List using templates. Include functions for Insertion, Deletion and search of a number, reverse the list.
13. Perform Stack operations using Linked List implementation.
14. Perform Stack operations using Array implementation.
15. Perform Queues operations using Circular Array implementation.
16. Create and perform different operations on Double-ended Queues using Linked-list implementation.
17. WAP to calculate factorial and to compute the factors of a given no. (i) using Recursion (ii) Using Iteration.

18. WAP to display Fibonacci series (ii)Using Recursion, (iii) Using Iteration
19. WAP to create a Binary Search Tree and include following operations in Tree:
20. Insertion (Recursive and Iterative Implementation).
21. Search a number in BST.
22. Display its pre-order, post-order and in-order traversals Recursively.
23. Display its pre-order, post-order and in-order traversals Iteratively.
24. Display its level-by-level traversals.
25. Count the non-leaf nodes and Leaf Nodes.
26. Display Height of Tree.
27. WAP to reverse the order of the elements in the Stack using additional Stack.
28. WAP to reverse the order of the elements in the Stack using additional Queue.
29. WAP to implement Lower Triangular Matrix using One-dimensional Array.
30. WAP to implement Upper Triangular Matrix using One-dimensional Array.
31. WAP to implement Symmetric Matrix using one-dimensional array.
32. WAP to Create a Threaded Binary Tree as per in-order Traversal, and Implement operations.

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	1		2	1	3	1		1		2	1
CO2	2	1	3	1		2	2	3	1		1		1	2
CO3	1	2	2	2		3	1	3	2		1		1	1
CO4	1	1	3	2		3	2	3	2		1		2	1



Program	**Bachelor of Business Administration**				
Year	**First**	**Semester**		**First**	
Course Name	**Business Environment**				
Code	**NBBA5102**				
Course Type	**DSC**	**L**	**T**	**P**	**Credit**
Pre-Requisite	10+2 in any discipline	**4**	**0**	**0**	**4**
Course Objectives	To Familiarize students with: Various external and internal factors that impact business and understand the economic, cultural, legal and political issues associated with national and international business.				
Course Outcomes					
CO1	Explain the types of business environment viz Political, Economic, Socio-cultural, Legal, Technological and Global environment.				
CO2	Analyse the existence of business under various Policies Framework laid by legal environment.				
CO3	Examine the role of public sector along with various government regulatory acts and policies regarding business environment including industrial, monetary and fiscal policies.				
CO4	Analyse and evaluate global business environment in terms of Global Trade Policies by respective Institutions along with determining the impact and prospects of Technology in shaping Business.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Module I: Introduction** Business Environment: Nature, dimensions and meaning. Components of business environment: economic, political, technological and social environment. Consumerism and consumer protection in India. A brief study of capitalism, socialism and mixed economy.	**15**	**1**
2	**Module II: Industrial and Legal Environment** Industrial Growth and policy, industrial licensing policy. MRTP. Economic planning: aims, objectives and framework of development planning in India. Legal	**15**	**2**

	Environment. India's Fiscal and Monetary Policies.		
3	**Module III: Public Sector and Economic Organizations** Public Sector: Concept, Rationale, Government Programme, Role of Public Sector in India. Foreign Trade Policies. Development Banks: IFCI, IDBI, SIDBI, IIBI.	**15**	**3**
4	**Module IV: Recent Economic Trends Recent Economic Trends** Economic Liberalization, Privatization and Globalization. Foreign investment policy. Export Promotion councils and boards. Import Control. EXIM policy, FEMA, IPR (International and Indian Patent Rights Acts). Anti-Pollution Act. Environmental Groups and Bodies. Euro I, II and III Norms, Introduction to Goods and Services Tax.	**15**	**4**

Suggested Readings

1. Mishra S. K. And Puri V. K., Economic Environment of Business, Himalaya Publication.
2. Paul, Justin., Business Environment Text and Cases, Tata McGraw Hill.
3. Shaikh and Saleem, Business Environment, Pearson, 1st Edition.

Online Resources

1. eGyanKosh: Business Environment online available at https://egyankosh.ac.in/handle/123456789/2898
2. NPTEL: Introduction to Business environment available at https://onlinecourses.swayam2.ac.in/imb22_mg02/preview

Course Articulation Matrix

PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	1	1									2	2	2
CO2	3	2	2	1	2							2	2	2
CO3	3	3	3	3	3	1	2			1		3	3	2
CO4	1	1	1	2	2	2	2	1				3	3	2

Program	**Bachelor of Business Administration**				
Year	**First**	**Semester**	**Second**		
Course Name	**Business Organisation**				
Code	**NBBA5203**				
Course Type	**DSC**	**L**	**T**	**P**	**Credit**
Pre-Requisite	10+2 from any discipline	**3**	**1**	**0**	4
Course Objectives	To familiarize students with: Management and business concepts and practices. Emerging challenges of managing resources, managing business processes and managing managers.				
Course Outcomes					
CO1	Understand the concept of business organization and principles of organization.				
CO2	Examine the role of sole proprietorship, Partnership firm, joint stock concerns and companies.				
CO3	Analyse the sources and methods of Business Finance and analyse working of financial institutions like IFCI, SFC, ICICI, IDBI and security market.				
CO4	Assessing market structure and applying it to different industries to understand the four P's of marketing structure of these industries. Applying the concepts of advertisement and sales promotion to real life situations.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Module I: Introduction to Organization** Concepts and objectives of business organization, establishment of a new business, pre-establishment considerations and social responsibility of business. Meaning, objective and principles of organization, line and staff, functional organization, concept of scalar chain.	**15**	**1**
2	**Module II: Forms of Business Organization** Sole Proprietorship: Meaning, characteristics and legal requirements. Partnership firms: Meaning, partnership deed and legal requirements as per Partnership Act 1932. Joint stock concerns: Meaning, features, kinds of companies, legal	**15**	**2**

	requirements as per Companies Act 2013.		
3	**Module III: Business Finance** Business Finance: Concept, need and significance. Methods of financing: long term, medium term and short term. National finance and international finance. Financial institutions: Brief introduction to IFCI, SFC, ICICI, IDBI. Security market: An introduction to primary and secondary market.	15	3
4	**Module IV: Marketing** Marketing: Concept of marketing, four P's of Marketing. Distribution channel: Meaning, importance, and significance of middlemen. Advertisement and sales promotion: Meaning and objectives. Introduction to Consumer Behaviour.	15	4

Suggested Readings

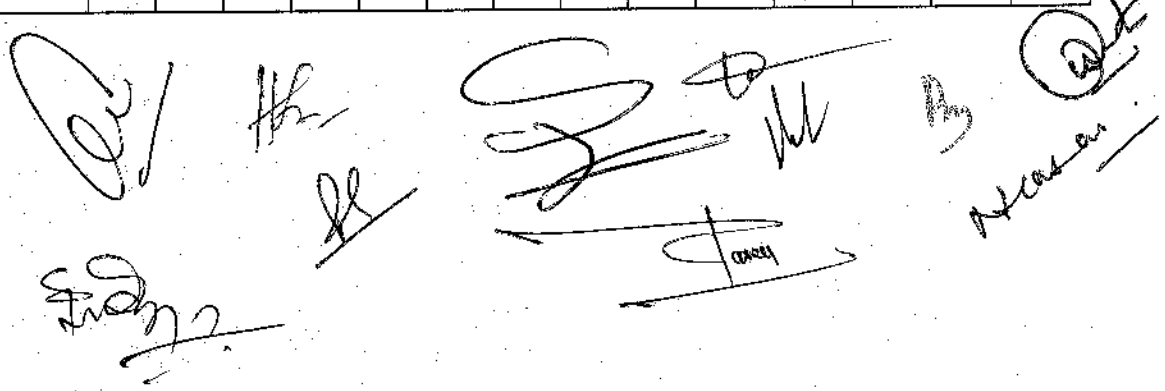
1. Tulsian P. C. and Pandey V., Business Organization and Management, Pearson Education.
2. Bhushan Y. K., Fundamentals of Business Organization and Management, Sultan Chand and Sons.
3. Chhabra T.N., Business Organisation, Dhanpat Rai and Sons.
4. Robert., Modern Business Administration, McMillan India.

Online Resources

1. SWAYAM: Business Organization and Management online available at https://onlinecourses.swayam2.ac.in/nou21_mg03/preview
2. eGyanKosh: Business Organisation online available at https://egyankosh.ac.in/handle/123456789/3592

Course Articulation Matrix

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1				1	1	1			2	2	1
CO2	3	1	2	1	2							2	2	1
CO3	3	3	3	3	3	1	2					3	3	1
CO4	1	1	1	2	2	2	2	1				3	3	1



Program	**For all UG Programs**				
Year	**1**	**Semester**		**1**	
Course Name	**Descriptive Statistics**				
Code	**NBSE1101**				
Course Type	**GE**	**L**	**T**	**P**	**Credit**
Pre-Requisite	**10+2 in any discipline**	**3**	**1**	**0**	**4**
Course Objectives	The general objectives of the course are to: Understand Statistics, its scope and importance in various fields. Learn difference between sample population data and its types. Understand graphical representation of different types of data. Differentiate between measures of central tendency & dispersion.				
Course Outcomes:					
CO1	To understand concept of sample vs. population and difference between different types of data.				
CO2	To be able to apply different methods for summarising data sets, Interpret histograms and ogives etc.				
CO3	To describe data with measures of central tendency and measures of dispersion.				
CO4	To understand measures of skewness, kurtosis and their utility.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Concept of statistical population, Attributes and variables (discrete and Continuous) ([2] Chapter 1); Primary data – designing a questionnaire and schedule, collection of primary data, Secondary data ([2] Chapter 3); Presentation of data: classification, tabulation ([2] Chapter 5).	15	CO1
2	Diagrammatic & graphical representation of grouped data. Frequency distributions, cumulative frequency distributions and their graphical representations, histogram, frequency polygon and ogives ([3] Chapter 3).	15	CO2
3	Measure of central tendency: Average or arithmetic mean, median, mode, geometric mean & harmonic mean for grouped and ungrouped data with their merits and demerits ([3] Chapter 4).	15	CO 3
4	Dispersion, merits and demerits of these measures ([1] Chapter 7); Moments, Shephard's correction for moments ([2] Chapter 9); Skewness and Kurtosis and their Measures ([1] Chapter 8); Measures based on quartiles (Quartiles, Deciles and percentiles) ([1] Chapter 7).	15	CO4

Suggested Readings

1. Beri, G.C. (2011). Business Statistics (3rd ed.), TMH Education Pvt. Ltd. New Delhi.
2. Gupta, S.P. (2011). Statistical Methods (41st ed.), Sultan Chand and Sons New Delhi.
3. Tulsian, P.C. and Tulsian, Bharat. (2019). Business Statistics (2nd ed.), Sultan Chand and Company Ltd. New Delhi.

