



OFFICE OF THE REGISTRAR MANIPUR TECHNICAL UNIVERSITY, IMPHAL

(A University established under the Manipur Technical University Act, 2016)
Recognised by UGC under Section 2(f) and Section 22 of UGC Act, 1956
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REGULATIONS (COURSES AND SYLLABI FOR MASTER OF TECHNOLOGY PROGRAMS IN COMPUTER SCIENCE & ENGINEERING)

NOTIFICATION

Imphal, 7th September, 2026

AC-MTU-1/2/2026-MTU-MTU: It is notified to all that in exercise of the powers conferred by Section 45 of the Manipur Technical University Act, 2016, on recommendation of Board of Studies and as approved by the Academic Council of Manipur Technical University in its 9th meeting held on 30th May, 2026, hereby makes the following Regulations (Courses and Syllabi of Master of Technology program in Computer Science & Engineering), namely:-

1. Short title and commencement:

- (a) These Regulations may be called the Regulations (Courses and Syllabi for Master of Technology program in Computer Science & Engineering) 2026
- (b) They shall come into effect from the academic session 2026-27

2. Definitions:

- (1) In these Regulations, unless the context otherwise requires, -

- (a) “Act” shall mean the Manipur Technical University Act, 2016
- (b) “Board of Studies” means the board of studies of a Department
- (c) “L”, “T”, “P”, “C”, shall mean respectively lecture hours per week, tutorial class hours per week, practical/ lab hours per week, credits per week.

- (2) Words and expressions not defined in the Regulations but defined in the Statutes and Ordinances shall have the same meanings as assigned to them in the Statutes and Ordinances.

3. The Course Structure for the Master of Technology program in Computer Science & Engineering-

The Course Structure for the Master of Technology program in Computer Science & Engineering shall be as follows, with the detailed course for I semester, II semester, III semester and IV semester along with contents as given at Appendix.

**Curriculum and Syllabus for
MASTER OF TECHNOLOGY
IN
COMPUTER SCIENCE AND ENGINEERING**



**Proposed CURRICULUM Structure
2026 Admission onwards**

**Department of Computer Science and Engineering,
Manipur Technical University**

Proposed Curriculum structure and syllabus
MASTER OF TECHNOLOGY
in
COMPUTER SCIENCE & ENGINEERING

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Department of Computer Science and Engineering
Proposed Curriculum Structure

MASTER OF TECHNOLOGY IN COMPUTER SCIENCE AND ENGINEERING

The Program Educational Objectives (PEOs) of MTech in
Computer Science and Engineering

Graduates are expected to:

- PEO 1:** Gain in-depth knowledge of advanced computational methods to apply to relevant real-world issues within the context of a specific application domain.
- PEO 2:** Design and develop innovative solutions making use of modern computing platforms by exhibiting commitment to ethical practices and lifelong learning.
- PEO 3:** Understand and contribute to prevalent literature for pursuing research in the field of computer science and engineering.
- PEO 4:** Exhibit technical and managerial skills in multidisciplinary domains and become competent professionals.

The Program Learning Outcomes (PLOs) of MTech in
Computer Science and Engineering

The main outcomes of the CSE (MTech) program are given here. At the end of the program, a student is expected to have:

PLO1	An understanding of the theoretical foundations and the limits of computing.
PLO2	An ability to adapt existing models, techniques, algorithms, data structures, etc., for efficiently solving problems.
PLO3	An ability to design, develop and evaluate new computer-based systems for novel applications which meet the desired needs of industry and society.
PLO4	Understanding and ability to use advanced computing techniques and tools.
PLO5	An ability to undertake original research at the cutting edge of computer science & its related areas.
PLO6	An ability to function effectively individually or as a part of a team to accomplish a stated goal.
PLO7	An understanding of professional and ethical responsibility.
PLO8	An ability to communicate effectively with a wide range of audiences.
PLO9	An ability to learn independently and engage in life-long learning.
PLO10	An understanding of the impact of IT-related solutions in an economic, social and environmental context.

PLO-PEO Mapping:

PLO / PEO	PEO 1: (Depth/ Application)	PEO 2: (Innovation/ Ethics)	PEO 3: (Research)	PEO 4: (Managerial)
PLO1: Theoretical Foundations	3	1	3	0
PLO2: Adapt Models/Algorithms	3	2	2	1
PLO3: Design Novel Systems	3	3	1	2
PLO4: Advanced Tools/Tech	2	3	2	2
PLO5: Original Research	1	2	3	1
PLO6: Individual & Team Work	1	1	1	3
PLO7: Professional & Ethical Resp.	0	3	1	2
PLO8: Effective Communication	1	2	3	3
PLO9: Life-long Learning	2	3	3	2
PLO10: Impact (Social/Econ/Env)	3	2	1	3

Department of Computer Science and Engineering
MANIPUR TECHNICAL UNIVERSITY
MTECH PROGRAMME STRUCTURE

SEMESTER-I							
Sl. No.	Course Category	Course No.	Name of the course	L	T	P	C
1	PCC	CS501	Distributed System	3	0	0	3
2	PCC	CS502	Advanced Data Structures	3	0	0	3
3	PCC	CS503	Research Methodology and IPR	4	0	0	4
4	PEC	CS5XX	Program Elective I	3	0	0	3
5	PEC	CS5YY	Program Elective II	3	0	0	3
6	OEC	CS5ZZ	Open Elective Course I	0	2	0	2
Practical							
7	PCC	CS504	Distributed System Laboratory	0	0	2	1
8	PCC	CS505	Advanced Data Structures Laboratory	0	0	2	1
			Total Credits	16	2	4	20
SEMESTER-II							
Sl. No	Course Category	Course No.	Name of the course	L	T	P	C
1	PCC	CS506	Advanced Algorithms	3	0	0	3
2	PCC	CS507	Soft Computing	3	0	0	3
3	PCC	CS508	Machine Learning	3	0	0	3
4	PEC	CS5XX	Program Elective III	3	0	0	3
5	PEC	CS5YY	Program Elective IV	3	0	0	3
6	OEC	CS5ZZ	Open Elective Course II	1	1	0	2
PRACTICAL							
7	PCC	CS509	Advanced Algorithms Laboratory	0	0	2	1
8	PCC	CS510	Machine Learning Laboratory	0	0	2	1
9	PCC	CS511	Mini Project with Seminar	0	0	2	1
			Total Credits	16	1	6	20
➤ <u>Exit option to qualify for a PG Diploma in Computer Science & Engineering:</u> Students opting for the exit option must complete a six- to eight-week industrial training from a reputed industry. ➤ <u>Continuation in the MTech Programme for Students Not Availing the Exit Option:</u> Students continuing in the program must also complete a four- to six-week industrial/academic training during the vacation period							

SEMESTER-III							
Sl. No	Course Category	Course No.	Name of the course	L	T	P	C
1	SI	CS601	Summer Internship	0	0	0	2
2	PRP	CS602	Project Phase I	0	0	36	18
			Total Credits	0	0	36	20
SEMESTER-IV							
Sl. No	Course Category	Course Code	Name of the course	L	T	P	C
1	PRP	CS603	Project Phase II	0	0	40	20
			Total Credits	0	0	40	20
Total Credits: 80							

Here,

L – Lecture

T – Tutorial

P - Practical

Total Credits: 80

Notes:

- 1) Any course of 8/12 weeks offered by Swayam -NPTEL during the respective semester as electives with the prior approval from the Program Coordinator.
- 2) A list of electives offered in each semester will be announced by the Departments based on the requirements and availability of faculty.
- 3) The evaluation (Online elective courses) will be based on assignments and internal assessments conducted by the concerned course instructor and examinations as per the MTU P.G ordinance.
- 4) Internship Evaluation will be performed based on presentation within 1st month of 3rd semester.
- 5) Project Phase II is the continuation of Project Phase I.

PROGRAMME CORE COURSES						
Sl. No.	Course code	Name of the course	L	T	P	C
1	CS501	Distributed Systems	3	0	0	3
2	CS502	Advanced Data Structures	3	0	0	3
3	CS503	Research Methodology and IPR	4	0	0	4
4	CS506	Advanced Algorithms	3	0	0	3
5	CS507	Soft Computing	3	0	0	3
6	CS508	Machine Learning	3	0	0	3

CORE COURSES LABORATORIES and OTHER COURSES						
Sl. No.	Course code	Name of the course	L	T	P	C
1	CS504	Distributed System Laboratory	0	0	2	1
2	CS505	Advanced Data Structures Laboratory	0	0	2	1
3	CS509	Advanced Algorithms Laboratory	0	0	2	1
4	CS510	Machine Learning Laboratory	0	0	2	1
5	CS511	Mini Project with Seminar	0	0	2	1

LIST OF ELECTIVES:

Elective-I						
Sl. No.	Course code	Name of the course	L	T	P	C
1	CS512	Cloud Computing	3	0	0	3
2	CS513	Data Science	3	0	0	3
3	CS514	Data Visualization	3	0	0	3
4	CS515	Data Preparation and Analysis	3	0	0	3
5	CS516	Data Warehousing and Data Mining	3	0	0	3
6	CS517	Mobile Applications and Services	3	0	0	3
7	CS518	Wireless Sensor Networks	3	0	0	3

Elective-II						
Sl. No.	Course code	Name of the course	L	T	P	C
1	CS521	Recommender System	3	0	0	3
2	CS522	Web Analytics and Development	3	0	0	3
3	CS523	Data Storage Technologies and Networks	3	0	0	3
4	CS524	Biometrics	3	0	0	3
5	CS525	Big Data Analytics	3	0	0	3
6	CS526	Mathematical Foundations of Computer Science	3	0	0	3
7	CS527	Introduction to Intelligent Systems	3	0	0	3
8	CS528	Web Search and Information Retrieval	3	0	0	3

Elective-III						
Sl. No.	Course code	Name of the course	L	T	P	C
1	CS530	Computer Vision	3	0	0	3
2	CS531	GPU Computing	3	0	0	3
3	CS532	Digital Forensics	3	0	0	3
4	CS533	Intrusion Detection	3	0	0	3
5	CS534	Network Security	3	0	0	3
6	CS535	Ethical Hacking	3	0	0	3
7	CS536	Advanced Wireless and Mobile Networks	3	0	0	3
8	CS537	Malware Analysis and Reverse Engineering	3	0	0	3
9	CS538	Smart Sensors and Internet of Things	3	0	0	3
10	CS539	Distributed Database	3	0	0	3
11	CS540	Advanced Machine Learning	3	0	0	3

Elective-IV						
Sl. No.	Course code	Name of the course	L	T	P	C
1	CS541	Quantum Computing	3	0	0	3
2	CS542	DNA Computing	3	0	0	3
3	CS543	Parallel Algorithms	3	0	0	3
4	CS544	Concurrency, Parallelism and Distributed System	3	0	0	3

5	CS545	Optimization Techniques	3	0	0	3
6	CS546	IOT Applications and Communication Protocols	3	0	0	3
7	CS547	IOT and Smart Cities	3	0	0	3
8	CS548	Sensor Networks and Internet of Things	3	0	0	3
9	CS549	Wireless Access Technologies	3	0	0	3
10	CS550	Data Encryption & Compression	3	0	0	3
11	CS551	Operating System Design	3	0	0	3
12	CS552	Secure Coding	3	0	0	3
13	CS553	Data Security and Access Control	3	0	0	3
14	CS554	Secure Software Design and Enterprise Computing	3	0	0	3

OEC Courses - I						
Sl. No.	Course code	Name of the course	L	T	P	C
1	CS581	English For Research Paper and Writing	0	2	0	2
2	CS582	Value Education	0	2	0	2
3	CS583	Constitution Of India	0	2	0	2

OEC Courses - II						
Sl. No.	Course code	Name of the course	L	T	P	C
1	CS584	Indian Knowledge System (IKS) In Computer Engineering	1	1	0	2
2	CS585	Pedagogy Studies	0	2	0	2

PROGRAMME CORE COURSES

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: DISTRIBUTED SYSTEM

Course Code: CS501

Credits: L:T:P:C:: 3:0:0:3

Course Objective: To introduce the fundamental concepts and issues of managing large volume of shared data in a parallel and distributed environment, and to provide insight into related research problems.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Design trends in distributed systems.

CLO2: Apply network virtualization.

CLO3: Apply remote method invocation and objects.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	2	2	2	1	1	2	2	2
CLO2	2	3	3	3	2	2	2	1	2	2
CLO3	2	3	3	3	2	2	1	2	2	2

Course Contents:

Module 1:

INTRODUCTION

Distributed data processing; What is a DDBS; Advantages and disadvantages of DDBS; Problem areas; Overview of database and computer network concepts

Distributed Database Management System Architecture Transparencies in a distributed DBMS; Distributed DBMS architecture; Global directory issues

Module 2:

Distributed Database Design

Alternative design strategies; Distributed design issues; Fragmentation; Data allocation

Semantics Data Control

View management; Data security; Semantic Integrity Control

Query Processing Issues

Objectives of query processing; Characterization of query processors; Layers of query processing; Query decomposition; Localization of distributed data

Module 3:

Distributed Query Optimization

Factors governing query optimization; Centralized query optimization; Ordering of fragment queries; Distributed query optimization algorithms

Transaction Management

The transaction concept; Goals of transaction management; Characteristics of transactions; Taxonomy of transaction models

Concurrency Control

Concurrency control in centralized database systems; Concurrency control in DDBSs; Distributed concurrency control algorithms; Deadlock management

Module 4:

Reliability

Reliability issues in DDBSs; Types of failures; Reliability techniques; Commit protocols; Recovery protocols

Module 5:

Parallel Database Systems

Parallel architectures; parallel query processing and optimization; load balancing

Module 6:

Advanced Topics

Mobile Databases, Distributed Object Management, Multi-databases

Total: 48 Hrs.

Textbooks:

1. Principles of Distributed Database Systems, M.T. Ozsú and P. Valduriez, Prentice-Hall, 1991.

Reference Books:

1. Distributed Database Systems, D. Bell and J. Grimson, Addison-Wesley, 1992.

Manipur Technical University
MTech in Computer Science and Engineering

Course Title: ADVANCE DATA STRUCTURE

Course Code: CS502

Credits: L:T:P:C : 3:0:0:3

Course Objective: The student should be able to choose appropriate data structures, understand the ADT/libraries, and use it to design algorithms for a specific problem. Students should be able to understand the necessary mathematical abstraction to solve problems. To familiarize students with advanced paradigms and data structure used to solve algorithmic problems. Student should be able to come up with analysis of efficiency and proofs of correctness.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- CLO1:** Understand the implementation of symbol table using hashing techniques.
- CLO2:** Develop and analyse algorithms for red-black trees, B-trees and Splay trees.
- CLO3:** Develop algorithms for text processing applications.
- CLO4:** Identify suitable data structures and develop algorithms for computational geometry problems.
- CLO5:** Solve new evolving problems.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	3	2	2	2	1	1	1	2	1
CLO2	3	3	3	2	3	1	1	1	2	1
CLO3	2	3	3	2	2	1	1	1	2	1
CLO4	2	3	3	2	3	1	1	1	2	1
CLO5	2	3	3	2	3	2	1	1	3	2

Course Contents:

Module 1:

Dictionaries: Definition, Dictionary Abstract Data Type, Implementation of Dictionaries.

Hashing: Review of Hashing, Hash Function, Collision Resolution Techniques in Hashing, Separate Chaining, Open Addressing, Linear Probing, Quadratic Probing, Double Hashing, Rehashing, Extendible Hashing

Module 2:

Skip Lists: Need for Randomizing Data Structures and Algorithms, Search and Update Operations on Skip Lists, Probabilistic Analysis of Skip Lists, Deterministic Skip Lists

Module 3:

Trees: Binary Search Trees, AVL Trees, Red Black Trees, 2-3 Trees, B-Trees, Splay Trees

Module 4:

Text Processing: String Operations, Brute-Force Pattern Matching, The Boyer Moore Algorithm, The Knuth-Morris-Pratt Algorithm, Standard Tries, Compressed Tries, Suffix Tries, The Huffman Coding Algorithm, The Longest Common Subsequence Problem (LCS), Applying Dynamic Programming to the LCS Problem

Module 5:

Computational Geometry: One-Dimensional Range Searching, Two-Dimensional Range Searching, constructing a Priority Search Tree, Searching a Priority Search Tree, Priority Range Trees, Quadrees, k-D Trees

Module 6:

Recent Trends in Hashing, Trees, and various computational geometry methods for efficiently solving the new evolving problem

Total: 48 Hrs

Textbook:

1. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 2nd Edition, Pearson, 2004.

