Curriculum Structure for Course-Work at PhD

Sr. No.	Title of the course	Units/ Modules	Credits	Contact hours/week	Examination	
					Internal Assessment Marks	UoP Assessment Marks
1.	**Research Methodology**	*05*	*05*	*05*	*50 (Continuous Evaluation)*	*100 (ESE)*
2	**Seminar**	--	*05*	*05*	*150* *(50 –Continuous Evaluation; 100-ESE)*	--
3-a.	**Mathematics for Engineering Research**	*02*	*04*	*04*	*150* *(50 –Continuous Evaluation; 100-ESE)*	--
3-b	**Advances in Domain Specific Engineering Research eg. Advances in Mechanical Engineering**	*03*	*06*	*06*		
	Total	**10**	**20**	**20**	**450**	

Important Comments:

- Combined passing for the courses 2 and 3 considering Continuous & End-Sem. Evaluation together and Internal & external evaluation together for course 1.

- **Grade structure:**
  Score in each subject 50% and above --- P (Pass) grade
  Score below 50% --- F (Fail) grade
  Absent for examination due to any reason --- I (Incomplete) grade
  Detained for short of attendance --- (FX) grade

- The course on "Research Methodology" shall be instructed and continuously assessed internally (at the Research Centre) for 50 marks and remaining 100 marks assessment shall be based on the candidate's performance in the question paper set at University end.

- The candidate shall deliver a seminar, i. e. Course no: 2 in the form of presentation, TWICE during the course-work, before a research committee comprising necessarily of the Guide and ONE other domain expert nominated by Head of the Research center.

- The course no: 3-a shall be instructed by expert faculty across various engineering disciplines from within the research centre, unit-wise.. Due guidance should be sought from Mathematics faculty as and when required.

- The course no: 3-b shall be instructed by domain specific expert faculty from within the department, inclusive of the research guide of the candidate/s.

- The courses 3-a and 3-b shall be continuously and completely assessed internally (at the Research Center) for 100% weightage, by the concerned teachers/guide engaged in instruction of the units.

- For continuous internal assessment, TWO class tests of 25 marks each should be conducted preferably.

Course 1: Research Methodology

Objectives

- Learn to focus on a research problem using scientific methods
- Learn methods to devise and design an experimentation set-up
- Learn basic instrumentation and data collection methods
- Learn parameter estimation and related modelling methods

Unit 1: Research Problem

Meaning of research problem
Sources of research problem
Criteria / Characteristics of a good research problem
Errors in selecting a research problem
Scope and objectives of research problem

Unit 2: Basic instrumentation

Instrumentation schemes
Static and dynamic characteristics of instruments used in experimental set up
Performance under flow or motion conditions
Data collection using a digital computer system
Linear scaling for receiver and fidelity of instrument
Role of DSP is collected data contains noise

Unit 3:Applied statistics

Regression analysis
Parameter estimation
Multivariate statistics
Principal component analysis
Moments and response curve methods
State vector machines and uncertainty analysis

Unit 4:Modelling and prediction of performance

Setting up a computing model to predict performance of experimental system
Multi-scale modelling and verifying performance of process system
Nonlinear analysis of system and asymptotic analysis
Verifying if assumptions hold true for a given apparatus setup
Plotting family of performance curves to study trends and tendencies
Sensitivity theory and applications

Unit 5: Developing a Research Proposal

Format of research proposal
Individual research proposal
Institutional proposal

Proposal of a student – a presentation and assessment by a review committee consisting of Guide and external expert only. Other faculty members may attend and give suggestions relevant to topic of research.

Reference Books

1. 'Research methodology: an introduction for science & engineering students', by Stuart Melville and Wayne Goddard
2. 'Research Methodology: An Introduction' by Wayne Goddard and Stuart Melville
3. 'Research Methodology: A Step by Step Guide for Beginners', by Ranjit Kumar, 2nd Edition
4. 'Research Methodology: Methods and Trends', by Dr. C. R. Kothari
5. 'Operational Research' by Dr. S.D. Sharma, Kedar Nath Ram Nath & co.
6. Software Engineering by Pressman

Course 2: **Seminar**

1: Formulating Problem Statement

Overview of research process: Formulating the Research Problem, Extensive Literature Review, Developing the objectives, preparing the Research Design including Sample Design, Collecting the Data, Analysis of Data, Generalization and Interpretation, Preparation of the Report or Presentation of Results-Formal write-ups of conclusions reached.

