



Re- accredited with A ++ Grade (CGPA 3.65) by NAAC
Category- I University Status awarded by UGC

No. 2026/June/AAMS/C-168/48226

Date: 05th June, 2026

CIRCULAR:-

Attention of all the Principals of the Affiliated Colleges, all Academic Heads of University Departments, the Directors of the Recognized Institutions/Centres, Director, Centre for Distance & Online Education, Director, Dharmaveer Anand Dighe Thane Sub-Campus, Co-ordinator, School of Engineering and Applied Sciences, Kalyan Sub-Campus, Director, Chitrakar Padmabhushan Dr.Dhananjay Keer Ratnagiri Sub-Campus, Director, Sindhudurg Sub-Campus, Principal, Vishwabhushan Bharatratna Dr. B. A. Ambedkar College, Ambadave, Ratnagiri and Principal, V.V. Dalvie College, Talere, Sindhudurg is invited to this office Circular No.2026/May/AAMS-III/C-73/42964 dated 08th May, 2026 relating to the **B.A / B.Sc. (Mathematics) (Sem V & VI) (Scheme - I).**

They are hereby informed that the recommendations made by the Board of Studies in **Mathematics** at its meeting held on 15th April, 2026 and subsequently passed by the Board of Deans at its meeting held on 15th May, 2026 vide item No.1 have been accepted by the Academic Council at its meeting held on 18th May, 2026 vide item No.6.15 (N). In accordance therewith syllabus of **B.A/B.Sc. (Hons. with Research) in Mathematics (Sem VII & VIII) (NEP 2020)** is introduced as per appendix with effect from the academic year 2026-27.

(The said circular is available on the University's website www.mu.ac.in).

MUMBAI – 400 032

05th June, 2026

To

All the Principals of the Affiliated Colleges, all Academic Heads of Departments, the Directors of the Recognized Institutions/Centres, Director, Centre for Distance & Online Education, Director, Dharmaveer Anand Dighe Thane Sub-Campus, Co-ordinator, School of Engineering and Applied Sciences, Kalyan Sub-Campus, Director, Chitrakar Padmabhushan Dr.Dhananjay Keer Ratnagiri Sub-Campus, Director, Sindhudurg Sub-Campus, Principal, Vishwabhushan Bharatratna Dr. B. A. Ambedkar College, Ambadave, Ratnagiri and Principal, V.V. Dalvie College, Talere, Sindhudurg

AC./6.15 (N)/18/5/2026

Copy forwarded with Compliments for information to:-

- 1) The Chairman, Board of Deans,
- 2) The Dean, Faculty of Science,
- 3) The Chairman, Board of Studies in Mathematics
- 4) The Director, Board of Examinations and Evaluation,
- 5) The Director, Department of Students Development,
- 6) The Director, Department of Information & Communication Technology,
- 7) The Director, Centre for Distance and Online Education (CDOE) Vidyanagari,
- 8) The Deputy Registrar, Admission, Enrolment, Eligibility & Migration Department (AEM),

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentar@gmail.com
17	The Director, Centre for Distance and Online Education (CDOE), Vidyanagari, director@idol.mu.ac.in
18	Director, Innovation, Incubation and Linkages, Dr. Sachin Laddha pinkumanno@gmail.com
19	Director, Department of Lifelong Learning and Extension (DLLE), dlleuniversityofmumbai@gmail.com

Copy for information :-	
1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

To,

1	The Chairman, Board of Deans pvc@fort.mu.ac.in
2	Faculty of Humanities, Offg. Dean 1. Prof.Anil Singh Dranilsingh129@gmail.com Offg. Associate Dean 2. Prof.Manisha Karne mkarne@economics.mu.ac.in 3. Dr.Suchitra Naik Naiksuchitra27@gmail.com
	Faculty of Commerce & Management, Offg. Dean, 1 Prin.Ravindra Bambardekar principal@model-college.edu.in Offg. Associate Dean 2. Dr.Kavita Laghate kavitalaghate@jbims.mu.ac.in 3. Prin.Kishori Bhagat kishoribhagat@rediffmail.com

	Faculty of Science & Technology Offg. Dean 1. Prof. Shivram Garje ssgarje@chem.mu.ac.in Offg. Associate Dean 2. Dr. Madhav R. Rajwade Madhavr64@gmail.com 3. Prin. Deven Shah sir.deven@gmail.com
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3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in DSW directr@dsd.mu.ac.in
6	The Director, Department of Information & Communication Technology, director.dict@mu.ac.in

As Per NEP 2020

University of Mumbai



Syllabus for B.A./B.Sc. (Hons. with Research) in Mathematics UG Fourth Year

Faulty	Science & Technology
Board of Studies	Mathematics
Semester	VII & VIII
From the Academic Year	2026-27

University of Mumbai



(As per NEP 2020)

Sr. No.	Heading	Particulars
1	Title of program O:	B.A./B.Sc. (Hons. with Research) in Mathematics
2	Exit Degree	B.A./B.Sc. (Hons. with Research) in Mathematics
3	Scheme of Examination R: _____	NEP 50% Internal 50% External, Semester End Examination Individual Passing in Internal and External Examination
4	Standards of Passing R: _____	40%
5	Credit Structure R: SU-530 I R: SU-530 J	Attached herewith
6	Semesters	Sem. VII & VIII
7	Program Academic Level	6.0
8	Pattern	Semester
9	Status	New
10	To be implemented from Academic Year	2026-27

Sd/-

Sign of the BOS
Name Prof. B. S. Desale
Chairman
BOS in Mathematics

Sd/-

Sign of the
Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science &
Technology

Sd/-

Sign of the Offg. Dean
Prof. Shivram S. Garje
Faculty of Science &
Technology

B.A./B.Sc. (Hons. with Research) in Mathematics

Credit Structure (Sem. VII & VIII)

	R: SU-530 I										
Vertical Level	Semester	1 Major		1A RM	2 Minor	3 OE/	4 VSC, SEC (VSEC)	5 AEC, VEC, IKS	6 OJT, FP, CEP, CC,RP	Cum. Cr. / Sem.	Degree/ Cum. Cr.
		Mandatory	Electives								
6.0	VII	10 (4+4+2) Real Analysis (4) Ordinary Differential Equation (4) Discrete Mathematics & Number Theory (2)	4 Guide Course I (4)	RM (4) Research Methodo- logy (4)	---	---	---	----	RP (4) Rese arch Proj ect (4)	22	UG Honours with Research Degree 176
	R: SU-530 J										
	VIII	10 (4+4+2) Algebra (4) Complex Analysis (4) Partial Differential Equations (2)	4 Guide Course II (4)	---	---	----	----	----	RP (8) Rese arch Proj ect (8)	22	
	Cum Cr.	68	16	4	18	12	14	14	30	44	
	Exit option: Award of Four year UG Honours with Research Degree in Major and Minor with 176 credits										

[Abbreviation - OE – Open Electives, RM – Research Methodology, VSC – Vocation Skill Course, SEC – Skill Enhancement Course, (VSEC), AEC – Ability Enhancement Course, VEC – Value Education Course, IKS – Indian Knowledge System, OJT – On Job Training, FP – Field Project, CEP – Community Engagement Project, CC – Co-Curricular, RP – Research Project]

Program Structure for Sem. VII & VIII

(NEP 2020)

B.A./B.Sc. (Hons. with Research) in Mathematics

Vertical No		Paper Title	Credits
Sem. VII			
1.	Mandatory	1. Real Analysis	4
		2. Ordinary Differential Equations	4
		3. Discrete Mathematics and Number Theory	2
	Electives	1. Guide Course I	4
1A.	Research Methodology		4
6.	Research Project		4
Credits			22
Sem. VIII			
	Mandatory	1. Algebra	4
		2. Complex Analysis	4
		3. Partial Differential Equations	2
	Electives	1. Guide Course II	4
6.	Research Project		8
Credits			22
Total Credits			44

Sem. - VII

Sem. - VII

Vertical – 1

Major

Mandatory

(4+4+2)

Syllabus
B.A./B.Sc. (Hons. with Research) in Mathematics
(Sem.- VII)

Title of Paper: 1111463701 : Real Analysis

Sr. No.	Heading	Particulars
1	Description of the course : Including but Not limited to :	Subject Real Analysis covers mathematical analysis techniques in the Real domain
2	Vertical :	Major
3	Type :	Theory + Practical
4	Credit:	4 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	Hours Allotted :	60 Hours + 8 – 10 Practicals
6	Marks Allotted:	100 Marks
7	Course Objectives: 1. The students will be introduced to Euclidean spaces and topology on them. 2. Students will learn about operator norms and their properties. 3. Students will interpret the concept of differentiability in an abstract manner. 4. The course will equip the students with the knowledge of basic theorems like the inverse function theorem, implicit function theorem and mean value theorem. 5. The course aims to demonstrate explicitly how Riemann integration works and the role of Fubini's theorem in calculations in a wide range of examples.	

