Academic Handbook

M.Tech. Programme

Academic Affairs

(2013-2014)

NATIONAL INSTITUTE OF TECHNOLOGY GOA

Course Curriculum

for

Master of Technology Programme

in

Computer Science and Engineering

Department of Computer Science and Engineering

National Institute of Technology Goa

Farmagudi, Ponda, Goa - 403 401

Semester-wise Credit Distribution

Semester	Total Credits
I	18
II	18
III	14
IV	14
Total Credits	**64**

Summary of Course Contents
(First year)

First Semester				
Sl. No	**Sub. Code**	**Subjects**	**L-T- P**	**Credits**
1	CS600	Advanced Algorithms & Analysis (AAA)	3-0-0	3
2	CS601	Advanced Computer Networks (ACN)	3-0-0	3
3	CS602	Mathematical Foundations of Computer Science (MFCS)	3-0-0	3
4	CS8**	Elective-I	3-0-0	3
5	CS603	Advanced Algorithms & Analysis Laboratory	0-0-3	2
6	CS604	Advanced Computer Networks Laboratory	0-0-3	2
7	CS605	Seminar	0-0-3	2
		Total Credits		**18**

Second Semester				
Sl. No	**Sub. Code**	**Subjects**	**L-T- P**	**Credits**
1	CS650	Advanced Database Systems (ADBS)	3-0-0	3
2	CS651	Advanced Computer Architecture (ACA)	3-0-0	3
3	CS652	Object Oriented Software Engineering (OOSE)	3-0-0	3
4	CS8**	Elective-II	3-0-0	3
5	CS653	Advanced Database Systems Laboratory	0-0-3	2
6	CS654	Object Oriented Software Engineering Laboratory	0-0-3	2
7	CS655	VIVA	-	2
8	HU650	Communication Skills and Technical Writing (Audit Course)	1-0-2	-
		Total Credits		**18**

Summary of Course Contents
(Second year)

Third Semester				
Sl. No	**Sub. Code**	**Subjects**	**L-T- P**	**Credits**
1	CS700	Major Project-I	0-0-12	8
2	CS8**	Elective-III	3-0-0	3
3	CS8**	Elective-IV	3-0-0	3
		Total Credits		**14**

Fourth Semester				
Sl. No	**Sub. Code**	**Subjects**	**L-T- P**	**Credits**
1	CS750	Major Project-II	0-0-21	14
		Total Credits		**14**

NOTE: The applicant must have a sufficient background in computer science and engineering to complete the degree requirements with reasonable performance. As the students with background other than computer science and engineering have been allowed to apply for M. Tech programme in computer science and engineering, they may not be allowed to get the admission into the programme, if they are not exposed to the prerequisites such as below.

Prerequisites for the Admission into the Programme	
1	Data Structures
2	Design and Analysis of Algorithms
3	Computer Organization and Architecture
4	Discrete Mathematics
5	Computer Networks
6	Database Management Systems

List of Electives

Program Specific Electives				
SI. No.	Course Code	Course Name	Total Credits (L-T-P)	Credits
1	CS800	Foundations of Cryptography	(3-0-0)	3
2	CS801	Wireless Sensor Networks	(3-0-0)	3
3	CS802	Advanced Compiler Design	(3-0-0)	3
4	CS803	Distributed Computing Systems	(3-0-0)	3
5	CS804	Design of Secure Protocols	(3-0-0)	3
6	CS805	Mobile Computing	(3-0-0)	3
7	CS806	Machine Learning	(3-0-0)	3
8	CS807	Health Informatics	(3-0-0)	3
9	CS808	Soft Computing	(3-0-0)	3
10	CS809	Service Oriented Architecture & Cloud Computing	(3-0-0)	3
11	CS810	Big Data Analytics	(3-0-0)	3
12	CS811	Pattern Recognition	(3-0-0)	3
13	CS812	Artificial Neural Networks	(3-0-0)	3
14	CS813	Computer Vision	(3-0-0)	3
15	CS814	Game Theory	(3-0-0)	3
16	CS815	Data Warehousing & Data Mining	(3-0-0)	3
17	CS816	E-Commerce	(3-0-0)	3
18	CS817	Advanced Operating Systems	(3-0-0)	3
19	CS818	Security and Privacy	(3-0-0)	3
20	CS819	Bioinformatics Algorithms	(3-0-0)	3
21	CS820	Graph Theory	(3-0-0)	3
22	CS821	Probability and Statistics	(3-0-0)	3
23	CS822	Program Analysis and Verification	(3-0-0)	3
24	CS823	Linear Algebra	(3-0-0)	3
25	CS824	Number Theory	(3-0-0)	3
26	CS825	Complexity Theory	(3-0-0)	3
27	CS826	Human Computer Interface	(3-0-0)	3

1-Credit Module Courses

SI. No.	Course Code	Course Name	Total Credits (L-T-P)	Credits
1	CS827	Special Module in Computational Geometry	(3-0-0)	1
2	CS828	Special Module in Parallel Computation	(3-0-0)	1
3	CS829	Special Module in Hardware Systems	(3-0-0)	1
4	CS830	Special Module in Theoretical Computer Science	(3-0-0)	1
5	CS831	Special Module in Artificial Intelligence	(3-0-0)	1
6	CS832	Special Module in High Speed Networks	(3-0-0)	1
7	CS833	Special Module in Concurrency	(3-0-0)	1
8	CS834	Special Module in NLP	(3-0-0)	1
9	CS835	Special Module in Numerical Methods	(3-0-0)	1
10	CS836	Special Module in CSE*	(3-0-0)	1

These courses will usually cover topics that are not generally covered in the regular courses. Interested students can register for these courses for credits, provided, the above semester-wise credit structure is followed. They are evaluated like any other courses and credits earned count towards degree requirements. The syllabi of these courses are not specified. It will be decided by the courses instructor from time to time. These courses can be given anytime in the semester. They are specially designed to take advantage of short time eminent visitors from Industry/Academics.

* The 1-credit module course CS836 will cover topics of current interest in computer science and engineering.

Audit Course*

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	HU650	Communication Skills and Technical Writing	1-0-2	-

(* No credits)

Proposed Course Contents

Subject Code CS600	**Advanced Algorithms & Analysis (AAA)**	**Credits: 3 (3-0-0)** **Total hours: 45**
Course Objectives	To study paradigms and approaches used to analyze and design algorithms and to appreciate the impact of algorithm design in practice.	
Module 1		**5 Hours**
Formal models of computation, time and space complexity, Proof of lower. **Algorithm design techniques**: Greedy algorithms, divide-and-conquer algorithms, dynamic programming, Branch-and-bound, amortization, optimal algorithms.		
Module 2		**15 Hours**
Algorithms on arrays: Selection and median-finding, counting, radix and bucket sorts, string matching (Rabin-Karp and Knuth-Morris-Pratt algorithms) etc., **Geometric algorithms :** Convex hulls, sweep paradigm, Voronoi diagrams. etc., **Algorithms on graphs :** Traversal, topological sort, minimum spanning trees, shortest path, network flow -preflow-push algorithms, max flow algorithm etc., **Arithmetic algorithms :** GCD, modular arithmetic, primality testing etc**.,** **Numerical algorithms, Internet algorithms.**		
Module 3		**10 Hours**
NP-Completeness: Polynomial time, Verification, NP-Completeness and reducibility, NP-Completeness proofs, NP-Complete problems.		
Module 4		**10 Hours**
Randomized algorithms: Monte Carlo and Las Vegas algorithm. Randomized algorithms for the problems in various domains viz., Graph algorithms, Geometric algorithms parallel and distributing algorithms, online algorithms, Number theory and algebra., etc.,		
Module 5		**5 Hours**
Approximation Algorithms: PTAS and FPTAS algorithms, Combinatorial algorithms- Setcover, cut , TSP etc. **Exact exponential algorithms:**		
Reference Books	1. T. Cormen, Charles E. Leiserson and Ronald D River, *Introduction to Algorithms*, PHI, 3rd edition, 2009. 2. Aho, Hopcroft and Ullman *The design and analysis of Computer Algorithms*, Addison Weseley, 1st edition, 1974. 3. M. R. Garey and D. S. Johnson, *Computers and Intractability*: *A Guide to the Theory of NP-Completeness*, Freeman, 1st edition, 1979. 4. Rajeev Motwani and Prabhakar Raghavan, *Randomized Algorithms*, Cambridge University, 1st edition, 1995. 5. Vijay V Vazirani, *Approximation Algorithms*, Springer, 2002.	

<table>
<tr><td>Subject Code
CS601</td><td>Advanced Computer Networks (ACN)</td><td>Credits: 3 (3-0-0)

Total hours: 45</td></tr>
<tr><td>Course Objectives</td><td colspan="2">To understand the theoretical and the practical aspects of the advanced networking principles including the distributed computing. The course involves the future networking principles also.</td></tr>
<tr><td colspan="2">Module 1</td><td>10 Hours</td></tr>
<tr><td colspan="3">Review of Basic Network Architectures: OSI reference model, TCP/IP reference model, ATM reference model; Applications(WWW, Audio/Video Streaming, Video conference, Networked Games, Client/Server); Traffic Characterization (CBR, VBR); Switching Paradigms; Multiplexing; Error Control; Flow Control, FTH, DTH, PON, ISDN, DSL, CATV, SONET, Optical Networks.</td></tr>
<tr><td colspan="2">Module 2</td><td>8 Hours</td></tr>
<tr><td colspan="3">Local Area Network Technologies: Fast Ethernet, Gigabit Ethernet, IEEE 802.11 WLAN, Bluetooth, Connecting LANs, VLANS.</td></tr>
<tr><td colspan="2">Module 3</td><td>10 Hours</td></tr>
<tr><td colspan="3">Internetworking: Interdomain Routing, BGP, IPv6, Multicast Routing Protocols, Multi Protocol Label Switching, Virtual Private Networks, High speed transport protocols, Quality of Service Mechanisms, Improving QoS in Internet, DiffServ and IntServ Architectures, RSVP.</td></tr>
<tr><td colspan="2">Module 4</td><td>12 Hours</td></tr>
<tr><td colspan="3">Distributed Systems: Naming, DNS, DDNS, Paradigms for Communication in Internet, Caching, Issues of Scaling in Internet and Distributed Systems, Caching Techniques forWeb, Protocols to Support Streaming Media, Multimedia Transport Protocols, Content Delivery Networks, Overlay and P2P Networks.</td></tr>
<tr><td colspan="2">Module 5</td><td>5 Hours</td></tr>
<tr><td colspan="3">Applications and Other Networking Technologies: RTP, RTSP, SIP, VoIP, Security Systems, SSH, PGP, TLS, IPSEC, DDoS Attack, Mitigation in Internet, Security in MPLS; Introduction to Cellular, Satellite and Ad hoc Networks.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. Behrouz A. Forouzan, Data Communications and Networking, 5th edition, Tata McGraw Hill, 2013.
2. Larry L. Peterson and Bruce S. Davie, Computer Networks: A Systems Approach, 4th edition, Morgan Kaufmann, 2007.
3. J. Walrand and P. Varaiya, High Performance Communication Networks, 2nd edition, Morgan Kauffman, 2000
4. Markus Hoffmann and Leland R. Beaumont, Content Networking: Architecture, Protocols, and Practice, Morgan Kauffman, 2005.</td></tr>
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<table>
<tr><td>Subject Code

CS602</td><td>Mathematical Foundations of Computer Science (MFCS)</td><td>Credits: 3 (3-0-0)

Total hours: 45</td></tr>
<tr><td>Course Objectives</td><td colspan="2">This course introduces the mathematical foundations for computer science, viz., Mathematical logic, Combinatorics, Boolean and linear algebra and Automata theory.</td></tr>
<tr><td colspan="2">Module 1</td><td>10 Hours</td></tr>
<tr><td colspan="3">Language of Math– Logic, Proof techniques, (infinite) sets, countable and uncountable sets, Functions, Relations, Cantor's diagonalization, Applications to undecidability, Induction, Recursion, Basic number theory: Divisibility, congruences, quadratic residues.</td></tr>
<tr><td colspan="2">Module2</td><td>6 Hours</td></tr>
<tr><td colspan="3">Combinatorics– General Counting methods, Recurrence relations, Generating Functions, Principle of Inclusion-Exclusion, Posets and Lattices - Permutations, Groups and algebraic structures.</td></tr>
<tr><td colspan="2">Module 3</td><td>09 Hours</td></tr>
<tr><td colspan="3">Automata, Grammars and Languages: Regular languages and finite automata, Context-free languages and pushdown automata, Turing machines, Some other computing models and formalisms, their equivalence with Turing machines, Undecidability.</td></tr>
<tr><td colspan="2">Module 4</td><td>10 Hours</td></tr>
<tr><td colspan="3">Probability– Sample space, Distributions, Random Variables, Expectation, Tail Inequalities - Chernoff Bound, Chebyshev inequality, Functions of random variables, Applications.</td></tr>
<tr><td colspan="2">Module 5</td><td>10 Hours</td></tr>
<tr><td colspan="3">Linear Algebra– Fields, Vector Spaces, Basis, Matrices and Linear Transformations, Eigen values, Orthogonality, Vector and Matrix Norms - Applications to optimization problems and graph theory.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. W. Feller, An Introduction to Probability Theory and Its Applications, Wiley; vol. 1 & 2, 1971.
2. Jean Gallier, Discrete mathematics, Springer, 2011.
3. John Hopcroft, Rajeev Motowani and Jeffrey Ullman, Automata Theory, Languages, and Computation, 3rd edition, 1974.
4. Gilbert Strang, Introduction to Linear Algebra, 4th Edition, Wellesley-Cambridge Press, Wellesley, MA, 2009.</td></tr>
</table>

<table>
<tr><td>Subject Code
CS603</td><td>Advanced Algorithms & Analysis Laboratory</td><td>Credits: 2 (0-0-3)
Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="2">To have hands on session with the algorithms.</td></tr>
<tr><td colspan="3">Experiments</td></tr>
<tr><td colspan="3">Experiments include the implementations of the algorithms related to various computational problems in various domains viz., Graph algorithms, Geometric algorithms, cryptographic algorithms, and numerical algorithms etc., using different design paradigms.
- Divide and conquer algorithms.
- Greedy algorithms
- Dynamic programming algorithms
- Branch and bound algorithms
Implementation of the randomized algorithms for various computational problems and comparison with their best deterministic counterparts.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. T. H. Cormen, C. L. Leiserson, R. L. Rivest, and C. Stein, Introduction to Algorithms, 3rd edition, MIT Press, 2009.
2. Harry R. Lewis and Larry Denenberg, Data Structures and Their Algorithms, Harper Collins, 1st edition, 1991.
3. Michael T. Goodrich and Roberto Tamassia, Algorithm Design: Foundations, Analysis, and Internet Examples, 2nd edition, John Wiley, 2008.
4. M. H. Alsuwaiyel, Algorithm Design Techniques and Analysis, vol. 7, World Scientific, 1999.
5. Sara Baase and Allen Van Gelder, Computer Algorithms: Introduction to Design and Analysis, Addison-Wesley, 2000.</td></tr>
</table>