Reference Books:

1. M T Goodrich, Roberto Tamassia, Algorithm Design, John Wiley, 2002.

Manipur Technical University
MTech in Computer Science and Engineering

Course Title: RESEARCH METHODOLOGY AND IPR

Course Code: CS503

Credits: L:T:P:C : 4:0:0:4

Course Objective: The course enables students to understand research problem formulation, literature review, research ethics, technical writing, and the fundamentals of intellectual property rights, including patents, copyrights, and technology transfer.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Formulate and analyse research problems, information, and ethics

CLO2: Construct a structured research proposal and technical article.

CLO3: Evaluate the role of IPR in innovation and national development.

CLO4: Apply the IPR as an incentive to inventors for further research work and investment in R & D.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	3	2	1	3	2	3	2	2	2
CLO2	1	2	2	1	3	2	2	3	2	2
CLO3	2	2	1	1	2	1	3	2	2	3
CLO4	1	2	2	1	3	2	3	2	3	3

Course Contents:

Module 1:

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. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentation.

Module 2:

Effective literature studies approaches, analysis Plagiarism,
Research ethics

Module 3:

Effective technical writing, how to write report, Paper Developing a Research Proposal,

Format of research proposal, a presentation and assessment by a review committee

Module 4:

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Module 5:

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Module 6:

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Total: 48 Hrs

Textbooks:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"

Reference Books:

1. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
2. Mayall, "Industrial Design", McGraw Hill, 1992.
3. Niebel, "Product Design", McGraw Hill, 1974.
4. Asimov, "Introduction to Design", Prentice Hall, 1962.
5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
6. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: ADVANCE ALGORITHM

Course Code: CS506

Credits: L:T:P:C : 3:0:0:3

Course Objective: Introduce students to the advance methods of designing and analysing algorithm. The students should be able to choose appropriate algorithms and use it for a specific problem. To familiarize students with basic paradigms and data structures used to solve advanced algorithmic problems. Students should be able to understand different classes of problems concerning their computation difficulties. To introduce the students to recent developments in the area of algorithmic design.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Analyse the complexity/performance of different algorithms.

CLO2: Determine the appropriate data structure for solving a particular set of problems.

CLO3: Categorize the different problems in various classes according to their complexity.

CLO4: Have an insight of recent activities in the field of the advanced data structure.

CLO5: Solve problem using recent searching and sorting techniques by applying recent data structures.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	3	2	2	2	1	1	1	2	1
CLO2	2	3	3	2	2	1	1	1	2	1
CLO3	3	3	2	1	3	1	1	1	2	1
CLO4	2	2	2	2	3	1	1	2	3	1
CLO5	2	3	3	2	3	2	1	1	3	2

Course Contents:

Module 1:

Sorting: Review of various sorting algorithms, topological sorting

Graph: Definitions and Elementary Algorithms: Shortest path by BFS, shortest path in edge-weighted case (Dijkstra's), depth-first search and computation of strongly connected components, emphasis on correctness proof of the algorithm and time/space analysis, example of amortized analysis

Module 2:

Matroids: Introduction to greedy paradigm, algorithm to compute a maximum weight maximal independent set. Application to MST.

Graph Matching: Algorithm to compute maximum matching. Characterization of maximum matching by augmenting paths, Edmond's Blossom algorithm to compute augmenting path.

Module 3:

Flow-Networks: Maxflow-mincut theorem, Ford-Fulkerson Method to compute maximum flow, Edmond-Karp maximum-flow algorithm

Matrix Computation: Strassen's algorithm and introduction to divide and conquer paradigm, inverse of a triangular matrix, relation between the time complexities of basic matrix operations, LUP-decomposition

Module 4:

Shortest Path in Graphs: Floyd-Warshall algorithm and introduction to dynamic programming paradigm. More examples of dynamic programming.

Modulo Representation of integers/polynomials: Chinese Remainder Theorem, Conversion between base-representation and modulo-representation. Extension to polynomials. Application: Interpolation problem

Discrete Fourier Transform (DFT): In complex field, DFT in modulo ring. Fast Fourier Transform algorithm. Schonhage-Strassen Integer Multiplication algorithm

Module 5:

Linear Programming: Geometry of the feasibility region and Simplex algorithm.

NP-completeness: Examples, proof of NP-hardness and NP-completeness

One or more of the following topics based on time and interest Approximation algorithms, Randomized Algorithms, Interior Point Method, Advanced Number Theoretic Algorithm.

Module 6:

Recent Trends in problem solving paradigms using recent searching and sorting techniques by applying recently proposed data structures

Total: 48 Hrs

Textbooks:

1. "Introduction to Algorithms" by Cormen, Leiserson, Rivest, Stein.
2. "The Design and Analysis of Computer Algorithms" by Aho, Hopcroft, Ullman.

Reference Books:

1. "Algorithm Design" by Kleinberg and Tardos.

Manipur Technical University
MTech in Computer Science and Engineering

Course Title: SOFT COMPUTING

Course Code: CS507

Credits: L:T:P:C: :3:0:0:3

Course Objective: To introduce soft computing concepts and techniques and foster their abilities in designing appropriate technique for a given scenario. To implement soft computing-based solutions for real-world problems. To give students knowledge of non-traditional technologies and fundamentals of artificial neural networks, fuzzy sets, fuzzy logic, genetic algorithms. To provide student a hand-on experience on MATLAB to implement various strategies.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- CLO1:** Identify and describe soft computing techniques and their roles in building intelligent machines.
- CLO2:** Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering problems.
- CLO3:** Apply genetic algorithms to combinatorial optimization problems.
- CLO4:** Evaluate and compare solutions by various soft computing approaches for a given problem.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	-	-	-	-	-	-	2	-
CLO2	2	3	2	3	-	-	-	-	2	-
CLO3	2	3	3	3	2	-	-	-	2	-
CLO4	3	3	2	3	2	-	-	-	3	2

Course Contents:

Module 1:

Introduction To Soft Computing and Neural Networks: Evolution of Computing: Soft Computing Constituents, From Conventional AI to Computational Intelligence: Machine Learning Basics

Module 2:

Fuzzy Logic: Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making.

Module 3:

Neural Networks: Machine Learning Using Neural Network, Adaptive Networks, Feed forward Networks, Supervised Learning Neural Networks, Radial Basis Function

Networks: Reinforcement Learning, Unsupervised Learning Neural Networks, Adaptive Resonance architectures, Advances in Neural networks

Module 4:

Genetic Algorithms: Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning: Machine Learning Approach to Knowledge Acquisition

Module 5:

Matlab/Python Lib: Introduction to Matlab/Python, Arrays and array operations, Functions and Files, Study of neural network toolbox and fuzzy logic toolbox, Simple implementation of Artificial Neural Network and Fuzzy Logic

Module 6:

Recent Trends in deep learning, various classifiers, neural networks and genetic algorithms. Implementation of recently proposed soft computing techniques.

Total: 48 Hrs

Textbooks:

1. Jyh:Shing Roger Jang, Chuen:Tsai Sun, EijiMizutani, Neuro:Fuzzy and Soft Computing, Prentice:Hall of India, 2003.
2. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic:Theory and Applications□, Prentice Hall, 1995.

Reference Books:

1. MATLAB Toolkit Manual

Manipur Technical University
MTech in Computer Science and Engineering

Course Title: MACHINE LEARNING

Course Code: CS508

Credits: L:T:P:C: :3:0:0:3

Course Objective: To learn the concept of how to learn patterns and concepts from data without being explicitly programmed in various IOT nodes. To design and analyse various machine learning algorithms and techniques with a modern outlook focusing on recent advances. Explore supervised and unsupervised learning paradigms of machine learning. To explore Deep learning technique and various feature extraction strategies

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Extract features that can be used for a particular machine learning approach in various IOT applications.

CLO2: To compare and contrast pros and cons of various machine learning techniques and to get an insight of when to apply a particular machine learning approach.

CLO3: To mathematically analyse various machine learning approaches and paradigms.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	3	3	2	2	-	-	-	1	2
CLO2	2	3	2	2	2	-	-	1	2	-
CLO3	3	2	1	1	3	-	-	-	1	-

Course Contents:

Module 1:

Supervised Learning (Regression/Classification)

- Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Naive Bayes
- Linear models: Linear Regression, Logistic Regression, Generalized Linear Models
- Support Vector Machines, Nonlinearity and Kernel Methods
- Beyond Binary Classification: Multi-class/Structured Outputs, Ranking

Module 2:

Unsupervised Learning

- Clustering: K-means/Kernel K-means
- Dimensionality Reduction: PCA and kernel PCA
- Matrix Factorization and Matrix Completion
- Generative Models (mixture models and latent factor models)

Module 3:

Evaluating Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods (Boosting, Bagging, Random Forests)

Module 4:

Sparse Modelling and Estimation, Modelling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning

Module 5:

Scalable Machine Learning (Online and Distributed Learning)

A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models, Introduction to Bayesian Learning and Inference.

Module 6:

Recent trends in various learning techniques of machine learning and classification methods for IOT applications. Various models for IOT applications.

Total: 48 Hrs

Textbooks:

1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
2. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.

Reference Books:

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online)

PROGRAMME ELECTIVE-I

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: CLOUD COMPUTING

Course Code: CS512

Credits: L:T:P:C : 3:0:0:3

Course Objective: The student will also learn how to apply trust-based security model to real-world security problems. An overview of the concepts, processes, and best practices needed to successfully secure information within Cloud infrastructures. Students will learn the basic Cloud types and delivery models and develop an understanding of the risk and compliance responsibilities and Challenges for each Cloud type and service delivery model.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Identify security aspects of each cloud model

CLO2: Develop a risk-management strategy for moving to the Cloud

CLO3: Implement a public cloud instance using a public cloud service provider

CLO4: Apply trust-based security model to different layer

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	1	2	2	2	-	3	-	1	2
CLO2	1	2	3	2	2	1	3	2	1	3
CLO3	-	2	3	3	1	2	2	-	2	1
CLO4	3	2	2	2	3	-	3	-	1	1

Course Contents:

Module 1:

Introduction to Cloud Computing

Online Social Networks and Applications, Cloud introduction and overview, Different clouds, Risks, Novel applications of cloud computing

Module 2:

Cloud Computing Architecture

Requirements Introduction Cloud computing architecture, On Demand Computing Virtualization at the infrastructure level, Security in Cloud computing environments, CPU Virtualization, A discussion on Hypervisors Storage Virtualization Cloud Computing Defined, The SPI Framework for Cloud Computing, The Traditional Software Model, The Cloud Services Delivery Model.

Cloud Deployment Models

Key Drivers to Adopting the Cloud, The Impact of Cloud Computing on Users, Governance in the Cloud, Barriers to Cloud Computing Adoption in the Enterprise

Module 3:

Security Issues in Cloud Computing

Infrastructure Security, Infrastructure Security: The Network Level, The Host Level, The Application Level, Data Security and Storage, Aspects of Data Security, Data Security Mitigation Provider Data and Its Security

Identity and Access Management

Trust Boundaries and IAM, IAM Challenges, Relevant IAM Standards and Protocols for Cloud Services, IAM Practices in the Cloud, Cloud Authorization Management

Module 4:

Security Management in the Cloud

Security Management Standards, Security Management in the Cloud, Availability Management: SaaS, PaaS, IaaS

Privacy Issues

Privacy Issues, Data Life Cycle, Key Privacy Concerns in the Cloud, Protecting Privacy, Changes to Privacy Risk Management and Compliance in Relation to Cloud Computing, Legal and Regulatory Implications, U.S. Laws and Regulations, International Laws and Regulations

Module 5:

Audit and Compliance

Internal Policy Compliance, Governance, Risk, and Compliance (GRC), Regulatory/External Compliance, Cloud Security Alliance, Auditing the Cloud for Compliance, Security-as-a-Cloud

Module 6:

Advanced Topics

Recent developments in hybrid cloud and cloud security

Total: 48 Hrs

Textbook:

- 1 Cloud Computing Explained: Implementation Handbook for Enterprises, John Rhoton, Publication Date: November 2, 2009

Reference Book:

- 1 Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance (Theory in Practice), Tim Mather, ISBN-10: 0596802765, O'Reilly Media, September 2009

Manipur Technical University
MTech in Computer Science and Engineering

Course Title: DATA SCIENCE
Course Code: CS513
Credits: L:T:P:C : 3:0:0:3

Course Objective: Provide you with the knowledge and expertise to become a proficient data scientist. Demonstrate an understanding of statistics and machine learning concepts that are vital for data science. Produce Python code to statistically analyse a dataset. Critically evaluate data visualisations based on their design and use for communicating stories from data.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Explain how data is collected, managed and stored for data science.

CLO2: Understand the key concepts in data science, including their real-world applications and the toolkit used by data scientists.

CLO3: Implement data collection and management scripts using MongoDB

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	2	2	2	1	1	1	1	2	2
CLO2	2	2	2	2	2	1	1	2	2	3
CLO3	1	3	3	3	2	2	1	2	2	3

Course Contents:

Module 1:

Introduction to core concepts and technologies: Introduction, Terminology, data science process, data science toolkit, Types of data, Example applications

Module 2:

Data collection and management: Introduction, Sources of data, Data collection and APIs, Exploring and fixing data, Data storage and management, Using multiple data sources

Module 3:

Central tendencies and distributions, Variance, Distribution properties and arithmetic, Samples/CLT, Basic machine learning algorithms, Linear regression, SVM, Naive Bayes.

Module 4:

Data visualisation: Introduction, Types of data visualisation, Data for visualisation: Data types, Data encodings, Retinal variables, Mapping variables to encodings, Visual encodings

Module 5:

Applications of Data Science, Technologies for visualisation, Bokeh (Python)

Module 6:

Recent trends in various data collection and analysis techniques, various visualization techniques, application development methods of used in data science.

Total: 48 Hrs

Textbooks:

1. Cathy O’Neil and Rachel Schutt. Doing Data Science, Straight Talk from The Frontline. O’Reilly.

Reference Books:

1. Jure Leskovek, AnandRajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press.

Manipur Technical University
MTech in Computer Science and Engineering

Course Title: DATA VISUALISATION

Course Code: CS514

Credits: L:T:P:C : 3:0:0:3

Course Objective: Familiarize students with the basic and advanced techniques of information visualization and scientific visualization. To learn key techniques of the visualization process. A detailed view of visual perception, the visualized data and the actual visualization, interaction and distorting techniques.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Familiar with the design process to develop visualization methods and visualization systems, and methods for their evaluation.

CLO2: Preparation and processing of data, visual mapping and the visualization.

CLO3: Have an understanding of large-scale abstract data.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	2	3	2	2	1	1	2	1	1
CLO2	2	3	2	3	1	-	-	-	1	-
CLO3	3	2	2	2	3	-	-	-	2	1

Course Contents:

Module 1:

Introduction of visual perception, visual representation of data, Gestalt principles, information overloads.

Module 2:

Creating visual representations, visualization reference model, visual mapping, visual analytics, Design of visualization applications

Module 3:

Classification of visualization systems, Interaction and visualization techniques misleading, Visualization of one, two and multi-dimensional data, text and text documents.

Module 4:

Visualization of groups, trees, graphs, clusters, networks, software, Metaphorical visualization

Module 5:

Visualization of volumetric data, vector fields, processes and simulations, Visualization of maps, geographic information, GIS systems, collaborative visualizations, Evaluating visualizations

Module 6:

Recent trends in various perception techniques, various visualization techniques, data structures used in data visualization.

