SOLAPUR UNIVERSITY, SOLAPUR

SYLLABUS

FOR

M.Sc. (Part-II) MATHEMATICS
(Semester III and IV)
Choice Based Credit System

WITH EFFECT FROM ACADEMIC YEAR 2016-17

(JUNE-2016).

SOLAPUR UNIVERSITY, SOLAPUR

SCHOOL OF COMPUTATIONAL SCIENCES

DEPARTMENT OF MATHEMATICS

Revised Syllabi of M.Sc. in Mathematics (Choice Based Credit System)

1) **Title of the course:** M.Sc. in Mathematics
2) **Pattern:** Semester and Credit system.
3) **Duration of Course**: 2 years
4) **Strength of the Students:** 40
5) **Eligibility:** For M. Sc. in Mathematics following candidates are eligible.
   (i) B.Sc. with Mathematics as principal level.
   (ii) B.Sc. with any subject as principal and Mathematics at subsidiary level.

M. Sc. program in Mathematics consists of 100 credits. Credits of a course are specified against the title of the course.

A Four Semester M.Sc. Mathematics Course

Semester	No. of Papers/ Practical's / Seminar	Marks	Credits
Semester I			
• Theory Papers	05	500	20
• Practical Papers	01	100	04
• Seminar/Tutorial/Home Assignment /Field Tour/ Industrial Visit	01	25	01
Semester II			
• Theory Papers	05	500	20
• Practical Papers	01	100	04
• Seminar/ Tutorial/Home Assignment /Field Tour/ Industrial Visit	01	25	01
Semester III			
• Theory papers	05	500	20
• Practical Papers	01	100	04
• Seminar/ Tutorial/Home Assignment /Field Tour/ Industrial Visit	01	25	01
Semester IV			
• Theory papers	05	500	20
• Practical Papers	01	100	04
• Seminar/ Tutorial/Home Assignment /Field Tour/ Industrial Visit	01	25	01
Total marks and credits for M.Sc. Course		**2500**	**100**

M.Sc. Part-II (Mathematics) revised syllabus (according to the Semester Pattern Examination and Choice Based Credit System) to be effective from the Academic Year 2016-17

Notations: A five – character code is given to each paper. In that "MM" stands for Master of Mathematics. The first digit following 'MM' is semester number. The second digit "0" stands for the compulsory paper, the digit "1" stands for the elective paper and the digit "2" stands for practical paper. The third digit indicates the serial number of the paper in that semester.

.M.Sc.II Mathematics Semester-III

Paper Code	Title of the Paper	Contact hours/week	Distribution of Marks for Examination			Credits
			Internal	External	Total	
MM-301	Functional Analysis	04	30	70	100	04
MM-302	Graph Theory	04	30	70	100	04
MM-313	Elective- I	04	30	70	100	04
MM-314	Elective- II	04	30	70	100	04
MM-315	Elective – III	04	30	70	100	04
MM-326	Practical – III (Batchwise)	12	30	70	100	04
	Seminar	02	25	--	25	01
Total		**34**	**205**	**420**	**625**	**25**

Elective Papers from which <u>Any Three</u> are to be chosen

1) Linear Algebra
2) Numerical Analysis
3) Modeling and Simulation
4) Differential Geometry
5) Fuzzy mathematics
6) Commutative Algebra – I
7) Fluid Dynamics
8) Approximation Theory

M.Sc. Mathematics Semester-IV

Paper Code	Title of the Paper	Contact hours/week	Distribution of Marks for Examination			Credits
			Internal	External	Total	
MM-401	Measure and Integration	04	30	70	100	04
MM-402	Partial Differential Equations	04	30	70	100	04
MM-413	Elective- I	04	30	70	100	04
MM-414	Elective- II	04	30	70	100	04
MM-415	Elective – III	04	30	70	100	04
MM-426	Practical – IV (Batch wise) and Project	12	30	70	100	04
	Seminar	02	25	--	25	01
Total		**34**	**205**	**420**	**625**	**25**

Elective Papers from which <u>Any Three</u> are to be chosen

1) Integral Equations
2) Operation Research
3) Probability Theory
4) Combinatory
5) Number Theory
6) Commutative Algebra – II
7) Lattice Theory
8) Distribution Theory

Each theory and practical paper will have 100 marks out of which 70 marks will be for Term End examination and 30 marks for Internal Assessment. The candidate has to appear for internal evaluation of 30 marks and external evaluation (University Examination) of 70 marks for each paper/ practical.

