SYLLABUS

MATHEMATICS

PROGRAMME – Master of Arts/Science (M. A./ M.Sc.) in Mathematics

(Semester Mode)

UNDER DISTANCE EDUCATION

(Approved by the 118th meeting of the Academic Council held on 27.12.2019)

DIRECTORATE OF OPEN AND DISTANCE LEARNING
DIBRUGARH UNIVERSITY
DIBRUGARH-786004
ASSAM, INDIA

SYLLABUS

M.A./M.Sc. (Mathematics)

UNDER DIRECTORATE OF OPEN AND DISTANCE LEARNING

DIBRUGARH UNIVERSITY

(Approved by the 118th Meeting of Academic Council held on 27.12.2019)

The M.A./M.Sc. Programme in Mathematics under Open and Distance Learning shall comprise of 16 (Sixteen) courses of hundred marks each.

There shall be 14 (Fourteen) compulsory courses till the fourth semester and 2 (two) optional courses in fourth semester to be selected from Group – **'A' or 'B' or 'C'**.

The snapshot of courses comprising the four semesters of M.A./M.Sc. Programme in Mathematics under Open and Distance Learning are as follows:

COURSE STRUCTURE:

FIRST SEMESTER
(FIRST SEMESTER
(All courses are compulsory)

Course code	Course Name	No. of Assignments	In Semester Marks	End Semester Marks	Credit Value of the course
MATH-101	Real Analysis	2	20	80	4
MATH-102	Algebra and Logic	2	20	80	4
MATH-103	Differential Geometry	2	20	80	4
MATH-104	Mechanics	2	20	80	4

SECOND SEMESTER
(All courses are compulsory)

Course code	Course Name	No. of Assignments	In Semester Marks	End Semester Marks	Credit Value of the course
MATH-201	Complex Analysis	2	20	80	4
MATH-202	Tensor	2	20	80	4
MATH-203	Differential Equations and Integral Equations	2	20	80	4
MATH-204	Inviscid Fluid Mechanics	2	20	80	4

THIRD SEMESTER

(All courses are compulsory)

Course code	Course Name	No. of Assignments	In Semester Marks	End Semester Marks	Credit Value of the course
MATH-301	Topology	2	20	80	4
MATH-302	Measure theory	2	20	80	4
MATH-303	Advanced Fluid Dynamics	2	20	80	4
MATH-304	Numerical Analysis	2	20	80	4

FOURTH SEMESTER

(MATH-401 & 402 are compulsory and one group among 'A', 'B', 'C' to be selected as Optional paper)

Course code	Course Name	No. of Assignments	In Semester Marks	End Semester Marks	Credit Value of the course
MATH-401	Functional Analysis	2	20	80	4
MATH-402	Computer programme	2	20	80	4
Optional paper (Any one group – 'A', 'B', 'C')					
MATH-403(A)	Number Theory	2	20	80	4
MATH-404(A)	Graph Theory	2	20	80	4
MATH-403(B)	Abstract Algebra	2	20	80	4
MATH-404(B)	Operator Theory	2	20	80	4
MATH-403(C)	Magneto-hydrodynamics	2	20	80	4
MATH-404(C)	Non-linear Dynamical System	2	20	80	4

1.0 Schedule of Programme:

A Post-Graduate programme under Distance Education shall be conducted in four parts – (Semester I, Semester II, Semester III and Semester IV). The schedule for the Distance Education System shall ordinarily be as shown below:

(i) Odd Semesters (i.e., First and Third): January to June
(including End Semester Examinations)

(ii) Even Semesters (i.e., Second and Fourth): July to December
(including End Semester Examinations)

The total marks in a Post-Graduate Programme in Open and Distance Learning shall be as follows:

a) All the M.A. /M.Sc. / M.Com. Programmes of DODL, D.U. are of 2-years duration and the total credit ranges from 64-72.
b) Total marks for the two years M.A. /M.Sc. / M.Com. Programmes of DODL, D.U. shall be 1600 per programme.
c) 20% of the marks in each course shall be assessed through assignments.
d) Rest 80% of the marks in each course (paper) shall be assessed through University End Semester Examination.

The syllabus for each course (paper) shall be divided into blocks and units keeping in view the Credit value of the course. The norms for delivery of courses through distance mode are as under:

Credit Value of the course	**Study input (hours)**	**Size of SLMs (unit)**	**No. of Counselling Sessions Theory (10% of total Study hours)**	*** Practical Session (hours)**
2 credits	60	6 – 8	6	60
3 credits	90	10-12	9	90
4 credits	120	14 – 16	12	120
6 credits	180	20 – 24	18	180

*Some Programmes have practical component also. Practical are held at designated Institutions/ Study Centres for which schedule is provided by the Study Centre. Attendance at practical is compulsory.

2.0 Assignment:

2.1 Assignment shall be a compulsory component of the evaluation process.

2.2 20% of each course (paper) shall be assessed through Assignments (Internal-Assessment – In Semester Examination). Rest **80%** of the marks in each course (paper) shall be assessed through University End-Semester Examination

2.3 The assignments to be submitted by a learner would depend upon the Credit value of the Course, as follows:

Credit value of the course	**No. of Assignments**
2 Credits	1
3 credits	2
4 credits	2
6 credits	2

2.4 A candidate may submit assignments in the office of the Directorate of Distance Education or his/her respective Study Centres within the stipulated time. Subsequently the study centres shall do the needful as per the instruction issued from the Directorate from time to time.

2.5 Marks secured on the assignments by the candidates, who appeared in the examinations but failed, shall be carried over to the next permissible chances.

2.6 Marks secured on the assignments by the candidates who filled in the examination forms but did not appear in the examination, shall also be carried over the next permissible chances.

