DEPARTMENT OF ELECTRONIC SCIENCE

University of Delhi South Campus

New Delhi 110021

Ph.D. COURSE WORK

February 2016

The Department of Electronic Science is offering the following three courses to students admitted for the Ph.D. Programme in Electronic Science.:

1. Research Methodology (ES-1)
2. Mathematical and Computational Techniques (ES-2)
3. Measurement and Characterization Techniques (ES-3)

The students admitted to the Ph.D. Programme in Electronic Science have to take a minimum of THREE papers. Course no. ES-1, Research Methodology is compulsory for all students. In addition the students have to take two additional papers which may be the two papers offered by the Department or from papers floated for Ph.D. Course work by other Departments of the Faculty of Interdisciplinary and Applied Sciences. However, students who have completed an M.Tech. or M.Phil. degree before joining the Ph.D. Programme will be required to take only the compulsory course ES-1, Research Methodology. Students can however opt to take more papers.

The courses have been specifically designed for the doctoral programme and cater to the requirements of all research areas offered by the Department.

The detailed syllabus and marking schemes for the courses is appended.

ES – 1 Research Methodology

Marks-100

UNIT 1

Introduction: Introduction and definition of Research. Classification of research- Experimental and Theoretical, Fundamental and Applied, Quantitative and Qualitative.Motivation for research. Research Methodology - definition of Problem, aim and objectives, historical background of investigation, issues and concerns related to scientific investigation.

Literature Review: Introduction to Peer-reviewed and Open access Journals, e-Journals and e-books,Reviews and Monographs. Impact factor of a Journal, h-index, i10-index.

Various tools for Literature review: Idea about print and digital resources,Common E-search engines for literature, Scopus, HEP-spires, Google Scholar, Scirus, SciFinder. Search for publications related to institutes/society (APS, AIP, IOP, IEEE, OSA, IEE etc.) or publishers (Elsevier-Science direct, etc.).

UNIT 2:

Measurements and Analysis: Designing an experiment, generation and recording of data. Numbers, units, abbreviations and nomenclature used in scientific writing.Accuracy and precision.Significant figures.

Error and uncertainty analysis: Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square).Correlation and regression. Least square curve fitting, spline fitting, Gaussian distribution.

Graphical Representation: Introduction to software for drawing and analysis of graphical representation of data like MS-Excel, ORIGIN, etc. Incorporation of error bars in graphs.

UNIT 3:

Scientific Writing: Art of scientific writing and presentation. Writing references. Research and scientific writing ethics- Importance, basic principle, issues of authorship (in a group or collaborative work), plagiarism, conflict of interest, research misconduct.

Intellectual Property: Introduction to intellectual property, patent, copyright, definition of invention and discovery, idea about patentability, importance of academia-industry interaction, marketing of research outcome.

Presentation: Preparation of Power point scientific presentation and Poster presentation.

UNIT 4:

MATLAB or other related software: Problem solving based on MATLAB or any other related Software.

This Course can be taken in self - study mode

MATLAB problems to be decided by the faculty involved in the course.

Examination mode: Internal Assessment: 20 Marks
Final Examination : 50 Marks
Presentations : 30 Marks

Suggested Reading:

1. Research Methodology: Methods and Techniques, C. R. Kothari and G. Gaurav, New Age International (2014).
2. Getting Started with MATLAB 7, RudraPratap, Oxford University Press (2006)

ES – 2 Measurement and Characterization Techniques

Marks-100

Unit I

Semiconductors: Inorganic and Organic, Crystalline, Polycrystalline, Amorphous, Polymers.
Defects: Surface Defects, Deep Defects, Oxide and Interface traps.
Basic Parameters: Energy Bands, Resistivity, Carrier Doping Density, Mobility, Carrier Lifetime, Contact Resistance, Series Resistance.
Heterojunctions and Nanostructures: Heterojunctions in devices, Quantum well and Superlattice structures, Quantum dots, Nano-tubes and Nano-rods etc.
Vacuum Techniques: Vacuum pumps (Rotary, Diffusion, Turbo molecular, Getter, Cryogenic and Ion pumps), Design of vacuum systems, Vacuum measurement system, Control system, Leak detection.

Unit 2

Elementary ideas of Material Synthesis: Physical Vapor deposition, Chemical Vapor Deposition, Spin Coating.
Structural/Morphological Characterization: X-Ray Diffraction (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Atomic Force Microscope (AFM), Scanning Tunneling Microscope (STM).
Spectral Characterization Techniques: UV-Vis Spectroscopy, Fourier Transform Spectroscopy (FTIR), Photoluminescence (PL), Raman Spectroscopy.
Electrical Characterization: Four-Point Probe, I-V characteristics of devices, C-V plots, Hall Effect.