<u>Internal Evaluation:</u>

- In case of theory papers internal examinations will be conducted by school.
- In case of practical paper 10 marks shall be for day-to-day journal and internal examination 20 mark will be conducted by the school.

External Evaluation (End of Term University Examination):

I) Nature of Theory question paper:

1) Each theory paper will be of 2:30 hours duration
2) There shall be 7 questions each carrying 14 marks.
3) Students have to attempt **five questions**.
4) Question No.1 is **compulsory** and shall contain 14 objective type sub-questions each carrying 1 mark.
5) Question No.2 is **compulsory** and shall contain 4 short answer / short note type sub-questions each carrying 3 or 4 marks.
6) Students have to attempt **any three** questions from Question N0. 3 to Question No. 7.
7) Question N0. 3 to Question No. 7 shall contain 2 long answer type sub-questions.

II) Nature of Practical question paper: (End of Term Examination)

For Sem-III: Practical examination will be conducted for 60 marks and is of 3 hours duration. There shall be 6 questions each of 15 marks, of which student has to attempt any 4 questions. VIVA will be for 10 marks.

For Sem-IV: i) Practical examination will be conducted for 40 marks and is of two hours duration. There shall be 3 questions each of 20 marks, of which a student has to attempt any 2 questions.

ii) Project work carries 30 marks. Project work consists of collecting information relative to project topic. Out of 30 marks, 10 marks are reserved for VIVA.

Equivalence for Theory Papers:

Semester No.	Old Syllabus		Revised Syllabus	
	Paper No.	**Title of the Paper**	**Paper No.**	**Title of the Paper**
III	MM-301	Functional Analysis	MM-301	Functional Analysis
	MM-302	Advanced Discrete Mathematics	MM-302	Graph Theory
	MM-303	Operation Research-I	MM-313	Elective-III
	MM-304	Linear Algebra	MM-314	Elective-I
	MM-305	Integral Equations	MM-315	Elective-II
IV	MM-401	Measure and Integration	MM-401	Measure and Integration
	MM-402	Partial Differential Equations	MM-402	Partial Differential Equations
	MM-403	Numerical Analysis	MM-413	Elective-I
	MM-404	Operation Research-II	MM-414	Elective-II
	MM-405	Boundary Value problems	MM-415	Elective-III

Detailed Syllabus of M.Sc. Semester- III (Mathematics)

MM:301 : Functional Analysis

Unit - 1

Banach spaces :

Normed linear spaces,Banach spaces, Quotient norm spaces, continuous linear transformations, equivalent norms,the Hahn-Banach theorem and its consequences. Conjugate space and separability, second conjugate space. The open mapping Theorem, The closed graph theorem, The conjugate of an operator, The uniform boundedness principle.

(25 Lectures)

Unit - 2

Hilbert spaces :

Definition and examples and simple properties, orthogonal complements, The projection theorem, orthogonal sets, The Bessels inequality, Fourier expansion and Perseval's equation,

(15 Lectures)

Unit - 3

Separable Hilbert spaces, The conjugate space, Riesz's theorem, The adjoint of on operators, self adjoint operators, Normal and unitary operators, projections. **(15 Lectures)**

Unit - 4

Contraction mapping and Banach fixed point theorem.

(05 Lectures)

Recommended Books :

1. G.F.Simmons **:** Topology and Modern Analysis, McGraw Hill (1963)

Reference Books :

1. D. Somsundram : A First Course in Fuctional Analysis, Narosa Publishing House
2. G.Bochman and Narici **:** Functional Analysis, Academic Press 1964
3. A.E.Taylor **:** Introduction to Functional analysis, John Wiley- and sons (1958)
4. A.L.Brown and Page **:** Elements of Functional Analysis, Van-Nastra Reinehold com (1970)
5. B.V.Limaye **:** Functioned Analysis New age international.
6. Erwie Krey Zig **:** Introduction to Functional Analysis with Applications, John Wiley and Sons.