8	Course Outcomes: 1. Students will be able to judge if the given Euclidean spaces are compact or not. 2. Students will be able to select Euclidean spaces that are compact, connected from the given list of spaces. 3. They will be able to predict if the given function is continuous/uniformly continuous or not. 4. Students will be able to test if the hypothesis of the implicit function theorem and implicit function theorem hold. If yes, they will further be able to explain the arising consequences. 5. Students will be able to evaluate the Riemann integral and illustrate how Fubini's theorem works.
9	Modules:- All results have to be done with proof unless otherwise stated. Module 1: Euclidean space R^n 1. Euclidean space R^n : inner product $\langle x, y \rangle = \sum_{j=1}^n x_j y_j$ of $x = (x_1, \dots, x_n), y = (y_1, \dots, y_n) \in R^n$ and properties, norm $\ x\ = \sqrt{\sum_{j=1}^n x_j^2}$ of $x = (x_1, \dots, x_n) \in R^n$, Cauchy-Schwarz inequality, properties of the norm function $\ x\$ on R^n. (Ref. W. Rudin or M. Spivak). 2. Standard topology on R^n : open subsets of R^n, closed subsets of R^n, interior A° and boundary ∂A of a subset A of R^n. (ref. M. Spivak) 3. Operator norm $\ T\$ of a linear transformation $T: R^n \rightarrow R^m$ ($\ T\ = \{ \ T(v)\ : v \in R^n \wedge \ v\ \leq 1 \}$) and its properties such as: For all linear maps $S, T: R^n \rightarrow R^m$ and $R: R^m \rightarrow R^k$ a. $\ S + T\ \leq \ S\ + \ T\$, b. $\ R \circ S\ \leq \ R\ \ S\$, and c. $\ cT\ = c \ T\ (c \in R)$. (Ref. C. C. Pugh or A. Browder) 4. Compactness: Open cover of a subset of R^n, Compact subsets of R^n (A subset K of R^n is compact if every open cover of K contains a finite subcover), Heine-Borel theorem (statement only), the Cartesian product of two compact subsets of R^n is compact (statement only), every closed and bounded subset of R^n is compact 5. Bolzano-Weierstrass theorem: Any bounded sequence in R^n has a convergent subsequence.

6. Functions and continuity and uniform continuity.

Module 2: Differentiable functions

1. Differentiable functions on R^n , the total derivative $(Df)_p$ of a differentiable function $f: U \rightarrow R^m$ at $p \in U$ where U is open in R^n , uniqueness of total derivative, differentiability implies continuity.(ref:[1] C.C.Pugh or[2] A.Browder)
2. Chain rule. Applications of chain rule such as:
 - I. Let γ be a differentiable curve in an open subset U of R^n . Let $f: U \rightarrow R$ be a differentiable function and let $g(t) = f(\gamma(t))$. Then $g'(t) = \langle (\nabla f)(\gamma(t)), \gamma'(t) \rangle$.
 - II. Computation of total derivatives of real valued functions such as
 - (a) the determinant function $\det(X), X \in M_n(R)$,
 - (b) the Euclidean inner product function $\langle x, y \rangle, (x, y) \in R^n \times R^n$.(ref. M. Spivak, W. Rudin)
3. Results on total derivative: partial derivatives, directional derivative $(D_u f)(p)$ of a function f at p in the direction of the unit vector, Jacobian matrix, Jacobian determinant. Results such as :
 - I. If the total derivative of a map $f = (f_1, \dots, f_m): U \rightarrow R^m$ (U open subset of R^n) exists at $p \in U$, then all the partial derivatives $\frac{\partial f_i}{\partial x_j}$ exists at p .
 - II. If all the partial derivatives $\frac{\partial f_i}{\partial x_j}$ of a map $f = (f_1, \dots, f_m): U \rightarrow R^m$ (U open subset of R^n) exist and are continuous on U , then f is differentiable.(ref. W. Rudin)
4. Derivatives of higher order, C^k -functions, C^∞ -functions.(ref. T. Apostol)

Module 3: Inverse function theorem and Implicit function theorem

1. Theorem (Mean Value Inequality): Suppose $f: U \rightarrow R^m$ is differentiable on an open subset U of R^n and there is a real number M such that $\|f(Df)_x\| \leq M \forall x \in U$. If the segment $[p, q]$ is contained in U , then $\|f(q) - f(p)\| \leq M\|q - p\|$. (ref. C. C. Pugh or A. Browder).
2. Mean Value Theorem: Let $f: U \rightarrow R^m$ is a differentiable on an open subset U of R^n . Let $p, q \in U$ such that the segment $[p, q]$ is contained in U . Then for every vector $v \in R^n$ there is a point $x \in [p, q]$ such that $\langle v, f(q) - f(p) \rangle = \langle v, (Df)_x(q - p) \rangle$. (ref:T. Apostol) If $f: U \rightarrow R^m$ is differentiable on a connected open subset U of R^n and $(Df)_x = 0$ for all $x \in U$

U , then f is a constant map.

3. Contraction mapping theorem. Inverse function theorem, Implicit function theorem.(ref. A. Browder)
4. Taylor expansion for a real valued C^m -function defined on an open subset of R^n , stationary points(critical points), maxima, minima, saddle points, second derivative test for extrema at a stationary point of a real valued C^2 -function defined on an open subset of R^n . Lagrange's method of undetermined multipliers.
(ref. T. Apostol)

Module 4: Riemann Integration

1. Riemann Integration over a rectangle in R^n , Riemann Integrable functions
2. Continuous functions are Riemann integrable,
3. Measure zero sets, Lebesgues Theorem(statement only)
4. Fubini's Theorem and applications. (Reference for Unit IV: M. Spivak, Calculus on Manifolds).

10 List of Practicals :

1. Euclidean spaces, operator norms and compactness.
2. Continuity and uniform continuity of functions, compactness and connectedness.
3. Results on total derivatives.
4. Chain rule and partial derivatives; C^k , C^∞ - functions.
5. Mean value theorem, Inverse function theorem, implicit function theorem.
6. Maxima, minima, Taylor expansion and Lagrange's method of multipliers.
7. Riemann Integration, Measurable sets.
8. Functions and Riemann integrability and Fubini's theorem.

11 Reference Books:

1. C. C. Pugh, Mathematical Analysis, Springer UTM.
2. A. Browder, Mathematical Analysis an Introduction, Springer.
3. T. Apostol, Mathematical Analysis, Narosa.
4. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill India.
5. M. Spivak, Calculus on Manifolds, Harper-Collins Publishers.