Online Resources

1. https://heecontent.upsdc.gov.in/Home.aspx
2. https://www.edx.org/search?q=statistics

Course Articulation Matrix													
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1			1	1	1					1	1
CO2	1	1	1			2		1					1	1
CO3	1	1	1			2		1					1	1
CO4	1	1	1			2		1					1	1

Program	**For all UG Programs**				
Year	**1**	**Semester**		**2**	
Course Name	**Probability & Distributions**				
Code	**NBSE1201**				
Course Type	**GE**	**L**	**T**	**P**	**Credit**
Pre-Requisite	**10+2 in any discipline**	**3**	**1**	**0**	**4**
Course Objectives	The general objectives of the course are to: understand concept of probability along with basic laws and axioms of probability. understand Addition & Multiplication theorems of probability. understand the concept of random variable (discrete and continuous), concept of probability distribution. knowledge of discrete & continuous distributions.				

Course Outcomes:	
CO1	To apply the concept of different terms used in probability.
CO2	To apply basic probability principles to solve real life problems.
CO3	To differentiate & apply different types of distributions.
CO4	To understand applications of discrete & continuous distributions to solve the problems.

Module	**Course Contents**	**Contact Hrs.**	**Mapped CO**
1	Basic Concepts of probability, Random Experiment, Trial, Sample Point, Sample space, events, Definitions of Mutually Exclusive, Exhaustive and Equally Likely events, Definitions of Probability: Classical, relative frequency and axiomatic approaches and their limitations ([2] Vol. 2, Chapter 1).	15	CO1
2	Theorems on Probability: Addition theorem of Probability for n Events, Theorem of Total Probability for n Events, Conditional Probability, Multiplication Theorem of Probability for n events, Independent Events. Bayes' Theorem and its Applications ([2] Vol. 2, Chapter 1).	15	CO2
3	Random variables – discrete and continuous, ([1], Chapter 10); probability mass function (pmf) and probability density function (pdf), Cumulative distribution function (cdf), Joint distribution of two random variables, marginal and conditional distributions, Independence of random variables ([3], Chapter 5); Expectation of a random variable and its properties, expectation of sum of random variables and product of independent random variables ([3], Chapter 6).	15	CO 3
4	Probability Distributions: Binomial, Poisson, Normal distribution and their properties ([1], Chapter 10).	15	CO4

Suggested Readings

1. Beri, G.C. (2011). Business Statistics (3rd ed.), TMH Education Pvt. Ltd. New Delhi.

2. Gupta, S.P. (2011). Statistical Methods (41st ed.), Sultan Chand and Sons New Delhi.
3. Gupta, S.C. and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics (10th ed.), Sultan Chand and Sons, New Delhi.

Online Resources

1. https://www.coursera.org/search?query=statistics&
2. https://www.edx.org/search?q=statistics

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1			1		1					1	1
CO2	1	2	1			1		1					1	1
CO3	1	2	2			2		1					1	1
CO4	1	2	2			2		1					1	1

Program	B.Sc. (Hons. / Hons. with Research) Mathematics				
Year	2	Semester	3		
Course Name	Group Theory				
Code	NBSM3301				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic Concept of algebraic structure.	3	1	0	4
Course Objectives	Group theory is building block of Modern Algebra. The objective of this course is to introduce fundamental theory of groups and their homomorphisms. Cayley Theorem and its application are also studied in detail.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Understand the fundamental concepts of subgroup, cyclic group, learn about Euler's Theorem, Fermat's little theorem.				
CO2	Know about fundamental concept of Permutation group, Alternating Group, Cayley theorem and its applications.				
CO3	Explain the significance of the notion of cosets, normal subgroups and Quotient groups.				
CO4	Recognize group homomorphism and group isomorphism.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Subgroups and Examples of Subgroups ([1] Chapter 3), Product of two Subgroups, Cyclic groups: Generator of Cyclic groups, Fundamental theorem of cyclic groups ([1] Chapter 4), Euler's φ –function, Euler's Theorem, Fermat's little theorem.	15	CO1
2	Permutation, Cycle notation for permutations, Properties of permutations, Even and odd permutations, alternating groups, Cayley's theorem and its applications ([1] Chapter 5).	15	CO2
3	Cosets, Properties of cosets, Lagrange's theorem ([1] Chapter 7), Cauchy's theorem for finite abelian groups, Normal subgroups, Simple groups, Quotient groups ([1] Chapter 9).	15	CO3
4	Group homomorphisms, Properties of homomorphisms, Fundamental Theorem of group homomorphism, Group isomorphisms, Properties of isomorphisms, First, second and third isomorphism theorems for groups ([1] Chapter 10).	15	CO4

Suggested Readings

1. Joseph A. Gallian, Contemporary Abstract Algebra (4th edition). Narosa
2. Vijay k Khanna and S K Bhambri, A Course in Abstract Algebra (4th edition), Vikash Publishing House Pvt Ltd.
3. John B. Fraleigh, A First Course in Abstract Algebra (7th edition). Pearson.
4. I. N. Herstein, Topics in Algebra (2nd edition). Wiley India.

Online Resources

1. https://archive.nptel.ac.in/courses/111/106/111106113/
2. https://onlinecourses.swayam2.ac.in/cec23_ma19/preview

Course Articulation Matrix													
PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2					2						1	1
CO2	2	2					2						1	1
CO3	1	2					2						1	1
CO4	1	2					2						1	1

Program	B.Sc. (Hons./ Hons. with Research) Mathematics				
Year	2	Semester	3		
Course Name	Multivariable Calculus				
Code	NBSM3302				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic of calculus and vector function	3	1		4
Course Objectives	The aim of the course is to develop an understanding of the concept of the differentiation and integration of the function of several variables and their applications.				
Course Outcomes: After completion of the course, students will be able to					
CO1	Learn conceptual variations while advancing from one variable to several variables in calculus.				
CO2	Understand the extrema of multivariable functions subject to the given constraints on variables.				
CO3	Inter-relationship amongst the line integral, double and triple integral formulations.				
CO4	Realize importance of Green, Gauss and Stokes' theorems in other branches of mathematics.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Functions of several variables, Limits and continuity, Partial differentiation, Higher order Partial derivatives, Total differentiation, Chain rule, Euler's theorem for homogeneous functions, Taylor's theorem for functions of two variables and more variables ([1] Chapter 15).	15	CO1
2	Envelopes and Evolutes, Extrema of functions of two and more variables, Method of Lagrange multipliers ([1] Chapter 15).	15	CO2
3	Double integration, Change of order of integration, Area by double integration, Triple integration, Volume by triple integrals, Dirichlet integral ([1] Chapter 17 & 18).	15	CO3
4	Gradient, Divergence and Curl, Line integrals, Surface integrals, Green's theorem, Stokes' theorem, The Gauss divergence theorem ([1] Chapter 17 & 18).	15	CO4

Suggested Readings

1. S. C. Malik and S. Arora, Mathematical Analysis, 4th Ed., Wiley Eastern Ltd., 2011.

2. G. Prasad, Text Book on Differential Calculus, PothishalaPtv. Ltd.

3. James Stewart (2012). Multivariable Calculus (6th edition). Thomson Brooks/Cole. Cengage.

4. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005

Online Resources

1 . https://archive.nptel.ac.in/courses/111/107/111107108/

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1		1			1					2	1
CO2	1	1	1		1			2					2	2
CO3	2	1	2		1			2					3	2
CO4	2	1	2		1			2					3	2

Program	B.Sc. (Hons./Hons. with Research) Mathematics				
Year	2	Semester	3		
Course Name	Partial Differential Equations				
Code	NBSM3303				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic Knowledge of differential equations	3	1	0	4
Course Objectives	The objective is to introduce the concept of partial differential equations and their applications.				
Course Outcomes: Upon successful completion of course, a student will be able to:					
CO1	Understand partial differential equations, their construction and existence of solution.				
CO2	Apply various analytical methods for computing solutions of various PDEs.				
CO3	Understand and solve the homogeneous and non-homogeneous equations with constant coefficients.				
CO4	Understand the formation and solution of some significant PDEs like wave equation, heat equation.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Order and degree of Partial differential equations, Concept of linear and non-linear partial differential equations, Classification of first order Partial differential equations, Derivation of partial differential equation by the elimination of arbitrary constants and arbitrary functions ([1] Chapter 1, Part III).	15	CO1
2	Lagrange's method, Some special type of equation which can be solved easily by methods other than the general method ([1] Chapter 2, Part III), Charpit's method, Special method of solutions applicable to certain standard form ([1] Chapter 3, Part III).	15	CO2
3	Homogeneous and non-homogeneous equations with constant coefficients ([1] Chapter 4 & 5, Part III), Partial differential equations reducible to equations with constant coefficients ([1] Chapter 6, Part III).	15	CO3
4	Second order PDE with variable coefficients ([1] Chapter 7, Part II), Classification of second order PDE ([1] Chapter 8, Part III), Solution of heat and wave equations in one and two dimensions by method of separation of variables ([2] Chapter 12).	15	CO4

Suggested Readings

1. M. D. Raisinghania, Advanced Differential Equations, Nineteenth Edition 2018 (Reprint with updates (2020), S. Chand.
2. Erwin Kreyszig, (2011). Advanced Engineering Mathematics (10th edition). Wiley.
3. TynMyint-U & Lokenath Debnath (2013). Linear Partial Differential Equation for Scientists and Engineers (4th edition). Springer India.
4. H. T. H. Piaggio (2004). An Elementary Treatise on Differential Equations and Their Applications. CBS Publishers.
5. S. B. Rao & H. R. Anuradha (1996). Differential Equations with Applications. University Press.
6. Ian N. Sneddon (2006). Elements of Partial Differential Equations. Dover Publications.