Unit 3

Electromagnetic Waves: Electromagnetic spectrum, RF and Microwave region and band designations, applications of RF and Microwaves.
Basic Transmission Line parameters: Lumped and distributed circuits, Transmission lines - propagation characteristics, reflection coefficient, VSWR, power, return loss, insertion loss, scattering parameters.
Guided Waves and Antenna: Rectangular waveguides and planar transmission lines for microwaves. Introduction to radiation, Antenna parameters – radiation pattern, gain, directivity, beamwidth, antenna efficiency, polarization etc.

Unit 4

Microwave Sources: Klystron - velocity modulation and bunching, output power and beam loading. Gunn Diode - Gunn effect, negative differential resistance, Gunn oscillation modes. IMPATT diode - impact ionization and transit time delay
Characterization Techniques at Microwave Frequencies: Microwave test bench components and measurements, principles of time-domain and frequency domain, broadband measurements of one-port and two port components, network analyzer - scalar and vector, spectrum analyzer. Antenna measurements - radiation pattern (E-plane, H-plane), beamwidth and gain of antenna.

Course can be taken by a group of faculty
There will be lab visit/demonstration component decided by the faculty involved in teaching
Examination mode: Internal Assessment: 20 Marks
Final Examination: 50 Marks
Laboratory Component: 30 Marks

Suggested Reading:

1. Physics of Semiconductor Devices, S. M. Sze and Kwok K. Ng, Wiley (2013).
2. Semiconductor Material and Device Characterization, Dieter K. Schroder, John Wiley & Sons inc. (1998)
3. Microwave Devices and Circuits, Samuel Y. Liao, Pearson.
4. Microwave Engineering, David M. Pozar, Kulkarni, Wiley (2012).
5. Antennas for all Applications, J. D. Kraus, R. J. Marhefka and A. S. Khan, McGraw Hill (2006)
6. Basic Microwave Techniques and Laboratory Manual, M. L. Sisodia and G. S. Raghuvanshi, New Age International (2011)

ES – 3 Mathematical and Computational Techniques

Marks-100

Unit 1

Numerical Methods in General: Introduction, Floating-Point form of numbers, Round-off, Stability of algorithms, Errors.
Solutions of Equations f(x)=0 by Iteration: Fixed point iteration, Bisection method, Newton-Raphson method, Secant method.
Interpolation: Lagrange interpolation, Newton's divided differences interpolation, Splines.
Numerical Integration and Differentiation: Trapezoidal rule, Simpson's rule, Gauss integration formulas, Numerical differentiation formulas.

Unit 2

Ordinary Differential Equations: Introduction to first order, second order, homogeneous, non-homogeneous equations, system of equations.
Orthogonal Functions in Mathematical Physics and Engineering: Bessel Functions, Spherical Bessel Functions, Legendre Polynomials, Associated Legendre Polynomials, Hermite Polynomials, Laguerre Polynomials, Associated Laguerre Polynomials, Chebyshev Polynomials – differential equations and orthogonality.
Numerical Methods for Differential Equations: First order equations – Euler-Cauchy method, Runga Kutta methods, Methods for higher order equations and system of equations.

Unit 3

Solution of linear system of equations: Elimination methods – Gauss' method, Cholesky method. Iterative methods – Jacobi's method, Gauss Seidel method, Relaxation, Over-Relaxation method. Curve fitting.
Matrix Eigenvalue Problems: Power Method, Jacobi's method.

Unit 4

Partial Differential Equations: Classification of partial differential equations. Homogeneous and non-homogeneous boundary conditions. Solutions by separation of variables and series expansion methods
Finite Difference Methods for Partial Differential Equations: Finite difference schemes in rectangular coordinates, Finite differencing of Parabolic partial differential equations – Diffusion equation, Finite differencing of Hyperbolic partial differential equations – Wave equation, Finite differencing for nonrectangular systems – cylindrical and spherical coordinates.
Variational Methods: Construction of functional from partial differential equations, Direct method – Rayleigh Ritz method, Indirect methods – collocation, Galerkin.

Course can be taken by a group of faculty
Examination mode: Internal Assessment: 50 Marks
Final Examination : 50 Marks

Suggested Reading:

1. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley (2010).
2. Numerical Techniques in Electromagnetics, Mattew N. O. Sadiku, CRC Press (2009).