12 Internal Continuous Assessment:

50%

External, Semester End Examination

50%

	Individual Passing in Internal and External Examination	
13	Continuous Evaluation through: Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc.(at least 3)	Solving Problems, Assignments, Tutorials, Seminar and Practicals

Syllabus
B.A./B.Sc. (Hons. with Research) in Mathematics
(Sem.- VII)
Title of Paper: 1111463702 :Ordinary Differential Equations

Sr. No.	Heading	Particulars
1	Description of the course : Including but Not limited to :	Subject ordinary differential equations covers theory and examples of existence and uniqueness of solution of ordinary differential equations
2	Vertical :	Major
3	Type :	Theory + Practical
4	Credit:	4 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	Hours Allotted :	60 Hours + 8 -10 Practicals
6	Marks Allotted:	100 Marks
7	Course Objectives: 1. Students will be introduced the conditions for existence and uniqueness of the solution of initial value problems. 2. Students will learn various techniques of solving Linear Ordinary Differential Equations with constant and variable coefficients. 3. The course aims to demonstrate the qualitative properties of solution of Ordinary Differential Equations.	

8	Course Outcomes: 1. Through this course students are expected to understand the basic concepts of existence and uniqueness of solutions of Ordinary Differential Equations (ODEs). 2. In case of nonlinear ODEs, students will learn how to construct the sequence of approximate solutions converges to the exact solution if exact solution is not possible. 3. Students will be able to understand the qualitative features of solutions. 4. Students will be able to identify Sturm Liouville problems and to understand the special functions like Legendre's polynomials and Bessel's function. 5. Students will be to understand the applicability of the above concepts in different disciplines of technology.
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9	Modules:- All results have to be done with proof unless otherwise stated.
	Module 1: Existence and Uniqueness of Solutions
	1. Existence and Uniqueness of solutions to initial value problem of first order ODE- both autonomous, non autonomous, ϵ-approximate solutions, 2. Ascoli lemma, Cauchy-Peano existence theorem, 3. Lipschitz condition, Picard's method of successive approximations, 4. Picard-Lindelof theorem, System of Differential equations. Reduction of n-th order differential equations. [Reference Unit-I of Theory of Ordinary Differential Equations; Earl A. Coddington and Norman Levinson, Tata McGraw Hill, India.]
	Module 2: Linear Equations with constant coefficients
	1. The second order homogeneous equations, Initial value problem for second order equations, Uniqueness theorem 2. Linear dependance and independence of solutions, Wronskian,a formula for the Wronskian, 3. The second order non-homogeneous equations, The homogeneous equations of order n, Initial value problem for n th order equations, 4. The nonhomogeneous equations of order n, Algebra of constant coefficient operators. [Reference Unit-II of Earl A. Coddington, An Introduction to Ordinary Differential Equations, Prentice-Hall of India.]

Module 3: Linear Equations with variable coefficients

1. Initial value problem for the homogeneous equation of order n , Existence and Uniqueness theorem
2. Solution of the homogeneous equations, Wronskian and linear independence
3. Reduction of the order of a homogeneous equation, the non-homogeneous equations of order n .

[Reference III of Earl A. Coddington, An Introduction to Ordinary Differential Equations, Prentice-Hall of India.]

Module 4: Sturm-Liouville Problem & Qualitative Properties of Solutions

1. Eigenvalue problem, Eigenvalues and Eigenfunctions,
2. The vibrating string problem, Sturm Liouville problems, homogeneous and non-homogeneous boundary conditions, orthogonality property of eigenfunctions, Existence of Eigenvalues and Eigenfunctions,
3. Sturm Separation theorem, Sturm comparison theorem. Power series solution of second order linear equations, ordinary points, singular points, regular singular points.
4. Existence of solution of homogeneous second order linear equation, solution of Legendre's equation, Legendre's polynomials, Rodrigues' formula, orthogonality conditions
5. Bessel differential equation, Bessel functions, Properties of Bessel function, orthogonality of Bessel functions.

[Reference Unit IV (24, 25), Unit V (Review), Unit-VII (40, 43, Appendix A) and Unit VIII (44, 45, 46, 47) : G. F. Simmons, Differential Equations with Applications and Historical Notes, Second Edition, Tata McGraw Hill, India]

10 List of Practicals :

1. The Lipschitz condition.
2. Picard's theorem for solving initial value problems
3. Solving a system of first order differential equations
4. Linear dependence and independence of functions, Wronskian of two or more functions.

	5. Solving an nth order homogeneous/non-homogeneous equation with constant coefficients. The particular integral may be evaluated using operator method or by the method of variation of parameters. 6. Solving linear, homogeneous differential equations of order n with variable coefficients, solving initial value problems. Reduction of the order of a homogeneous 7. Differential equation and solving the same. Solution of the corresponding nonhomogeneous differential equation. 8. Solving eigenvalue problem, eigenvalues and eigenfunctions, solving vibrating string problem, Sturm Liouville problem, orthogonality of its eigenfunctions. 9. Sturm Separation theorem, Sturm Comparison theorem, Power series solution of second order linear differential equations, ordinary points, singular points, regular singularity. 10. Solution of Legendre's equation, legendre polynomials, Rodrigue's formula, orthogonality of legendre polynomials. 11. Bessel's differential equation, Bessel's functions and their properties, orthogonality of Bessel's functions.	
11	Reference Books: 1. Earl A., Coddington and Norman Levinson, Theory of Ordinary Differential Equations; Tata McGraw Hill, India. 2. Earl A. Coddington, An Introduction to Ordinary Differential Equations, PrenticeHall of India. 3. G. F. Simmons, Differential Equations with Applications and Historical Notes, Second Edition, Tata McGraw Hill, India 4. Hurewicz W., Lectures on ordinary differential equations, M.I.T. Press. 5. Morris W. Hirsch and Stephen Smale, Differential Equations, Dynamical Systems, Linear Algebra, Elsevier.	
12	Internal Continuous Assessment: 50%	External, Semester End Examination 50%
	Individual Passing in Internal and External Examination	
13	Continuous Evaluation through: Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc.(at least 3)	Solving Problems, Assignments, Tutorials, Semnar and Practicals

Syllabus

B.A./B.Sc. (Hons. with Research) in Mathematics

(Sem.- VII)

Name of the Course: 1111463703 :Discrete Mathematics and Number Theory

Sr. No.	Heading	Particulars
1	Description of the course:	Subject Discrete Mathematics and Number Theory covers various counting principles and related examples
2	Vertical :	Major
3	Type :	Practical
4	Credit:	2 credits (30 Hours of Practical work in a semester)
5	Hours Allotted :	30 Hours
6	Marks Allotted:	50 Marks
7	Course Objectives (CO): 1. The course aims to develop theory of linear diophantine equations and conditions for solving them. 2. To identify arithmetic functions and in particular the multiplicativity of the functions τ, σ and ϕ. 3. To associate various methods of solving recurrence relations 4. To recognize the applications of Polya theory of counting for various enumeration problems including those in other sciences.	
8	Course Outcomes (OC): At the end of the course, the students will be able to 1. Apply mathematical techniques to compute solutions of linear diophantine equations 2. Analyze conditions under which techniques of counting for many real-life problems. 3. Justify/check solutions of real life problems using inclusion-exclusion principle. 4. Construct solutions to coloring problems and enumeration problems in other scientific domains.	

9	Modules:-
	Module 1: Basics of Number theory and counting (8 Lectures and 7 Practicals)
	1. Divisibility, Linear Diophantine equations 2. Congruences and their properties 3. Arithmetic functions σ, τ, φ 4. Multiplicative properties of arithmetic functions 5. Permutations (with and without repetition) and combinations, 6. Equivalence to solving equations with non-negative integral solutions. 7. Selections with Repetitions from multisets.
	Module 2: Techniques of counting and Polya theory (7 Lectures and 8 Practicals)
	1. Pigeon-hole principle - Inclusion Exclusion principle and its applications like counting derangements - Methods to solve recurrence relations with constant coefficients: homogeneous recurrence relations - Methods to solve non-homogeneous recurrence relations - Group action (specially for permutation groups), Orbit stabiliser theorem - Burnside Lemma and its applications - Cycle index, Polya's Formula - Applications of Polya's Formula to counting problems in sciences.
10	List of Practicals 1. Arithmetic functions and congruences. 2. Distribution of distinguishable and indistinguishable objects into distinguishable 3. and indistinguishable boxes (with conditions on distribution), Counting problems 4. from multisets. 5. Inclusion-exclusion principle and recurrence relations. 6. Counting via Burnside's lemma and Polya's formula.
11	Recommended Text Books 1. D. M. Burton, Introduction to Number Theory, McGraw-Hill. 2. Nadkarni and Telang, Introduction to Number Theory 3. V. Krishnamurthy:Combinatorics: Theory and applications, Affiliated East-West Press. 4. Richard A. Brualdi: Introductory Combinatorics, Pearson.