Online Resources

1. **https://www.youtube.com/playlist?list=PLgMDNELGJ1CZpu0rJvVh-bUHGFINS7xIk**
2. **https://www.youtube.com/playlist?list=PLOzRYVm0a65eWglxWw5WzQLrlG2EaiTli**

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1		1	1		2					2	1
CO2	1	1	1					1					2	1
CO3	1	1	1					1					1	1
CO4	2	1	1		1			1					2	1

Program	B.Sc. (Hons./Hons. with Research) Mathematics				
Year	2	Semester	4		
Course Name	Ring Theory and Vector Spaces				
Code	NBSM3401				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Foundation of Group theory	3	1	0	4
Course Objectives	The general objective of the course is to develop in depth understanding of rings and vector spaces.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Understand the fundamental concepts of Ring, Subring, Integral domain, Field.				
CO2	Know about basic concept of Ideals, Prime Ideals and Maximal Ideal.				
CO3	Learn about ring homomorphism, Polynomial ring, Remainder and Factor theorem.				
CO4	Understand the basic concept of Vector Space, subspace, bases and dimension.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Introduction to Rings, Properties of Rings, Examples of ring including Z_m, Z[i], Z[w], Matrix ring, Quaternion ring, quotient ring, Subrings, Integral Domain, Fields ([2] Chapter 4).	15	CO1
2	Characteristics of a Ring, Ideals, Properties of Ideals, Factor Rings, Prime Ideals and Maximal ideals ([2] Chapter 5).	15	CO2
3	Ring Homomorphism, Properties of Ring Homomorphisms, First isomorphism theorem of rings, Ring of polynomials over R, Addition and Multiplication in R[x], Division algorithm for F[x], Remainder theorem, Factor Theorem ([1] Chapter 8).	15	CO3
4	Vector Space: Definition and Examples, Linear combination, Subspace, Linear dependance and Independence, Bases, Dimensions, Quotient space, Dimension of Quotient space ([1] Chapter 10).	15	CO4

Suggested Readings

1. Vijay K Khanna and S K Bhambri (2013). A Course in Abstract Algebra (4th edition), Vikash Publishing House Pvt Ltd.
2. John B. Fraleigh (2007). A First Course in Abstract Algebra (7th edition). Pearson.
3. I. N. Herstein (2006). Topics in Algebra (2nd edition). Wiley India.
4. Ramji Lal. Algebra (Volume I), Shail Publication.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc21_ma06/preview
2. https://onlinecourses.nptel.ac.in/noc22_ma76/preview

Course Articulation Matrix														
PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2					2						1	1
CO2	1	2					2						1	1
CO3	2	2					2						2	1
CO4	1	2	1				2						1	1

Program	B.Sc. (Hons./ Hons. with Research) Mathematics				
Year	2	Semester	4		
Course Name	Riemann Integration and Series of Function				
Code	NBSM3402				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic of calculus, sequence and series	3	1		4
Course Objectives	The aim of the course is to develop an understanding of the concept of the integration of bounded functions on a closed and bounded interval.The sequence and series of real valued functions and important class of series of functions.				
Course Outcomes: After completion of the course, students will be able to					
CO1	Learn about some of the classes and properties of Riemann integrable functions and the applications of the Fundamental theorems of integration.				
CO2	Learn about Cauchy criterion for uniform convergence and Weierstrass M-test for uniform convergence.				
CO3	Know about the concept of the inter-changeability of differentiability and interability with infinite sum.				
CO4	Approximate transcendental function in terms of power series a well as differentiation and integration of power series.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Riemann integration, inequalities of upper and lower sums, Riemann conditions of integrability, Riemann sum and definition of Riemann integral through Riemann sums, Riemann integrability of monotonic and continuous functions properties of the Riemann integral. ([1]Chapter 9).	15	CO1
2	Definition and integrablity of piecewise continuous and monotonic functions, Intermediate value theorem, Mean value theorem for integrals, Fundamental theorems of calculus. ([1]Chapter 9).	15	CO2
3	Pointwise and uniform convergence of sequence of functions, Pointwise and uniform convergence of series of functions, theorems on the continuity and derivability of the sum function of a series of functions, Cauchy criterion and Weierstress M-test for uniform convergence. ([1] Chapter 12).	15	CO3
4	Power series, Radius of convergence, Cauchy Hadamard theorem, Differentiation and integration of power series, Abel's theorem ([1] Chapter 13)	15	CO4

Suggested Readings

1. S.C. Malik and S.Arora, Mathematical Analysis, 2nd Ed., Wiley Eastern Ltd., 1991

2. K.A. Ross, Elementary Analysis, The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

3. R.G.Bartle and D.R. Bartle, Introduction to Real Analysis, (4th Edition), John Wiley and Sons(Asia) Pvt. Ltd, Singapore, 2010.

4. Charles G.Denlinger, Elements of Real Analysis, Joness and Bartlett (Student Edition),2011.

5. Shanti Narayan, Elements of Real Analysis, (6th Edition) S.Chand Publication, 2006.

Online Resources

1. https://nptel.ac.in/courses/122104017

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1		1			1					1	1
CO2	2	2	1		1			1					1	2
CO3	2	2	2		1			2					2	3
CO3	2	2	2		1			2					2	3

Program	B.Sc. (Hons./ Hons. with Research) Mathematics				
Year	2	Semester	4		
Course Name	Graph Theory				
Code	NBSM3403				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic set operations in Mathematics	3	1		4
Course Objectives	The objectives of the course are to understand and apply the fundamental concepts in graph theory.				

Course Outcomes: After completion of the course, students will be able to

CO1	Acquire the basic ideas of Graphs.
CO2	Optimize the solutions to real problems like travelling salesman problem and shortest path etc.
CO3	Understand the concept of planarity and matrix representation of graph
CO4	Know the concepts and applications of Coloring, Covering and Partitioning.

Module	Course Contents	Contact Hrs.	Mapped CO
1	Graph and basic properties of graphs, finite and infinite graphs, incidence and degree, isolated and pendent vertices, Null graph, pseudo graph, complete graph, bipartite graph ([1] Chapter 1), Isomorphism, subgraphs, walk, path and circuits, connected graph, disconnected graph and components ([1] Chapter 2).	15	CO1
2	Euler circuit, Euler graph, Chinese post man problem, Hamiltonian circuit, Hamiltonian graph, travelling salesman problem ([1] Chapter 2). Directed and weighted graph, shortest path, Dijikstra's algorithm, Floyed-Warshall algorithm. ([1] Chapter 7 & 11).	15	CO2
3	Cut-sets and its properties, connectivity of graph, planar graph, maps and region, Eulers formula, planarity of graph, matrix representation of graph and its applications ([1] Chapter 7 & 11).	15	CO3
4	Coloring, Covering and Partitioning: Chromatic number, Chromatic Partitioning, Chromatic Polynomial, Matching, Covering, Four colour conjecture, Five-colour theorem, enumeration of graph. ([1] Chapter 8).	15	CO4

Suggested Readings

1. Narsingh Deo, *Graph Theory with Applications to Engineering and Computer Science,* Prentice Hall.
2. B. A. Davey and H. A. Priestley, *Introduction to Lattices and Order*, Cambridge University Press, Cambridge, 1990.
3. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory,* 2ndEdition, Pearson Education (Singapore), Indian Reprint 2003.
4. Rudolf Lidl and Gunter Pilz, *Applied Abstract Algebra*, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

Online Resources

1. https://books.google.com/books?id=k86aDwAAQBAJ
2. https://nptel.ac.in/courses/111101080

Course Articulation Matrix

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1					2					2	1
CO2	2	2	2		1			2					3	2
CO3	2	2	1		1			2					3	2
CO3	2	1	1					2					2	2

Program	B.Sc. (Hons./Hons. with Research) Mathematics				
Year	3	Semester	5		
Course Name	Linear Algebra				
Code	NBSM3501				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Foundation of Groups and Vector Spaces	3	1	0	4
Course Objectives	This course aims at providing the fundamental knowledge pertaining to Linear Algebra such as linear transformation, rank nullity theorem, Inner Product Space, Adjoints, Unitary operator and Normal Operator.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Understand the basic concept of Linear Transformation, Algebra of Linear Transformation, Rank Nullity Theorem.				
CO2	Know about Matrix of Linear Transformation and relate matrix and Linear Transformation, Linear Functional, Dual and Double Dual Space.				
CO3	Compute inner product and determine orthogonality on vector spaces, apply Gram-Schmidt orthogonalization process.				
CO4	To find Adjoints, Unitary Operators, Normal Operator and orthogonal compliment.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Linear Transformations: Definition, Examples and Algebra of Linear Transformation, Rank and nullity of a linear transformation and rank-nullity theorem, Linear Operator, Isomorphism ([1] Chapter 11).	15	CO1
2	Matrix of a linear transformation, Linear Functionals, Annihilator, Dual Space, Dual Basis, Double Dual space ([1] Chapter 11).	15	CO2
3	Inner product spaces and orthogonality, Cauchy Schwarz inequality, Orthogonal and Orthonormal Vectors, Gram Schmidt orthogonalization process ([1] Chapter 13).	15	CO3
4	Orthogonal Compliment, Orthogonal Projection, Linear Functionals and Adjoints, Unitary Operators, Normal Operator ([1] Chapter 11).	15	CO4

Suggested Readings

1. Vijay K Khanna and S K Bhambri (2013). A Course in Abstract Algebra(4th edition), Vikash Publishing House Pvt Ltd.
2. Kenneth Hoffman & Ray Kunze (2015). Linear Algebra (2nd edition). Prentice-Hall.
3. Nathan Jacobson (2009). Basic Algebra I & II (2nd edition).Dover Publications.
4. Vivek Sahai &Vikas Bist (2013). Linear Algebra (2nd Edition).Narosa Publishing House.
5. Gilbert Strang (2014). Linear Algebra and its Applications (2nd edition).Elsevier

Online Resources

1. https://onlinecourses.nptel.ac.in/noc20_ma21/preview
2. https://archive.nptel.ac.in/courses/111/104/111104137/#

Course Articulation Matrix														
PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1	2					2						1	1
CO2	2	2				1	2						2	1
CO3	2	2				1	2						1	1
CO4	2	2				1	2						1	1