MM – 302 : GRAPH THEORY

Unit - 1 Fundamental Concepts :

Graphs, Matrices and isomorphism decomposition, connection in Graphs, bipartite graphs, Eulerian circuits, vertex degrees, and Graphic sequences.

(15 lectures)

Unit – 2 Trees and Distance :

Trees, Distance in trees and Graphs, Enumeration of trees Caycley's formula, Spanning trees in graphs, minimum spanning trees, Kruskal's algorithm, shortest paths, Dijkstra's Algorithm.

(15 lectures)

Unit – 3 Matchings :

Maximum Matchings, Hall's matching condition, Min-Max Theorems, Maximum bipartite Matching, weighted bipartite matching.

(15 lectures)

Unit – 4 Connectivity and Paths :

Connectivity, edge-connectivity, blocks, 2-connected graphs, Vertex and Edge Colorings and Upper Bounds. – Definitions and Examples, Brooks' Theorem.

(15 lectures)

Recommended Books :-

1) West D.B. Introduction to Graph Theory (Second edition), Prentice Hall of India, New Delhi (2009).

Chapters : 1, 2, 3.1, 3.2, 4.1,5.1

2) Frank Harary :Graph Theory Addison-Wesley Publishing Company

Reference Books :

1. J. Clark, D.A. Holton, A First Look at Graph Theory, Allied Publishers.

2.R. J. Wilson, Introduction to Graph Theory, (Fourth Edition), Pearson Education, Singapore (2003).

MM 313: Elective – I
Linear Algebra

Unit – 1: Linear Transformations
Linear functional, The double dual, The transpose of a linear transformation, characteristic values, Annihilator polynomials, invariant subspaces.

(20 Lecture)

Unit – 2: Elementary canonical forms:
Triangulabity, diagonalizabitlity,
Direct sum decompositions, Invariant direct sums,The primary decomposition theorem.

(10 Lecture)

Unit – 3
Jordan and Rational Forms:
The Jordan form, computation of Invariant factors, Companion matrix ,the rational form

(20 Lecture)

Unit – 4
Inner Product Spaces:
Linear functional and adjoints, unitary operators, Normal operators,
Operators on Inner Product Spaces:
Forms on Inner product spaces, positive forms, more on forms, spectral theory .

(10 Lecture)

Recommended Books :

1. K.Hoffman and Ray Kunze : Linear Algebra, Prentice Hall of India,Pvt Ltd. 1989.
2. Vivek Sahai, Vikas Bist : Linear Algebra, Alpha Science International

Reference Books :

1. David M.Barton **:** Abstract and linear Algebra, Addison Wesley Publishing Co.
2. Sharma, Vasistha & vasistha: Linear Algebra, Krishna prakashan ltd. Meerut. 2005.
3. Friedberg H. Stephen, Insel J. Arnold, Spence E. Lawrence , Eastern Economy Edition

MM 314 : *Elective – II*
Differential Geometry

Unit I **(15 lectures)**

1.1 Tangent vectors and tangent vector fields, frame fields.
1.2 Reparametrization of curves, standard curves.
1.3 Directional derivative
1.4 Differential forms
1.5 Speed of curve

Unit II **(15 lectures)**

2.1 Frenet formulas for unit speed and for arbitrary speed curves
2.2 Isometries in E^3
2.3 Translation, Rotation, Orthogonal Transformation
2.4 Frenet approximation of curves
2.5 Covariant derivatives

Unit III **(15 lectures)**

3.1 Calculus on Surface
3.2 Co-ordinate patches
3.3 Surface, Surface of revolution
3.4 Patch Computation
3.5 Parametrization of a region X(D) in M
3.6 Differentiable functions and Tangent vectors

Unit IV **(15 lectures)**

4.1 Shape Operator
4.2 Normal curvature
4.3 Guassian and mean curvature

Recommended Books:

1. O'Neill, B.: Elementary Differential geometry, Academic Press, London 1966

Reference Books:

2. Millman, R. and Parker, G.D. : Elements of differential geometry: Prentice-Hall of India Pvt. Ltd. 1977

3. Hicks, N. : Notes of differential geometry, Princeton University Press (1968)

4. Nirmala Prakash : Differential Geometry, Tata McGraw-Hill 1981

MM 315 : *Elective – III*

Numerical Analysis.