Total: 48 Hrs

Textbooks:

1. WARD, GRINSTEIN, KEIM, Interactive Data Visualization: Foundations, Techniques, and Applications. Natick: A K Peters, Ltd.

Reference Books:

1. E. Tufte, The Visual Display of Quantitative Information, Graphics Press.

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: DATA PREPARATION AND ANALYSIS

Course Code: CS515

Credits: L:T:P:C : 3:0:0:3

Course Objective: To prepare the data for analysis and develop meaningful Data Visualizations

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Able to extract the data for performing the Analysis.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	2	2	3	2	-	-	-	1	1

Course Contents:

Module 1:

Data Gathering and Preparation:

Data formats, parsing and transformation, Scalability and real-time issues

Module 2:

Data Cleaning:

Consistency checking, Heterogeneous and missing data, Data Transformation and segmentation

Module 3:

Exploratory Analysis:

Descriptive and comparative statistics, Clustering and association, Hypothesis generation

Module 4:

Visualization:

Designing visualization Time series, Geolocated data, Correlations and connections, Hierarchies and networks, and interactivity.

Total: 48 Hrs

Textbooks:

1. Making sense of Data: A practical Guide to Exploratory Data Analysis and Data Mining, by Glenn J. Myatt

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: DATA WAREHOUSING AND DATA MINING

Course Code: CS516

Credits: L:T:P:C : 3:0:0:3

Course Objective: The objective of this course is to introduce data warehousing and mining techniques. Application of data mining in web mining, pattern matching and cluster analysis is included to aware students of broad data mining areas.

Course Learning Outcomes:

After completion of course, students would be able to:

- CLO1:** Study of different sequential pattern algorithms
CLO2: Study the technique to extract patterns from time series data and its application in real world.
CLO3: Can extend the Graph mining algorithms to Web mining
CLO4: Help in identifying the computing framework for Big Data

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	1	2	2	-	-	-	1	-
CLO2	2	3	2	2	2	-	-	1	1	2
CLO3	2	3	3	2	3	-	-	-	2	1
CLO4	1	2	2	3	1	1	-	-	2	2

Course Contents:

Module 1:

Introduction to Data Warehousing; Data Mining: Mining frequent patterns, association and correlations; Sequential Pattern Mining concepts, primitives, scalable methods.

Module 2:

Classification and prediction; Cluster Analysis – Types of Data in Cluster Analysis, Partitioning methods, Hierarchical Methods; Transactional Patterns and other temporal based frequent patterns.

Module 3:

Mining Time series Data, Periodicity Analysis for time related sequence data, Trend analysis, Similarity search in Time-series analysis.

Module 4:

Mining Data Streams, Methodologies for stream data processing and stream data systems, Frequent pattern mining in stream data, Sequential Pattern Mining in Data Streams, Classification of dynamic data streams, Class Imbalance Problem; Graph Mining; Social Network Analysis.

Module 5:

Web Mining, Mining the web page layout structure, mining web link structure, mining multimedia data on the web, Automatic classification of web documents and web usage mining; Distributed Data Mining.

Module 6:

Recent trends in Distributed Warehousing and Data Mining, Class Imbalance Problem; Graph Mining; Social Network Analysis

Total: 48 Hrs

Textbooks

1. Jiawei Han and M Kamber, Data Mining Concepts and Techniques, Second Edition, Elsevier
2. Publication, 2011.
3. Vipin Kumar, Introduction to Data Mining - Pang-Ning Tan, Michael Steinbach, Addison Wesley, 2006.

References Books

1. G Dong and J Pei, Sequence Data Mining, Springer, 2007.

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: MOBILE APPLICATIONS AND SERVICES.

Course Code: CS517

Credits: L:T:P:C::3:0:0:3

Course Objective:

- This course presents the three main mobile platforms and their ecosystems, namely Android, iOS, and PhoneGap/WebOS.
- It explores emerging technologies and tools used to design and implement feature-rich.
- It also takes into account both the technical constraints relative to storage capacity, processing capacity, display screen, communication interfaces, and the user interface, context and profile mobile applications for smartphones and tablets

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: identify the target platform and users and be able to define and sketch a mobile application

CLO2: understand the fundamentals, frameworks, and development lifecycle of mobile

application platforms including iOS, Android, and PhoneGap

CLO3: Design and develop a mobile application prototype in one of the platforms (challenge project)

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	3	3	2	1	2	2	3	2	2
CLO2	2	2	2	3	2	1	1	2	2	2
CLO3	2	3	3	3	2	2	2	3	2	3

Course Contents:

Module 1:

Introduction: Introduction to Mobile Computing, Introduction to Android Development Environment, Factors in Developing Mobile Applications, Mobile Software Engineering, Frameworks and Tools, Generic UI Development Android User

Module 2:

More on UIs: VUIs and Mobile Apps, Text-to-Speech Techniques, Designing the Right UI, Multichannel and Multimodal UIs,. Storing and Retrieving Data, Synchronization and Replication of Mobile Data, Getting the Model Right, Android Storing and Retrieving Data, Working with a Content Provider

Module 3:

Communications via Network and the Web: State Machine, Correct Communications Model, Android Networking and Web, Telephony Deciding Scope of an App, Wireless Connectivity and Mobile Apps, Android Telephony

Notifications and Alarms: Performance, Performance and Memory Management, Android Notifications and Alarms, Graphics, Performance and Multithreading, Graphics and UI Performance, Android Graphics

Module 4:

Putting It All Together: Packaging and Deploying, Performance Best Practices, Android Field Service App, Location Mobility and Location Based Services Android

Multimedia: Mobile Agents and Peer-to-Peer Architecture, Android Multimedia

Module 5:

Platforms and Additional Issues: Development Process, Architecture, Design, Technology Selection, Mobile App Development Hurdles, Testing, Security and Hacking, Active Transactions, More on Security, Hacking Android

Module 6:

Recent trends in Communication protocols for IOT nodes, mobile computing techniques in IOT, agents-based communications in IOT

Total: 48 Hrs

Textbooks:

1. Wei-Meng Lee, Beginning Android™ 4 Application Development, 2012 by John Wiley & Sons

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: WIRELESS SENSOR NETWORKS

Course Code: CS518

Credits: L:T:P:C : 3:0:0:3

Course Objective: Architect sensor networks for various application setups. Devise appropriate data dissemination protocols and model links cost.

Understanding of the fundamental concepts of wireless sensor networks and have a basic knowledge of the various protocols at various layers. Evaluate the performance of sensor networks and identify bottlenecks.

Course Learning Outcomes:

After completion of course, students would be able to:

CLO1: Describe and explain radio standards and communication protocols for wireless sensor networks.

CLO2: Explain the function of the node architecture and use of sensors for various applications. Be familiar with architectures, functions and performance of wireless sensor networks systems and platforms.

CLO-PLO mapping matrix:

CO/PO	PLO1	PLO2	PL3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	1	1	2	2	-	-	1	2	1
CLO2	2	3	3	2	2	1	-	-	1	2

Course Contents:

Module 1:

Introduction to Wireless Sensor Networks: Course Information, Introduction to Wireless Sensor Networks: Motivations, Applications, Performance metrics, History and Design factors

Network Architecture: Traditional layered stack, Cross-layer designs, Sensor Network Architecture

Hardware Platforms: Motes, Hardware parameters

Module 2:

Introduction to ns-3: Introduction to Network Simulator 3 (ns-3), Description of the ns-3 core module and simulation example.

Module 3:

Medium Access Control Protocol design: Fixed Access, Random Access, WSN protocols: synchronized, duty-cycled

Introduction to Markov Chain: Discrete time Markov Chain definition, properties, classification and analysis

MAC Protocol Analysis: Asynchronous duty-cycled. X-MAC Analysis (Markov Chain)

Module 4:

Security: Possible attacks, countermeasures, SPINS, Static and dynamic key distribution

Total: 48 Hrs

Textbooks:

1. W. Dargie and C. Poellabauer, “Fundamentals of Wireless Sensor Networks – Theory and Practice”, Wiley 2010
2. KazemSohraby, Daniel Minoli and TaiebZnati, “wireless sensor networks - Technology, Protocols, and Applications”, Wiley Interscience 2007

Reference Books:

1. Takahiro Hara, Vladimir I. Zadorozhny, and Erik Buchmann, “Wireless Sensor Network Technologies for the Information Explosion Era”, springer 2010

PROGRAMME ELECTIVE-II

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: RECOMMENDER SYSTEM
Course Code: CS521
Credits: L:T:P:C : 3:0:0:3

Course Objective: To learn techniques for making recommendations, including non-personalized, content-based, and collaborative filtering. To automate a variety of choice-making strategies with the goal of providing affordable, personal, and high-quality recommendations.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Design recommendation system for a particular application domain.

CLO2: Evaluate recommender systems on the basis of metrics such as accuracy, rank accuracy, diversity, product coverage, and serendipity

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	3	3	2	2	-	-	-	1	2
CLO2	2	2	3	3	3	-	-	1	1	1

Course Contents:

Module 1:

Introduction: Overview of Information Retrieval, Retrieval Models, Search and Filtering Techniques: Relevance Feedback, User Profiles, Recommender system functions, Matrix operations, covariance matrices, Understanding ratings, Applications of recommendation systems, Issues with recommender system.

Module 2:

Content-based Filtering: High level architecture of content-based systems, Advantages and drawbacks of content-based filtering, Item profiles, discovering features of documents, pre-processing and feature extraction, obtaining item features from tags, Methods for learning user profiles, Similarity based retrieval, Classification algorithms.

Module 3:

Collaborative Filtering: User-based recommendation, Item-based recommendation. Model based approaches, Matrix factorization, Attacks on collaborative recommender systems.

Module 4:

Hybrid approaches: Opportunities for hybridization, Monolithic hybridization design: Feature combination, Feature augmentation, Parallelized hybridization design: Weighted, Switching, Mixed, Pipelined hybridization design: Cascade Meta-level, Limitations of hybridization strategies

Module 5:

Evaluating Recommender System: Introduction, General properties of evaluation research, Evaluation designs: Accuracy, Coverage, confidence, novelty, diversity, scalability, serendipity, Evaluation on historical datasets, Offline evaluations.

Module 6:

Types of Recommender Systems: Recommender systems in personalized web search, knowledge-based recommender system, social tagging recommender systems, Trust-centric recommendations, Group recommender systems.

Total: 48 Hrs

Textbooks:

1. Jannach D., Zanker M. and FelFering A., Recommender Systems: An Introduction, Cambridge University Press (2011), 1st ed.
2. Charu C. Aggarwal, Recommender Systems: The Textbook, Springer (2016), 1st ed.

Reference Books:

1. Ricci F., Rokach L., Shapira D., Kantor B.P., Recommender Systems Handbook, Springer(2011), 1st ed.
2. Manouselis N., Drachsler H., Verbert K., Duval E., Recommender Systems For Learning, Springer (2013), 1st ed.

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: WEB ANALYTICS AND DEVELOPMENT

Course Code: CS522

Credits: L:T:P:C: :3:0:0:3

Course Objective: The course explores use of social network analysis to understand growing connectivity and complexity in the world ranging from small groups to WWW.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Become familiar with core research communities, publications, focused on web and social media analytics and research questions engaged in.

CLO-PLO mapping matrix:

CO/PO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	1	-	1	3	-	2	2	3	1

Course Contents:

Module 1:

Introduction – Social network and Web data and methods, Graph and Matrices, Basic measures for individuals and networks, Information Visualization

Module 2:

Web Analytics tools: Click Stream Analysis, A/B testing, Online Surveys

Module 3:

Web Search and Retrieval: Search Engine Optimization, Web Crawling and indexing, Ranking Algorithms, Web traffic models.

Module 4:

Making Connection: Link Analysis, Random Graphs and Network evolution, Social Connects: Affiliation and identity.

Module 5:

Connection:

Connection Search, Collapse, Robustness Social involvements and diffusion of innovation

Module 6:

Recent trends in sensor network and IOT architecture, Automation in Industrial aspect of IOT.

Total: 48 Hrs

Textbooks:

1. Mandler, B., Barja, J., Mitre Campista, M.E., Cagá_ová, D., Chaouchi, H., Zeadally, S., Badra, M., Giordano, S., Fazio, M., Somov, A., Vieriu, R.-L., Internet of Things. IoT Infrastructures, Springer International Publishing

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: DATA STORAGE TECHNOLOGIES AND NETWORKS

Course Code: CS523

Credits: L:T:P:C : 3:0:0:3

Course Objective: To provide learners with a basic understanding of Enterprise Data Storage and Management Technologies

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Learn Storage System Architecture

CLO2: Overview of Virtualization Technologies, Storage Area Network

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	2	1	-	-	-	-	1	-
CLO2	2	2	3	3	1	-	-	-	2	1

Course Contents:

Module 1:

Storage Media and Technologies – Magnetic, Optical and Semiconductor Media, Techniques for read/write Operations, Issues and Limitations.

Module 2:

Usage and Access – Positioning in the Memory Hierarchy, Hardware and Software Design for Access, Performance issues.

Module 3:

Large Storages – Hard Disks, Networked Attached Storage, Scalability issues, Networking issues

Module 4:

Storage Architecture - Storage Partitioning, Storage System Design, Caching, Legacy Systems.

Module 5:

Storage Area Networks – Hardware and Software Components, storage clusters/guide.

Storage QoS–Performance, Reliability, and Security issues.

Module 6:

Recent Trends related to Copy data management, Erasure coding, and Software defined storage appliances.

Total: 48 Hrs

Textbooks:

1. The Complete Guide to Data Storage Technologies for Network-centric Computing Paperback–Import, Mar 1998 by Computer Technology Research Corporation

Reference Books:

1. Data Storage Networking: Real World Skills for the CompTIA Storage by Nigel Poulton

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: BIOMETRICS

Course Code: CS524

Credits: L:T:P:C : 3:0:0:3

Course Objective: The objective of this course is to introduce Biometric and traditional authentication methods. Application of biometric systems in government sector and various face recognition and finger print recognition methods are included.

Course Learning Outcomes:

After completion of course, students would be able to:

- CLO1:** Perform R&D on biometrics methods and systems.
- CLO2:** A good understanding of the various modules constituting a biometric system.
- CLO3:** Familiarity with different biometric traits and to appreciate their relative significance.
- CLO4:** A good knowledge of the feature sets used to represent some of the popular biometric traits.
- CLO5:** Evaluate and design security systems incorporating biometrics.
- CLO6:** Recognize the challenges and limitations associated with biometrics.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	2	3	2	3	1	-	-	2	-
CLO2	3	1	2	2	1	-	-	-	1	-
CLO3	2	1	2	1	1	-	-	1	1	-
CLO4	2	3	2	2	2	-	-	-	1	-
CLO5	1	2	3	3	2	1	2	-	1	2
CLO6	3	2	1	1	2	-	3	1	2	2

Course Contents:

Module 1:

Introduction and Definitions of biometrics, Traditional authenticated methods and technologies.

Module 2:

Biometric technologies: Fingerprint, Face, Iris, Hand Geometry, Gait Recognition, Ear, Voice, Palm print, On-Line Signature Verification, 3D Face Recognition, Dental Identification and DNA.

Module 3:

The Law and the use of multi biometrics systems.

Module 4:

Statistical measurement of Biometric. Biometrics in Government Sector and Commercial Sector.

Module 5:

Case Studies of biometric system, Biometric Transaction. Biometric System Vulnerabilities.

Module 6:

Recent trends in Biometric technologies and applications in various domains.
Case study of 3D face recognition and DNA matching.

Total: 48 Hrs

Textbooks:

1. Biometrics for network security, Paul Reid, Hand book of Pearson
2. K. Jain, R. Bolle, S. Pankanti (Eds.), BIOMETRICS: Personal Identification in Networked Society, Kluwer Academic Publishers, 1999.
3. J. Wayman, A.K. Jain, D. Maltoni, and D. Maio (Eds.), Biometric Systems: Technology, Design and Performance Evaluation, Springer, 2004.
4. Anil Jain, Arun A. Ross, Karthik Nanda kumar, Introduction to biometric, Springer, 2011.

