

FOUR-YEAR UNDERGRADUATE PROGRAM

under
THE NEW CURRICULUM AND CREDIT FRAMEWORK, 2022

NEW SYLLABUS

for

MATHEMATICS

(w.e.f. the academic session 2023-2024)



UNIVERSITY OF NORTH BENGAL

Raja Rammohunpur, P.O. - NBU Campus

District - Darjeeling, Pin - 734013, West Bengal, India



B.SC. MATHEMATICS SYLLABUS

NEW SYLLABUS		2023 FOUR-YEAR UNDERGRADUATE PROGRAM (FYUGP)
REVISED SYLLABUS		2023 THREE-YEAR UG HONS/PROG COURSE (CBCS)
OLD SYLLABUS		2018 THREE-YEAR UG HONS/PROG COURSE (CBCS)

SESSION	1 ST SEM	2 ND SEM	3 RD SEM	4 TH SEM	5 TH SEM	6 TH SEM	7 TH SEM	8 TH SEM
2023-2027 & onwards								
2022-2025								
2021-2024								
2020-2023								
2019-2022								
2018-2021								

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MATHEMATICS 4-YEAR UNDERGRADUATE PROGRAM

CREDIT AND HOURS			
L	Lecture	1 Credit	1 Hour
T	Tutorial	1 Credit	1 Hour
P	Practical		
PNLB	Practical Non-Lab Base	1 Credit	2 Hours
PLB	Practical Lab Based	1 Credit	2 Hours
PAPER TYPE			
TH	Theory		
TH+PNLB	Theory + Practical Non-Lab Base		
TH+PLB	Theory + Practical Lab Based		

CREDIT & MARK DISTRIBUTION

Sl. No.	Course Type	Course Level	Course Credit	Full Marks	Marks Distribution		
					Non-practical Based Course (TH)	Practical Based Course (TH+PLB/TH+PNLB)	
1	Major Course	MAJ	100-400	4 (3+1)	75	60+10*+5 [#]	40+20+10*+5 [#]
2	Minor Course	MIN	100-300	4 (3+1)	75	60+10*+5 [#]	40+20+10*+5 [#]
3	Skill Enhancement Course	SEC	100	3 (2+1)	75	-----	40+20+10*+5 [#]
4	Multidisciplinary Course	MDC	100	3	75	60+10*+5 [#]	-----
5	Value Added Course	VAC	100	4 (3+1)	75	-----	-----
6	Ability Enhancement Course	AEC	100	2	50	-----	-----
7	Vocational Course ^{\$}	VOC	----	4	----	-----	-----

* Continuous Evaluation (10 Marks)

Class Attendance (5 Marks)

\$ Optional: In case of Certificate Level/ Diploma Level Exit

4-Year Undergraduate Mathematics Course Structure

SEMESTER-1

Paper Code	Paper Level	Paper	Paper Description	Paper Type	Full Marks	Credit		Page No.
						L	T/P	
UMATMAJ11001	100	MAJ	Classical and Linear Algebra	TH	75	3	1	1
UMATSEC11001	100	SEC	Logic, Integers, and Boolean Algebra	TH+PNLB	75	2	1	2
UMATMIN10001	100	MIN	Classical and Linear Algebra	TH	75	3	1	4
UPOAMDC 11001-11021	100	MDC	MDC-POOL A	TH	75	3	---	----
UBNG/UHIN/UNEP/ USAN/UURD/UENG AEM10001	100	AEC	MIL Bengali/MIL Hindi/MIL Nepali/ MIL Sanskrit/MIL Urdu/Alternative English	TH	50	2	---	----
UINDVAC 1202A/1202B	100	VAC	Understanding India/ Digital Marketing	TH	75	4	---	----

SEMESTER-2

Paper Code	Paper Level	Paper	Paper Description	Paper Type	Full Marks	Credit		Page No.
						L	T/P	
UMATMAJ12002	100	MAJ	Calculus and Geometry	TH	75	3	1	5
UMATSEC12002	100	SEC	Graph Theory	TH+PNLB	75	2	1	6
UMATMIN10001	100	MIN	Classical and Linear Algebra	TH	75	3	1	8
UPOBMDC 12022-12042	100	MDC	MDC-POOL B	TH	75	3	---	9
UENGAEL10001	100	AEC	Compulsory English	TH	50	2	---	----
UENVVAC11001	100	VAC	Environmental Education	TH	75	4	---	----

SEMESTER-3

Paper Code	Paper Level	Paper	Paper Description	Paper Type	Full Marks	Credit		Page No.
						L	T/P	
UMATMAJ23003	200	MAJ	Real Analysis	TH	75	3	1	10
UMATMAJ23004	200	MAJ	Differential Equations	TH	75	3	1	11
UMATMAJ23005	200	MAJ	Group Theory	TH	75	3	1	12
UMATSEC23003	100	SEC	C-programming Language	TH+PLB	75	2	1	13
UMATMIN20002	200	MIN	Calculus, Geometry and Group Theory	TH	75	3	1	15
UBNG/UHIN/UNEP/ USAN/UURD/UENG AEM20002	100	AEC	MIL Bengali/MIL Hindi/MIL Nepali/ MIL Sanskrit/MIL Urdu/Alternative English	TH	50	2	---	----

SEMESTER-4

Paper Code	Paper Level	Paper	Paper Description	Paper Type	Full Marks	Credit		Page No.
						L	T/P	
UMATMAJ24006	200	MAJ	Theory of Real and Complex Functions	TH	75	3	1	16
UMATMAJ24007	200	MAJ	Mechanics	TH	75	3	1	17
UMATMAJ24008	200	MAJ	Ring Theory and Lattice Theory	TH	75	3	1	18
UMATMIN20002	200	MIN	Calculus, Geometry and Group Theory	TH	75	3	1	19
UPOCMDC 24043-24063	200	MDC	MDC-POOL C	TH	75	3	---	----
UENGAEL20002	100	AEC	Compulsory English	TH	50	2	---	----

Dr. Paltu Sarkar (Chairperson)
UG Board of Studies in Mathematics
University of North Bengal

DETAILED SYLLABUS

SEMESTER-1

(MAJOR, SKILL ENHANCEMENT, AND MINOR COURSES)

Semester-1											
Paper Description	Classical and Linear Algebra		Paper Code				UMATMAJ11001				
Paper (Type)	Major Course (Theory)		Credit				Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
100	4 Hours/week	2 Hr. 30 Min	3	1	--	4	60	---	10	5	75

CLASSICAL AND LINEAR ALGEBRA

Classical Algebra

Unit 1: **10 classes**

Complex numbers: Polar representation, De Moivre's theorem for rational indices and its applications. Trigonometric, logarithm, exponential and hyperbolic functions of complex variable.

Unit 2: **15 classes**

Theory of equations: Fundamental theorem of Classical Algebra (statement only), relation between roots and coefficients, symmetric functions of roots, transformation of equation, Descartes' rule of signs, Sturms' theorem, cubic equation (Cardan's method), biquadratic equation (Ferrari's method).

Unit 3: **5 classes**

Inequality: $AM \geq GM \geq HM$, theorem of weighted means and m -th power theorem (statement only), Cauchy-Schwartz inequality (statements only) and its application.

Linear Algebra

Unit 4: **15 classes**

Matrices: Inverse of a matrix, characterizations of invertible matrices, elementary operations and matrices, echelon matrix, row/column reduced echelon matrix, rank of matrix, normal forms, equivalency and congruency of matrices.

Unit 5: **10 classes**

Systems of linear equations: Consistency in equivalence system, Solution of homogeneous system $AX=O$, Solution of nonhomogeneous system $AX=B$ using row reduced echelon form.

