SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE

PRE PHD COURSE WORK SYLLABUS

Under the

Faculty of Science and Technology

ELECTRONIC SCIENCE

TO BE IMPLEMENTED FROM JUNE 2020

Objectives of the Pre-Ph.D. Course:

1. To organize a path leading to successful research work in Electronic Science.

2. The intention is to introduce the candidate to

- the foundations of core mathematical modeling and research methodology,
- current trends in the rapidly evolving field and
- the intellectual and philosophical framework necessary to explore wide spectrum of research in design and development of systems in electronic science and prepare the student to start the Ph.D. research project.

STRUCTURE OF SYLLABUS

COURSE CODE	COURSES	COURSE NAME	CREDITS
	Course 1 (compulsory)	Research Methodology	04
	Course 2	Writing Research Proposals	01
		Writing Reviews	01
		Seminars	02
	Subject Specific Advanced Level Course(compulsory) Course 3	Subject 1. System Modeling and Product Design	02
		Subject 2. Characterization techniques and Instrumentation	02
		Subject 3. Signals and systems	02
	Course 3 Elective course	Subject 4. Electives are listed below	02
	Course 4 (compulsory)	Publication Ethics	02
	Total credits		**18**

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SUBJECT SPECIFIC ADVANCED LEVEL COURSE

Course 3: Subject 1: System Modeling and Product design

Credits: 02

UNIT 1: System modeling concepts:

Introduction to System Modeling and Simulation, Simulation Software Tools, Continuous, Discrete Event, Combined and other Modeling Techniques , The Modeling Process, Statistics of Simulation and Monte Carlo Analysis, Model Analysis, Validation and Verification, Current and Future Directions of Simulation for Complex Systems

UNIT 2: Basics of Product Design

Overview of Electronic Product Design, Top-Down and Bottom-Up Approach, Considering Power Supply Design as an example, Ergonomic and Aesthetics, Definition with Example, issues in Designing Electronic Products, Design of Controls and Display w.r.t. Ergonomic and Aesthetics Consideration.

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SUBJECT SPECIFIC ADVANCED LEVEL COURSE

Course 3: Subject 2: Characterization Techniques and Instrumentation

Credits: 02

UNIT 1: Material characterization Techniques

X-ray diffraction (XRD); Neutron diffraction – Reflection High energy electron Diffraction (RHEED), Low energy Electron Diffraction (LEED), Optical microscopy (OM), Transmission Electron Microscopy (TEM); Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Microanalysis (EDS), Rutherford backscattering spectrometry (RBS), Atomic force microscopy (AFM) and related scanning probe microscopy (SPM), Scanning Tunneling Microscopy (STM), UV-VIS spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy

Thermal, Magnetic and Electrical Characterization Techniques: Thermal Gravimetric Analysis (TGA), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC) and Differential Mechanical Analysis (DMA), Nuclear magnetic resonance (NMR) spectroscopy, Electron paramagnetic resonance (EPR) or electron spin resonance (ESR), Electrical resistivity in bulk and thin films, Hall effect, Magnetoresistance, Impedance spectroscopy

UNIT 2: Electronic Instrumentation Techniques

Electrocardiogram (ECG), The Electroencephalogram (EEG), Electrical Impedance Plethysmography/Pneumography, Pulse Oximetry, Optical Spectrum Analyzers, Optical Time-Domain Reflectometer (OTDR), Optical Power Meters, Optical Attenuators, Optical Spectrum Analyzers, Vector network analyser (VNA), Spectrum analyzer, lock in amplifier, LCR-Q meters, microwave power meter, Electrometer, Electrochemical Impedance Spectroscopy, Scanning Electrochemical Microscope, Impedance Analyzer,

Calibration: Electrical, Mechanical, Flow, Pressure, Temperature

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SUBJECT SPECIFIC ADVANCED LEVEL COURSE

Course 3: Subject 3: Signals and Systems

Credits: 02

UNIT-1 : Linear Time-Invariant (LTI) Systems

Introduction, Discrete-Time LTI Systems: Representation of Discrete-Time Signals in Terms of Impulses, convolution and correlation

Continuous-Time LTI Systems: The Convolution Integral, The Representation of CT Signals in Terms of Impulses,

Properties of LTI Systems-Invertibility, Causality and Stability, Impulse response of an LTI System,

Linear Constant-Coefficient Differential Equations and, Difference Equations,

Block Diagram Representations of First-Order Systems, Singularity Functions.

UNIT 2: Fourier and Z Transform

The Continuous-Time Fourier Transform (CTFT), Representation of Aperiodic Signals, Examples, Properties, Systems Characterized by Linear Constant-Coefficient Differential Equations. The Discrete-Time Fourier Transform (DTFT), Examples, Discrete Fourier Transform for Periodic Signals, Properties, The Magnitude-Phase Representation of the Fourier Transform, Systems Characterized by Linear Constant-Coefficient Difference Equations, application to various communication system analysis.