5. A. Tucker: Applied Combinatorics, John Wiley & Sons.
6. Norman L. Biggs: Discrete Mathematics, Oxford University Press.
7. Kenneth Rosen: Discrete Mathematics and its applications, Tata McGraw Hills.
8. Sharad S. Sane, Combinatorial Techniques, Hindustan Book Agency, 2013.

12	Internal Continuous Assessment: 25%	External, Semester End Examination 25%
	Individual Passing in Internal and External Examination	
13	Continuous Evaluation through: Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc.(at least 3)	Solving Problems, Assignments, Tutorials, Seminar and Practicals

Research Methodology (4)

Syllabus
B.A./B.Sc. (Hons. with Research) in Mathematics
(Sem.- VII)
Title of Paper: 1111463704 : Research Methodology

Sr. No.	Heading	Particulars
1	Description of the course : Including but Not limited to :	Subject Research methodology covers ethical research and latex typing of mathematical equations
2	Vertical :	Major
3	Type :	Theory + Practical
4	Credit:	4 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	Hours Allotted :	60 Hours & 8 – 10 Practicals
6	Marks Allotted:	100 Marks
7	Course Objectives: 1. To understand the meaning of research methodology 2. To learn how to define research problems 3. To learn how to review literature and research report 4. To learn how to use various tools available in Latex 5. To learn use of Mathematical softwares.	

8	Course Outcomes: After completion of the course, learners would be able to: 1. Initiate some research work, research project of their own 2. Write Literature review and Research report. 3. Make Question paper, write Thesis, Resume in Latex 4. Draw pictures and Plot graphs in Latex, Make beamer presentation. 5. Use mathematical software for better understanding of Mathematical Concepts.
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9	Modules:-
	Module 1: Introduction to Research Methodology
	1. Meaning of Research, Objectives of Research, Motivations in Research 2. Ethics of research (Legal issues, copyright, plagiarism) 3. Types of Research, Research Approaches 4. Significance of Research, Research Methods v/s Methodology 5. Research and Scientific Methods, Research Process, Criteria of good Research. 6. Defining the Research Problem: What is Research Problem? Selecting the problem, Necessity of and Techniques in defining the problem.
	Module 2: Research literature and review
	1. Review of Literature: Purpose of the Review 2. Identification of the related Literature, Organizing the related Literature, Archive. 3. Research Report: General format of the Research report, writing technical research report, 4. Writing a research proposal, research paper, chapter writing, Ph.D. thesis, Erratum, Proof reading 5. Keywords and Phrases, Mathematical subject Classifications and indexing 6. Short communication, fast track communication of a research paper, Poster/Oral presentation, Plenary talks, Invited talks of a conference/ workshop.
	Module 3: LaTeX
	1. Getting Started with LaTeX: Installing and using LaTeX 2. Working with LaTeX online using Overleaf, Preamble, Basic Syntax: Creating a Title Page, Page Numbering and Headings, Modifying Text, 3. Use packages. Fonts, symbols, indenting, paragraphs, line spacing, word spacing, titles and subtitles

4. Document class, page style, parts of the documents, table of contents, Command names and arguments, environments, declarations , Theorem like declarations, comments within text
5. Writing equations, Matrix, Tables, Math in Latex, Advanced Math in Latex. Page Layout: Titles, Abstract, Chapters, Sections, Equation references, citation. Table of contents, generating new commands,
6. Figure handling, numbering, List of figures, List of tables, Generating bibliography and index.
7. Beamer presentation
8. Tikz: drawing simple pictures, Function plotting, drawing pictures with nodes

Module 4: Mathematics Software

1. Use of Mathematical software Geogebra / Scilab/ wxMaxima/ Mathematica/ Matlab.

10 List of Practicals :

1. Basic of Latex.
2. Practical on mathematical tools.
3. Practical on Table of contents, generating new commands.

11 Reference Books:

1. C.R. Kothari and Gaurav Garg, Research Methodology Methods and Techniques, New Age International Publishers, 2019.
2. Stefan Kottwitz, LaTeX Beginner's Guide, Packt Publications.

12 Internal Continuous Assessment:

50%

External, Semester End Examination

50%

Individual Passing in Internal and External Examination

13 Continuous Evaluation through:

Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc. (at least 3)

Solving Problems, Assignments, Tutorials, Seminar and Practicals

SEM VII

Vertical – 1

Major

Electives

(4)

B.A./B.Sc. (Hons. with Research) in Mathematics**(Sem.- VII)****Title of Paper: Elective 1111463705 : Guide Course I**

Sr. No.	Heading	Particulars
1	Description of the course : Including but Not limited to :	Considering various mathematical research specializations, a generalized course structure often fails to provide the specific theoretical or computational tools required for a student's unique research topic. To align with NEP 2020 principles of flexibility, student-centric learning and multidisciplinary approach, we propose to introduce Guide Course I (Core Tools) as 4-credit elective courses in the semester VII. These courses will be designed by the research guide/supervisor to directly address the mathematical requirements of the student's research topic.
2	Vertical :	Major : Elective
3	Type :	Theory + Practical
4	Credit:	4 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	Hours Allotted :	60 Hours
6	Marks Allotted:	100 Marks

7	Course Objectives: 1. Students will be introduced to fundamental concepts required in the research area in which the student wishes to take up the research project. 2. Students will learn various techniques in the specific subject area in one-to-one interaction with the guide. 3. The course aims to demonstrate current trends, interdisciplinary / multidisciplinary approaches, and practical applications in the research field chosen by the student.
8	Course Outcomes: 1. Through this course students are expected to understand the basic concepts of the research area in which work will be taken up. 2. Students will learn how to identify and define a relevant research problem. 3. Students will be able to understand how to conduct a comprehensive review of existing literature and identify research gaps. 4. Students will be able to identify possible open problems to work upon. 5. Students will be able to understand how to collect and analyze data for the research problem they wish to work on.
9	Modules:- ➤ Students are required to choose "Guide Course I" (Core Tools) and "Guide Course II" (Advanced Applications) as specialized elective subjects in each semester. ➤ The content and curriculum of these courses are to be designed specifically by the concerned Research Guide. ➤ The course material must align with the fundamental requirements of the student's research topic / area of specialization. ➤ The course outline, as designed by the guide, must be approved by the Departmental Committee chaired by Head of Department. ➤ Emphasize that the Faculty Advisor / Guide plays a key role in advising students on these course selections. ➤ Ensure that these courses are distinct from core subjects and cater to personalized research needs. ➤ Examination of the elective subject "Guide Course I" and "Guide Course II" as to be conducted as per rules and regulations of the University of Mumbai. ➤ Guide course topics may be chosen from the broad research area as follows, focusing on current trends, interdisciplinary / multidisciplinary approaches, and

practical applications in the respective field

1. Advanced Algebra
2. Advanced Analysis
3. Topology
4. Applied Analysis
5. Geometric Analysis
6. Differential Equations
7. Fractional Calculus
8. Fractional Differential Equations
9. Differential Geometry
10. Fourier Analysis
11. Harmonic Analysis
12. Numerical Analysis
13. Finite Element Analysis
14. Numerical Methods for PDE
15. Data Analysis
16. Financial Mathematics
17. Fuzzy Mathematics
18. Stochastic Calculus
19. Integral Transforms
20. Boundary Value Problem
21. Calculus of Variation
22. Special Functions
23. Advanced Computing Techniques
24. Linear and Non-linear Programming
25. Dynamical Systems
26. Mathematical Physics
27. Mathematical Biology
28. Mathematical Economics
29. Mechanics of Deformable Solids
30. Fluid Mechanics
31. Continuum Mechanics
32. Statistical Mechanics
33. Commutative Algebra
34. Matrix Algebras