<table>
<tr><td>Subject Code
CS604</td><td>Advanced Computer Networks Laboratory</td><td>Credits: 2 (0-0-3)
Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="2">To provide hands on in the topics studied in advanced computer networks course</td></tr>
<tr><td colspan="3">This laboratory focuses on developing applications inter process communication tools such as pipes, FIFOs, message queues and sockets. Broadly applications will be of the following nature:
1. Developing basic network client server programs to exchange data, stream audio and video
2. To develop a chat application
3. To develop a networked multi-party game
4. Simulation of the routing algorithms
5. Exercises to explore transport protocols
6. Simulation of the distributed systems
7. Running clock synchronization algorithms</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. Larry L. Peterson and Bruce S. Davie, Computer Networks: A Systems Approach, 4th edition, Morgan Kaufmann, 2007.
2. W. Richard Stevens, Bill Fenner and Andrew M. Rudoff, UNIX Network Programming, 3rd edition, Addison Wesley, 2003.
3. Elliotte Rusty Harold, Java Network Programming, 3rd edition, O'Reilly, 2004.</td></tr>
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<tr><td>Subject Code
CS605</td><td>Seminar</td><td>Credits: 2 (0-0-3)</td></tr>
<tr><td>Course Objectives</td><td colspan="2">Students will have to choose a topic in CSE's current trends or industry practices, prepare a write up, and present it along with a suitable demonstration.</td></tr>
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<tr><td>Subject Code CS650</td><td colspan="2">Advanced Database Systems (ADBS)</td><td>Credits: 3 (3-0-0)
Total hours: 45</td></tr>
<tr><td>Course Objectives</td><td colspan="3">To develop an appreciation of emerging database trends as they apply to semi-structured data, the internet, and object-oriented databases. To explain the process of DB Query processing and evaluation. To understand and evaluate the aspects of database security.</td></tr>
<tr><td colspan="3">Module 1</td><td>8 Hours</td></tr>
<tr><td colspan="4">Distributed database concepts, overview of client-server architecture and its relationship to distributed databases, concurrency control heterogeneity issues, persistent programming languages, object identity and its implementation, clustering, indexing, client server object bases, cache coherence.</td></tr>
<tr><td colspan="3">Module 2</td><td>10 Hours</td></tr>
<tr><td colspan="4">Parallel databases: Parallel architectures, performance measures, shared nothing/shared disk/shared memory based architectures, data partitioning, intra-operator parallelism, pipelining, scheduling, load balancing, query processing- index based, query optimization: cost estimation, query optimization: algorithms, online query processing and optimization, XML, DTD, XPath, XML indexing, adaptive query processing.</td></tr>
<tr><td colspan="3">Module 3</td><td>10 Hours</td></tr>
<tr><td colspan="4">Advanced transaction models: Save points, sagas, nested transactions, multi-level transactions, Recovery, multilevel recovery, shared disk systems, distributed systems 2PC, 3PC, replication and hot spares, data storage, security and privacy- multidimensional k- anonymity, data stream management.</td></tr>
<tr><td colspan="3">Module 4</td><td>8 Hours</td></tr>
<tr><td colspan="4">Models of spatial data: Conceptual data models for spatial databases (e.g. pictogram enhanced ERDs), logical data models for spatial databases: raster model (map algebra), vector model, spatial query languages, need for spatial operators and relations, SQL3 and ADT. spatial operators, OGIS queries.</td></tr>
<tr><td colspan="3">Module 5</td><td>9 Hours</td></tr>
<tr><td colspan="4">Access Control-Models, Policy. Trust management and Negotiations, Secure data outsourcing, Security in Advanced Database systems, Security in Data Warehouses and OLAP systems, Spatial database security, Security for workflow systems, Database watermarking.</td></tr>
<tr><td>Reference Books</td><td colspan="3">1. AviSilberschatz, Henry Korth, and S. Sudarshan, Database system concepts, 5th edition, McGraw Hill, 2005.
2. R. Elmasri and S. Navathe, Fundamentals of database systems, Benjamin - Cummings,5th edition, 2007.
3. Ceri S and Pelagatti G, Distributed databases principles and systems, 2nd edition, Mc-Graw Hill, 1999.
4. S. Castino, M. Fugini, G. Martella and P. Samarati (eds), Database Security, Addison Wesley, 1994.
5. Michael Gertz, Sushil Jajodia, Handbook of Database Security: Applications and Trends, Springer, 2008.</td></tr>
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<table>
<tr><td>Subject Code
CS651</td><td colspan="2">Advanced Computer Architecture (ACA)</td><td>Credits: 3 (3-0-0)
Total hours: 45</td></tr>
<tr><td>Course Objectives</td><td colspan="3">To understand the design principles of the modern computing systems</td></tr>
<tr><td colspan="3">Module 1</td><td>10 Hours</td></tr>
<tr><td colspan="4">Principles of computer organization: Data representation, data path design- pipelined arithmetic unit design, representation of instructions- instruction set architectures (RISC and CISC), instruction format, design of the control unit; memory hierarchy design-basic memory cell, memory chip, memory unit, cache memory unit design with mapping methods and multi-level cache design, design of memory management unit; I/O methods

Pipelined processor design: overlapped execution of instructions, pipeline hazards, pipeline idealism,</td></tr>
<tr><td colspan="3">Module 2</td><td>13 Hours</td></tr>
<tr><td colspan="4">Superscalar processor: Parallel pipelines, instruction level parallelism, out of order execution of instructions, semantic constraints: register data flow techniques, memory data flow techniques, control flow techniques, dynamic techniques.</td></tr>
<tr><td colspan="3">Module 3</td><td>11 Hours</td></tr>
<tr><td colspan="4">High performance computing architectures: Parallel computer models and program parallelism, Classification of machines, SISD, SIMD and MIMD, Conditions of parallelism, data and resource dependencies, hardware and software parallelism, program partitioning and scheduling, grain size latency, program flow mechanism, control flow versus data flow, data flow architecture, demand driven mechanisms, comparison of flow mechanisms.</td></tr>
<tr><td colspan="3">Module 4</td><td>11 Hours</td></tr>
<tr><td colspan="4">Advanced processor architectures: Multithreaded processors, multi-core processors, multi-processor systems, cache-coherence protocols, directory based protocols. Storage systems: strage area networks, RAID architecture, Graphics processing units.</td></tr>
<tr><td>Reference Books</td><td colspan="3">1. John Paul Shen and Mikko H. Lipasti, Modern processor design - Fundamentals of superscalar processors, Tata McGraw Hill, 2005.
2. V. Rajaraman and C. Sivarama murthy, Parallel Computer: Architecture and Programming, PHI, 2000.
3. K. Hwang and F.A. Briggs, Computer Architecture and Parallel Processing, McGraw Hill, 1984.
4. John L. Hennesy and David A. Patterson, Computer Architecture- A quantitative approach, 4th edition, Elsevier, 2007
5. Dezso Sima, Terence Fountain and Peter Kacsuk, Advanced Computer Architectures: A design space approach, Addison Wesley, 1997.
6. John P. Hayes, Computer Architecture and Organization, 3rd edition, McGraw Hill, 1998.</td></tr>
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<table>
<tr><td>Subject Code

CS652</td><td>Object Oriented Software Engineering (OOSE)</td><td>Credits: 3 (3-0-0)

Total hours: 45</td></tr>
<tr><td>Course Objectives:</td><td colspan="2">This course introduces Object-oriented software engineering (OOSE) - which is a popular technical approach to analyzing, designing an application, system, or business by applying the object-oriented paradigm and visual modeling.</td></tr>
<tr><td colspan="2">Module 1</td><td>11 Hours</td></tr>
<tr><td colspan="3">Introduction to software engineering - software engineering concepts, software engineering development activities, managing software development, project organization and communication; Introduction to UML - UML notations – package diagrams, component diagrams, deployment diagrams, use-case diagrams, activity diagrams, class diagrams, sequence diagrams, interaction overview diagrams, composite structure diagrams, state machine diagrams, timing diagrams, object diagrams, communication diagrams.</td></tr>
<tr><td colspan="2">Module 2</td><td>12 Hours</td></tr>
<tr><td colspan="3">Requirements elicitation - functional and nonfunctional requirements, completeness, consistency, clarity and correctness, realism, verifiability and traceability; requirements elicitation activities – identifying actors, scenarios, use-cases; maintaining traceability and documentation. Analysis modeling – analysis object models and dynamic models, entity, boundary and control objects, generalization and specialization; analysis activities – from use cases to objects, managing and documenting analysis.</td></tr>
<tr><td colspan="2">Module 3</td><td>11 Hours</td></tr>
<tr><td colspan="3">System design concepts – subsystem and classes, services and subsystem interfaces, coupling and cohesion, layers and partitions; system design activities – from objects to subsystems; addressing design goals – mapping subsystems to processors and components, identifying and storing persistent data, providing access control, designing the global control flow, identifying services and boundary conditions; managing and documenting system design; object design – specifying interfaces.</td></tr>
<tr><td colspan="2">Module 4</td><td>11 Hours</td></tr>
<tr><td colspan="3">Mapping models to code – model transformation, refactoring, forward engineering, reverse engineering, transformation principles; mapping activities; managing implementation; testing concepts – faults, erroneous states and failures; testing activities – component inspection, usability testing, unit testing, integration testing, system testing; managing and documenting testing. Rationale management, configuration management, project management, software lifecycle.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. Bernd Bruegge and Allen H. Dutoit, Object-Oriented Software Engineering Using UML, Patterns, and Java, 3rd edition, Pearson Education, 2009.
2. Grady Booch, Robert A. Maksimchuk, Michael W. Engle, Bobbi J. Young, Jim Conallen and Kelli A. Houston, Object-Oriented Analysis and Design with Applications, 3rd edition, Addison-Wesley.
3. Mike O'Docherty, Object-Oriented Analysis and Design: using UML, Wiley Publication, 2005.
4. Alan Dennis, Barbara Haley Wixom and David Tegarden, Systems Analysis and Design with UML 2.0 - An Object-Oriented Approach, 4th edition, Wiley, 2012.</td></tr>
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<table>
<tr><td>Subject Code

CS653</td><td>Advanced Database Systems Laboratory</td><td>Credits: 2 (0-0-3)
Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="2">To have hands on session of the Database concepts</td></tr>
<tr><td colspan="3">1. Database schema design

2. Database creation,

3. SQL programming and report generation using a commercial RDBMS like ORACLE/SYBASE/DB2/SQL-Server/INFORMIX.

4. Students are to be exposed to front end development tools, ODBC and CORBA calls from application Programs.

5. Internet based access to databases and database administration.

6. A project on distributed databases (decided by the instructor.)

7. Implementation of Role based model for a database system.

8. Database security exercises.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. AviSilberschatz, Henry Korth, and S. Sudarshan, Database system concepts, 5^{th} edition, McGraw Hill, 2005.
2. Ralf HartmutGuting and Markus Schneider, Moving objects databases, Morgan Kaufman, 2005.
3. R. Elmasri and S. Navathe, Fundamentals of database systems, 5^{th} edition Benjamin - Cummings, 2007.
4. Raghu Ramakrishnan, Database management systems, McGraw-Hill, 2000.
5. Ceri S and Pelagatti G, Distributed databases principles and systems, 2^{nd} edition, Tata Mc-Graw Hill, 1999.</td></tr>
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<table>
<tr><td>Subject Code
CS654</td><td>Object Oriented Software Engineering (OOSE) Laboratory</td><td>Credits: 2 (0-0-3)
Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="2">The participants are expected to analyze application scenarios and design information systems using the Unified Modeling Language (UML). Furthermore, the designed systems are to be implemented using object-oriented programming language such as Java.</td></tr>
<tr><td colspan="3">Select domain of interest (e.g. e-Commerce) and identify multi-tier software application to work on (e.g. e-Ticketing). Analyze, design and develop this application using OOSE approach:
1. Develop an IEEE standard SRS document. Also develop risk management and project plan (Gantt chart).
2. Identify use cases and develop the use case model.
3. Identify the business activities and develop an UML Activity diagram.
4. Identity the conceptual classes and develop a domain model with UML Class diagram.
5. Using the identified scenarios find the interaction between objects and represent them using UML Interaction diagrams.
6. Draw the state chart diagram.
7. Identify the user interface, domain objects, and technical services. Draw the partial layered, logical architecture diagram with UML package diagram notation.
8. Implement the technical services layer.
9. Implement the domain objects layer.
10. Implement the user interface layer.
11. Draw component and deployment diagrams.
Suggested Software Tools: ArgoUML, Eclipse IDE, Visual Paradigm for UML, StarUML, and Rational Software Architect.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. Bernd Bruegge and Allen H. Dutoit , Object-Oriented Software Engineering Using UML, Patterns, and Java, 3rd edition, Pearson Education, India, 2009.
2. Grady Booch, Robert A. Maksimchuk, Michael W. Engle, Bobbi J. Young, Jim Conallen and Kelli A. Houston, Object-Oriented Analysis and Design with Applications, 3rd edition, Addison-Wesley, 2007.
3. Mike O'Docherty, Object-Oriented Analysis and Design: using UML, John Wiley & Sons, 2005.
4. Alan Dennis, Barbara Haley Wixom and David Tegarden, Systems Analysis and Design with UML 2.0 - An Object-Oriented Approach, 4th edition, Wiley, 2012.</td></tr>
</table>

Subject Code CS655	**VIVA**	**Credits: 2**
Course Objectives	Students will have to attend for a viva-voce in presence of all the faculty of the department for the evaluation of the subjects studied in the first year (I and II semesters) with a suitable demonstration.	

Subject Code **HU650 (Audit Course)**	**Communication Skills and Technical Writing**	**Credits: 0 (1-0-2)** **Total hours: 45**
Course Objectives	This course is meant for developing Professional Communication and Technical Writing Skills among the students. The Lab hours will give emphasis on Technical Presentation and Seminar (on different emerging topics) followed by question-answer and discussion.	
Module 1		**12 hours**
Introduction to Communication-Definition-Types-Classifications, Writing Exercises-Paragraph- Précis-Summary/Executive Summary/Abstract		
Module 2		**8 hours**
Technical Reports-Types-Format-Nuances to be followed		
Module 3		**10 hours**
Preparation of Technical Document-Reports-Instruction Manuals-Project Proposal (Prefatory Part- Main Part- Terminal Section)		
Module 4		**15 hours**
Presentation of Technical Report (Kinesics, Proxemics, and Professional Ethics)		
Reference Books:	1. Raman and Sharma, *Communication Skills*, New Delhi: OUP, 2011. 2. Mandel, Steve, *Technical Presentation Skills: A Practical Guide for Better Speaking* (Revised Edition), Crisp Learning, 2000. 3. Wood, Millett, *The Art of Speaking*, New York: Drake Publishers, 1971. 4. Lencioni, Patrick, *The Five Dysfunctions of a Team*: NJ, John Wiley and Sons, 2006.	