3.0 Examination and Evaluation

3.1 Examination and Evaluation shall be done on a continuous basis.

3.2 There shall be 20% marks for internal assessment (In Semester) and 80% marks for End- Semester Examination in each course during every Semester.

3.3 There shall be no provision for re-evaluation of the answer-scripts of the End-Semester Examinations. However, a candidate may apply for re-scrutiny.

3.4 Internal assessment is assignment based or OMR based.

3.5 End Semester Examination:

3.5.1 There shall be one End-Semester Examination carrying 80% marks in each course of a Semester covering the entire syllabus prescribed for the course. The End Semester Examination is normally a written / laboratory-based examination.

3.5.2 The Controller of Examinations shall make necessary arrangements for notifying the dates of the End-Semester Examinations and other procedures as per Dibrugarh University Rules (at least 20 days in advance) and the Academic Calendar / Date Sheet notified by the University / DODL, Dibrugarh University.

3.5.3 The End-Semester Examination for each course shall be of three hours duration.

3.5.4 Setting of question papers, moderation of question papers, evaluation of answer scripts, scrutiny, tabulation of marks etc. and announcement of result of results, shall be governed by the Dibrugarh University Examination Ordinance 1972 (as emended up to date).

3.6 Betterment Examination:

3.6.1 A learner shall be entitled to take the “Betterment Examination” in any two theory courses of any of the four semesters after passing the Fourth Semester Examination only once. In this case the higher marks secured by the student shall be retained. The learner shall have to apply for betterment

examination within one year after passing the Fourth Semester Examination.

3.6.2 No betterment shall be allowed in the practical examination.

3.7 A learner shall be declared as passed a course, provided he / she secures at least 45% marks in the course (paper) in aggregate in the In-and End-Semester Examination.

3.8 A learner shall be declared as passed a Semester, provided he / she passes all the courses of a Semester independently.

3.9 The marks of In – Semester Examinations (i.e., Internal Assessment) obtained by the learner shall be carried over for declaring any result.

3.10 A learner who fails or does not appear in one or more courses of any End Semester Examinations up to Fourth Semester shall be provisionally promoted to the next higher Semester with the failed course(s) as carry over course(s). Such learners will be eligible to appear in the carry over course in the next regular examinations of those courses. However, the following restrictions shall be applicable:

"A learner shall be entitled to avail the chance for a maximum of 5 consecutive years from the date of admission to clear a course or courses as well as the whole programme".

3.11 If a learner clears the Fourth Semester Examination before clearing all the courses of the previous semesters, the result of such candidate shall be kept withheld and his / her results shall be announced only after he / she clears the courses of the previous semesters.

3.12 A learner must pass all his / her Semester Examinations within 5 years from the date of admission to the First Semester of any programme.

3.13 A learner shall be declared to have passed the Fourth Semester M.A. / M. Sc. / M. Com. Degree Programme provided he / she has passed all the Semesters and in all the course separately.

3.14 The system of evaluation in DODL, D.U. is different from that of the Conventional Department of the University. It has a multi-tier system of evaluation:

3.14.1 Self-assessment exercise within each unit of study.

3.14.2 Continuous evaluation mainly through assignments and/or Internal Assessment Examination through Multiple Choice Questions (MCQ) using OMR sheet.

3.14.3 Term-end examination.

3.14.4 Project work (Programme specific).

3.15 The marks secured by a student in the Assignment / IA – In Semester Examination (20% of each course) is added with the marks secured in that course in End Semester examination which is 80% of the course.

3.16 The following scale of grading system shall be applied to indicate the performance of students in terms of letter grade and grade points as given below:

% of marks obtained in a course (Assignment + Term End)	Letter Grade	Grade Point	Qualitative Level
Above 95	O	10	Outstanding
85 – < 95	A^+	9	Excellent
75 – < 85	A	8	Very Good
65 – < 75	B^+	7	Good
55 – < 65	B	6	Above Average
50 – <55	C	5	Average
45 – < 50	P	4	Pass
Below 45	F	0	Fail
0	Abs/I	0	Absent / Incomplete

3.17 The letter Grade 'B^+' and above shall be considered First Class; the Letter Grade (s) 'B' to 'P' shall be considered as Second Class. However, letter Grade 'B' shall be considered as Second Class with minimum of 55% marks.

3.18 A learner is considered to have completed a course successfully and earned Letter Grade other than 'F' (Failed) or Abs / I (Absent / Incomplete).

3.19 If a learner secures 'F' Grade in a Course, he / she shall have to reappear in the Course in the next legitimate chance.

3.20 Result of the learners appeared in the 'Betterment' examination shall not be counted for the award of Prizes / Medals / Rank or Distinction.

3.21 A learner shall have to pay a prescribed fee to appear in the 'Betterment' Examination fixed by the University from time to time.

4.0 Conversion of Marks to Grades and Calculation of GPA (Grade Point Average)

In the Credit and Grade Point System, the assessment of individual courses in the concerned examinations will be on the basis of marks only, but the marks shall later be converted into Grade by some mechanism wherein the overall performance of the learners can be reflected after considering the Credit Points for any given course. However, the overall evaluation shall be designated in terms of Grade. There are some abbreviations used here that need understanding of each and every parameter involved in grade computation and the evaluation mechanism. The abbreviation and formulae used are as under:

4.1 Abbreviations and Formula's Used:

G : Grade
GP : Grade Points
C : Credits

CP : Credit Points

CG : Credit X Grade (Product of Credit & Grades)

ΣC_iG_i: Sum of Product of i^{th} Credits & Grade Points

ΣC_i: Sum of i^{th} Credit Points.

$$SGPA = \frac{\Sigma C_i G_i}{\Sigma C_i}$$

SGPA : Semester Grade Point Average shall be calculated for each End Semester Examination.

