

Pre Ph.D. Course Work in Mathematics

(As per Ph.D. regulations-2022)

Structure of the Course Work

Sr. No.	Nature of Course	Name of Course	Credits	L	T	P
1.	Mandatory	Research Methodology	4	3	1	-
2.	Mandatory	Research Publication Ethics	2	2	-	-
3.	Core (discipline specified)	Subject Related Theory Paper	4	3	1	-
4.	Interdisciplinary	Seminar*	4	-	-	-
Total			14	08	02	-

- * The evaluation of seminar will be based on the submission of project report on the topic of research or relevant area followed by the evaluation through presentation.

IKG Punjab Technical University
Department of Research

Total Marks 100

L3:T1:P0

Syllabi common to All branches/disciplines

PAPER I – RESEARCH METHODOLOGY

Unit-I

15

Part A: OBJECTIVES AND TYPES OF RESEARCH: Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process, Research methods vs Methodology. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical.

Part -B - RESEARCH FORMULATION – Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem, Literature review, Primary and secondary sources, reviews, treatise, monographs-patents, various tool for search, Critical literature review–Identifying gap areas from literature review - Development of working hypothesis.

Unit-II

10

RESEARCH DESIGN AND METHODS – Research design- Basic Principles- Need of research design-Features of good design – Important concepts relating to research design – Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models. Developing a research plan-Exploration, Description, Diagnosis, Experimentation. Determining experimental and sample designs.

Unit-III

10

STATISTICAL TECHNIQUES AND TOOLS

Introduction of statistics – Functions, Limitations, Measures of central tendency, Arithmetic mean, Median, Mode, Standard deviation, Co-efficient of variation, (Discrete series and continuous series), Correlation, Regression, Multiple Regression, Sampling distribution, Standard error, Concept of point and interval estimation, Level of significance, Degree of freedom, Analysis of variance, One way and two-way classified data- ‘F’-test.

Unit-IV

10

Part A: - REPORTING AND THESIS WRITING – Structure and components of scientific reports - Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout, structure, and Language of typical reports – Illustrations and tables- Bibliography, referencing and footnotes - Oral presentation – Planning – Preparation –Practice – Making presentation – Use of visual aids - Importance of effective communication.

Part -B: - APPLICATION OF RESULTS AND ETHICS - Environmental impacts - Ethical issues -ethical committees - Commercialisation – Copy right – royalty - Intellectual property rights and patent law – Trade Related aspects of Intellectual Property Rights-Reproduction of

published material – Plagiarism - Citation and acknowledgement - Reproducibility and accountability.

Reference

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. *An introduction to Research Methodology*, RBSA Publishers.
2. Kothari, C.R., 1990. *Research Methodology: Methods and Techniques*. New Age International. 418p.
3. Sinha, S.C. and Dhiman, A.K., 2002. *Research Methodology*, Ess Ess Publications. 2 volumes.
4. Trochim, W.M.K., 2005. *Research Methods: the concise knowledge base*, Atomic Dog Publishing. 270p.
5. Wadehra, B.L. 2000. *Law relating to patents, trademarks, copyright designs and geographical indications*. Universal Law Publishing.

Additional reading

1. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009. *Research Methods: A Process of Inquiry*, Allyn and Bacon.
2. Carlos, C.M., 2000. *Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options*. Zed Books, New York.
3. Coley, S.M. and Scheinberg, C. A., 1990, "*Proposal Writing*", Sage Publications.
4. Day, R.A., 1992. *How to Write and Publish a Scientific Paper*, Cambridge University Press.
5. Fink, A., 2009. *Conducting Research Literature Reviews: From the Internet to Paper*. Sage Publications
6. Leedy, P.D. and Ormrod, J.E., 2004 *Practical Research: Planning and Design*, Prentice Hall.
7. Satarkar, S.V., 2000. *Intellectual property rights and Copyright*. Ess Ess Publications.

Research and Publication Ethics (RPE)
(2 Credits)

Course structure

- The course comprises of six modules listed in table below. Each module has 4-5 Units.

Modules	Unit title	Teaching hours
Theory		
RPE 01	Philosophy and Ethics	4
RPE 02	Scientific Conduct	4
RPE 03	Publication Ethics	7
Practice		
RPE 04	Open Access Publishing	4
RPE 05	Publication Misconduct	4
RPE 06	Database and Research Metrics	7
	Total	30

Syllabus in Details

THEORY

- **RPE 01: PHILOSOPHY AND ETHICS (3hrs.)**
 1. Introduction to Philosophy: definition, nature and scope, concept, branches
 2. Ethics: definition, moral Philosophy, nature of moral judgements and reactions
- **RPE 02: SCIENTIFIC CONDUCT (5 hrs.)**
 1. Ethics with respect to science and research
 2. Intellectual honesty and research integrity
 3. Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP)
 4. Redundant publications: duplicate and overlapping publications, salami slicing.
 5. Selective reporting and misrepresentation of data

- **RPE 03: PUBLICATION ETHICS (7hrs.)**

1. Publication Ethics: definition, introduction, and importance
2. Best practices/standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types.
5. Violation of publication ethics, authorship, and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

PRACTICE

- **RPE 04: OPEN ACCESS PUBLISHING (4 hrs.)**

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving Policies.
3. Software tool to identify predatory publications developed by SPPU.
4. Journal finder/journal suggestion tool viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

- **RPE 05: PUBLICATION MISCONDUCT (4 hrs.)**

A. Group Discussion (2hrs.)

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2hrs.)