Unit 6: **5 classes**

Eigen values and eigen vectors of a square matrix, characteristic equation of a matrix, Cayley-Hamilton theorem, and its use in finding the inverse of a matrix.

Suggested Reading Books:

- S. Lang, Introduction to Linear Algebra, *Springer*.
- S.K. Mapa, Higher Algebra: Classical, *Levant*.
- S.K. Mapa, Higher Algebra: Abstract & Linear, *Levant*.
- W.S. Burnstine and A.W. Panton, Theory of equations, *Creative Media*.
- S.H. Friedberg, A.J. Insel and L.E. Spence, Linear Algebra, *Pearson Edu. Pub. (Indian)*.
- K. Hoffman and R. Kunze, Linear algebra, *Prentice Hall India*.
- T. Andreescu and D. Andrica, Complex Numbers from A to Z, *Birkhause*.
- V. Sahai and V. Bist, Linear Algebra, *Narosa Pub. House*.
- D.C. Lay, Linear Algebra and its Applications, *Pearson Edu. Pub. (Indian)*.

Semester-1											
Paper Description	Logic, Integers, and Boolean Algebra			Paper Code				UMATSEC11001 (A)			
Paper (Type)	Skill Enhancement Course (Theory)			Credit				Marks			
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
100	2 Hours/week	2 Hours	2	--	--	2	40	---	10	5	55

LOGIC, INTEGERS, AND BOOLEAN ALGEBRA

Logic

Unit 1 :

10 classes

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

Integers

Unit 2 :

10 classes

Well-ordering property of positive integers, principles of mathematical induction, division algorithm, divisibility and Euclidean algorithm, congruence relation between integers, Fundamental Theorem of Arithmetic (statement only), solution of linear congruence equations, Chinese remainder theorem.

Boolean Algebra

Unit 3 :

10 classes

Boolean algebra, Boolean polynomials, minimal and maximal forms of Boolean polynomials, method of Quinn-McCluskey, Karnaugh diagrams. Logic gates, switching circuits and applications of switching circuits.

Suggested Reading Books:

- R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, *Pearson Edu. India*.
- E.G. Goodaire and M.M. Parmenter, Discrete Mathematics with Graph Theory, *Pearson Edu. India*.
- J.A. Gallian, Contemporary Abstract Algebra, *Narosa Pub. House*.
- R. Lidl and G. Pilz, Applied Abstract Algebra, Undergraduate Texts in Mathematics, *Springer, Indian*.
- H.R. Lewis, C.H. Papadimitriou, C. Papadimitriou, Elements of the Theory of Computation, *PHI*.
- M.K. Sen, S. Ghosh, P. Mukhopadhyay and S. K. Maity, Topics in Abstract Algebra, *Universities Press*.
- L. Mohapatra, Elements of Discrete Mathematics, *Tata McGrawHill*.
- I.M. Copi, Symbolic Logic, *Pearson Edu. India*.
- K.H. Rosen, Discrete Mathematics and Its Applications with Combinatorics and Graph Theory, *Tata McGrawHill*.

Semester-1											
Paper Description	Logic, Integers, and Boolean Algebra					Paper Code			UMATSEC11001 (B)		
Paper (Type)	Skill Enhancement Course (Practical Non-Lab Based)					Credit			Marks		
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
100	2 Hours/week	2 Hour	---	--	1	1	---	20	---	---	20

LOGIC, INTEGERS, AND BOOLEAN ALGEBRA (PRACTICAL)

(Using hand calculation or any mathematical software)

- 1) Using congruence, find the remainder when a large integer is divided by an integer:
 (E.g. (a) 7 divides 333^{333}
 (b) 15 divides 17^{404}
 (c) 16 divides 777^{777}
 (d) 42 divides $3^{1000020}$
 (e) $4|1^5 + 2^5 + 3^5 + 4^5 + \dots + 100^5$
 (f) $13|1! + 2! + \dots + 70!$
 (g) $17|(2^{3n+1} + 3.5^{2n+1}), n \geq 1$ etc.)
- 2) Find the last digit/last two digits of a large integer (using congruence):
 (E.g. (a) $19^{19^{19}}$ (b) 73^{73} (c) 33^{100} (d) 13^{13} (e) 7^{100} etc.)
- 4) Code validation problems: ISBN code, UPC code, EAN codes, Credit card number, GST number (GSTIN).
- 5) Sketch XOR, NAND, NOR, and XNOR Gates, and find their truth table. Simplify the logical circuits using these gates and draw the simplest form.
- 6) Sketch the logic circuits corresponding to simple real-life situations.
 (E.g.: Doorbell, Burglar Alarm, Freezer warning Buzzer, Mixed Task (mixing colors), inverter, Coffee/Soup vending machine, Automatic watering system, Automatic car door open warning system, temperature detector circuits, etc.)

Semester-1											
Paper Description	Classical and Linear Algebra			Paper Code				UMATMIN10001			
Paper (Type)	Minor Course (Theory)			Credit				Marks			
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
100	4 Hours/week	2 Hr. 30 Min	3	1	-- -	4	60	---	10	5	75

CLASSICAL AND LINEAR ALGEBRA

Classical Algebra

Unit 1: **10 classes**

Complex numbers: Polar representation, De Moivre's theorem for rational indices and its applications. Trigonometric, logarithm, exponential and hyperbolic functions of complex variable.

Unit 2: **15 classes**

Theory of equations: Fundamental theorem of Classical Algebra (statement only), relation between roots and coefficients, symmetric functions of roots, transformation of equation, Descartes' rule of signs, Sturms' theorem, cubic equation (Cardan's method), biquadratic equation (Ferrari's method).

Unit 3: **5 classes**

Inequality: $AM \geq GM \geq HM$, theorem of weighted means and m -th power theorem (statement only), Cauchy-Schwartz inequality (statements only) and its application.

Linear Algebra

Unit 4: **15 classes**

Matrices: Inverse of a matrix, characterizations of invertible matrices, elementary operations and matrices, echelon matrix, row/column reduced echelon matrix, rank of matrix, normal forms, equivalency and congruency of matrices.

Unit 5: **10 classes**

Systems of linear equations: Consistency in equivalence system, Solution of homogeneous system $AX=O$, Solution of nonhomogeneous system $AX=B$ using row reduced echelon form.

Unit 6: **5 classes**

Eigen values and eigen vectors of a square matrix, characteristic equation of a matrix, Cayley-Hamilton theorem, and its use in finding the inverse of a matrix.

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- S.K. Mapa, Higher Algebra: Abstract & Linear, *Levant*.
- W.S. Burnstine and A.W. Panton, Theory of equations, *Creative Media*.
- S.H. Friedberg, A.J. Insel and L.E. Spence, Linear Algebra, *Pearson Edu. Pub. (Indian)*.
- K. Hoffman and R. Kunze, Linear algebra, *Prentice Hall India*.
- T. Andreescu and D. Andrica, Complex Numbers from A to Z, *Birkhause*.
- V. Sahai and V. Bist, Linear Algebra, *Narosa Pub. House*.
- D.C. Lay, Linear Algebra and its Applications, *Pearson Edu. Pub. (Indian)*.

DETAILED SYLLABUS

SEMESTER-2

(MAJOR, SKILL ENHANCEMENT, AND MINOR COURSES)

Semester-2											
Paper Description	Calculus and Geometry		Paper Code				UMATMAJ12002				
Paper (Type)	Major Course (Theory)		Credit				Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
100	4 Hours/week	2 Hr. 30 Min	3	1	-- -	4	60	---	10	5	75

CALCULUS AND GEOMETRY

Calculus

Unit 1 : **15 classes**

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x dx$, $\int \cos^n x dx$, $\int \sec^n x dx$, $\int \tan^n x dx$, $\int (\log x)^n dx$, $\int \sin nx \cos^m x dx$, $\int \sin nx \cos mx dx$ etc.

