

Pre-Ph.D. Course: Paper I Research Methodology

1. UNIT I

What is research?, Research methods and research methodology, Basic and Applied Research, Selection of a research topic, Literature Survey, Internet as a medium of research, Reference Collection, Assessing the current status, Hypothesis, Mode of approach, Actual Investigation - experiment, analysis and results; theoretical research, critical thinking, investigation, survey, *ab initio*, semi-empirical, empirical search; Inquiry, Quest, Exploration, innovation (innovative ideas), Discovery and Invention in science; knowledge and creativity, Presenting a scientific seminar-oral report, Art of writing a research paper and thesis, Outline of a report, Layout of a research report/ PhD thesis, Documentation in Latex, Quality of research, quantitative measurement by Impact factor, h-index, Scientometry, etc.

Ethics in Research, Awareness about Guidelines of Research Ethics of Goa University,

What is plagiarism? Intent versus consequences, taking good notes, Citations and Acknowledgements, Using quotes, Paraphrasing.

2. UNIT II

Uncertainties in Measurements: Measuring Errors, Uncertainties, Parent and Sample Distributions, Mean and Standard Deviation of Distributions, Binomial Distributions, Poisson Distribution, Gaussian or Normal Error Distribution, Lorentzian Distribution; Approximation and Errors in Computing: Significant Digits, Numerical Errors, Modelling errors, Conditioning and Stability, Convergence of Iterative Processes.

Error Analysis: Instrumental and Statistical Uncertainties, Propagation of Errors, Application of Error Equations, method of Least squares, Statistical Fluctuations, Probability Tests, χ^2 Test of a distribution.

Curve fitting (Regression Analysis); Least square Fit to a Straight line, error estimation of the fitted parameters, limitations of the least square method, Least squares fit to a polynomial, matrix solution, Goodness of a fit, Linear Correlation Coefficient, Multivariable Correlations.

3. UNIT III (For Experimental students)

1. Methods of Material Preparation:

Crystal Growth, Single Crystal, Zone melting, Epitaxy, Compaction and Sintering, Methods of quenching, Sol-gel process, Deposition technique, Chemical Analysis.

2. Vacuum Techniques:

Production and Measurement of Vacuum, Different types of Vacuum Systems and Guages, their Working and limitations, Leak Detection

3. Methods of Characterization:

X-ray Diffraction, Raman, IR, Ultraviolet, Mossbauer Spectroscopies, Transport and Magnetic Measurement Techniques, Scanning and Transmission Electron Microscopy, Differential Scanning Calorimetry, etc. – Principles and Applications

4. UNIT III (For Theory students)

1. Computer Programming and Numerical Techniques:

C/Fortran/Python Programming, Finite Differential Calculus, Interpolation and Extrapolation, Roots of Equations, Solution of Simultaneous Linear Algebraic Equation, Linear and Non Linear Least squares, Curve fitting, Numerical Differentiation and Integration, Fourier Transform Techniques, Numerical solution of Ordinary Differential Equations, Matrix Eigen value problem, Monte Carlo and Maximum Entropy method.

References

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8. Fundamentals of Vacuum Technology, A. Pipko, V. Pliskovsky, B. N. Korolev, Mir Publishers, Moscow (1984)
9. Thin Film Technology and Applications, K. L. Chopra, Tata McGraw-Hill, New Delhi (1985)
10. An Introduction to Electron Microscopy Instrumentation, Imaging and Preparation, Andres Kaech (reading material)
11. Fundamentals of Molecular Spectroscopy, C. Banwell and E. M. McCash, Tata McGraw-Hill, New Delhi, (2000)
12. Numerical Recipes in C, C. W. Press, S. A. Teukolsky, W. T. Vetterling and B. P. Flannery, Cambridge University Press (2008)
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