Use of plagiarism software like Turnitin, Urkund, and other open-source software tools.

- **RPE 06: DATABASES AND RESEARCH METRICS (7hrs.)**

- A. Databases (4hrs.)**

1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

- B. Research Metrics (3hrs.)**

1. Impact Factor of journal as per Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g-index, i10 index, altmetrics

Core (Discipline Specified) Subjects

(Candidate can opt any one)

Subject Title: Methods in Applied Mathematics

Subject Code: PHDM-101

L	T	P	Credits
3	1	0	4

UNIT-I

Integral equations: Their origin and classification, Relation between differential and integral equations. IVP and BVP reducible to Integral equations, Integral equations with separable kernels, Method of successive approximations, Classical Fredholm theory.

UNIT-II

Fourier series and its Convergence, Gibbs phenomenon, Integration and Differentiation of Fourier series, the phase angle form of Fourier series, Complex Fourier series and frequency spectrum, Fourier integrals, Fourier Cosine and sine Integrals, Complex Fourier Integrals.

UNIT-III

Fourier Transforms, Properties of Fourier Transforms and its Applications, Convolution, Fourier Cosine and Sine Transforms, Discrete Fourier Transforms, Fast Fourier Transforms, Solution of equations, Hankel and Mellin transforms and their applications.

UNIT-IV

Wavelets, History of wavelets, The Haar wavelets, the Stromberg Wavelet, Wavelet expansion, Multiresolution analysis with Haar wavelets, Periodic wavelets, General Construction of wavelets, Wavelet transform versus Fourier transform. Simple applications of Wavelet theory.

Recommended Books:

1. Ram P. Kanwal: Linear Integral Equations, Academic Press, 1971.
2. Abdul J. Jeeri: Introduction to Integral Equations with Applications. Monographs and Text

- Books in Pure and Applied Mathematics. Marcel Dekker. INC,1985.
3. F.B. Hilderbrand: Methods of Applied Mathematics. Dover Publication,1965.
 4. Lokenath Debnath and Dambaru Bhatta: Integral Transforms and Their Applications, 2nd Edition, Chapman and Hall/ CRC,2006.
 5. Brian Davies: Integral Transforms and Their Applications, Text Books in Applied Mathematics, Vol 41, 3rd Edition, Springer, 2002.
 6. P. Wojtaszczyk: A Mathematical Introduction to wavelets, Cambridge University Press.
 7. Veronique Delouille: An Introduction to Wavelet Analysis, Connexions, 2009.
 8. Willard Miller, Introduction to the Mathematics of Wavelets, University of Minnesota, 2006.
 9. Peter O' Neil: Advanced Engineering Mathematics, Cengage Learning, 2006.

Subject Title: Advanced Number Theory
Subject Code: PHDM-102

L	T	P	Credits
3	1	0	4

Unit-I

Partitions, Compositions, Ferrers graphs, Jacobi's triple product identity, Congruence properties of $p(n)$, Rogers-Ramanujan identities, Basic hypergeometric series, q -binomial theorem, Sylvester's theorem (Statement only), Heine's transformation (Statement only).

Unit-II

Restricted partitions, q -Gauss theorem, Gaussian polynomials, Bailey's lemma (weak version) (Statement only), Rogers lemma, q -Saalschutz's theorem (Statement only), Finite version of q -Saalschutz's theorem.

Unit-III

Schur's theorem, Gollnitz-Gordon identities, Generalization and various analogues of Rogers-Ramanujan identities, Bailey's lemma (strong version) (Statement only), Watson's q -analogue of Whipple's theorem (Statement only) and its applications in deriving Rogers-Ramanujan identities and Gollnitz-Gordon identities.

Unit-IV

Rank & Crank of a partition, n -colour partitions, Conjugate and self-conjugate n -colour partitions, Restricted n -colour partitions, Rogers-Ramanujan type identities for n -colour partitions.

Simple applications of number theory in ATM cash dispenser, conjugacy classes of symmetric groups.

Recommended Books:

1. Agarwal, A.K., Padmavathamma and Subbarao, M.V., Partition Theory, Atma Ram & Sons, Chandigarh, 2005.
2. Andrews, G.E., The Theory of Partitions, Encyclopedia of Mathematics and its Applications (Addison-Wesley), 1976, Re-issued: Cambridge University Press, Cambridge, 1988.
3. Gasper, G. and Rahman, M., Basic Hypergeometric Series, Encyclopedia of Mathematics and its Applications, Vol. 35, Cambridge University Press, Cambridge, 1990.
4. Agarwal, R.P., Resonance of Ramanujan Mathematics, Vol. 1 (New Age International), 1996.
5. Gupta, H., Selected Topics in Number Theory, ABACUS Press, 1980.
6. N.J. Fine, Basic Hypergeometric Series and Applications, Mathematical Surveys and Monographs, No. 27, American Mathematical Society, 1988.