Reference Books:

1. Biometric Systems: Technology, Design and Performance Evaluation, J. Wayman, A.K. Jain, D. Maltoni, and D. Maio
2. D. Maltoni, D. Maio, A. K. Jain, and S. Prabhakar, Handbook of Fingerprint Recognition, Springer Verlag, 2003.

Manipur Technical University
MTech in Computer Science and Engineering

Course Title: BIG DATA ANALYTICS

Course Code: CS525

Credits: L:T:P:C : 3:0:0:3

Course Objective: Understand big data for business intelligence. Learn business case studies for big data analytics. Understand NoSQL big data management. Perform map-reduce analytics using Hadoop and related tools

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Describe big data and use cases from selected business domains

CLO2: Explain NoSQL big data management

CLO3: Install, configure, and run Hadoop and HDFS

CLO4: Perform map-reduce analytics using Hadoop

CLO5: Use Hadoop related tools such as HBase, Cassandra, Pig, and Hive for big data analytics

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	2	2	1	1	1	1	2	2	3
CLO2	2	2	2	2	2	1	1	1	2	2
CLO3	1	2	2	3	2	2	1	1	2	2
CLO4	2	3	3	3	3	2	1	2	2	3
CLO5	2	3	3	3	3	2	1	2	2	3

Course Contents:

Module 1:

What is big data, why big data, convergence of key trends, unstructured data, industry examples of big data, web analytics, big data and marketing, fraud and big data, risk and big data, credit risk management, big data and algorithmic trading, big data and healthcare, big data in medicine, advertising and big data, big data technologies, introduction to Hadoop, open source technologies, cloud and big data, mobile business intelligence, Crowd sourcing analytics, inter and trans firewall analytics.

Module 2:

Introduction to NoSQL, aggregate data models, aggregates, key-value and document data models, relationships, graph databases, schemeless databases, materialized views, distribution models, sharding, master-slave replication, peer peer replication, sharding and replication, consistency, relaxing consistency, version stamps, map-reduce, partitioning and combining, composing map-reduce calculations.

Module 3:

Data format, analyzing data with Hadoop, scaling out, Hadoop streaming, Hadoop pipes, design of Hadoop distributed file system (HDFS), HDFS concepts, Java interface, data flow, Hadoop I/O, data integrity, compression, serialization, Avro, file-based data structures

Module 4:

MapReduce workflows, unit tests with MRUnit, test data and local tests, anatomy of MapReduce job run, classic Map-reduce, YARN, failures in classic Map-reduce and YARN, job scheduling, shuffle and sort, task execution, MapReduce types, input formats, output formats

Module 5:

Hbase, data model and implementations, Hbase clients, Hbase examples, praxis. Cassandra, Cassandra data model, Cassandra examples, Cassandra clients, Hadoop integration.

Module 6:

Pig, Grunt, pig data model, Pig Latin, developing and testing Pig Latin scripts. Hive, data types and file formats, HiveQL data definition, HiveQL data manipulation, HiveQL queries.

Total: 48 Hrs

Textbooks:

1. Michael Minelli, Michelle Chambers, and AmbigaDhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.

Reference Books:

1. P. J. Sadalage and M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.
2. Tom White, "Hadoop: The Definitive Guide", Third Edition, O'Reilley, 2012.
3. Eric Sammer, "Hadoop Operations", O'Reilley, 2012.
4. E. Capriolo, D. Wampler, and J. Rutherglen, "Programming Hive", O'Reilley, 2012.
5. Lars George, "HBase: The Definitive Guide", O'Reilley, 2011.
6. Eben Hewitt, "Cassandra: The Definitive Guide", O'Reilley, 2010.
7. Alan Gates, "Programming Pig", O'Reilley, 2011.

Manipur Technical University
MTech in Computer Science and Engineering

Course Title: MATHEMATICAL FOUNDATION OF COMPUTER SCIENCE

Course Code: CS526

Credits: L:T:P:C::3:0:0:3

Course Objective: To understand the mathematical fundamentals that is prerequisites for a variety of courses like Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning. To develop the understanding of the mathematical and logical basis to many modern techniques in information technology like machine learning, programming language design and concurrency. To study various sampling and classification problems.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: To understand the basic notions of discrete and continuous probability.

CLO2: To understand the methods of statistical inference, and the role that sampling distributions play in those methods

CLO3: To be able to perform correct and meaningful statistical analyses of simple to moderate complexity.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	1	1	1	1	1	1	2	1
CLO2	3	3	2	2	2	1	1	1	2	1
CLO3	2	3	3	2	2	1	1	1	2	2

Course Contents:

Module 1:

Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate Central Limit Theorem, Probabilistic inequalities, Markov chains

Module 2:

Random samples, sampling distributions of estimators, Methods of Moments and Maximum Likelihood,

Module 3:

Statistical inference, Introduction to multivariate statistical models: regression and classification problems, principal components analysis, The problem of overfitting model assessment.

Module 4:

Graph Theory: Isomorphism, Planar graphs, graph colouring, Hamilton circuits and Euler cycles. Permutations and Combinations with and without repetition. Specialized techniques to solve combinatorial enumeration problems

Module 5:

Computer science and engineering applications

Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning.

Module 6:

Recent Trends in various distribution functions in mathematical field of computer science for varying fields like bioinformatic, soft computing, and computer vision.

Total: 48 Hrs

Textbooks:

1. John Vince, Foundation Mathematics for Computer Science, Springer.

Reference Books:

1. K. Trivedi. Probability and Statistics with Reliability, Queuing, and Computer Science Applications. Wiley.
2. M. Mitzenmacher and E. Upfal. Probability and Computing: Randomized Algorithms and Probabilistic Analysis.
3. Alan Tucker, Applied Combinatorics, Wiley

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: INTRODUCTION TO INTELLIGENT SYSTEMS

Course Code: CS527

Credits: L:T:P:C : 3:0:0:3

Course Objective: The aim of the course is to introduce to the field of Artificial Intelligence (AI) with emphasis on its use to solve real world problems for which solutions are difficult to express using the traditional algorithmic approach. It explores the essential theory behind methodologies for developing systems that demonstrate intelligent behaviour including dealing with uncertainty.

Course Learning Outcomes:

After completion of course, students would be able to:

CLO1: Able to Demonstrate knowledge of the fundamental principles of intelligent systems and would be able to analyse and compare the relative merits of a variety of AI problem solving techniques.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	3	2	2	2	-	-	-	1	1

Course Contents:

Module 1:

Biological foundations to intelligent systems I: Artificial neural networks, Backpropagation networks, Radial basis function networks, and recurrent networks.

Module 2:

Biological foundations to intelligent systems II: Fuzzy logic, knowledge Representation and inference mechanism, genetic algorithm, and fuzzy neural networks.

Module 3:

Search Methods: Basic concepts of graph and tree search. Three simple search methods: breadth-first search, depth-first search, and iterative deepening search.

Heuristic search methods: best-first search, admissible evaluation functions, hill climbing search. Optimisation and search, such as stochastic annealing and genetic algorithm

Module 4:

Knowledge representation and logical inference: Issues in knowledge representation. Structured representation, such as frames, scripts, semantic networks and conceptual graphs. Formal logic and logical inference. Knowledge-based systems structures, its basic components. Ideas of Blackboard architectures.

Module 5:

Reasoning under uncertainty and Learning Techniques on uncertainty reasoning such as Bayesian reasoning, Certainty factors and Dempster-Shafer Theory of Evidential reasoning, A study of different learning and evolutionary algorithms, such as statistical learning and induction learning.

Module 6:

Recent trends in Fuzzy logic, Knowledge Representation

Total: 48 Hrs

Textbooks:

1. Luger G.F. and Stubblefield W.A. (2008). Artificial Intelligence: Structures and strategies for Complex Problem Solving. Addison Wesley, 6th edition.
2. Russell S. and Norvig P. (2009). Artificial Intelligence: A Modern Approach. Prentice-Hall, 3rd edition.

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: WEB SEARCH AND INFORMATION RETRIEVAL

Course Code:CS528

Credits: L:T:P:C::3:0:0:3

Course Objective:

The objective of the course is to introduce information retrieval models and query languages. Application of web search and information retrieval in social networks is also included.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- CLO1:** To identify basic theories and analysis tools as they apply to information retrieval.
- CLO2:** To develop understanding of problems and potentials of current IR systems.
- CLO3:** To learn and appreciate different retrieval algorithms and systems.
- CLO4:** To apply various indexing, matching, organizing, and evaluating methods to IR problem.
- CLO5:** To become aware of current experimental and theoretical IR research.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	1	2	2	1	1	1	2	1
CLO2	2	3	2	2	2	1	1	2	2	2
CLO3	2	3	2	2	2	1	1	1	2	1
CLO4	2	3	3	3	2	2	1	2	2	2
CLO5	2	2	2	2	3	1	1	2	3	2

Course Contents:

Module 1:

Information retrieval model, Information retrieval evaluation, Searching the Web

Module 2:

Document Representation, Query languages and query operation, Meta-data Search.

Module 3:

Indexing and searching, Scoring and ranking feature vectors.

Module 4:

Ontology, domain specific search, parallel and distributed information retrieval.

Module 5:

Text and multimedia languages, social networks

Module 6:

Recent trends in Web search and Information retrieval techniques.

Total: 48 Hrs

Textbooks:

1. C. D. Manning, P. Raghavan and H. Schütze, Introduction to Information Retrieval, Cambridge University Press, 2008 (available at <http://nlp.stanford.edu/IR-book>).
2. Chakrabarti, S. (2002). Mining the web: Mining the Web: Discovering knowledge from hypertext data. Morgan-Kaufman.

Reference Books:

1. B. Croft, D. Metzler, T. Strohman, Search Engines: Information Retrieval in Practice, Addison-Wesley, 2009 (available at <http://ciir.cs.umass.edu/irbook/>).
2. R. Baeza-Yates, B. Ribeiro-Neto, Modern Information Retrieval, Addison-Wesley, 2011 (2nd Edition).

PROGRAMME ELECTIVE-III

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: COMPUTER VISION

Course Code:CS530

Credits: L:T:P:C : 3:0:0:3

Course Objective: Be familiar with both the theoretical and practical aspects of computing with images. Have described the foundation of image formation, measurement, and analysis. Understand the geometric relationships between 2D images and the 3D world. Grasp the principles of state-of-the-art deep neural networks

Course Learning Outcomes:

After completion of course, students would be able to:

CLO1: Developed the practical skills necessary to build computer vision applications.

CLO2: To have gained exposure to object and scene recognition and categorization from images.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	3	3	3	2	1	-	-	2	1
CLO2	2	3	2	2	3	-	-	-	1	-

Course Contents:

Module 1:

Overview, computer imaging systems, lenses, Image formation and sensing, Image analysis, pre-processing and Binary image analysis

Module 2:

Edge detection, Edge detection performance, Hough transform, corner detection

Module 3:

Segmentation, Morphological filtering, Fourier transform

Module 4:

Feature extraction, shape, histogram, colour, spectral, texture, using CVIPtools, Feature analysis, feature vectors, distance /similarity measures, data preprocessing

Module 5:

Pattern Analysis:

Clustering: K-Means, K-Medoids, Mixture of Gaussians

Classification: Discriminant Function, Supervised, Unsupervised, Semi-supervised

Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA, and non-parametric methods.

Module 6:

Recent trends in Activity Recognition, computational photography, and Biometrics

Total: 48 Hrs

Textbooks:

1. Computer Vision: Algorithms and Applications by Richard Szeliski.

Reference Books:

1. Deep Learning, by Goodfellow, Bengio, and Courville.
2. Dictionary of Computer Vision and Image Processing, by Fisher et al.

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: GPU COMPUTING

Course Code: CS531

Credits: L:T:P:C: :3:0:0:3

Course Objective: To learn parallel programming with Graphic Processing Unit (GPUs)

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Students would learn concepts in parallel programming, implementation of programs on GPUs, debugging and profiling parallel programs

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	3	3	3	3	2	1	1	2	1

Course Contents:

Module 1:

Introduction: History, Graphics Processors, Graphics Processing Units, GPGPUs.

Clock speeds, CPU / GPU comparisons, Heterogeneity, Accelerators, Parallel programming, CUDA OpenCL / OpenACC, Hello World Computation Kernels, Launch parameters, Thread hierarchy, Warps /Wavefronts, Thread blocks / Workgroups, Streaming multiprocessors, 1D / 2D /3D thread mapping, Device properties, Simple Programs

Module 2:

Memory: Memory hierarchy, DRAM / global, local / shared, private / local, textures, Constant Memory, Pointers, Parameter Passing, Arrays and dynamic Memory, Multi-dimensional Arrays, Memory Allocation, Memory copying across devices, Programs with matrices, Performance evaluation with different memories

Module 3:

Synchronization: Memory Consistency, Barriers (local versus global), Atomics, Memory fence. Prefix sum, Reduction. Programs for concurrent Data Structures such as Worklists, Linked-lists. Synchronization across CPU and GPU

Functions: Device functions, Host functions, Kernels functions, Using libraries (such as Thrust), and developing libraries.

Module 4:

Support: Debugging GPU Programs. Profiling, Profile tools, Performance aspects

Streams: Asynchronous processing, tasks, Task-dependence, overlapped data transfers, Default Stream, Synchronization with streams. Events, Event-based-Synchronization - Overlapping data transfer and kernel execution, pitfalls.

Module 5:

Case Studies: Image Processing, Graph algorithms, Simulations, Deep Learning

Module 6:

Advanced topics: Dynamic parallelism, Unified Virtual Memory, Multi-GPU processing, Peer access, Heterogeneous processing

Total: 48 Hrs.

Textbooks:

1. Programming Massively Parallel Processors: A Hands-on Approach; David Kirk, Wen-mei Hwu; Morgan Kaufman; 2010

Reference Books:

1. CUDA Programming: A Developer's Guide to Parallel Computing with GPUs; Shane Cook; Morgan Kaufman; 2012

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: DIGITAL FORENSICS

Course Code:CS532

Credits: L:T:P:C : 3:0:0:3

Course Objective: Provides an in-depth study of the rapidly changing and fascinating field of computer forensics. Combines both the technical expertise and the knowledge required to investigate, detect and prevent digital crimes. Knowledge on digital forensics legislations, digital crime, forensics processes and procedures, data acquisition and validation, e-discovery tools. E-evidence collection and preservation, investigating operating systems and file systems, network forensics, art of steganography and mobile device forensics

Course Learning Outcomes:

After completion of the course, students would be able to:

CLO1: Computer forensics, digital detective and various processes, policies and procedures

CLO2: E-discovery, guidelines and standards, E-evidence, tools and environment.

CLO3: Email and web forensics and network forensics.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	1	2	2	2	1	3	2	2	2
CLO2	1	2	2	3	2	1	3	3	2	3
CLO3	3	2	3	3	3	2	2	2	1	2

Course Contents:

Module 1:

Digital Forensics Science: Forensics science, computer forensics, and digital forensics.

Computer Crime: Criminalistics as it relates to the investigative process, analysis of cyber-criminalistics area, holistic approach to cyber-forensics

Module 2:

Cyber Crime Scene Analysis: Discuss the various court orders etc., methods to search and seizure electronic evidence, retrieved and un-retrieved communications,

Discuss the importance of understanding what court documents would be required for a criminal investigation.

Module 3:

Evidence Management & Presentation: Create and manage shared folders using operating system, importance of the forensic mindset, define the workload of law enforcement, explain what the normal case would look like, define who should be notified of a crime, parts of gathering evidence, Define and apply probable cause.

Module 4:

Computer Forensics: Prepare a case, begin an investigation, understand computer forensics workstations and software, conduct an investigation, complete a case, Critique a case

Network Forensics: open-source security tools for network forensic analysis, requirements for preservation of network data.

Module 5:**Legal Aspects of Digital Forensics:**

Legacy Foundations: IT Act 2000 and its amendments (IT Act 2008); electronic governance and statutory penalties.

