PG Program [M. Tech. – Computer Engineering] Curriculum Structure

W.e.f AY 2019-20 and Applicable for batches admitted from AY 2019-20 to 2022-23

List of Abbreviations

Abbreviation	Title	No of courses	Credits	% of Credits
PSMC	Program Specific Mathematics Course	1	4	5.9%
PSBC	Program Specific Bridge Course	1	3	4.4%
DEC	Department Elective Course	3	9	13.2%
MLC	Mandatory Learning Course	2	0	0%
PCC	Program Core Course	6	22	32.4%
LC	Laboratory Course	2	2	2.9%
IOC	Interdisciplinary Open Course	1	3	4.4%
LLC	Liberal Learning Course	1	1	1.5%
SLC	Self Learning Course	2	6	8.8%
SBC	Skill Based Course	2	18	26.5%

Semester I

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1.	PSMC	COC-19001	Probability, Statistics and Queuing Theory	3	1	--	4
2.	PSBC	COC-19002	Algorithms and Complexity Theory	3	--	--	3
3.	DEC		**Department Elective -I**	3	--	--	3
		COC(DE)-19001	1. Distributed Operating System				
		COC(DE)-19002	2. Artificial Intelligence				
		COC(DE)-19003	3. Advanced Graph Theory				
4.	MLC	ML-19011	Research Methodology and Intellectual Property Rights	2	--	--	--
5.	MLC	ML-19012	Effective Technical Communication	1	--	--	--
6.1	PCC	COC-19003	Topics in Databases	3	--	--	3
6.2	PCC	COC-19004	Advanced Computer Networks	3	--	--	3
6.3	PCC	COC-19005	Advanced Computer Architecture	3	--	--	3
6.4	LC	COC-19006	Topics in Databases - Laboratory	--	--	2	1
6.5	LC	COC-19007	Advanced Computer Networks – Laboratory	--	--	2	1
6.6	LC	COC-19008	Advanced Computer Architecture – Laboratory	--	--	2	1
			Total	**21**	**1**	**6**	**22**

Interdisciplinary Open Course (IOC): Every department shall offer one IOC course (in Engineering/Science/Technology). A student can opt for an IOC course offered by a department except the one offered by his /her department.

Semester II

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1.	IOC		*Interdisciplinary Open Course	3	--	--	3
2.	DEC		**Department Elective –II**	3	--	--	3
		COC(DE)-19004	1. Data Analytics				
		COC(DE)-19005	2. Cloud Computing and Virtualization				
		COC(DE)-19006	3. Natural Language Processing				
		COC(DE)-19007	4. Advanced Algorithms				
3.	DEC		**Department Elective –III**	3	--	--	3
		COC(DE)-19009	1. Bioinformatics (BI)				
		COC(DE)-19010	2. Advanced Compiler Construction (ACC)				
		COC(DE)-19011	3. Deep Learning				
4.	LLC	LL-19001	Liberal Learning Course	1	--	--	1
5.1	PCC	COC-19009	Data Mining and Machine Learning	3		--	3
5.2	PCC	COC-19010	Security in Computing	3		--	3
5.3	PCC	COC-19011	Embedded Systems	3		--	3
5.4	LC	COC-19012	Data Mining and Machine Learning - Laboratory	--		2	1
5.5	LC	COC-19013	Security in Computing - Laboratory	--		2	1
5.6	LC	COC-19014	Embedded Systems - Laboratory	--		2	1
			Total	**19**	**--**	**6**	**22**

***:** Department is going to offer **'Data Structures'** as IOC for students of other departments.

Semester-III

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1.	SBC	COC-19015	Dissertation Phase – I	--	--	12	6
2.	SLC	COC-19016	Massive Open Online Course –I	3	--	--	3
3.	SLC	COC-19017	Massive Open Online Course –II	3	--	--	3
			Total	**6**	**--**	**12**	**12**

Semester-IV

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1.	SBC	COC-19018	Dissertation Phase – II	--	--	24	12
			Total	**--**	**--**	**24**	**12**

[COC-19001] Probability, Statistics and Queuing Theory

Teaching Scheme
Lectures: 3 hrs/week
Tutorial: 1hr/week

Examination Scheme
T1, T2 – 20 marks each
End-Sem Exam – 60 marks

Course Outcomes:

Students will be able to:

1. Solve various problems on probability, statistics and queuing theory.
2. Analyze the given probabilistic model of the problem.
3. Use the techniques studied in probability, statistics and queuing theory to solve problems in domains such as data mining, machine learning, network analysis.

Unit 1: Basic Probability Theory [2 Hrs]
Probability axioms, conditional probability, independence of events, Bayes' rule, Bernoulli trials

Unit 2: Random Variables and Expectation [10 Hrs]

- Discrete random variables: Random variables and their event spaces, Probability Mass Function, Discrete Distributions such as Binomial, Poisson, Geometric etc., Indicator random variables

- Continuous random variables: Distributions such as Exponential, Erlang, Gamma, Normal etc., Functions of a random variable

- Expectation: Moments, Expectation based on multiple random variables, Transform methods, Moments and Transforms of some distributions such as Binomial, Geometric, Poisson, Gamma, Normal

Unit 3: Stochastic Processes [6 Hrs]
Introduction and classification of stochastic processes, Bernoulli process, Poisson process, Renewal processes

Unit 4: Markov chains [8 Hrs]

- Discrete-Time Markov chains: computation of n-step transition probabilities, state classification and limiting probabilities, distribution of time between time changes, M/G/1 queuing system

- Continuous-Time Markov chains: Birth-Death process (M/M/1 and M/M/m queues), Non-birth-death processes, Petri nets

Unit 5: Statistical Inference **[8 Hrs]**
Parameter Estimation – sampling from normal distribution, exponential distribution, estimation related to Markov chains, Hypothesis testing.

Unit 6: Regression and Analysis of Variance **[6 Hrs]**
Least square curve fitting, Linear and non-linear regression, Analysis of variance.

Text Books:

1. Ronald Walpole, Probability and Statistics for Engineers and Scientists, Pearson, ISBN-13: 978-0321629111

References:

1. Kishor Trivedi, Probability and Statistics with Reliability, Queuing, and Computer Science Applications, John Wiley and Sons, New York, 2001, ISBN number 0-471-33341-7

[COC-19002] Algorithms and Complexity Theory

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each
End-Sem Exam – 60 marks

Course Outcomes:

Students will be able to:

1. Analyze the asymptotic performance of algorithms
2. Apply important algorithmic design paradigms for solving problems
3. Understand the complexity theory

Unit-I: Mathematical Foundation **[6 Hrs]**
Growth of functions – Asymptotic notation, Standard notation and common functions, Summations, solving recurrences.

Unit-II: Analysis of Algorithms **[8 Hrs]**
Necessity of time and space requirement analysis of algorithms, Worst case analysis of common algorithms and operations on elementary data structures (e.g. Heapsort), Average case analysis of Quicksort, Amortized analysis.

Unit-III: Standard Design Techniques-I **[6 Hrs]**
Divide and Conquer, Greedy method.

Unit-IV: Standard Design Techniques-II **[8 Hrs]**
Dynamic programming, Graphs and Traversals.

Unit-V: Standard Design Techniques-III **[6 Hrs]**

Backtracking, Branch-and-bound.

Unit VI: Complexity Theory **[6 Hrs]**
Lower-bound arguments, Introduction to NP-Completeness, Reducibility (SAT, Independent Set, 3VC, Subset Su, Hamiltonian Circuit etc), Introduction to approximation algorithms.

Text Books:
1. Thomas Cormen, Charles Leiserson, Ronald Rivest and Cliford Stein, "Introduction to Algorithms" , PHI

Reference Books:
1. E. Horowitz and S. Sahni. "Fundamentals of Computer Algorithms" , Galgotia, 1991

[COC(DE)-19001] Distributed Operating Systems

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each
	End-Sem Exam – 60 marks

Course Outcomes:

Students will be able to:
1. Explain Characteristics and challenges of distributed systems.
2. Distinguish the design issues in distributed operating systems
3. Discuss RPC mechanisms, Distributed Shared Memory for inter process communication
4. Summarize the Synchronization issues in Resource and Process management, Process Migration, Distributed File System etc
5. Deconstruct the key components in distributed systems

Unit I: Fundamentals and Message Passing **[10 Hrs]**
Fundamentals: Characteristics and challenges of distributed systems. Design issues in distributed operating systems; Architectural models, DCE. Message passing: Desirable features of good message passing systems, Issues in IPC by message passing; Synchronization, Buffering, Multi-datagram Messages, Encoding and decoding of message data, process Addressing, Failure Handling, Group Communication.

Unit II: Remote procedure Call **[7 Hrs]**
RPC Model, Transparency of RPC, Implementing RPC mechanisms, RPC messages, Server management, parameter-passing semantics, call semantics Communication protocols for RPC, Client-Server Binding, RPC in Heterogeneous Environment.