Arc length of a curve including parametric curves, area enclosed by a curve, area between two curves.

Unit 2 : **15 classes**

Higher order derivatives, Leibnitz rule and its applications to the problems of the type $e^{ax+b} \sin x$, $e^{ax+b} \cos x$, $(ax + b)^n \sin x$, $(ax + b)^n \cos x$ etc. L'Hospital's rule and its applications.

Concept of simple and closed curves and their parameterizations, Pedal equation, envelopes, evolute, asymptotes, radius of curvature. Concavity, convexity, cusps and inflection points.

Geometry

Unit 3 : **15 classes**

2D: Reflection properties of conics, rotation of axes and second degree equations, classification of conics using the discriminant, polar equations of conics.

Unit 4 : **15 classes**

3D: Spheres, cylindrical surfaces, cones, ellipsoids, paraboloids, hyperboloids, plane sections of conicoids, generating lines, classification of quadrics.

Suggested Reading Books:

- G.B. Thomas and R.L. Finney, Calculus, Pearson Education, Delhi.
- M.J. Strauss, G. L. Bradley, and K. J. Smith, Calculus, Pearson Education, Delhi.
- H. Anton, I. Bivens and S. Davis, Calculus, John Wiley and Sons (Asia) P. Ltd., Singapore.
- R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer Verlag.
- S.K. Mapa, Introduction to Real Analysis, *Levant*.
- S.C. Malik and S. Arora, Mathematical Analysis, *New Age International*.
- R.K. Ghosh and K.C. Maity, An Introduction to Analysis, *New Central Book Agency*.
- R.K. Ghosh and K.C. Maity, Integral Calculus, *New Central Book Agency*.
- J.G.Chakravorty and P.R. Ghosh, Advanced Mathematical Geometry, Dhar & Sons.
- U. Chatterjee and N. Chatterjee, Advanced Analytical Geometry of Two and Three Dimensions, *Academic Pub*.
- R.M. Khan, Analytical Geometry of Two and Three Dimensions & Vector Analysis, *New Central Book Agency*.

Semester-2											
Paper Description	Graph Theory		Paper Code				UMATSEC12002 (A)				
Paper (Type)	Skill Enhancement Course (Theory)		Credit				Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
100	2 Hours/week	2 Hours	2	--	--	2	40	---	10	5	55

GRAPH THEORY

Unit 1 : **9 classes**

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

Unit 2 : **9 classes**

Eulerian circuits, Hamiltonian cycles, Eulerian and Hamiltonian graphs, representation of a graph by a matrix, adjacency matrix, incidence matrix, and weighted graphs.

Unit 3 : **12 classes**

Traveling salesman's problem, shortest path, Dijkstra's algorithm, Warshall algorithm, Tree and their properties, spanning tree, Kruskal's Algorithm, Forest, Connectivity, matching in bipartite graphs, matching in general graphs.

Suggested Reading Books:

- D.S. Malik, M.K. Sen, and S. Ghosh, Introduction to Graph Theory, *Cengage Learning Asia*.
- B.A. Davey and H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press.
- E.G. Goodaire and M.M. Parmenter, Discrete Mathematics with Graph Theory, *Pearson Edu. India*.
- D.B. West, Introduction to Graph Theory, *PHI*.
- N. Deo, Graph Theory with Applications to Engineering and Computer Science, *PHI*.
- R. Diestel, Graph Theory, *Springer-Verlag*.

Semester-2											
Paper Description	Graph Theory					Paper Code			UMATSEC12002 (B)		
Paper (Type)	Skill Enhancement Course (Practical Non-Lab Based)					Credit			Marks		
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
100	2 Hours/week	2 Hours	---	--	1	1	---	20	---	---	20

GRAPH THEORY (PRACTICAL)

(Using hand calculation or any mathematical software)

- Travelling salesman problems:
E.g.: Given a list of tourist spots in Darjeeling district and mention the distances between each pair of spots. If we start from Siliguri, what is the possible shortest path that visits each one exactly once and returns to the original place at Siliguri?"
- Without lifting pencil puzzles (Euler Paths & Circuits):
E.g.: How can you sketch a given shape on paper without taking off the pen as well as without tracing the same line twice?
- Draw bipartite graphs for different networks like ecological networks, epidemiological networks, biomedical networks, biomolecular networks, etc.
- Find the solution to matching problems (matching job seekers with job vacancies or assigning students to project supervisors, Stable Marriage problem), social network problems (connections between users and interests), etc. using bipartite graphs.
- Sketch the graph of real-life situations like landing cables, LAN networks, a network of pipes for drinking water or natural gas, an electric grid, tour operations, etc., and find the solution using **Kruskal's algorithm**.
- Sketching graphs related to the problems of digital mapping services in google maps (like GPS, to calculate the shortest or quickest route), social networking applications, robotic paths (like robot car to take to reach a specific location while avoiding obstacles), logistics, and transportation (most efficient routes for vehicles and to optimize delivery schedule), Emergency Services (ambulance, fire truck, or police car) and then find the shortest path using **Dijkstra's algorithm**.

Semester-2											
Paper Description	Classical and Linear Algebra		Paper Code				UMATMIN10001				
Paper (Type)	Minor Course (Theory)		Credit				Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
100	4 Hours/week	2 Hr. 30 Min	3	1	-- -	4	60	---	10	5	75

CLASSICAL AND LINEAR ALGEBRA

Classical Algebra

Unit 1: **10 classes**

Complex numbers: Polar representation, De Moivre's theorem for rational indices and its applications. Trigonometric, logarithm, exponential and hyperbolic functions of complex variable.

Unit 2: **15 classes**

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Unit 5: **10 classes**

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Unit 6: **5 classes**

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- S.H. Friedberg, A.J. Insel and L.E. Spence, Linear Algebra, *Pearson Edu. Pub. (Indian)*.
- K. Hoffman and R. Kunze, Linear algebra, *Prentice Hall India*.
- T. Andreescu and D. Andrica, Complex Numbers from A to Z, *Birkhauser*.
- V. Sahai and V. Bist, Linear Algebra, *Narosa Pub. House*.
- D.C. Lay, Linear Algebra and its Applications, *Pearson Edu. Pub. (Indian)*.

Semester-2											
Paper Description	Introduction to Linear Programming		Paper Code				UPOBMDC12034				
Paper (Type)	Multidisciplinary Course (Theory)		Credit				Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH		CE	ATT	Total
100	3 Hours/week	2 Hours 30 Min	3	---	---	3	60	---	10	5	75

INTRODUCTION TO LINEAR PROGRAMMING

Unit 1 :

30 classes

Introduction to linear programming problem (LPP), definition of related terminology such as constraints, objective functions, optimization, different types of LPP, and mathematical formation of LPP. Feasible and infeasible regions. Definition of type of solutions: basic solution (BS), feasible solution (FS), basic feasible solution (BFS), degenerate and non-degenerate BFS. Matrix notation of LPP, graphical method of solution for LPP in two variables. Slack and surplus variables, standard form of LPP.

Unit 2 :

15 classes

Mathematical formulation of Transportation models. Matrix formation of transportation problem (TP), Determine the initial basic feasible solution of TP using North-West corner method, and Vogel approximation method (optimality not required).

Suggested Reading Books:

- M.S. Bazaraa, J.J. Jarvis and H.D. Sherali, Linear Programming and Network Flows, John Wiley and Sons, India.
- F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, Tata McGraw Hill, Singapore.
- H.A. Taha, Operations Research: An Introduction, Prentice-Hall India.
- G. Hadley, Linear Programming, Narosa Publishing House, New Delhi.
- P. M. Karak, Linear Programming, *New Central Book Agency*.
- J.G. Chakravorty and P.R. Ghosh, Linear Programming, *Dhur & Sons*.
- D. C. Sanyal and K. Das, Introduction to Linear Programming, *Dhur & Sons*.