Subject Code CS800	**Foundations of Cryptography (FC)**	**Credits: 3 (3-0-0) Total hours: 45**
Course Objectives	The purpose of the course is to familiarize the students to the arithmetic topics that have been at the centre of interest in applications of number theory, particularly in cryptography. It also includes familiarizing the students with cryptography, cryptographic protocols and the latest elliptic curve systems.	
Module 1		**12 Hours**
Mathematical preliminaries: Number theory and algebra, Finite fields.		
Module 2		**6 Hours**
Symmetric key encryption: Stream ciphers and block ciphers.		
Module 3		**10 Hours**
Public key cryptography, Digital signatures, Attacks, Hash functions, Authentication schemes, Key exchange algorithm, Public key infrastructure.		
Module 4		**8 Hours**
Identification schemes, Interactive proofs, Commitment protocols, Zero knowledge proofs, Non-interactive proofs.		
Module 5		**9 Hours**
Secret sharing schemes, Digital cash, Electronic voting, Elliptic curve, Elliptic curve cryptosystems, Identity based encryption.		
Reference Books	1. Neal Koblitz, *Number theory and cryptography*, Springer, 2007. 2. Hans Delfs, Helmut Knebl, *Introduction to Cryptography: Principles and Applications*, Springer, 2002. 3. Alfred J. Menezes, Paul C. van Oorschot, Scott A. Vanstone, *Handbook of Applied Cryptography*, CRC Press, 1996. 4. Rudolf Lidl, Herald Niederreiter, *Introduction to Finite Fields and their Applications*, Cambridge University Press, 1994. 5. Ivan Niven, Herbert S. Zukerman, Hugh L.Montgomery, *An Introduction to the Theory of Numbers*, John Wiley, 1991.	

<table>
<tr><td>Subject Code

CS801</td><td>Wireless Sensor Networks (WSN)</td><td>Credits: 3 (0-0-3)

Total hours: 45</td></tr>
<tr><td>Course Objectives:</td><td colspan="2">A wireless sensor network (WSN) is a network of spatially distributed autonomous sensors those monitor physical or environmental conditions and cooperatively pass their data through the network to a main location. This course introduces the wireless sensor networks technology and discusses challenges in the design and management of wireless sensor networks.</td></tr>
<tr><td colspan="2">Module 1</td><td>9 hours</td></tr>
<tr><td colspan="3">Introduction to WSN, WSN applications - structural health monitoring, traffic control, healthcare, pipeline monitoring, precision agriculture, active volcano, underground mining, sensor node architecture and operating systems.</td></tr>
<tr><td colspan="2">Module 2</td><td>11 hours</td></tr>
<tr><td colspan="3">WSN architectural framework, physical layer – source encoding, channel encoding, modulation, signal propagation, wireless MAC protocols – energy efficiency, scalability, adaptability, low latency and predictability, reliability, network layer – routing metrics, flooding and gossiping, routing protocols.</td></tr>
<tr><td colspan="2">Module 3</td><td>11 hours</td></tr>
<tr><td colspan="3">Node and network management, power management – local power management, dynamic power management, time synchronization in WSN – basics and protocols, localization – ranging techniques, range-based localization, range-free localization, event-driven localization, WSN security – fundamentals and challenges, security attacks, protocols and mechanisms for security.</td></tr>
<tr><td colspan="2">Module 4</td><td>14 hours</td></tr>
<tr><td colspan="3">Sensor network programming, radio basics, introduction to ZigBee – network topology, addressing basics, PAN addresses, channels, basic ZigBee chat, advanced ZigBee, introduction to Arduino, serial flow control, building WSN with Zigbee and Arduino, IEEE 802.15.4 and ZigBee security.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. Ian F. Akyildiz, Mehmet Can Vuran, Wireless Sensor Networks in Communications and Networking, Wiley, 2011.
2. Robert Faludi , Building Wireless Sensor Networks: with ZigBee, XBee, Arduino, and Processing, O'Reilly Media, 2010.
3. Ibrahiem M. M. El Emary, S. Ramakrishnan, Wireless Sensor Networks: From Theory to Applications, CRC Press, 2013.
4. Waltenegus Dargie, Christian Poellabauer, Fundamentals of Wireless Sensor Networks: Theory and Practice, Wiley-Blackwell, 2010.</td></tr>
</table>

Subject Code CS802	**Advanced Compiler Design (ACD)**	**Credits: 3 (3-0-0)** **Total hours: 45**
Course Objectives	Describe the steps and algorithms used by language translators, Recognize the underlying formal models such as finite state automata, push-down automata and their connection to language definition through regular expressions and grammars, Discuss the effectiveness of optimization. To understand the advancements in compiler construction.	
Module 1		**6 Hours**
Introduction to compiler design, Model of a Compilers, Translators, Interpreters, Assemblers, Languages, Computer Architecture vs Compiler Design, Lexical analyzer, Regular expressions and finite automata.		
Module2		**6 Hours**
Introduction to context free grammars, BNF notation, Syntax Analysis.		
Module 3		**8 Hours**
Parsing Techniques: Top-down parsing and Bottom-up parsing, general parsing strategies, brute force approach, recursive descent parser and algorithms, simple LL(1) grammar, bottom-up parsing-handle of a right sentential form, shift reduce parsers, operator precedence parsers, LR, SLR, Canonical LR, LALR grammar and parsers, error recover strategies for different parsing techniques.		
Module 4		**10 Hours**
Symbol table, syntax-directed translation schemes, intermediate code generation, translation schemes for programming language constructs, runtime storage allocation. Code generation, improvement and instruction selection: Issues, basic blocks and flow graphs, register allocation, DAG representation of programs, code generation from DAG, peep hole optimization, dependence analysis and redundancy elimination, specifications of machine.		
Module 5		**15 Hours**
Code optimization: source of optimizations, optimization of basic blocks, loops, global dataflow analysis, procedural and inter-procedural optimization, instruction scheduling optimization for memory hierarchy, solution to iterative dataflow equations. Compilation for high performance architecture; Portability and retargetability, Selected topics from compilers for imperative, object-oriented and mark-up languages, parallel and distributed programming and concurrency.		
Reference Books	1. Alfred V. Aho, Ravi Sethi & Jeffrey D. Ullman, *Compilers; Principles, Techniques & Tools*, Addison- Wesley Publication, 2001. 2. William A. Barrett, John D. Couch, *Compiler Construction, Theory and Practice*, Galgotia, 2000. 3. Steven S. Muchnik, *Advanced Compiler Design & Implementation*, Morgan Kaufmann Publishers, 1997. 4. Michael L. Scott, *Programming Language Pragmatics*, Morgan Kaufmann,	

	2009. 5. Randy Allen and Ken Kennedy, *Optimizing Compilers for Modern Architectures*, Morgan Kaufmann, 2001.

Subject Code **CS803**	**Distributed Computing Systems (DCS)**	**Credits: 3 (3-0-0)** **Total hours: 45**
Course Objectives	This course covers abstractions and implementation techniques for the design of distributed systems. It focuses on server design, network programming, naming, storage systems, security, and fault tolerance.	
Module 1		**10 Hours**
Introduction Distributed Systems and applications, Distributed vs parallel systems, models of distributed systems, Message Passing mechanisms IPC and RPC.		
Module2		**12 Hours**
Clock synchronization, physical & logical clocks, vector clocks, verifying clock algorithms, mutual exclusion using time stamp, election algorithms, Distributed mutual exclusion using time stamps, token & quorums, centralized & distributed algorithms, proof of correctness & complexity, drinking philosophers problem, Implementation & performance evaluation of DME Algorithms.		
Module 3		**11 Hours**
Leader election algorithms, global states, global predicates, termination detection, Control of distributed computation, disjunctive predicates, performance evaluation of leader election algorithms on simulated environments.		
Module 4		**12 Hours**
Distributed File Systems and Services, Shared data, Synchronization Transaction and Concurrency Control. Distributed databases, Name service, Timing & Coordination, Replication, Security and Fault Tolerance.		
Reference Books	1. Vijay K Garg, *Elements of Distributed Computing*, Wiley & Sons, 2002. 2. Pradeep Sinha, *Distributed Operating Systems- Concepts and Design*, PHI, 2000. 3. A.S. Tanenbaum, M.V. Steen, *Distributed Systems – Principles and Paradigms*, PHI, 2003 4. George Couloris, Jean Dollimore, Time Kindberg, *Distributed Systems: Concepts & Design*", Addison Wesley, 2003. 5. Nancy Lynch, *Distributed Algorithm*, Morgan Kaufmann Publishers, 1996.	

<table>
<tr><td>Subject Code
CS804</td><td>Design of Secure Protocols (DSP)</td><td>Credits: 3 (3-0-0)

Total hours: 45</td></tr>
<tr><td>Course Objectives</td><td colspan="2">In this course, we investigate the paradigm of practice-oriented provable security in the context of public key cryptography. Central to this paradigm is the notion of security definition of a cryptographic task. Next comes the problem of designing protocols that can be proven secure assuming the intractability of certain computational problem(s) or the security of some atomic primitive(s). Several such cryptographic protocols will be studied in the course.</td></tr>
<tr><td colspan="2">Module 1</td><td>8 Hours</td></tr>
<tr><td colspan="3">Introduction to Cryptography: Basics of Symmetric Key Cryptography, Basics of Assymetric Key Cryptography, Hardness of Functions . One-way functions, one-way trapdoor functions. Notions of Semantic Security (SS) and Message Indistinguishability (MI): Proof of Equivalence of SS and MI, Hard Core Predicate, Trap-door permutation.</td></tr>
<tr><td colspan="2">Module 2</td><td>6 Hours</td></tr>
<tr><td colspan="3">Formal Notions of Attacks: Attacks under Message Indistinguishability: Chosen Plaintext Attack (IND-CPA), Chosen Ciphertext Attacks (IND-CCA1 and IND-CCA2), Attacks under Message Non-malleability: NM-CPA and NM-CCA2, Inter-relations among the attack model. Random Oracles: Provable Security and asymmetric cryptography, hash functions One-way functions: Weak and Strong one way functions</td></tr>
<tr><td colspan="2">Module 3</td><td>9 Hours</td></tr>
<tr><td colspan="3">Provably secure Pseudo-random Generators (PRG): Blum-Micali-Yao Construction, Construction of more powerful PRG, Relation between One-way functions and PRG, Pseudo-random Functions (PRF). Building a Pseudorandom Permutation. Provable security under different attacks of block ciphers, stream ciphers. Symmetric Encryption.</td></tr>
<tr><td colspan="2">Module 4</td><td>10 Hours</td></tr>
<tr><td colspan="3">Message authentication: MAC, Authenticated encryption. Public key encryption: the notions of indistinguishability and semantic security including the question of equivalence of definitions, security against chosen plaintext and chosen ciphertext attacks. Some concrete public key encryption and identity-based encryption schemes and their security.</td></tr>
<tr><td colspan="2">Module 5</td><td>12 Hours</td></tr>
<tr><td colspan="3">Digital signatures and the notion of existential unforgability under chosen message attacks. Key agreement protocols and secure channels. The random oracle assumption. The quantitative measure of security including the questions of tightness in security reduction and concrete security. Shamir's Secret Sharing Scheme, Formally Analyzing Cryptographic Protocols. Case Studies.</td></tr>
</table>

Reference Books	1. Hans Delfs, Helmut Knebl, *Introduction to Cryptography: Principles and Applications*, Springer, 2002. 2. Wenbo Mao, *Modern Cryptography, Theory and Practice*, Prentice Hall, 2003. 3. Oded Goldreich, *Foundations of Cryptography*, Cambridge University Press, Vol-I and Vol-II, 2007. 4. Shaffi Goldwasser and Mihir Bellare, *Lecture Notes on Cryptography*, Available at http://citeseerx.ist.psu.edu. 5. Jonathan Katz, Yehuda Lindell, *Introduction to Modern Cryptography: Principles and Protocols*, Chapman & Hall/CRC Cryptography and Network Security Series, 2007.

<table>
<tr><td>Subject Code

CS805</td><td>Mobile Computing (MC)</td><td>Credits: 3 (3-0-0)

Total hours: 45</td></tr>
<tr><td>Course Objectives:</td><td colspan="2">This course briefly introduces the basic concepts, principles and developments in mobile computing. This includes major mobile communication technologies, mobile computing algorithms and support for mobility in current communication systems and Internet.</td></tr>
<tr><td colspan="2">Module 1</td><td>10 Hours</td></tr>
<tr><td colspan="3">History of wireless communications, market for mobile communications, open research topics, simplified reference model, wireless transmission technologies – frequencies for radio transmission, signals, antennas, signal propagation, multiplexing, modulation, spread spectrum, cellular networks.</td></tr>
<tr><td colspan="2">Module 2</td><td>11 Hours</td></tr>
<tr><td colspan="3">Medium access control – techniques and algorithms, telecommunication systems – GSM, GPRS, DECT, TETRA, UMTS, CDMA, 3G, satellite systems – GEO, LEO, MEO, routing, localization, handover, wireless LAN – IEEE 802.11, HIPERLAN, Bluetooth.</td></tr>
<tr><td colspan="2">Module 3</td><td>12 Hours</td></tr>
<tr><td colspan="3">Mobile network layer – Mobile IP, DHCP, mobile ad-hoc networks, mobile transport layer – indirect TCP, snooping TCP, mobile TCP, security issues in mobile computing.</td></tr>
<tr><td colspan="2">Module 4</td><td>12 Hours</td></tr>
<tr><td colspan="3">Support for mobility in current communication systems and Internet – wireless application protocol, file systems, mobile web applications, mobile native applications, web 2.0, Voice over IP.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. Jochen Schiller, Mobile Communications, Pearson Education Limited, 2003.
2. Roopa Yavagal, Asoke K Talukder, Mobile Computing – Technology, Applications and Service, McGraw-Hill Professional, 2006.</td></tr>
</table>

<table>
<tr><td>Subject Code
CS806</td><td>Machine Learning (ML)</td><td>Credits: 3 (3-0-0)
Total hours: 45</td></tr>
<tr><td>Course Objectives</td><td colspan="2">Machine learning is concerned with the question of how to make computers learn from experience. Machine learning techniques are used to create spam filters, to analyze customer purchase data, to understand natural language, or to detect fraudulent credit card transactions. This course will introduce the fundamental set of techniques and algorithms that constitute machine learning as of today, ranging from classification methods like decision trees and support vector machines, over structured models like hidden Markov models, to clustering and matrix factorization methods for recommendation.</td></tr>
<tr><td colspan="2">Module 1</td><td>8 Hours</td></tr>
<tr><td colspan="3">Algorithmic models of learning. Learning classifiers, functions, relations, grammars, probabilistic models, value functions, behaviors and programs from experience. Bayesian, maximum a posteriori, and minimum description length frameworks.</td></tr>
<tr><td colspan="2">Module 2</td><td>12 Hours</td></tr>
<tr><td colspan="3">Parameter estimation, sufficient statistics, decision trees, neural networks, support vector machines, Bayesian networks, bag of words classifiers, N-gram models; Markov and Hidden Markov models, probabilistic relational models, association rules, nearest neighbor classifiers, locally weighted regression, ensemble classifiers.</td></tr>
<tr><td colspan="2">Module 3</td><td>14 Hours</td></tr>
<tr><td colspan="3">Computational learning theory, mistake bound analysis, sample complexity analysis, VC dimension, Occam learning, accuracy and confidence boosting. Dimensionality reduction, feature selection and visualization. Clustering, mixture models, k-means clustering, hierarchical clustering, distributional clustering.</td></tr>
<tr><td colspan="2">Module 4</td><td>11 Hours</td></tr>
<tr><td colspan="3">Reinforcement learning; Learning from heterogeneous, distributed, data and knowledge. Selected applications in data mining, automated knowledge acquisition, pattern recognition, program synthesis, text and language processing, internet-based information systems, human-computer interaction, semantic web, and bioinformatics and computational biology.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. Bishop, C., Pattern Recognition and Machine Learning, Berlin: Springer-Verlag, 2006.
2. Tom Mitchell, Machine Learning, McGraw Hill, 1997.
3. Hastie, Tibshirani, Friedman, The Elements of Statistical Learning, Springer, 2001.
4. Sergios Theodoridis, Konstantinos Koutroumbas, Pattern Recognition, Academic Press, 2009.</td></tr>
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<table>
<tr><td>Subject Code
CS807</td><td>Health Informatics (HI)</td><td>Credits: 3 (3-0-0)
Total hours: 45</td></tr>
<tr><td>Course Objectives:</td><td colspan="2">This course introduces the field of health informatics - which is an intersection of biomedical science, patient care, public health and information technology.</td></tr>
<tr><td colspan="2">Module 1</td><td>10 Hours</td></tr>
<tr><td colspan="3">Overview of health informatics, computer architectures and software engineering for healthcare and biomedicine, standards in health informatics.</td></tr>
<tr><td colspan="2">Module 2</td><td>12 Hours</td></tr>
<tr><td colspan="3">Healthcare data, information and knowledge, health information exchange, health information security, health information infrastructure, biomedical decision making, introduction to bioinformatics.</td></tr>
<tr><td colspan="2">Module 3</td><td>12 Hours</td></tr>
<tr><td colspan="3">Electronic health record systems, telemedicine, patient monitoring systems, public health informatics, patient-centered care systems.</td></tr>
<tr><td colspan="2">Module 4</td><td>11 Hours</td></tr>
<tr><td colspan="3">Evidence-based medicine and clinical practice guidelines, ethics in health informatics, health information technology policy, future of health informatics.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. Edward H. Shortliffe, James J. Cimino, Biomedical Informatics: Computer Applications in Health Care and Biomedicine , Springer, 2012.
2. Robert E Hoyt , Nora Bailey, Ann Yoshihashi, Health Informatics: Practical Guide For Healthcare And Information Technology Professionals, lulu.com, 2012.</td></tr>
</table>