Unit III: Distributed Shared Memory & Synchronization **[7 Hrs]**
General Architecture of DSM Systems, Design and Implementation issues in DSM, Consistency Models, Implementing Sequential Consistency Model, Page based distributed shared memory, shared – variable distributed shared memory, object-based distributed shared memory. Replacement Strategy, Thrashing, Heterogeneous DSM, Advantages of DSM, Synchronization : Clock Synchronization, Event Ordering, Mutual Exclusion, Deadlock, Election Algorithms.

Unit IV: Resource and Process management **[6 Hrs]**
Desirable features of good global scheduling algorithms, Task Assignment Approach, Load-Balancing Approach, Load-Sharing Approach, Process management: Process Migration, Threads.

Unit V: Distributed File System and Naming **[6 Hrs]**
File-Accessing Models, File-Sharing Semantics, File-caching Schemes, File Replication, Fault Tolerance, Atomic Transactions, Design Principles, Naming: Fundamental Terminologies and Concepts, System-Oriented names, Object-Locating Mechanisms, Human-Oriented names, Name cache, Naming and Security.

Unit VI: Security **[6 Hrs]**
Potential Attacks to Computer Systems, Cryptography, Authentication, Access Control, Digital Signatures.

Text Books:

1. Sinha P. K., Distributed Operating Systems Concepts and Design, PHI, 1997

References:
1. Tanenbaum A. S., Distributed Operating Systems, Pearson Education India, 1995

[COC(DE)-19002] Artificial Intelligence

Teaching Scheme	Examination Scheme
Lectures: 3 hrs/week	T1, T2 – 20 marks each
	End-Sem Exam – 60 marks

Course Outcomes:
Student will be able to
1. apply basic search techniques for problem solving.
2. explain how to represent Knowledge required for problem solving.
3. apply reasoning to sift through data.
4. utilize AI for application in real world.

Unit I: **[6 Hrs]**
Introduction: Artificial Intelligence, AI Problems, AI Techniques, The Level of the Model, Criteria For Success. Defining the Problem as a State Space Search, Problem Characteristics, Production Systems, Search: Issues in The Design of Search Programs, Un-Informed Search, BFS, DFS; Heuristic Search Techniques: Generate-And- Test, Hill Climbing, Best-First Search, A* Algorithm, Problem Reduction, AO*Algorithm, Constraint Satisfaction, Means-Ends Analysis

Unit II: **[6 Hrs]**
Knowledge Representation: Procedural Vs Declarative Knowledge, Representations & Approaches to Knowledge Representation, Forward Vs Backward Reasoning, Matching Techniques, Partial Matching, Fuzzy Matching Algorithms and RETE Matching Algorithms

Unit III: **[6 Hrs]**
Symbolic Logic: Propositional Logic, First Order Predicate Logic: Representing Instance and is-a Relationships, Computable Functions and Predicates, Syntax & Semantics of FOPL, Normal Forms, Unification &Resolution, Representation Using Rules, Natural Deduction; Structured Representations of Knowledge: Semantic Nets, Partitioned Semantic Nets, Frames, Conceptual Dependency, Conceptual Graphs, Scripts, CYC

Unit IV: **[6 Hrs]**
Reasoning under Uncertainty: Introduction to Non-Monotonic Reasoning, Truth Maintenance Systems, Logics for Non-Monotonic Reasoning, Model and Temporal Logics; Statistical Reasoning: Bayes Theorem, Certainty Factors and Rule-Based Systems, Bayesian Probabilistic Inference, Bayesian Networks, Dempster-Shafer Theory, Fuzzy Logic: Crisp Sets, Fuzzy Sets, Fuzzy Logic Control, Fuzzy Inferences & Fuzzy Systems

Unit V: **[6 Hrs]**
Natural Language Processing: Role of Knowledge in Language Understanding, Approaches Natural Language Understanding, steps in The Natural Language Processing, Syntactic Processing and Augmented Transition Nets, Semantic Analysis, NLP Understanding Systems; Planning: Components of a Planning System, Goal Stack Planning, Hierarchical Planning, Reactive Systems

Unit VI: **[6 Hrs]**
Machine Learning: Knowledge and Learning, learning by Advise, Examples, learning in problem Solving, Symbol Based Learning, Explanation Based Learning, Version Space, ID3 Decision Based Induction Algorithm, Unsupervised Learning, Reinforcement Learning, Supervised Learning: Perceptron Learning, Back propagation Learning, Competitive Learning, Hebbian Learning.

Text Book:
1. Artificial Intelligence, George F Luger, Pearson Education Publications
2. Artificial Intelligence, Elaine Rich and Knight, Mcgraw-Hill Publications

References:
1. Introduction To Artificial Intelligence & Expert Systems, Patterson, PHI 2.
2. Multi Agent systems- a modern approach to Distributed Artificial intelligence, Weiss.G, MIT Press.
3. Artificial Intelligence: A modern Approach, Russell and Norvig, Printice Hall

[COC(DE)-19003] Advanced Graph Theory

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each
End-Sem Exam – 60 marks

Course Outcomes:
Students will get

1. Familiarity with basic concepts and terminology of graph theory
2. Exposure to advanced topics such as matchings, graph coloring etc.

Unit I: Matching and Factors **[8 Hrs]**
Matchings in Bipartite Graphs, Hall's Matching Condition, Min-Max Theorems, Independent Sets, Tutte's 1-Factor Theorem, Maximum Bipartite Matching , Stable Matching, Dominating set andpath cover, Gallai-Millgram theorem. Dilworth's theorem.

Unit II: Connectivity and Paths **[6 Hrs]**
Cuts and Connectivity, Flows in Directed Graphs, Connectivity: vertex connectivity, edge connectivity, 2-connected and 3-coonected graphs, Menger's theorem and its applications, Network flows : Min cut max flow theorem.

Unit III: Graph Coloring **[6 Hrs]**
Vertex coloring, Brook's theorem, Edge coloring, Planarity, 5-coloring planar graphs, Kuratowsky's theorem.

Unit IV: Special classes of graphs **[6 Hrs]**
Perfect graphs, Interval Graphs, Chordal Graphs, Weak perfect graph theorem.

Unit V: Algebraic Graph Theory **[6 Hrs]**
Graphs and matrices, Automorphisms, Cayley Graphs, Spectral Graph Theory.

Unit VI: Analytic Graph Theory **[8 Hrs]**
Extremal graph theory, Random Graphs, Ramsey theory, Probabilistic method.

Text Books:

1. Douglas B. West, "Introduction to Graph Theory", Pearson Education India; 2nd edition (2015), ISBN-10: 9789332549654, ISBN-13: 978-9332549654
2. Béla Bollobás, Modern Graph Theory, Springer, 2013, ISBN-10: 9788181283092, ISBN-13: 978-818128309

Reference Books:

1. Reinhard Diestel, Graph Theory, 4th edition (2010), ISBN-10: 3642142788,
   a. ISBN-13: 978-3642142789
2. Adrian Bondy and U.S.R. Murty, "Graph Theory", Springer, 1st edition (2008), ISBN-10: 1846289696, ISBN-13: 978-1846289699

Internet Resources:
1. NPTEL Course: https://nptel.ac.in/courses/106108054/

[ ] MLC- Research Methodology and Intellectual Property Rights

Teaching Scheme	**Evaluation Scheme**
Lectures: 1 hr/week	**Continuous evaluation**
	Assignments/Presentation/Quiz/Test

Course Outcomes (COs):

Student will be able to

1. Understand research problem formulation and approaches of investigation of solutions for research problems
2. Learn ethical practices to be followed in research
3. Apply research methodology in case studies
4. Acquire skills required for presentation of research outcomes (report and technical paper writing, presentation etc.)
5. Infer that tomorrow's world will be ruled by ideas, concept, and creativity
6. Gather knowledge about Intellectual Property Rights which is important for students of engineering in particular as they are tomorrow's technocrats and creator of new technology
7. Discover how IPR is regarded as a source of national wealth and mark of an economic leadership in context of global market scenario
8. Study the national & International IP system
9. Summarize that it is an incentive for further research work and investment in R & D, leading to creation of new and better products and generation of economic and social benefits

Unit I: [5 Hrs]

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 instrumentations.

Unit II: [5 Hrs]

Effective literature studies approaches, analysis

Use Design of Experiments /Taguchi Method to plan a set of experiments or simulations or build prototype

Analyze your results and draw conclusions or Build Prototype, Test and Redesign

Unit III: [5 Hrs]

Plagiarism, Research ethics

Effective technical writing, how to write report, Paper.