DETAILED SYLLABUS

SEMESTER-3

(MAJOR, SKILL ENHANCEMENT, AND MINOR COURSES)

Semester-3											
Paper Description	Real Analysis		Paper Code				UMATMAJ23003				
Paper (Type)	Major Course (Theory)		Credit				Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
200	4 Hours/week	2 Hr. 30 Min	3	1	--	4	60	---	10	5	75

REAL ANALYSIS

Unit 1:

15 classes

Review of Algebraic and order properties of \mathbb{R} , ε -neighborhood of a point in \mathbb{R} . Idea of countable and uncountable subsets of \mathbb{R} . Bounded above sets, bounded below sets, bounded sets, unbounded sets. Suprema and infima with their properties and supporting examples. Completeness property of \mathbb{R} and its equivalent properties. Archimedean property, density property of \mathbb{R} , intervals. Limit point and isolated point of a set, open set, closed set, derived set and their properties. Bolzano-Weierstrass theorem on limit point, Nested interval theorem. compact sets in \mathbb{R} , Heine-Borel Theorem.

Unit 2:

15 classes

Sequences: Sequence, bounded sequence, convergent sequence, limit and limit points of a sequence, uniqueness of limit of convergent sequences, \liminf & \limsup . Limit theorems, Monotone sequences, monotone convergence theorem, Sandwich theorem, Subsequences, divergence criteria. Monotone subsequence theorem (statement only), Bolzano Weierstrass theorem for sequences. Cauchy sequence, Cauchy's convergence criterion.

Unit 3:

15 classes

Limits of functions (ε - δ approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limit. Infinite limits and limits at infinity.

Continuous functions, sequential criterion for continuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem.

Unit 4:

15 classes

Series: Infinite series, convergence and divergence of infinite series, Cauchy criterion. Tests for convergence: comparison test, limit comparison test, D'Alembert's ratio test, Cauchy's nth root test, integral test. Absolutely convergent series (Ratio test, Root test), conditionally convergent series (Leibniz's test) and alternating series. Re-arrangement of terms.

Suggested Reading Books:

- R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003.
- K. A. Ross, Elementary Analysis : The Theory of Calculus, Springer, 2004.
- A. Mattuck, Introduction to Analysis, Prentice Hall, 1999.
- S. R. Ghorpade and B. V. Limaye, a Course in Calculus and Real Analysis, Springer, 2006.
- T. Apostol, Mathematical Analysis, Narosa Publishing House.
- Courant and John, Introduction to Calculus and Analysis, ,Voll II, Springer.
- W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
- T. Tao, Analysis II, Hindustan Book Agency, 2006.

Semester-3											
Paper Description	Differential Equations		Paper Code				UMATMAJ23004				
Paper (Type)	Major Course (Theory)		Credit				Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
200	4 Hours/week	2 Hr. 30 Min	3	1	--	4	60	---	10	5	75

DIFFERENTIAL EQUATIONS

Unit 1:

30 classes

Differential equations: General, particular, explicit, implicit and singular solutions of a differential equation. First order and first-degree equations: Existence theorem (statement only), Exact equation, integrating factors and different calculating rules (statement of relevant results), linear equation and Bernoulli equations, special integrating factors and transformations. First order but not of first-degree equations: Clairaut's equation.

General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications. Higher order linear equations with constant coefficients: complementary function and particular integral, method of undetermined coefficients, method of variation of parameters, Euler's homogeneous equation. Second order linear equations with variable coefficients: method of variation of parameters, reduction to normal form, change of dependent and independent variables.

Unit 2:

12 classes

Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients. Basic theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions.

Unit 3:

10 classes

Lipschitz condition and Picard's Theorem (Statement only). Autonomous system, Equilibrium points, Interpretation of the phase plane.

Unit 4:

8 classes

Power series solution of a differential equation about an ordinary point, solution about a regular singular point.

Simple eigen value problems.

Suggested Reading Books:

- B. Barnes and G. R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, Taylor and Francis, London and New York, 2009.
- C. H. Edwards and D. E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.
- S. L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
- M. L. Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
- D. Murray, Introductory Course in Differential Equations, Longmans Green and Co.
- Boyce and Dprima, Elementary Differential equations and boundary Value problems, Wiley.
- G. F. Simmons, Differential Equations, Tata McGraw Hill.

Semester-3											
Paper Description	Group Theory		Paper Code				UMATMAJ23005				
Paper (Type)	Major Course (Theory)		Credit				Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
200	4 Hours/week	2 Hr. 30 Min	3	1	--	4	60	---	10	5	75

GROUP THEORY

Unit 1:

20 classes

Equivalence relations, partially ordered relation, functions, permutations, even and odd permutations, invertible functions.

Groupoid, semigroup, monoid, groups, finite and infinite groups, commutative groups. Basic properties of groups. Finite semigroup with cancellation properties, semigroup containing unique solution of $ax = b$ and $xa = b$. Well-known groups: \mathbb{Z}_n , U_n , $M_n(\mathbb{R})$, $GL(n, \mathbb{R})$, $SL(n, \mathbb{R})$, Klein's 4 group, multiplicative group of n -th roots of unity, symmetric group S_n (e.g. S_3, S_4, S_5, \dots), alternating group A_n , Dihedral group, Quaternion group etc.

Unit 2:

10 classes

Subgroups and its basic properties. Union, intersection and product of subgroups, necessary and sufficient condition for a subset of a group to be a subgroup. Centralizer, normalizer and center of a group.

Unit 3:

18 classes

Order of a group, order of an element. Cyclic groups, cosets, normal subgroups & factor/quotient groups and their basic properties. Lagrange's theorem and consequences including Fermat's Little theorem, Cauchy's theorem for finite abelian groups, necessary and sufficient conditions for a subgroup of a group to be a normal subgroup.

Unit 4:

12 classes

Group homomorphisms & isomorphisms and their basic properties, Cayley's theorem, First, Second and Third isomorphism theorems and their simple problems.

Suggested Reading Books:

- J. B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
- M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
- J. A. Gallian, Contemporary Abstract Algebra, Narosa Publishing House, New Delhi, 1999.
- J. J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.
- I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
- D. S. Malik, John M. Mordeson and M. K. Sen, Fundamentals of abstract algebra.
- S.K. Mapa, Higher Algebra: Abstract & Linear, *Levant*.

Semester-3											
Paper Description	C-programming Language		Paper Code				UMATSEC23003 (A)				
Paper (Type)	Skill Enhancement Course (Theory)		Credit				Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
100	2 Hours/week	2 Hour	2	--	0	2	40	---	10	5	55

C-PROGRAMMING LANGUAGE

Unit 1 5 classes

An overview of history of computers and architecture of computer. Concept of compiler, assembler, machine language, high level language, object-oriented language, programming language and importance of C programming.

Unit 2 5 classes

Characters, Constants and variables data types. Expression, statements, declaration. Operators: Arithmetic operators, increment and decrement operators, relational operators, logical operators, assignment operators, conditional operators.

Unit 3 10 classes

Conditional control statements: If, if-else, nested if-else statements. Switch, break and continue statements. Loop control statements: For, while and do-while statements.

Unit 4 10 classes

Arrays, One, two and multidimensional arrays, declaration and type of arrays. Reading and displaying elements of arrays.

User-defined Functions: Function Prototype, Definition of functions, Type of functions, local and global variables in a function, type of return values, function declaration, nesting of functions, main () function, recurrence of function. Library functions, e.g. stdio.h, math.h, string.h, stdlib.h, etc. No arguments and no return values, arguments but no return values, arguments with return values, no arguments but returns a value.

