

UM-DAE Centre for Excellence in Basic Sciences
Outline of course structure for the M. Sc. (Integrated)
Mathematics stream

FIRST YEAR

(P: Physics, M: Mathematics, C: Chemistry, B: Biology, G: General, H: Humanity)

SEMESTER –I

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
M 101	Mathematics I	[2 +1]	3
P101	Mechanics	[2 +1]	3
C 101	Chemical Structures & Bonding	[2 +1]	3
B 101	General Biology	[2 +1]	3
G 101	Computer Basics	[2 +1]	3
H 101	Communication Skills	[2 +0]	1
		Contact hrs/per week Lab	Credits
PL101	Physics Laboratory	[3]	2
CL 101	Chemistry Laboratory	[3]	2
BL 101	Biology Laboratory	[3]	2
GL 101	Computer Laboratory	[3]	2

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SEMESTER –II

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
M 201	Mathematics II	[2 +1]	3
P 201	Electricity & Magnetism	[2 +1]	3
C 201	Chemical Thermodynamics and Equilibrium	[2 +1]	3
B 201	Molecular Biology	[2 +1]	3
G 201	Electronics & Instrumentation	[2 +1]	3
H 201	History of Science	[2 +0]	1
		Contact hrs/per week Lab	Credits
PL201	Physics Laboratory	[3]	2
CL 201	Chemistry Laboratory	[3]	2
BL 201	Biology Laboratory	[3]	2
GL 201	Electronics Laboratory	[3]	2

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SECOND YEAR

SEMESTER -III

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
M 301	Mathematical Methods	[3 +1]	4
M 302	Analysis I	[3 +1]	4
M 303	Algebra I	[3 +1]	4
M 304	Topology I	[3 +1]	4
G 301	Statistical Techniques & Applications	[2 +1]	3
H 301	World Literature	[2 +0]	1
		Contact hrs/per week Lab	Credits
ML 301	Computational Mathematics Laboratory	6	6

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SEMESTER -IV

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
M 401	Algebra II	[3 +1]	4
M 402	Analysis II	[3 +1]	4
M 403	Topology II	[3 +1]	4
M 404	Differential Equations & Dynamics	[3 +1]	4
G 401	Environmental Science	[2 +1]	3
		Contact hrs/per week Lab	Credits
ML 401	Computational Mathematics Laboratory	6	6

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THIRD YEAR

SEMESTER -V

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
M 501	Analysis III	[3 +1]	4
M 502	Algebra III	[3 +1]	4
M 503	Discrete Mathematics	[3 +1]	4
G 501	Numerical Methods	[3 +1]	4
G 502	Earth Science	[2 +1]	3
		Contact hrs/per week Lab	Credits
ML 501	Computational Mathematics Laboratory	6	6

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SEMESTER -VI

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
M 601	Analysis IV	[3 +1]	4
M 602	Algebraic Number Theory	[3 +1]	4
M 603	Differential Geometry	[3 +1]	4
M 604	Optimization	[3 +1]	4
G 601	Energy	[2 +1]	3
		Contact hrs/per week Lab	Credits
ML 601	Computational Mathematics Laboratory	6	6

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FOURTH YEAR

SEMESTER -VII

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
M 701	Analysis V	[3 +1]	4
M 702	Algebra IV	[3 +1]	4
M 703	Partial Differential Equations	[3 +1]	4
P 703	Astronomy & Astrophysics	[3 +1]	4
E 701	Elective I	[3 +1]	4
		Contact hrs/per week Lab	Credits
ML 701	Computational Mathematics Laboratory	3	3
PR 700	Project	-	6

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SEMESTER -VIII

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
M 801	Probability & Applications	[3 +1]	4
M 802	Stochastic Analysis	[3 +1]	4
M 803	Finite Fields & Coding Theory	[3 +1]	4
E 801	Elective II	[3 +1]	4
E 802	Elective III	[3 +1]	4
		Contact hrs/per week Lab	Credits
ML 801	Computational Mathematics Laboratory	3	3
PR 800	Project	-	6

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FIFTH YEAR

SEMESTER -IX

Subject Code	Subject	Contact hrs/per week Theory + Tutorials	Credits
M 901	Lie Groups & Applications	[3 + 1]	4
M 902	Algebraic Geometry & Applications	[3 + 1]	4
M 903	Financial Mathematics	[3 + 1]	4
E 901	Elective IV	[3 + 1]	4
E 902	Elective V	[3 + 1]	4
		Contact hrs/per week Lab	Credits
ML 905	Computational Mathematics Laboratory	3	3
PR 900	Project	-	6

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SEMESTER -X

Subject Code	Subject	Contact hrs/per week Lab	Credits
E 1001	Special Course	[3 + 1]	4
PR 1000	Project	-	24

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Total Credits: 264

Analysis I: Metric spaces & basic topics as found, for example, in Rudin
Analysis II: Several variables leading to inverse & implicit function theorems.
Analysis III: Complex analysis.
Analysis IV: Measure Theory, ordinary differential equations.
Analysis V: Functional analysis, Fourier analysis.

Algebra I: Groups, rings, fields.
Algebra II: More on groups, rings, fields & linear algebra leading to spectral theorem.
Algebra III: Galois theory & representation theory.
Algebra IV: Commutative algebra & applications.

Electives:

1. Industrial Mathematics
2. Econometrics
3. Perturbation Theory
4. Wavelet Analysis & Applications
5. Differential Geometry & Applications
6. Mathematical Applications to Engineering
7. Representation Theory & Applications
8. Fractals & Applications
9. Mathematics & Nano Technology
10. Quantum Computing
11. Fluid Mechanics
12. Homological Algebra & Applications
13. Algebraic Topology & Applications
14. Combinatorial Design Theory
15. Advanced Topics in Topology & Geometry
16. Advanced Numerical Techniques

Syllabus for MA 101 – Mathematics I (Calculus of one variable)

Review of real numbers, their completeness with respect to order; the Archimedean property.