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<tr><td>Subject Code
CS808</td><td colspan="2">Soft Computing (SC)</td><td>Credits: 3 (3-0-0)
Total hours:45</td></tr>
<tr><td>Course Objectives</td><td colspan="3">To deal with the uncertainty that is inherent in any pattern recognition task. The uncertainty is natural in the real world also and human brain deals with it efficiently.</td></tr>
<tr><td colspan="3">Module 1</td><td>10 Hours</td></tr>
<tr><td colspan="4">Introduction to artificial neural networks (ANNs): artificial neuron as a computational model of a biological neuron, activation functions, learning laws, architectures for neural networks, Perceptron: learning law, convergence theorem. Multilayer feed forward neural networks: Structure, error back propagation learning, delta learning law, generalized delta rule, learning factors, convergence theorem, momentum factor in learning, conjugate based learning method, bias-variance dilemma</td></tr>
<tr><td colspan="3">Module 2</td><td>8 Hours</td></tr>
<tr><td colspan="4">Deep learning: feedback neural networks, recurrent neural networks, convolution neural networks, Boltzan machine; Competitive learning models: principal component analysis, self-organizing map (SOM); Pulsed neural networks</td></tr>
<tr><td colspan="3">Module 3</td><td>13 Hours</td></tr>
<tr><td colspan="4">Basic concepts of fuzzy logic: crisp set-properties, relations and operations, fuzzy set theory, membership, types of membership functions, uncertainty, fuzzification, Decision making using the fuzzy sets, fuzzy inference systems, defuzzification methods, Application of fuzzy systems, Introduction to Type-2 fuzzy logic systems: The structure, inference system with different fuzzy membership functions: Fuzzy clustering method: soft clustering, fuzzy K-means clustering method: Neuro-fuzzy systems: fuzzy logic with adaptive learning, adaptive neuro-fuzzy inference systems: Fuzzy-neuro systems: Fuzzy perceptron and learning method for the same, fuzzy back propagation network,</td></tr>
<tr><td colspan="3">Module 4</td><td>14 Hours</td></tr>
<tr><td colspan="4">Evolutionary computing: optimization problem solving - finding best solution, minimum seeing algorithms, natural optimization methods, Genetic algorithms: Overview, a simple genetic algorithm, binary genetic algorithm, continuous parameter genetic algorithm. Advanced operations and techniques in genetic search, genetics-based machine learning – introduction and application, genetic algorithms in scientific methods. Genetic algorithms for combinatorial optimization, theoretical foundations of genetic algorithms, SASEGASA – parallel genetic algorithm. Introduction to genetic programming, applications of genetic programming, data-based modeling with genetic programming. Other evolutionary computing methods such as: ant colony optimization, swarm optimization.</td></tr>
<tr><td>Reference Books</td><td colspan="3">1. Satish Kumar, Neural networks: A classroom approach, Tata McGraw Hill, 2011.
2. B. Yegnanarayana, Artificial Neural Networks, Printice Hall India, 1999.
3. J. S. R. Lang, C. T. Sun and E. Mizutaju, Neuro-fuzzy and soft computing, Pearson Education, 1996.
4. David E. Goldberg , Genetic Algorithms in Search, Optimization, and Machine</td></tr>
</table>

	Learning, Addison-Wesley, 1989. 5. Michael Affenzeller, Stephan Winkler, Stefan Wagner, Andreas Beham, *Genetic Algorithms and Genetic Programming: Modern Concepts and Practical Applications*, CRC Press. 2009.

Subject Code CS809	**Service Oriented Architecture and Cloud Computing (SOAC)**	**Credits: 3 (3-0-0)** **Total hours: 45**
Course Objectives:	This course introduces the fields of: 1) Service-oriented architecture (SOA) - which is a software architecture design pattern based on discrete pieces of software providing application functionality as services to other applications. 2) Cloud computing – which is a model for delivering services in which resources are retrieved from the internet through web-based tools and applications.	
Module 1		**12 hours**
Introduction to SOA – fundamentals, characteristics, misperceptions, benefits and pitfalls, continuing evolution of SOA, principles of service orientation, service layers, Web services and SOA – web services framework, WSDL, SOAP, activity management and composition, advanced messaging, metadata and security.		
Module 2		**8 hours**
Planning and analysis for building SOA – SOA delivery lifecycle phases, service-oriented analysis, service modeling, service modeling applications, SOA patterns for performance, scalability and availability, security and manageability patterns, message exchange patterns, service consumer patterns, service integration patterns.		
Module 3		**10 hours**
Service-oriented design, services composition, service design guidelines, business process design, WS-BPEL, fundamental WS-* extensions, SOA platforms.		
Module 4		**15 hours**
Introduction to cloud computing, major models – software as a service, platform as a service, and infrastructure as a service, adopting SOA with cloud computing, data in the cloud – Cassandra, MangoDB, intelligence in the cloud, cloud security and governance.		
Reference Books	1. Thomas Erl, *Service-Oriented Architecture: Concepts, Technology, and Design*, Prentice Hall, 2005. 2. Arnon Rotem-Gal-Oz, *SOA Patterns*, Manning Publications Company, 2012. 3. Michael Rosen, Boris Lublinsky, Kevin T. Smith, Marc J. Balcer, *Applied SOA: Service-Oriented Architecture and Design Strategies*, John Wiley & Sons, 2012. 4. Richard Hill, Laurie Hirsch, Peter Lake, Siavash Moshiri, *Guide to Cloud Computing: Principles and Practice*, Springer-Verlag, London, 2013. 5. Douglas K. Barry, *Web Services, Service-Oriented Architectures, and Cloud Computing, The Savvy Manager's Guide*, Morgan Kaufmann Publishers , 2nd Edition, 2003.	

<table>
<tr><td>Subject Code

CS810</td><td>Big Data Analytics (BDA)</td><td>Credits: 3 (3-0-0)

Total hours: 45</td></tr>
<tr><td>Course Objectives:</td><td colspan="2">Big data refers to a collection of large and complex data sets those are difficult to process using traditional data processing applications. The challenges include capture, curation, storage, search, sharing, transfer, analysis and visualization. This course introduces concepts and techniques to overcome these challenges and to infer laws from large data sets to reveal relationships, dependencies, and to perform predictions of outcomes and behaviors.</td></tr>
<tr><td colspan="2">Module 1</td><td>11 Hours</td></tr>
<tr><td colspan="3">Introduction – small and big data, statistics and machine learning, statistical data mining; Providing structure to unstructured data – machine translation, autocoding, indexing, term extraction; Identification, deidentification and reidentification; ontologies and semantics; introspection; data integration and software interoperability; immutability and immortality; measurement; big data and healthcare.</td></tr>
<tr><td colspan="2">Module 2</td><td>12 Hours</td></tr>
<tr><td colspan="3">Big data techniques – data range, denominator, frequency distributions, mean and standard deviation, estimation-only analysis; big data analysis – clustering, classifying, recommending and modeling, data reduction, normalizing and adjusting data; special considerations – theory in search of data, data in search of a theory, overfitting, bigness bias, too much data, fixing data; stepwise approach to big data analysis – formulate a question, resource evaluation, reformulate a question, query output adequacy, data description and reduction, algorithm selection, results review; failure, legalities and societal issues.</td></tr>
<tr><td colspan="2">Module 3</td><td>11 Hours</td></tr>
<tr><td colspan="3">Variable assessment - correlation coefficient, scatterplots; paired-variable assessment – CHAID based data mining; symmetrizing ranked data – scales of measurement, Stem-and-Leaf display, Box-and-Whiskers plot; many-variable assessment – principle component analysis; logistic regression; ordinary regression; regression coefficient; predictive contribution coefficient.</td></tr>
<tr><td colspan="2">Module 4</td><td>11 Hours</td></tr>
<tr><td colspan="3">R language – data modeling in R, importing data into R, Hadoop – different Hadoop modes, Hadoop Distributed File System (HDFS) – fundamentals and architecture, MapReduce – fundamentals and architecture, Hadoop security, Hadoop programming in Java, Integrating R and Hadoop – RHIPE, RHadoop, data analytics with R and Hadoop, importing and exporting data from various databases, Hive, RBase, Apache Pig- large data analysis platform, automating data processing with Oozie.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. Jules J Berman, Principles of Big Data: Preparing, Sharing, and Analyzing Complex Information, Morgan Kaufman-Elsevier, 2013.
2. Bruce Ratner , Statistical and Machine-Learning Data Mining: Techniques for Better Predictive Modeling and Analysis of Big Data, 2nd Edition, CRC Press, 2011.
3. Michael Milton, Head First Data Analysis: A learner's guide to big numbers, statistics, and good decisions, O'Reilly Media Inc., 2009.
4. Big Data Now: 2012 Edition, O'reilly Media Inc., 2012.
5. Vignesh Prajapati , Big Data Analytics with R and Hadoop, Packt Publishing, 2013.</td></tr>
</table>

<table>
<tr><td>Subject Code
CS811</td><td colspan="2">Pattern Recognition (PR)</td><td>Credits: 3 (3-0-0)
Total hours:45</td></tr>
<tr><td>Course Objectives</td><td colspan="3">To build intelligent systems based on the learning framework.</td></tr>
<tr><td colspan="3">Module 1</td><td>12 Hours</td></tr>
<tr><td colspan="4">Pattern classification: Bayesian decision theory, minimum-error-rate classification, classifiers, discriminant functions, decision surfaces, normal (Gaussian) density, continuous and discrete values features, Bayesian networks (graphical models)</td></tr>
<tr><td colspan="3">Module 2</td><td>8 Hours</td></tr>
<tr><td colspan="4">Methods for parameter estimation: maximum likelihood estimation, maximum a posteriori estimation, Bayesian estimation, Gaussian mixture models
Sequential pattern classification: Hidden Markov models for dynamic patterns</td></tr>
<tr><td colspan="3">Module 3</td><td>10 Hours</td></tr>
<tr><td colspan="4">Non-parametric method for density estimation: Parzon window and K-nearest neighbor method
Methods for dimensionality reduction: Fisher's discriminant analysis, Principal component analysis
Non metric methods: Decision trees, classification and regression trees (CART), recognition of strings</td></tr>
<tr><td colspan="3">Module 4</td><td>8 Hours</td></tr>
<tr><td colspan="4">Discriminant analysis: Models for decision surfaces, linear discriminant analysis-perception model, minimum mean squared error based learning, support vector machines
Repression: Linear models for regression, polynomial regression, Bayesian regression</td></tr>
<tr><td colspan="3">Module 5</td><td>7 Hours</td></tr>
<tr><td colspan="4">Pattern clustering (unsupervised learning): Criterion functions for clustering, methods for clustering-hard and soft clustering, K-means, GMM, hierarchical clustering methods, cluster validation methods</td></tr>
<tr><td>Reference Books</td><td colspan="3">1. Richard O. Duda, Peter E. Hart and David G. Stork, Pattern Classification, 2nd Edition, John Wiley & Sons, 2012.
2. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
3. Sergios Theodoridis and Konstantinos Koutroumbas, Pattern Recognition, 4th Edition, Academic Press-Elsevier, 2009</td></tr>
</table>

<table>
<tr><td>Subject Code
CS812</td><td colspan="2">Artificial Neural Networks (ANN)</td><td>Credits: 3 (3-0-0)
Total hours:45</td></tr>
<tr><td>Course Objectives</td><td colspan="3">To study a computational model of the human neural system though it is still not known the exact functioning of the same.</td></tr>
<tr><td colspan="3">Module 1</td><td>8 Hours</td></tr>
<tr><td colspan="4">Biological neuron, artificial neuron as a computational model of a neuron, activation functions, architectures for ANNs, linear neural networks, Hebbs learning law,</td></tr>
<tr><td colspan="3">Module 2</td><td>14 Hours</td></tr>
<tr><td colspan="4">Non-linear neural networks: Perceptron- learning law, convergence theorem; multilayer feed forward neural networks-structure, activation functions, error back propagation learning, delta learning law, generalized delta rule, learning factors, convergence criteria, momentum factor in learning, conjugate gradient method for learning, universal approximation theorem, cross validation method for selecting the architecture, bias-variance dilemma</td></tr>
<tr><td colspan="3">Module 3</td><td>8 Hours</td></tr>
<tr><td colspan="4">Statistical learning theory, principle of empirical risk minimization, Radial basis function networks: RBF networks for function approximation, RBF networks for pattern classification, Support vetcor machines: SVM for linearly separable classes, SVM for linearly non-separable classes, SVM for nonlinearly separable classes using kernels, multi-class pattern classification using SVMs,</td></tr>
<tr><td colspan="3">Module 4</td><td>8 Hours</td></tr>
<tr><td colspan="4">Feedback neural networks: Problem of pattern storage and retrieval, discrete Hopfiled networks, dynamical systems, energy function of hopfield model, energy analysis of hopfiled model.</td></tr>
<tr><td colspan="3">Module 5</td><td>7 Hours</td></tr>
<tr><td colspan="4">Introduction to deep neural networks, convolution neural networks, recurrent neural networks, Boltzman machine.</td></tr>
<tr><td>Reference Books</td><td colspan="3">1. B. Yegnanarayana, Artificial Neural Networks, Printice Hall India Learning Pvt. Ltd, 2009.
2. Sathish Kumar, Neural Networks: A Classroom Approach, 3rd Edition, Tata McGraw Hill, 2011.
3. Simon S. Haykin, Neural Networks and Learning Machines, 3rd Edition, Prentice Hall, 2009</td></tr>
</table>