Substantive Cyber Crimes under Bharatiya Nyaya Sanhita (BNS): Definition of digital/movable property; data theft, unauthorized extraction, and criminal breach of trust; cyber-terrorism and organized cybercrime syndicates; forensics of digital misinformation, deepfakes, and identity offenses.

Procedural Mandates under Bharatiya Nagarik Suraksha Sanhita (BNSS): Statutory roles of forensic experts; mandatory forensic collection for severe offenses; legal frameworks for the search, seizure, and isolation of hardware, digital storage, and cloud assets; mandatory audiovisual recording protocols during scene-of-crime operations.

Admissibility of Electronic Evidence under Bharatiya Sakshya Adhinyam (BSA): Primary vs. Secondary digital records; mathematical integrity of electronic footprints and hash-value verification; criteria and compliance for generating statutory electronic certificates; cross-border data challenges and chain-of-custody documentation.

Module 6:

Mobile Forensics: mobile forensics techniques, mobile forensics tools.

Recent trends in mobile forensic techniques and methods for search and seizure electronic evidence

Total: 48 Hrs

Textbooks:

- 1 John Sammons, The Basics of Digital Forensics, Elsevier

Reference Books:

1. John Vacca, Computer Forensics: Computer Crime Scene Investigation, Laxmi Publications

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: INTRUSION DETECTION

Course Code: CS533

Credits: L:T:P:C: :3:0:0:3

Course Objective: Compare alternative tools and approaches for Intrusion Detection through quantitative analysis to determine the best tool or approach to reduce risk from intrusion. Identify and describe the parts of all intrusion detection systems and characterize new and emerging IDS technologies according to the basic capabilities all intrusion detection systems share.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Apply knowledge of the fundamentals and history of Intrusion Detection in order to avoid common pitfalls in the creation and evaluation of new Intrusion Detection Systems. Evaluate the security an enterprise and appropriately apply Intrusion Detection tools and techniques in order to improve their security posture

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	3	3	2	1	2	-	2	2

Course Contents:

Module 1:

The state of threats against computers, and networked systems-Overview of computer security solutions and why they fail-Vulnerability assessment, firewalls, VPN's -Overview of Intrusion Detection and Intrusion Prevention-Network and Host-based IDS

Module 2:

Classes of attacks - Network layer: scans, denial of service, penetration-
Application layer: software exploits, code injection-Human layer: identity theft, root access-Classes of attackers-Kids/hackers/sop
Hesitated groups-Automated: Drones, Worms, Viruses

Module 3:

A General IDS model and taxonomy, Signature-based Solutions, Snort, Snort rules, Evaluation of IDS, Cost sensitive IDS

Module 4:

Anomaly Detection Systems and Algorithms-Network Behaviour Based Anomaly Detectors (rate based)-Host-based Anomaly Detectors-Software Vulnerabilities- State transition, Immunology, Payload Anomaly Detection

Module 5:

Attack trees and Correlation of alerts-Autopsy of Worms and Botnets-Malware Detection-Obfuscation, polymorphism-Document vectors

Module 6:

Email/IM security issues-Viruses/Spam-From signatures to thumbprints to zero-day detection-Insider Threat Issues-Taxonomy-Masquerade and Impersonation- Traitors, Decoys and Deception-Future: Collaborative Security

Total: 48 Hrs

Textbooks:

1. The Art of Computer Virus Research and Defense, Peter Szor, Symantec Press ISBN 0-321- 30545-3
2. Crimeware, Understanding New Attacks and Defenses, Markus Jakobsson and Zulfikar Ramzan, Symantec Press, ISBN: 978-0-321-50195-0 2008

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: NETWORK SECURITY

Course Code: CS534

Credits: L:T:P:C::3:0:0:3

Course Objective:

- To learn the basics of security and various types of security issues.
- To study different cryptography techniques available and various security attacks.
- Explore network security and how they are implemented in real world.
- To get an insight of various issues of Web security and biometric authentication.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- CLO1:** To have an understanding of the basics of security and issues related to it.
- CLO2:** Understanding of biometric techniques available
- CLO3:** How the biometric techniques are used in today's world.
- CLO4:** Security issues in web and how to tackle them.
- CLO5:** Learn mechanisms for transport and network security

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	1	2	1	1	2	1	2	2
CLO2	2	2	1	2	2	1	2	1	2	2
CLO3	2	2	2	2	1	1	3	2	2	3
CLO4	2	3	2	3	2	1	3	2	2	3
CLO5	3	3	2	3	2	1	2	1	2	3

Course Contents:

Module 1:

Data security: Review of cryptography. Examples RSA, DES, ECC.

Module 2:

Authentication, non-repudiation and message integrity. Digital signatures and certificates. Protocols using cryptography (example Kerberos). Attacks on protocols

Module 3:

Network security: Firewalls, Proxy-Servers, Network intrusion detection.

Transport security: Mechanisms of TLS, SSL, IPSec.

Module 4:

Web security – SQL injection, XSS, etc. Software security and buffer overflow. Malware types and case studies. Access Control, firewalls and host/network intrusion detection.

Module 5:

Other topics: Biometric authentication, Secure E-Commerce (ex. SET), Smart Cards, Security in Wireless Communication.

Module 6:

Recent trends in IOT security, IDS and Biometric.

Total: 48 Hrs

Textbooks:

1. W. R. Cheswick and S. M. Bellovin. Firewalls and Internet Security. Addison Wesley, 1994.
2. W. Stallings. Cryptography and Network Security. Prentice Hall, 1999.

Reference Books:

- 1 B. Schneier. Applied Cryptography. Wiley, 1999.

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: ETHICAL HACKING

Course Code: CS535

Credits: L:T:P:C : 3:0:0:3

Course Objective: Introduces the concepts of Ethical Hacking and gives the students the opportunity to learn about different tools and techniques in Ethical Hacking and security, and practically apply some of the tools.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- CLO1:** Understand the core concepts related to malware, hardware and software vulnerabilities and their causes
- CLO2:** Understand the ethics behind hacking and vulnerability disclosure
- CLO3:** Appreciate the Cyber Laws and the impact of hacking
- CLO4:** Exploit the vulnerabilities related to computer systems and networks using state-of-the-art tools and technologies

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	1	2	2	1	2	1	2	2
CLO2	2	1	1	1	1	1	3	2	2	3
CLO3	2	1	1	1	1	1	3	2	2	3
CLO4	2	3	3	3	3	2	3	2	2	3

Course Contents:

Module 1:

Introduction to Ethical Disclosure: Ethics of Ethical Hacking, Ethical Hacking and the legal system, Proper and Ethical Disclosure

Module 2:

Penetration Testing and Tools: Using Metasploit, Using BackTrackLiveCD, Linux Distribution

Module 3:

Vulnerability Analysis: Passive Analysis, Advanced Static Analysis with IDA Pro, Advanced Reverse Engineering

Module 4:

Client-side browser exploits, Exploiting Windows Access Control Model for Local Elevation Privilege, Intelligent Fuzzing with Sulley, From Vulnerability to Exploit

Module 5:

Malware Analysis: Collecting Malware and Initial Analysis, Hacking Malware

Module 6:**Advanced Topics**

Case study of vulnerability of cloud platforms and mobile platforms & devices.

Total: 48 Hrs.

Textbooks:

1. Shon Harris, Allen Harper, Chris Eagle and Jonathan Ness, Gray Hat Hacking: The Ethical Hackers' Handbook, TMH Edition
2. Jon Erickson, Hacking: The Art of Exploitation, SPD

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: ADVANCED WIRELESS AND MOBILE NETWORKS

Course Code: CS536

Credits: L:T:P:C : 3:0:0:3

Course Objective: The students should get familiar with the wireless/mobile market and the future needs and challenges.

To get familiar with key concepts of wireless networks, standards, technologies and their basic operations

To learn how to design and analyse various medium access

To learn how to evaluate MAC and network protocols using network simulation software tools. The students should get familiar with the wireless/mobile market and the future needs and challenges.

Course Learning Outcomes:

After completion of the course, students would be able to:

CLO1: Demonstrate advanced knowledge of networking and wireless networking and understand various types of wireless networks, standards, operations and use cases. Be able to design WLAN, WPAN, WWAN, Cellular based upon underlying propagation and performance analysis.

CLO2: Demonstrate knowledge of protocols used in wireless networks and learn simulating wireless networks.

CLO3 Design wireless networks exploring trade-offs between wire line and wireless links.

CLO4 Develop mobile applications to solve some of the real-world problems.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	3	2	2	-	-	-	1	2
CLO2	2	2	2	3	2	1	-	-	2	-
CLO3	2	3	3	2	2	-	-	-	1	1
CLO4	1	3	3	3	1	2	-	1	2	2

Course Contents:

Module 1:

Introduction:

Wireless Networking Trends, Key Wireless Physical Layer Concepts, Multiple Access Technologies -CDMA, FDMA, TDMA, Spread Spectrum technologies, Frequency reuse, Radio Propagation and Modelling, Challenges in Mobile Computing: Resource poorness, Bandwidth, energy etc.

Wireless Local Area Networks:

IEEE 802.11 Wireless LANs Physical & MAC layer, 802.11 MAC Modes (DCF & PCF)
IEEE 802.11 standards, Architecture & protocols, Infrastructure vs. Adhoc Modes, Hidden

Node & Exposed Terminal Problem, Problems, Fading Effects in Indoor and outdoor WLANs, WLAN Deployment issues

Module 2:

Wireless Cellular Networks:

1G and 2G, 2.5G, 3G, and 4G, Mobile IPv4, Mobile IPv6, TCP over Wireless Networks, Cellular architecture, Frequency reuse, Channel assignment strategies, Handoff strategies, Interference and system capacity, improving coverage and capacity in cellular systems, Spread spectrum Technologies.

Module 3:

WiMAX (Physical layer, Media access control, Mobility and Networking), IEEE 802.22 Wireless Regional Area Networks, IEEE 802.21 Media Independent Handover Overview

Wireless Sensor Networks

Introduction, Application, Physical, MAC layer and Network Layer, Power Management, Tiny OS Overview.

Module 4:

Wireless Pans

Bluetooth AND Zigbee, Introduction to Wireless Sensors.

Module 5:

Security

Security in wireless Networks Vulnerabilities, Security techniques, Wi-Fi Security, DoS in wireless communication.

Module 6:

Advanced Topics

IEEE 802.11x and IEEE 802.11i standards, Introduction to Vehicular Adhoc Networks

Total: 48 Hrs

Textbooks:

1. Schiller J., Mobile Communications, Addison Wesley 2000
2. Stallings W., Wireless Communications and Networks, Pearson Education 2005

Reference Books:

1. Stojmenic Ivan, Handbook of Wireless Networks and Mobile Computing, John Wiley and Sons
2. Inc 2002
3. Yi Bing Lin and Imrich Chlamtac, Wireless and Mobile Network Architectures, John Wiley and
4. Sons Inc 2000
5. Pandya Raj, Mobile and Personal Communications Systems and Services, PHI 200

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: MALWARE ANALYSIS AND REVERSE ENGINEERING

Course Code: CS537

Credits: L:T:P:C : 3:0:0:3

Course Objective: The objective of this course is to provide an insight to fundamentals of malware analysis which includes analysis of JIT compilers for malware detection in legitimate code. DNS filtering and reverse engineering is included.

Course Learning Outcomes:

On completion of the course the student should be able to:

CLO1: To understand the concept of malware and reverse engineering.

CLO2: Implement tools and techniques of malware analysis.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	2	2	2	1	2	1	2	2
CLO2	2	3	3	3	3	2	3	2	2	3

Course Contents:

Module 1:

Malware Forensics

Fundamentals of Malware Analysis (MA), Reverse Engineering Malware (REM) Methodology, Brief Overview of Malware analysis lab setup and configuration, Introduction to key MA tools and techniques, Behavioural Analysis vs. Code Analysis, Resources for Reverse-Engineering Malware (REM) Understanding Malware Threats, Malware indicators, Malware Classification, Examining Clam AV Signatures, Creating Custom Clam AV Databases, Using YARA to Detect Malware Capabilities, Creating a Controlled and Isolated Laboratory, Introduction to MA Sandboxes, Ubuntu, Zeltser's REMnux, SANS SIFT, Sandbox Setup and Configuration New Course Form, Routing TCP/IP Connections, Capturing and Analysing Network Traffic, Internet simulation using INetSim, Using Deep Freeze to Preserve Physical Systems, Using FOG for Cloning and Imaging Disks, Using MySQL Database to Automate FOG Tasks, Introduction to Python, Introduction to x86 Intel assembly language, Scanners: Virus Total, Jotti, and No Virus Thanks, Analysers: Threat Expert, CWSandbox, Anubis, Joebox, Dynamic Analysis Tools: Process Monitor, Regshot, HandleDiff, Analysis Automation Tools: Virtual Box, VM Ware, Python, Other Analysis Tools.

Module 2:

Malware and Kernel Debugging

Using TSK for Network and Host Discoveries, Using Microsoft Offline API to Registry Discoveries, Identifying Packers using PEiD, Registry Forensics with Reg Ripper Plugins, Bypassing Poison Ivy's Locked Files, Bypassing Conficker's File System ACL Restrictions, Detecting Rogue PKI Certificates.

Module 3:

Opening and Attaching to Processes, Configuration of JIT Debugger for Shellcode Analysis, Controlling Program Execution, Setting and Catching Breakpoints, Debugging with Python Scripts and Py Commands, DLL Export Enumeration, Execution, and Debugging, debugging a VMware Workstation Guest (on Windows), Debugging a Parallels Guest (on Mac OS X). Introduction to WinDbg Commands and Controls, Detecting Rootkits with WinDbgScripts, Kernel Debugging with IDA Pro.

Module 4:**Memory Forensics and Volatility**

Memory Dumping with MoonSols Windows Memory Toolkit, Accessing VM Memory Files Overview of Volatility, Investigating Processes in Memory Dumps, Code Injection and Extraction, Detecting and Capturing Suspicious Loaded DLLs, Finding Artifacts in Process Memory, Identifying Injected Code with Malfind and YARA.

Module 5:**Researching and Mapping Source Domains/Ips**

Using WHOIS to Research Domains, DNS Hostname Resolution, Querying Passive DNS, Checking DNS Records, Reverse IP Search New Course Form, Creating Static Maps, Creating Interactive Maps.

Module 6:

Case study of Finding Artifacts in Process Memory, Identifying Injected Code with Malfind and YARA.

Total: 48 Hrs

Textbooks:

1. Michael Sikorski, Andrew Honig "Practical Malware Analysis: The Hands-On Guide to Dissecting

Reference Books:

1. Malicious Software" publisher Williampollock

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: SMART SENSORS AND INTERNET OF THINGS

Course Code: CS538

Credits: L:T:P:C : 3:0:0:3

Course Objective: Able to understand the application areas of IOT, able to realize the revolution of Internet in Mobile Devices, Cloud & Sensor Networks, able to understand building blocks of Internet of Things and characteristics.

Course Learning Outcomes:

After completion of the course, students would be able to:

- CLO1:** Understand the vision of IoT from a global context.
- CLO2:** Determine the Market perspective of IoT.
- CLO3:** Use of Devices, Gateways and Data Management in IoT.
- CLO4:** Application of IoT in Industrial and Commercial Building Automation and Real-World Design Constraints.
- CLO5:** Building state of the art architecture in IoT.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	1	1	1	1	1	2	2	2	3
CLO2	1	2	2	1	1	1	2	2	2	3
CLO3	2	3	2	3	2	2	2	2	2	2
CLO4	2	3	3	3	2	2	3	2	2	3
CLO5	3	3	3	3	3	2	2	2	2	3

Course Contents:

Module 1:

Environmental Parameters Measurement and Monitoring: Why measurement and monitoring are important, effects of adverse parameters for the living being for IOT

Module 2:

Sensors: Working Principles: Different types; Selection of Sensors for Practical Applications Introduction of Different Types of Sensors such as Capacitive, Resistive, Surface Acoustic Wave for Temperature, Pressure, Humidity, Toxic Gas etc

Module 3:

Important Characteristics of Sensors: Determination of the Characteristics Fractional order element, Constant Phase Impedance for sensing applications such as humidity, water quality, milk quality Impedance Spectroscopy: Equivalent circuit of Sensors and Modelling of Sensors Importance and Adoption of Smart Sensors

Module 4:

Architecture of Smart Sensors: Important components, their features Fabrication of Sensor and Smart Sensor: Electrode fabrication: Screen printing, Photolithography, Electroplating Sensing film deposition: Physical and chemical Vapor, Anodization, Sol-gel

Module 5:

Interface Electronic Circuit for Smart Sensors and Challenges for Interfacing the Smart Sensor, Usefulness of Silicon Technology in Smart Sensor and Future scope of research in smart sensor

Module 6:

Recent trends in smart sensor for day-to-day life, evolving sensors and their architecture.