	35. Lie Algebras 36. Representation theory of Finite Groups 37. Number Theory 38. Algebraic Number Theory 39. Quadratic Forms 40. Advanced Counting Techniques in Discrete Mathematics 41. Graph Theory 42. Coding Theory 43. Design Theory 44. Probability Theory 45. Statistics 46. Cryptography 47. R Programming 48. Python Programming 49. Machine Learning 50. Mathematics for Artificial Intelligence 51. OR any specialized subjects as per AMS Classification (MSC 2020)
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10	Reference Books: As suggested by the guide.	
11	Internal Continuous Assessment: 50%	External, Semester End Examination 50%
	Individual Passing in Internal and External Examination	
12	Continuous Evaluation through: Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc.(at least 3)	Solving Problems, Assignments, Tutorials, Seminar and Practicals

Research Project (4)

Syllabus
B.A./B.Sc. (Hons. with Research) in Mathematics
(Sem.- VII)
Title of Paper: 1111463706 : Research Project

Sr. No.	Heading	Particulars
1	Description of the course : Including but Not limited to :	The Research Project (Dissertation) is designed to cultivate independent research skills, critical thinking, and advanced knowledge in the specific field of study. Students are expected to demonstrate systematic planning, rigorous execution, and ethical conduct.
2	Vertical :	Research Project
3	Type :	Theory + Practical
4	Credit:	4 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	Hours Allotted :	60 Hours & 8 – 10 Practicals
6	Marks Allotted:	100 Marks
7	Course Objectives: 1. To understand the meaning of ethical research 2. To learn how to define research problems 3. To learn how to review literature and identify research gap 4. To learn how to analyze data 5. To learn how to interpret results	

8	Course Outcomes: After completion of the course, learners would be able to: 1. Initiate research work, research project independently 2. Write Research report. 3. Use mathematical software for Mathematical analysis. 4. Use e learning resources
9	Modules:- General Guidelines ➤ A comprehensive structure for an individual research project, adhering strictly to the requirement that it should be carried out independently by each student, with no batch or group work permitted. ➤ As part of the practical training components of research project, all researchers are required to dedicate a minimum of two (2) hours per week to approved e-learning resources. This mandatory time is intended to enhance research methodology and technical skills. Fulfillment of this requirement must be documented in the weekly progress report by the concerned research supervisor. ➤ To ensure high precision, robustness, and efficient handling of complex non-linear problems, it is recommended to utilize advanced soft computing tools and mathematical software like Matlab, Mathematica, MathCAD, Maple etc for the modeling, simulation, optimization tasks and 2D/3D graphical representation. ➤ To foster innovative research, the University encourages interdisciplinary and multidisciplinary studies. When a research student's topic bridges two or more distinct disciplines requiring expertise not fully available within a single department, provision is made for the appointment of a co-guide to ensure comprehensive supervision from other University Department or any Academic Institute. Project Stages : Students has to ➤ Identify and define a relevant research problem. ➤ Conduct a comprehensive review of existing literature and identify research gaps. ➤ Formulate a research design and methodology. ➤ Collect and analyze data. ➤ Interpret results and draw evidence-based conclusions.

Formatting Guidelines : As per tex template provided.

Structure of the Project

- Title Page: Title, Student Details, Supervisor Details, Institutional Affiliation.
- Certificate & Declaration: Originality certificate signed by the guide and student.
- Abstract/Synopsis: Summary of the problem, methodology, findings, and conclusion (500 words).
- Acknowledgments
- Table of Contents,
- List of Figures/Tables
- Chapter 1: Introduction: Background, Problem Statement, Objectives, Scope.
- Chapter 2: Literature Review: Critical review, theoretical framework, identifying research gaps.
- Chapter 3: Methodology: Research design, sampling, data collection tools, analysis techniques.
- Chapter 4: Results and Analysis: Data presentation, interpretations, and discussions.
- Chapter 5: Conclusion and Recommendations: Summary of findings, implications, and future research.
- References/Bibliography: Consistent citation style.
- Appendices: Raw Data tables, Letters or any other supporting documents.

Evaluation Criteria

To ensure academic rigour, impartiality, and compliance with national and institutional standards, the draft of research project dissertation of semester II must be evaluated by an external examiner other than home University Department who are active researchers in the respective research topic. Whereas the appointment of an external examiner from home University Department for assessment of the draft of research project dissertation of semester I is permitted. Moreover in the both semesters respective research project guide will be act as an internal examiner.

Guidelines for the assessment and evaluation is as follows

- Proposal/Literature Review (15%): Depth of analysis.
- Methodology (20%): Appropriateness and clarity.
- Analysis and Results (20%): Accuracy and depth.
- Discussion & Conclusion (10%): Critical thinking.
- Final Report Presentation (15%): Formatting and structure.
- Viva Voce/ Defense (20%): Defense of the study.

	➤ Total weightage will be divided as 50% external and 50% internal examiner.	
10	Reference Books: As per requirement of research topic	
11	Internal Continuous Assessment : (Internal Examiner : Research Guide) 50%	External, Semester End Examination (Internal Examiner) 50%
	Individual Passing in Internal and External Examination	
12	Continuous Evaluation through: Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc. (at least 3)	Solving Problems, Assignments, Tutorials, Seminar and Practicals

Sem. – VIII

Sem. – VIII

Vertical – 1

Major

Mandatory

(4+4+2)

Syllabus
B.A./B.Sc. (Hons. with Research) in Mathematics
(Sem.- VIII)

Title of Paper: 1111463801 :Algebra

Sr. No.	Heading	Particulars
1	Description the course : Including but Not limited to :	Subject Algebra covers fundamentals of group theory, ring theory and field theory.
2	Vertical :	Major
3	Type :	Theory
4	Credit:	4 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	Hours Allotted :	60 Hours
6	Marks Allotted:	100 Marks
7	Course Objectives: 1. Students will be introduced class equation of a group. 2. Students will recognize if a group is simple. 3. The course aims to equip students to identify isomorphism type of finite abelian group. 4. The instructor will discuss how students can recognize prime and maximal ideals in various rings. The objective is to introduce students to the important notion of localization. Through problem solving the course will discuss applications of the above concepts in many special situations. 5. On completion, the course will enable students to associate the degree to a given algebraic extension. The course will prove the fundamental theorem of Galois theory which are useful in applications, specially for algebraic extensions of finite fields.	

8	Course Outcomes: 1. The students will be able to demonstrate how one derives the class equation for a given group. 2. They will be able to employ the techniques of the Sylow theorems to compute normal subgroups and check if a group is simple or not. Also they will be to analyze properties of various ideals and use them for deciding the nature of the underlying ring. 3. Students will be able to differentiate between irreducible and reducible polynomials. 4. Students will be able to examine if a given extension of fields is Galois or not. 5. Students will be able to determine the subgroups of the Galois group so that the fixed fields can be determined.
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9	Modules:-
	Module 1: Unit I. Groups actions and Sylow theorems: (7 Lectures and 8 Practicals) (Revise: normal subgroups, quotient groups, group homomorphisms and first fundamental theorem of group theory, Group action, Orbit-Stabilizer theorem.)
	1. Centralizers and normalizers through group actions 2. Examples of group actions. 3. Class equation 4. Cauchy's theorem 5. Sylow's theorems 6. Applications of Sylow theorems and simple groups 7. A_5 is simple
	Module 2: Basics of ring theory : (8 Lectures and 7 Practicals)
	1. Commutative rings, polynomial rings, prime ideals, maximal ideals 2. Prime avoidance lemma, Nilradical, Jacobson radical, Integral domains, units, associates 3. Euclidean domains, Principal ideal domains, Unique factorization domains, Norms 4. Polynomial rings over fields, irreducible polynomials, criterion for irreducibility and ideal generated by irreducible polynomial 5. Eisenstein's criterion, Cyclotomic polynomials are irreducible. (Reference: 1) D.S. Dummit and R.M. Foote, Abstract Algebra, 2) Algebra by M. Artin 3) Algebra by Serge Lang.) Unit III. Algebraic and normal extensions (7 Lectures and ????)