Subject Code CS813	**Computer Vision (CV)**	**Credits: 3 (3-0-0)** **Total hours:45**
Course Objectives	To expose the students to fundamental and advanced topics in computer vision with a focus on image statistics, machine learning techniques, and applied vision for graphics also.	
Module 1		**10 Hours**
Introduction and overview, pinhole cameras, radiometry terminology. Sources, shadows and shading: Local shading models- point, line and area sources; photometric stereo. Color: Physics of color; human color perception, Representing color; A model for image color; surface color from image color.		
Module 2		**13 Hours**
Image Processing: Linear filters: Linear filters and convolution; shift invariant linear systems- discrete convolution, continuous convolution, edge effects in discrete convolution; Spatial frequency and Fourier transforms; Sampling and aliasing; filters as templates; Normalized correlations and finding patterns. Edge detection: Noise; estimating derivatives; detecting edges. Texture: Representing texture; Analysis using oriented pyramid; Applications; Shape from texture. The geometry and views: Two views.		
Module 3		**12 Hours**
Stereopsis: Reconstruction; human stereo; Binocular fusion; using color camera. Segmentation by clustering: Human vision, applications, segmentation by graph theoretic clustering. Segmentation by fitting a model, Hough transform; fitting lines, fitting curves;		
Module 4		**10 Hours**
3D reconstruction, model based vision- face recognition, face detection, image/scene classification, motion tracking, surveillance, content based image and video retrieval		
Reference Books	1. Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer, 2011. 2. David A Forsyth and Jean Ponce, *Computer Vision, A Modern Approach*, Pearson Education, Limited, 2011 3. Schalkoff R. J., *Digital Image Processing and Computer Vision*, John Wiley & Sons Australia, Limited, 1989 4. Rafael C. Gonzalez and Richard E. Woods, *Digital Image Processing*, 3rd Eidtion, Pearson Eductaion India, 2009 5. Milan Sonka, Vaclav Hlavac and Roger Boyle, *Image Processing, Analysis, and Machine Vision*, 4th Edition, Cengage Learning, 2014	

Subject Code CS814	**Game Theory (GMT)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	Game theory and mechanism design offer an important tool to model, analyze, and solve decentralized design problems involving multiple autonomous agents that interact strategically in a rational and intelligent way. This course provides a sound foundation of game theory and mechanism design to enable the audience to apply them to problem solving in a rigorous way.	
Module 1		**7 Hours**
Introduction and Outline of the Course, Definitions, Utilities, Rationality, Intelligence, Common Knowledge, Classification of Games.		
Module 2		**14 Hours**
Non-Cooperative Game Theory: Extensive Form Game, Strategic Form Games with Illustrative Examples, Dominant Strategy Equilibria, Pure Strategy Nash Equilibrium with Illustrative Examples and Key Results, Mixed Strategy Nash Equilibrium with Illustrative Examples and Key Results such as the Nash Theorem, Computation of Nash Equilibria and introduction to algorithmic theory, Matrix Games: Saddle Points, Minimax Theorem, Bayesian Games, Bayesian Nash Equilibrium, Evolutionary Game Theory (ESS Strategies), Repeated Game.		
Module 3		**12 Hours**
Mechanism Design: The Mechanism Design Environment, Social Choice Functions with Illustrative Examples , Implementation of Social Choice Functions, Incentive Compatibility and Revelation Theorem, Gibbard-Satterthwaite and Arrow Impossibility Theorem, Vickrey-Clarke-Groves (VCG) Mechanisms, Bayesian Mechanisms (dAGVA), Revenue Equivalence Theorem, Myerson Optimal Auction, Further Topics in Mechanism Design		
Module 4		**12 Hours**
Correlated Strategies and Correlated Equilibrium, The Nash Bargaining Problem, Coalitional Games (Transferable Utility Games), The Core, The Shapley Value, Other Solution Concepts: Kernel, Nucleolus.		
Reference Books	1. Martin J. Osborne, *An Introduction to Game Theory*, Oxford University Press, 2009. 2. Roger B. Myerson, *Game Theory: Analysis of Conflict*,Harvard University Press, 1997. 3. Y. Narahari, Dinesh Garg, Ramasuri Narayanam, and Hastagiri Prakash, *Game Theoretic Problems in Network Economics and Mechanism Design Solutions*, Springer, London, 2009.	

Subject Code CS815	**Data Warehousing and Data Mining (DWM)**	**Credits: 3 (3-0-0)** **Total hours: 45**
Course Objectives	Following this course, students will be able to 1) Learn the concepts of database technology, 2) Understand data mining principles and techniques, 3) Discover interesting patterns from large amounts of data to analyze and extract patterns to solve problems, make predictions of outcomes. 4) Evaluate systematically supervised and unsupervised models and algorithms with respect to their accuracy, 5) Design and implement of a data-mining application using sample, realistic data sets and modern tools.	
Module 1		**12 Hours**
Introduction to data warehousing, building a data warehouse, mapping the data warehouse to a multiprocessor architecture, OLAP technology for data mining, data warehouse, multidimensional data model, data warehouse architecture, data warehouse implementation, OLAP guidelines, multidimensional versus multi relational OLAP, categories of tools, DBMS schemas for decision support data extraction, cleanup and transformation tools for metadata, development of data cube technology, from data warehousing to data mining, data generalization, efficient methods for data cube computation, further development of data cube and OLAP Technology, attribute-oriented induction.		
Module 2		**8 Hours**
Introduction to data mining tasks, objectives (classification, clustering, association rules, sequential patterns, regression, deviation detection).		
Module 3		**8 Hours**
Data and preprocessing (data cleaning, feature selection, dimensionality reduction), Curse of Dimensionality		
Module 4		**8 Hours**
Classification (decision-tree based approach, rule-based approach, instance-based classifiers, Bayesian Approach: Naive and Bayesian networks, classification model evaluation).		
Module 5		**9 Hours**
Clustering (partitional methods, hierarchical methods, graph-based methods, density-based methods, cluster validation methods), anomaly/outlier detection (introduction to various types of outliers, statistical-based, density-based and other methods for outlier detection).		

Reference Books	1. Jiawei Han and Micheline Kamber, *Data mining: Concepts and techniques*, 3rd Edition, Morgan Kaufmann publishers, 2012. 2. Raph Kimball and Margy Ross, *Data warehouse toolkit*, 3rd Edition, John Wiley & Sons Publications, 2013. 3. Gordon Linoff and Michael. J. Berry, *Data mining techniques: Marketing, sales, customer support*, 3rd Edition, John Wiley & Sons, 2011.

Subject Code **CS816**	**E-Commerce (EC)**	**Credits: 3 (3-0-0)** **Total hours: 45**
Course Objectives	To provide principles of e-commerce from a business perspective.	
Module 1		**11 Hours**
Infrastructure and tools for e-commerce, current trends in e-commerce applications development, the business of internet commerce, enterprise level e-commerce.		
Module 2		**12 Hours**
Security and encryption, electronic payment systems, search engines, intelligent agents in e-commerce, on-line auctions, data mining for e-commerce.		
Module 3		**12 Hours**
Web metrics, recommended systems, knowledge management, mobile e-commerce, legal, ethical and social issues.		
Module 4		**10 Hours**
Seminars and mini projects.		
Reference Books	1. Henry Chan, Raymond Lee, Tharam Dillon and Elizabeth Chang, *E-Commerce-Fundamentals and application*, John Wiley & Sons 2007. 2. G. Winfield Treese and Lawrence C. Stewart, *Designing Systems for Internet Commerce*, Addison-Wesley Professional, 2003. 3. M. L. Brodie and Dieter Fensel, *Ontologies: A Silver Bullet for Knowledge Management and ECommerce*, Springer, 2004. 4. Olaf Zimmermann, Mark Tomlinson and Stefan Peuser, *Perspectives on Web Services*", Springer, 2004.	

Subject Code CS817	**Advanced Operating Systems (AOS)**	**Credits: 3 (3-0-0)** **Total hours: 45**
Course Objectives	To provide comprehensive and up-to-date coverage of the major developments in distributed operating system, multi-processor operating system and database operating system.	
Module 1		**8 Hours**
Architectures of distributed systems , system architecture types, issues in distributed OS, communication networks, primitives, theoretical foundations, inherent limitations of a distributed system, lamp ports logical clocks, vector clocks, casual ordering of messages, global state, cuts of a distributed computation, termination detection, distributed mutual exclusion.		
Module 2		**12 Hours**
Distributed deadlock detection, introduction, deadlock handling strategies in distributed systems, issues in deadlock detection and resolution, control organizations for distributed deadlock detection, centralized, distributed and hierarchical deadlock detection algorithms , agreement protocols.		
Module 3		**10 Hours**
Distributed shared memory, architecture, algorithms for implementing DSM, memory coherence and protocols, design issues, distributed scheduling, issues in load distributing, components of a load distributing algorithm, stability, load distributing algorithm, performance comparison, selecting a suitable load sharing algorithm, requirements for load distributing, task migration and associated issues. Failure recovery and Fault tolerance: Introduction, basic concepts, classification of failures, backward and forward error recovery, recovery in concurrent systems, consistent set of check points, synchronous and asynchronous check pointing and recovery, check pointing for distributed database systems, recovery in replicated distributed databases.		
Module 4		**8 Hours**
Protection and security, preliminaries, the access matrix model and its implementations, safety in matrix model, advanced models of protection. Cryptography basics, multiple encryption and authentication in distributed systems.		
Module 5		**7 Hours**
Multiprocessor OS, database OS, database systems, a concurrency control model, problem, serializability theory, distributed database systems, concurrency control algorithms.		
Reference Books	1. Mukesh Singhal and Niranjan G. Shivorothri, *Advanced Concepts in Operating systems: Distributed, Multiprocessor and Database Operating Systems*, McGraw-Hill Education, 1994. 2. Andrew S. Tanenbaum, *Distributed Operating systems*, Pearson Education, 2008. 3. Doreen L. Galli, *Distributed operating systems: concepts and practice*, Prentice Hall, 2000. 4. Abraham Silberschatz and Avi Silberschatz, *Applied Operating systems*, John Wiley & Sons, 2000. 5. Lubomir F. Bic and Alan C. Shaw, *Operating systems Principles*, Prentice Hall PTR, 2003.	

Subject Code **CS818**	**Security and Privacy (S&P)**	**Credits: 3 (3-0-0)** **Total hours: 45**
Course Objectives	This course introduces the concepts of security and privacy.	
Module 1		**10 Hours**
Introduction: Basic concepts: number theory, Formal analysis and design of algorithms and protocols.		
Module2		**10 Hours**
Provable Security, Cryptosystems; Privacy: Foundations of Privacy, Differential Privacy: Definitions and Early Uses.		
Module 3		**10 Hours**
Privacy Regulations, Noiseless Differential Privacy, Privacy preserving Data Mining techniques.		
Module 4		**15 Hours**
Privacy preserving data publishing: Fundamental Concepts: anonymization methods, privacy models, anonymization method for trasaction data, trajectory data, social networks data and textual data. One-Time Data Publishing, Multiple-Time Data Publishing :Graph Data .Other Data Types . Access control of outsourced data. Future Research Directions		
Reference Books	1. T. Shaw, *Information Security and Privacy*, American Bar Association, 2012. 2. M. Bailey, *Complete Guide to Internet Privacy, Anonymity and Security*, Nerel Online, 2011. 3. Raymond Chi-Wing Wong, Ada Wai-Chee Fu, *Privacy-Preserving Data Publishing: An Overview*, Morgan and claypool publishers, 2010.	

Subject Code CS819	**Bioinformatics Algorithms (BA)**	**Credits: 3 (3-0-0)** **Total hours:45**
Course Objectives	To explore fundamental algorithmic techniques in bioinformatics and computational biology that are enabling the current revolution in life sciences and medicine It will serve as the foundation course for students of computer science who are interested in doing research or pursue career in computational biology or in bioinformatics.	

Module 1	
Introduction to molecular biology – Basic introduction including DNA, proteins, central dogma etc., what is it involved in analyzing a DNA, role of bioinformatics	
Module 2	
Pairwise sequence alignments – Global, semi-global and local alignments, gap penalty functions, Hirshberg's space-saving algorithm, banded dynamic programming. Multiple sequence alignments – sum-of-pairs scoring function, Carillo-Lippman heuristic, approximation algorithms, tree alignments.	
Module 3	
String data structures and algorithms – look-up tables, suffix arrays and suffix trees, construction algorithms, basic applications of suffix trees, lowest common ancestors.	
Module 4	
Genome assembly – overlap-layout-consensus and graph based methods. Comparative genomics – Identifying gene clusters and evolutionarily conserved sequences. Pairwise and multiple genome comparisons.	
Module 5	
Phylogenetics – distance based methods including ultrametric and additive distances, character based methods including parsimony and perfect phylogeny, heuristic methods.	

Reference Books	1. N. C. Jones & P. A. Pevzner, *An Introduction to Bioinformatics Algorithms*, MIT Press, 2004. 2. R. Durbin, S. Eddy, A. Krogh, G. Mitchison, *Biological sequence analysis: probabilistic models of proteins and nucleic acids*, Cambridge University Press, 1998. 3. S. Aluru, *Handbook of computational molecular biology*, Chapman and Hall/CRC, 2005.

Subject Code **CS820**	# Graph Theory (GT)	**Credits: 3 (3-0-0)** **Total hours: 45**
Course Objectives	The intension of this course is to introduce the subject of graph theory to computer science students in a thorough way. While the course will cover all elementary concepts such as coloring, covering, Hamiltonicity, planarity, connectivity and so on, it will also introduce the students to some advanced concepts.	
Module 1		**8 Hours**
Definitions, pictorial representation of a graph, isomorphic graphs, sub graphs, matrix representations of graphs, degree of a vertex, special graphs, complements, larger graphs from smaller graphs, connected graphs and shortest paths, walks, trails, paths, cycles, connected graphs, cut-vertices and cut-edges, blocks, connectivity, weighted graphs and shortest paths, weighted graphs, Dijkstra's shortest path algorithm, Floyd-Warshall shortest path algorithm		
Module2		**8 Hours**
Trees, Definitions and characterizations, number of trees, Cayley's formula, minimum spanning trees, Kruskal's algorithm, Prim's algorithm, bipartite graphs, Eulerian graphs, Fleury's algorithm, Chinese Postman problem. .		
Module 3		**8 Hours**
Hamilton Graphs, necessary conditions and sufficient conditions, independent sets, coverings and matchings, matchings in bipartite graphs, Hall's theorem, Konig's theorem, perfect matching's in graphs, vertex Colorings, basic definitions, cliques and chromatic number, greedy coloring algorithm.		
Module 4		**9 Hours**
Edge colorings, Gupta-Vizing theorem, class-1 and class-2 graphs, edge-coloring of bipartite, graphs, planar graphs, basic concepts, Euler's formula and its consequences, characterizations of planar graphs, 5-color-theorem, directed graphs, directed walks, paths and cycles, Eulerian and Hamilton digraphs.		
Module 5		**12 Hours**
Planarity (duality, Euler's formula, characterization, 4-color theorem); Advanced topics (perfect graphs, matroids, Ramsay theory, extremal graphs, random graphs); Applications.		
Reference Books	1. D. B. West, *Introduction to Graph Theory*, 2nd edition, Prentice Hall, 2000. 2. R. Diestel, *Graph Theory (Graduate Texts in Mathematics)*, 2nd edition, Springer-Verlag, 2000. 3. J.A. Bondy and U.S.R. Murty, *Graph Theory (Graduate Texts in Mathematics)*, Springer, 2011. 4. R. P. Grimaldi, *Discrete and Combinatorial Mathematics: An Applied Introduction*, 5th edition, Pearson Education, Asia, 2003. 5. N. Alon and J. Spenser, *The Probabilistic Method*, 3rd edition, John Wiley and Sons, 2008.	