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

Unit IV: [4 Hrs]

Introduction to the concepts Property and Intellectual Property, Nature and Importance of Intellectual Property Rights, Objectives and Importance of understanding Intellectual Property Rights

Unit V: [7 Hrs]

Understanding the types of Intellectual Property Rights: -Patents-Indian Patent Office and its Administration, Administration of Patent System – Patenting under Indian Patent Act , Patent

Rights and its Scope, Licensing and transfer of technology, Patent information and database. Provisional and Non Provisional Patent Application and Specification, Plant Patenting, Idea Patenting,
Integrated Circuits, Industrial Designs, Trademarks (Registered and unregistered trademarks), Copyrights, Traditional Knowledge, Geographical Indications, Trade Secrets, Case Studies

Unit VI: **[4 Hrs]**
New Developments in IPR, Process of Patenting and Development: technological research, innovation, patenting, development, International Scenario: WIPO, TRIPs, Patenting under PCT

Reference Books:

1. Aswani Kumar Bansal : Law of Trademarks in India
2. B L Wadehra : Law Relating to Patents, Trademarks, Copyright,
    a. Designs and Geographical Indications.
3. G.V.G Krishnamurthy : The Law of Trademarks, Copyright, Patents and
    a. Design.
4. Satyawrat Ponkse: The Management of Intellectual Property.
5. S K Roy Chaudhary & H K Saharay : The Law of Trademarks, Copyright, Patents
6. Intellectual Property Rights under WTO by T. Ramappa, S. Chand.
7. Manual of Patent Office Practice and Procedure
8. WIPO : WIPO Guide To Using Patent Information
9. Resisting Intellectual Property by Halbert ,Taylor & Francis
10. Industrial Design by Mayall, Mc Graw Hill
11. Product Design by Niebel, Mc Graw Hill
12. Introduction to Design by Asimov, Prentice Hall
13. Intellectual Property in New Technological Age by Robert P. Merges, Peter S. Menell, Mark A. Lemley

[ ] MLC-Effective Technical Communication

Teaching Scheme:	**Evaluation Scheme:**
Lectures: 1hr / week	**100M: 4 Assignments (25M each)**

Course Outcomes (COs):

Student will be able to

1. Produce effective dialogue for business related situations
2. Use listening, speaking, reading and writing skills for communication purposes and attempt tasks by using functional grammar and vocabulary effectively
3. Analyze critically different concepts / principles of communication skills
4. Demonstrate productive skills and have a knack for structured conversations
5. Appreciate, analyze, evaluate business reports and research papers

Unit I: Fundamentals of Communication **[4 Hrs]**
7 Cs of communication, common errors in English, enriching vocabulary, styles and registers

Unit II: Aural-Oral Communication **[4 Hrs]**
The art of listening, stress and intonation, group discussion, oral presentation skills

Unit III: Reading and Writing **[4 Hrs]**
Types of reading, effective writing, business correspondence, interpretation of technical reports and research papers

Reference Books

1. Raman Sharma, "Technical Communication", Oxford University Press.
2. Raymond Murphy "Essential English Grammar" (Elementary & Intermediate) Cambridge University Press.
3. Mark Hancock "English Pronunciation in Use" Cambridge University Press.
4. Shirley Taylor, "Model Business Letters, Emails and Other Business Documents" (seventh edition), Prentise Hall
5. Thomas Huckin, Leslie Olsen "Technical writing and Professional Communications for Non-native speakers of English", McGraw Hill.

[COC-19003] Topics in Databases

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each
	End-Sem Exam – 60 marks

Course Outcomes:

Students will be able to:

1. Understand foundation of the RDBMS theory
2. Understand internal functioning of RDBMS
3. Understand advanced topics of RDBMS
4. Analyze and understand the latest trends of RDBMS

Unit I: Transaction Management **[10 hrs]**

- Overview of transaction management: Transaction Concept, Transaction State, Implementation of Atomicity and Durability, Concurrent Executions, Serializability, Recoverability
- Concurrency Control: Lock-Based Protocols, Timestamp-Based Protocols, Validation-Based Protocols
- Recovery System: Recovery and Atomicity, Log-Based Recovery, Recovery with Concurrent Transactions, ARIES (Algorithm for Recovery and Isolation Exploiting Semantics), which supports partial rollbacks of transactions, fine granularity (e. g., record) locking and recovery using write-ahead logging (WAL)

Unit II: Query Execution **[10 hrs]**

Architecture of Query Execution Engines, Disk Access, Measures of Query Cost, Introduction to Physical-Query-Plan Operators, One-Pass Algorithms for Database Operations, Nested-Loop Joins, Two-Pass Algorithms Based on Sorting, Two-Pass Algorithms Based on Hashing, Index-Based Algorithms, Algorithms Using More Than Two Passes.

Unit III: Query Optimization **[10 hrs]**

Basic Optimization Strategies, Algebraic Manipulation, Optimizations of Selections in System R.

Unit IV: Case Studies: **[10 hrs]**

Hadoop Distributed File System: Study of Hadoop Distributed File System, HIVE - Data warehousing application built on top of Hadoop, MapReduce framework, Dynamo – a structured storage system, Eventual Consistency Model for Distributed Systems.

Text Books and Research Papers:

1. Hector Garcia-Molina, Jeffrey D. Ullman and Jennifer Widom, "Database System:The Complete Book", Pearson, 2nd edition (2008), ISBN-10: 0131873253, ISBN-13: 978-0131873254
2. Raghu Ramakrishnan and Johannes Gehrke, "Database Management Systems", McGraw Hill Education, 3rd edition (2014), ISBN-10: 9339213114, ISBN-13: 978-9339213114
3. C. Mohan, "ARIES: A Transaction Recovery Method Supporting Fine-Granularity Locking and Partial Rollbacks Using Write-Ahead Logging", ACM Transactions on Database Systems, Vol. 17, No. 1, March, 1992, pp. 94–162.
4. P. Selinger, M. Astrahan, D. Chamberlin, Raymond Lorie and T. Price, "Access Path Selection in a Relational Database Management System", Proceedings of ACM SIGMOD, pp 23-34, 1979
5. Jeffrey Dean and Sanjay Ghemawat, "MapReduce: Simplified Data Processing on Large Clusters", Communications of the ACM, vol. 51, no. 1, pp. 107-113, 2008
6. Fay Chang, Jeffrey Dean, Sanjay Ghemawat, Wilson C. Hsieh, Deborah A. Wallach, Mike Burrows, Tushar Chandra, Andrew Fikes, and Robert E. Gruber, "Bigtable: A Distributed Storage System for Structured Data", Proceedings of Operating Systems Design and Implementation , pp. 205-218, 2006.
7. W. Vogels, "Eventually Consistent", ACM Queue, vol. 6, no. 6, December 2008
8. Goetz Graefe, "Query Evaluation Techniques for Large Databases", ACM Computing Surveys, Vol. 25, No. 2, June 1993

Reference Books:

1. Korth, Silberschatz and Sudarshan, "Database System Concepts", Tata McGraw Hill, 6th edition (2013), ISBN-10: 9332901384, ISBN-13: 978-9332901384
2. R. Elmasri, and S. Navathe, "Fundamentals of Database Systems", Pearson, 7th edition (2017), ISBN-10: 9789332582705, ISBN-13: 978-9332582705

Internet Resources:

1. http://hadoop.apache.org

[COC-19004] Advanced Computer Networks

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each
End-Sem Exam – 60 marks

Course Outcomes:

Student will be able to

1. Understand issues in the design of network processors and design network systems.
2. Analyze different possible solutions for communications at each network layer.
3. Simulate working of wired and wireless networks to understand networking concepts.
4. Develop solutions by applying knowledge of mathematics, probability, and statistics to network design problems.
5. Understand and compare various storage and networking technologies.

Unit I: **[4 Hrs]**

Routing Algorithms, Congestion Control, Quality of Service, Queue Management, High Speed Networks, Performance Modeling and Estimation

Unit II: **[6 Hrs]**

IPv4 deficiencies, patching work done with IPv4, IPv6 addressing, multicast, Anycast, ICMPv6, Neighbour discovery, Routing

Unit III: **[6 Hrs]**

Centralized and Distributed Control and Data Planes, SDN Controllers, Data Center Concepts, Network Function Virtualization, Mininet, Programming SDNs, Openflow Switch, Wire Protocol, Openstack Neutron plug-in

Unit IV: **[6 Hrs]**

MAC Protocols for Ad Hoc Wireless Networks, Routing Protocols for Ad Hoc Wireless Networks, Multicast routing in Ad Hoc Wireless Networks, Transport Layer and Security Protocols for Ad Hoc Wireless Networks, Quality of Service in Ad Hoc Wireless Networks.

Unit V: **[6 Hrs]**

SNMPv1 Network Management: Organization and Information Models, SNMPv2: major changes, SNMPv3, RMON, Network Management Tools, Systems, and Engineering, Network Management Applications.

Unit VI: **[6Hrs]**

Storage and Networking Concepts, Fiber Channel Internals, Fiber Channel SAN Topologies, Fiber Channel Products, IP SAN Technology, IP SAN Products, Management of SANs, SAN Issues.

Text Books:

1. Mani Subramanian, Timothy A. Gonsalves,N. Usha Rani; Network Management: Principles and Practice; Pearson Education India, 2010
2. William Stallings, High-Speed Networks and Internets, Pearson Education, 2nd Edition, 2002.
3. C. Siva Ram Murthy, B.S. Manoj, Ad Hoc Wireless Networks: Architectures and Protocols, Prentice Hall, 2004
4. Muthukumaran B, Introduction to High Performance Networks, Tata Mc Graw Hill, 2008

Reference Books:

1. Thomas D NAdeau and Ken Grey, Software Defined Networking, O'Reilly, 2013
2. Pete Loshin IPv6, Theory, Protocols and Practice, Morgan Kaufmann, 2nd Edition, 2004
3. Tom Clark, Designing Storage Area Networks, A Practical Reference for Implementing Fibre Channel and IP SANs, Addison-Wesley Professional, 2nd Edition, 2003.

