

**Course Structure & Syllabus**  
**of**  
**Master of Philosophy (M. Phil.)**  
**in**  
**Mathematics**  
**(Session 2019 – 2020 Onward)**



**Department of Mathematics**  
**Veer Surendra Sai University of Technology (VSSUT)**  
**Siddhi Vihar, P.O.: Engineering College**  
**Burla, Sambalpur–768018, Odisha, India**  
**[www.vssut.ac.in](http://www.vssut.ac.in)**

## VISION

The Department of Mathematics strives to be internationally recognized for its academic excellence through the depth of teaching and research, and making students technologically and mathematically competent with strong ethics contributing to the rapid advancement of the society.

## MISSION

M1. To transform young people to competent and motivated professionals.

M2. To produce PG students with strong foundation to join research or serve in academics.

M3. To cater to the development of the nation, particularly in Odisha for research and training.

## PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The program educational objectives of M. Phil. in Mathematics are:

1. To provide an M. Phil. course, suitable for students of high ability, combining and relating mathematics, science and technology.
2. To prepare students for further study and research, particularly in areas requiring the application of mathematics.
3. To enrich students with a knowledge of mathematics, its research potential and the interaction between them.

## PEO-MISSION MATRIX

	<b>M1</b>	<b>M2</b>	<b>M3</b>
<b>PEO1</b>	<b>3</b>	<b>2</b>	<b>1</b>
<b>PEO2</b>	<b>1</b>	<b>3</b>	<b>2</b>
<b>PEO3</b>	<b>2</b>	<b>2</b>	<b>3</b>

## PROGRAMME OUTCOMES (POs)

The Program Outcomes of M. Phil. in Mathematics are:

PO1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document
PO3	An ability to demonstrate a degree of mastery over Mathematics which is at a level higher than the requirements in the undergraduate program in Mathematics.
PO4	An ability to identify, analyse and formulate complex mathematical problems to reach logical conclusion.
PO5	An ability to apply knowledge of Mathematics in different field of science and technology.
PO6	An ability to recognize the need for and to ready for lifelong learning to keep updated on technological changes.

## **Program Specific Outcomes (PSOs)**

PSO1	Design and analyse the mathematical models for the problem related to science, technology, and other socio-economic world.
PSO2	Apply knowledge of Mathematics in different fields of science & technology, and to provide an opportunity to pursue careers in research and development, teaching and allied areas related to Mathematical Science.

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## Course Structure of 1 Year M.Phil. (Mathematics)

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Course Code	Name of the Course	L–T–P	Credit
<b>FIRST SEMESTER</b>			
MPMA0101	Problem Solving in Analysis, Algebra and Topology	3–1–0	04
----	Elective-I	3–1–0	04
MPHU0101	Research Methodology and Intellectual Property Rights	3–1–0	04
----	Seminar	0–0–3	02
MPMA0102	Review of the Research papers	0–0–0	04
MPCAC100--	Audit I	0-2-0	00
<b>Total Credits</b>			<b>18</b>
<b>SECOND SEMESTER</b>			
----	Elective II	3–1–0	04
----	Seminar	0–0–3	02
----	Dissertation	0-0-0	12
<b>Total Credits</b>			<b>18</b>
<b>Total Credit = 18 + 18 = 36</b>			

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## List of Elective Courses (Theory)

MPMAPE11	Distribution Theory and Calculus on Banach Spaces	3-1-0	04
MPMAPE12	Advanced Matrix Analysis	3-1-0	04
MPMAPE13	Advanced Fluid Dynamics	3-1-0	04
MPMAPE21	Multi-objective Optimization	3-1-0	04
MPMAPE22	Advanced Numerical Analysis	3-1-0	04
MPMAPE23	Fourier Analysis	3-1-0	04

### Audit course 1 & 2

Sl.No.	Course Code	Subject Name
1.	MPCAC---	English for Research Paper Writing
2.	MPCAC---	Disaster Management
3.	MPCAC---	Sanskrit for Technical Knowledge
4.	MPCAC---	Value Education
5.	MPCAC---	Stress Management by Yoga
6.	MPCAC---	Optimization Technique
7.	MPCAC---	Constitution of India
8.	MPCAC---	Pedagogy Studies
9.	MPCAC---	Personality Development through Life Enlightenment Skills.
10.	MPCAC---	Computational and Statistical Method
11.	MPCAC---	Application of GIS