<table>
<tr><td>Subject Code

CS821</td><td colspan="2">Probability and Statistics (P&S)</td><td>Credits: 3 (3-0-0)

Total hours: 45</td></tr>
<tr><td>Course Objectives</td><td colspan="3">Probability and Statistics is one of the most important branches of the mathematical sciences. Knowledge of these topics is critical to decision-making and to the analysis of data. Using concepts of probability and statistics, individuals are able to predict the likelihood of an event occurring, organize and evaluate data, and identify the significance of statements.</td></tr>
<tr><td colspan="3">Module 1</td><td>8 Hours</td></tr>
<tr><td colspan="4">Algebra of Sets: sets and classes, limit of a sequence of sets, rings, sigma-rings, fields, sigma-fields, monotone classes. Probability: Classical, relative frequency and axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Bayes' Theorem and independence, problems.</td></tr>
<tr><td colspan="3">Module2</td><td>8 Hours</td></tr>
<tr><td colspan="4">Random Variables: Discrete, continuous, mixed random variables, probability mass, density and cumulative distribution functions, mathematical expectation, moments, probability and moment generating function, median and quantiles, Markov inequality, Chebyshev's inequality, problems.</td></tr>
<tr><td colspan="3">Module 3</td><td>12 Hours</td></tr>
<tr><td colspan="4">Distributions: (Special) Discrete uniform, binomial, geometric, negative binomial, hypergeometric, Poisson, continuous uniform, exponential, gamma, Weibull, Pareto, beta, normal, lognormal, inverse Gaussian, Cauchy, double exponential distributions, reliability and hazard rate, reliability of series and parallel systems, problems. (Joint): Joint, marginal and conditional distributions, product moments, correlation and regression, independence of random variables, bivariate normal distribution, problems. (Sampling): The Central Limit Theorem, distributions of the sample mean and the sample variance for a normal population, Chi-Square, t and F distributions, problems.</td></tr>
<tr><td colspan="3">Module 4</td><td>10 Hours</td></tr>
<tr><td colspan="4">Estimation: Unbiasedness, consistency, the method of moments and the method of maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems of normal populations, confidence intervals for proportions. Testing of Hypotheses: Null and alternative hypotheses, the critical and acceptance regions, two types of error, power of the test, the most powerful test, Neyman-Pearson Fundamental Lemma, tests for one sample, two sample problems for normal populations, tests for proportions, Chi-square goodness of fit test, applications.</td></tr>
<tr><td colspan="3">Module 5</td><td>7 Hours</td></tr>
<tr><td colspan="4">Transformations: functions of random vectors, distributions of order statistics, distributions of sums of random variables, problems.</td></tr>
<tr><td>Reference Books</td><td colspan="3">1. V.K. Rohatgi, A.K. Md. E. Saleh, An Introduction to Probability & Statistics, 2nd edition, Wiley-Interscience, 2000.
2. J.S. Milton & J.C. Arnold, Introduction to Probability and Statistics - Principles and Applications for Engineering and the Computing Sciences, 4th edition, McGraw-Hill Higher Education, 2002.
3. H.J. Larson, Introduction to Probability Theory and Statistical Inference, 3rd edition, Wiley, 1982.
4. S.M. Ross, Introduction to Probability & Statistics for Engineers and Scientists, 4th edition, Elsevier AP, 2009.
5. S.M. Ross, A First Course in Probability, 9th edition, Pearson, 2012.</td></tr>
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<tr><td>Subject Code

CS822</td><td colspan="2">Program Analysis and Verification (PAV)</td><td>Credits: 3 (3-0-0)

Total hours: 45</td></tr>
<tr><td>Course Objectives:</td><td colspan="3">This course teaches techniques for model checking - a formal verification technique for assessing functional properties of information and communication systems. Model checking is an automated technique to check the absence of errors and it is considered as an intelligent and effective debugging technique.</td></tr>
<tr><td colspan="3">Module 1</td><td>9 hours</td></tr>
<tr><td colspan="4">Introduction to code verification, the mathematical model and numerical algorithm, the order-verification procedure and its benefits, design of coverage test suite, finding exact solutions, numerical algorithm development, testing for code robustness and code efficiency, dealing with codes that make non-ordered approximations.</td></tr>
<tr><td colspan="3">Module 2</td><td>11 hours</td></tr>
<tr><td colspan="4">The semantic analysis – the precondition, the post condition, the principles of top-down refinement, program correctness – programs without loops, iterative programs, program test for any implementation – black box testing, static analysis – intermediate program representation, program dependencies, tell about a program without its execution, dynamic analysis – structural program testing, dynamic program analysis.</td></tr>
<tr><td colspan="3">Module 3</td><td>11 hours</td></tr>
<tr><td colspan="4">System verification – model checking, modeling concurrent systems, linear-time properties, regular properties, linear temporal logic, computation tree logic, equivalences and abstraction, partial order reduction, timed automata, probabilistic systems – Markov chain and Markov decision processes.</td></tr>
<tr><td colspan="3">Module 4</td><td>14 hours</td></tr>
<tr><td colspan="4">Finding bugs in concurrent systems, building verification models, an overview of PROMELA, defining correctness claims, using design abstraction, automata and logic, PROMELA semantics, search algorithms and optimization, model abstraction, using SPIN and XSPIN – the TimeLine editor, a verification model of a telephone switch, sample SPIN models.</td></tr>
<tr><td>Reference Books</td><td colspan="3">1. P. Knupp, K. Salari, Verification of Computer Codes in Computational Science and Engineering, Chapman & Hall/CRC, 2002.
2. J. Laski, W. Stanley, Software Verification and Analysis: An Integrated, Hands-On Approach, Springer, 2009.
3. B. Berard, M. Bidoit, A. Finkel, F. Laroussinie, A. Petit, L. Petrucci, P. Schnoebelen, P. McKenzie, Systems and Software Verification: Model-Checking Techniques and Tools, Springer, 2001.
4. G. Holzmann, The SPIN Model Checker: Primer and Reference Manual, Addison-Wesley, 2003.
5. C. Baier, J. P. Katoen, K. G. Larsen, Principles of Model Checking, MIT Press, 2008.</td></tr>
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<tr><td>Subject Code
CS823</td><td>Linear Algebra (LA)</td><td>Credits: 3 (3-0-0)
Total hours: 45</td></tr>
<tr><td>Course Objectives</td><td colspan="2">To have a hand on in linear algebra to understand matrices and use them to various engineering applications.</td></tr>
<tr><td colspan="2">Module 1</td><td>9 hours</td></tr>
<tr><td colspan="3">Introduction to vectors: Vectors and linear combinations, dot products, matrices.
Solving linear equations: Vectors and linear equations, idea of elimination, eliminations using matrices, matrix operations, inverse of a matrix, LU and LDU factorizations, transposes and permutations</td></tr>
<tr><td colspan="2">Module 2</td><td>9 hours</td></tr>
<tr><td colspan="3">Vector spaces and subspaces: The null subspace of A: Solving Ax=0, the rank and row reduced form, basis and dimension, four fundamental subspaces</td></tr>
<tr><td colspan="2">Module 3</td><td>9 hours</td></tr>
<tr><td colspan="3">Orthogonality: Projections, least squares approximations, orthogonal bases and Gram-Schmidt
Determinants: Properties of determinants, Formulas for determinants, applications of determinants</td></tr>
<tr><td colspan="2">Module 4</td><td>9 hours</td></tr>
<tr><td colspan="3">Eigen values and Eigen vectors: Introduction to Eigen values and Eigen vectors, diagonalization of a matrix, differential equations, symmetric matrices, positive definite matrices,</td></tr>
<tr><td colspan="2">Module 5</td><td>9 hours</td></tr>
<tr><td colspan="3">Applications: Matrices in engineering, graphs and networks, Markov matrices linear programming, Fourier series, computer graphics, Gaussian elimination in practice</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. G. Strang, Introduction to Linear Algebra, 4th Edition, Wellesley-Cambridge Press, Wellesley, MA, 2009.
2. G. Strang, Linear algebra and its applications, Thomson Books, 2006.</td></tr>
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<tr><td>Subject Code
CS824</td><td>Number Theory (NT)</td><td>Credits: 3 (3-0-0)
Total hours: 45</td></tr>
<tr><td>Course Objectives</td><td colspan="2">This course introduces the number theory, Algebraic structures and the computational aspects of number theory.</td></tr>
<tr><td colspan="2">Module 1</td><td>8 Hours</td></tr>
<tr><td colspan="3">Preliminaries: Well ordering principle, Mathematical Induction. Divisibility Theory in Integers: Divisibility properties, Division Theorem, greatest common Divisor, Euclidean algorithm, Diophantine equation. Primes and their distribution: The fundamental theorem of arithmetic.</td></tr>
<tr><td colspan="2">Module2</td><td>15 Hours</td></tr>
<tr><td colspan="3">Theory of Congruences: Basic properties of congruences, Divisibility tests, Linear congruences, Chinese Remainder Theorem, Fermat's theorem, Euler's theorem, Quadratic Residues and Reciprocity. Arithmetic Functions, Diophantine Equations.</td></tr>
<tr><td colspan="2">Module 3</td><td>10 Hours</td></tr>
<tr><td colspan="3">Groups, Rings, Finite fields, Elliptic Curves, Elliptic Curve arithmetic</td></tr>
<tr><td colspan="2">Module 4</td><td>12 Hours</td></tr>
<tr><td colspan="3">Large integer computations: Computations in Z_n ; Primality testing of Integers; Integer Factorization algorithms. Computations in groups, Rings and Fields. Algorithms for discrete logarithms ; Polynomial arithmetic ; Sequence generation; Algorithms for Finite fields.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. N. Koblitz, A Course in Number theory and Cryptography, 2nd edition, Springer, 1994.
2. V. Shoup, A Computational Introduction to Number Theory and Algebra, Cambridge Press, 2008.
3. H. Cohen, A course in Computational algebraic number theory, 4th printing, Springer, 2000.
4. R. Lidle, H. Niderreiter, Finite Fields (Encyclopedia of Mathematics and its Applications), 2nd edition, Cambridge University press, 2008.</td></tr>
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<tr><td>Subject Code

CS825</td><td colspan="2">Complexity Theory (CT)</td><td>Credits: 3 (3-0-0)

Total hours: 45</td></tr>
<tr><td>Course Objectives</td><td colspan="3">This course introduces computational complexity theory.</td></tr>
<tr><td colspan="3">Module 1</td><td>10 Hours</td></tr>
<tr><td colspan="4">Fundamental concepts: problems and algorithms, Turing machines, computability.</td></tr>
<tr><td colspan="3">Module2</td><td>12 Hours</td></tr>
<tr><td colspan="4">Complexity Classes: P, NP and co-NP, Relationship between complexity classes, Reduction and completeness, NP-complete problems, P vs NP.</td></tr>
<tr><td colspan="3">Module 3</td><td>12 Hours</td></tr>
<tr><td colspan="4">Diagonalization and Relativization. Space complexity: PSPACE and PSPACE-completeness; NL and NL-completeness. The polynomial hierarchy: optimization problems. Non-uniform complexity. Communication complexity and circuit lower bounds.</td></tr>
<tr><td colspan="3">Module 4</td><td>11 Hours</td></tr>
<tr><td colspan="4">Randomized computation: RP, BPP, ZPP. Error reduction. Probabilistic algorithms. Randomized space complexity. Approximation and Inapproximability. Interactive proofs.</td></tr>
<tr><td>Reference Books</td><td colspan="3">1. S. Arora and B. Barak, Computational Complexity: A Modern Approach, Cambridge University Press, 2009,
2. C. H. Papadimitriou, Computational Complexity, 1st edition, Addison Wesley, 1993.</td></tr>
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<tr><td>Subject Code

CS826</td><td>Human Computer Interface (HCI)</td><td>Credits: 3 (3-0-0)

Total hours: 45</td></tr>
<tr><td>Course Objectives:</td><td colspan="2">Human-Computer Interface (HCI) refers to the design, prototyping, and evaluation of user interfaces to computers. The following topics are covered by this course: human capabilities, interface technology, interface design methods and interface evaluation.</td></tr>
<tr><td colspan="2">Module 1</td><td>11 hours</td></tr>
<tr><td colspan="3">Human perception, human vision, Gestalt principles describing human visual perception, visual structure, color vision, peripheral vision, attention and memory, attention shape thought and action, recognition and recall, learning from experience, performing learned actions, problem solving and calculation, factors affecting learning, time requirements.</td></tr>
<tr><td colspan="2">Module 2</td><td>12 hours</td></tr>
<tr><td colspan="3">Usability of interactive systems – guidelines, principles and theories; development processes – managing design processes, evaluating interface designs, software tools; interaction styles – direct manipulation and virtual environments, menu selection, form filling and dialog boxes, command and natural languages, interaction devices, collaboration; design issues – Quality of Service, balancing function and fashion, user manuals, online help and tutorials, information search and visualization; societal and individual impact of user interfaces.</td></tr>
<tr><td colspan="2">Module 3</td><td>11 hours</td></tr>
<tr><td colspan="3">Interaction design – introduction, the process, the user experience; understanding and conceptualizing interaction – conceptual models, interface metaphors, interaction types; cognitive aspects – cognition frameworks; social interaction; emotional interaction; interfaces – interface types, natural user interfaces, choosing interface.</td></tr>
<tr><td colspan="2">Module 4</td><td>11 hours</td></tr>
<tr><td colspan="3">Data gathering; data analysis, interpretation and presentation; practical issues in the process of interaction design; establishing requirements – data gathering and processing, task description, task analysis; design, prototyping and construction – conceptual design, physical design, scenarios, prototypes; evaluation – types of evaluation, evaluation case studies, inspections – heuristic evaluation and walkthroughs, analytics, predictive models; evaluation framework – DECIDE – a framework to guide evaluation.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1. B. Shneiderman, C. Plaisant, M. Cohen and S. Jacobs, Designing the User Interface: Strategies for Effective Human-Computer Interaction, 5th Edition, Person Education, 2009.
2. J. Johnson, Designing with the Mind in Mind: Simple Guide to Understanding User Interface Design Rules, Elsevier/Morgan-Kaufmann, 2010.
3. H. Sharp, Y. Rogers, J. Preece, Interaction Design: Beyond Human - Computer Interaction, 3rd edition, Wiley, 2011.
4. D. Norman, The Design of Everyday Things, Currency/ Doubleday, 1990.</td></tr>
</table>