[COC-19005] Advanced Computer Architecture

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each
	End-Sem Exam – 60 marks

Course Outcomes:

Student will be able to

1. Understand the history , evolution , classifications & current trends of Computer Architecture; Learn to evaluate & compare System's performance using standard benchmarks
2. Understand the basics of advanced microprocessor techniques & the salient features of state-of-the- art processors deployed in current High Performance Computing systems
3. Understand the differences between System Area Networks & Storage Area Networks & learn the current Networking Technologies for implementing them
4. Learn the advanced RAID Levels, compare SAS vs SATA Disks & understand the implementation of a hierarchical Storage System
5. Understand the System Software Architecture, various parallel programming models, message passing paradigms & typical HPCC software stack
6. Understand, through the case studies of a few selected representative systems, the implementation of architectural concepts learnt through CO-1 to CO-5

Unit I: System Architecture [8 Hrs]

History /Evolution, Definition: Hardware /Software Architecture, Flynn's Classification: SISD,SIMD,MISD,MIMD. Physical Models: PVP, MPP, SMP& Cluster of Workstations (COW). Memory Architectures: Shared, Distributed & Hybrid. UMA, NUMA, CC-NUMA. Performance Metrics & Benchmarks (Micro/Macro) Architectural Trends based on TOP 500 List of Supercomputers.

Unit II: Advanced Microprocessor Techniques [8 Hrs]

CISC, RISC, EPIC, Superscalar, Superpipelined Architectures, Superscalar/ Superpipelined, In Order Execution /Out of Order Execution (OOO), ILP, TLP, Power Wall, Moore's Law

Redefined, Multicore Technologies, Intel's Tick-Talk Model. Study of State-of-the- ART Processors : Intel / AMD X86-64 Bit Series: Intel Xeon Family (Xeon Haswell & Broadwell Architectures), Intel Xeon Phi Coprocessors (MIC Architecture) Intel/IBM Itanium/Power Series (Power 4 - Power 9). Introduction to Graphics Processing Units (GPU-NVIDIA).

Unit III: System Interconnects **[4 Hrs]**

SAN : System Area Networks, Storage Area Networks including InfiniBand, Gigabit Ethernet, Scalable Coherent Interface (SCI) Standard.

Unit IV: Storage **[4 Hrs]**

Internal/External , Disk Storage, Areal Density ,Seek Time ,Disk Power, Advanced RAID Levels, SATA vs SAS Disks ,Network Attached Storage (NAS) ,Direct Attached Storage (DAS), I/O Performance Benchmarks.

Unit V: Software Architecture **[8 Hrs]**

Parallel Programming Models: Message Passing ,Data Parallel , MPI/PVM .Typical HPCC Software Stack including Cluster Monitoring Tools, Public Domain Software like GANGLIA, CUDA Programming Environment.

Unit VI: Case Studies **[8 Hrs]**

A typical Peta Scale System based on Hybrid CPU/GPU Architectures, IBM SP System, C-DAC's latest PARAM Systems [PARAM Yuva-II], Sequent NUMA Q, Case Study of a Domain Specific Architecture (DSA).

Text Books:

1. John L. Hennesy and David Patterson, Computer Architecture : A Quantitative Approach, 6th Edition, Elsevier
2. Kai Hwang and Zhiwei Xu, Scalable Parallel Computers, McGraw- Hill, 1998.
3. Data Manuals of respective Processors available at Website

Reference Books:

1. Peter S. Pacheco, "An Introduction to Parallel Programming", Morgan Kaufmann, Elsevier Series, 2011, ISBN:978-0-12-374260-5.

[COC-19006] Topics in Databases Laboratory

Teaching Scheme:	**Examination Scheme:**
Practical: 2 hrs/week	Term Work: 50 marks
	Oral Examination: 50 marks

Course Outcomes:

Students will be able to:

1. Relate theory with practice by performing programming assignments
2. Analyze various algorithms and implementation options to solve a problem

Suggested List of Assignments:

1. Write a program to check if a given schedule is serial, serializable, conflictserilaizable.
2. Simulate recovery using undo, redo and undo-redo logging.
3. Simulate ARIES recovery system.
4. Implement disk-based algorithms for sorting.
5. Implement hash-based natural join, sort-based natural-join.
6. Study MySQL/Postgres query optimizer code.
7. Comparing the query evaluation performance before and after applying query optimization techniques.
8. Implementation of MapReduce algorithms for Matrix multiplication and GroupBy operation

[COC-19007] Advanced Computer Networks Laboratory

Teaching Scheme:	**Examination Scheme:**
Practical: 2 hrs/week	Term Work: 50 marks
	Oral Examination: 50 marks

Course Outcomes:

Students will:

1. Be able to relate theory with practice by performing programming assignments
2. Get proficiency in designing programming solutions
3. Get proficiency in variety of tools and environments like C, C++, Java, and Linux OS
4. Be able to analyze various algorithms and implementation options to solve a problem
5. Learn to work in teams while carrying out the assignments
6. Imbibe good programming practices

Suggested List of Assignments:

1. Create a Virtual Machine setup and perform socket programming.
2. Implement intradomain routing algorithms.
3. Implement TCP congestion control algorithms.
4. Perform Wireshark packet sniffing experiment.
5. Do the network analysis using NMAP - the Network MAPper.
6. SSH to coep.org.in and run a traceroute to google.com. List the results, then interpret and report your findings.
7. Implement a web proxy that passes requests and data between multiple web clients and web servers.
8. Write an Internet chat server by using Berkeley Sockets API.
9. Design a client server application for solving roots of a quadratic equation by making use of appropriate API's.

[COC-19008] Advanced Computer Architecture Laboratory

Teaching Scheme:	**Examination Scheme:**
Practical: 2 hrs/week	Term Work: 50 marks
	Oral Examination: 50 marks

Course Outcomes:

Student will be able to

1. Analyze performance of programs using perf tool.
2. Implement shared memory programs using OpenMP.
3. Implement message passing programs in distributed environment.
4. Program GPU architecture using CUDA.
5. Demonstrate the different steps involved in building of a simple cluster.

List of Assignments:

1. Study and installation of 'perf tool' to understand performance details of matrix multiplication program
2. MPI - OpenMP cluster setup over LAN and executing matrix multiply on it
3. CUDA/ OpenACC environment setup and execution of matrix multiply code
4. Study of Intel PIN tool
5. Case study of any architectural open source simulator for any architecture simulation and modelling

Reference Books:

1. Peter S. Pacheco, "An Introduction to Parallel Programming", Morgan Kaufmann, Elsevier Series, 2011, ISBN:978-0-12-374260-5.
2. Jason Sanders, Edward Kandrot, "CUDA by Example: An Introduction to General Purpose GPU Programming", 2011, ISBN:978-0-13-138768-3.

[IOC] Data Structures

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each
	End-Sem Exam – 60 marks

Course Outcomes:

Students will be able to:

1. Apply and implement advanced data structures, such as B-trees, multi-way trees, balanced trees, heaps, priority queues, to solve computational problems
2. Analyze the time and space complexity of advanced data structures and their supported operations
3. Compare the time and space tradeoff of different advanced data structures and their common operations

Unit I: [6 Hrs]

Review of Basic Concepts: Abstract data types, Data structures, Algorithms, Big Oh, Small Oh, Omega and Theta notations, Solving recurrence equations, Master theorems, Generating function techniques, Constructive induction.

Unit II: **[8 Hrs]**

Advanced Search Structures for Dictionary ADT: Splay trees, Amortized analysis, 2-3 trees, 2-3-4 trees, Red-black trees, Randomized structures, Skip lists, Treaps, Universal hash functions.

Unit III: **[6 Hrs]**

Advanced Structures for Priority Queues and Their Extensions: Binary Heap, Min Heap, Max Heap, Binomial heaps, Leftist heaps, Skewed heaps, Fibonacci heaps and its amortized analysis, Applications to minimum spanning tree algorithms

Unit IV: **[6 Hrs]**

Data Structures for Partition ADT: Weighted union and path compression, Applications to finite state automata minimization, Code optimization.

Unit V: **[6 Hrs]**

Graph Algorithms: DFS, BFS, Biconnected components, Cut vertices, Matching, Network flow; Maximum-Flow / Minimum-Cut; Ford–Fulkerson algorithm, Augmenting Path.

Unit VI: **[8 Hrs]**

Computational Geometry: Geometric data structures, Plane sweep paradigm, Concurrency, Java Threads, Critical Section Problem, Race Conditions, Re-entrant code, Synchronization; Multiple Readers/Writers Problem.