Reference Books

- B. W. Kernighan and D. M. Ritchi : The C-Programming Language, 2nd Edi, Prentice Hall, 1977.
- E. Balagurnsamy : Programming in ANSI C, Tata McGraw Hill, 2004.
- Y. Kanetkar : Let Us C ; BPB Publication, 1999.
- C. Xavier : C-Language and Numerical Methods, New Age International.
- V. Rajaraman : Computer Oriented Numerical Methods, Prentice Hall of India, 1980.

Semester-3											
Paper Description	C-programming Language		Paper Code				UMATSEC23003 (B)				
Paper (Type)	Skill Enhancement Course (Practical Lab Based)		Credit				Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
100	2 Hours/week	2 Hour	---	--	1	1	---	20	---	---	20

C-PROGRAMMING LANGUAGE
(PRACTICAL)

1. Write a program to print (a) first 100 natural numbers, (b) even numbers and (c) odd numbers in 1-100.
2. Write a program to print all numbers between 30 to 50, and all even numbers between 70 and 95.
3. Write a program to calculate the sum or product of (a) first 100 natural numbers, (b) first 25 even natural numbers and (c) odd numbers between 30 and 90.
4. Read 10 numbers from keyboard and find their sum, product and average.
5. Write a program to find (a) the last digit (b) sum and product of all digits of a given number.
6. Read 3 numbers from keyboard and find the maximum and minimum of them.
7. Write a program to find factorial of a given number.
8. Find the maximum and minimum element of a given array.
9. Sort the elements of an array in ascending and descending order.
10. Write a program to print all numbers of a given array in reverse order.
11. Write a program to print all (a) prime numbers (b) even numbers from a given array.
12. Write a program to print a matrix.
13. Write a program to find the addition and the product of two matrices.
14. Find the transpose of a given matrix.
15. Find the product of two matrices.
16. Write a program to check whether a number is even or odd.
17. Write a program to check whether a number is a prime number or not.
18. Write a program to check whether a number is Armstrong number or not.
19. Write a program to check whether a number is Perfect numbers.
20. Compute the area of (a) rectangle (b) triangle having lengths of 3 sides (c) circle.
21. Find the distance between two points (p,r) and (q,s).
22. Find the intersection point of two intersecting straight lines $ax + by = c$ and $px + qy = r$.
23. Find the solution of a quadratic equation.
24. Write a program to solve a system of two linear equations in two unknowns.
25. Write a function to calculate addition, product of two numbers.
26. Write a function to calculate the factorial of a number.

etc.

Semester-3											
Paper Description	Calculus, Geometry and Group Theory			Paper Code				UMATMIN20002			
Paper (Type)	Minor Course (Theory)			Credit				Marks			
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
200	4 Hours/week	2 Hr. 30 Min	3	1	-- -	4	60	---	10	5	75

CALCULUS, GEOMETRY AND GROUP THEORY

Calculus:

Unit 1:

10 classes

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x dx$, $\int \cos^n x dx$, $\int \sec^n x dx$, $\int \tan^n x dx$, $\int (\log x)^n dx$, $\int \sin^n x \cos^m x dx$ etc. Successive derivatives, Leibnitz rule and its applications. Indeterminate forms, L'Hospital's rule and its applications.

Unit 2:

13 classes

Volume and surface areas of solids formed by revolution of known plane curves and areas (simple problems only). Concept of parameterizations of a curve. Envelopes, asymptotes, radius of curvature. Concavity, convexity, and inflection points.

Geometry:

Unit 3:

13 classes

2D: Rotation of axes and second-degree equations, pair of straight lines, classification of conics using the discriminant, polar equations of conics.

Unit 4:

13 classes

3D: Spheres, cylindrical surfaces, cones, ellipsoids, paraboloids, hyperboloids, classification of quadrics.

Group Theory:

Unit 5:

11 classes

Equivalence relations, functions, permutations, even and odd permutations. Definitions and examples of Groups, finite and infinite groups, commutative groups. Elementary properties of groups. Some well-known groups: \mathbb{Z}_n , U_n , $M_n(\mathbb{R})$, Klein's 4-group, multiplicative group of n -th roots of unity, symmetric group S_n etc. Definition and examples of subgroup. Statement of necessary and sufficient condition for a subset of a group to be a subgroup and its simple applications.

Suggested Reading Books:

- G.B. Thomas and R.L. Finney, Calculus, Pearson Education, Delhi.
- M.J. Strauss, G. L. Bradley, and K. J. Smith, Calculus, Pearson Education, Delhi.
- H. Anton, I. Bivens and S. Davis, Calculus, John Wiley and Sons (Asia) P. Ltd., Singapore.
- R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer Verlag.
- S.K. Mapa, Introduction to Real Analysis, *Levant*.
- S.C. Malik and S. Arora, Mathematical Analysis, *New Age International*.
- R.K. Ghosh and K.C. Maity, Integral Calculus, *New Central Book Agency*.
- J.G.Chakravorty and P.R. Ghosh, Advanced Mathematical Geometry, Dhar & Sons.

DETAILED SYLLABUS

SEMESTER-4

(MAJOR AND MINOR COURSES)

Semester-4											
Paper Description	Theory of Real and Complex Functions		Paper Code				UMATMAJ24006				
Paper (Type)	Major Course (Theory)		Credit				Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
200	4 Hours/week	2 Hr. 30 Min	3	1	-- -	4	60	---	10	5	75

THEORY OF REAL AND COMPLEX FUNCTIONS

Theory of Real Functions:

Unit 1:

18 classes

Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, absolute extremum theorem.

Rolle's theorem. Lagrange and Cauchy mean value theorem, intermediate value property of derivatives- Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials.

Unit 2:

10 classes

Taylor's theorem with Lagrange's form and Cauchy's form of remainder, application of Taylor's theorem to convex functions. Taylor's series and Maclaurin's series expansions of exponential, trigonometric functions, $\log(1+x)$, $1/(ax+b)$ and $(x+1)^n$ etc.

Unit 3:

12 classes

Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions.

Series of functions. Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.

Theory of Complex Functions:

Unit 4:

20 classes

Geometric representation of complex numbers, stereographic projection. Complex functions, continuity and differentiability of complex functions, analytic functions, Cauchy-Riemann equation, harmonic functions, Milne's method (statement only). Conformal mapping, Bilinear transformation (simple problems).

Suggested Reading Books:

- R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003.
- K. A. Ross, Elementary Analysis : The Theory of Calculus, Springer, 2004.
- A. Mattuck, Introduction to Analysis, Prentice Hall, 1999.
- S. R. Ghorpade and B. V. Limaye, a Course in Calculus and Real Analysis, Springer, 2006.
- T. Apostol, Mathematical Analysis, Narosa Publishing House.
- Courant and John, Introduction to Calculus and Analysis, ,Voll II, Springer.
- W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
- T. Tao, Analysis II, Hindustan Book Agency, 2006.
- J. W. Brown and R. V. Churchill, Complex Variables and Applications, McGraw-Hill Int. Edi. 2009.

Semester-4											
Paper Description	Mechanics		Paper Code				UMATMAJ24007				
Paper (Type)	Major Course (Theory)		Credit				Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
200	4 Hours/week	2 Hr. 30 Min	3	1	-- -	4	60	---	10	5	75

MECHANICS

Dynamics:

Unit 1:

30 classes

Motion of a particle along a straight line. Simple harmonic motion, Two-dimensional equation of motion in Cartesian and Polar coordinate systems. Tangent and normal components of velocity and acceleration. Central force and central orbit. Motion in a plane under central forces. Motion under the inverse square law, Kepler's laws, modelling ballistics and planetary motion.

