PG Department of Computer Science & IT

University of Jammu

DETAILED SYLLABUS

FOR

Pre Ph.D. Course Work

PG Department of Computer Science & IT
University of Jammu

Pre – Ph.D. Course Work Syllabus

Paper – 1
Title: Research Methodology
Max Marks: 100

Credits - 04
Time: 3 Hrs

UNIT – 1: RESEARCH DESIGN

Research – Meaning, Philosophy, Ethics, Process, Types of Research – Exploratory, Conclusive
Scientific research – types and characteristics, Criteria for the selection of a research problem, Research proposal

Data collection methodology – Primary data collection methods, Measurement techniques, Characteristics – reliability, validity, etc.
Secondary data collection methods – Library research references, bibliography, abstract, etc.

UNIT – 2: HIGHER TECHNICAL EDUCATION: AN OVERVIEW

Growth of Engineering Colleges and Polytechnic Colleges and the problems associated

Roles and functions in development and quality assurance of Technical Education – AICTE, UGC, Universities, AICTE, NBA, NAAC, NKN, State Governments, Directorate of Technical Education, etc.

Analysis – Industry interaction, collaborative research, IPRs, present scenario, Entrepreneurship, Techno park, XII Five Year Plan for Higher and Technical Education

UNIT – 3: RESEARCH: EXPERIMENTAL DESIGN

Construct validity – Measurement, MTMM matrix, nomological network, pattern matching
Reliability – Theory and types

Experimental Design – Introduction, Completely Randomized Design, Randomized Complete Block Design, Latin Square Factorial Design, Analysis of Covariance, etc.

Quasi Experimental Design – Basic and types

UNIT – 4: STATISTICAL ANALYSIS THROUGH SPSS

SPSS – Introduction, basic steps of data analysis, SPSS environment – data files, main menu, toolbars, running an analysis, viewing results

Quantitative and qualitative analysis techniques – Hypothesis testing, chi-square, t-test, correlation and regression analysis, analysis of variance, choosing appropriate techniques

UNIT – 5: MATLAB – TECHNICAL COMPUTING AND SIMULATION

MATLAB

Introduction and Key Features
Exercises on:
Matrix Operations – Operations, Matrices from Matrices
Statements, Text Strings
Functions, Control Execution Flow, Functions – user defined, Library
Data Input and Output

Accessing, Analyzing and Visualizing Data – Reading different formats

SIMULATION TECHNIQUES

Introduction, Simulation Experimental setup
Exercise: Simulating the behavior of a complex system

SCHEME FOR PAPER SETTING

The question paper shall consist of Eight (8) long answer type questions covering the entire syllabus. The candidates are required to answer any Five (5) questions. Answer to each question should not exceed 500 words. Each question shall be of 20 marks.

(5 x 20 = 100 marks)

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Pre – Ph.D. Course Work Syllabus

Paper - 2
Title: Research and Publication Ethics
Max Marks: 50

Credits - 02
Time: 2 Hrs

Overview

- This course has total 6 units focusing on basics of philosophy of science and ethics, research integrity, publication ethics. Hands-on-sessions are designed to identify research misconduct and predatory publications. Indexing and citation databases, open access publications, research metrics (citations, h-index, Impact Factor, etc.) and plagiarism tools will be introduced in this course.

Course Structure

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

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

Syllabus in Detail

THEORY

- **RPE 01: PHILOSOPHY AND ETHICS**

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgements and reactions

- **RPE 02: SCIENTIFIC CONDUCT**

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

- **RPE 03: PUBLICATION ETHICS**

1. Publication ethics: definition, introduction and importance
2. Best practices / standards setting initiatives and guidelines: COPE, WA-ME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

PRACTICE

- **RPE 04: OPEN ACCESS PUBLISHING**

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

- **RPE 05: PUBLICATION MISCONDUCT**

A. Group Discussions

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools

Use of plagiarism software like Turnitin, Urkund and other open source software tools