Problem statement – Conditions and steps in selecting a research problem, Understanding the Key research area of interest, How to get new ideas (Criticizing a paper), Finding a good problem: Top-down and Bottom-up approach, Creative thinking techniques, Coming up with a problem statement

Defining objectives – How to find objectives, characteristics of objectives

2: Literature survey

Overview – What is literature survey, Functions of literature survey, maintaining a notebook, developing a Bibliography

Methods of data collection – Observation, survey, contact methods, experimental, determining sample design

Searching for publications – Publication databases, search engines and patent databases, Find some/all of the references for a given paper, including those that are not on the web,

Online tools – google, CiteSeer, ACM Digital Library, IEEE, The on-line Computer Science bibliography, Survey papers, Finding material not on the web, Searching patents

3: How to study a scientific paper

Summarizing paper – Reading abstracts and finding ideas, conclusion, Advantages of their approach, the drawbacks of the papers (What is lacking – can be found in the sections such as future work) Generalize results from a research paper to related research problems

Comparing the approach - Identify weaknesses and strengths in recent research articles in the subject

4: Publishing a paper

How to write scientific paper - Structure of a conference and journal paper, how (and How Not) to write a Good Systems Paper: Abstract writing, chapter writing, discussion, conclusion, references, bibliography, and In-class discussion of technical writing examples

Poster papers, review papers, how to organize thesis/ Project report, How to write a research proposal? How research is funded?

Research ethics – Legal issues, copyright, plagiarism

General advice about writing technical papers in English - Tips for writing correct English

5: How to present scientific paper

Talk structure, basic presentations skills

Documentation and presentation tools – LATEX, Microsoft office, PowerPoint and SLITHY

Reference Books:

Lecture Notes and presentations

Course 3-a: Mathematics for Engineering Research

Note: Each Unit is of 2 credits. A candidate has to take any *two* units (4 credits)

Unit 1: Linear algebra: Linear system solution: full and sparse matrices, least squares solution, Eigenvalues

Reference Books:

- I. S. Sokolnikiff, "Mathematical Methods of Physics and Engineering", McGraw Hill
- Murray R. Spiegel, "Advanced Mathematics for engineers and scientist", Schaum's out line series, McGraw Hill Intl Co., New Delhi.

Unit 2: System of nonlinear equations: Newton (and related) methods, Limiters

Reference Books:

- I. S. Sokolnikiff, "Mathematical Methods of Physics and Engineering", McGraw Hill
- Murray R. Spiegel, 'Advanced Mathematics for engineers and scientist', Schaum's out line series, McGraw Hill International Book Co., New Delhi.

Unit 3: Dynamical System: Analytical and numerical solutions, Stability of numerical methods, Dynamical system stability

Reference Books

- I. S. Sokolnikiff, "Mathematical Methods of Physics and Engineering", McGraw Hill
- Erwin Kreyszig, 'Advanced Engineering Mathematics', John Wiley and sons Inc., 8th Edition, 2003.

Unit 4: Partial differential equations I: Elliptic systems, Solution methods, multi grid and other efficient algorithms

Reference Books

- Numerical Partial differential equations: finite difference methods, J W Thomas, Springer
- Mathematical Methods of Physics and Engineering, I. S. Sokolnikiff, McGraw Hill

Unit 5: Partial differential equations II: Parabolic and Hyperbolic systems, 1-d and 2-d solution methods, stability analysis

Reference Books

- I. S. Sokolnikiff, "Mathematical Methods of Physics and Engineering", McGraw Hill
- J W Thomas, "Numerical Partial differential equations: finite difference methods", Springer

Unit 6: Complex Analysis: Integration in the complex plane, residues, improper integral evaluation

Reference Books

- Serge Lang, Complex Analysis, Springer Verlag

Unit 7: Transform Techniques: Laplace, Fourier transforms, FFT, z-transforms, Other linear transforms, Applications, Karhunen-Loeve transforms, System analysis in transform domain,

Reference Books

- N. Sneddon: The use of Integral Transform, McGraw Hill, New York 1972.
- L Debnath: Integral Transforms and their Applications CRC Press, Inc. 2nd Ed. R.

Unit 8: Optimisation: Linear systems with constraints, unconstrained nonlinear systems constrained nonlinear cases

Reference Books

- Jorge Nocedal and Stephen Wright; Numerical Optimization, Springer, 2nd edition, (2006)
- S. S. Rao; Engineering Optimization: Theory and Practice, Wiley, 4th edition, (2009)

Unit 9: Stochastic Processes: Games theory, Probability, Reliability and Random numbers, CDF and PDF, Random processes, Moments, Models of random processes.