System of particles, center of mass. Motion of a center of mass, motion about center of mass. Principle of conservation of linear momentum and angular momentum. Rigid body, centre of gravity, moment and product of inertia, radius of gyration. Theorems of parallel and perpendicular axis. Calculation of momentum inertia, Routh's law.

Statics:

Unit 2:

30 classes

Co-planar forces: Astatic equilibrium, positions of equilibrium of a particle lying on a smooth plane curve under the action of given forces. Virtual work: Principle of virtual work, converse of the principle of virtual work. Forces in three dimensions: Poincot's central axis. Moment of a force about a line, axis of a couple, resultant of any number of couples acting on a rigid body, reduction of a system of forces acting on a rigid body. Resultant force is an invariant of the system but the resultant couple is not an invariant. A given system of forces can have only one central axis. Wrench, Pitch, Intensity and Screw. Condition that a given system of forces may have a single resultant. Invariants of a given system of forces. Equation of the central axis of a given system of forces. Stable and Unstable equilibrium: Field of forces, conservative field, potential energy of a system.

Suggested Reading Books:

- S. L. Loney, An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press.
- S. L. Loney, Elements of Statics and Dynamics I and II
- N. Dutta and R.N. Jana, Dynamics of particle, Shreedhar Prakashani.
- S. Ganguly and S. Saha, Analytical dynamics of particle, New central book agency.
- M.C. Ghosh, Analytical Statics, Shreedhar Prakashani.
- S.A. Mollah, Analytical Statics, Books and Allied.
- B.C. Das and B.N. Mukherjee, Statics, U.N. Dhur and Sons.

Semester-4											
Paper Description	Ring Theory and Lattice Theory		Paper Code				UMATMAJ24008				
Paper (Type)	Major Course (Theory)		Credit				Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total
200	4 Hours/week	2 Hr. 30 Min	3	1	-- -	4	60	---	10	5	75

RING THEORY AND LATTICE THEORY

Ring Theory:

Unit 1:

18 classes

Rings and its properties. Well-known rings: Matrix ring, \mathbb{Z}_n , $\mathbb{Z}[i]$, $\mathbb{Q}[i]$, ring of quaternions, polynomial ring $R[x]$, ring of continuous functions etc. Divisors of zero, units, cancellation property \Leftrightarrow no zero divisors, Characteristics of a ring, integral domains, ID \Leftrightarrow cancellation property. Fields, every field is an ID, finite integral domain is a field, etc. Subrings & subfields and their necessary and sufficient conditions.

Unit 2:

16 classes

Ideals, ideal generated by a subset of a ring, principal ideals, operations on ideals: sum ($A + B$), intersection, union & product (AB) etc. Prime ideals, maximal ideals, Quotient rings and its properties.

Unit 3:

10 classes

Ring homomorphisms & isomorphisms and their properties, Isomorphism theorems I, II & III and their simple applications.

Lattice Theory:

Unit 4:

16 classes

Lattice: Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, lattices as ordered sets, lattices as algebraic structures, sublattices, products and homomorphisms. Definition, examples and properties of modular and distributive lattices.

Suggested Reading Books:

- J. B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
- M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
- J. A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, 1999.
- J. J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.
- I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
- D. S. Malik, John M. Mordeson and M. K. Sen, Fundamentals of abstract algebra. B. A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge 1990.
- E. G. Goodaire and M. M. Parmenter, Discrete Mathematics with Graph Theory, (2nd Ed.), Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.

Semester-4												
Paper Description	Calculus, Geometry and Group Theory					Paper Code		UMATMIN20002				
Paper (Type)	Minor Course (Theory)					Credit		Marks				
Paper Level	Class Hours	Sem. End Exam.	L	T	P	Total	TH	PRC	CE	ATT	Total	
200	4 Hours/week	2 Hr. 30 Min	3	1	--	4	60	---	10	5	75	

CALCULUS, GEOMETRY AND GROUP THEORY

Calculus:

Unit 1: **10 classes**

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x dx$, $\int \cos^n x dx$, $\int \sec^n x dx$, $\int \tan^n x dx$, $\int (\log x)^n dx$, $\int \sin^n x \cos^m x dx$ etc. Successive derivatives, Leibnitz rule and its applications. Indeterminate forms, L'Hospital's rule and its applications.

Unit 2: **13 classes**

Volume and surface areas of solids formed by revolution of known plane curves and areas (simple problems only). Concept of parameterizations of a curve. Envelopes, asymptotes, radius of curvature. Concavity, convexity, and inflection points.

Geometry:

Unit 3: **13 classes**

2D: Rotation of axes and second-degree equations, pair of straight lines, classification of conics using the discriminant, polar equations of conics.

Unit 4: **13 classes**

3D: Spheres, cylindrical surfaces, cones, ellipsoids, paraboloids, hyperboloids, classification of quadrics.

Group Theory:

Unit 5: **11 classes**

Equivalence relations, functions, permutations, even and odd permutations. Definitions and examples of Groups, finite and infinite groups, commutative groups. Elementary properties of groups. Some well-known groups: \mathbb{Z}_n , U_n , $M_n(\mathbb{R})$, Klein's 4-group, multiplicative group of n -th roots of unity, symmetric group S_n etc. Definition and examples of subgroup. Statement of necessary and sufficient condition for a subset of a group to be a subgroup and its simple applications.

Suggested Reading Books:

- H. Anton, I. Bivens and S. Davis, Calculus, John Wiley and Sons (Asia) P. Ltd., Singapore.
- R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer Verlag.
- S.K. Mapa, Introduction to Real Analysis, *Levant*.
- S.C. Malik and S. Arora, Mathematical Analysis, *New Age International*.
- R.K. Ghosh and K.C. Maity, Integral Calculus, *New Central Book Agency*.
- J.G.Chakravorty and P.R. Ghosh, Advanced Mathematical Geometry, Dhar & Sons.

Dr. Paltu Sarkar (Chairperson)
UG Board of Studies in Mathematics
University of North Bengal

QUESTION PATTERN
MAJOR, MINOR, SKILL ENHANCEMENT PAPER

THEORY EXAM.

For 60 Marks paper:

Group	Total Questions	Question to be answered	Mark of each Question	Total Marks
A	6	4	3	$12 = 4 \times 3$
B	6	4	6	$24 = 4 \times 6$
C	4	2	12	$24 = 2 \times 12$
Total Marks				60

For 40 Marks paper:

Group	Total Questions	Question to be answered	Mark of each Question	Total Marks
A	8	5	1	$5 = 5 \times 1$
B	5	3	5	$15 = 3 \times 5$
C	4	2	10	$20 = 2 \times 10$
Total Marks				40

PRACTICAL EXAM.