- **RPE 06: DATABASES AND RESEARCH METRICS**

A. Databases
   1. Indexing databases
   2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics
   1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
   2. Metrics: h-, i10 index, altmetrics

SCHEME FOR PAPER SETTING

The question paper shall consist of Eight (8) long answer type questions covering the entire syllabus. The candidates are required to answer any Five (5) questions. Answer to each question should not exceed 300 words. Each question shall be of 10 marks. (5 x 10 = 50 marks)

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Pre – Ph.D. Course Work Syllabus

Paper – 3
Specialization Course:
Title: Machine Learning and Computing
Max Marks: 150

Credits - 06
Time: 03 Hrs

Objective of the Course:

To provide a comprehensive understanding of core machine learning concepts, algorithms, optimization strategies, and advanced computing paradigms, with a special emphasis on Large Language Models (LLMs) and their transformative applications, particularly in healthcare. The course bridges foundational ML with cutting-edge computing techniques to equip students for research and industry roles in AI-driven systems.

Unit I: Introduction to Machine Learning

Definition and scope of Machine Learning; relationship with Artificial Intelligence, Data Science, and Computing. Types of Machine Learning: Supervised Learning (classification and regression), Unsupervised Learning (clustering and dimensionality reduction), Semi-supervised Learning, and an overview of Reinforcement Learning. Basics of Machine Learning: Data pre-processing (cleaning, normalization, feature scaling, handling missing values), feature engineering and selection, training-testing split, cross-validation. Model evaluation metrics: Accuracy, precision, recall, F1-score, ROC-AUC, confusion matrix, MSE, RMSE, R^2 for regression. Bias-variance tradeoff, overfitting and underfitting, Introduction to ensemble methods (bagging and boosting) and their role in improving model performance.

Unit II: Reinforcement Learning

Reinforcement Learning (RL) Fundamentals: Agent-environment interaction, Markov Decision Process (MDP), states, actions, rewards, policy, value functions.Dynamic Programming: Policy iteration and value iteration for solving MDPs.Model-free RL: Monte Carlo methods, Temporal Difference (TD) learning, Q-Learning, SARSA.Advanced RL:

Deep Reinforcement Learning (DQN, Double DQN, Dueling DQN), Policy Gradient methods (REINFORCE, Actor-Critic), Proximal Policy Optimization (PPO).

Unit-III Transfer Learning

Transfer Learning Fundamentals: Definition, motivation (data scarcity, computational cost), types (inductive, transductive, unsupervised).Transfer Learning Techniques: Feature-based transfer, instance-based transfer, parameter-based transfer, fine-tuning pre-trained models.

Unit IV: Approaches of Optimization in Machine Learning

Optimization in ML: Objective functions, loss landscapes, convexity vs non-convexity, local vs global minima.First-Order Optimization: Gradient Descent (Batch GD, Stochastic GD, Mini-batch GD), learning rate selection and scheduling.Advanced Gradient-Based Methods: Momentum, Nesterov Accelerated Gradient, AdaGrad, RMSProp, Adam and its variants (AdamW, AMSGrad).Second-Order Optimization: Newton's method, Quasi-Newton methods (BFGS, L-BFGS), Hessian approximation.Constrained Optimization: Lagrange multipliers,

projected gradient descent, and applications in SVMs.Regularization Techniques: L1 (Lasso), L2 (Ridge),

Unit V: Advanced Computing Approaches Using LLMs

Evolution of LLMs: From RNNs/LSTMs to Transformers; introduction to foundational models (BERT, GPT series, T5).Basics of LLMs: Tokenization (BPE, WordPiece), embeddings, positional encoding, autoregressive vs autoencoding models.Transformer Architecture: Self-Attention mechanism, Multi-Head Attention, Scaled Dot-Product Attention, Feed-Forward Networks.