## FIRST SEMESTER

**MPMA0101    PROBLEM SOLVING IN ANALYSIS, ALGEBRA, AND TOPOLOGY**

**4 Credits [3-1-0]**

**Analysis:** Real Analysis & Complex Analysis, Functional Analysis

**Algebra:** Abstract Algebra & Linear Algebra

**Topology:** Topology,

[**Note:** The problems will be solved from the relevant portions of the Syllabus of Post-graduate course of VSSUT]

### **Course Outcomes:**

Upon completion of the course, the students will be able to:

CO1	Develop problems on Real Analysis
CO2	Organize problems on Complex Analysis and applications
CO3	Recognize Abstract Algebra & Linear Algebra with various problems
CO4	Demonstrate Topological spaces and solve various problems
CO5	Analyse problems on Functional Analysis

### **Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

### **Program Articulation Matrix row for this Course**

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

**MPHU0101 RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS**

**4 Credits**

**[3-1-0]**

**Module –I**

Meaning of research problem, Sources of research problem, Characteristics of a good research problem, Scope and objectives of research problem, synthesizing.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, citation, impact factor, h-index, i-10 index.

**Module –II**

Effective literature studies approaches, analysis, Plagiarism, Research ethics, Effective technical writing, how to write report and paper, Developing a Research Proposal, Format of research proposal, a presentation and assessment by a reviewer.

**Module –III**

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. Procedure for grants of patents.

**Module –IV**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Module –V**

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, case study.

**Reference Books:**

1. Kothari C. K. (2004) 2/e, Research Methodology--Methods and Techniques (New Age International, New Delhi).
2. Krishnswamy, K.N., Shivkumar, Appa Iyer and Mathiranjana M. (2006) Management Research Methodology; Integration of Principles, Methods and Techniques (Pearson Education, New Delhi).
3. Fundamental of research Methodology and Statistics, Yogesh Kumar Singh (New Age International Publisher
4. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science and engineering students
5. T Ramappa, Intellectual Property rights under WTO, S. Chand, 2008.

**Course Outcomes:**

Upon completion of the course, the students will be able to:

CO1	Design and formulate research problem
CO2	Analyze research related information and follow research ethics
CO3	Recognize that today's world is controlled by Computer, Information Technology but tomorrow world will be ruled by ideas, concept, and creativity.
CO4	Describe when IPR would take such important place in growth of individuals & nation and to emphasise the need of information about Intellectual Property Right to be promoted among students
CO5	Analyse that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products

## Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

### Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

## SECOND SEMESTER

MPMA02

**DISSERTATION**

**12 Credits**

A candidate shall be required to write a dissertation under the guidance of a supervisor appointed by the M.Phil. Committee/DAC. The dissertation will consist of a critical survey of some topic of interest in Mathematics, and /or involving research component.

## List of Electives

### MPMAPE11      DISTRIBUTION THEORY AND CALCULUS ON BANACH SPACES

**4 Credits [3-1-0]**

***Module I:***

Test functions and distributions, some operations with distributions, local properties of distributions,

***Module II:***

Convolutions of distributions, tempered distributions

***Module III:***

Fourier transforms, fundamental solutions.

***Module IV:***

The Frechet derivative, chain rule and mean value theorems and applications

***Module V:***

Implicit function theorem, extremum problems and Lagrange multipliers.

**Reference Books:**

1. W. Cheney: Analysis for Applied Mathematics; Springer -Verlag, 2001.
2. S. Kesavan: Topics in Functional Analysis and Applications; New Age International Publishers, 2008
3. W. Rudin: Functional Analysis; Tata Mc-Graw Hill, 1991.
4. Robert S. Strichartz: A guide to distribution theory and Fourier transforms; World Scientific Publishing Co., 2003.