Practical Lab Based (PLB)	20 Marks	Exam. Duration
Note Book + Viva	6 Marks	-----
2 Problems \times 7 Marks Each	14 Marks	2 Hours
Practical Non-Lab Based (PNLB)	20 Marks	Exam. Duration
Note Book + Viva	5 Marks	-----
3 Problems \times 5 Marks Each	15 Marks	2 Hours

ANNEXURE

Further List of Suggested Reading Books

Classical, Abstract and Linear Algebra, Group Theory, Ring Theory, Boolean Algebra

1. Topics in Algebra: I. N. Herstein (*Wiley Eastern Ltd.*)
2. Abstract Algebra: N. P. Chaudhuri (*Tata McGraw Hill*)
3. A First Course in Abstract Algebra: J. B. Fraleigh (*Pearson Education*)
4. A course in abstract algebra, V.K. Khanna and S.K. Bhambri, (*Vikas Publishing House*)
5. University Algebra: N. S. Gopala Krishnan (*New Age International*)
6. CBCS Mathematics: D. Chatterjee and B.K. Pal, (*U.N Dhur & Sons*)
7. Algebra: R. M. Khan (*New Central Book Agency*)
8. CBCS Integral Calculus and Differential Equations, D. Chatterjee and B.K. Pal, (*U.N Dhur & Sons*)
9. CBCS Algebra, D. Chatterjee and B.K. Pal, (*U.N Dhur & Sons*)
10. Higher Algebra, J.G. Chakravorty and P.R. Ghosh, (*U.N Dhur & Sons*)
11. Linear Algebra, P.K. Saikia (*Pearson, India*)
12. Linear Algebra, A.R. Vasistha, J.N. Sharma and A.K. Vasistha, (*Krishna Prakashan*)

Integral and Differential Calculus

13. Introduction to Real Analysis: D. R. Sherbert and R. G. Bartle (*Wiley*)
14. Advanced Mathematical Analysis: Utpal Chatterjee (*Academic Publishers*)
15. Mathematical Analysis: Problems and Solutions: S. Bandyopadhyay (*Academic Publishers*)
16. Mathematical Analysis: S. N. Mukhopadhyay and A. K. Layek (*U. N. Dhur and Sons*)
17. A Course of Mathematical Analysis: S. Narayan (*S. Chand & Co.*)
18. Problems in Mathematical Analysis: B. P. Demidovich (*Mir Publication*)
19. An Introduction to Analysis-Differential Calculus, Part I & II: R. K. Ghosh and K. C. Maity (*New Central Book Agency*)
20. Integral Calculus & Differential Equations: B. C. Das and B. N. Mukherjee (*U.N.Dhur and Sons*)
21. Differential Calculus: B. C. Das & B. N. Mukherjee (*U.N. Dhur and Sons*)
22. Differential Calculus: S. Narayan (*S. Chand & Co.*)
23. Application of Calculus: S. K. Maity & S. Bandyopadhyay (*Academic Publishers*)
24. Application of Calculus: D. Sengupta (*Books & Allied*)
25. Calculus and its Applications: Goldstein, Lay, Schneider, Asmar (*Pearson Education*)
26. Integral Calculus: S. Narayan (*S. Chand & Co.*)
27. An Introduction to Analysis-Integral Calculus: R. K. Ghosh and K. C. Maity (*New Central Book Agency*)
28. Integral Calculus and Differential Equations: D. Chatterjee (*Tata McGraw Hill*)
29. Calculus: Volume I and II: T. Apostol (*Narosa Publishing House*)

Analytical Geometry (Two & Three Dimension)

30. Analytical Geometry and Vector Algebra: N. Datta and R. N. Jana (*Shreedhar Prakashani*)
31. Co-ordinate Solid Geometry: B. Nand, B. S. Tyagi and B. D. Sharma (*Kedar Nath Ram Nath*)
32. Analytical Geometry of two and three Dimensions: A. N. Das (*New Central Book Agency*)
33. Vector Geometry & Elements of Calculus, A. Dey, (*Pearson India*)

Discrete Mathematics and Graph Theory

34. Discrete Mathematics: J. K. Sharma (*Macmillan*)
35. Introduction to Discrete Mathematics: M. K. Sen and B. C. Chakraborty (*Books & Allied*)
36. Discrete Mathematics with Graph Theory: E. G. Goodaire and M. M. Parmenter (*Pearson Education*)
37. Discrete Mathematics, S. Lipschutz and M.L. Lipson, (*Tata McGraw Hill*)

Theory of Complex Analysis

38. S J. Bak and D. J. Newman, Complex Analysis, 2nd Ed., Undergraduate texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.
39. S. Ponnusamy, Foundations of Complex analysis.
40. E. M. Stein and R. Shakrachi, Complex Analysis, Princeton University Press.

Outlines of 4-year Undergraduate Program with Major in Mathematics

A student taking Mathematics as a Major course has to opt

1. Any two from the following Science group as Minor Courses:

SCIENCE							
1	Anthropology	2	Botany	3	Chemistry	4	Computer Science
5	Economics	6	Food Technology	7	Geology	8	Microbiology
9	NCC	10	Physics	11	Physiology	12	Statistics
13	Tea Science	14	Zoology				

2. Two papers from the following as Ability Enhancement Courses (AEC):

I. Anyone from the following (two papers each) for 1st and 3rd Semesters:

Sl. No.	Sem.	Paper Levels	Paper Code	Paper Description	Credit	Full Marks
1	1	100	UENGAEM10001	Alternative English	2	50 (30+15+5)
	3	100	UENGAEM20002	Alternative English	2	50 (30+15+5)
2	1	100	UBNGAEM10001	MIL Bengali	2	50 (30+15+5)
	3	100	UBNGAEM20002	MIL Bengali	2	50 (30+15+5)
3	1	100	UHINAEM10001	MIL Hindi	2	50 (30+15+5)
	3	100	UHINAEM20002	MIL Hindi	2	50 (30+15+5)
4	1	100	UNEPAEM10001	MIL Nepali	2	50 (30+15+5)
	3	100	UNEPAEM20002	MIL Nepali	2	50 (30+15+5)
5	1	100	USANAEM10001	MIL Sanskrit	2	50 (30+15+5)
	3	100	USANAEM20002	MIL Sanskrit	2	50 (30+15+5)
6	1	100	UURDAEM10001	MIL Urdu	2	50 (30+15+5)
	3	100	UURDAEM20002	MIL Urdu	2	50 (30+15+5)

II. Another Language Core Course (LCC) English (Compulsory) (two papers) for 2nd and 4th Semesters:

Sl. No.	Sem.	Paper Levels	Paper Code	Paper Description	Credit	Full Marks
1	2	100	UENGAEL10001	English Compulsory	2	50 (30+15+5)
2	4	100	UENGAEL20002	English Compulsory	2	50 (30+15+5)

3. Three papers in the following as Skill Enhancement Courses (SEC):

Sem.	Paper Levels	Paper Code	Paper Description	Credit	Full Marks
1	100	UMATSEC11001	Logic, Integers, and Boolean Algebra	3	75 (60+15+5)
2	100	UMATSEC11002	Graph Theory	3	75 (60+15+5)
3	100	UMATSEC11003	C-Programming Language	3	75 (60+15+5)

4. Two papers in the following as Value-Added Courses (VAC):**I. Any one from the following for Semester 1:**

Sem.	Paper Levels	Paper Code	Paper Description	Credit	Full Marks
1	100	UINDVAC1202A	Understanding India (UI)	4	75 (60+15+5)
1	100	UDIMVAC1202B	Digital Marketing (DM)	4	75 (60+15+5)

II. Another VAC Compulsory paper for Semester 2:

Sem.	Paper Levels	Paper Code	Paper Description	Credit	Full Marks
2	100	UENVVAC11001	Environmental Education (EE)	4	75 (60+15+5)

5. Vocational Courses (Optional):

In case of Certificate Level (2nd Sem.)/ Diploma Level (4th Sem.) exit, a student has to choose one paper from the following:

SL. No.	Paper Levels	Paper Code	Paper Description	Credit	Full Marks
1	100	UCRTVOC00001	Beauty and Wellness	4	75 (60+15+5)
2	100	UCRTVOC00002	GST Filing	4	75 (60+15+5)
3	100	UCRTVOC00003	Hospitality Management	4	75 (60+15+5)
4	100	UCRTVOC00004	NSS	4	75 (60+15+5)
5	100	UCRTVOC00005	Office Administration	4	75 (60+15+5)
6	100	UCRTVOC00006	Soft Skill and Personality Development	4	75 (60+15+5)