Total: 48 Hrs

Textbooks:

1. Yasuura, H., Kyung, C.-M., Liu, Y., Lin, Y.-L., Smart Sensors at the IoT Frontier, Springer International Publishing

Reference Books:

1. Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensors and Systems, Springer International Publishing

Manipur Technical University
MTech in Computer Science and Engineering

Course Title: DISTRIBUTED DATABASE

Course Code:CS539

Credits: L:T:P:C : 3:0:0:3

Course Objective: The objective of course is to provide insight to distributed database, normalization techniques and integrity rules. It also includes parallel database systems along with object-oriented models.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Able to understand relational database management systems,

CLO2: Normalization to make efficient retrieval from database and query.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	2	2	1	1	1	1	2	2
CLO2	3	3	3	2	2	1	1	1	2	2

Course Contents:

Module 1:

Introduction: Distributed Data processing, Distributed database system (DDBMS), Promises of DDBMSs, Complicating factors and Problem areas in DDBMSs, Overview Of Relational DBMS Relational Database concepts, Normalization, Integrity rules, Relational Data Languages, Relational DBMS.

Module 2:

Distributed DBMS Architecture: DBMS Standardization, Architectural models for Distributed DBMS, Distributed DBMS Architecture. Distributed Database Design: Alternative design Strategies, Distribution design issues, Fragmentation, Allocation. Semantic Data Control: View Management, Data security, Semantic Integrity Control.

Module 3:

Overview of Query Processing: Query processing problem, Objectives of Query Processing, Complexity of Relational Algebra operations, characterization of Query processors, Layers of Query Processing.

Introduction to Transaction Management: Definition of Transaction, Properties of transaction, types of transaction. Distributed Concurrency Control: Serializability theory, Taxonomy of concurrency control mechanisms, locking bases concurrency control algorithms.

Module 4:

Parallel Database Systems: Database servers, Parallel architecture, Parallel DBMS techniques, Parallel execution problems, Parallel execution for hierarchical architecture.

Module 5:

Distributed Object Database Management systems: Fundamental Object concepts and Object models, Object distribution design. Architectural issues, Object management, Distributed object storage, Object query processing. Transaction management. Database Interoperability: Database Integration, Query processing.

Module 6:

Recent approaches, models and current trends in improving the performance of Distributed Database.

Total: 48Hrs

Textbooks:

1. Principles of Distributed Database Systems, Second Edition, M. Tamer Ozsu
Patrick Valduriez
2. Distributed Databases principles and systems, Stefano Ceri, Giuseppe Pelagatti,
Tata McGraw Hill.

Manipur Technical University
MTech in Computer Science and Engineering

Course Title: ADVANCED MACHINE LEARNING

Course Code:CS540

Credits: L:T:P:C::3:0:0:3

Course Objective:

- To introduce key concepts in pattern recognition and machine learning, including specific algorithms for classification, regression, clustering and probabilistic modelling.
- To give a broad view of the general issues arising in the application of algorithms to analysing data, common terms used, and common errors made if applied incorrectly.
- To demonstrate a toolbox of techniques that can be immediately applied to real world problems, or used as a basis for future research into the topic.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- CLO1:** Key concepts, tools and approaches for pattern recognition on complex data sets
- CLO2:** Kernel methods for handling high-dimensional and non-linear patterns
- CLO3:** State-of-the-art algorithms such as Support Vector Machines and Bayesian networks.
- CLO4:** Solve real-world machine learning tasks: from data to inference
- CLO5:** Theoretical concepts and the motivations behind different learning frameworks

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	1	2	1	–	–	–	2	1
CLO2	2	3	2	3	2	–	–	–	2	1
CLO3	2	3	3	3	2	–	–	–	2	1
CLO4	2	3	3	3	3	2	–	1	2	2
CLO5	3	2	1	2	3	–	–	–	3	1

Course Contents:

Module 1:

Key concepts, Supervised/Unsupervised Learning, Loss functions and generalization, Probability Theory, Parametric vs non-parametric methods, Elements of Computational Learning Theory Ensemble Learning, Bagging, Boosting, Random Forest

Module 2:

Kernel Methods for non-linear data, Support Vector Machines, Kernel Ridge Regression, Structure Kernels, Kernel PCA, Latent Semantic Analysis

Module 3:

Bayesian methods for using prior knowledge and data, Bayesian inference, Bayesian Belief Networks and Graphical models, Probabilistic Latent Semantic Analysis, The Expectation-Maximisation (EM) algorithm, Gaussian Processes

Module 4:

Dimensionality Reduction - CCA, LDA, ICA, NMF – Canonical Variates - Feature Selection vs Feature Extraction

Module 5:

Filter Methods - Sub-space approaches - Embedded methods Low-Rank approaches - Recommender Systems. Application areas - Security - Business – Scientific

Module 6:

Recent trends in supervised and unsupervised learning algorithm, dimensional reducibility, feature selection and extraction

Total: 48 Hrs

Textbooks:

1. Christopher M. Bishop, Pattern Recognition and Machine Learning.

Reference Books:

1. John Shawe-Taylor and Nello Cristianini, Kernel Methods for Pattern Analysis.

PROGRAMME ELECTIVE-IV

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: QUANTUM COMPUTING

Course Code:CS541

Credits: L:T:P:C::3:0:0:3

Course Objective:

The course will provide an insight of basic of quantum physics from a computer scientist's perspective, and how it describes reality and understands the philosophical implications of quantum computing

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: knowledge of Vector spaces, Matrices, Quantum state, Density operator and Quantum Measurement theory.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	3	3	2	3	1	1	1	2	1

Course Contents:

Module 1:

Qubit & Quantum States: The Qubit, Vector Spaces. Linear Combination of Vectors, Uniqueness of a spanning set, basis & dimensions, inner Products, orthonormality, Gram-Schmidt orthogonalization, bra-ket formalism, the Cauchy-schwarz and triangle Inequalities.

Module 2:

Matrices & Operators: Observables, The Pauli Operators, Outer Products, The Closure Relation, Representation of operators using matrices, outer products & matrix representation, matrix representation of operators in two-dimensional spaces, Pauli Matrix, Hermitian unitary and normal operator, Eigen values & Eigen Vectors, Spectral Decomposition, Trace of an operator, important properties of Trace, Expectation Value of Operator, Projection Operator, Positive Operators,

Module 3:

Commutator Algebra, Heisenberg uncertainty principle, polar decomposition & singular values, Postulates of Quantum Mechanics.

Module 4:

Tensor Products: Representing Composite States in Quantum Mechanics, Computing inner products, Tensor products of column vectors, operators and tensor products of Matrices.

Density Operator: Density Operator of Pure & Mix state, Key Properties, Characterizing Mixed State, Practical Trace & Reduce Density Operator, Density Operator & Bloch Vector.

Module 5:

Quantum Measurement Theory: Distinguishing Quantum states & Measures, Projective Measurements, Measurement on Composite systems, Generalised Measurements, Positive Operator- Valued Measures.

Module 6:

Recent trends in Quantum Computing Research, Quantum Computing Applications of Genetic Programming.

Total: 48Hrs

Textbooks:

1. An Introduction to Quantum Computing Phillip Kaye, Raymond Laflamme, Michele Mosca

Reference Books:

1. Quantum Computing without Magic by Zdzislaw Meglicki
2. Quantum Computing Explained By DAVID Mc MAHON
3. Quantum Computer Science By Marco Lanzagorta, Jeffrey Uhlmann

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: DNA COMPUTING

Course Code: CS542

Credits: L:T:P:C::3:0:0:3

Course Objective:

The course aims to provide an introduction to DNA computing and the mathematical theory involved in DNA computing

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Familiar with DNA sequence matching algorithms. Parallelism in DNA computing algorithms

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	3	3	2	3	1	1	1	2	2

Course Contents:

Module 1:

Introduction: DNA Structure, Sequence and Processing of DNA Introduction to molecular computing

Module 2:

Mathematical Theory: Mathematical Theory of DNA Computing;

Module 3:

Introduction to language theory, Sticker systems

Module 4:

Parallelism of DNA strands; Watson Crick Automata; Insertion-Deletion Systems; Splicing circular strings

Module 5:

Distributed H Systems, Splicing revisited.

Module 6:

Recent trends and applications of DNA Computing in computer networks.

Total: 48 Hrs

Textbooks:

1. DNA Computing by Paun, Gheorghe, Rozenberg, Grzegorz, Salomaa, Arto; Springer publication

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: PARALLEL ALGORITHMS

Course Code:CS543

Credits: L:T:P:C::3:0:0:3

Course Objective:

The course focuses on an alternative to the sequential model, parallel algorithm performance measure, and application of parallel algorithms in different domains.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: know about parallel computing model PRAM, LMCC, etc., efficiency of parallel algorithms, parallel sorting network, parallel search algorithm, Permutation, graph algorithm, combinations.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	3	3	2	3	1	1	1	2	1

Course Contents:

Module 1:

Sequential model, need of alternative model, parallel computational models such as PRAM, LMCC, Hypercube, Cube Connected Cycle, Butterfly, Perfect Shuffle Computers, Tree model, Pyramid model, Fully Connected model, PRAMCREW, EREW models, simulation of one model from another one.

Module 2:

Performance Measures of Parallel Algorithms, speed-up and efficiency of PA, Cost optimality, an example of illustrate Cost-optimal algorithms- such as summation, Min/Max on various models.

Module 3:

Parallel Sorting Networks, Parallel Merging Algorithms on CREW/EREW/MCC/, Parallel Sorting Networks on CREW/EREW/MCC/, linear array

Module 4:

Parallel Searching Algorithm, Kth element, Kth element in X+Y on PRAM, Parallel Matrix Transportation and Multiplication Algorithm on PRAM, MCC, Vector- Matrix Multiplication, Solution of Linear Equation, Root finding.

Module 5:

Graph Algorithms - Connected Graphs, search and traversal, Combinatorial Algorithms- Permutation, Combinations, Derangements.

Module 6:

Case study of parallel sorting networks, which include CREW, EREW and their performance analysis for various problems.

Total: 48Hrs.

Textbooks:

1. Designing Efficient Algorithms for Parallel Computers by M.J. Quinn, McGraw Hill.
2. Design and Analysis of Parallel Algorithms by S.G. Akl

Reference Books:

1. Parallel Sorting Algorithm” by S.G. Akl, Academic Press

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: CONCURRENCE, PARALLELISM AND DISTRIBUTED SYSTEM

Course Code: CS544

Credits: L:T:P:C::3:0:0:3

Course Objective:

This course will cover the basic concept of distributed system, architecture of distributed system, distributed object models, communication between distributed system, The concept of synchronization, agreement, distributed transaction, parallel processing

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: At the end of course the student will know about challenges faced while designing distributed system, architectural, fundamental and security model of distributed system, Remote Method Invocation, Remote Procedure Call, Event Notification system, fragmentation, Commit Protocols, Locking Scheme, Distributed Deadlock and Parallel system design and query

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	3	3	2	3	2	2	2	2	2

Course Contents:

Module 1:

Fundamentals of Distributed Computing: Architectural models for distributed and mobile computing systems, Basic concepts in distributed computing.

Distributed Operating Systems: Overview, network operating systems, Distributed file systems, Middleware, client/server model for computing.

Module 2:

Communication: Layered protocols, RPC, RMI, Remote objects. Basic Algorithms in Message Passing Systems, Leader Election in Rings, and Mutual Exclusion in Shared Memory, Message Passing, PVM and MPI.

Module 3:

Process Concepts: Threads, Clients and Servers, Code migration, Agent based Synchronization: Clock synchronization, Logical clocks, Election algorithms, Mutual exclusion, Distributed transactions, Naming concepts, Security in distributed systems, Distributed objects, CORBA, Distributed COM

Module 4:

Distributed Databases: Distributed Data Storage, Fragmentation & Replication, Transparency, Distributed Query Processing and Optimization, Distributed Transaction Modelling and concurrency Control, Distributed Deadlock, Commit Protocols.

Module 5:

Parallel Processing: Basic Concepts: Introduction to parallel processing, Parallel processing terminology, Design of parallel algorithms, Design of Parallel Databases, Parallel Query Evaluation.

Module 6:

Recent trends in multiprocessor and distributed operating systems designs. Case study of parallel algorithms and optimization techniques.

Total: 48 hrs.

Textbooks:

1. Distributed Systems, Principles and Paradigm by Tannenbaum, A, Maarten Van Steen, Prentice Hall India, 2002
2. Distributed Systems by Coulouris, Dollimore and Kindberg, Pearson, 2009.

Reference Books:

1. Fundamentals of Database Systems”, 4th Edition by Elmars, Navathe, Somayajulu, Gupta Pearson Education, 2007
2. Modern Operating Systems 2nd Edition by Tanenbaum, A Prentice Hall India, 2001.

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: OPTIMIZATION TECHNIQUES

Course Code: CS545

Credits: L:T:P:C: :3:0:0:3

Course Objective: The objective of this course is to provide insight to the mathematical formulation of real-world problems. To optimize these mathematical problems using nature-based algorithms. And the solution is useful specially for NP-Hard problems.

Course Learning Outcomes:

After completion of the course, students would be able to:

CLO1: Formulate optimization problems.

CLO2: Understand and apply the concept of optimality criteria for various types of optimization problems.

CLO3 Solve various constrained and unconstrained problems in single and multivariable.

CLO4 Apply the methods of optimization in a real-life situation.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	2	-	-	-	-	-	2	2
CLO2	3	3	2	2	2	-	-	-	2	-
CLO3	2	3	3	3	2	-	-	-	2	-
CLO4	2	3	3	2	2	2	-	2	3	3

Course Contents:

Module 1:

Engineering application of Optimization, Formulation of design problems as mathematical programming problems.

Module 2:

General Structure of Optimization Algorithms, Constraints, The Feasible Region.

Module 3:

Branches of Mathematical Programming: Optimization using calculus, Graphical Optimization, Linear Programming, Quadratic Programming, Integer Programming, Semi Definite Programming.

Module 4:

Optimization Algorithms like Genetic Optimization, Particle Swarm Optimization, Ant Colony Optimization etc.

Module 5:

Real life Problems and their mathematical formulation as standard programming problems.

Module 6:

Recent trends: Applications of ant colony optimization, genetics and linear and quadratic programming in real world applications.

Total: 48 Hrs

Textbooks:

1. Laurence A. Wolsey (1998). Integer programming. Wiley. ISBN 978-0-471-28366-9.
2. Practical Optimization Algorithms and Engineering Applications Andreas Antoniou.
3. An Introduction to Optimization Edwin K., P. Chong & Stanislaw h. Zak.
4. Dimitris Bertsimas; Robert Weismantel (2005). Optimization over integers. Dynamic Ideas. ISBN 978-0-9759146-2-5.

Reference Books:

1. John K. Karlof (2006). Integer programming: theory and practice. CRC Press. ISBN 978-0-8493-1914-3.
2. H. Paul Williams (2009). Logic and Integer Programming. Springer. ISBN 978-0-387-92279-9.
3. Michael Jünger; Thomas M. Liebling; Denis Naddef; George Nemhauser; William R. Pulleyblank; Gerhard Reinelt; Giovanni Rinaldi; Laurence A. Wolsey, eds. (2009). 50 Years of Integer Programming 1958-2008: From the Early Years to the State-of-the- Art. Springer. ISBN 978-3-540-68274-5.
4. Der-San Chen; Robert G. Batson; Yu Dang (2010). Applied Integer Programming: Modeling and Solution. John Wiley and Sons. ISBN 978-0-470-37306-4.