Text Books:

1. Introduction to Algorithms; 3rd Edition; by by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein; Published by PHI Learning Pvt. Ltd. ; ISBN-13: 978-0262033848 ISBN-10: 0262033844
2. Algorithms; 4th Edition; by Robert Sedgewick and Kevin Wayne; Pearson Education, ISBN-13: 978-0321573513

References:

1. Algorithms; by S. Dasgupta, C.H. Papadimitriou, and U. V. Vazirani; Published by Mcgraw-Hill, 2006; ISBN-13: 978-0073523408 ISBN-10: 0073523402
2. Algorithm Design; by J. Kleinberg and E. Tardos; Published by Addison-Wesley, 2006; ISBN-13: 978-0321295354 ISBN-10: 0321295358

[COC(DE)-19004] Data Analytics

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each
End-Sem Exam – 60 marks

Course Outcomes:

Student will be able to:

1. Identify and assess the opportunities, needs and constraints for data collection, and explore various types of datasets and features.
2. Analyze the business issues that data science and analytics can address and resolve.
3. Identify the methods by which data can be collected, stored, secured, analyzed, interpreted, forecasted, visualized, reported and applied in a business environment
4. Describe how data can be interpreted beyond its basic analysis to tell a story relevant and meaningful to its organization, and how these stories can be utilized to gain competitive advantage through strategic application
5. Design case studies on social media analytics.

Unit I: Fundamentals of Data Analytics **[8 Hrs]**

Data Analytics Basics, Data Types, Analytics Types, Data Analytics Steps: Data Pre-Processing, Data Imputation, Data Cleaning, Data Transformation, Data Visualization, and Data Engineering. Descriptive, Predictive, and Prescriptive Analytics.

Unit II: Data Analytics with Python **[8 Hrs]**

Data Analytics using Python, Statistical Procedures, Web Scraping in Python, Advanced analytics, NumPy, Pandas, SciPy, Matplotlib.

Unit III: Correlated Data Analysis **[7 Hrs]**

Analysis of Variance and Co-Variance, ANOVA results, Chi-Square Statistical Test, Examine Regression results, Regressing Analysis, Linear Regression and its analysis, Logistic Regression and its analysis.

Unit IV: Decision Trees and Cluster Analysis **[9 Hrs]**

Decision Tree Problem Analysis, Decision tree Construction, Decision Tree Algorithms; Applications of Cluster Analysis, Definition of Cluster, representing clusters, Clustering Techniques, K-Means Algorithm for Clustering, Advantages and Disadvantages of K-Means Clustering.

Unit V: Social Media Analytics **[8 Hrs]**

Datasets, Analysis of Social Network Dataset Features, Learning Models and Validation, Association Rule Mining, artificial Neural Networks for web analytics.

Text Books:

1. Anil Maheshwari, “Data Analytics made accessible,” Amazon Digital Publication, 2014.
2. Song, Peter X. -K, “Correlated Data Analysis: Modeling, Analytics, and Applications”, Springer-Verlag New York 2007.
3. Glenn J. Myatt, Wayne P. Johnson, “Making Sense of Data I: A Practical Guide to Exploratory Data Analysis and Data Mining”, Wiley 2009.

Reference Books:

1. Thomas H. Davenport, Jeanne G. Harris and Robert Morison, “Analytics at Work: Smarter Decisions, Better Results”, Harvard Business Press, 2010
2. Rachel Schutt, Cathy O’Neil, “Doing Data Science”, O’REILLY, 2006.

3. Shamanth Kumar Fred Morstatter Huan Liu "Twitter Data Analytics", Springer-Verlag, 2014.

[COC(DE)-19005] Cloud Computing and Virtualization

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each
End-Sem Exam – 60 marks

Course Outcomes:

Student will be able to

1. Characterize the distinctions between various cloud models and services
2. Compare the functioning and performance of virtualization of CPU, memory and I/O with traditional systems
3. Familiar with cloud platforms and technologies like AWS, vSphere etc.
4. Create a cloud infrastructure after learning OpenStack components
5. Analyze the security risks associated with virtualization, cloud computing and evaluate how to address them

Unit I: [6 Hrs]

Introduction: Benefits and challenges to Cloud architecture, Cloud delivery models- SaaS, PaaS, LaaS. Cloud Deployment Models- Public Cloud, Private Cloud, Community Cloud and Hybrid Cloud, Service level agreements in clouds, case Studies on Cloud services, Cloud Adoption Challenges.

Unit II: [10 Hrs]

Virtualization: Role of virtualization in enabling the cloud, Levels of Virtualizations, Types of Virtualization: Compute, Network and Storage Virtualizations, Virtual Machine, Hypervisor: Type 1 and 2, Examples of Hypervisors.

Server Virtualization: X86 architecture, Protected mode, Rings of Privileges, Virtualization challenges, Full virtualization and Binary Translation, Ring De-Privileging, Handling Sensitive instructions, ESXi, Para-Virtualization, Xen, Hardware Assisted Virtualization, System call and hardware interrupts handling in virtualized systems, Intel VTx, KVM, VM Migration

Unit III: [8 hrs]

Memory and I/O Virtualization: Memory management and I/O with traditional OS, Challenges in virtualized system, Shadow page Tables in Full Virtualized system, EPT/NPT, 2D Page walks, I/O in Virtualized Systems, Emulation, Split drivers of Xen, Direct I/O, Intel VTd, VMCS

Unit IV: [6 Hrs]

Cloud Orchestration: Elements of Cloud Orchestration, Examples platforms: OpenStack and vSphere, OpenStack Deep dive: Covers Networking, Storage, Authentication modules of OpenStack, Nova, Quantum, Keystone and Cinder, Swift.

Unit V: [4 hrs]

Cloud Platforms: Overview and Architecture, Azure, Google App Engine, Amazon Web Services.

Unit VI: **[8 Hrs]**

Virtualization Security: Security Challenges Raised by Virtualization, Virtualization Attacks, VM Migration Attacks, Launch Pad for Brute Force attacks, Security Solutions, Hypervisor-Based Segmentation, case studies of Hypervisors.

Cloud Security: Issues with Multi-tenancy, Isolation of users/VMs from each other, VM vulnerabilities, hypervisor vulnerabilities, VM migration attacks, Cloud based DDOS, Developing cloud security models, end-to-end methods for enforcing Security, Security policies and programming models with privacy aware APIs

Text Books:

1. Kai Hwang, Geoffrey and KJack, Distributed and Cloud computing, Elsevier
2. Shailendra Singh, Cloud Computing, Oxford Higher Education, , 2018

References:

1. Danielle Ruest and Nelson Ruest, Virtualization, A beginners Guide, Tata McGraw Hill,2009
2. Tom White, Hadoop: The Definitive Guide, O'REILLY, 3rd Edition, 2012
3. Dinakar Sitaram and Geetha Manjunath, Moving to the cloud, Elsevier

On-line Course Resources:

1. Understanding Full Virtualization, Para Virtualization and Hardware Assist, VMware White paper
2. AMD-V Nested Paging, white paper, July 2008
3. Patent: US 8533428 B2, Translating a Guest Virtual Address to a Host Physical Address as Guest Software Executes on a Virtual Machine, 2013
4. Darren Abramson, et. all, Intel Virtualization Technology for Directed I/O, Intel Technology Journal, Vol. 10, Issue 3, 2006
5. Uhlig, R., et al., "Intel Virtualization Technology", IEEE Computer Society, 38(5), pp 48-56, , 2005
6. "OpenStack Docs: Current", http://docs.openstack.org/
7. " vSphere 5 Documentation Center: ",http://pubs.vmware.com/vsphere-50/index.jsp
8. "Google App Engine", https://developers.google.com/appengine/
9. "Windowsazure :Microsoft's Cloud Platform| Cloud hosting |Cloud Service ", http://www.windowsazure.com/en-us/
10. Hadoop Performance Tuning, Impetus Technologies Inc., October 2009

[COC(DE)-19006] Natural Language Processing

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each
	End-Sem Exam – 60 marks

Course Outcomes:

Student will be able to

1. Demonstrate the understanding of basic text processing techniques in NLP.
2. Design, implement and evaluate part-of-speech taggers and parsers for a language.
3. Build language models and demonstrate Word Sense Disambiguation using WordNet.

4. Analyze and build word embeddings for different languages.

Unit I: Introduction **[6 Hrs]**
What is NLP, Fundamental and Scientific goals, Engineering goals, stages of NLP, problems in NLP, Applications of NLP, Empirical Laws of language, zipf's law, Heap's law.

Unit II: Basic Text Processing **[8 Hrs]**
Tokenization, word token, word type, sentence segmentation, feature extraction, issues in tokenization for different languages, word segmentation, text segmentation, normalization, case folding, Spelling Correction, Morphology, Stemming, Porters Algorithm, , lemmatization, spelling correction - dynamic programming approach for finding edit distance, N-gram Language Modeling- context sensitive spelling correction, probabilistic language model, auto completion prediction, Evaluation and perplexity, Smoothing techniques.

Unit III: POS Tagging **[8 Hrs]**
Sequence labeling tasks of NLP, POS tagging, POS tag sets, Hidden Markov Model- Introduction, Markov Processes, HMM characterization -Likelihood of a sequence (Forward Procedure, Backward Procedure), Best state sequence (Viterbi Algorithm), Re-estimation(Baum-Welch - Forward-Backward Algorithm) , Models for Sequential tagging – Maximum Entropy, Conditional Random Field.