CGPA : Cumulative Grade Point Average shall be calculated for the entire programme by considering all semesters taken together. It shall be calculated by the formula given below:

$$CGPA = (\sum\sum C_{ni}\, G_{ni}) / (\sum\sum C_{ni})$$

Here,

C_i = number of credit for the i^{th} course,

G_i = grade point obtained in the i^{th} course,

C_{ni}= number of credit if the i^{th} course n^{th} the year,

G_{ni}= grade point of the i^{th} course of the n^{th} year

After calculating the SGPA* for an individual semester and the CGPA* for the entire Programme, the value can be matched with the grade in the Grade Point table in (3.16) above.

4.2 Conversion Formula:

Ordinarily the CGPA earned by a student may be converted to percentage of marks by following the formula mentioned as under:

CGPA×10 = Percentage of Marks

4.3 Grade Card / Sheet (Reporting of Learners Performance):

The Grade Card / Sheet issued at the end of end term examination to each learner shall contain the following:

a. The marks obtained by a learner in each course,
b. The credit earned for each course registered for that semester,
c. The performance in each course indicated by the letter grade,
d. The Semester Grade Point Average (SGPA),
e. The cumulative Grade Point Average (CGPA) and
f. Conversion formula.

* SGPA and CGPA shall be rounded off to 2 decimal points and reported to the Grade Card (Sheet) and Transcript.

4.4 Transcript:

The University may issue consolidated Transcript on request to the Controller of Examinations which shall contain letter grades, grade points, GPA and CGPA mentioning the Course Title in detail, medium of instruction and programme duration.

4.5 Rules for admission of Unsuccessful and Absentee Candidates

Unsuccessful learners who fail to complete the programme within the stipulated time may take readmission in the programme by paying fees fixed by the University from time to time.

4.6 General:

For any matter not covered under these Regulations for the Directorate of Open and Distance Learning, the existing Dibrugarh University Rules, Ordinances and the Dibrugarh University Act, 1965 (as amended), The Dibrugarh University Examination Ordinance, 1972 (as amended up to date) and the Dibrugarh University Distance Education Ordinance, 2006 (amended up to date) shall be applicable.

Detailed syllabus:

Course: MATH-101 (First Semester)
Real Analysis
Credits: 4

Block I: Metric Spaces **Marks-25**

Metric space and its topology, Weierstrass theorem, Compactness, Connectedness, Heine Borel theorem, Continuity and Compactness, Continuity and Connectedness, Uniform Continuity, Completeness.

Block II: Riemann - Stieltjes Integral **Marks-25**

Definition and Existence of Riemann - Stieltjes Integral, Properties of the Integral, Integration and Differentiation, the fundamental theorem of calculus, Integration of vector-valued functions.

Block III: Uniform Convergence **Marks-30**

Sequences and series of functions, Point wise and Uniform convergence, Cauchy criterion for uniform Convergence, Supremum test, Weierstrass M test, Uniform Convergence and Continuity, Uniform Convergence and Riemann-Stieltjes integration, Uniform Convergence and Differentiation, Weierstrass's approximation, theorem, Power series and uniqueness theorem for power series.

Recommended Books and Suggested Readings:

1. S.C. Malik and S. Arora, Mathematical Analysis, New Age International (P) Ltd.
2. Walter Rudin, Principles of Mathematical analysis, McGrawHil.
3. T.M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi.

Course: MATH-102 (First Semester)
Algebra and Logic
Credits: 4

Algebra

Block I: Groups **Marks-16**

Conjugate Elements, Class equations of finite groups, Structure Theory of Groups, Sylow's theorem, Cauchy's theorem on order of a finite group, Finite Abelian groups, Solvable Groups.

Block II: Rings **Marks-20**

Polynomial rings, Factorization in R(x), Factorization theory in Integral Domains, Euclidian Domain, Unique Factorization Domain, Algebraic Extension of Fields.

Block III: Linear Algebra **Marks-20**

Vector Spaces and Subspaces, Basis and Dimensions, Linear Mappings, matrices and linear operators, Linear functionals and the dual space.

Logic

Block IV: Preliminaries on Logic **Marks-12**

The prepositional Calculus sentential connectives, truth tables, tautologies, adequate sets of connectives, Validity, consequence, applications of the statement calculus.

Block V: Symbolizing Everyday Language **Marks-12**

Symbolizing everyday language, quantifiers, interpretations, satisfiability and truth, Models validity, consequences.

Recommended Books and Suggested Readings:

1. Basic Abstract Algebra by P.B. Bhattacharya, S.K. Jain, S.R. Nagpaul, Cambridge University Press.
2. Modern Algebra by Surjeet Singh and Quazi Zamiruddin, Vikash Publications.
3. Schaum's Outline of Theory and Problems of Linear algebra by S. Lipschutz. Mc Graw - Hill Book Co.
4. Introduction to Mathematical logic by Van Nostrand.
5. Set Theory and Logic by Robert R. Stoll.

Course: MATH-103 (First Semester)
Differential Geometry
Credits: 4

Block 1 **Marks-12**

Space curves, tangent plane, Normal Plane, Osculating plane, principal normal, binormal, rectifying plane, curvature, torsion, screw curvature, Serret Frenet formula, helices.

Block 2 **Marks-12**

Fundamental of space curves, uniqueness theorem, osculating circle, osculating sphere, involute and evolute, spherical indicatrix and Bertrand curves.

Block 3 **Marks-14**

Different forms of surfaces, order of contact between curves and surfaces. Class of a surface, regular and singular points on a surface, curvilinear co-ordinates, parametric curves, tangent plane and normal.

Block 4 **Marks-14**

One parametric family of surfaces, characteristics, envelope, edge of regression, Ruled surface, developable surface, developable associated with a surface curve, osculating developable, polar developable, rectifying developable, two parameters family of surface.

