# 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**

FYUGP

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

## Contents

# 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 McGraw Hill.*
- I.M. Copi, Symbolic Logic, *Pearson Edu. India.*
- K.H. Rosen, Discrete Mathematics and Its Applications with Combinatories and Graph Theory, *Tata McGraw Hill.*

| 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) $4|1^5 + 2^5 + 3^5 + 4^5 + \cdots + 100^5$
   (f) $13|1! + 2! + \cdots . + 70!$
   (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.)

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| 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.

## 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).*

# 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 $\int sin^n x\, dx$, $\int \cos^n x\, dx, \int \sec^n x\, dx, \int \tan^n x\, dx$, $\int (logx)^n\, dx$, $\int \sin nx \cos^m x\, dx$, $\int \sin nx \cos mx\ dx$ 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 it's 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 Mathemetical 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, Graphic 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)*

1. 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?".
2. 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?
3. Draw bipartite graphs for different networks like ecological networks, epidemiological networks, biomedical networks, biomolecular networks, etc.
4. 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.
5. 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**.
6. 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.**

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| 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**

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.5

## 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-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 $\mathbb{R}$, $\varepsilon$-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, lim inf & lim sup. 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 ($\varepsilon$-$\delta$ 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 Diprima, 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: $\mathbb{Z}_n$, $U_n$, $M_n(R)$, $GL(n, \mathbb{R})$, $SL(n, \mathbb{R})$, 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.

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| 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 $\int sin^n x\,dx, \int \cos^n x\,dx, \int \sec^n x\,dx, \int \tan^n x\,dx, \int (logx)^n\,dx, \int \sin^n x \cos^m x\,dx$ etc. Successive derivatives, Leibnitz rule and its applications. Indeterminate forms, L'Hospital's rule and it's 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: $\mathbb{Z}_n$, $U_n$, $M_n(R)$, 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 Mathemetical 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: Poinsot'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**

Ring 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. Subring & subfield and their necessary and sufficient conditions.

**Unit 2:** **16 classes**

Ideals, ideal generated by a subset of a ring, principal ideal, 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 $\int sin^n x\,dx, \int \cos^n x\,dx, \int \sec^n x\,dx, \int \tan^n x\,dx, \int (logx)^n\,dx, \int \sin^n x \cos^m x\,dx$ etc. Successive derivatives, Leibnitz rule and its applications. Indeterminate forms, L'Hospital's rule and it's 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 Group, finite and infinite groups, commutative group. Elementary properties of groups. Some well-known groups: $\mathbb{Z}_n$, $U_n$, $M_n(R)$, 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 Mathemetical 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 × 7 Marks Each | 14 Marks | 2 Hours |
| **Practical Non-Lab Based (PNLB)** | **20 Marks** | **Exam. Duration** |
| Note Book + Viva | 5 Marks | ----- |
| 3 Problems × 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. Apstol *(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.

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# 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 | CREDIT | 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*********