Reference Books

- Kishor S. Trivedi, Probability and Statistic with Reliability, Queuing and computer Science Applications, Prentice-Hall of India.

Unit 10: Soft Computing: Genetic Algorithms, Fuzzy Logic, Neural Networks, Tabu Search, Simulated Annealing, Swarm Intelligence, Hyper Heuristics, Support Vector Machines

Reference Books

- Jorge Nocedal and Stephen Wright, "Numerical Optimization", Springer, 2nd edition, (2006)
- S. S. Rao, "Engineering Optimization: Theory and Practice", Wiley, 4th edition, (2009)
- Edmund Burke and Graham Kendall (Ed.), "Search Methodologies: Introductory tutorials in optimization and decision support systems", Springer, 2005.

Unit 11: Signal Detection and Estimation: Signal Detection and Estimation, Mathematical Modelling and analysis of various filters

Unit 12: Switching and Queuing Theory: Various models, Design requirements and issues, transmission techniques, media, switching theory, performance issues

Unit 13: Joint Time-Frequency Analysis: Wavelet transforms and its variants, analysis, limitations, applications, multi-resolution theory, Wigner-Viley distribution, Time series analysis and applications.

Unit 14: Computational Wave Theory: Maxwell equations, Poynting vector, wave types, interface conditions, orthogonality, hybrid computational methods, method of moments, low and high frequency applications

Unit 15: Finite Differences and Interpolation

Differences of polynomial, Factorial Notation
Newton's Interpolation Formulae, Interpolation with unequal intervals.
Numerical differentiation, Numerical integration.

Reference Books

- :Higher Engineering Mathematics.-by Dr B.S Grewal, Khanna Publishers.
- Advanced Engineering Mathematics. - by C.Ray Wylie, L.C.Burret International Students Edition
- Advanced Engineering Mathematics. -by Erwin Kreyszig, 8th Edition Wilay Students Edition.

Unit 16: Numerical Solutions of Ordinary Differential Equations:

Taylor Series Method, Euler's method, Modified Euler's method
Runge's Method, Runge Kutta method, Predictor -Corrector methods. Simultaneous first order differential equations. Applications to Engineering problems.

Reference Books:

- Numerical methods for Engineers -by S.C Chapra, R.P.Canale 3rd Edition Mc Graw Hill Publishers.
- Introductory Methods of Numerical Analysis - by S.S Sastry Prentice Hall of India
- Numerical Methods by Balguruswamy. Published by Tata. Mc Graw Hill

- Numerical Solutions of Partial Differential Equations:

Unit 17: Difference Equations , Solutions of difference equations. Finite difference approximations to partial derivatives. Finite difference method of finding solution of one dimensional heat equation, two dimensional heat equation and wave equation. Solutions of Laplace and Poisson equation.

Reference Books

- Numerical methods for Engineers-by S.C Chapra, R.P.Canale 3rd Edition Mc Graw Hill Publishers.
- Numerical Methods - by Dr.B.S.Grewal Khanna Publishers
- Advanced Engineering Mathematics. -by Erwin Kreyszig, 8th Edition Wilay Students Edition.

Unit 18: .Statistical Quality Control and Stochastic Processes: Control charts: $\tilde{X}$ Chart,R-Chart,P-chart and np charts etc. Markov process, Markov chain, Stochastic differential equations. Applications to physical problems.

Reference Books

- Advanced Methods of Mathematical Physics -by R S.Kaushal and D.Parashar, Narosa Publishing House
- Advanced Engineering Mathematics. -by Erwin Kreyszig, 8th Edition Wiley Students Edition.

Unit 19: Matrices :

Definitions of various types of matrices, Elementary matrix transformations linear transformation formations .Orthogonal trans formation. Eigen values and Eigen vectors. Problems orizing from Markov's stochastic process. Numerical method for finding Eigen value and Eigen vectors and applications to mass spring problems and coupled masses. Applications of matrices for finite element methods

Reference Books

- Applied Mathematics for Engineers and physicists by Pipes and Harvill International students edition.
- The finite Element method 3rd edition , -by O.C.Zienkiewicz, Tata Mc Graw Hill

- Advanced Engineering Mathematics. -by Erwin Kreyszig, 8th Edition, Wilay Students Edition.

Assignments:

- Each unit will have at least 1 assignment.
- Programming assignments will be based on engineering problems