Module 3: Algebraic and normal extensions : (7 Lectures and 8 Practicals)

1. Algebraic extensions, Finite extensions, degree of an algebraic element, degree of a field extension. 2. Multiplication rule of degree of field extension
2. If α is algebraic over the field F and $m_\alpha(x)$ is the minimum polynomial of α over F , then $F(\alpha)$ is isomorphic to $F[X]/(m_\alpha(X))$,
3. Algebraically closed field
4. Splitting field and examples of degrees of splitting field
5. Normal extension

Module 4: Galois theory : (8 Lectures and 7 Practicals)

1. Separable elements, Separable polynomials
2. $x^{p^n} - x$ over F_p is separable. Separable extensions,
3. Primitive element theorem
4. Splitting field of $x^{p^n} - x$ over F_p (i.e., existence and uniqueness of finite fields),
5. Fixed field, Automorphism group, Frobenius automorphism
6. Galois extension, Galois group: definition and examples
7. Fundamental theorem of Galois theory
8. Galois group over finite fields

10 List of Practicals

1. Revision and problems based on Class equation, center and normalizer
2. Sylow theorems, Simple groups and structure theorem for finite abelian groups.
3. Identifying types of ideals in various rings
4. Euclidean domains, Principal ideal domains and Unique factorization domains
5. Irreducibility of polynomials
6. Algebraic extensions and degree of extension
7. Separable polynomials, elements and algebraic extensions
8. Galois groups, fixed fields, finite fields.

10 Recommended Text Books :

1. David S. Dummit, Richard M. Foote, Abstract Algebra, John Wiley & Sons.
2. N. Herstein, Topics in Algebra, Wiley-India.
3. Serge Lang, Algebra, GTM 211, Springer-Verlag.
4. Michael Artin: Algebra, Prentice-Hall India.
5. N.S. Gopalkrishnan: University Algebra, New Age International, third edition, 2015.
6. John B. Fraleigh, A first course in abstract algebra, Pearson New International Edition.

	7. Nathan Jacobson, Basic Algebra I, II, B. W. H. Freeman and Company. 8. Joseph Gallian, Contemporary Abstract Algebra, CRC Press.	
12	Internal Continuous Assessment: 50%	External, Semester End Examination 50%
	Individual Passing in Internal and External Examination	
13	Continuous Evaluation through: Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc.(at least 3)	Solving Problems, Assignments, Tutorials, Semnar and Practicals

Syllabus
B.A./B.Sc. (Hons. with Research) in Mathematics
(Sem.- VII)

Title of Paper : 1111463802 :Complex Analysis

Sr. No.	Heading	Particulars
1	Description of the course : Including but Not limited to :	Subject Complex Analysis covers theory and examples of mathematical analysis in complex domain
2	Vertical :	Major
3	Type :	Theory + Practical
4	Credit:	4 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	Hours Allotted :	60 Hours & 8 – 10 Practicals
6	Marks Allotted:	100 Marks
7	Course Objectives: 1. Students will be introduced the difference of complex differentiation and real differentiation. 2. Students will be made to understand the smoothness of holomorphic maps. 3. The objective is to see how to simplify real integration through complex one.	
8	Course Outcomes: 1. In this course the students will learn about series of functions and power series. The concept of radius of convergence will be introduced and calculated. 2. This course gives insight of complex integration which is different from integration of real valued functions. In particular, Cauchy integral formula will be proved. 3. The students will learn that if a function is once (complex) differentiable then it is infinitely many times differentiable. This will be a sharp contrast with the theorems of real analysis.	

4. The various properties of Möbius transformations that have a wide variety of applications along with major theorems of theoretical interest like Cauchy-Goursat theorem, Morera's theorem, Rouché's theorem and Casorati-Weierstrass theorem will be studied.

9 Modules:-

Module 1: Holomorphic functions (8 Lectures and 7 Practicals)

1. Note: A complex differentiable function defined on an open subset of $\mathbb{C}$ is called a holomorphic function.
2. Review: Complex numbers, Geometry of the complex plane, Weierstrass's M-test and its application to uniform convergence, Ratio and root test for convergence of series of complex numbers. (no questions to be asked).
3. Stereographic projection, Sequence and series of complex numbers, Sequence and series of functions in $\mathbb{C}$, Complex differential functions, Chain rule for holomorphic function.
4. Power series of complex numbers, Radius of convergence of power series, Cauchy-Hadamard formula for radius of convergence of power series. Abel's theorem: let $\sum_{n \geq 0} a_n(z - z_0)^n$ be a power series of radius of convergence $R > 0$. Then the function $f(z)$ defined by $f(z) = \sum a_n(z - z_0)^n$ is holomorphic on the open ball $|z - z_0| < R$ and $f'(z) = \sum_{n \geq 1} n a_n(z - z_0)^{n-1}$ for all $|z - z_0| < R$. Trigonometric functions, Applications of Abel's theorem to trigonometric functions.
5. Applications of the chain rule to define the logarithm as the inverse of exponential, branches of logarithm, principle branch $l(z)$ of the logarithm and its derivative on $\mathbb{C} \setminus \{z \in \mathbb{C} | \Re(z) \leq 0, \Im(z) = 0\}$.

Module 2: Contour integration, Cauchy-Goursat theorem (7 Lectures and 8 Practicals)

1. Contour integration,
2. Cauchy-Goursat Theorem for a rectangular region or a triangular region.
3. Cauchy's theorem (general domain),
4. Cauchy integral formula, Cauchy's estimates,
5. The index (winding number) of a closed curve,
6. Primitives. Existence of primitives,

7. Morera's theorem.
8. Power series representation of holomorphic function (Taylor's theorem).

Module 3: Properties of Holomorphic functions (8 Lectures and 7 Practicals)

1. Entire functions,
2. Liouville's theorem.
3. Fundamental theorem of algebra.
4. Zeros of holomorphic functions,
5. Identity theorem.
6. Counting zeros;
7. Open Mapping Theorem,
8. Maximum modulus theorem,
9. Schwarz's lemma.
10. Automorphisms of unit disc.
11. Isolated singularities: removable singularities and Removable singularity theorem, poles and essential singularities.
12. Laurent Series development.
13. Casorati-Weierstrass's theorem.

Module 4: Residue calculus and Mobius transformation (7 Lectures and 8 Practicals)

1. Residue Theorem and evaluation of standard types of integrals by the residue calculus method. Argument principle.
2. Rouché's theorem,
3. Mobius Transformation.

10 List of Practicals

1. Weierstrass M-test, root test, ratio test and computations of radius of convergence.
2. Abel's theorem and branch of the logarithm.
3. Cauchy Goursat theorem and applications of Cauchy's theorem.
4. Winding number, primitives and power series representation of functions.
5. Entire functions and zeroes of holomorphic functions.
6. Isolated singularities, removable singularities, essential singularities and poles.
7. Residue theorem and evaluation of integrals.