Unit IV: Syntax **[10 Hrs]**
Constituency and dependency parsing, Constituency parser -Syntactic structure, Parsing methodology, Different parsing algorithms, Parsing in case of ambiguity, Probabilistic parsing, CKY algorithm, Issues in parsing, Dependency parsing- Syntactic structure, Parsing methodology, Transition-Based Dependency Parsing, Graph-Based dependency parsing, Evaluation, Co-reference resolution, Named-entity recognition.

Unit V: Knowledge Base and Semantics **[6 Hrs]**
WordNet: Word Senses, Word relations, Word similarity and thesaurus methods, Word sense disambiguation, WordNet. Lexical and Distributional Semantics - Introduction, models of semantics, applications.

Unit VI: Word Embeddings **[6 Hrs]**
Introduction, one-hot vectors, methods of generating word embeddings, Skip-gram, CBOW, Glove model, Fast Text model, evaluation measures-rough scores.

Text Books:

1. Daniel Jurafsky and James H. Martin, "Speech and Language Processing", Second Edition, Prentice Hall, 2008, ISBN: 978-0131873216.
2. Allen James, "Natural Language Understanding", Second Edition, Benjamin/Cumming, 1994, ISBN: 978-0805303346.
3. Chris Manning and Hinrich Schuetze, "Foundations of Statistical Natural Language Processing", MIT Press, ISBN: 978-0262133609.

Reference Books:

1. Journals: Computational Linguistics, Natural Language Engineering, Machine Learning, Machine Translation, Artificial Intelligence.
2. Conferences: Annual Meeting of the Association of Computational Linguistics (ACL), Computational Linguistics (COLING), European ACL (EACL), Empirical Methods in NLP (EMNLP), Annual Meeting of the Special Interest Group in Information Retrieval (SIGIR), Human Language Technology (HLT).

[COC(DE)-19007] Advanced Algorithms

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each
Tutorial: 1hr/week	End-Sem Exam – 60 marks

Course Outcomes:

Students will be able to:

1. Understand various algorithm design paradigms and solve typical problems using those paradigms
2. Apply the advanced techniques to solve real life problems

Unit-I: Computational Geometry [8 Hrs]

Convex hull, Closest pair of points, Line segment intersection

Unit-II: Approximation Algorithms [8 Hrs]

Vertex cover problem, Traveling Salesperson problem, Set covering problem

Unit-III: Randomized Algorithms [8 Hrs]

Quick sort, Max-cut algorithm, Primality Testing

Unit-IV: Parallel Algorithms [8 Hrs]

Theoretical models of parallel computation: variants of the PRAM model, Performance of parallel algorithms, Quick sort, Bitonic sort

Unit-V: Streaming Algorithms [8 Hrs]

Finding frequent items deterministically, Estimating the number of distinct elements, Finding frequent items via Sketching, Estimating frequency moments

Text Books:

1. Thomas Cormen, Charles Leiserson, Ronald Rivest and Cliford Stein, “Introduction to Algorithms” , PHI
2. Jure Leskovec, Anand Rajaraman and Jeffrey Ullman, “Mining of Massive Datasets”, Dreamtech Press

Reference Books:

1. Rajeev Motwani and Prabhakar Raghavan, “Randomized Algorithms”, Cambridge University Press
2. Vijay V. Vazirani, "Approximation Algorithms", Springer

[COC(DE)-19009] Bioinformatics

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each
	End-Sem Exam – 60 marks

Course Outcomes:

Students will be able to:

1. Learn various algorithms for sequencing and alignments
2. Implement proof of concepts for the algorithm studied with some sample data
3. Evaluate how networks, algorithms, and models are employed in bioinformatics
4. Compare the molecular biology techniques for drug design for various diseases

Unit I: Introduction **[6 Hrs]**

Introduction, chronological history of Bioinformatics, evolution of Bioinformatics,Objectives of Bioinformatics, Importance of bioinformatics, Bioinformatics inbusiness, future scope of Bioinformatics. Protein Structure and Functions, Nature of Chemical Bonds Molecular Biology tools, Polymerase chain reaction.

Unit II: Sequence Alignment **[6 Hrs]**

Simple alignments, Gaps, Scoring Matrices, Global and Local Alignments, Smith-Waterman Algorithm, BLAST, FASTA, Multiple sequence Alignments, Gene Prediction, Statistical Approaches to Gene Prediction, Spliced Alignment

Unit III: GenomeAlgorithms **[8 Hrs]**

The dawn of sequencing, the biological sequence or structure deficit, humangenome project and its status, homology and analogy, web browsers. Genome Rearrangements, Sorting by Reversals, Block Alignment and the Four-Russians Speedup, Constructing Alignments in Sub-quadratic Time, Protein Sequencing and Identification, the Peptide Sequencing Problem

Unit IV: Microarray Data Analysis **[6 Hrs]**

Microarray technology for genome expression study, Image analysis for data extraction, Data analysis for pattern discovery, gene regulatory network analysis. Building a sequence search protocol, practicalapproach for structural and functional interpretation.

Unit V: Phylogenetic Analysis **[8 Hrs]**

Neighbor’s relation method, Neighbor-joining method, Maximum likelihood Approaches, Multiple Sequence Methods Structural Biology, Sequence, organisms, 3D structures, complexes, Assemblies, Case Studies, examples.

Unit VI: Drug Discovery &Design **[6 Hrs]**

Similarities/differences between drugs and receptors, Target identification , Target Validation , Lead Identification ,lead optimization , preclinical Pharmacology & Taxology, protein-ligand docking, Massively Parallel Signature Sequencing (MPSS), SOLiD sequencing, Single molecule real time (SMRT) sequencing.

Text Books:

1. Dan E. Krane, Michael L. Raymer, “Fundamental Concepts of Bioinformatics,”, Pearson Education, Inc. Fourth Edition, 9780805346336.
2. Harshawardhan P. Bal, “Bioinformatics Principles and Applications”, Tata McGraw-Hill, seventh reprint, 9780195692303.

Reference Books:

1. Teresa Attwood, David Parry-Smith, “Introduction to Bioinformatics”, Pearson Education Series, 9788180301971
2. R. Durbin, S. Eddy, A. Krogh, G. Mitchison., “Biological Sequence Analysis: Probabilistic Models of proteins and nucleic acids”, Cambridge University Press, 9780521629713.
3. Arthur M. Lesk, Introduction to Bioinformatics, Oxford University Press, 3rd Edition,2008
4. Andreas D. “Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins”, Second Edition,
5. Baxevanis, B. F. Francis Ouellette.Des Higgins (Editor), Willie Taylor Bioinformatics: A Biologist's Guide to Biocomputing and the Internet, Stuart M. Brown

[COC(DE)-19010] Advanced Compiler Construction

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each
	End-Sem Exam – 60

Course Outcomes:

Students will be able to:

1. Understand the design of Compiler
2. Design a prototype for the toy compiler

Unit I: Introduction [6 Hrs]

Review of Compiler Structure, Advanced Issues in Elementary Topics, Importance of Code Optimization, Structure of Optimizing Compilers, Placement of Optimizations in Aggressive Optimizing Compilers

Unit II: Context –Sensitive Analysis & Intermediate Representation [6 Hrs]

Introduction to type systems, The Attribute –grammar framework, Adhoc Syntax directed translation, Harder problems in type inference and changing associativity, Issues in designing an intermediate languages, Graphical & Linear IR, Static-single Assignment form, Mapping values to names & symbol tables.

Unit III: Code Optimization [8 Hrs]

Introduction, Redundant expressions, Scope of optimization, Value numbering over regions larger than basic blocks, Global redundancy elimination, Cloning to increase context, Inline substitution, Introduction to control flow analysis, Approaches to control flow analysis, Interval analysis and control trees, Structural analysis, Reaching definitions.

Unit IV: Data Flow Analysis & Scalar Optimization **[10 Hrs]**
Basic concepts : Lattices, flow functions and fixed points, Iterative data flow analysis, Lattice of flow functions, Control –tree based data flow analysis, Structural analysis and interval analysis, Static Single Assignment (SSA) form, Dealing with arrays, structures and pointers, Advanced topics: Structures data-flow algorithms and reducibility, Inter procedural analysis (Control flow, data flow, constant propagation, alias), Inter procedural register allocation, Aggregation of global references, Introduction to scalar optimization, Machine –independent and dependent transformations, Example optimizations (eliminating useless and unreachable code, code motion, specialization, enabling other transformation, redundancy elimination)., Advanced topics (Combining optimizations, strength reduction).

Unit V: Instruction Selection & Scheduling **[8 Hrs]**
Introduction, Instruction selection and code generation via Sethi Ullman, Aho Johnson algorithm, Instruction selection via tree-pattern matching, Instruction selection via peephole optimization, Learning peephole patterns, Generating instruction sequences, Introduction to instruction scheduling, The instruction scheduling problem, List scheduling, Regional scheduling.