Program	B.Sc. (Hons. / Hons. with Research) Mathematics				
Year	3	Semester	5		
Course Name	Set Theory and Metric Spaces				
Code	NBSM3502				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic knowledge of Real Analysis	3	1	0	4
Course Objectives	The objective of the course is to introduce the concepts of finite and infinite sets, partially ordered sets and Metric spaces.				
Course Outcomes: Upon successful completion of course, a student will be able to:					
CO1	Understand the concepts of countable and uncountable sets and the cardinality of a set.				
CO2	Understand several standard concepts of metric spaces.				
CO3	Identify the continuity of a function defined on metric spaces.				
CO4	Understand concept of completeness of metric space.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Finite and infinite sets, Countable and uncountable sets, Cardinality of sets ([2] Chap. 4), Partially ordered set ([1] Chapter 14), Axiom of choice ([1] Chapter 15), Zorn's lemma ([1] Chapter 16), Schröder Bernstein theorem ([1] Chapter 22).	15	CO1
2	Definition and examples of metric spaces, Distance between two sets, Diameter of a set, Open spheres and closed spheres, Neighborhood of a point, Interior point and its properties, Open sets, Limit points and its properties, Closed sets, Adherent Point, closure of a set, Interior of a set, exterior and boundary points ([2] Chapter 19).	15	CO2
3	Subspaces of metric space, Dense sets, nowhere dense sets, separable spaces, Product of metric spaces, Continuous functions on metric space, properties of continuous functions, uniform continuity ([2] Chapter 19).	15	CO3
4	Cauchy and Convergent sequences, Complete metric Space, properties of complete metric space, Cantor's intersection theorem, Baire's category theorems ([2] Chapter 19).	15	CO4

Suggested Readings:

1. P. R. Halmos (1974), Naive Set Theory, Springer.
2. Shanti Narayan (2012), Elements of Real Analysis 13th edition, S. Chand Publication
3. E. T. Copson (1988), Metric Spaces, Cambridge University Press.
4. P. K. Jain & Khalil Ahmad (2019), Metric Spaces Narosa.
5. S. Kumaresan (2011), Topology of Metric Spaces (2nd edition) Narosa.
6. Satish Shirali & Harikishan L. Vasudeva (2006), Metric Spaces, Springer-Verlag.

7. Micheál O'Searcoid (2009), Metric Spaces, Springer-Verlag.
8. G. F. Simmons (2004), Introduction to Topology and Modern Analysis. McGraw-Hill.

Online Resources

1. **https://www.youtube.com/playlist?list=PLbMVogVj5nJSxFihV-ec4A3z_FOGPRCo-**

Course Articulation Matrix														
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	1	1		1			1					1	1
CO2	1	1	1		1			1					1	1
CO3	1	1	1		1			1					2	1
CO4	1	1						1					1	1

Program	B.Sc. (Hons./ Hons. with Research) Mathematics				
Year	3	Semester	5		
Course Name	Numerical Analysis				
Code	NBSM3503				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic knowledge of Calculus	3	1	0	4
Course Objectives	The aim of this course is to understand the concept of Numerical Integration., interpolation and extrapolation.				

Course Outcomes: Upon successful completion of syllabus, a student will be able to:

CO1	Obtain numerical solutions of algebraic and transcendental equations.
CO2	Find numerical solutions of system of linear equations and check the accuracy of the solutions.
CO3	Learn about various interpolating and extrapolating methods.
CO4	Apply various numerical methods in real life problems.

Module	Course Contents	Contact Hrs.	Mapped CO
1	Round-off error and computer arithmetic, Local and global truncation errors, Algorithms, and convergence ([2] Chapter 4). Bisection method, False position method, Newton's method, and secant method for solving equations ([2] Chapter 6).	15	CO1
2	Partial and scaled partial pivoting, Lower and upper triangular (LU) decomposition of a matrix and its applications, Thomas method for tridiagonal systems, Gauss-Jacobi, Gauss-Seidel and successive over-relaxation (SOR) methods ([1] Chapter 3).	15	CO2
3	Finite difference operators, Gregory-Newton forward and backward difference interpolations. Lagrange and Newton Divided difference Interpolations ([1] Chapter 4). Numerical differentiation, Numerical Integration: Trapezoidal rule, Simpson's rules ([1] Chapter 5).	15	CO3
4	Numerical solution of ODE; introduction, Taylor's Series method, Picard's method of successive approximation, Euler's Method, Runge -Kutta method of order 1 and 2. ([2] Chapter 13).	15	CO4

Suggested Readings

1. M..K..Jain, S R K Iyengar, R K Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publishers, 7th Edition, 2019.
2. E. Balagurusamy, Numerical Methods, McGraw-Hill, International Edition, 2015.

Online Resources

1. https://heecontent.upsdc.gov.in/ScarchContent.aspx
2. https://swayam.gov.in/explorer?searchText=statistics

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1			1	1	1					1	1
CO2	1	1	1			2		1					1	1
CO3	1	1	1			2		1					1	1
CO4	1	1	1			2		1					1	1

Program	B.Sc. (Hons./Hons. with Research) Mathematics				
Year	3	Semester	6		
Course Name	Complex Analysis				
Code	NBSM3601				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic concept of Real Analysis	3	1	0	4
Course Objectives	The objective is to introduce the concept of the functions of complex variables, analytic functions, contour integrations and some applications.				
Course Outcomes: Upon successful completion of course, a student will be able to:					
CO1	Understand the concept of the limit, continuity and differentiability of functions of complex variables.				
CO2	Understand the concept of an analytic function and their properties.				
CO3	Understand the complex integration and their properties and apply these to evaluate complex contour integrals.				
CO4	Represent functions as Taylor and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Complex number, Algebra of complex numbers and their geometrical representation, Regions in the complex plane, Complex functions and their limits including limit at infinity, Continuity and Differentiability ([1] Chapter 1, 2).	15	CO1
2	Analytic functions, Cauchy Riemann equations, sufficient conditions for differentiability, Harmonic functions ([1] Chapter 2), Analyticity and zeros of exponential, trigonometric and logarithmic functions. ([1] Chapter 3).	15	CO2
3	Contours, Contour Integrals, Cauchy theorem (without proof), Cauchy-Goursat theorem (without proof), Cauchy integral formula, Derivative of analytic function, Liouville's theorem, Fundamental theorem of algebra ([1] Chapter 4).	15	CO3
4	Power series, Radius of convergence, Taylor series, Laurent series, Nature of singularities ([1] Chapter 5), Residues, Cauchy's residue theorem, Jordan's lemma (without proof), Evaluation of proper and improper integrals ([1] Chapter 6).	15	CO4

Suggested Readings

1. James Ward Brown & Ruel V. Churchill (2009). Complex Variables and Applications (VIIIth edition). McGraw-Hill Education.
2. Lars V. Ahlfors (2017). Complex Analysis (3rd edition). McGraw-Hill Education.
3. Joseph Bak & Donald J. Newman (2010). Complex Analysis (3rd edition). Springer.
4. John B. Conway (1973). Functions of One Complex Variable. Springer-Verlag.
5. Theodore W. Gamelin (2001). Complex Analysis. Springer-Verlag.
6. George Polya & Gordon Latta (1974). Complex Variables. Wiley.
7. H. A. Priestley (2003). Introduction to Complex Analysis. Oxford University Press.

Online Resources

1. https://www.youtube.com/playlist?list=PLbMVogVj5nJS_i8vfVWJG16mPcoEKMuWT

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1					1					2	1
CO2	1	1	1	1				1					1	1
CO3	2	1	1		1			1					2	1
CO4	2	1	2	1	1	1		2					2	1

Program	B.Sc. (Hons./ Hons. with Research) Mathematics				
Year	3	Semester	6		
Course Name	Integral Transform and Fourier Analysis				
Code	NBSM3602				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic Knowledge of Calculus	3	1		4
Course Objectives	The aim of the course is to develop an understanding of the concept the characteristics and properties of Laplace, inverse Laplace transforms, Fourier transforms and the concept of Fourier series expansion of functions and harmonic analysis.				

Course Outcomes: After completion of the course, students will be able to

CO1	Understand the concept of Laplace transform.
CO2	Understand the concept of Inverse Laplace transform and apply to solve the differential equations.
CO3	Determine Fourier Integral, Fourier sine and cosine transform of a function.
CO4	Expand periodic functions into Fourier series the knowledge of which is useful in signal processing and determine the Fourier sine, cosine series for functions defined on an interval.

Module	Course Contents	Contact Hrs.	Mapped CO
1	Laplace transform, Linearity, First Shifting theorem, Change of scale property, Existence theorem, Laplace transforms of derivatives and integrals, Laplace transforms. ([1] Chapter 6).	15	CO1
2	Convolution theorem, Inverse Laplace transform, Linearity property of inverse Laplace transform, Inverse transform of derivatives, Applications of Laplace transform in obtaining solutions of ordinary differential equations and integral equations ([1] Chapter 6).	15	CO2
3	Fourier Integral, Fourier complex transform, Fourier and inverse Fourier transforms Fourier sine and cosine transforms, Inverse Fourier sine and cosine transforms, Linearity property, Change of scale property, Shifting property, Relation between Fourier and Laplace transforms. Convolution theorem for Fourier transform, Its application. ([2] Chapter 20).	15	CO3
4	Periodic functions, Trigonometric series, Fourier series of period 2π, Euler's formulae, Functions having arbitrary period, Change of interval, Even and odd functions, Half range sine and cosine series. Harmonic Analysis. ([1] Chapter 11).	15	CO4

Suggested Readings

1. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley.
2. B.S. Grewal, Higher Engineering Mathematics, 33rd Edition-Fifth reprint, KhannaPublishers.
3. Charles K. Chui (1992). An Introduction to Wavelets.Academic Press.
4. Walter Rudin (2017). Fourier Analysis on Groups. Dover Publications.
5. A.Zygmund (2002).Trigonometric Series (3rd edition). Cambridge University Press

Online Resources

1 . https://archive.nptel.ac.in/courses/111/106/111106139/

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2		1			2					3	1
CO2	2	2	2		1			2					3	1
CO3	2	1	2		1			2					2	1
CO4	2	1	2					1					2	1