Block 5 **Marks-14**

Fundamental Forms: First order magnitude, first fundamental form, second fundamental forms, geometric interpretation of the second fundamental form, Weinarten equation. Family of curves, angle between two directions, orthogonal trajectories.

Block 6 **Marks-14**

Curves on a Surface: Normal section, Normal curvature, Meusnier's theorem, principal directions, principal curvature, mean curvature, Gaussian curvature, lines of curvature, Rodrigues's formula, Euler theorem.

First fundamental form, conjugate directions, asymptotic lines theorem of Beltramiand, geodesics, geodesic tangent, torsion and curvature of a geodesic, geodesic curvature and geodesic torsion, normal angle, kg = kn tan w, k2 = kg2 + ku2. Liouville's formula for kg.

Recommended Books and Suggested Readings:

1.Differential Geometry by Weatherburn, Radha Publishing House.
2.Differential Geometry by Eisenhart, Pribceton University Press.

Course: MATH-104 (First Semester)

Mechanics

Credits: 4

Block I **Marks-16**

Rigid Body Motion, Eulerian Angles, Angular momentum and Kinetic Energy of the rigid body, motion about a point, method of solving problems of rigid body motion, Euler's equation of motion, torque free motion of a rigid body. Poinsot's geometrical description of motion of rigid body.

Block II **Marks-16**

Lagrangian Formulation, Holonomic and non-holonomic dynamical systems, rheonomic and scleronomic dynamical systems, generalized co-ordinates and degrees of freedom, generalised velocity, generalised forces.

Momenta and kinetic energy in terms of generalised velocities, D'Alembert's principle and Lagrange's equation of motion, generalised momenta and kinetic energy in terms of generalised velocities.

Block III **Marks-24**

Technique of calculus of variation. Euler's Equation, the brachistochrone problem. The configuration space and the Hamilton's principle of least action, Derivation of Lagrange's equation from Hamilton's principle, Lagrange's equation of motion for nonholonomic systems. Conservation theorems and symmetry properties, the Routhian function, Lagrange's equation for small oscillation.

Block IV **Marks-24**

Hamilton's Equation, Hamilton's canonical equation of motion, canonical variable, cyclic co-ordinates, canonical transformation, generating functions, Lagrange's and Poisson's brackets, Integral invariants of Poincare, Hamilton Jacobi Theory, Hamilton's Principle function, Jacobi's complete integral, time-independent Hamilton Jacobi equation, separation of variables.

Recommended Books and Suggested Readings:

1. Classical Mechnics: by H Goldstein, Narosa publishing house, Delhi.
2. Classical Mechanics: by C.R. Mandal, Prentice Hall, New Delhi.
3.Dynamics Part II: by A.S. Ramsay, CBS Publisher, Delhi.
4.Classical Mechanics: by Gupta Kumar and Sharma, Meerut.

Course: MATH-201 (Second Semester)
Complex Analysis
Credits: 4

Block I: Complex Integration **Marks-35**
Complex integration, Cauchy-Goursat theorem, Morera's theorem, Cauchy's integral formula, Higher order derivatives, Cauchy's inequality, Liouville's theorem, Fundamental theorem of algebra, Maximum modulus theorem, Schwartz lemma.

Block II: Series **Marks-30**
Taylor series, Laurent series, Classification of singularities, residues, Cauchy's residue theorem, Evaluation of integrals, Rouche's theorem, argument principle.

Block III: Conformal Mappings **Marks-15**
Bilinear transformation and its properties, conformal mappings and their properties.

Recommended Books and Suggested Readings:
1. R.V. Churchill & J.W. Brown, Complex Variables and Applications, 5th edition, 1990.
2. Murray R. Spiegel, Theory and problems of Complex variables (Schaum's Outline series), SI (Meric) edition, 1981.

Course: MATH-202 (Second Semester)
Tensor
Credits: 4

Block 1: Basic Concepts **Marks-16**
Summation convention, Kronecker delta, Generalized Kronecker delta. Permutation symbols, Determinants in tensor notation, General curvilinear co-ordinates, Basic vectors and reciprocal base vectors, Examples.

Block 2: Tensor Algebra **Marks-16**
Absolute and relative tensors, Symmetric and skew-symmetric tensors, Addition and subtraction of tensors, Outer product, Contraction, Inner product, Quotient rule, Examples.

Block 3 **Marks-16**
The line element, Metric tensor, Associated tensors, Length of a curve, magnitude of a vector, Angle between two vectors, Vector algebra in tensor notation, Physical components of a tensor, Examples.

Block 4: Christoffel symbols **Marks-16**
Definition of Christoffel symbols, Christoffel symbols in terms of metric tensors, Christoffel symbols in orthogonal co-ordinate systems, Examples.

Block 5: Covariant differentiation **Marks-16**

The covariant derivatives of tensors, Rules of covariant derivative, Gradient, Divergence, Curl and Laplacian in tensor notation, Riemann-Christoffel tensor, Examples.

Recommended Books and Suggested Readings:

1.Vector and Tensor Analysis by Harry Lass, Mc Graw Hill Book Company.
2.Tensor calculus by Barry Spain, Radha Publishing House.
3.Vectors, Tensor and Basic equations of Fluid Dynamics by R. Aris, Dover Publication.

Course: MATH-203 (Second Semester)
Differential Equations and Integral Equations
Credits: 4

Block I: Differential Equations **Marks-44**

Ordinary Differential Equations: Initial-value problems. Boundary value problems, Existence and uniqueness theorem of the solution of $dy/dx = f(x,y)$. Strum-Liouville boundary-value problems, Wronskian.

Partial Differential Equations of First & Second Order: Partial differential equations, Origins of first-order partial differential equations, Cauchy's problem for first-order equations, Linear equations of the first order, Integral surface passing through a given curve. Surface orthogonal to a given system of surfaces.

