

# Ph.D., MATHEMATICS

## COURSE WORK SYLLABUS

(w.e.f. 2021)



DEPARTMENT OF MATHEMATICS

The Gandhigram Rural Institute – Deemed to be University

Gandhigram-624 302 Tamilnadu

DEPARTMENT OF MATHEMATICS

Ph.D., COURSE WORK

(BOARD OF STUDIES MEETING HELD ON 18.01.2021)

Sl. No.	Items	Credits
1.	Research Methodology	4
2.	Basic Concepts and Theory in the Subject Area : Basic Concepts in Mathematics	4
3.	Specific area of research / Area of Specialization	4
4.	Research and Publication Ethics	2

**UNIT- I**

**Research Methodology: An introduction:** Meaning of Research – Objectives of Research – Motivation in Research –Types of Research – Research Approaches – Significance of Research– Research Methods versus Methodology– Research and Scientific Method – Importance of Knowing How Research is Done – Research Process – Criteria of Good Research – Problems Encountered by Researchers in India. **Interpretation and Report Writing:** Meaning of Interpretation – Why Interpretation – Technique of Interpretation – Precaution in Interpretation – Significance of Report Writing – Different Steps in Writing Report – Layout of the Research Report – Types of Reports – Oral Presentation – Mechanics of Writing a Research Report – Precautions for Writing Research Reports–Conclusions.

**UNIT- II**

**Compact Operators:** Some characterizations – Space of compact operators – Further properties.

**UNIT- III**

**Spectral Results for Banach Space Operators:** Eigen spectrum and approximate Eigen spectrum. **Spectrum and Resolvent Set:** Spectral radius – Spectral mapping theorem.

**UNIT- IV**

**Modules:** Definitions and Examples -Direct Sums- Free Modules- Vector Spaces- Some Pathologies- Quotient Modules- Homomorphisms- Simple Modules- Modules over P I D's

**UNIT- V**

**ODE with Constant Coefficients:** Introduction– Properties of the Exponential of a Matrix – Non homogeneous Systems –Structure of the Solution Space: A Special Case – The General Case – Some Examples– Real Solutions – The Jordan Canonical Form of a Matrix – The Behavior of Solutions of Large  $t$ – Higher-Order Equations.

**TEXT BOOKS:**

1. C.R. Kothari, “**Research Methodology: Methods & Techniques**”, New Age International Publishers, 2004.  
**Unit I**– Chapters 1 and 14.
2. M. Thamban Nair, **Functional Analysis-** A First Course, Prentice Hall of India Private Limited, New Delhi, 2008.  
**Units II**–Chapter 9 (Section 9.1 to 9.3)  
**Unit III** – Chapter 10 (Section 10.1 to 10.2.2)
3. C. Musili, “**Introduction to rings and modules**”, 2<sup>nd</sup> revised edition, Narosa Publishing House Pvt. Ltd, New Delhi, 1994.  
**Unit IV**– Chapter 5 (Section 5.1-5.9).
4. Earl A. Coddington and Robert Carlson, “**Linear ordinary differential equations**”, Society for Industrial and Applied Mathematics, 2013.  
**Unit V**– Chapters 3 (Section 3.1 to 3.7).

## REFERENCES

1. C. Goffman and G. Pedrick, **First Course in Functional Analysis**, Prentice-Hall of India, New Delhi, 1995.
2. David S. Dummit and Richard M, Foote, **Abstract Algebra**, Third Edition, John Wiley & Sons, Inc. , 2004.
3. H. Anton and C. Rorres, **Elementary Linear Algebra: Applications Version**, John Wiley, New York, 1994.
4. Earl A Coddington and N. Leviston, **Theory of Ordinary Differential Equations**, McGraw-Hill, New York, 1992.

### UNIT I

**Structure of Bilinear Forms:** Preliminaries, Orthogonal Sums – Quadratic Maps- Symmetric Forms, Orthogonal Bases – Symmetric Forms over Ordered Fields- Hermitian Forms- The Spectral Theorem (Hermitian Case) – The Spectral Theorem (Symmetric Case)

### UNIT II

**Convex Sets and Convex Cones:** Introduction and Preliminary Definitions – Convex Sets and their Properties – Convex Hulls – Separation and Support of Convex Sets – Convex Polyhedra – Convex Cones.

**Convex and Concave Functions:** Definitions and Basic Properties – Differentiable Convex Functions – Generalization of Convex Functions.

### UNIT III

**Graph Theory:** Introduction – Basic Concepts – Subgraphs – Degrees of Vertices – Paths and Connectedness – Automorphism of Simple Graph – Line Graphs – Operations on Graphs Trees: Definition, Characterization and Simple Properties– Centers and Centroids – Counting the Number of Spanning Trees – Cayley’s Formula. Independent Sets and Matchings: Vertex Independent Sets and Vertex Covering – Edge-Independent Sets.