Subject Title: Advanced Numerical Methods
Subject Code: PHDM-103

L	T	P	Credits
3	1	0	4

Unit-I

Iterative Methods for Linear Systems & Eigenvalue problem: The classical iterative methods: Jacobi, Gauss-Seidel and Successive Over Relaxation (SOR) methods. Conjugate gradient method. Eigenvalues & eigenvectors: Rayleigh power method & Givens method.

Unit-II

Finite Difference Methods: Explicit and implicit schemes, consistency, stability and convergence, Lax equivalence theorem, numerical solutions to elliptic, parabolic and hyperbolic partial differential equations.

Unit-III

Approximate Methods of Solution: Rayleigh-Ritz, collocation and Galerkin methods, properties of Galerkin approximations, Petrov-Galerkin method, Generalized Galerkin method.

Unit-IV

Finite Element Method (FEM): FEM for second order problems, One and two dimensional problems, The finite elements (elements with a triangular mesh and a rectangular mesh and three dimensional finite elements), Fourth-order problems, Hermite families of elements, iso-parametric elements, numerical integration. Simple applications of FEM to address heat transfer problems.

Recommended Books:

1. Jain, M.K, Iyengar, S.R.K. and Jain, R.K., Numerical Methods for Scientific and Engineering Computation, 5th Edition, New Age international, 2008.
2. Hoffman Joe D., Numerical methods for Engineers and Scientists, McGraw-Hill, 1993.
3. Atkinson, K.E, An Introduction to Numerical Analysis, 2ⁿ Edition, John Wiley, 2004.
4. Gupta R.S., Elements of Numerical Analysis, McMillan India, 2009.
5. Seshu P., Textbook of Finite Element Analysis, Prentice Hall India, 2003.

Subject Title: Continuum Mechanics
Subject Code: PHDM-104

L	T	P	Credits
3	1	0	4

Unit-I

Continuum Hypothesis: Notion of Continuum. Configuration of a Continuum, Mass and Density, Description of motion, Material and Spatial Coordinates

Analysis of Strain: Affine Transformation, infinitesimal Affine Deformation, Geometrical interpretation of the Components of Strain, Strain Quadric of Cauchy, Principal Strains, Invariants, General Infinitesimal Deformation, Examples of strain, Notation, Equations of Compatibility, Finite Deformation

Unit-II

Analysis of Stress: Body and Surface Forces, Stress Tensor, Note on Notation and Units, Equations of Equilibrium, Transformation of Coordinates, Stress Quadric of Cauchy, Maximal Normal and Shear Stresses, Examples of Stresses.

Unit-III

Stress Strain Relations: Hookes law, Generalized Hookes law, Homogeneous isotropic bodies, Elastic moduli of isotropic bodies, Equilibrium Equations for an isotropic elastic solid, Dynamical equations of an isotropic elastic solid.

The strain energy function and its connection with Hooke's law, Uniqueness of solution of the Boundary-value problems of Elasticity, Saint-Venant's principle.

Unit-IV

Fundamental laws of continuum mechanics: Conservation of mass, Balance of linear momentum, Balance of angular momentum, General solutions of the Equation of Equilibrium, Balance of energy, Entropy inequality, Constitutive Equations

Recommended Books:

1. Sokolnikoff, I.S., Mathematical Theory of Elasticity, Krieger Publishing Company (1983)
2. Chandrasekharaiah and Debnath, Continuum Mechanics, Academic Press (1994).
3. Jog. C. S., Foundations and Applications of Mechanics: volume I: continuum Mechanics, Narosa Publications, (2006).

Subject Title: Advanced Analysis
Subject Code: PHDM-105

L	T	P	Credits
3	1	0	4

Unit-I

Distributions: Test functions & Distributions, Some Operations with Distributions, Supports and singular Supports of Distributions, Convolution of functions, Convolution of Distributions, Fundamental solutions,

Unit-II

The Fourier Transform, The Schwartz Space, The Fourier Inversion formula, Tempered Distributions.

Unit-III

Sobolev spaces: Definition and basic properties, Approximation by smooth functions, Extension theorems, Imbedding theorems, compactness theorem, Dual spaces, fractional order spaces, trace spaces, trace theory.

Unit-IV

Weak solutions of elliptic boundary value problems: Some abstract variational problems, examples of elliptic boundary value problems, Regularity of weak solutions, Examples of Galerkin method, Maximum Principles, eigenvalue problems, Introduction to Finite element methods.

Recommended Books:

1. S. Kesavan: Topics in Functional Analysis and Applications, New Age Publishers (P) Limited; 2003. Chap-1,2, and 3.