Unit VI:Register Allocation **[6 Hrs]**
Introduction, Issues in register allocation, Local register allocation and assignment, Moving beyond single block, Global register allocation and assignment, Variations on Graph Coloring Allocation, Harder problems in register allocation, CASE Study of GCC compiler.

Text Books:

1. Keith D. Cooper and Linda Torczon, Engineering a Compiler, Elsevier-Morgan Kaufmann Publishers, 2004.
2. Steven S. Muchnick, Advanced Compiler Design Implementation, Elsevier-Morgan Kaufmann Publishers, 2003.
3. Uday Khedker, Amitabha Sanyal, Bageshri Karkare , Data Flow Analysis: Theory and Practice, CRC Press, 2009

References:

1. Andrew Appel, Modern Compiler Implementation in C: Basic Techniques, Cambridge University Press, 1997.
2. Y.N. Srikant, Priti Shankar, The Compiler Design Handbook: Optimizations and Machine Code Generation, CRC Press, 2nd Edition, 2002.
3. David R. Hanson , Christopher W. Fraser, A Retargetable C Compiler: Design and Implementation, Addison-Wesley, 1995
4. Morgan, Robert, Building an Optimizing Compiler, Digital Press Newton, 1998.
5. John Levine, Tony Mason & Doug Brown, Lex and Yacc, O'Reilly

[COC(DE)-19011] Deep Learning

Teaching Scheme **Examination Scheme**

Lectures: 3 hrs/week | T1, T2 – 20 marks each
End-Sem Exam – 60 marks

Course Outcomes:

Student will be able to

1. Understand the fundamentals of neural networks.
2. Design feed forward networks with backpropagation.
3. Analyze neural networks for performance.
4. Apply attention mechanism to the neural network.

Unit I: Basics [4 Hrs]

Biological Neuron, Idea of computational units, McCulloch–Pitts unit and Thresholding logic, Linear Perceptron, Perceptron Learning Algorithm, Linear separability. Convergence theorem for Perceptron Learning Algorithm.

Unit II: Feedforward Networks [6 Hrs]

Introduction to neural network and multilayer perceptrons (MLPs) , representation power of MLPs, sigmoid neurons, gradient descent, feedforward neural networks representation, Backpropagation.

Unit III: Optimization Techniques [8 Hrs]

Gradient Descent, Batch Optimization, Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Saddle point problem in neural networks, Regularization methods (dropout, drop connect, batch normalization).

Unit IV: Autoencoders [10 Hrs]

Autoencoders, Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders, Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout, Greedy Layerwise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization.

Unit V: Convolutional Neural Networks (CNN) [8 Hrs]

Introduction to CNN, Building blocks of CNN, Transfer Learning, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, Visualizing CNNs, Guided Backpropagation, Fooling Convolutional Neural Networks.

Unit VI: Recurrent Neural Networks (RCNN) [8 Hrs]

Introduction to RCNN, Backpropagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs, Encoder Decoder Models, Attention Mechanism.

Text Books:

1. Deep Learning- Ian Goodfelllow, Yoshua Benjio, Aaron Courville, The MIT Press

References:

1. Neural Networks: A Systematic Introduction, Raúl Rojas, 1996
2. Pattern Recognition and Machine Learning, Christopher Bishop, 2007

[COC-19009] Data Mining and Machine Learning

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each
	End-Sem Exam – 60 marks

Course Outcomes:

Students will

1. Understand Supervised, unsupervised and semi supervised machine learning algorithm
2. Study of probabilistic analysis, parametric and non-parametric algorithms
3. Estimation of Maximum Likelihood, losses and risks for sample implementation
4. Study and Compare various classification, association, clustering algorithms
5. Apply data mining algorithms for solving real life problems
6. Discuss active areas of research in Data Mining and Machine Learning

Unit1: Introduction [6 Hrs]

Introduction to data mining, Applications, Motivation, Data mining knowledge discovery process, kinds of data, data mining techniques, issues in data mining Introduction to Machine Learning: What is machine learning, Applications of ML, Design Perspective and Issues in ML, Supervised, Unsupervised, Semi-supervised learning with applications and issues.

Unit 2: Input, Output and Data Pre-processing [6 Hrs]

Input : Concepts, instances and attributes, Output: Knowledge Representation: Decision tables, Decision trees, Decision rules, Rules involving relations, Instance-based representation. Data Pre-processing-data cleaning, data integration and transformation, data reduction, data discretization and concept hierarchy generation.

Unit 3: Classification, Diagnostic and Prediction [8 Hrs]

Introduction to Classification, issues regarding classification, Classification: Model (or hypothesis) representation, decision boundary, cost function, gradient descent, regularization. Diagnostic: debugging a learning algorithm, evaluating a hypothesis (Model selection), training/validating/testing procedures (offline and online training of models), diagnosing bias versus variance and vice versa, and bias/variance, learning curves, regularization techniques Accuracy and Error measures: classifier accuracy measures, predictor error measure, evaluating the accuracy of a classifier or predictor, Confusion metric, precision, recall, tradeoff between both, accuracy, Analysis of ROC, AUC.

Unit 4: Decision tree, Probabilistic classifier, Clustering [6 Hrs]

Decision Tree: representation, hypothesis, issues in Decision Tree Learning, Pruning, Rule extraction from Tree, Learning rules from Data. Probabilistic classifier: Bayes rule, Maximum Likelihood Estimation, case study, Clustering :Unsupervised learning technique, Similarity and

Distance Measures, k-means and k-medoids algorithm, optimization objective, random initialization, choosing value of k, EM algorithm.

Unit 5: Association Rule Mining and Support Vector Machines **[6 Hrs]**
Mining Frequent Patterns, Associations and Correlations: Basic concepts, Apriori algorithm for finding frequent itemsets using candidate generation, generating association rules from frequent itemsets, from association to correlation analysis Support Vector Machines: Objective(optimization), hypothesis, SVM decision boundary, kernels : RBF and others.

Unit 6: Advanced Techniques **[6 Hrs]**
Neural Networks, use case involving the use of neural network, role of various activation functions, SVD, Latent Dirichlet Allocation model, Latent Semantic Indexing, Models for Time-series forecasting - AR, MA, ARMA, ARIMA.

Text Books:

1. Tom Mitchell, Machine Learning, McGraw-Hill, 1997.
2. Jiawei Han Micheline Kamber, Data Mining Concepts and Techniques, Latest Edition

References:

1. Ethem Alpaydin, Introduction to Machine Learning, PHI, 2005
2. D. Hand, H. Mannila and P. Smyth. Principles of Data Mining. Prentice-Hall. 2001
3. K.P. Soman, R. Longonathan and V. Vijay, Machine Learning with SVM and Other Kernel Methods, PHI-2009
4. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer 2006.
5. M. H. Dunham. Data Mining: Introductory and Advanced Topics. Pearson Education. 2001
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6. T. Fawcett, "An introduction to ROC analysis," *Pattern Recognit. Lett.*, vol. 27, no. 8, pp. 861–874, 2006. Link: https://people.inf.elte.hu/kiss/13dwhdm/roc.pdf

[COC-19010] Security in Computing

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each
End-Sem Exam – 60 marks

Course Outcomes:

Students will be able to:

1. Demonstrate the importance of security in networked computing environments
2. Determine appropriate mechanisms such as encrypt, decrypt and transmit messages using cryptographic techniques for protecting networked systems.
3. Analyze high level the vulnerabilities and threats in the Internet and networked computing systems.
4. Develop basic system security mechanisms, such as those used in operating systems, file systems and computer networks
5. Discuss the issues concerning various threats to wireless networks, encryption and decryption

Unit I: Introduction **[6 Hrs]**
Cryptography and Modern Cryptography, Basic concepts: threats, vulnerabilities, controls; risk; Security services, security policies, security mechanisms. Active vs. Passive attacks, Historical Ciphers and Their cryptanalysis, one time passwords (Vernam's Cipher)

Unit II: Number Theory **[6 Hrs]**
Review of number theory and algebra, computational complexity, probability and information theory, primality testing, the Euclidean algorithm – Congruences: Definitions and properties – linear congruences, residue classes, Euler's phi function – Fermat's Little Theorem – Chinese Remainder Theorem

Unit III: Symmetric Key Encryption **[6 Hrs]**
Cryptography and cryptanalysis, DES, Triple DES, AES, IDEA, CAST-128, RC4, Modes of operation.

Unit IV: Public Key Cryptography **[6 Hrs]**
RSA cryptosystem, Diffie-Hellman, Elliptic curve cryptography, Rabin, ElGamal, Goldwasser-Micali, Blum-Goldwasser cryptosystems.

Unit V: Threats To Wireless Network **[6 Hrs]**
Wireless availability, Privacy Challenges. Risks: denial of Service, Insertion Attacks, interception and monitoring wireless traffic, Mis-configuration. Wireless Attack: Surveillance, War Driving, Client-to-Client Hacking, Rogue Access Points, Jamming and Denial of Service.