Introduction to LLMs in Healthcare: Opportunities and challenges (multimodal data, regulatory compliance like HIPAA/GDPR).Medical Text Processing: Named Entity Recognition (NER), relation extraction, medical coding using BioBERT, ClinicalBERT, Med-PaLM.Clinical

Bias in medical predictions, explainability (SHAP/LIME for LLMs), data privacy (federated learning, differential privacy), hallucination mitigation.

SCHEME FOR PAPER SETTING

The question paper shall consist of Ten (10) long answer type questions covering the entire syllabus. The candidates are required to answer any Six (6) questions. Answer to each question should not exceed 500 words. Each question shall be of 25 marks.

(6 x 25 = 150 marks)

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Pre - Ph.D. Course Work Syllabus

Paper – 3
Specialization Course:
Title: Machine Learning & Quantum Intelligence **Credits - 06**
Max Marks: 150 **Time: 3 Hrs**

OBJECTIVES: -

The objective of the given course is to equip the given scholars with rigorous knowledge of classical ML paradigms i.e., supervised, unsupervised, deep learning, and reinforcement learning — alongside quantum computing foundations, essential for Quantum Machine Learning (QML). It bridges AI with quantum technologies, enabling researchers to design, evaluate, and implement intelligent systems across both paradigms and contribute original work at the frontier of Quantum AI.

Unit I

Supervised Learning & Model Evaluation

Linear Models: Simple and Multiple Linear Regression, Logistic Regression for classification, and Regularization (L1 Lasso, L2 Ridge). Non-Linear Classifiers: Decision Trees, Random Forests, and Gradient Boosting (XGBoost). Kernel Methods: Support Vector Machines (SVM), the Kernel Trick, and Radial Basis Functions (RBF). Evaluation Framework: Cross-validation, Confusion Matrices, ROC-AUC, and the Bias-Variance Trade-off.

Unit II

Unsupervised Learning & Feature Engineering

Clustering: K-Means, Hierarchical Clustering (Dendrograms), and Density-Based Clustering (DBSCAN). Dimensionality Reduction: Principal Component Analysis (PCA) and Singular Value Decomposition (SVD). Feature Transformation: Scaling, Normalization, and One-Hot Encoding. Probabilistic Modeling: Gaussian Mixture Models (GMM) and Expectation-Maximization.

Unit III

Neural Networks & Reinforcement Learning

Neural Foundations: Perceptrons, Multi-Layer Perceptrons (MLP), and the Backpropagation algorithm. Deep Learning: Introduction to Convolutional Neural Networks (CNN) and LSTMs. Large Language Models (LLMs): Architectures, Fine-Tuning (LoRA/QLoRA), RAG Pipelines, and Ethical Alignment. Reinforcement Learning (RL): The Agent-Environment loop, Markov Decision Processes (MDP), and Q-Learning. Optimization: Stochastic Gradient Descent (SGD), Adam optimizer, and Dropout for regularization.

Unit IV

Quantum Computing Foundations for ML

Quantum Mechanics for CS: Qubits, Bloch Sphere representation, Superposition, and Entanglement. Quantum Circuits: Basic gates (Hadamard, Pauli X/Y/Z, CNOT) and the concept of Measurement.Quantum Data Encoding: Mapping classical data to quantum states (Basis, Amplitude, and Angle encoding). Variational Circuits: Parameterized Quantum Circuits (PQC) as the "Neural Networks" of the quantum world.

Unit V

Quantum Machine Learning (QML) Algorithms

Quantum-Enhanced Supervised Learning: Quantum Support Vector Machines (QSVM) and Quantum Kernels. Quantum Neural Networks (QNN): Hybrid Classical-Quantum training loops and the "Barren Plateau" problem. Quantum Optimization: Variational Quantum Eigensolver (VQE) and Quantum Approximate Optimization Algorithm (QAOA). Hardware & Future: The NISQ era (Noisy Intermediate-Scale Quantum), decoherence, and Quantum Advantage in ML.

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(6 x 25 = 150 marks)