Unit – 1 **(20 Lectures)**

Errors in numerical calculations and solution of algebraic and transcendental equations.

1.1 Numbers and their accuracy

1.2 Mathematical preliminaries.

1.3 Errors & their computation: Absolute, relative & percentage errors.

1.4 A general error formula

1.5 Error in series approximation

1.6 The iteration method & it's rate of convergence.

1.7 The method of false position & its rate of convergence

1.8 Secant method & its rate of convergence.

1.9 Newton Raphson method and its rate of convergence.

Unit – 2 :

Interppolation and Numerical Differentiation. **(20 Lectures)**

2.1 Errors in polynomial interpolation.

2.2 Finite Differences: Forward, Backward & Central Differences, Symbolic relations & separation of symbols.

2.3 Newton's Formula for interpolation.

2.4 Lagrange's interpolation formula and error in Lagrange's interpolation formuls.

2.5 Divided differences & their properties.

2.6 Newton's general interpolation formula.

Unit – 3 : **(10 Lectures)**

Numerical solutions of system of linear equations & Eigen Values.

3.1 Gaussian elimination method.

3.2 Method of factorization (LU decomposition)

3.3 Iterative Method: Gauss Seidal Method.

3.4 Eigen value problem: Householder's method.

3.5 Eigen value of symmetric tridiagonal matrix.

3.6 Power method for largest Eigen value.

Unit – 4 : **(10 Lectures)**

Numerical Integration and Solutions of ordinary differential equations

4.1 Numerical Integration: Trpezoidal rule Simpson's $1/3^{rd}$ rule and Simpson's $3/8^{th}$ rule.

4.2 Errors in the above methods.

4.3 Solution of differential equation by Taylor's series: Euler's method and Euler's modified method.

Recommended Text Book :

1) S. S. Sastry Introductory Methods of Numerical Analysis, 3^{rd} edition, Prentice Hall of India, 2001
2) M. K. Jain, S.R.K. Iyengar, S.R. Iyenger, R. K. Jain, Numerical Methods for scientific and Engineering computation, 3^{rd} edition, wiley Eastern Ltd., 1992

Reference Book :

1) Atkinson K. E., An Introduction to Numerical Analysis, John Wiley and Sons, N. Y., 1978.
2) Froberg C. E., Introduction to Numerical Analysis, Johns Hopkins University Press, Baltimore, 1950.

MM – 326
Practical – III

Unit – 1 : Functional Analysis
1) Problems on Banach Spaces
2) Problems on Hilberts spaces
3) Problems on Conjugate Spaces
4) Problems on Contraction Mapping

Unit – 2 : Graph Theory
1) Problems on Graphs
2) Problems on Trees
3) Problems on Matchings
4) Problems on connectivity and paths

Unit – 3 : Linear Algebra
1) Problems on Linear Transformations
2) Problems on Elementray Canonical forms
3) Problems on Rational and Jordan Forms
4) Problems on Inner Product Spaces and Operators on IPS

Unit – 4 : Differential Geometry
1)Problems on Euclidean spaces
2)Problems on Frenet formulas
3)Problems on Co-varient derivatives
4)Problems on Calculus on surface

Unit – 5 : Numerical Analysis
1)Problems on Numerical Calculations and Solutions of algebraic and transcendental equations.
2)Problems on interpolation and Numerical Differentiation
3)Problems on Numerical solutions of system of linear equations and Eigen Values
4)Problems on Numerical Integration and Solutions of ordinary Differential Equations

Detailed Syllabus of M. Sc. Semester – IV (Mathematics)

MM 401 : Measure and Integration.

Unit - 1

Measure and Integration **:** Measure space, Measurable function, Integration Fatous lemma (statement only), Generalization of monotone and Lebesque convergence theorem.

(20 Lectures)

Unit - 2

Signed Measure **:** Hahn Decomposition, Jordan Decomposition, Radon-Nikodym theorem Lebesque Decomposition.

(20 Lectures)

Unit - 3

Measure and Outer Measure :

Outer Measure and measurability, the Extension theorem, Product measures, Fubini's and Tonelli's theorem.