Course Curriculum

for

Master of Technology Programme

in

Electronics and Communication Engineering Department

National Institute of Technology Goa

Farmagudi, Ponda, Goa - 403 401

Semester-wise Credit Distribution

Semester	Total Credits
I	19
II	17
III	14
IV	14
Total Credits	**64**

M.Tech. Program Name: VLSI

Semester-wise Distribution of the Courses

Semester I				
SI. No.	**Course Code**	**Course Name**	**Total Credits** (L-T-P)	**Credits**
1	EC600	Digital IC Design	(3-0-0)	3
2	EC601	Analog IC Design	(3-0-0)	3
3	EC602	Semiconductor Device Theory and Modelling	(3-0-0)	3
4	EC603	Digital Signal Processing	(3-0-0)	3
5	EC604	IC Design Laboratory	(0-0-6)	3
6	EC605	Semiconductor Device Simulation Laboratory	(0-0-3)	2
7	EC606	Seminar	(0-0-3)	2
Total Credits				**19**

Semester II				
SI. No.	**Course Code**	**Course Name**	**Total Credits** (L-T-P)	**Credits**
1	EC650	VLSI Testing and Testability	(3-0-0)	3
2	EC651	VLSI Technology	(3-0-0)	3
3		Elective I	(3-0-0)	3
4		Elective II	(3-0-0)	3
5	EC652	System Design Laboratory	(0-0-6)	3
6	EC653	VIVA-VOCE	-	2
7	HU650*	Communication Skills and Technical Writing	(1-0-2)	-
Total Credits				**17**

Semester III				
SI. No.	**Course Code**	**Course Name**	**Total Credits** (L-T-P)	**Credits**
1		Elective III	(3-0-0)	3
2		Elective IV	(3-0-0)	3
3	EC700	Major Project-I	(0-0-12)	8
Total Credits				**14**

Semester IV				
SI. No.	**Course Code**	**Course Name**	**Total Credits** (L-T-P)	**Credits**
1	EC750	Major Project-II	(0-0-21)	14
Total Credits				**14**

List of Electives

Electives				
SI. No.	**Course Code**	**Course Name**	**Total Credits** (L-T-P)	**Credits**
1	EC800	Optoelectronics and Photonics	(3-0-0)	3
2	EC801	Architectural Design of IC	(3-0-0)	3
4	EC802	Digital Design using FPGA	(3-0-0)	3
5	EC803	System on CHIP	(3-0-0)	3
6	EC804	Mixed Signal Design	(3-0-0)	3
7	EC805	VLSI Embedded Systems	(3-0-0)	3
8	EC806	VLSI Design Automation	(3-0-0)	3
9	EC807	Compound Semiconductor Devices	(3-0-0)	3
10	EC808	Nano-electronic Device Engineering	(3-0-0)	3
11	EC809	Active Filter Design	(3-0-0)	3
12	EC810	Low Power VLSI Design	(3-0-0)	3
13	EC811	Power Management IC's	(3-0-0)	3
14	EC812	Advanced Topics in VLSI	(3-0-0)	3
15	EC813	Memory Design & Testing	(3-0-0)	3
16	EC814	IC for Broadband communication	(3-0-0)	3
17	EC815	CMOS RF IC Design	(3-0-0)	3
18	EC816	Advanced Antenna Theory	(3-0-0)	3
19	EC817	VLSI Signal Processing	(3-0-0)	3
20	EC818	Multi-rate Signal Processing	(3-0-0)	3

21	EC819	Multimedia Systems	(3-0-0)	3
22	EC820	Selected Topics in ECE - I		1
23	EC821	Selected Topics in ECE - II		2
24	EC822	Selected Topics in ECE - III	(3-0-0)	3

Program Electives				
SI. No.	**Course Code**	**Course Name**	**Total Credits** (L-T-P)	**Credits**
1	EC850	Data Structures and Algorithms	(3-0-0)	3
2	EC851	Advanced Computer Architecture	(3-0-0)	3
3	EC852	Optimization Techniques	(3-0-0)	3
4	EC853	Linear Algebra	(3-0-0)	3
5	EC854	Random Processes	(3-0-0)	3

Core Subject Syllabus

<table>
<tr><td>Subject Code

EC600</td><td colspan="2">Digital IC Design</td><td>Credits: 3(3-0-0)

Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="3">To understand the fundamental properties of digital Integrated circuits using basic MOSFET equations and to develop skills for various logic circuits using CMOS related design styles. The course also involves analysis of performance metrics.</td></tr>
<tr><td>Module 1</td><td>Implementation of strategies for digital ICs</td><td colspan="2">10 hours</td></tr>
<tr><td colspan="4">Custom Circuit design, Cell based and Array based design implementations. Static and Dynamic Characteristics of CMOs inverter, Power dissipation, Logical effort.</td></tr>
<tr><td>Module 2</td><td>Designing combinational and sequential circuits</td><td colspan="2">14 hours</td></tr>
<tr><td colspan="4">Static CMOS design, Different styles of logic circuits, Logical effort of complex gates, Static and dynamic properties of complex gates, Dynamic CMOS Logic. Timing metrics of sequential circuits, Dynamic latches and Registers. Pipelining.</td></tr>
<tr><td>Module 3</td><td>Interconnect and Timing Issues</td><td colspan="2">12 hours</td></tr>
<tr><td colspan="4">Circuit characterization and performance estimation - Resistance, Capacitance
estimation - Switching characteristics - Delay models –Timing issues in Digital circuits, Power dissipation. Impact of Clock Skew and Jitter.</td></tr>
<tr><td>Module 4</td><td>Memory Design</td><td colspan="2">6 hours</td></tr>
<tr><td colspan="4">Read-Only Memories, ROM cells, Read-write memories (RAM), dynamic memory design, 6 transistor SRAM cell, Sense amplifiers.</td></tr>
<tr><td colspan="4">Reference Books

1. Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolic Digital Integrated Circuits - A design perspective, Pearson, 2003.
2. M. Kang & Y. Leblebici, CMOS Digital Integrated Circuits, McGraw Hill, 1999.
3. John P. Uyemura, Introduction to VLSI Circuits, Wiley India Pvt. Ltd., 2012.
4. Eugene Fabricius, Introduction to VLSI Design, New Ed Edition, Tata McGraw - Hill Education, 1990.
5. Material from the Journal of Solid-state Circuits and the International Solid-state Circuits Conference proceedings.</td></tr>
</table>

<table>
<tr><td>Subject Code

EC601</td><td>Analog IC Design</td><td>Credits: 3(3-0-0)

Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="2">This course covers the analysis and design of analog integrated circuits starting from basic building blocks to different implementations of the amplifiers in CMOS technology.</td></tr>
<tr><td>Module 1</td><td>CMOS amplifiers basics</td><td>12 hours</td></tr>
<tr><td colspan="3">Introduction to MOS Capacitances, passive components and their parasitics, small and large signal modelling and analysis. Different Single stage and Differential Amplifiers, Current Mirrors.</td></tr>
<tr><td>Module 2</td><td>Multi-stage amplifiers</td><td>12 hours</td></tr>
<tr><td colspan="3">Telescopic and Folded cascode amplifiers, Slew-rate, Pole splitting, Two-stage amplifiers - analysis, Frequency response, Stability compensation, Common mode feedback analysis, feedback amplifier topologies.</td></tr>
<tr><td>Module 3</td><td>References</td><td>6 hours</td></tr>
<tr><td colspan="3">Supply independent biasing, Bandgap reference, Constant-Gm biasing.</td></tr>
<tr><td>Module 4</td><td>Nonlinearity, Mismatch and Layout</td><td>10 hours</td></tr>
<tr><td colspan="3">Noise: Types of Noise, noise model, Nonlinearity of Differential Circuits, Capacitor nonlinearity, Mismatch analysis, Offset cancellation techniques,

Layout Techniques</td></tr>
<tr><td colspan="3">Reference Books

1. B. Razavi, Design of Analog CMOS Integrated Circuits, Mcgraw-Hill Education, 2002.
2. David Johns & Ken Martin, Analog Integrated Circuit Design, Wiley-India, 2008.
3. P. Allen & D. R. Holberg, CMOS Analog Circuit Design, Oxford Press, 2011.
4. P. Gray, P. Hurst, S. Lewis, R. Meyer, Analysis and Design of Analog Integrated Circuits, Wiley-India, 2008.
5. Gregorian and Temes, Analog MOS Integrated Circuits for Signal Processing, Wiley-India, 2008.</td></tr>
</table>

<table>
<tr><td>Subject Code

EC602</td><td colspan="2">Semiconductor Device Theory and Modelling</td><td>Credits: 3(3-0-0)

Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="3">To familiarize with the physical concepts behind the operation of microelectronic devices and also covers high performance, high speed semiconductor devices used in VLSI systems.</td></tr>
<tr><td>Module 1</td><td>Concentration and motion of carriers in Semiconductor bulk</td><td colspan="2">8 hours</td></tr>
<tr><td colspan="4">Valence band and Energy band models of intrinsic and extrinsic semiconductors. Thermal equilibrium carrier concentration. Carrier transport phenomena, Recombination and generation.</td></tr>
<tr><td>Module 2</td><td>Quantitative theory of PN junctions</td><td colspan="2">10 hours</td></tr>
<tr><td colspan="4">Band diagrams, electrostatics of a p-n junction diode, ideal static I-V characteristics and deviations including breakdown, ac small signal equivalent circuit, switching characteristics, Schottky junctions, Ohmic contacts.</td></tr>
<tr><td>Module 3</td><td>BJT</td><td colspan="2">10 hours</td></tr>
<tr><td colspan="4">Bipolar device Design and Modeling, Small and large signal models, Non-ideal effects, breakdown voltage, charge storage, Multidimensional effects, Bipolar Device optimization & performance factors for digital and analog circuits, Brief overview of BJT CAD SPICE model and VBIC model introduction.</td></tr>
<tr><td>Module 4</td><td>MOSFET Alternate MOS structures</td><td colspan="2">14 hours</td></tr>
<tr><td colspan="4">Analysis of MOSFET, Calculation of threshold voltage. Static I-V characteristics of MOSFETs, MOSFET capacitances, C-V characteristics, Channel length modulation, body bias effect and short channel effects, MOS switch, MOSFET models for calculation, Alternate MOS structures (SOI devices and Multi-gate MOSFETs) in brief.</td></tr>
<tr><td colspan="4">Reference Books

1. M. S. Tyagi, Introduction to Semiconductor materials and Devices, John Wiley & Sons, 1991.
2. S. M. Sze, Modern Semiconductor Device Physics, Wiley, 1998.
3. Yuan Taur & Tak H Ning, Fundamentals of Modern VLSI Devices, Cambridge University Press, 1998.
4. Ben G. Streetman, Solid State Electronic Devices, Prentice Hall, Fifth Edition, 2000.
5. J. P. Colinge, FinFETs and other multigate transistors, Springer, 2007.</td></tr>
</table>

<table>
<tr><td>Subject Code

EC603</td><td>Digital Signal Processing</td><td>Credits: 3(3-0-0)

Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="2">To expose to the basic concepts in digital processing system design with emphasis on the digital filter design and related algorithmic and implementation issues. Specifically, focus will be on FIR, IIR Filters classical and optimized design techniques, issues related to finite word length and advantage of specific structures for implementation. Various specific digital filters will be discussed and their use for some signal processing applications will be also discussed.</td></tr>
<tr><td>Module 1</td><td>Review of Signals and Systems</td><td>8 hours</td></tr>
<tr><td colspan="3">Introduction to CT signals and systems, DT signals and systems, Frequency analysis of signals, Transform domain analysis of LTI systems, DFT- Properties, FFT algorithms.</td></tr>
<tr><td>Module 2</td><td>Design of Digital Filters</td><td>12 hours</td></tr>
<tr><td colspan="3">Digital filter structures, IIR Digital filter design and implementation, FIR digital filter design and implementation, Digital filter applications, Optimization Techniques in Filter Design.</td></tr>
<tr><td>Module 3</td><td>Finite Word length problems in Digital Filters</td><td>12 hours</td></tr>
<tr><td colspan="3">Representation of binary numbers in digital filters, Fixed and Floating point representation, Error due to quantization, truncation and round off, Implementation of different structures, Issues associated with IIR filters.</td></tr>
<tr><td>Module 4</td><td>Introduction to Multi-rate Signal Processing</td><td>10 hours</td></tr>
<tr><td colspan="3">Sampling rate conversion, Decimation by an integer factor, Interpolation by an integer factor, Sampling rate conversion by a rational factor, Sampling rate converter as a time variant system, Practical structures for decimators and interpolators. Multi stage implantation of digital filters.</td></tr>
<tr><td colspan="3">Reference Books

1. John G. Proakis, and Dimitris G. Manolakis, Digital Signal Processing Principles, Algorithms and Applications, Pearson, 2002.
2. P.S.R. Diniz, E. A. B. da Silva, and S. L. Netto, Digital Signal Processing System Analysis and Design, Cambridge, 2010.
3. Sanjit K. Mitra,Digital Signal Processing A Computer-Based Approach, McGraw Hill, 2003.
4. Vinay K. Ingle and John G. Proakis, Essential of Digital Signal Processing using MATLAB, Cengage Learning, 2012.
5. P. P. Vaidyanathan, Multirate Systems and Filter Banks, Pearson-Education, Delhi, 2004.
6. N. J. Fliege N J, Multirate Digital Signal Processing, John Wiley and sons, 1994.</td></tr>
</table>

Subject Code **EC604**	**IC Design Laboratory**	Credits:3 (0-0-6) Total hours: 84
Course Objectives	This course introduces CMOS schematic design, layout techniques, automated design tools, netlist synthesis, place & route and timing verification. EDA Tools will be introduced in this course.	
Module 1	**Digital IC design**	
Schematic simulation of CMOS Inverter, power and delay issues and Layout techniques. Pre layout simulation, Parasitic extraction, Post layout simulation. Design of Adders, Multiplier and Shifters, Synthesis with timing constraints, Pre layout simulation, Floor planning, Placement, Routing, Parasitic extraction, Post layout simulation. Standard cell layout techniques.		
Module 2	**Analog IC design**	
Single stage amplifiers: Completer characterization of Common source amplifier, Common drain amplifiers, Common Gate amplifiers, Cascode amplifiers. Differential amplifiers: Completer characterization of Single stage differential amplifiers, Folded Cascode, Telescopic amplifiers Two-stage amplifiers. Layout techniques		

Reference Books

1. James R.Armstrong, F.Gail Gray, *VHDL Design Representation and Synthesis*, Pearson Education, 2007.
2. Jan M Rabaey, *Digital Integrated Circuits - A Design Perspective*, Prentice Hall, Second Edition, 2005.
3. Naveed A. Sherwani, *Algorithms for VLSI Physical Design Automation*, Springer, Third Edition,1999.
4. B. Razavi, *Design of Analog CMOS Integrated Circuits*, McGraw-Hill Education, 2002.
5. Allan Hastings, *The Art of Analog Layout*, Prentice Hall, Second Edition, 2005.