	8. Möbius transformations.	
10	Recommended Text Books 1. J.B. Conway, Functions of one Complex variable, Springer. 2. A.R. Shastri: An introduction to complex analysis, Macmillan. 3. Serge Lang: Complex Analysis. Springer. 4. L.V. Ahlfors:Complex analysis, McGraw Hill. 5. R. Remmert: Theory of complex functions, Springer. 6. J.W. Brown and R.V. Churchill:Complex variables and Applications, McGraw-Hill.	
11	Internal Continuous Assessment: 50%	External, Semester End Examination 50%
	Individual Passing in Internal and External Examination	
12	Continuous Evaluation through: Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc. (at least 3)	Solving Problems, Assignments, Tutorials, Seminar and Practicals

Syllabus

B.A./B.Sc. (Hons. with Research) in Mathematics

(Sem.- VII)

Name of the Course: 1111463803 : Partial Differential Equations

Sr. No.	Heading	Particulars
1	Description of the course:	Subject Partial Differential Equations theory of first order and second order PDE and related examples
2	Vertical :	Major
3	Type :	Practical
4	Credit:	2 credits (30 Hours of Practical work in a semester)
5	Hours Allotted :	30 Hours
6	Marks Allotted:	50 Marks
7	Course Objectives (CO): 1. Students will be introduced the geometrical interpretation of the solution of Partial Differential Equations. 2. Students will learn the Cauchy's initial value problems. 3. The course aims to demonstrate the classification and properties of second order Partial Differential Equations.	
8	Course Outcomes (OC): 1. Students are expected to understand the basic concepts and method of finding the solution of first and second order Partial Differential Equations 2. Students will be able to know the classification of second order PDEs, singularity and fundamental solution. 3. Students will be able to know the role of Green's function in the solution of Partial Differential Equations.	

Module 1: First Order Partial Differential Equations (8 Lectures and 7 Practicals)

1. First order partial differential equations in two independent variables,
2. Semilinear and Quasilinear equations in two independent variables,
3. method of characteristics,
4. Cauchy Problem, General solutions.
5. Non-linear equations in two independent variables: Monge Strip and Charpit Equations,
6. Solution of Cauchy problem, Determination of Complete integral, solution of Cauchy problem,

[Reference Unit-I (1.1,1.2, 1.3, 1.4)of Phoolan Prasad & Renuka Ravindran, Partial Differential Equations, Wiley Eastern Limited, India]

Module 2: Second Order Partial Differential Equations (8 Lectures and 7 Practicals)

1. Classifications of second order partial differential equations in two and more than two independent variables,
2. Method of reduction to normal form,
3. The Cauchy problem.
4. Potential theory and elliptic differential equations,
5. Boundary value problems and Cauchy problem,
6. Poisson's theorem, the mean value and the Maximum-Minimum properties

[Reference Unit-II (2.1, 2.2) of Phoolan Prasad & Renuka Ravindran, Partial Differential Equations, Wiley Eastern Limited, India]

7. Singularity functions and the fundamental solution,
8. Green functions, Greens identities, Green's function for m-dimensions sphere of radius R, Green's functions
9. Dirichlet problem in the plane, Neumann's function in the plane.

[Reference Unit-II (2.2.2):1. Phoolan Prasad & Renuka Ravindran, Partial Differential

Equations, Wiley Eastern Limited, India and 2. Unit VIII of Yehuda Pinchover and Jacob Rubinstein, An Introduction to Partial Differential Equations, Cambridge

	University Press]
10	List of Practicals 1. Designing and analytical Solution of the Cauchy problem 2. Problems based on Monge Strip and Charpit Equations 3. Classification of the second order PDE by reducing into normal forms 4. Designing and the solution of the boundary value problems using Green's function.
11	Recommended Text Books 1. Phoolan Prasad & Renuka Ravindran, Partial Differential Equations, Wiley Eastern Limited, India. 2. Yehuda Pinchover and Jacob Rubinstein, An Introduction to Partial Differential Equations, Cambridge University Press. 3. T.Amaranath, An Elementary Course in Partial Differential Equations, Narosa. 4. F. John, Partial Differential Equations, Springer publications. 5. G.B. Folland, Introduction to partial differential equations, Prentice Hall.

12	Internal Continuous Assessment: 25%	External, Semester End Examination 25%
	Individual Passing in Internal and External Examination	
13	Continuous Evaluation through: Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc.(at least 3)	Solving Problems, Assignments, Tutorials, Seminar and Practicals

SEM VIII

Vertical – 1

Major

Electives

(4)

B.A./B.Sc. (Hons. with Research) in Mathematics**(Sem.- VII)****Title of Paper: Elective 1111463804 :Guide Course II**

Sr. No.	Heading	Particulars
1	Description of the course : Including but Not limited to :	Considering various mathematical research specializations, a generalized course structure often fails to provide the specific theoretical or computational tools required for a student's unique research topic. To align with NEP 2020 principles of flexibility, student-centric learning and multidisciplinary approach, we propose to introduce Guide Course II (Advanced Applications) as 4-credit elective courses in the semester VIII. These courses will be designed by the research guide/supervisor to directly address the mathematical requirements of the student's research topic.
2	Vertical :	Major
3	Type :	Theory + Practical
4	Credit:	4 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	Hours Allotted :	60 Hours
6	Marks Allotted:	100 Marks

7	Course Objectives: 1. Students will be introduced to fundamental concepts required in the research area in which the student wishes to take up the research project. 2. Students will learn various techniques in the specific subject area in one-to-one interaction with the guide. 3. The course aims to demonstrate current trends, interdisciplinary / multidisciplinary approaches, and practical applications in the research field chosen by the student.
8	Course Outcomes: 1. Through this course students are expected to understand the basic concepts of the research area in which work will be taken up. 2. Students will learn how to identify and define a relevant research problem. 3. Students will be able to understand how to conduct a comprehensive review of existing literature and identify research gaps. 4. Students will be able to identify possible open problems to work upon. 5. Students will be able to understand how to collect and analyze data for the research problem they wish to work on.

9 Modules:-

General Guidelines

- Students are required to choose "Guide Course I" (Core Tools) and "Guide Course II" (Advanced Applications) as specialized elective subjects in each semester.
- The content and curriculum of these courses are to be designed specifically by the concerned Research Guide.
- The course material must align with the fundamental requirements of the student's research topic / area of specialization.
- The course outline, as designed by the guide, must be approved by the Departmental Committee chaired by Head of Department.
- Emphasize that the Faculty Advisor / Guide plays a key role in advising students on these course selections.
- Ensure that these courses are distinct from core subjects and cater to personalized research needs.
- Examination of the elective subject "Guide Course I" and "Guide Course II" as to be conducted as per rules and regulations of the University of Mumbai.
- Guide course topics may be chosen from the broad research area as follows, focusing on current trends, interdisciplinary / multidisciplinary approaches, and practical applications in the respective field
 1. Advanced Algebra
 2. Advanced Analysis
 3. Topology
 4. Applied Analysis
 5. Geometric Analysis
 6. Differential Equations
 7. Fractional Calculus
 8. Fractional Differential Equations
 9. Differential Geometry
 10. Fourier Analysis
 11. Harmonic Analysis
 12. Numerical Analysis
 13. Finite Element Analysis
 14. Numerical Methods for PDE
 15. Data Analysis
 16. Financial Mathematics

17. Fuzzy Mathematics
18. Stochastic Calculus
19. Integral Transforms
20. Boundary Value Problem
21. Calculus of Variation
22. Special Functions
23. Advanced Computing Techniques
24. Linear and Non-linear Programming
25. Dynamical Systems
26. Mathematical Physics
27. Mathematical Biology
28. Mathematical Economics
29. Mechanics of Deformable Solids
30. Fluid Mechanics
31. Continuum Mechanics
32. Statistical Mechanics
33. Commutative Algebra
34. Matrix Algebras
35. Lie Algebras
36. Representation theory of Finite Groups
37. Number Theory
38. Algebraic Number Theory
39. Quadratic Forms
40. Advanced Counting Techniques in Discrete Mathematics
41. Graph Theory
42. Coding Theory
43. Design Theory
44. Probability Theory
45. Statistics
46. Cryptography
47. R Programming
48. Python Programming
49. Machine Learning
50. Mathematics for Artificial Intelligence
51. OR any specialized subjects as per AMS Classification (MSC 2020)