Nonlinear partial differential equations of the first order, Compatible systems of first-order equations, Charpit's method. Special types of first-order equations, Jacobi's method, Linear partial differential equations of second order with constant co-efficient, Characteristic curves of second-order equations, Reduction to canonical forms, Separation of variables, Solutions of nonlinear equations of the second order by Monge's method.

Laplace's Equation, The Wave Equation, The Diffusion Equation: The occurrence of Laplace's equation in Physics, Boundary value problems, Solution of Laplace's equation by separation of variables, The theory of Green's function for Laplace's equation.

The occurrence of the Wave equation in Physics, Elementary solutions of the one-dimensional Wave equation, The occurrence of the Diffusion equation in Physics, Elementary solution of the Diffusion equation, Solution of the Diffusion equation by separation of variables.

Block II: Integral Equations **Marks-36**

Volterra Integral Equations: Basic concepts, Relationship between linear differential equations and Volterra integral equations, Resolvent kernel of Volterra integral equation, Solution of integral equation by resolvent kernel. The method of successive approximations, Convolution-type equations, Volterra integral equations with limits $(x - a)$, Volterra integral equations of the first kind, Euler integrals, Abel's problem, Able's integral equation and its generalizations, Volterra integral equations of the first kind of the convolution type.

Fredholm Integral Equations: Fredholm equations of the second kind. The method of Fredholm determinants, Iterated kernels, Constructing the resolvent kernel with the aid of iterated kernels, Integral equations with degenerate kernel, Characteristic numbers and eigenfunctions, Solution

of homogeneous integral equations with degenerate kernel, Nonhomogeneous symmetric equations.

Recommended Books and Suggested Readings:

1. Differential equations by Shepley L. Ross, John Wiley & Sons.
2. Elements of partial differential equations by Ian. N. Sneddon, Mc Graw - Hill Book Company.
3. Problems and exercises in integral equations by George Yankovsky, MIR Publishers.
4. Differential Equations by George F. Simmons, Tata McGraw-Hill Publishing Company Limited, New Delhi.

Course: MATH-204 (Second Semester)

Inviscid Fluid Mechanics

Credits: 4

Block I: Kinematics **Marks-12**

Real and ideal fluid, velocity of a fluid at a point, stream lines and path lines, steady and unsteady flows, velocity potential, rotational and irrotational motions, local and particle rate of change, equation of continuity, examples, acceleration of a fluid at a point, general analysis of fluid motion.

Block II: Equations of Motion **Marks-12**

Euler's equation of motion, Bernoulli's equation, steady motion under conservative forces, impulsive motion. circulation, Kelvin's circulation theorem.

Block III: General Theory of Irrotational Motion **Marks-20**

Potential flow, mean value of velocity potential, deductions from Green's theorem, kinetic energy of a liquid, Kelvin's minimum energy theorem, uniqueness theorems.

Block IV: Motion in Two Dimensions **Marks-20**

Meaning of two-dimensional flow, stream function complex potential for standard two-dimensional flows, sources sinks and doublets, two-dimensional image systems, Milne-Thomson circle theorem and its applications, Magnus effect, Blasius theorem, infinite circular cylinder in uniform stream with circulation.

Block V: Axi-Symmetric Motion in Three Dimension **Marks-16**

Axi-symmetric flows, Stoke's stream function and its physical meaning, stationary sphere in a uniform stream, pressure on the surface of a sphere, thrust on a hemisphere, d'Alembert's paradox, stream lines, sphere moving with constant velocity in a liquid which is otherwise at rest, kinetic energy of the fluid.

Recommended Books and Suggested Readings:

1. Text book of Fluid Dynamics by F. Chorlton, CBS Publishers & Distributions, 1999, 4596/1A, 11 Darya Ganj, New Delhi-1100052 (India).
2. A Treatise on Hydrodynamics Part by W.H. Besant and A.S.Ramsey, The English Language Book Society and G.Bell and Sons, Ltd., London.
3. Theoretical Hydrodynamics, by L.M. Milne Thomson, Macmillan & Co.
4. Modern Fluid Dynamics by N. Curle and H. J. Davies, Van- Nostrand Reinhold Company, 1968.

Course: MATH-301 (Third Semester)
Topology
Credits: 4

Block I: Topological spaces **Marks-25**

Definition and examples of topological spaces, Closed sets, Closure, Dense subsets, Neighborhoods, Interior, exterior and boundary, accumulation points and derived sets, Bases and sub-bases Subspaces and relative topology, Product topology (only finite case), quotient topology, Continuous functions and homeomorphism.

Block II: Separation and countability **Marks-20**

First and second countability spaces, Lindelöf's space. Separable spaces, Second countability and separability. Separation axioms T0, T1, T2, T3, T4; their characterization and basic properties.

Block III: Compactness **Marks-18**

Compactness, Continuous function and compact sets, basic properties of compactness, compactness and finite intersection properties.

Block IV: Connectedness **Marks-17**

Connectedness spaces, connectedness on the real line, components, Path wise connectedness.

Recommended Books and Suggested Readings:

1. K. D. Joshi, Introduction to General Topology, Wiley Eastern Ltd.
2. M. G. Murdeswar, General Topology, Wiley Eastern Ltd.
3. James R. Munkres, Topology, A first course, Prentice Hall of India Pvt. Ltd., New Delhi.
4. George F. Simmons, Introduction to topology and Modern Analysis, Mc Graw- Hill Book Company.
5. B. C. Chatterjee, S. Ganguly, M.R. Adhikari, A textbook of Topology, Asian Books Pvt. Ltd.

Course: MATH-302 (Third Semester)
Measure Theory
Credits: 4

Block I: Measurable Sets **Marks-30**

Algebra and s-algebra generated by a class of subsets, Outer measure, Lebesgue measure, measurable sets and their properties, Borel sets, Cantor's ternary set, characterization of measurable sets non measurable sets, Idea of measure in R2 and R3.