The Z-Transform, The Region of Convergence, The Inverse Z-Transform, Properties of the Z-Transform, Differentiation in the Z Domain, The Initial-Value Theorem, Analysis and Characterization of LTI Systems Using Z-Transforms, Causality, Stability, LTI Systems Characterized by Linear Constant-Coefficient Difference Equations

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ELECTRONIC SCIENCE

SUBJECT SPECIFIC ADVANCED LEVEL COURSE

Subject 4: Research Centre will offer minimum 2 elective courses from the following. Students can opt for any one out of these Elective Courses

Elective Subject number	**Title of the Elective Subject**	**Credits**
Elective 1:	Machine Intelligence (AI-ML)	2
Elective 2:	Battery Management System	2
Elective 3:	Internet of Things	2
Elective 4:	Wavelet Transforms and systems	2

Detailed Syllabus of Elective Subjects are as follows:

Elective 1: MACHINE INTELLIGENCE (AI-ML) 2 CREDITS

Unit 1: Introduction

Overview of Artificial Intelligence and Introduction to Computational Intelligence, Artificial Neural Networks – Artificial Neurons, Supervised and unsupervised learning, Radial Basis Networks, Reinforce learning

Unit 2: Artificial immune systems

Introduction, Genetic Algorithms, Evolutionary strategies, Differential Evolution, Cultural Algorithms, Co-evolution, Swarm Intelligence : Particle Swarm Optimization, Ant Colony Optimization, Bee Colony Optimization, Artificial immune systems (AIS): Natural Immune Systems, AIS Architecture, AIS models.

Elective 2: BATTERY MANAGEMENT SYSTEM 2 CREDITS

Unit 1: Basics of Battery Management System

Lithium-ion cell terminology, major functions provided by a battery-management system and their purpose - Identify the major components of a lithium-ion cell and their purpose - Understand how a battery-management system "measures" current, temperature, and isolation.

Functions of Battery Management Systems:

Identify electronic components that can provide protection and specify a minimum set of protections needed - Compute stored energy in a battery pack - List the manufacturing steps of different types of lithium-ion cells and possible failure modes.

Unit 2: Types of Battery Modelling:

Static modelling of battery: static model parameters of the battery, lab test to determine the parameters of battery model, static equivalent circuit determination.

Dynamic modelling of battery, parameters affecting the dynamic model, lab test to determine the dynamic model parameters, dynamic equivalent circuit determination.

Elective 3: INTERNET OF THINGS AND CLOUD COMPUTING 2 CREDITS

Unit 1: Introduction to Internet of Things

Introduction to IoT – IoT definition – Characteristics – IoT Complete Architectural Stack – IoT enabling Technologies – IoT Challenges.

Sensors and Hardware for IoT – Hardware Platforms – Arduino, Raspberry Pi, Node MCU. A Case study with any one of the boards and data acquisition from sensors.

Protocols for IoT – Infrastructure protocol (IPV4/V6/RPL), Identification (URIs), Transport (Wifi, Lifi, BLE), Discovery, Data Protocols, Device Management Protocols. – A Case Study with MQTT/CoAP usage-IoT privacy, security and vulnerability solutions.

Case studies with architectural analysis: IoT applications – Smart City – Smart Water – Smart Agriculture – Smart Energy – Smart Healthcare – Smart Transportation – Smart Retail – Smart waste management.

Unit 2: Cloud computing

Introduction to Cloud Computing – Service Model – Deployment Model- Virtualization Concepts – Cloud Platforms – Amazon AWS – Microsoft Azure – Google APIs.

IoT and the Cloud – Role of Cloud Computing in IoT – AWS Components – S3 – Lambda – AWS IoT Core -Connecting a web application to AWS IoT using MQTT- AWS IoT Examples. Security Concerns, Risk Issues, and Legal Aspects of Cloud Computing- Cloud Data Security.

Elective 4: WAVELET THEORY AND APPLICATIONS 2 CREDITS

Unit 1: Introduction Wavelet Transform

Wavelets from filters, Classes of wavelets: Haar, Daubechies, bi-orthogonal. Continuous Wavelet Transform Continuous wavelet transform (CWT), Time and frequency resolution of the continuous wavelet transform, Inverse continuous wavelet transform, Redundancy of CWT, Zoom property of the continuous wavelet transform, Filtering in continuous wavelet transform domain.

Discrete Wavelet Transform and Filter banks. Orthogonal and bi-orthogonal two-channel filter banks, Design of two-channel filter banks, Tree-structured filter banks, Non-linear approximation in the Wavelet domain, multi resolution analysis, Construction and Computation of the discrete wavelet transform, the redundant discrete wavelet transform. Multirate discrete time systems, Parameterization of discrete wavelets, , Two dimensional, wavelet transforms and Extensions to higher dimensions, wave packets

Unit 2: Applications Signal and Image compression

Detection of signal changes, analysis and classification of audio signals using CWT, Wavelet based signal de-noising and energy compaction, Wavelets in adaptive filtering, Adaptive wavelet techniques in signal acquisition, coding and lossy transmission, Digital Communication and Multicarrier Modulation, Trans multiplexers , Image fusion, Edge Detection and object isolation.