6. Three papers in the following as Multidisciplinary Courses (MDC):

Each one chosen from Pool-A, B, and C excluding courses belonging to the group of the Major and/or Minor subjects chosen and excluding those courses already undergone at the Higher Secondary Level (12th) class)

Sem.	Paper Levels	Paper Code	Paper Description	Credit	Full Marks
1	100	UPOAMDC 11001-11021	MDC-POOL A	3	75 (60+15+5)
2	100	UPOAMDC 12022-12042	MDC-POOL B	3	75 (60+15+5)
4	200	UPOAMDC 24043-24063	MDC-POOL C	3	75 (60+15+5)

Dr. Paltu Sarkar (Chairperson)
UG Board of Studies in Mathematics
University of North Bengal

Detailed Course Structure for 3/4 Year Undergraduate Program

MDC- POOL A FOR SEMESTER I ONLY

SL	SEM	PAPER	PAPER CODE	PAPER LEVELS	PAPER DESCRIPTION	CREDIT	PAPER TYPE	FULL MARKS	MARKS IN THEO	MARKS IN PRC	MARKS IN CE	MARKS IN ATT
1	1	MDC	UPOAMDC11001	100	Cultural Anthropology	3		75			10	5
2	1	MDC	UPOAMDC11002	100	Performing Arts	3		75			10	5
3	1	MDC	UPOAMDC11003	100	Introduction to Basic Bioinformatics	3		75			10	5
4	1	MDC	UPOAMDC11004	100	Chemistry in Action	3		75			10	5
5	1	MDC	UPOAMDC11005	100	Accounting and Finance	3		75			10	5
6	1	MDC	UPOAMDC11006	100	Microfinance and Financial Inclusion	3		75			10	5
7	1	MDC	UPOAMDC11007	100	Fundamentals of Data Science	3		75			10	5
8	1	MDC	UPOAMDC11008	100	Introduction to African Literature	3		75			10	5
9	1	MDC	UPOAMDC11009	100	Fundamentals of Remote Sensing	3		75			10	5
10	1	MDC	UPOAMDC11010	100	History of North Bengal	3		75			10	5
11	1	MDC	UPOAMDC11011	100	Management of Libraries and Information Centres	3		75			10	5
12	1	MDC	UPOAMDC11012	100	Community Journalism	3		75			10	5
13	1	MDC	UPOAMDC11013	100	Sports Management	3		75			10	5

14	1	MDC	UPOAMDC11014	100	Behavioural Science	3		75			10	5
15	1	MDC	UPOAMDC11015	100	Statistical Survey	3		75			10	5
16	1	MDC	UPOAMDC11016	100	Human Rights	3		75			10	5
17	1	MDC	UPOAMDC11017	100	Tibetan Language and Culture	3		75			10	5
18	1	MDC	UPOAMDC11018	100	Gender Studies	3		75			10	5
19	1	MDC	UPOAMDC11019	100	Great Indian Educators	3		75			10	5
20	1	MDC	UPOAMDC11020	100	Distance Education	3		75			10	5
21	1	MDC	UPOAMDC11021	100	Studies of Sexualities	3		75			10	5

Detailed Course Structure for 3/4 Year Undergraduate Program

MDC- POOL B FOR SEMESTER II ONLY

SL	SEM	PAPER	PAPER CODE	PAPER LEVELS	PAPER DESCRIPTION	CREDIT	PAPER TYPE	FULL MARKS	MARKS IN THEO	MARKS IN PRC	MARKS IN CE	MARKS IN ATT
22	2	MDC	UPOBMDC12022	100	Local Language and Folk Culture	3		75			10	5
23	2	MDC	UPOBMDC12023	100	Understanding Shakespeare and Tagore	3		75			10	5
24	2	MDC	UPOBMDC12024	100	Strategic and Area Studies	3		75			10	5
25	2	MDC	UPOBMDC12025	100	Introduction to Polymers	3		75			10	5
26	2	MDC	UPOBMDC12026	100	Conservation Biology	3		75			10	5
27	2	MDC	UPOBMDC12027	100	Human Resources Management	3		75			10	5
28	2	MDC	UPOBMDC12028	100	Web Technology	3		75			10	5
29	2	MDC	UPOBMDC12029	100	Software Development	3		75			10	5
30	2	MDC	UPOBMDC12030	100	Sustainable Development	3		75			10	5
31	2	MDC	UPOBMDC12031	100	Graphic Novels	3		75			10	5

32	2	MDC	UPOBMDC12032	100	Disaster Management	3		75			10	5
33	2	MDC	UPOBMDC12033	100	Media Science	3		75			10	5
34	2	MDC	UPOBMDC12034	100	Introduction to Linear Programming	3		75			10	5
35	2	MDC	UPOBMDC12035	100	Introduction to Astronomy	3		75			10	5
36	2	MDC	UPOBMDC12036	100	Ergonomics and Sports Medicine	3		75			10	5
37	2	MDC	UPOBMDC12037	100	International Relations	3		75			10	5
38	2	MDC	UPOBMDC12038	100	Sociology of Development	3		75			10	5
39	2	MDC	UPOBMDC12039	100	Tourism and Travel Management	3		75			10	5
40	2	MDC	UPOBMDC12040	100	Education of Children with Special Needs	3		75			10	5
41	2	MDC	UPOBMDC12041	100	Mental Health and Hygiene	3		75			10	5
42	2	MDC	UPOBMDC12042	100	Literature of Eastern Himalayas	3		75			10	5

Detailed Course Structure for 3/4 Year Undergraduate Program

MDC- POOL C FOR SEMESTER IV ONLY

SL	SEM	PAPER	PAPER CODE	PAPER LEVELS	PAPER DESCRIPTION	CRED IT	PAPER TYPE	FULL MARKS	MARKS IN THEO	MARKS IN PRC	MARKS IN CE	MARKS IN ATT
43	4	MDC	UPOCMDC24043	200	Pharmacognosy and Medicinal Plants	3		75			10	5
44	4	MDC	UPOCMDC24044	200	Basic Programming	3		75			10	5
45	4	MDC	UPOCMDC24045	200	Bio Entrepreneurship	3		75			10	5
46	4	MDC	UPOCMDC24046	200	Business Regulations	3		75			10	5
47	4	MDC	UPOCMDC24047	200	Cognitive Science	3		75			10	5
48	4	MDC	UPOCMDC24048	200	Constitutional Law	3		75			10	5
49	4	MDC	UPOCMDC24049	200	E-commerce	3		75			10	5
50	4	MDC	UPOCMDC24050	200	Environmental Microbiology	3		75			10	5
51	4	MDC	UPOCMDC24051	200	Global Environment and Health	3		75			10	5
52	4	MDC	UPOCMDC24052	200	Green Chemistry	3		75			10	5

53	4	MDC	UPOCMDC24053	200	Guidance and Counselling	3		75			10	5
54	4	MDC	UPOCMDC24054	200	ICT Fundamentals	3		75			10	5
55	4	MDC	UPOCMDC24055	200	Introduction to Cosmic Ray Physics	3		75			10	5
56	4	MDC	UPOCMDC24056	200	Mathematical Economics	3		75			10	5
57	4	MDC	UPOCMDC24057	200	Nutrition and Diet	3		75			10	5
58	4	MDC	UPOCMDC24058	200	Political Economy and Development	3		75			10	5
59	4	MDC	UPOCMDC24059	200	Postcolonial Literature	3		75			10	5
60	4	MDC	UPOCMDC24060	200	Public Administration	3		75			10	5
61	4	MDC	UPOCMDC24061	200	Rural Studies	3		75			10	5
62	4	MDC	UPOCMDC24062	200	Social Work	3		75			10	5
63	4	MDC	UPOCMDC24063	200	Development Studies of Indian Economy	3		75			10	5

*******THE END*******