Block II: Measurable Functions **Marks-30**

Properties of measurable functions, step functions, characteristic functions, simple functions, continuous functions, set measure zero, Borel measurable function.

Egoroff theorem, realization of non-negative measurable functions as the Limit of an increasing sequence of simple functions, Lusin's theorem, Frechet theorem, convergence in measure.

Block III: Lebesgue Integral **Marks-20**

Reimann Integrals, comparison to Lebesgue and Reimann integrable functions, Lebesgue integral of a simple function, Bounded convergence theorem, Integral of a non-negative measurable Lebesgue integral, dominated convergence theorem.

Recommended Books and Suggested Readings:

1. Real Analysis (ed -3) by H.L. Royden, Mc Millan, New York, 1988.
2. Measure and Integration by G.D. Berra, New Age International Publication, 1992.
3. Principles of Mathematical Analysis (ed-3) by W. Rudin, Mc Graw Hill, Khogakusha, International Students Edition, 1976.

Course: MATH-303 (Third Semester)
Advance Fluid Dynamics
Credits: 4

Block I: Vortex Motion **Marks-15**

The vorticity vector, vortex lines, Helmholtz's vorticity theorems, equation for the rate of change of vorticity, line vortices, image of a line vortex in an infinite plane, single infinite row of line vortices, Karman vortex street.

Block II: Equations of Motion for Viscous Flow **Marks-20**

Stress components in a real fluid, relation between Cartesian components of stress, translational motion of fluid element, stress analysis in fluid motion, relation between stress and rate of strain, the coefficient of viscosity and laminar flow.

The Navier-Stokes equation of motion of a viscous fluid, rate of change of circulation, diffusion of vorticity, energy dissipation due to viscosity, dimensional analysis, Reynolds number.

Block III: Exact Solutions of Navier-Stokes Equation **Marks-25**

Parallel flow, Parallel flow through a straight channel, Couette flow and generalized Couette flow, Hagen-Poiseuille flow through a pipe, the flow between tow concentric rotating cylinders. Flow due to a plane wall suddenly set in motions, unsteady flow between two parallel plates, Flow due to an oscillating plate.

Block IV: Boundary Layer Theory **Marks-20**

The boundary layer concept, boundary layer thickness, displacement, energy and momentum thickness, the phenomenon of separation and vortex formation.

Prandtl's boundary layer equations, similar solutions of the boundary layer equations, the boundary layer along a flat plate, the momentum and energy integral equations for the boundary layer.

Recommended Books and Suggested Readings:

1. Text book of Fluid Dynamics by F. Chorlton, CBS Publishers & Distributers, 4596/1-A, 11 Daryaganj, New Delhi-110002. Pages: 75, 76, 126, 127, 174, 207, 208, 310-314, 318-324338-345 for Block - I &II.
2. Boundary Layer Theory written by Dr. Hermann Schilichting translated by Dr. J. Kestin, McGraw Hill Book Company Inc., New York.
3. An Introduction to Fluid Dynamics by R.K. Rathy, Oxford & IBH Publishing Co. Calcutta for Block -V.

4. Viscous Fluid Dynamics by J.L. Bansal Oxford & IBH Publishing Co, New Delhi,Bombay, Calcutta.
5. Theoretical Hydrodynamics by L.M. Milne Thomson, McMillan, London.
6. Viscometric flows of Non-Newtonian Fluids by B. D. Coleman, H. Markkovitz and W. Nell, Springer-Verlag New York Inc. 1996.

Course: MATH-304 (Third Semester)
Numerical Analysis
Credits: 4

Block I **Marks-16**

Matrix Algebra: Matrix inversion, solution of simultaneous equation by Gauss method of elimination, Gauss-Jordan method, Gauss-Seidel iteration methods, Gauss Jacobi, Crout's Methods.

Block II **Marks-16**

Solution of algebraic and Transcendental Equations: The method of false position, Newton-Raphson method, method of iteration, bisection method, secant method.

Block III **Marks-16**

Numerical Quadrature: Cote's formula, Trapezoidal quadrature, Simpson's quadrature, Weddle's quadrature, Gauss quadrature.

Block IV **Marks-16**

Solution of Differential Equations: Euler's method, Milne's Predictor-corrector method Runga-Kutta methods, finite difference method for first order equations, wave equations and diffusion equation.

Block V **Marks-16**

Curve Fitting: Normal equations, least square method, Chebychev polynomials and curve fitting.

Recommended Books and Suggested Readings:

1. Computer Based Numerical Algorithms by E.V. Krishnamurthy and S.K. Sen, East-West Press Pvt.Ltd.
2. Numerical Mathematical Analysis by J.B. Scourbourough.
3. Introduction to Numerical Analysis by F. B. Hildebrand, Tata McGraw Hill.

Course: MATH-401(Fourth Semester)
Functional Analysis
Credits: 4

Block I: Normed Linear Spaces and Banach Spaces **Marks-15**
Definition, examples and basic properties, the Euclidean space E_n, the unitary space C_n, The space (n), lp, The space, The Sequence Space, The Function Space C [a, b], Theorems, Subspaces, Quotient Spaces.

Block II: Bounded Linear Operators on Normed and Banach Space **Marks-20**
Definitions, Examples and Properties of Bounded Linear Operators, Spaces of Bounded Linear Operators, Open Mapping Theorem (Statement only) and its consequences, Closed Graph Theorem and its consequences.

Block III: Bounded Linear Functionals on Normed and Banach Space **Marks-15**
Examples and properties of bounded linear functions, Dual Spaces, Hahn- Banach Theorem and its Consequences.