(10 Lectures)

Unit - 4

Inner measure and its properties. Baire Borel sets and positive linear functional and Borel measures.

(10 Lectures)

Recommend Books:

1.Royden H.L:Real Analysis (Third Edition Practice Hall (2002).

Reference Books :

1. Berberian, S.K. **:** Measure and Intergration McMillan, N.Y. 1965
2. Friedman A. **:** Foundations of Modern Analysis, Helf Rinehart and Winston, 1970
3. Wheeden R.L. and Zygmund A. **:** Measure and integral, Marcel Dakker, 1977
4. Halmos, P.R. : Measure Theory **:** Van Nostrand 1950
5. A Murkherjee and K.Pethoven : Real and Functional Analysis, Plenum Press 1978.
6. Rana J.K. **:** Measure and integration Narosa (1997)
7. P . K. Jain and V.P. Gupta :- Lebesgue measure and Integration , Anushan Publication

MM : 402 : Partial Differential Equations

Unit - 1
First order Partial Differential Equations :

Curves and surfaces, classification of integrals , linear equations of first order, Pfaffians, compatible systems, Charpits method , Jacobi method.

(15 Lectures)

Unit -2
Integral surfaces through a given curve, quasi linear equations, nonlinear first order pde.

(15 Lectures)

Unit - 3
Second order Partial Differential Equations :

Genesis of Second order Partial Differential Equations , Classification, one dimensional wave equations, vibrations, of a string, families of equipotential surface.

(15 Lectures)

Unit -4
Maximum and minimum principles, Dirichlets and Neumann problems. Dirichlet problem for circle, Harnacks theorem. Greens theorem (Statement only) , Classification in case of n variables.

(15 Lectures)

Recommended Books :
T. Amarnath: An elementary course in Partial differential equations, Narosa publication, 1987.

Reference:
1. Ordinary and Partial Differential Equatios : M. D. Raisinghania , S Chand Publications
2. Frite John **:** Partial Differential Equations.
3. R.McOwen **:** Partial differential equations, Prentice Hall 1995
4. G.Folland : Partial Differential Equations Prentice Hall India 1995

MM- 413 Elective – I
Integral Equations

Unit - 1

Preliminary concepts **:** Introduction, Some problems which give rise to integral equations, Classification of linear integral equations, Integro -differential equations, conversions of initial value problems to Volterra type integral equations and boundary value problems Fredholm type integral equations, Conversion of Sturm Liouville problems to integral equations, Solution of Sturm Liouville problems.

(15 Lectures)

Unit - 2

Fredholm Equations **:** Integral equations with separable (Degenerate), Hermitian and symmetric Kernel, The operator method in the theory of integral equations, Hilbert-Schmidt theorem. Construction of Green function and its use in solving Boundary Value Problems

(15 Lectures)

Unit - 3

Volterra Equations **:** Types of Volterra equations, Resolvent kernel of Volterra equations, Methods of successive approximations, Convolution type kernels. Aplication of Fourier and Laplace transforms to the solution of Volterra integral equations.

(20 Lectures)

Unit - 4 Determination of Iterated Kernels and Resolvent Kernels
Solution of fredholms integral equations by successive approximations

(10 Lectures)

Recommended Books :

1. Kanwal, R.P**. :** Linear Integral Equations, Theory and Techniques, Academic Press (1971)
2. Chambers, L.G**. :** Integral Equations : A Short Course, International Text Book Co., (1976)

Reference Books :

1) C.D.Green **:** Integral Equation Methods, Thomas Nelson and Sons (1969)
2) J.A. Cochran **:** The Analysis of linear Integral Equations, Mc-Graw Hill (1972)
3) Krasnow M.A.: Kislov and G. Hakaronke : Problems and exerciscs in integral equations Mir Publications (1971)
4) Pundir and Pundir : Integral Equations
5)M.D.Raisinghania: Linear Integral Equations,Kedar Nath Ram Nath MEERUT DELHI.

MM 414 :Elective-II
OPERATIONS RESEARCH

Unit-1. Convex Sets and Functions: Convex sets, supporting and separating hyperplanes, convex polyhedra and polytope, extreme points, convex functions. Linear Programming Problem (LPP): Introduction to linear programming problems, Graphical solution to LPP, Standard LPP (SLPP), basic solution and basic feasible solution to SLPP. Methods for solving LPP: Simplex Algorithm, Two-phase simplex method, Big M method .