Program	B.Sc. (Hons./ Hons. with Research) Mathematics				
Year	3	Semester	6		
Course Name	Differential geometry & Tensor analysis				
Code	NBSM3603				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic Knowledge of calculus and geometry	3	1	0	4
Course Objectives	The aim of the course is to develop an understanding of the concept of curvature of curves, geodesic and tensor algebra.				
Course Outcomes: After completion of the course, students will be able to					
CO1	Learn various properties of curve including Frenet – Serret formulae and their aplications.				
CO2	This course covers the Local theory of Curves, Local theory of surfaces, Geodesics.				
CO3	Recognize the tensor calculus, tensor product of vector spaces, transformation formulae, contraction special tensors, and inner product.				
CO4	Apply various concept of differential calculus in tensors.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Arc length, Curvature and the Frenet - Serret formulae, Fundamental existence and uniqueness theorem for curves, Non-unit speed curves ([1] Chapter 5).	15	CO1
2	The first fundamental form, Arc length of curves on surfaces, Gauss and Weingarten formulae, Geodesics, The second fundamental form. The fundamental theorem of surfaces ([1] Chapter 6&7).	15	CO2
3	Contravariant and covariant vectors, Transformation formulae, Tensor product of two vector spaces, Tensor of type (r, s), Symmetric and skew-symmetric properties, Contraction of tensors, Quotient law, Inner product of vectors([1] Chapter 1).	15	CO3
4	Fundamental tensors, Associated covariant and contravariant vectors, Inclination of two vectors and orthogonal vectors, Christoffel symbols, Law of transformation of Christoffel symbols, Covariant derivatives of covariant and contravariant vectors, Covariant differentiation of tensors.([1] Chapter 2 &3).	15	CO4

Suggested Reading

1. P.K. Nayak, Textbook of Tensor Calculus and Differential Geometry, PHI Learning Pvt. Ltd.
2. Christian Bär (2010). Elementary Differential Geometry. Cambridge University Press
3. R. S. Mishra (1965). A Course in Tensors with Applications to Riemannian Geometry. PothishalaPvt. Ltd.
4. Sebastián Montiel & Antonio Ross (2009). Curves and Surfaces. American Mathematical.

Online Resources

1. NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.asp
4. https://archive.nptel.ac.in/courses/111/104/111104095/

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	2					1					1	2
CO2	1	1	1					2					2	1
CO3	2	2	1					2					1	2
CO4	1	1	2					1					1	2

Program	B.Sc. (Hons./ Hons. with Research) Mathematics				
Year	4	Semester	7		
Course Name	Discrete Mathematics				
Code	NBSM3701				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basics of set theory and calculus	3	1		4
Course Objectives	The objectives of the course are to understand and apply the fundamental concepts in discrete mathematics.				

Course Outcomes: After completion of the course, students shall be able to

CO1	Understand the notion of mathematical thinking, mathematical proofs and algorithmic thinking, and be able to apply the problem solving.
CO2	Understand asymptotic notation, its significance and be able to use it to analyse asymptotic performance for some basic algorithmic examples.
CO3	Understand the concepts of mathematical logic for analyzing propositions and proving theorems
CO4	Understand some basic properties of Tree and be able to relate these to practical examples.

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Introduction;**Sets - finite and infinite sets, uncountably infinite sets, functions, relations, operations on relation, composite relations, equality of relations ,properties of binary relations, closure, partial ordering relations ([1] Chapter 2). Counting - Pigeonhole principle, permutation and combination, mathematical induction, principle of inclusion and exclusion ([1] Chapter 5 and 6).	15	CO1
2	**Growth of Functions and Recurrences:** Asymptotic notations, summation formulas and properties, bounding summations, approximation by integrals ([1] Chapter 3). Recurrence Relation & Generating function: recurrence relations, linear recurrence relations with constant coefficients and their solution, numeric function, generating functions, solution of recurrence relation by method of generating functions ([1] Chapter 8).	15	CO2
3	**Propositional Logic**: Definition of propositions, Well-formed formulas, tautologies, satisfiability, contradiction, algebra of proposition, Normal form, theory of inference ([1] Chapter 12).	15	CO3
4	Trees and its Properties, Pendant vertices in a tree, Distance and centers in a tree, Spanning tree, Cayley's Formula, Minimal spanning tree, Prim and Kruskal's algorithm. Traversing of tree. ([2] Chapter3).	15	CO4

Suggested Readings

1. Kenneth Rosen, Discrete Mathematics and Its Applications, Sixth Edition,McGraw Hill 2006.
2. NarsinghDeo, *Graph Theory with Applications to Engineering and Computer Science,* Prentice Hall.
3. j. P. Tremblay and R Manohar, Discrete Mathematical structure wit Application to computer Science. Tata McGraw Hill
4. T.H. Coremen, C.E Leiserson, R. L Rivest, Introduction to algorithms, 3rd edition Prentice Hall on India, 2009.
5. M. O. Albertson and J. P. Hutchinson, Discrete Mathematics with Algorithms, John Wiley Publication, 1988.
6. D.J. Hunter, Essentials of Discrete Mathematics, Jones and Bartlett Publishers, 2008.

Online Resources

1. https://books.google.com/books?id=k86aDwAAQBAJ
2.https://nptel.ac.in/courses/111101080

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1					1					1	2
CO2	1	2	2		2			2					2	2
CO3	1	2	1					1					2	1
CO4	1	1	2		2			2					2	2

Program	B.Sc.(Hons./Hons. with Research) Mathematics				
Year	4	Semester	8		
Course Name	Ordinary and Partial Differential Equations				
Code	NBSM3801				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic concept of ODE and PDE	3	1	0	4
Course Objectives	The objective is to introduce the concept of ODE, existence and uniqueness solution and various analytic methods for computing the solutions of partial differential equations.				
Course Outcomes: Upon successful completion of course, a student will be able to:					
CO1	Understand ordinary differential equations of various types, their solutions, and fundamental concepts about their existence.				
CO2	Understand the concept of autonomous system, Phase Plane and Its phenomena, types of critical points and stability for Linear Systems.				
CO3	Understand the concept and applications of eigen value problems and differential equations of Strum Liouville type.				
CO4	Apply various analytic methods for computing solutions of various PDEs.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Linear Second Order Equations; Initial value problem ([1] Chapter 3), Existence and Uniqueness by Picard's Theorem ([1] Chapter 13), Wronskian, Separation and comparison theorems, Poincare phase plane, Operator Methods for Finding Particular Solutions ([1] Chapter 11)	15	CO1
2	Autonomous System, The Phase Plane and Its Phenomena, Types of Critical Points. Stability, Critical Points and Stability for Linear Systems, Stability by Liapunov's Direct Method, Simple Critical Points of Nonlinear Systems. ([1] Chapter 11).	15	CO2
3	Boundary Value Problems; Sturm–Liouville system, Eigen values and eigen functions ([3] Chapter 5), Simple properties, Expansion in eigen functions, Green's function method ([3] Chapter 6).	15	CO3
4	Partial Differential Equations; Cauchy problems and characteristics, Classification of Second order PDE's, Reduction to canonical forms, Derivation of the equations of mathematical physics and their solutions by separation of variables. ([2] Chapter 2)	15	CO4

Suggested Readings

1. G. F. Simmons, Ordinary Differential Equations with Applications and Historical Notes. Tata McGraw Hill Edition, III[rd] Edition, 2017.
2. IAN. Sneddon: Theory of Partial differential equations, McGraw-Hill, International Student Edition.
3. R. Courant and D. Hilbert: Methods of Mathematical Physics, Vol. I. & II, Tata McGraw-Hill, New Delhi, 1975

Online Resources

1. **https://www.youtube.com/playlist?list=PLLy_2iUCG87CX7wprwaVnYbVce1ftGlDV**

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	1	1		1			1					2	1
CO2	2	1	1		1			2					2	1
CO3	1	1	1	1				1					1	1
CO4	2	1	1	1				2					2	1

Program	B.Sc. (Hons./ Hons. with Research) Mathematics				
Year	3	Semester	5		
Course Name	Mathematical Modelling				
Code	NBSME3501				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Basic of differential equations and linear programming.	3	1		4
Course Objectives	The objective of this course is to introduce the students to understand and create various mathematical models and their applications in everyday life.				
Course Outcomes: After completion of the course, students will be able to					
CO1	Able to assess and articulate what type of modelling techniques are appropriate for a given physical system.				
CO2	Construct a mathematical model of a given physical system and analyze it.				
CO3	Learnt to predictions of the behaviour of a given physical system based on the analysis of its mathematical model.				
CO4	Learn about mathematical models through Linear Programming.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Introduction to Mathematical modelling, its need, techniques and classifications. Mathematical modelling in Population dynamics, Economics, Medicine, Arms race and Battles. ([1] Chapter 3).	15	CO1
2	Mathematical modelling through in Planetary motions, Circular motion, motion of Satellites and miscellaneous mathematical models ([1] Chapter 4).	15	CO2
3	Mathematical modelling through difference equations: Economics and Finance, Population Dynamics and Genetics ([1] Chapter 5).	15	CO3
4	.Modelling through linear programming; graphical solution, simplex method ([1] Chapter 10).	15	CO4

Suggested Readings

1. J. N.Kapur, Mathematical Modeling, New Age International Publisher, 2005.

2. Frank R.Giordano, D.Maurice Weirand William P. Fox : A First Course in Mathematical Modeling, Thomson Learning, Londonand NewYork, 2003.

3. J. N.Kapur, Mathematical Modeling in medicine and Biology, New Age Publication. [4]. D.N. Burghes, Mathematical Modeling in the Social Management and LifeScience, Ellie Herwood and John Wiley.