Block IV: Inner Product and Hilbert Spaces **Marks-15**
Definitions and basic properties of inner product spaces and Hilbert spaces, orthogonality of vectors orthogonal complements and projection theorem, orthonormal set of vectors and Fourier analysis, complete orthonormal set.

Block V: Linear Functionals and Linear Operators on Inner Product and Hilbert Spaces **Marks-15**
Bounded Linear functions, Hilbert-adjoint operators, self-adjoint operators, normal operators, unitary operators, Orthogonal Projection Operators.

Recommended Books and Suggested Readings:
1. P. K. Jain, O.P. Ahuja, and K. Ahmed, Functional Analysis, New Age International (P) Limited.
2. B. Choudhary and S. Nanda, Functional Analysis with Applications. New Age International (P) Limited.
3. E. Kreyszing, Introductory Functional Analysis with Applications, John Wiley & Sons, New York.
4. B. V. Limaye, Function Analysis Wiley Eastern Ltd.
5. I. J. Maddox, Elements of Functional Analysis, Cambridge University Press.

Course: MATH-402 (Fourth Semester)
Computer Programme
Credits: 4

Block I: Introduction to C- Programming **Marks-10**
Basic Programming concept.
The programming to solving problem: Flowcharts, Algorithm.

Block II: Structure of C-language **Marks-10**
Variables: Data types.
Input and output statements.
Samples of Simple C- programme Errors.

Block III: Operators in C **Marks-15**
Arithmetic Operators, comparison operators, Logical operators, precedence among the different types of operators, the parenthesis.

Block IV: Decision making and Branching **Marks-10**
If statement, IF ..... ELSE statement, multiple criteria using AND and OR, nested Ifs, The DO case statement.

Block V: Loops **Marks-15**
The WHILE loop, DO..... WHILE loop, REPEAT..... UNTIL loop, the FOR loop. Nested Loop, Breaking out of a loop, skipping a part of a loop.

Block-VI: Function **Marks-10**
Subprograms, functions, standard functions, function Libraries.

Block-VII: Arrays **Marks-10**
Declaring an array, Array elements strings as array, multidimensional array.

Recommended Books and Suggested Readings:
1. Programming in C. V. Rajaraman, Prentice Hall of India.

Optional Courses: Choose any one Group ('A' or 'B' or 'C')

Course: MATH-403(A) (Fourth Semester)
Number Theory
Credits: 4

Block I **Marks-20**

Quadratic Residues: Quadratic residues, primitive roots, the Legendre symbol, Euler's criterion,
Gauss' lemma, the Law of quadratic reciprocity, Jacobi symbol.

Block II **Marks-20**

Diophantine equations: Equation ax+by=c, the equation x2+y2=z2 and x4+y4=z4 Fermat's last theorem. Representation of a number by sum of two squares, sum of three squares, Four square problem.

Block III **Marks-20**

Farey Fractions and Continued Fractions: Farey Sequence, Continued Fractions, Notion of Convergent and infinite Continued Fractions, Application to Equations, Quadratic Irrationals, Pell's equation, Fibonacci Numbers.

Block IV **Marks-20**

Algebraic Number: Algebraic number, Algebraic Number field, Algebraic integers.
Quadratic Field: Quadratic Fields, Units in Quadratic Field, Prime in Quadratic Field, Definition, units in quadratic field, prime in quadratic field.

Recommended Books and Suggested Readings:

1. A First Course in Theory of Numbers, By K. C. Chowdhury, Asian Books Pvt. Ltd. 2004.
2. An Introduction to the Theory of Numbers 3rd Edition by I. Niven an H.S. Zuckerman, Wiley Eastern Limited, 1972.

Course: MATH-404(A) (Fourth Semester)
Graph Theory
Credits: 4

Block I **Marks-16**

Graph: Definition of Graph, Finite and infinite graphs, Incidence and degree, Isolated vertex, Pendant vertex, Null graph, a brief history of graph theory, Isomorphism 01' graphs Subgraphs, Walks, Paths, Circuits, connected graphs, Disconnected graphs, Component, Euler graphs, Hamiltonian paths and circuits.

Trees, some properties of trees, Pendant vertices in tree, Distance and centers in a tree, Rooted and binary trees, Labelled graph, spanning tress, Finding all spanning trees of a graph.

Block II **Marks-16**

Operations on Graphs: Cut-sets, Some properties of a cut-set, Connectivity and separability, Blocks, Planar and non-planar graphs, Kuratowski's two graphs.

Different representations of a graph, Matrix representation of graphs, Incidence matrix, Adjacency matrix, Graph matchings, Graph coverings.

Block III **Marks-16**

Directed Graphs: Definition of Directed graphs (digraph), Some types of digraphs, Digraphs and binary relations, Directed paths and connectedness, Acyclic digraphs and decyclization.

Enumeration of graphs, Types of enumeration. Counting labeled trees, Counting unlabeled tress.

Block IV **Marks-16**

Algorithms, Shortest-path algorithms, Shortest path from a specified vertex to another specified vertex, Shortest path between all pairs of vertices, Transitive closure of a digraph, Activity network, Topological sorting, Critical path, Graphs in Computer programming (basic concepts).

Block V **Marks-16**

Data Structures: Concept of Data structures, Data structure operations, Time-space tradeoff, Complexity of algorithms (Analysis of algorithms), Strings, String constants, String, variables, String operations, Word processing, Linear arrays, Representation of linear arrays in memory', Traversing linear arrays, Inserting and deleting in linear arrays. Pointers, Pointer arrays, Records, Record structures, Linked lists, Representations of linked lists in memory, Stacks, Array representation of stacks, Arithmetic expressions using stacks, Recursion, Queue.