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: IOT APPLICATIONS AND COMMUNICATION PROTOCOLS

Course Code: CS546
Credits: L:T:P:C::3:0:0:3

Course Objective:

- Basic introduction of all the elements of IoT-Mechanical, Electronics/sensor platform, Wireless and wireline protocols, Mobile to Electronics integration, Mobile to enterprise integration
- Open source/commercial electronics platform for IoT-Raspberry Pi, Arduino, ArmMbedLPC
- Open source /commercial enterprise cloud platform for IoT-Ayla, iO Bridge, Libellium, Axeda, Cisco fog cloud

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- CLO1:** To understand merging technological options, platforms and case studies of IoT implementation in home & city automation
- CLO2:** Determine the Market perspective of IoT.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	2	2	2	1	1	2	2	2	3
CLO2	1	2	2	1	1	1	2	2	2	3

Course Contents:

Module 1:

Basic function and architecture of a sensor — sensor body, sensor mechanism, sensor calibration, sensor maintenance, cost and pricing structure, legacy and modern sensor network.

Development of sensor electronics — IoT vs legacy, and open-source vs traditional PCB design style.

Development of sensor communication protocols, Protocols: Modbus, relay, Zigbee, Zwave, X10, Bluetooth, ANT, etc.

Business driver for sensor deployment — FDA/EPA regulation, fraud/tempering detection, supervision, quality control and process management.

Different kind of calibration Techniques: manual, automation, infield, primary and secondary calibration — and their implication in IoT.

Powering options for sensors: battery, solar, WiTricity, Mobile and PoE

Module 2:

Zigbee and Zwave — advantage of low power mesh networking. Long distance Zigbee. Introduction to different Zigbee chips.

Bluetooth/BLE: Low power vs high power, speed of detection, class of BLE.

Introduction of Bluetooth vendors & their review.

Wireless protocols such as Piconet and packet structure for BLE and Zigbee

Other long distance RF communication link.

LOS vs NLOS links, Capacity and throughput calculation

Application issues in wireless protocols: power consumption, reliability, PER, QoS, LOS

Module 3:

PCB vs FPGA vs ASIC design

Prototyping electronics vs Production electronics

QA certificate for IoT- CE/CSA/UL/IEC/RoHS/IP65

Basic introduction of multi-layer PCB design and its workflow

Electronics reliability-basic concept of FIT and early mortality rate

Environmental and reliability testing-basic concepts

Basic Open-source platforms: Arduino, Raspberry Pi, Beaglebone

Module 4:

Introduction to Mobile app platform for IoT: Protocol stack of Mobile

app for IoT, Mobile to server integration, iBeacon in iOS, Window Azure,

Linkafy Mobile platform for IoT, Axeda, Xively

Module 5:

Database implementation for IoT: Cloud based IoT platforms, SQL vs NoSQL, Open sourced vs. Licensed Database, Available M2M cloud platform, AxedaXively, Omega NovoTech, Ayla Libellium, CISCO M2M platform, AT &T M2M platform, Google M2M platform

Module 6:

Recent trends in home automation, IOT-locks, Energy optimization in home

Total: 48 Hrs

Textbooks:

1. Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key Applications and Protocols, Wiley-Blackwell.

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: IOT AND SMART CITIES

Course Code: CS547

Credits: L:T:P:C::3:0:0:3

Course Objective:

- Explain the basic methodologies and techniques of the arts and humanities, social sciences, business, and science and technology
- to describe the current practices and future trends of smart cities;
- Capacity of critique the current practice and provide recommendations.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- CLO1:** Understanding the fundamental knowledge of the sustainable and smart city
- CLO2:** Understand the technologies used for sustainable and smart cities
- CLO3:** Integrate and apply the learned knowledge to conduct a case study in an organised way
- CLO4:** Present the study clearly to audiences.
- CLO5:** Demonstration of critical thinking and discovery.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	2	1	1	1	1	2	2	2	3
CLO2	2	2	2	2	1	1	2	2	2	3
CLO3	2	3	3	2	2	2	2	3	2	3
CLO4	1	2	1	1	1	2	1	3	2	2
CLO5	2	3	2	1	2	1	2	2	3	2

Course Contents:

Module 1:

Introduction and Applications: smart transportation, smart cities, smart living, smart energy, smart health, and smart learning.

Module 2:

IoT Reference Architecture- methods to assist local governments to develop international good e-practice

Module 3:

Methods to redesign and redefine back and front offices in order to build smarter and transparent governments

Module 4:

Methods to design public mobile services aimed at efficiency, cost saving and participation with attention for e-inclusion

Module 5:

Methodologies for user involvement, profiling customers and identifying needs; test methodologies to transfer these needs in appropriate services; and test techniques to fit the right channel to the specific services and customers thereby setting a framework for a higher level of e-services in the NSR

Module 6:

Pilot new service channels, Bluetooth services for public transport, online forms in mobile phones and wireless city services

Total: 48 Hrs

Textbooks:

1. Smart City on Future Life - Scientific Planning and Construction by Xianyi Li.
2. The Age of Intelligent Cities: Smart Environments and Innovation-for-all Strategies (Regions and Cities) by Nicos Komninos.

Reference Books:

1. Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia by Anthony Townsend

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: SENSOR NETWORKS AND INTERNET OF THINGS

Course Code: CS548

Credits: L:T:P:C::3:0:0:3

Course Objective:

- The course gives an overview of various topics related to wireless sensor networks, which are expected to be the basis for the emerging Internet of Things.
- The course covers topics related to various subdisciplines of computer science such as hardware, operating systems, distributed systems, networking, security and databases.
- Able to understand wireless sensor network (WSN) specific issues, such as localization, time synchronization, and topology control, are addressed as well.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- CLO1:** Identify requirements from emerging WSN applications on WSN platforms, communication systems, protocols and middleware
- CLO2:** Understand, compare and evaluate communication and network protocols used in WSNs
- CLO3:** Discuss and evaluate mechanisms and algorithms for time synchronization and localization in WSNs
- CLO4:** Understand and discuss requirements for the design of security mechanisms to be used in WSNs
- CLO5:** Understand and discuss the requirements for the design of middleware systems to be used in WSNs

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	3	2	2	2	2	2	2	2	2
CLO2	3	3	2	2	3	1	1	1	2	1
CLO3	3	3	3	2	3	1	1	1	2	1
CLO4	2	3	3	2	3	2	3	2	2	3
CLO5	2	3	3	3	3	2	2	2	2	3

Course Contents:

Module 1:

Introduction and Applications: smart transportation, smart cities, smart living, smart energy, smart health, and smart learning. Examples of research areas include for instance: Self-Adaptive Systems, Cyber Physical Systems, Systems of Systems, Software Architectures and Connectors, Software Interoperability, Big Data and Big Data Mining, Privacy and Security

Module 2:

IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.

Real-World Design Constraints- Introduction, Technical Design constraints hardware, Data representation and visualization, Interaction and remote control.

Module 3:

Industrial Automation- Service-oriented architecture-based device integration, SOCRADES: realizing the enterprise integrated Web of Things, IMC-AESOP: from the Web of Things to the Cloud of Things, **Commercial Building Automation-** Introduction, Case study: phase one-commercial building automation today, Case study: phase two-commercial building automation in the future.

Module 4:

Hardware Platforms and Energy Consumption, Operating Systems, Time Synchronization, Positioning and Localization, Medium Access Control, Topology and Coverage Control, Routing: Transport Protocols, Network Security, Middleware, Databases

Module 5:

IOT Physical Devices & Endpoints: What is an IOT Device, Exemplary Device Board, Linux on Raspberry, Interface and Programming & IOT Device

Module 6:

Recent trends in sensor network and IOT architecture, Automation in Industrial aspect of IOT

Total: 48 Hrs

Textbooks:

1. Mandler, B., Barja, J., Mitre Campista, M.E., Cagá_ová, D., Chaouchi, H., Zeadally, S.Badra, M., Giordano, S., Fazio, M., Somov, A., Vieriu, R.-L., Internet of Things. IoT Infrastructures, Springer International Publishing

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: WIRELESS ACCESS TECHNOLOGIES

Course Code: CS549

Credits: L:T:P:C::3:0:0:3

Course Objective:

- Overview of wireless access technologies, Fixed wireless access networks. Terminal mobility issues regarding wireless access to Internet
- Introduction to various Network topologies, hotspot networks, Communication links: point-to-point, point-to-multipoint, multipoint-to-multipoint.
- To provide an overview of Standards for most frequently used wireless access networks: WPAN, UWB, WLAN, WMAN, WWAN. Network services. Wireless access networks planning, design and installation.
- To get an insight of Wireless networking security issues, Wireless access network exploitation and management, software requirements, link quality control.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- CLO1:** Interpret basic terms and characteristics of wireless access networks
- CLO2:** Compare various wireless access technologies
- CLO3:** Analyze measurements of wireless access network parameters
- CLO4:** Assess security issues in wireless networks
- CLO5:** Choose a modulation technique for wireless transmission

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	1	1	1	1	1	1	2	2
CLO2	2	3	2	2	2	1	1	1	2	2
CLO3	2	3	2	3	2	1	1	1	2	2
CLO4	2	2	2	2	2	1	3	2	2	3
CLO5	3	3	3	2	2	1	1	1	2	2

Course Contents:

Module 1:

Necessity for wireless terminals connectivity and networking. Wireless networking advantages and disadvantages, Overview of wireless access technologies. Narrowband and broadband networks, fixed and nomadic networks. Wireless local loop (WLL), Public Switched Telephone Network (PSTN) interfaces.

Module 2:

Fixed wireless access (FWA) networks, frequency bands for different networks. Criteria for frequency bands allocation, Network topologies, hotspot networks. Communication links: point-to-point (PTP), point-to-multipoint (PMP), multipoint-to-multipoint (MTM).

Module 3:

Standards for most frequently used wireless access networks: WPAN (802.15, Bluetooth, DECT, IrDA), UWB (Ultra-Wideband), WLAN (802.11, Wi-Fi, HIPERLAN, IrDA), WMAN (802.16, WiMAX, HIPERMAN, HIPERACCESS), WWAN (802.20), Other technologies for broadband wireless access, Local Multipoint Distribution Service (LMDS), Multichannel Multipoint Distribution Service (MMDS). Ad Hoc networks, Network services. Services types based on carrier frequency and bandwidth.

Module 4:

Wireless access networks planning, design and installation. Services provision, legislative and technical aspects, Technical and economic factors for network planning: expenses, coverage, link capacity, network complexity and carrier-to-interference ratio (C/I). Base station or access point allocation. Base station and access point equipment.

Terminal mobility issues regarding wireless access to Internet. Wireless networking security issues.

Module 5:

Example of laptop or handheld PC wireless connection in real environment. PC wireless interface equipment. Wireless access network exploitation and management, software requirements, link quality control.

Business model, wireless network services market, market research and marketing, service providers, wireless data application service providers (WDASP) and their role on public telecommunication services market, billing systems.

Module 6:

Recent trends in wireless networking and various access mechanisms, new standards of wireless communication.

Total: 48 Hrs

Textbooks:

1. M. P. Clark, Wireless Access Networks: Fixed Wireless Access and WLL Networks Design and Operation, John Wiley & Sons, Chichester

Reference Books:

1. D. H. Morais, Fixed Broadband Wireless Communications: Principles and Practical
 - a. Applications, Prentice Hall, Upper Saddle River
2. R. Pandya, Introduction to WLLs: Application and Deployment for Fixed and Broadband Services, IEEE Press, Piscataway

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: DATA ENCRYPTION & COMPRESSION

Course Code: CS550

Credits: L:T:P:C::3:0:0:3

Course Objective:

This course will cover the concept of security, types of attacks experienced, encryption and authentication for deal with attacks, what data compression is, the need and techniques of data compression

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: At the end of this course the student will have the knowledge of plaintext, cipher text, RSA and other cryptographic algorithm, Key Distribution, Communication Model, Various models for data compression

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	3	2	2	2	1	2	1	2	2

Course Contents:

Module 1:

Introduction to Security: Need for security, Security approaches, Principles of security, Types of attacks.

Encryption Techniques: Plaintext, Cipher text, Substitution & Transposition techniques, Encryption & Decryption, Types of attacks, Key range & Size.

Module 2:

Symmetric & Asymmetric Key Cryptography: Algorithm types & Modes, DES, IDEA, Differential & Linear Cryptanalysis, RSA, Symmetric & Asymmetric key together, Digital signature, Knapsack algorithm.

User Authentication Mechanism: Authentication basics, Passwords, Authentication tokens, Certificate based & Biometric authentication, Firewall

Module 3:

Case Studies of Cryptography: Denial of service attacks, IP spoofing attacks, Secure inter branch payment transactions, Conventional Encryption and Message Confidentiality, Conventional Encryption Principles, Conventional Encryption Algorithms, Location of Encryption Devices, Key Distribution.

Public Key Cryptography and Message Authentication: Approaches to Message Authentication, SHA-1, MD5, Public-Key Cryptography Principles, RSA, Digital, Signatures, Key Management.

Module 4:

Introduction: Need for data compression, Fundamental concept of data compression & coding, Communication model, Compression ratio, Requirements of data compression, Classification.

Methods of Data Compression: Data compression-- Loss less & Lossy

Module 5:

Entropy encoding-- Repetitive character encoding, run length encoding, Zero/Blank encoding; Statistical encoding-- Huffman, Arithmetic & Lempel-Ziv coding; Source encoding-- Vector quantization (Simple vector quantization & with error term); Differential encoding—Predictive coding, Differential pulse code modulation, Delta modulation, Adaptive differential pulse code modulation; Transform based coding

Module 6:

Recent trends in encryption and data compression techniques.

Total: 48 Hrs

Textbooks:

1. Cryptography and Network Security by B. Forouzan, McGraw-Hill.
2. The Data Compression Book by Nelson, BPB.

Reference Books:

1. Cryptography & Network Security by AtulKahate, TMH.

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: OPERATING SYSTEM DESIGN.

Course Code: CS551

Credits: L:T:P:C::3:0:0:3

Course Objective:

The objective of the course is to provide an introduction to operating system design and the concepts of processes, process lifecycle, and scheduling approaches.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Understanding advanced concepts in operating systems.

CLO2: Learning principles of Distributed and multiprocessor operating systems

CLO-PLO mapping matrix:

CLO/PL O	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO1 0
CLO1	3	2	2	2	2	1	1	1	2	1
CLO2	3	3	3	2	3	2	1	1	2	2

Course Contents:

Module 1:

Computer system and operating system overview, Operating system functions and design issues, Design approaches, Types of advanced operating systems

Module 2:

Process abstraction, Process management, system calls, Threads, Symmetric multiprocessing and micro-kernels.

Module 3:

Scheduling: Uniprocessor, Multiprocessor and Real time systems, concurrency, classical problems, mechanisms for synchronization: semaphores, monitors, Process deadlock and deadlock handling strategies

Module 4:

Memory management, Virtual memory concept, Virtual machines, I/O management, File and disk management, Operating system security.

Module 5:

Distributed Operating system: Architecture, Design issues, Distributed mutual exclusion, Distributed deadlock detection, shared memory, Distributed scheduling. Multiprocessor operating systems: architecture, operating system design issues, threads, process synchronization, process scheduling, memory management, reliability and fault tolerance.

Module 6:

Recent trends in Operating system design and their applicability to HPC.

Total: 48 Hrs.

Textbooks:

1. Advanced concept in operating system: M. Singhal, N.G. Shivratri
2. Operating system internal and design principles: William Stallings

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: SECURE CODING

Course Code:CS552

Credits: L:T:P:C : 3:0:0:3

Course Objective: Understand the basics of secure programming. Understand the most frequent programming errors leading to software vulnerabilities. Identify and analyse security problems in software. Understand and protect against security threats and software vulnerabilities. Effectively apply their knowledge to the construction of secure software systems

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: Write secure programs and identify various risk in the software.