Online Resources

1. https://www.slideshare.net/slideshow/kapur-j-n-mathematical-modelling-pdf/265434733

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1		2			2					3	2
CO2	2	2	2		2			2					3	3
CO3	2	2	2		3			2					3	3
CO3	2	2	1		2			1					2	2

Program	B.Sc. (Hons./ Hons. with Research) Mathematics				
Year	3	Semester	5		
Course Name	Mechanics				
Code	NBSME3502				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Basic knowledge of Trigonometry and Calculus	3	1		4
Course Objectives	The aim of the course is to develop understanding of the effects of forces on the movement of bodies including both bodies in motion and bodies at rest.				
Course Outcomes: After completion of the course, students will be able to					
CO1	understand the concept of centroid and centre of gravity of simple and complex geometrical shape.				
CO2	understand the concept of common catenary and obtain equations of common catenary, principle of virtual work and its significance.				
CO3	understand concept of simple harmonic motion (SHM) and its geometrical representation.				
CO4	understand concept of kinematics and kinetics of the motion and Kepler's laws of planetary motion.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Centre of gravity of plane are a including a uniform thin straight rod, triangle, circular arc, semicircular area and quadrant of a circle, Centre of gravity of a plane area bounded by a curve, Centre of gravity of a volume of revolution ([1] Chapter 8).	15	CO1
2	Common catenary, Intrinsic and Cartesian equations of the common catenary ([1] Chapter 8). Principle of virtual work for a system of coplanar forces acting on a particle or at different points of a rigid body, Forces which can be omitted in forming the equations of virtual work.([1]Chapter 5).	15	CO2
3	Simple harmonic motion (SHM) and its geometrical representation, SHM under elastic forces, Motion under inverse square law ([2] Chapter 2), Motion in resisting media ([2] Chapter 7).	15	CO3
4	Kinematics and kinetics of the motion, Expressions for velocity and acceleration in Cartesian, polar and intrinsic coordinates. Equation of motion under a central force, Differential equation of the orbit, (p, r) equation of the orbit, Apses and apsidal distances, Kepler's laws of planetary motion ([2] Chapter 4,5 & 6).	15	CO4

Suggested Readings

1. S. L. Loney (2006), An Elementary Treatise on Statics, Kalyani Publishers, New Delhi.
2. S. L. Loney (1987), An Elementary Treatise on the Dynamics of a Particle

and of Rigid Bodies, Kalyani Publishers, New Delhi.
3. P.L. Srivatava (1964). Elementary Dynamics. Ram Narin Lal, Beni Prasad Publishers, Allahabad.
4. J.L. Synge & B.A., Griffith (1949). Principles of Mechanics, McGraw- Hill.

Online Resources

1. NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.asp

Course Articulation Matrix

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1		2		2						2	1
CO2	1	2	1		1		2						2	1
CO3	2	2	2		2		2						2	2
CO4	1	1	2		1		2						1	2

Program	B.Sc. (Hons./Hons. with Research) Mathematics				
Year	3	Semester	5		
Course Name	Number Theory				
Code	NBSME3503				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Basic understanding of set theory and logic	3	1	0	4
Course Objectives	The objective of this course is to introduce the concept of number theoretic functions and their properties.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Learn about some fascinating discoveries related to the properties of prime numbers and some of the open problems in number theory.				
CO2	Know the properties of Number Theory.				
CO3	Know about number theoretic functions and modular arithmetic.				
CO4	Acquire the basic knowledge of Legendre symbol and its properties and Quadratic Reciprocity law.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Divisibility theorem in Integers, Primes and their Distributions, Fundamental Theorem of Arithmetic, Greatest Common Divisor, Euclidean Algorithms, Linear Diophantine Equation ([1] Chapter 2), Goldbach Conjecture ([1] Chapter 3).	15	CO1
2	Introduction to Congruence, Linear Congruence. Chinese Remainder Theorem ([1] Chapter 4), Polynomial Congruence, System of Linear Congruence, complete set of Residues, Chinese Remainder Theorem, Fermat's Little Theorem, Wilsons Theorem ([1] Chapter 5).	15	CO2
3	Number Theoretic Functions, Sum and Number of Divisors, Totally Multiplicative Functions, Definition and Properties of the Dirichlet Product, the Mobius Inversion Formula, Greatest Integer Function ([1] Chapter 6), Euler's Phi function, Euler's Theorem, Reduced Set of Residues ([1] Chapter 7).	15	CO3
4	Order of an integer modulo n, Primitive Roots of Primes, Composite Numbers having Primitive Roots ([1] Chapter 8), Euler's Criterion, Legendre Symbol and its Properties, Quadratic Reciprocity Law ([1] Chapter 6).	15	CO4

Suggested Readings

1. D. M. Burton, Elementary Number Theory, (6thEditiobn), McGraw Hill.
2. K.H. Rosen, Elementary Number Theory & its Applications, Pearson AdditionWesley.
3. I. Niven and H.S. Zuckerman, An Introduction to Theory of Numbers, Wiley Eastern Pvt. Ltd.

4. Neville Robinns, Beginning Number Theory (2nd Edition), Narosa Publishing HousePvt. Limited, Delhi.

Online Resources

1. https://archive.nptel.ac.in/courses/111/101/111101137/
2. https://archive.nptel.ac.in/courses/111/103/111103020/

Course Articulation Matrix													
PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2	2			1	1	1					2	1
CO2	1	2				1	1	1					2	1
CO3	2	2	2			2	2	2					2	1
CO4	1	1	1			2	1	1					1	1

Program	B.Sc. (Hons./ Hons. with Research) Mathematics				
Year	3	Semester	6		
Course Name	Boolean Algebra & Automata Theory				
Code	NBSME3601				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Basic of set theory and logic	3	1		4
Course Objectives	To illustrate Boolean algebra with various techniques of circuit verification, extend concepts of poset by study of lattice, study of automata theory and make solving in mathematics and computer science problems.				
Course Outcomes: After completion of the course, students shall be able to					
CO1	Acquire the knowledge of Lattices theory				
CO2	Understand the knowledge of Boolean algebra and able to optimize simple logic using Karnaugh maps.				
CO3	Elaborate and expand their understanding of the tools helpful in the implementation of circuit design.				
CO4	Develop a strong background in reasoning about finite state automata and formal languages.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Definition, examples and basic properties of ordered sets, partial order set, Hasse diagram, duality principle, product of two poset, lattices and its properties, sub-lattices, direct product and homomorphism, isomorphic lattice, distributive lattice, bounded lattice, complemented lattices, modular lattice ([1] Chapter7).	15	CO1
2	Booleanalgebras, principle of duality, Boolean polynomials, minimal forms of Boolean polynomials, Boole's Theorem, Disjunctive normal form, conjunctive normal form, Bool's Expansion Theorem, Quinn-McCluskeymethod,Karnaughdiagrams.([1]Chapter10).	15	CO2
3	Introduction to Switching algebra, Switching Functions, ([2]Chapter3). Logic Gates, Truth Tables, Digital Circuits, Combinational Circuits, Equivalent circuit, Circuit Simplification, draw logic circuit from Boolean expression, Designing of combinational circuits- Half Adder, Full Adder, Decoders, Encoders, Multiplexers and its applications. ([2]Chapter5).	15	CO3
4	Finite Automata- Basic concepts of automation theory, Deterministic Finite Automation (DFA), transition function, transition table, Non Deterministic Finite Automata (NDFA), Mealy and Moore machine, Minimization of finite automation([3]Chapter2).	15	CO4

Suggested Readings

1. Kenneth H. Rosen, Discrete Mathematics and its Applications, 7th Ed., McGraw-Hill, Indian Edition, 2012.
2. Elliott Mendelson: Boolean algebra and SwitchingCircuits, McCraw Hi11.2020.
3. John E. Hoprcroft, Rajeev Motwani, Jeffrey D. Ullman: Introduction to Automata Theory, Languages and Computation, Pearson Education, 2000
4. K. L. P. Mishra and N. Chandrasekaran, Theory of Computer Science, Automata, Languages and Computation, 3rd Ed. Printice Hall of India Pvt. Ltd., New Delhi, 2008.
5. Peter Linz, Formal Languages and Automata, Narosa Publishing House, New Delhi.
6. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, (2nd Ed.), Pearson Education (Singapore), Indian Reprint 2003.

Online Resources

https://heecontent.upsdc.gov.in/
https://archive.nptel.ac.in/courses/111/103/111103016/
https://archive.nptel.ac.in/courses/106/105/106105185/

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1		1								1	2
CO2	1	2	2		2								2	2
CO3	2	2	2		2								2	2
CO4	2	2	1										1	1

.Program	B.Sc. (Hons./ Hons. with Research) Mathematics				
Year	3	Semester		6	
Course Name	Analytical Geometry				
Code	NBSME3602				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Basic Concept of Co-ordinate Geometry	3	1	0	4
Course Objectives	The aim of the course is to develop an understanding of the concept of conicoid, plane section of conicoid, generating line of conicoid with their mathematical equations using analytical methods.				
Course Outcomes: After completion of the course, students will be able to					
CO1	Gain the ability to analyze and classify conicoids and understand their nature and geometrical properties.				
CO2	Understand the nature of plane sections of conicoids, umbilics of a paraboloid and classify the general equation of second degree.				
CO3	Gain the ability to determine generating lines and classify the quadrics.				
CO4	Understand the concept of central points and General equation of second degree..				

Module	Course Contents	Contact Hrs.	Mapped CO
1	The conicoid: The general equation of second degree, shapes of surfaces. Intersection of a line with conicoid; tangent lines and tangent plane at a point, condition of tangency, director sphere, normal, number of normals from a given point. Plane of contact. The polar plane of a point. Enveloping cone and cylinder ([1] Chapter 8).	15	CO1
2	Plane sections of conicoids: Nature of the plane section of central conicoid; axes of central plane section, area plane sections, axes of non-central plane section, circular sections, sections of paraboloids, circular sections of paraboloids, umbilics of a paraboloid, ([1] Chapter 9).	15	CO2
3	Generating line of conicoids: Ruled surfaces, generating lines of a hyperboloid of one sheet, equations of the two generating lines, projections of the generators, intersection of perpendicular generator of the hyperboloid, central point, hyperbolic paraboloid, central points, line of striction ([1] Chapter 10).	15	CO3
4	General equation of second degree: Reduction to canonical forms with classification, Polar plane of a point. Diameter plane conjugate to a given direction. Principal direction and planes. Transformations of coordinates. Quadrics of revolution.([1] Chapter 11).	15	CO4

Suggested Readings

1. Shanti Narayan, Dr. P.K. Mittal, Analytical Solid Geometry, 16th Ed. S. Chand Publishing.
2. S. L. Loney The Elements of Coordinate Geometry, McMillan and Company, London.
3. R. J. T. Bill, Elementary Treatiseon Coordinate Geometry of Three Dimensions, McMillan India Ltd, 1994.