(20 Lectures)

Unit-2. Duality in LPP: Concept of duality, Theorems related to duality, complementary slackness property and development of dual simplex algorithm. Integer Linear Programming Problem (ILPP): The concept of cutting plane, Gomory's method of cutting plane for all ILPP and mixed ILPP, Branch and Bound method (Algorithm only).

(20 Lectures)

Unit-3 Quadratic Programming Problem (QPP): Definition of QPP, Kuhn-Tucker conditions, Algorithms for solving QPP: Wolfe's and Beale's algorithm.

(10 Lectures)

Unit-4. Theory of Games: Two person zero sum games, Minimax and Maxmin principles, Saddle point, Mixed strategies; Rules of dominance, Solution of 2 x 2 game by Algebraic method, Graphical method, Reduction of game problem as LPP, Minimax and Maxmin theorem (without proof).

(10 Lectures)

Recommended Books :

1)Sharma S.D : Operations Research, Macmillan Publishers India Ltd.

Reference Books:

1) Hadley G. (1969): Linear Programming, Addision Wesley.
2) Taha H. A. (1971): Operations Research an Introduction, Macmillan N. Y.
3) Kanti Swaroop, Gupta and Manmohan (1985): Operations Research, Sultan Chand & Co.
4) Sharma J. K. (2003): Operations Research Theory and Applications, 2nd Ed. Macmillan India ltd.
5) Sharma J. K. (1986): Mathematical Models Operations Research, Macgraw Hill.

MM 415: Elective-III

PROBABILITY THEORY

Unit-1: Classes of sets, Sequence of sets, limsup and liminf and limit of sequence of sets, field, σ- field, σ- field generated by a class, Borel σ-field. Probability measure, Probability space, properties of probability measure-continuity, mixture of probability measures. Lebesgue and Lebesgue-Steltjes measures on R. Independence of events.

(15 Lectures)

Unit-2: Measurable function, random variable, distribution of a random variable, simple random variable, elementary random variable, liminf, limsup and limit of sequence of random variables. Method of obtaining a random variable as a limit of sequence of simple random variables. Integration of a measurable function with respect to a measure.

(9 Lectures)

Unit-3: Expectation of a random variable, independence. Characteristic function, simple properties, Inversion theorem and uniqueness property (Statement only).

(6 Lectures)

Unit-4: Monotone convergence theorem, Fatous Lemma, Dominated Convergence theorem, Borel-Cantelli Lemma and their applications. Convergence of sequence of random variables, Convergence of distribution, Continuity theorem (Statement only), Almost sure convergence, a characterizing property, convergence in probability, uniqueness of limit. Yule Slutsky results and preservation under continuous transform (Statement only). convergence in r^{th} mean, interrelationships.

(12 Lectures)

Unit-5: Weak and Strong laws of large numbers, Kolmogorov's three series theorem for almost sure convergence (statement only), Liaponove's Lindeberg-Feller Theorems on CLT (statement only). Application of the above results.

(8 Lectures)

Reference Books:

1. Bhat B. R. (1999): Modern Probability Theory (3rd ed.).New Age International (P) Ltd..
2. Billingsley P.(1986): Probability and Measure-.John Wiley and Sons.
3. Alan Karr (1993): Probability Theory-Springer Verlag.
4. Kingman, J F C and Taylor, S.J.(1966): Introduction to Measure and Probability-Cambridge University Press.
5. Dudly, R.M.(1989): Real Analysis and Probability- Wadsworth and Brooks/ Cole.
6. Ash Robert (1972): Real Analysis and Probability-Academic Press.

MM – 426 Practical – IV

Unit – 1 : Measure and Integration

1) Problems on Measurable Space and signed Measure
2) Problems on Inner, Outer Measure and Product Measure.

Unit – 2 Partial Differential Equation

1) Problems on first order Partial Differential Equations
2) Problems on second order Partial Differential Equations

Unit – 3 Elective-I

Atleast two practicals should be conducted

Unit – 4 Elective-II

Atleast two practicals should be conducted

Unit – 5 Elective-III

Atleast two practicals should be conducted