Unit VI: Wireless Network Security **[6 Hrs]**
Access Point-Based Security Measures, Thin Party Security Methods, Funk's Steel-Belted Radius, VVLAN Protection Enhancements, Blue-tooth Security Implementation, Security in WIMAX, UWB security, Satellite network security

Text Books:

1. William Stallings, Cryptography and Network Security, Prentice Hall, 4th Edition, 2006
2. Behrouz A Forouzan, Cryptography & Network Security, McGraw-Hill, 2008
3. Atul Kahate, Cryptography and Network Security, Tata McGraw-Hill, 2nd Edition, 2008.
4. William Stallings, Network Security Essentials Applications and Standards, Pearson Education, New Delhi.

References:

1. C. Pfleeger and S. Pfleeger, Security in Computing, Prentice Hall,4th Edition, 2007.
2. Eric Maiwald, Fundamentals of Network Security, McGraw-Hill, 2004.
3. Jay Ramachandran, Designing Security Architecture Solutions, Wiley Computer Publishing, 2002.
4. Bruce Schneier, Applied Cryptography, John Wiley & Sons Inc, 2001.
5. Charlie Kaufman, Radia Perlman and Mike Speciner, Network Security Private Communication in a public world, Prentice Hall of India Private Ltd., New Delhi

[COC-19011] Embedded Systems

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each
End-Sem Exam – 60

Course Outcomes:

Students will be able to:
1. Explain Characteristics & Salient Features of Embedded Systems
2. Analyze Architecture & Recent Trends of Embedded Systems
3. Discuss PIC and ARM families
4. Understand general process of embedded system development and implement them.
5. Explain communication interface for wired and wireless protocols
6. Discuss hardware and software design methodologies for embedded systems

Unit I: Overview of Embedded Systems [4 Hrs]
Introduction, Definition, Characteristics & Salient Features, Classification, Application Areas, Overview of Embedded System Architecture & Recent Trends.

Unit II: Hardware Architecture [8 Hrs]
Embedded Hardware based on Microprocessors, Microcontrollers & DSPs. Study of PIC Microcontrollers: PIC16C6X/7X Family & Applications. Study of ARM Family : ARM 7,9,10 &11: Overview & Architecture Comparison, Detailed Study of ARM7-TDMI including Core Architecture, ARM/Thumb State, On Chip Debug & Development Support, AMBA Bus, Applications.

Unit III: Communication Interface [6 Hrs]
Serial, Parallel, Wired Wireless Protocols Wired : CAN ,I2C,USB, FireWire Wireless : Blue Tooth , IrDA, IEEE802.11.

Unit IV: Software Architecture [6 Hrs]
Concepts: Embedded OS, Real-Time Operating Systems (RTOS), Detailed Study of RT Linux ,Hand Held OS, Windows CE. & Development Tools.

Unit V: Embedded Systems for Automotive Sector [6 Hrs]
Electronic Control Units (ECU) for Engine Management, Antilock Braking System (ABS), Crusie Control, Design Challenges, Legislative Emission Norm, Interface Standards, Developmental Tools Navigation Systems : Global Positioning System (GPS):Detailed Study & Applications.

Unit VI: [4 Hrs]
Smart Cards: Classifications, Interfacing, Standards & Applications.
RFID Systems: Technology, RFID Tag ,RFID Reader, Applications.

Unit VII: Case Studies [6 Hrs]
Embedded System for Mobile Applications, DSP Based Embedded System, Networked Embedded System & Digital Camera.

Text Books:

1. K.V.K. Prasad, Embedded / Real Time Systems: Concepts, Design and Programming Black Book, Dreamtech Press, 2005.

References:

1. Vahid F. and Givargies T., Embedded Systems Design, John Wiley X. Sons, 2002
2. John B Peatman, Design with PIC Microcontrollers, Pearson Education, 1998
3. Liu, Real-Time Systems, Pearson Education, 2000.
4. Technical Manuals of ARM Processor Family available at ARM Website on Net

[COC-19012] Data Mining and Machine Learning Laboratory

Teaching Scheme:
Practical: 2 hrs/week

Examination Scheme:
Term Work: 50 marks
Oral Examination: 50 marks

Course Outcomes:

Students will be able to :

1. Apply data preprocessing techniques on any data.
2. Apply all possible evaluation measures and diagnoses required on kinds of data
3. Apply learning techniques like classification, decision tress, naive bayesian model, clustering, SVM, ANN, etc., to solve a real-life problem.
4. Demonstrate the ability to analyze different machine learning algorithms using exploratory data analysis techniques
5. Compare and contrast the strengths and weaknesses of various Machine Learning approaches

Suggested list of Assignments:

1. Take any benchmark dataset (both numeric and text) and apply preprocessing techniques on it.

2. Compare the performance of 10 machine learning models for regression data set (eg. UCI repository Breast Cancer dataset) for the data partition of 70-30% with acceptable error of ±100. The comparative study of machine learning models should be of the form:

Model	Method	Package	r	R2	Error	Accuracy
M1						
M2						
…						
M10						

3. Study 5 feature selection techniques on the regression data set considered in (2) and report top five features. The study of feature selection techniques should be represented as :

Feature Selection Technique	Tops 5 Features

T1	
T2	
..	
T5	

4. Estimate the accuracy of the Naive Bayes classifier on the breast cancer data set using 5-fold cross-validation.

5. Implement the SVM algorithm with RBF. Estimate the precision, recall, accuracy, and F-measure on the text classification task for each of the 10 categories using 10-fold cross-validation of Reuters dataset.

6. Implement both the *k*-means algorithm and the Hierarchical Agglomerative Clustering (HAC) algorithm. For both, assume that all features are real-valued. Also assume that there is no need for normalization of the features. Use the L_n-norm for distance calculations with a default value of n=2 (Euclidean).
Note that the datasets you are to test your algorithms with contain labeled items. You will need to ignore the label (target attribute, always last here) while clustering.
Implement the *k*-means clustering algorithm and the HAC algorithm (using single linkage). For *k*-means, your program should automatically try $2 <= k <= 7$ and compute the squared error in each case. You should then return the value of *k* that produces the lowest squared error, together with that error. For HAC, you should compute (and store) the squared errors of all possible clustering's (as they are built from the bottom up). Upon completion, you should return the value of *t* (distance threshold) that produces the lowest squared error, the corresponding number of clusters, and the corresponding error.
Use the algorithms on the Iris dataset(available on UCI repository) .
Compare the best number of clusters obtained by *k*-means and HAC. How do these also compare with the underlying structure of the dataset in which there are 3 classes of iris plants?
Experiment with your distance metric -- can you find a value of *n* for the L_n-norm that changes the number of clusters found?
Graph the value of the squared error for each clustering as HAC executes (with no threshold). What do you observe? Is this surprising?

7. Implement the Apriori algorithm. Build your own association task. Design your task so that it contains some simple associations you can check your algorithm against. List these associations. Run Apriori for various combinations of *minsup* and *minconf* values. Verify that the associations you designed into the task are discovered by your algorithm.
Note: The teacher taking the course can change the list of assignments. This is just a guideline of list of assignments.

[COC-19013] Security in Computing Laboratory

Teaching Scheme:
Practical: 2 hrs/week

Examination Scheme:
Term Work: 50 marks
Oral Examination: 50 marks

Course Outcomes:

Students will be able to:

1. Design own encryption technique using the concepts they studied
2. Demonstrate the practical importance of security in computing
3. Analyze the implementations for time required to generate keys and encryption/decryption process also various possible attacks
4. Install and configuring the proxy server, Firewall and IDS

Suggested list of assignments:

1. Design and Implement your own encryption/ decryption algorithm using any programming language
2. Design an experiment to estimate the amount of time to Generate key pair (RSA): Encrypt n bit message (RSA), Decrypt n bit message (RSA), As function of key size, experiment with different n-bit messages. Summarize your conclusion.
3. Implementation of email security using PGP (create yourself a 1024-bit PGP key. Use your name and email address for your key label. Use PGP to verify the signature on this assignment.
4. Install any Proxy Server and configure an application gateway.
5. Install any Firewall and configure it as per the defined security policy.
6. Install, Configure and study any Intrusion Detection System (IDS).

[COC-19014] Embedded Systems Laboratory

Teaching Scheme:
Laboratory: 2 Hrs/week

Examination Scheme:
Continuous Evaluation : 50 marks
End-Sem Exam: 50 Marks

Course Outcomes:

Student will be able to

1. Develop prototype codes using commonly available on and off chip peripherals with and without interrupts on Cortex M3/M4 development boards

Suggested list of Assignments:

Experiments to be carried out on Tiva (TM4C123X) Launch-pads:

1. Blink an LED with software delay, delay generated using the SysTick timer.
2. System clock real time alteration using the PLL modules.
3. Control intensity of an LED using PWM implemented in software and hardware.
4. Control an LED using switch by polling method, by interrupt method and flash the LED once every five switch presses.
5. Key matrix and alphanumeric LCD interfacing and programming.
6. UART programming with accessing TX ad RX buffers directly and using DMA.
7. Recording of analog readings at the output of rotary potentiometer connected to ADC channel.
8. Programming (ISL 29023) Ambient and Infrared Light sensor available on Sensor Hub Booster Pack using I^2C interface.
9. Calling C functions from assembly programs and vice versa.