Online Resources

1. NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.aspx

Course Articulation Matrix

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2					1			1		1	2
CO2	2	1	2					2			2		2	2
CO3	1	2	1					1			1		1	2
CO4	2	1	2					1			2		2	1

Program	B.Sc. (Hons./Hons. with Research) Mathematics				
Year	3	Semester	6		
Course Name	Module Theory				
Code	NBSME3603				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Foundation of Ring Theory.	3	1	0	4
Course Objectives	The aim of this course is to introduce the fundamental concepts of Modules.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Acquire basic knowledge of Module and submodule.				
CO2	Understand Module Homomorphism.				
CO3	Identify Simple Module, Noetherian Modules etc.				
CO4	Understand various theorems associated with Module.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Introduction to Modules over arbitrary rings, examples, Free Modules, submodules, Quotient modules.([1] Chapter 3)	15	CO1
2	Module Homomorphism, Direct sum, Direct product, Generators of module over commutative ring, rank of free module ([1] Chapter 3).	15	CO2
3	Simple module, Modules over PID, Module with chain condition, Noetherian Modules, Noetherian ring.([1] Chapter 10)	15	CO3
4	Artinian module, Artinian rings, Hilbert basis theorem, Tensor product of modules, Properties of Tensor Products ([1] Chapter 10).	15	CO4

Suggested Readings

1. S. Lang, Algebra, Addison Wesley.
2. V.Sahai &V.Bist, Algebra, Fourth Edition, Narosa.
3. I.B.S.Passi and I.S.Luther, Algebra, Volume 3 Modules, Narosa.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc22_ma76/preview
2. https://archive.nptel.ac.in/courses/111/105/111105161

Course Articulation Matrix														
PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1	2					2						1	1
CO2	1	1					1						1	1
CO3	2	2					2						1	1
CO4	2	2					2						1	1

Program	B.Sc. (Hons./Hons. with Research) Mathematics				
Year	4	Semester	7		
Course Name	Abstract Algebra				
Code	NBSME3701				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Foundation of Group theory and Ring theory	3	1	0	4
Course Objectives	This course is aimed at developing the theoretical concepts of group, ring, bilinear and quadratic form of matrix.				

Course Outcomes: Upon successful completion of syllabus, a student will be able to:

CO1	Understand the basic concepts of group actions and their applications.
CO2	Recognize the fundamental theorem of finitely generated abelian group.
CO3	Learn about basic concept of Principal integral domain, Unique factorization domain.
CO4	Explain the significance of Matrix of Bilinear form and Quadratic form.

Module	Course Contents	Contact Hrs.	Mapped CO
1	Automorphism, Inner automorphism and conjugate elements, Characteristic subgroups, Conjugate elements, Relation of conjugacy and classes of conjugate elements, Self-conjugate elements, Counting principle and the class equation of a finite group, Group actions, Orbits and stabilizers, Orbit-stabilizer theorem, Sylow theorems (With out proof) ([2] Chapter 4).	15	CO1
2	External Direct Product: Definition and Examples, Properties of External direct product, group of unit modulo n as an external direct product, Fundamental theorem of finitely generated abelian group. ([1] Chapter 8)	15	CO2
3	Euclidean domains, Principal ideal domain (PID), Unique factorization domains, Fundamental Theorem of Arithmetic, ([2] Chapter 9), Gauss Theorem ([5] Chap. 7).	15	CO3
4	Bilinear forms, Matrix of a Bilinear forms, Quadratic Forms, Matrix of a Quadratic forms, Quadratic forms corresponding to any given symmetric matrix. ([6] Chapter 12).	15	CO4

Suggested Readings

1. Joseph A. Gallian, Contemporary Abstract Algebra (4th edition). Narosa
2. Vijay k Khanna and S K Bhambri, A Course in Abstract Algebra (4th edition), Vikash Publishing House Pvt Ltd.
3. John B. Fraleigh, A First Course in Abstract Algebra (7th edition). Pearson.
4. I. N. Herstein, Topics in Algebra (2nd edition). Wiley India.
5. Ramji Lal, Algebra (Volume II), Shail Publication.
6. Schaum's outlines, Linear Algebra, third edition, Tata McGraw-Hills.

Online Resources

1. https://archive.nptel.ac.in/courses/111/106/111106131/
2. https://digimat.in/nptel/courses/video/111105161/L18.html

Course Articulation Matrix														
PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2					2						1	1
CO2	1	2					2						1	1
CO3	2	2					2						1	1
CO4	2	2					2						1	1

Program	B.Sc. (Hons./Hons. with Research) Mathematics				
Year	4	Semester	7		
Course Name	Topology				
Code	NBSME3702				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Basic knowledge of Real Analysis	3	1	0	4
Course Objectives	The objective of the course is to introduce the concept of the topological spaces and their properties.				
Course Outcomes: Upon successful completion of course, a student will be able to:					
CO1	Understand the concepts of topological spaces and the basic definitions of open sets, neighbourhood, interior, exterior, closure and their axioms for defining topological space.				
CO2	Understand the concept of compactness, ascoli's theorem.				
CO3	Understand how points of space are separated by open sets, Housdroff spaces and their importance.				
CO4	Understand connectedness and topological properties.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Topological Spaces: The Definition and examples, Elementary concepts, Open bases and open subbases, Weak topologies ([1] Chapter 3).	15	CO1
2	Compactness: Compact spaces, Products of spaces, Tychonoff's theorem and locally compact spaces, Compactness for metric spaces, Ascoli's theorem. ([1] Chapter 4).	15	CO2
3	Separation: T1 spaces and Hausdorff spaces, Completely regular spaces and normal spaces, Urysohn's lemma and the Tietze extension theorem, The Urysohn imbedding theorem. ([1] Chapter 5).	15	CO3
4	Connectedness: Connected spaces, The components of a spaces, Totally disconnected spaces, Locally connected spaces. ([1] Chapter 6).	15	CO4

Suggested Readings

1. G.F. Simmon's: Introduction to Topology and Modern Analysis, Tata McGraw Hill Edition.
2. W. J. Pervin: Foundations of General Topology.
3. Willard: Topology, Academic press.
4. Vicker: Topology via logic, (School of Computing, Imperial College, London).
5. J. R. Munkers: Topology, A First Course, Prentice Hall of India Pvt. Ltd.

Online Resources

1. https://www.youtube.com/playlist?list=PLbMVogVj5nJRR7zYZifYopb52zjoScx1d

Course Articulation Matrix														
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	1	1	1				2					2	1
CO2	1	1	1					1					1	1
CO3	1	1	1					1					1	1
CO4	1	1	1					1					1	1

Program	B.Sc. (Hons. /Hons. with Research) Mathematics				
Year	4	Semester	7		
Course Name	Real Analysis				
Code	NBSME3703				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Basic topology of Euclidean spaces, metric space and convergence.	3	1	0	4
Course Objectives	The aim of the course is to develop the concepts compactness and connectedness o of the metric and differentiation and integration of the function of several variables and their applications.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Understand the concepts of compactness and connectedness in the metric space.				
CO2	Learn the concepts of Continuity and Compactness, Continuity and connectedness and Reimann Stielties integral and its properties.				
CO3	Understand the concepts of Riemann Stielties integral and its properties.				
CO4	Demonstrate the concepts of uniform convergence and approximation of continuous function.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Metric spaces, Compact sets, Perfect sets, Connected sets ([1] Chapter 2)	15	CO1
2	Limits of functions, Continuous functions, Continuity and Compactness, Continuity and connectedness, Discontinuities, Monotone functions. ([1] Chapter 4)	15	CO2
3	Definition and existence of the Riemann Stieltjes integral, Properties of the integral, Integration of vector valued functions, Rectifiable curves. ([1] Chapter 6)	15	CO3
4	Sequences and series of functions: Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Approximation of a continuous function by a sequence of polynomials. ([1] Chapter 7)	15	CO4

Suggested Readings

1. Walter Rudin, *Principle of Mathematical Analysis* (3rd edition) McGraw- Hill, 1976, International Student Edition.
2. K. Knopp, *Theory and Application of Infinite Series*.
3. T. M. Apostol, *Mathematical Analysis*, Narosa Publishing House, New Delhi, 1985.
4. P. Natanson: Theory of Functions of a Real Variable, Volume 1, Frederick Pub. Co., 1964
5. H. L. Royden: Real Analysis, McMillan Publication Co. Inc. New York.

Online Resources

https://archive.nptel.ac.in/courses/111/106/111106053/

Course Articulation Matrix													
PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1	2	1				1						1	1
CO2	1	2	1				2						1	1
CO3	2	2	1				2						2	1
CO4	2	2	2				2						2	1

Program	B.Sc. (Hons./Hons. with Research) Mathematics				
Year	4	Semester	7		
Course Name	Fuzzy Mathematics				
Code	NBSME3704				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Basic Knowledge of set theory	3	1	0	4
Course Objectives	The aim of this course is to develop the fundamental concepts such as fuzzy sets, operations and fuzzy relations				
Course Outcomes: Upon successful completion of course, a student will be able to:					
CO1	interpret fuzzy set theory and the concepts of fuzzy relations.				
CO2	identify the similarities and differences between probability theory and fuzzy set theory.				
CO3	Understand the concepts of classical and multivalued logics.				
CO4	interpret fuzzy set theory and uncertainty concepts				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Classical and Fuzzy sets: Crisp sets, Crisp relation, Maxmin composition, Properties of membership function, Fuzzy sets and their basic concepts, Operations on fuzzy sets, Fuzzy arithmetic, Fuzzy relations, Fuzzy relation equations based on sup–i composition and Inf–i composition, Fuzzification and Defuzzification.(Chapter 2, 3[1]).	15	CO1
2	Possibility theory and fuzzy sets: Possibility theory, Fuzzy measure, Evidence theory, Fuzzy sets and possibility theory. (Chapter 1, 15[1]).	15	CO2
3	Fuzzy and Classical logic: Multivalued logic, Fuzzy propositions, Fuzzy quantifiers, Inference from conditional fuzzy propositions, Fuzzy statistical process control. (Chapter 5, 8, 10[1]).	15	CO3
4	Uncertainty based Information: Information and Uncertainty, Non specificity of Crisp sets, Non specificity of Fuzzy sets, Fuzziness of Fuzzy sets, Fuzzy sets in Business management, Psychology, Foods and nutrition with good number of case studies.(Chapter 1, 8, 13[1]).	15	CO4

Suggested Readings

1. T.J. Ross: *Fuzzy Logic with Engineering and Applications*,Wiley Student Edition, 2010.
2. B.M Ayyub and L.N. Kanal: *Analysis and Management of Uncertainty: Theory and Application*, North Holland, New York, 1992.
3. W. Bandler and W. Nather: *Fuzzy Data Analysis*, Kluwer Academic Press, 1996.
4. A. Wesley: *Fuzzy Mathematical Techniques with Applications*, 1985.
5. J.K. George: *Fuzzy Sets and Fuzzy Logic, Theory and Applications*, Yuan Prentice Hall,2006.