**Course Outcomes:**

Upon completion of the course, the students will be able to:

CO1	Demonstrate problems and applications of functions and distributions
CO2	Analyze knowledge of convolution of distributions
CO3	Compute Fourier transforms of desired functions
CO4	Recognize basic working knowledge of the Frechet derivative
CO5	Apply implicit function theorem

**Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

**Program Articulation Matrix row for this Course**

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

**Module I:**

Unitary equivalence and normal matrices; Schur's unitary triangularization theorem and its implications

**Module II:**

The Jordan form and its applications, other canonical forms and factorizations, Polar decomposition; Triangular factorizations, LU-decomposition, QR-decomposition (factorization) canonical forms

**Module III:**

Norms for vectors and matrices; vector norms on matrices. Positive definite matrices; the Polar form and singular value decompositions

**Module IV:**

The Schur's product theorem; congruences; the positive definite ordering.

**Module V:**

Non-negative matrices and Primitive matrices. Stochastic and doubly stochastic matrices.

**Reference Books:**

1. A. Bermann and R. Plemmans: Non-negative Matrices in Mathematical Sciences, Academic Press, 1979.
2. R.A. Horn and C.R. Johnson: Matrix Analysis, Vol. I, Cambridge Univ. Press, 1985.
3. H. Minc: Non-negative matrices, Wiley Interscience, 1988.
4. E. Seneta: Non-negative matrices, Wiley, New York, 1973.

**Course Outcomes:**

Upon completion of the course, the students will be able to:

CO1	Demonstrate a basic working knowledge of the Unitary triangularization
CO2	Recognize the Jordan form and its applications
CO3	Analyse knowledge of positive definite matrices and its use
CO4	Apply Schur's product theorem
CO5	Demonstrate problems and applications of Stochastic and doubly stochastic matrices

**Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

**Program Articulation Matrix row for this Course**

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

**Module I:**

Introduction: Facts about viscosity and heat transfer, General theory of stress and strain, Fundamental equation of viscous compressible fluids, Equation of state, Equation of continuity, Equation of motion, Equation of energy

**Module II:**

Some exact solution of Navier Stokes equation: Introduction, Laminar flow between parallel walls, plane coquette flow, plane Poiseuille flow, Hagen Poiseuille flow in a circular pipe, Flow in vicinity of a stagnation point, One dimensional steady flow of a viscous compressible fluid

**Module III:**

Dimensional analysis and  $\pi$ - theorem, Reynolds law of similarity, Important non-dimensional quantities with their physical significance.

**Module IV:**

Boundary layer theory: Two dimensional Boundary layer flow over a flat plate, Axial symmetric flow of Boundary layer, Momentum integral equation of Boundary layer flow,

**Module V:**

Boundary layer of an incompressible fluid on a surface with pressure gradient, Boundary layer on a circular cylinder, Boundary layer of a compressible fluid on a flat plate.

**Reference Books:**

1. Viscous Flow Theory I- Laminar Flow, Shih-I – Pai, D. Van Nostrand Company
2. Modern Fluid Dynamics, C. Kleinstreuer, Springer
3. An introduction to Fluid Dynamics, G.K. Batchelor, Cambridge Univ. Press

**Course Outcomes:**

Upon completion of the course, the students will be able to:

CO1	Apply governing equation in modelling a physical problem
CO2	Describe basic working knowledge of some exact solution of Navier Stokes equation.
CO3	Recognize the knowledge of Dimensional analysis
CO4	Incorporate momentum integral equation of boundary layer flow
CO5	Demonstrate problems and applications of Boundary layer flow

**Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

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**Program Articulation Matrix row for this Course**

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

**Module I:**

Optimization with Multiple Criteria, Criterion Space, Orders and Cones, Classification of Multi-objective programming Problems, Multiple Criteria Examples, Utility Functions

**Module II:**

Efficient solutions, Non-dominated points, Bounds on the Non-Dominated Sets, Weakly and strictly Efficient solutions, Proper Efficiency and Proper Non-dominance, Related theorems

**Module III:**

Weighted Sum Scalarization: (Weak) Efficiency, Proper Efficiency, Optimality Conditions. Scalarization Techniques: The  $\epsilon$ -Constraint Method, The Hybrid Method, The Elastic Constraint Method and Benson's Method.