Sequences and series; tests for their convergence and basic properties of their limits and sums; radius of convergence.

Functions of one real variable and their graphs; limits, continuity and their basic properties; continuity of standard functions.

Differentiation; interpretation of the derivative as slope, velocity and rate of change; derivatives of sums and products; the chain rule; derivative of the inverse of a function; derivatives of standard functions.

Roll's and Mean value theorems; their geometric interpretations.

Higher order derivatives; application of derivatives to finding maxima and minima and to curve sketching.

The integral as the limit of the lower and upper Riemann sums and as an area; connection with an antiderivative and the Fundamental Theorem of Calculus.

Applications of integration.

Brief description of limits and continuity of functions of several variables; partial derivatives and directional derivatives; extreme values and saddle points; iterated integration.

Vector fields; gradient, divergence and curl: definitions, properties and physical interpretations.

Texts/References

Inder K. Rana, Calculus@iitb, Concepts and Examples, Version 1.2, matth4all 2009.

G. B. Thomas and R.L. Finney, Calculus and Analytic Geometry, 9th ed., Addison-Wesley/Narosa, 1998.

James Steward, Calculus, Thomson Press, 2006.

Syllabus for MA 201 – Mathematics II (Linear Algebra and Calculus of Several Variables)

Algebra of matrices (mainly over the field of real numbers, but mention other fields also); special matrices (scalar, diagonal, upper and lower triangular, etc).

Linear equations and their matrix representations; row-echelon form, Gauss-Jordan elimination; general and particular solutions; homogeneous equations.

Invertible matrices and elementary matrices; computation of inverse using elementary row operations.

Determinants and their properties; minors and cofactors; determinant of a product of matrices; adjoint of a matrix; invertible matrices and determinants. Cramer's rule;

Rank of a matrix; rank and invertibility.

Vector spaces (mainly over the field of real numbers, but mention other fields also); examples including the space of polynomials, the space of functions, the solution space of a system of homogeneous linear equations, and row and column spaces of a matrix.

Span, linear independence, basis; dimension and its uniqueness (without proof);

Linear transformations; isomorphisms; kernel and image; the dimension formula;

Eigenvalues and eigenvectors of a square matrix or a linear operator; computation of eigenvalues and eigenvectors; characteristic polynomial; sums and products of eigenvalues, similar matrices, diagonalization. (Most of the results to be discussed without proof.)

Review of geometric properties of vectors in \mathbf{R}^2 and \mathbf{R}^3 ; dot, cross and scalar triple products, their properties and their geometric interpretation.

Vector fields; review of definitions and basic properties of gradient, divergence, directional derivatives, divergence, curl and the Laplace operator.

Paths and curves in \mathbf{R}^2 and \mathbf{R}^3 ; tangent, velocity, acceleration and force vectors; arc length.

A brief overview of differentials.

Double integrals as limits of Riemann sums and as volumes; their computation as iterated integrals, elementary regions.

Triple integrals as limits of Riemann sums; their computation as iterated integrals, elementary regions.

Change of variables; the Jacobian determinant; spherical and cylindrical coordinates.

Application of double and triple integrals to finding volume, centre of mass, etc.

Line integrals, their dependence on parametrization, their computation; work done.

Parameterized surfaces; normal to a surface; surface area; surface integrals and their dependence on parametrization; their computation. .

Oriented surfaces; statement of Green's theorem and its application to computing the area of a region; statements of Stokes' theorem, and Gauss' divergence theorem.

Conservative vector fields.

Texts/References

(1) D.J.S. Robinson, A Course in Linear Algebra with Applications, World Scientific.

G. B. Thomas and R.L. Finney, Calculus and Analytic Geometry, 9th ed., Addison-Wesley/Narosa, 1998.

(3) J. Marsden, A. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer

(4) Inder K. Rana, Calculus@iitb, Concepts and Examples, Version 1.2, matth4all 2009.

Syllabus for MA 301 – Mathematical Methods: Complex Analysis and Differential Equations

Complex Variables , Analytic functions and the Cauchy-Riemann equations, Power series, Conformal mappings.

Line integrals, Cauchy integral theorem and its consequences.

The residue formula and computation of definite integrals.

Linear differential equations, Methods for solving them in the constant coefficient case and the Variable coefficients, Bernoulli, Euler equations, Wronskian and linear independence, initial and boundary value problems, mixed problems, successive approximations, power series method, Legendre, Hermite, Chebyshev equations, separation of variables, Vibrations of a String, Fourier method.

Laplace transforms and its applications to solving differential equations.

Fourier transforms and some of its applications.

Texts/References:

J.D. Fisher : Complex variables, Dover

L.V. Ahlfors : Complex Analysis, McGraw Hill

Churchill and Brown: Complex Variables, Academic Press

J.B. Conway : Functions of one complex variable, Springer Student Edition

M. A. Ablowitz & A.S. Fokas : Complex Variables, Introduction and Applications, Cambridge Texts in Applied Mathematics

R. Remmert, Theory of Complex Functions, Springer International Edition

P.P.G . Dyke, An Introduction to Laplace transforms and Fourier Series, Springer, SUMS

G.F. Simmons : Differential equations with Applications and Historical Notes, Mc Graw Hill

W.E. Boyce & R.C. Diprima : Elementary Differential Equations and Boundry Value Problems, John Wiley