Online Resources

https://youtu.be/oWqXwCEfY78?list=PLjZ9ULh2Ff9FWvv-DiZHP6RN0kMr_4aW4

Course Articulation Matrix													
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1				1	1					2	1
CO2	1	1	1				2	1					2	1
CO3	1	2	1				2	1					2	1
CO4	2	2	1				2	1					2	1

Program	B.Sc. (Hons./Hons. with Research) Mathematics				
Year	4	Semester	8		
Course Name	Advance Algebra				
Code	NBSME3801				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Foundation of Groups, Fields	3	1	0	4
Course Objectives	The objective of this course is to introduce fundamental concepts of Field Theory and Galois Theory.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Understand the concept of extension of field.				
CO2	Understand the concept splitting field, normal extension, Multiple roots.				
CO3	Understand the concept of Galois theory.				
CO4	Know about the idea of using algebra to bear on geometrical problems.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Algebraic extensions of fields; Irreducible polynomials and Eisenstein criterion, Adjunction of roots-Algebraic extensions, algebraically closed fields ([3] Chapter 6).	15	CO1
2	Normal and separable extensions; Splitting fields, Normal extensions, Multiple roots, Finite Fields-Separable extensions ([2] Chapter 11).	15	CO2
3	Galois theory; Automorphism groups and fixed fields, Fundamental theorem of Galois theory, Fundamental theorem of Algebra ([3] Chapter 10).	12	CO3
4	Roots of unity, Polynomials solvable by radicals, Ruler and Compass constructions ([5] Chapter 15).	13	CO4

Suggested Readings

1. Joseph A. Gallian, Contemporary Abstract Algebra (4th edition). Narosa
2. Ramji Lal, Shail Publication, Algebra (Volume 2)
3. John B. Fraleigh, A First Course in Abstract Algebra (7th edition). Pearson.
4. I. N. Herstein, Topics in Algebra (2nd edition). Wiley India.
5. Vijay K Khanna and S K Bhambri, A Course in Abstract Algebra(4th edition), Vikash Publishing House Pvt Ltd.

Online Resources

1. Introduction to Galois Theory - Course (nptel.ac.in)
2. https://math.mit.edu/~dav/galois.pdf

Course Articulation Matrix														
PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	1					2						1	1
CO2	1	2					2						1	1
CO3	2	2					2						2	1
CO4	1	1					2						1	1

Program	B.Sc. (Hons./Hons. with Research) Mathematics				
Year	4	Semester	8		
Course Name	Advance Real Analysis				
Code	NBSME3802				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Basic knowledge of real analysis.	3	1	0	4
Course Objectives	The aim of this course is to develop the advanced concept of real analysis and give sufficient knowledge of the subject which can be used by students for further applications in their respective domains of interest.				

Course Outcomes: Upon successful completion of syllabus, a student will be able to:

CO1	Understand the concepts of measure and Lebesgue measure.
CO2	Learn the properties of Lebesgue integral and understand the concepts of non-negative functions.
CO3	Understand the convergence and differentiation of a monotone functions.
CO4	Understand the importance of Minkowski and Holder's inequalities.

Module	Course Contents	Contact Hrs.	Mapped CO
1	Algebra of sets, Borel sets, Outer measure, Measurable sets and Lebesgue measure, A non-measurable set, Measurable functions, Little word's three principles. ([1] Chapter 3).	15	CO1
2	The Lebesgue integral of a bounded function over a set of finite measure, The integral of a non-negative function, The general Lebesgue integral. ([1] Chapter 4).	15	CO2
3	Convergence in measure, Differentiation of a monotone functions, Functions of bounded variation. ([1] Chapter 5).	15	CO3
4	Differentiation of an integral, Absolute continuity, The Lp-spaces, The Minkowski and Holder's inequalities, Convergence and completeness. ([1] Chapter 4 & 5).	15	CO4

Suggested Readings

1. H. L. Royden: Real Analysis , Pearson Education (3rd Edition) (Low Price Edition).
2. P. R. Halmos: Measure Theory, Van Nostrand, 1950.
3. G. de Barra: Measure Theory and Integration, Wiley Eastern, 1981.
4. E. Hewitt and K. Stromberg: Real and Abstract Analysis, Springer, 1969.
5. P. K. Jain and V. P. Gupta: Lebesgue Measure and Integration, New Age International, New Delhi, 2000.
6. Walter Rudin: Principle of Mathematical Analysis (3rd edition) McGraw Hill, International Student Edition, 1976.

Online Resources

1. https://archive.nptel.ac.in/courses/111/108/111108135/
2. https://onlinecourses.nptel.ac.in/noc20_ma02/preview

Course Articulation Matrix													
PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1	2	1				2						1	1
CO2	2	2	1				2						1	1
CO3	2	2	2				2						2	1
CO4	2	2	2				2						2	1

Program	B.Sc. (Hons./Hons. with Research) Mathematics				
Year	4	Semester	8		
Course Name	Functional Analysis				
Code	NBSME3803				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Basic knowledge of Set theory, vector space.	3	1	0	4
Course Objectives	At the end of this course the students will be able to understand a strong foundation in functional analysis, focusing on various spaces.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	To understand topological-algebraical structures and the methods by which the knowledge of these methods can be applied to analytic problems				
CO2	Understand the concept of normed linear spaces and various properties operators defined on them.				
CO3	Understand the main properties of bounded operators between Banach and Hilbert spaces, the basic results associated to different types of convergences in normed spaces and the spectral theorem and some of its applications.				
CO4	Understand the concept of the spectrum of bounded operators and how much it will be helpful in solving certain differential equations.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Banach Spaces; Definition and some examples continuous linear transformations, The Hahn-Banach theorem ([1] Chapter 9).	15	CO1
2	The natural imbedding of N in N**, the open mapping theorem, Closed Graph Theorem, The conjugate of an operator, The uniform boundedness Theorem. ([1] Chapter 9).	15	CO2
3	Pre-Hilbert space and Hilbert spaces; The definition and some simple properties, Orthogonal complements, orthogonal sets, the conjugate space H*. ([1] Chapter 10, [2] Chapter 3).	15	CO3
4	The adjoint of an operator, Self adjoint operators, Normal and Unitary operators, Projections. Finite dimensional spectral theory; Spectrum of an operator, the spectral theorem. ([1] Chapter 10& 11).	15	CO4

Suggested Readings

1. G. F Simmons, Introduction to Topology & Modern Analysis, McGraw Hill Education (India) Pvt. Ltd., New Delhi.
2. E. Kreyszig, Introductory Functional Analysis with applications, John-Wiley and Sons, New York.
3. Walter Rudin, Functional Analysis, McGraw Hill, New Delhi.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc22_ma22/preview
2. https://archive.nptel.ac.in/courses/111/105/111105037/

Course Articulation Matrix														
PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2					2	1					1	1
CO2	1	1					2						1	1
CO3	2	2					2	1					1	1
CO4	1	1					2						1	1

Program	B.Sc. (Hons./Hons. with Research) Mathematics				
Year	4	Semester	8		
Course Name	Computational Fluid Dynamics				
Code	NBSME3804				
Course Type	DSE	L	T	P	Credit
Pre-Requisite	Basic knowledge of fluid dynamics	3	1	0	4
Course Objectives	The objective is to introduce the concept of the basics of fluid flow, its model and tool to solve the fluid flow problems.				
Course Outcomes: Upon successful completion of course, a student will be able to:					
CO1	Develop concept of computational fluid dynamics and the application of PDE.				
CO2	To apply CFD codes in the design of fluid systems and components.				
CO3	Provide the essential numerical background for solving the PDE's governing the fluid flow and use of viscous terms in the NS equations.				
CO4	Understand boundary layer flow, Incompressible & compressible viscous flow.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Introduction: Basics of CFD, Advances of computational fluid dynamics, Partial Differential Equations Types, Governing equations and assumptions, Boundary conditions ([5] Chapter 2).	15	1
2	Basics of Discretization Techniques: Explicit schemes, implicit schemes ([5] Chapter 3), Grid generation ([5] Chapter 10), Finite Difference Method, Finite Volume Method and Finite Element Method ([5] Chapter 4).	15	2
3	Solving the Fluid Dynamic Equations: Flows governed by reduced Navier-Stokes Equations, Convective-Diffusive equations, Internal and external flows, supersonic inviscid flows ([1] Vol. 2 Chapter 16).	15	3
4	Laminar boundary layer flow, unsteady boundary layers, finite difference methods for two dimensional flows ([1] Vol. 2 Chapter 11), Incompressible ([1] Vol. 2 Chapter 17) & compressible Viscous Flow ([1] Vol. 2 Chapter 18).	15	4

Suggested Readings:

1. C. A. J. Fletcher, Computational Techniques for Fluid Dynamics, Volume 1 & 2, Springer Verlag, 1992.
2. C. Y. Chow, Introduction to Computational Fluid Dynamics, John Wiley, 1979.
3. M. Holt, Numerical Methods in Fluid Mechanics, Springer Verlag, 1977.
4. H. J. Wirz and J. J. Smolderen, Numerical Methods in Fluid Dynamics, Hemisphere, 1978.
5. D. A. Anderson, J. C. Tannehill and R. H. Pletcher, Computational Fluid Dynamics and Heat
6. Transfer, McGraw Hill, 1984.

Online Resources

1. **https://archive.nptel.ac.in/courses/112/105/112105254/**
2. **https://www.youtube.com/playlist?list=PL8EAF844326CBB2E3**

Course Articulation Matrix														
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	1						1					2	1
CO2	1	1	1					1					1	1
CO3	1	1						1					1	1
CO4	1	1						1					1	1