Recommended Books and Suggested Readings:

1. Graph theory with applications to engineering and computer science by Narshing Deo, Prentice-Hall of India Private Limited, New Delhi.
2. Theory and problems of data structures by Seymour Lipschutz, Schaum's online series, McGraw-Hill Book Company.
3. Graph Theory of F. Harary, Addison Wesley, 1969.
4. Data Structure and Algorithms by A. V. Aho, J.E. Hopcroft & J. D. Ulman, Addison Wesley, 1983.

Course: MATH-403(B) (Fourth Semester)
Abstract Algebra
Credits: 4

Block I **Marks-20**

Modules and Vector Spaces: Definition and examples, Submodules and direct sums, R-homomorphisms and quotient modules. Completely reducible modules, Free modules, Representation of linear mappings, Rank of a linear mapping.

Block II **Marks-20**

Normal and separable extensions: Splitting fields, Normal extensions, multiple roots, finite fields, Separable extensions.

Block III **Marks-20**

Galois Theory: Automorphism of Groups and fixed, field, Fundamental theorem of Galois theory, Fundamental theorem of Algebra, Applications of Galois theory to classical problems, Roots of unity and cyclotomic polynomials, Cyclic extensions, Polynomials solvable by radicals, Ruler and compass constructions.

Block IV **Marks-20**

Chain condition on rings: Noetherian modules and rings, Hilbert basis theorem. Artinian modules and rings.

Recommended Books and Suggested Readings:

1. P.B. Bhattacharya, S.K. Jain, S.R. Nagpaul, Basic abstract algebra, Cambridge University Press, Indian edition.
2. I. N. Herstein, Topics in Algebra, Wiley eastern Ltd., New Delhi.
3. S. Singh and Q. Zameeruddin, Modern algebra, Vikas Publising House Pvt. Ltd.
4. University Algebra, N.S. Gopalakrishna Wiley Eastern Ltd.

Course: MATH-404(B) (Fourth Semester)
Operator Theory
Credits: 4

Block I **Marks-20**

Spectral Theory of linear operators in Normed Spaces, Spectral theory in Finite dimensional Normed spaces.
Basic concepts, Spectral properties of bounded linear operators Banach Algebra.

Block II **Marks-20**

Compact Linear operators and their spectrum, Compact linear operators in normed spaces, Spectral properties of compact linear operators

Block III **Marks-20**

Spectral theory of bounded self-adjoint linear operators, positive operators, projection operators and their spectrum.

Block IV **Marks-20**

Unbounded Linear operator in Hilbert Spaces, Unbounded Linear operators and their Hilbert adjoint operators.
Symmetric and self-adjoint operators, Closed linear operators and closures, Multiple and Differential Operators.

Recommended Books and Suggested Readings:

1. Introductory Functional Analysis with Applications by Erwin Keryszing, John Wiley & Sons.

Course: MATH-403(C) (Fourth Semester)
Magneto Hydro Dynamics
Credits: 4

Block I: MHD Approximations **Marks-16**

The electrical properties of fluid: the electric and magnetic field, Lorentz force, action at a distance, the low frequency approximations, energetic aspect of MHD, Magnetic energy.

Block II: The Kinematic Aspects of MHD **Marks-20**

The magnetic induction equation, the analogy with vorticity, Diffusion, and convection of magnetic field, Magnetic Reynolds number, the dynamo problem, Alfven's theorems, Cowlings problem, Ferraro's law of iso-rotation.

The two-dimensional kinematic problem with field in the direction of no variation, the two-dimensional kinematic problem with field in the direction of variation, the two-dimensional kinematic problem with Current in the direction of no variation.

Block III: The Magnetic Forces and Its Effects **Marks-18**

The magnetic force and the inertia force, Magnetic stresses, Principal directions and stress.

Magnetohydrostatic, the linear pinch confinement scheme, the force free field, the magnetic force in moving fluid, invalidation of Kelvin's theorem on vorticity, the case of irrotational force per unit mass.

Block IV: Boundary Conditions **Marks-16**

Boundary conditions for magnetic field, boundary condition for current, boundary conditions for electric field, boundary condition on velocity.

Block V: Linear Magnetohydrodynamics **Marks-10**

Linearised MHD equations for (i) one dimensional case: The Steady Hartmann flow problems, Posiseuille type flow, Couth type flow, Linear Alfven Waves.

Recommended Books and Suggested Readings:

1. A Text Book of Magnetohydrodynamics by J. A. Schercliff. Academic Press.
2. An Introduction to Magneto-fluid Mechanics by V.C.A. Ferraro and C. Plumton Oxford, University Press.

Course: MATH-404 (C) (Fourth Semester)
Nonlinear Dynamical System
Credits: 4

Block I **Marks-16**

Nonlinear Systems and Bifurcation: Introduction to nonlinear system, origin of bifurcation theory, transcritical bifurcation, pitchfork bifurcation, Hopf bifurcation.
Classification of bifurcation of equilibrium points, classifications of bifurcation in one dimension, imperfections, classification of bifurcations in higher dimensions.

Block II **Marks-32**

Difference Equations: Introduction to difference equations, stability of fixed points, periodic solutions and their stability.
Attractors and volumes. The logistic equation, iterated maps of complex plane, logistic map, square map, Julia Set, Mandelbrot set.

Block III **Marks-32**

Ordinary Differential Equations: Autonomous system, nonautonomous system, Duffing equation, Hamiltonian systems, geometry of orbits, stability of periodic solution. Second order autonomous differential systems, linear systems.
The Lyapunov's method of Proving stability and instability of equilibrium points, Lyapunov's theorem. The Lindstedt-Poincare method, Limit cycles. The Poincare Bendixson theorem, vanderpol's equation.

Recommended Books and Suggested Readings:

1. Nonlinear Systems by P. G. Drazin, Cambridge University Press, 1992.
2. Nonlinear Dynamics and Chaos Geometric Methods for Engineers and Scientists. J. M. J. Thompson, H. B. Stewart John Willey And Sons. New York.

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