### UNIT IV

**Nonlinear Systems: Local Theory:** Some Preliminary Concepts and Definitions – The Fundamental Existence-Uniqueness Theorem – Dependence on Initial conditions and Parameters – The Maximal Interval of Existence – The Flow Defined by a Differential Equation.

### UNIT V

**Nonlinear Systems: Local Theory:** Linearization – The Stable Manifold Theorem – The Hartman-Grobman Theorem – Stability and Liapunov Functions- Saddles, Nodes, Foci and Centers.

### TEXT BOOKS

1. Serge Lang, “**Algebra**”, Springer-Verlag, New York, 2002.  
**Unit I** – Chapter XV (Sections 1-7)
2. S MSinha, “**Mathematical Programming- Theory and Methods**” 1<sup>st</sup> Edition, Elsevier, a division of Reed Elsevier India Pvt.Ltd., 2006.  
**Unit II** - Chapters 8 and 9 (Sections 8.1 to 9.3)
3. R. Balakrishnan and K. Ranganathan, “**A text book of graph theory**”, Springer-Verlag New York, Springer International Edition, 2000.  
**Unit III** – Chapter -1 (Sections 1.0 to 1.7), Chapter -4 (Section 4.0 to 4.4), Chapter -5 (Sections 5.0 to 5.2)
4. Perko, L. “**Differential equations and dynamical systems**” 3<sup>rd</sup> Edition, Springer-Verlag New York, 2013.  
**Unit IV** –Chapter 2 (Sections 2.1 to 2.5)  
**Unit V** –Chapter 2 (Sections 2.6 to 2.10)

## REFERENCES

1. Micheal Artin, **Algebra**, Prentice Hall, New Jersey, 1991.
2. Narsingh Deo, **Graph Theory with Applications to Engineering and Computer Science**, Eastern Economy Edition, PHI Learning Pvt. Ltd, Delhi, 2016.
3. A. K. Nandakumaran, P. S. Datti, and Raju K. George, **Ordinary Differential Equations: Principles and Applications**, Cambridge University Press, 2017.
4. D A Sanchez, **Ordinary Differential Equations and Stability Theory: An Introduction**, W H Freeman and Company, San Francisco 1968.

Core Course  
21MATH0103

SPECIFIC AREA OF RESEARCH /  
AREA OF SPECIALIZATION

Credits: 4

The course on Area of Specialization of the candidate shall be decided by the Doctoral Committee meeting as per Ph.D. regulation (from July 2020 session), vide item: 6.1.

Core Course  
21MATH0104

RESEARCH AND PUBLICATION ETHICS

Credits: 4

## **THEORY**

### **REP 01**

**PHILOSOPHY AND ETHICS:** Introduction to philosophy: definition, nature and scope, concept, branches – Ethics: definition, moral philosophy, nature of moral judgments and reactions.

### **REP 02**

**SCIENTIFIC CONDUCT:** Ethics with respect to science and research – Intellectual honesty and research integrity – Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP) – Redundant publications: duplicate and overlapping publications, salami slicing – Selective reporting and misrepresentation of data.

### **REP 03**

**PUBLICATION ETHICS :** Publication ethics: definition, introduction and importance – Best practices I standards setting initiatives and guidelines: COPE, WAME, etc. – Conflicts of interest – Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types – Violation of publication ethics, authorship and contributor ship – Identification of publication misconduct, complaints and appeals – Predatory publishers and journals.

## **PRACTICE**

### **REP 04**

**OPEN ACCESS PUBLISIDNG:** Open access publications and initiatives – SHERPA/RoMEO online resource to check publisher copy right & self-archiving policies – Software tool to identify predatory publications developed by SPPU – Journal finder/ journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

### **REP 05**

#### **A. Group Discussions (2hrs.)**

Subject specific ethical issues, FFP, authorship – Conflicts of interest – 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.

## REP 06

### DATABASES AND RESEARCH METRICS

#### A. Databases (4hrs.)

Indexing databases – Citation databases: Web of Science, Scopus, etc.

#### B. Research Metrics (3hrs.)

Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score –  
Metrics: h-index, gindex, i10index, altmetrics.

## References

1. Bird, A. (2006). *Philosophy of Science*. Routledge.
2. MacIntyre, Alasdair (1967) *A Short History of Ethics*. London.
3. P. Chaddah, (2018) *Ethics in Competitive Research: Don't get scooped; don't get plagiarized*, ISBN: 978-9387480865
4. National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). *On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition*. National Academies Press.

## Course structure

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

Modules	Unit Title	Teaching hours
<b>Theory</b>		
RPE 01	Philosophy and Ethics	4
RPE 02	Scientific Conduct	4
RPE 03	Publication Ethics	7
<b>Practice</b>		
RPE 04	Open Access Publishing	4
RPE 05	Publication Misconduct	4
RPE 06	Databases and Research Metrics	7
	<b>Total</b>	<b>30</b>