CLO2: Eliminate security problems in the open-source software.

CLO3: Real-time software and vulnerabilities associated with it.

CLO4: Interrelate security and software engineering.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	3	3	2	1	-	3	-	2	2
CLO2	1	3	2	3	2	2	2	-	2	1
CLO3	3	2	3	2	2	-	1	-	1	2
CLO4	2	2	3	2	1	1	3	1	2	2

Course Contents:

Module 1:

Introduction to software security, managing software security risk, selecting software development technologies, An open source and closed source, Guiding principles for software security, Auditing software, Buffet overflows, Access control, Race conditions, Input validation, Password authentication

Module 2:

Anti-tampering, protecting against denial-of-service attack, Copy protection schemes, Client-side security, Database security, Applied cryptography, Randomness and determinism

Module 3:

Buffer Overrun, Format String Problems, Integer Overflow, and Software Security Fundamentals SQL Injection, Command Injection, Failure to Handle Errors, and Security Touchpoints

Module 4:

Cross Site Scripting, Magic URLs, Weak Passwords, Failing to Protect Data, Weak random numbers, improper use of cryptography

Module 5:

Information Leakage, Race Conditions, Poor usability, failing to protect network traffic, improper use of PKI, trusting network name resolution

Module 6:

Case study of Cross Site Scripting, Magic URLs, Weak Passwords Buffet overflows, Access control, Race conditions.

Total: 48 Hrs

Textbooks:

1. J. Viega, M. Messier. Secure Programming Cookbook, O'Reilly.
2. M. Howard, D. LeBlanc. Writing Secure Code, Microsoft

Reference Books:

1. J. Viega, G. McGraw. Building Secure Software, Addison Wesley

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: DATA SECURITY AND ACCESS CONTROL

Course Code:CS553

Credits: L:T:P:C : 3:0:0:3

Course Objective: The objective of the course is to provide fundamentals of database security. Various access control techniques mechanisms were introduced along with application areas of access control techniques

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

CLO1: In this course, the students will be enabled to understand and implement classical models and algorithms

CLO2: They will learn how to analyse the data, identify the problems, and choose the relevant models and algorithms to apply.

CLO3: They will further be able to assess the strengths and weaknesses of various access control models and to analyse their behaviour

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	3	2	2	1	-	-	-	1	-
CLO2	2	3	3	3	2	-	-	-	2	1
CLO3	3	2	2	2	2	-	3	-	1	2

Course Contents:

Module 1:

Introduction to Access Control, Purpose and fundamentals of access control, brief history, Policies of Access Control, Models of Access Control, and Mechanisms, Discretionary Access Control (DAC), Non- Discretionary Access Control, Mandatory Access Control (MAC). Capabilities and Limitations of Access Control Mechanism: Access Control List (ACL) and Limitations, Capability List and Limitations.

Module 2:

Role-Based Access Control (RBAC) and Limitations, Core RBAC, Hierarchical RBAC, Statically Constrained RBAC, Dynamically Constrained RBAC, Limitations of RBAC. Comparing RBAC to DAC and MAC Access control policy.

Module 3:

Biba's integrity model, Clark-Wilson model, Domain type enforcement model, mapping the enterprise view to the system view, Role hierarchies- inheritance schemes, hierarchy structures and inheritance forms, using SoD in real system Temporal Constraints in RBAC, MAC AND DAC. Integrating RBAC with enterprise IT infrastructures: RBAC for WFMSs, RBAC for UNIX and JAVA environments Case study: Multi-line Insurance Company

Module 4:

Smart Card based Information Security, Smart card operating system fundamentals, design and implantation principles, memory organization, smart card files, file management, atomic operation, smart card data transmission ATR, PPS Security techniques- user identification, smart card security, quality assurance and testing, smart card life cycle-5 phases, smart card terminals.

Module 5:

Recent trends in Database security and access control mechanisms. Case study of Role-Based Access Control (RBAC) systems.

Module 6:

Recent Trends related to data security management, vulnerabilities in different DBMS.

Total: 48 Hrs

Textbooks:

1. Role Based Access Control: David F. Ferraiolo, D. Richard Kuhn, Ramaswamy Chandramouli.

Manipur Technical University
M.Tech in Computer Science and Engineering

Course Title: SECURE SOFTWARE DESIGN AND ENTERPRISE COMPUTING

Course Code: CS554

Credits: L:T:P:C : 3:0:0:3

Course Objective: To fix software flaws and bugs in various software. To make students aware of various issues like weak random number generation, information leakage, poor usability, and weak or no encryption on data traffic, Techniques for successfully implementing and supporting network services on an enterprise scale and heterogeneous systems environment. Methodologies and tools to design and develop secure software containing minimum vulnerabilities and flaws.

Course Learning Outcomes:

After completion of course, students would be able to:

CLO1: Differentiate between various software vulnerabilities.

CLO2: Software process vulnerabilities for an organization.

CLO3: Monitor resources consumption in a software.

CLO4: Interrelate security and software development process.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	3	2	2	2	1	2	1	2	2
CLO2	2	2	3	2	2	2	3	2	2	3
CLO3	2	3	2	3	2	1	2	1	2	2
CLO4	2	3	3	3	3	2	3	2	2	3

Course Contents:

Module 1:

Secure Software Design

Identify software vulnerabilities and perform software security analysis, Master security programming practices, Master fundamental software security design concepts, Perform security testing and quality assurance.

Module 2:

Enterprise Application Development

Describe the nature and scope of enterprise software applications, Design distributed N-tier software application, Research technologies available for the presentation, business and data tiers of an enterprise software application, Design and build a database using an enterprise database system, Develop components at the different tiers in an enterprise system, Design and develop a multi-tier solution to a problem using technologies used in enterprise system, Present software solution.

Module 3:

Enterprise Systems Administration

Design, implement and maintain a directory-based server infrastructure in a heterogeneous systems environment, monitor server resource utilization for system reliability and

availability, Install and administer network services (DNS/DHCP/Terminal Services/Clustering/Web/Email).

Module 4:

Obtain the ability to manage and troubleshoot a network running multiple services, Understand the requirements of an enterprise network and how to go about managing them.

Module 5:

Handle insecure exceptions and command/SQL injection, defend web and mobile applications against attackers, software containing minimum vulnerabilities and flaws.

Module 6:

Case study of DNS server, DHCP configuration and SQL injection attack.

Total: 48 Hrs.

Textbooks:

1. Theodor Richardson, Charles N Thies, Secure Software Design, Jones & Bartlett
2. Kenneth R. van Wyk, Mark G. Graff, Dan S. Peters, Diana L. Burley, Enterprise Software Security, Addison Wesley.

PROGRAMME OEC COURSES

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Course Title: ENGLISH FOR RESEARCH PAPER AND WRITING

Course Code: CS581

Credits: L:T:P:C:: 0:2:0:2

Course Objective: Understand how to improve your writing skills and level of readability. Learn about what to write in each section. Understand the skills needed when writing a Research Paper.

Course Learning Outcomes:

Upon successful Completion of this Course, students will be able to:

- CLO1:** Apply principles of effective academic writing, including clarity, Conciseness, sentence structure, and paragraph organisation, to produce well-structured research Content.
- CLO2:** Analyse and implement techniques such as paraphrasing, avoiding plagiarism, hedging, and proper structuring of research papers, including title, abstract, and introduction.
- CLO3:** Develop and organise the core sections of a research paper, including literature review, methodology, results, discussion, and conclusions, following standard academic Conventions.
- CLO4:** Interpret and critically evaluate research papers and technical reports to improve academic writing quality and research understanding.
- CLO5:** Utilize appropriate academic phrases, editing strategies, and review techniques to produce a high-quality, publication-ready research paper.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	1	1	-	-	1	1	3	2	-
CLO2	2	1	1	-	2	-	3	3	2	-
CLO3	2	2	2	1	2	-	1	3	2	-
CLO4	2	2	1	1	3	-	1	3	3	-
CLO5	2	2	2	1	3	1	2	3	3	1

Course Contents:

(4 Hours)

Module 1:

Planning and Preparation, Word Order, breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

(4 Hours)

Module 2:

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

(4 Hours)

Module 3:

Review of the Literature, Methods, Results, Discussion, Conclusions, and the Final Check

Module 4:

(4 Hours)

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, and skills needed when writing a Review of the Literature

(4 Hours)

Module 5:

Skills are needed when writing the Methods, skills are needed when writing the Results, skills are needed when writing the Discussion, and skills are needed when writing the Conclusions

Module 6:

(4 Hours)

Useful phrases, how to ensure the paper is as good as it could possibly be the first- time submission

Textbooks:

1. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press

References:

1. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book.
2. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)

Manipur Technical University
MTech in Computer Science and Engineering

Course Title: VALUE EDUCATION

Course Code: CS582

Credits: L:T:P:C:: 0:2:0:2

Course Objective: Students will be able to: Understand the value of education and self-development, imbibe good values in students, let the students know about the importance of character.

Course Learning Outcomes:

Upon successful Completion of this course, students will be able to:

CLO1: Knowledge of self-development

CLO2: Learn the importance of Human values

CLO3: Developing the overall personality

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	1	-	-	-	-	2	2	1	3	1
CLO2	1	-	-	-	-	2	3	2	2	3
CLO3	1	1	1	-	-	3	2	3	3	2

Course Contents:

(4 Hours)

Module 1:

Values and self-development –Social values and individual attitudes. Work ethics, the Indian vision of humanism. Moral and non- moral valuation. Standards and principles. Value judgements

(6 Hours)

Module 2:

Importance of the cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline

Module 3:

(6 Hours)

Personality and Behaviour Development - Soul and Scientific Attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour. Universal brotherhood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation.

(6 Hours)

Module 4:

Character and Competence –Holy books vs Blind faith. Self-management and good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-Control. Honesty, Studying effectively

Textbooks:

1. Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

Manipur Technical University
MTech in Computer Science and Engineering

Course Title: CONSTITUTION OF INDIA

Course Code: CS583

Credits: L:T:P:C:: 0:2:0:2

Course Objective: Students will be able to: Understand the premises informing the twin themes of liberty and freedom from a civil right perspective. To address the growth of Indian opinion regarding modern Indian intellectuals' Constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism. To address the role of socialism in India after the Commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

Course Learning Outcomes:

Upon successful Completion of this course, students will be able to:

- CLO1:** Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian Politics.
- CLO2:** Discuss the intellectual origins of the framework of argument that informed the Conceptualization of social reforms leading to revolution in India.
- CLO3:** Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- CLO4:** Discuss the passage of the Hindu Code Bill of 1956.

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	2	-	-	1	1	2	2	2	3
CLO2	3	2	-	-	2	-	3	2	2	3
CLO3	2	3	1	-	2	1	3	2	2	3
CLO4	2	2	-	-	1	-	3	2	2	3

Course Contents:

(4 Hours)

Module 1:

History of Making of the Indian Constitution:

History, Drafting Committee, (Composition & Working)

(4 Hours)

Module 2:

Philosophy of the Indian Constitution:

Preamble, Salient Features

(4 Hours)

Module 3:

Contours of Constitutional Rights & Duties:

Fundamental Rights, Right to Equality, Right to Freedom, right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, right to constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

(4 Hours)

Module 4:

Organs of Governance:

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions

Module 5:

(4 Hours)

Local Administration:

District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation., Panchayati raj: Introduction, PRI: Zila Panchayat, Elected officials and their roles, CEO Zila Panchayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy

(4 Hours)

Module 6:

Election Commission:

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

Textbooks:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.

References:

1. M. P. Jain, Indian Constitution Law, 7th Edition., Lexis Nexis, 2014.
2. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

**Course Title: INDIAN KNOWLEDGE SYSTEM (IKS) IN COMPUTER
ENGINEERING**

Course Code: CS584

Credits: L:T:P:C:: 0:2:0:2

Course Objective:

1. To facilitate the students with the Concepts of Indian traditional knowledge and to make them understand the importance of the roots of Indian Knowledge System.
2. To make students acquaint with the facets of traditional knowledge& their relevance and help them be able to apply it to their day-to-day life.

Course Learning Outcomes:

Upon successful Completion of this course, students will be able to:

CLO1: Students will be able to gain insights into the Concept of traditional knowledge and its relevance

CLO2: Understand and connect up the basics of Indian traditional knowledge with modern perspective

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2						3	2	2	3
CLO2	2	2	2				3	2	2	3

Course Contents:

Module 1:

Indian Knowledge System: An Introduction:

Defining Indian Knowledge System. Importance of Ancient Knowledge, The IKS Corpus. Introduction to Traditional Knowledge: Concept & Definition, Nature, Scope and Importance of Traditional Knowledge. The Vedic Corpus: Introduction to Vedas, The Four Vedas. Philosophical System: Development and Unique Features. Bhagavad Gita

Module 2:

Science, Engineering and Technology in IKS:

Mathematics: Unique Aspects of Indian Mathematics, Great Mathematicians and their Contributions. Astronomy: Unique Aspects of Indian Astronomy, Historical Developments of Astronomy in India. Engineering & Technology: Indian S&T Heritage, Metals and Metalworking Technology, Literary Sources for S&T. Traditional Medicine System.

Module 3:

Humanities and Social Sciences in IKS:

Health, Wellness & Psychology: Definition of Health, Emotional Intelligence, Yoga & its Relevance to Health & Wellness, Indian Approach to Psychology. Governance and Public Administration: Arthasastra, The Kautilyan State, The Administrative Set-up.

Total: 24 Hrs.

Textbooks:

1. Mahadevan, B., Bhat, V.R. & Nagendra Pavana RN, (2022). Introduction to Indian Knowledge System: Concepts and Applications. PHI Learning

Manipur Technical University
MTech in Computer Science and Engineering
Course Title: PEDAGOGY STUDIES
Course Code: CS585
Credits: L:T:P:C:: 0:2:0:2

Course Objective: Students will be able to: Review existing evidence on the review topic to inform program design and Policy making undertaken by the DfID, other agencies and researchers. Identify critical evidence gaps to guide the development.

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- CLO1:** What pedagogical practices are being used by teachers in formal and informal classrooms in developing Countries?
- CLO2:** What is the evidence on the effectiveness of these pedagogical practices, in what Conditions, and with what Population of learners?
- CLO3:** How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

CLO-PLO mapping matrix:

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	3	1	-	2	1	2	2	2	2
CLO2	2	3	2	-	3	-	2	2	3	2
CLO3	2	3	3	1	3	2	2	2	3	3

Course Contents:

(4 Hours)

Module 1:

Introduction and Methodology:

Aims and rationale, Policy background, Conceptual framework and Terminology. Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions. Overview of methodology and searching.

(2 Hours)

Module 2:

Thematic overview:

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

(4 Hours)

Module 3:

Evidence on the effectiveness of pedagogical practices. Methodology for the in-depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

(4 Hours)

Module 4:

Professional development: alignment with classroom practices and follow up support Peer support. Support from the head teacher and the Community. Curriculum and assessment Barriers to learning: limited resources and large class sizes

Module 5:

(2 Hours)

Research gaps and future directions

Research design. Contexts. Pedagogy. Teacher education. Curriculum and assessment
Dissemination and research impact.

Textbooks:

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, *Compare*, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, *Journal of Curriculum Studies*, 36 (3): 361-379.
3. AkyeamPong K (2003) Teacher training in Ghana - does it Count? Multi-site teacher education research project (MUSTER) Country report 1. London: DFID.

References:

1. AkyeamPong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic math and reading in Africa: Does teacher preparation Count? *International Journal Educational Development*, 33 (3): 272–282.
2. Alexander RJ (2001) *Culture and pedagogy: International Comparisons in primary education*. Oxford and Boston: Blackwell.
3. Chavan M (2003) *Read India: A mass scale, rapid, ‘learning to read’ campaign*.