10	Reference Books: As suggested by the guide.	
11	Internal Continuous Assessment: 50%	External, Semester End Examination 50%
	Individual Passing in Internal and External Examination	
12	Continuous Evaluation through: Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc.(at least 3)	Solving Problems, Assignments, Tutorials, Seminar and Practicals

Research Project (8)

Syllabus
B.A./B.Sc. (Hons. with Research) in Mathematics
(Sem.- VII)
Title of Paper: 1111463805 : Research Project

Sr. No.	Heading	Particulars
1	Description of the course : Including but Not limited to :	The Research Project (Dissertation) is designed to cultivate independent research skills, critical thinking, and advanced knowledge in the specific field of study. Students are expected to demonstrate systematic planning, rigorous execution, and ethical conduct.
2	Vertical :	Research Project
3	Type :	Theory + Practical
4	Credit:	4 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	Hours Allotted :	60 Hours & 8 – 10 Practicals
6	Marks Allotted:	100 Marks
7	Course Objectives: 1. To understand the meaning of ethical research 2. To learn how to define research problems 3. To learn how to review literature and identify research gap 4. To learn how to analyze data	

	5. To learn how to interpret results
8	Course Outcomes: After completion of the course, learners would be able to: 1. Initiate research work, research project independently 2. Write Research report. 3. Use mathematical software for Mathematical analysis. 4. Use e learning resources

9	Modules:- General Guidelines ➤ A comprehensive structure for an individual research project, adhering strictly to the requirement that it should be carried out independently by each student, with no batch or group work permitted. ➤ As part of the practical training components of research project, all researchers are required to dedicate a minimum of two (2) hours per week to approved e-learning resources. This mandatory time is intended to enhance research methodology and technical skills. Fulfillment of this requirement must be documented in the weekly progress report by the concerned research supervisor. ➤ To ensure high precision, robustness, and efficient handling of complex non-linear problems, it is recommended to utilize advanced soft computing tools and mathematical software like Matlab, Mathematica, MathCAD, Maple etc for the modeling, simulation, optimization tasks and 2D/3D graphical representation. ➤ To foster innovative research, the University encourages interdisciplinary and multidisciplinary studies. When a research student's topic bridges two or more distinct disciplines requiring expertise not fully available within a single department, provision is made for the appointment of a co-guide to ensure comprehensive supervision from other University Department or any Academic Institute. Project Stages : Students has to ➤ Identify and define a relevant research problem. ➤ Conduct a comprehensive review of existing literature and identify research gaps. ➤ Formulate a research design and methodology. ➤ Collect and analyze data. ➤ Interpret results and draw evidence-based conclusions.
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Formatting Guidelines : As per tex template provided.

Structure of the Project

- Title Page: Title, Student Details, Supervisor Details, Institutional Affiliation.
- Certificate & Declaration: Originality certificate signed by the guide and student.
- Abstract/Synopsis: Summary of the problem, methodology, findings, and conclusion (500 words).
- Acknowledgments
- Table of Contents,
- List of Figures/Tables
- Chapter 1: Introduction: Background, Problem Statement, Objectives, Scope.
- Chapter 2: Literature Review: Critical review, theoretical framework, identifying research gaps.
- Chapter 3: Methodology: Research design, sampling, data collection tools, analysis techniques.
- Chapter 4: Results and Analysis: Data presentation, interpretations, and discussions.
- Chapter 5: Conclusion and Recommendations: Summary of findings, implications, and future research.
- References/Bibliography: Consistent citation style.
- Appendices: Raw Data tables, Letters or any other supporting documents.

Evaluation Criteria

To ensure academic rigour, impartiality, and compliance with national and institutional standards, the draft of research project dissertation of semester II must be evaluated by an external examiner other than home University Department who are active researchers in the respective research topic. Whereas the appointment of an external examiner from home University Department for assessment of the draft of research project dissertation of semester I is permitted. Moreover in the both semesters respective research project guide will be act as an internal examiner.

Guidelines for the assessment and evaluation is as follows

- Proposal/Literature Review (15%): Depth of analysis.
- Methodology (20%): Appropriateness and clarity.
- Analysis and Results (20%): Accuracy and depth.
- Discussion & Conclusion (10%): Critical thinking.

	➤ Final Report Presentation (15%): Formatting and structure. ➤ Viva Voce/ Defense (20%): Defense of the study. ➤ Total weightage will be divided as 50% external and 50% internal examiner.	
10	Reference Books: As per requirement of research topic	
11	Internal Continuous Assessment : (Internal Examiner : Research Guide) 50%	External, Semester End Examination (Internal Examiner) 50%
	Individual Passing in Internal and External Examination	
12	Continuous Evaluation through: Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc. (at least 3)	Solving Problems, Assignments, Tutorials, Seminar and Practicals

QUESTION PAPER PATTERN

(External and Internal)

1. Scheme of Examination

A. For Four Credit Course

1. 50 : 50 scheme for UG Fourth year (Honour's with Research) courses i. e. 50 marks for continuous internal assessment and 50 marks for end semester examination.
2. Separate head of passing is required for internal and end semester examination.
3. **Mid semester examination** shall be of 50 (40+10) marks.

Items	Marks	Duration	Remark
Internal Test (Theory component)	30	40 marks examination of 2 hours duration	Based on Unit-I and II
Internal Test (Practical component)	10		
Journal Certification and Viva (Minimum 75% attendance is compulsory)	10		At the end of semester based on all practical's as per the list provided in syllabus
Total	50		

4. The end semester examination shall be of 50 marks and 2.5 hours duration (It consist of two sections. Section-I (Theory 30 marks), Section-II (Practical 20 marks))

Question No	Unit	Theory/Practical	Max. Marks	Total marks including options
Section-I (Theory Component)				
Q1	Unit I and II	Theory	10	15
Q2	Unit III and IV	Theory	10	15
Q3	Common	Theory	10	15
Section-II (Practical Component)				
Q4	Unit III	Practical	10	15
Q5	Unit IV	Practical	10	15

B. For Two Credit Course:

25 : 25 scheme for all PG courses i.e. 25 marks for continuous assessment and 25 marks for end semester examination. Separate head of passing is required for internal and end semester examination.

Mid semester examination shall be of 25 (15+10) marks.

Items	Marks	Duration	Remark
Internal Test (Practical component)	15	15 marks examination of 1 hour duration	Based on Unit-I
Journal Certification and Viva (Minimum 75% attendance is compulsory)	10		At the end of semester based on all practical's as per the list provided in syllabus
Total	25		

The end semester examination shall be of 25 marks and 1.5 hours duration

Question No	Unit	Practical	Max. Marks	Total marks including options
Q1	Unit I	Practical	12	18
Q2	Unit II	Practical	13	20
Total Marks			25	

Scheme of evaluation R8435 for B. Sc. Fourth Year (Honours with Research)**Mathematics:**

- A) 100% internal evaluation scheme for University Department of Mathematics. Both Mid and End semester examinations will be conducted by the Department and answer books will be shown to the students.
- B) For affiliated UG centers end semester examination will be conducted by the University.

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result	Grading Point
9.00 - 10.00	90.0 - 100	O (Outstanding)	10
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)	9
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)	8
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)	7
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)	6
5.00 - < 5.50	50.0 - < 55.0	C (Average)	5
4.00 - < 5.00	40.0 - < 50.0	P (Pass)	4
Below 4.00	Below 40.0	F (Fail)	0
Ab (Absent)	-	Ab (Absent)	0

Sd/-

**Sign of the BOS
Name Prof. B. S. Desale
Chairman
BOS in Mathematics**

Sd/-

**Sign of the
Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science &
Technology**

Sd/-

**Sign of the Offg. Dean
Prof. Shivram S. Garje
Faculty of Science &
Technology**