**Module IV:**

Non-scalarizing Techniques: Lexicographic Optimality, Lexicographic Max-Ordering Optimization

**Module-V**

Introduction to Multi-Criteria Linear Programming: Notations and Definitions, Duality, Simplex method and Bi-objective Linear programs

**Reference Books:**

1. Matthias Ehrgott: Multi-criteria Optimization, Springer Berlin. Heidelberg-2005, Second Edition,
2. Ralph E.Steuer: Multi-Criteria Optimization, Theory Computation and Application, John Wiley and Sons, 1986.
3. James P.Ignizio : Linear Programming in Single and Multiple Objective Systems, Prentice Hall Inc. , Englewood Cliffs, N.J - 07632, 1982.

**Course Outcomes:**

Upon completion of the course, the students will be able to:

CO1	Recognize the formulation of the Multiple Objective Model of practical problems
CO2	Describe compromise solution of the formulated problems
CO3	Demonstrate several scalarization techniques
CO4	Analyse knowledge of different non-scalarizing techniques
CO5	Demonstrate a basic working knowledge of the Multi-objective linear programming problem

**Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

**Program Articulation Matrix row for this Course**

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

**Module - I**

The Bisection Method, Newton's Method, The Secant Method, Muller's Method, A General Theory for One-Point Iteration Methods, Roots of Polynomials

**Module - II**

Approximation of functions: Weierstrass theorem and Taylor's theorem, Minimax approximation problem, least square approximation problem, orthogonal polynomials, least square approximation problem (Continued).

**Module - III**

Numerical solution of systems of linear equations: Gaussian Elimination, pivoting and scaling in Gaussian Elimination, variants of Gaussian Elimination, Error analysis, Residual correction method, iteration methods, Error prediction and acceleration.

**Module - IV**

Eigen value location, error and stability results; The Power Method, Orthogonal Transformations Using Householder Matrices, The Eigenvalues of a Symmetric Tridiagonal Matrix, The QR Method.

**Module - V**

Polynomial Interpolation Theory, Hermite interpolation, Trigonometric Interpolation. Piecewise polynomial interpolation (Cubic spline interpolation, B-spline curves)

**Reference Books:**

1. An introduction to Numerical Analysis (2nd Edition) – Kendall E Atkinson (Wiley)

**Course Outcomes:**

Upon completion of the course, the students will be able to:

CO1	Compute roots of polynomials using numerical methods
CO2	Analyze idea for approximating functions
CO3	Describe solution of system of linear equations numerically and perform error estimation
CO4	Recognize the applications of eigenvalues and eigenvectors
CO5	Demonstrate knowledge of polynomial approximation of continuous functions

**Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

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**Program Articulation Matrix row for this Course**

	PO1	PO2	PO3	PO4	PO5	PO6
Course	3	1	3	3	2	1

**Module-I**

Trigonometric series and Fourier series, Fourier series of  $2\pi$  and arbitrary periodic function, Half range expansion. Fourier integral, Fourier sine and cosine integral

**Module-II**

The convergence problems. Dirichlets integral. The Riemann Lebesgue theorem. Convergence tests. Dini's Jordan's, de la Vallée Poussin test and its relation. The conjugate Fourier series, convergence of conjugate series

**Module-III**

Summability of Fourier series by arithmetic means. Fejers theorem, Summability throughout an interval. Weierstrass approximation theorem. Fejer - Lebesgue theorem.

**Module-IV**

Continuous function with divergent Fourier series. (C, 1) Summability of Fourier and conjugate series. A-Summability of Fourier series. The A-Summability of conjugate series. Gibb's phenomenon

**Module-V**

Special Methods of Summation. Norlund mean. Regularity and consistency of Norlund means, Inclusion Equivalence. Euler means, Abelian mean, Abel theorem on inclusion for abelian means, Holders mean ad theorem. The equivalence theorem. Cesaro and Abel Summability, Cesaro means as Norlund mean.

**Reference Books:**

1. E. C Titchmarsh, The Theory of Function, Oxford University Press.
2. G. H. Hardy, Divergent Series, AMS Chelsea Publishing.

**Course Outcomes:**

Upon completion of the course, the students will be able to:

CO1	Recognize trigonometric series and Fourier series
CO2	Describe basic working knowledge of Dirichlets integral and Riemann Lebesgue theorem
CO3	Apply knowledge of Summability of Fourier series by arithmetic means
CO4	Analyse A-summability of Fourier series
CO5	Demonstrate problems and applications of Regularity and consistency of Norlund means

**Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

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**Program Articulation Matrix row for this Course**

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