<table>
<tr><td>Subject Code

EC605</td><td>Semiconductor Device Simulation Laboratory</td><td>Credits: 3 (0-0-3)

Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="2">This course covers the analysis and design of pn diode, BJT, MOSFET and novel device structures.</td></tr>
<tr><td>Module 1</td><td>2D simulations</td><td></td></tr>
<tr><td colspan="3">Use device simulator to generate a pn diode structure. Simulate I-V characteristics and also get the C-V characteristics. Find the carrier concentration, electron and hole concentration, electric field, potential distribution (at different biases) and doping distribution across the structure. Check the current and capacitance values with hand calculations. Extract Vbi from capacitance characteristics. Freeze different models one used. Process simulates the same structure with same/similar doping levels. Exporting the process simulated structure in to device simulator, extract I-V and C-V characteristics and make similar observations as in device simulation and explain the differences if any.</td></tr>
<tr><td>Module 2</td><td>BJT simulations</td><td></td></tr>
<tr><td colspan="3">Bipolar devices are integral part of high speed circuit. Any given MOSFET has a parasitic BJT. If not taken care in device design, the parasitic BJT may lead to very different behavior. The aim of these experiments is to understand the different effects in BJT. For a lateral/planar BJT, the following experiments can be performed:
1) Variation in α, β_{dc} and γ with base doping and base width and respective current characteristics
2) Variation in α, β_{dc} and γ with emitter width and respective current characteristics</td></tr>
<tr><td>Module 3</td><td>3D MOS device</td><td></td></tr>
<tr><td colspan="3">Simulate a 3D MOS device (FINFET/SOI/Piller MOSFET, Tri-gate MOSFET GAA MOSFET) and obtain their characteristics.</td></tr>
<tr><td colspan="3">Reference Books

1. User Manuals of respective software.
2. Jean- Pierrie Colinge, Silicon-on-insulator Technology: Materials to VLSI, Springer, Second Edition, 1997.
3. M.S. Tyagi, Introduction to Semiconductor materials and Devices, John Wiley & Sons, 1991.
4. J. P. Colinge, FinFETs and other multigate transistors, Springer, 2007.</td></tr>
</table>

Subject Code **EC650**	**VLSI Testing and Testability**	Credits: 3 (3-0-0) Total hours: 42
Course Objectives	This course covers introduction to the concepts and techniques of VLSI (Very Large Scale Integration) design verification and testing. Details of test economy, fault modeling and simulation, defects, Automatic Test Pattern Generation (ATPG), design for testability, and built-in self-test (BIST) also covered.	
Module 1	**Fundamental of VLSI testing**	12 hours
Basic of VLSI testing, Scope of testing and verification in VLSI design process, Issues in test and verification of complex chips, embedded cores and SOCs.		
Module 2	**Fault Modeling and testing**	12 hours
Fault models, fault detection and redundancy, fault equivalence and fault location, fault dominance, automatic test pattern generation, Design for testability, Scan design, Test interface and boundary scan. System testing and test for SOCs. Delay fault testing.		
Module 3	**Test automation and Design verification**	10 hours
BIST for testing of logic and memories, Test automation, Design verification techniques based on simulation, analytical and formal approaches.		
Module 4	**Functional and Timing verification**	8 hours
Functional verification, Timing verification, Formal verification, Basics of equivalence checking and model checking, Hardware emulation.		

Reference Books

1. M. Abramovici, M. A. Breuer and A. D. Friedman, *Digital Systems Testing and Testable Design*, Jaico Publishing House, 1990.
2. T. Kropf, *Introduction to Formal Hardware Verification*, Springer Verlag, 2000.
3. Neil H. E. Weste and Kamran Eshraghian, *Principles of CMOS VLSI Design,* Addison Wesley, Second Edition, 1993.
4. Neil H. E. Weste and David Harris, *Principles of CMOS VLSI Design*, Addison Wesley, Third Edition, 2004.
5. M. Bushnell and V. D. Agrawal, *Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits*, Kluwer Academic Publishers, 2000.

<table>
<tr><td>Subject Code

EC651</td><td>VLSI Technology</td><td>Credits: 3 (3-0-0)

Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="2">This course aims at understanding the manufacturing methods and their underlying scientific principles in the context of technologies used in VLSI chip fabrication.</td></tr>
<tr><td>Module 1</td><td>Crystal Growth, Wafer manufacturing and Clean rooms</td><td>12 hours</td></tr>
<tr><td colspan="3">CMOS Process flow starting from Substrate selection to multilevel metal formation, comparison between bulk and SOI CMOS technologies.
Crystal structure, Czochralski and FZ growth methods, Wafer preparation and specifications, SOI Wafer manufacturing.
Clean rooms, wafer cleaning and gettering: Basic concepts, manufacturing methods and equipment, Measurement methods.</td></tr>
<tr><td>Module 2</td><td>Photolithography and Oxidation</td><td>10 hours</td></tr>
<tr><td colspan="3">Photolithography: Light sources, Wafer exposure systems, Photoresists, Baking and development, Mask making, Measurement of mask features and defects, resist patterns and etched features.
Oxidation: Wet and Dry oxidation, growth kinetics and models, defects, measurement methods and characterization.</td></tr>
<tr><td>Module 3</td><td>Diffusion and Ion-implantation</td><td>8 hours</td></tr>
<tr><td colspan="3">Diffusion: Models for diffused layers, Characterization methods, Segregation, Interfacial dopant pileup, oxidation enhanced diffusion, dopant-defect interaction.
Ion-implantation: Basic concepts, High energy and ultralow energy implantation, shallow junction formation & modeling, Electronic stopping, Damage production and annealing, RTA Process & dopant activation</td></tr>
<tr><td>Module 4</td><td>Thin film Deposition, Etching Technologies and Back-end Technology</td><td>12 hours</td></tr>
<tr><td colspan="3">Thinfilm Deposition: Chemical and physical vapour deposition, epitaxial growth, manufacturing methods and systems, deposition of dielectrics and metals commonly used in VLSI, Modeling deposition processes.
Etching Technologies: Wet etching, Plasma etching, RIE, Etching of materials used in VLSI, Modeling of etching.
Back-end Technology: Contacts, Vias, Multi-level Interconnects, Silicided gates and S/D regions, Reflow & planarization, Multi-chip modules and packaging.</td></tr>
<tr><td colspan="3">Reference Books

1. James Plummer, M. Deal and P.Griffin, Silicon VLSI Technology, Prentice Hall Electronics, 2000.
2. Stephen Campbell, The Science and Engineering of Microelectronics, Oxford University Press, 1996.
3. S. M. Sze (Ed), VLSI Technology, McGraw Hill, Second Edition, 1988.
4. S.K. Ghandhi, VLSI Fabrication Principles, John Wiley Inc., New York, 1983.
5. C.Y. Chang and S. M. Sze (Ed), ULSI Technology, McGraw Hill Companies Inc, 1996.</td></tr>
</table>

Subject Code **EC652**	**System Design Laboratory**	Credits:3 (0-0-6) Total hours: 84
Course Objectives	This course covers the Laboratory topics based on the core and elective subjects. Example syllabus based on electives like System on chip or CMOS RF IC is given below. a) **System on chip lab** course introduces CAD tool for system design and implementation of Prototype SoC platform using FPGA and ARM processor boards. Xilinx ISE, EDK and ARM tool-chain will be used in this course. b) The objective of this course is to cover the design issue related to **RF IC Design**.	
Module 1	**System on chip**	

Development of embedded systems in both ARM and FPGA platforms. Examples on multiprocessor environments. Application case studies of signal processing applications FFT, FIR, DCT, JPEG, H.264 etc. Custom IP interfacing techniques for different protocols for above applications. Embedded OS development on FPGA/ARM platforms and device driver development.

Mini Project

Module 2	**RF IC Design**	

Characterization of a MOS transistor for RF, Design of a tuned LNA and performance analysis, Design of a VCO and performance analysis, Design of a mixer based on a Gilbert cell.

Mini Lab Projects

Reference Books:

1. Doug Amos, Austin Lesea and Rene Richter, *FPGA-Based Prototyping Methodology Manual Best Practices in Design-for-Prototyping*, Synopsys, Inc, Mountain View, 2010.
2. Ron Sass and Andrew G. Schmidt, *Embedded Systems Design with Platform FPGAs Principles and Practices*, Elsevier Inc, 2010.
3. J. Staunstrup and W. Wolf, *Data books of ARM7/ARM9*, *Hardware/Software Co-Design: Principles and Practice*, Kluwer Academic Publishers, 1997.
4. Silage, Dennis, *Embedded Design Using Programmable Gate Arrays*, Book stand Publishing, 2008.
5. K.V.K.K. Prasad, *Embedded Real Time Systems: Concepts, Design & Programming*, Dreamtech Publication, 2003.
6. G. DeMicheli, R. Ernst, and W. Wolf, *Readings in Hardware/Software Co-Design*, Academic Press, 2002.
7. *User manual of the tools for RF IC design.*
8. Razavi, B., *RF microelectronics.2nd ed. int.* Pearson Education International, 2012.
9. Lee, T.H., *The design of CMOS radio-frequency integrated circuits*. 2nd ed. Cambridge: Cambridge University Press, 2004.

<table>
<tr><td>Subject Code

EC606</td><td>Seminar</td><td>Credits: 2 (0-0-3)</td></tr>
<tr><td>Course Objectives</td><td colspan="2">Students will have to choose a topic in current VLSI related areas or industry practices and prepare a write up along with suitable presentation and demonstration.</td></tr>
</table>

<table>
<tr><td>Subject Code

EC654</td><td>VIVA-VOCE</td><td>Credits: 2</td></tr>
<tr><td>Course Objectives</td><td colspan="2">Students will have to attend for a viva-voce in front of all the faculty of the department for the evaluation of the subjects studied in the first year (I and II semesters) with a suitable demonstration.</td></tr>
</table>

<table>
<tr><td>Subject Code

HU650* (Audit Course)</td><td colspan="2">Communication Skills and Technical Writing</td><td>Credits: 0 (1-0-2)

Total hours: 45</td></tr>
<tr><td>Course Objectives</td><td colspan="3">This course is meant for developing Professional Communication and Technical Writing Skills among the students. The Lab hours will give emphasis on Technical Presentation and Seminar (on different emerging topics) followed by question-answer and discussion.</td></tr>
<tr><td>Module 1</td><td></td><td colspan="2">12 hours</td></tr>
<tr><td colspan="4">Introduction to Communication-Definition-Types-Classifications, Writing Exercises-Paragraph- Précis-Summary/Executive Summary/Abstract</td></tr>
<tr><td>Module 2</td><td></td><td colspan="2">8 hours</td></tr>
<tr><td colspan="4">Technical Reports-Types-Format-Nuances to be followed</td></tr>
<tr><td>Module 3</td><td></td><td colspan="2">10 hours</td></tr>
<tr><td colspan="4">Preparation of Technical Document-Reports-Instruction Manuals-Project Proposal (Prefatory Part- Main Part-Terminal Section)</td></tr>
<tr><td>Module 4</td><td></td><td colspan="2">15 hours</td></tr>
<tr><td colspan="4">Presentation of Technical Report (Kinesics, Proxemics, and Professional Ethics)</td></tr>
<tr><td colspan="4">Reference Books

1. Raman and Sharma, Communication Skills, OUP, 2011.
2. Mandel, Steve, Technical Presentation Skills: A Practical Guide for Better Speaking (Revised Edition), Crisp Learning, 2000.
3. Wood, Millett, The Art of Speaking, Drake Publishers, 1971.
4. Lencioni, Patrick, The Five Dysfunctions of a Team, John Wiley and Sons, 2006.</td></tr>
</table>

Subject Code **EC800**	**Optoelectronics and Photonics**	Credits: 3(3-0-0) Total hours: 42
Course Objectives	This course will cover basic laser theory, semiconductor physics, optical properties of semiconductors and quantum wells, optical detection and noises, electromagnetic waves. The primary emphasis will be on semiconductor materials and devices.	
Module 1	**Semiconductor lasers**	10 hours
Semiconductor lasers for optical fiber communications, Fabry-Perot cavity, heterostructure semiconductor lasers, single frequency semiconductor lasers, semiconductor lasers for coherent systems. Distributed feedback in Ga-As-P lasers.		
Module 2	**Photo detectors and Optical Receiver Operation**	12 hours
Device structure and fabrication, photo-detectors for fiber optics, reverse bias photo-detectors, dark current, quantum efficiency, signal to notice ratio, types of detectors. Receivers for digital fiber optic communication systems: basic components, detectors for digital fiber optic receivers, PIN diode, Avalanche photodiode, Fronts ends for digital fiber optic receivers, equalizer for optical communication, receivers, PIN-FET receivers for longer wavelength communication systems.		
Module 3	**Transmission System**	12 hours
Coherent optical fiber transmission systems, coherent detection principles, comparison of direct and coherent performance, homodyne and heterodyne systems. Nonlinear process in optical fibers, phase matching in waveguide, phase matched harmonic generation in waveguides. Second harmonic generation (SHG) in integrated optics, Cerenkov configuration SHG.		
Module 4	**Sensor and Devices**	8 hours
Optical fiber sensor and devices, intensity modulation through light interruption, distributed sensing with fiber optics. Basic principles of interferometric optical fiber sensor, signal processing in mono mode fiber optic sensor, photonic band gap materials.		
Reference Books 1. G. Keiser, *Optical fiber communication*, McGraw-Hill, 2008. 2. J. Seniar, *Optical fiber Communication*, Prentice-Hall International, 1985. 3. A. K. Ghatak, *Introduction to optical fiber*, Cambridge University Press, 1998. 4. Max Born & Emil Wolf, *Principles of Optics,* Cambridge University Press, 1999. 5. Saleh & Teich, *Fundamentals of Photonics,* Wiley-Interscience, 2007.		

Subject Code **EC801**	**Architectural Design of ICs**	Credits: 3(3-0-0) Total hours: 42
Course Objectives	This course covers algorithm, architecture and circuit design trade-offs to optimize for power, performance and area.	
Module 1		12 hours
VLSI Design flow, general design methodologies, Mapping algorithms into Architectures: Signal flow graph, data dependences, data-path synthesis, control structures, critical path and worst case timing analysis, concept of hierarchical system design; Data-path element: Data-path design philosophies, fast adder, multiplier, driver etc.		
Module 2		12 hours
Data-path optimization, application specific combinatorial and sequential circuit design, CORDIC unit; Pipeline and parallel architectures: Architecture for real time systems, latency and throughput related issues, clocking strategy, power conscious structures, array architectures; Control strategies: Hardware implementation of various control structures, micro-programmed control techniques, VLIW architecture		
Module 3		10 hours
Testable architecture: Controllability and observability, boundary scan and other such techniques, identifying fault locations, self-reconfigurable fault tolerant structures.		
Module 4		8 hours
Trade-off issues: Optimization with regard to speed, area and power, asynchronous and low power system design, ASIC (application specific integrated circuits) and ASISP (application specific instruction set processors) design		

Reference Books

1. U. Meyer-Baese, *Digital Signal Processing with Field Programmable Gate Arrays*, Springer-Verlag, 2001.
2. S. Y. Kung, *VLSI Array Processors.Prentice*, Prentice-Hall, 1988.
3. K. Parhi, *VLSI Digital Signal Processing Systems*, Wiley & Sons, 1999.
4. J. Rabaey, A. Chandrakasan and B. Nikolic, *Digital Integrated Circuits: A Design Perspective,* Prentice Hall, Second Edition, 2003.

Subject Code EC802	**Digital Design using FPGAs**	Credits: 3(3-0-0) Total hours: 42
Course Objectives	To learn field programmable gate array (FPGA) technologies and utilize associated computer aided design (CAD) tools. To synthesize digital systems with testing strategies and construct test benches.	
Module 1	**Introduction**	08 hours
Digital system design options and trade-offs, Design methodology and technology overview, High Level System Architecture and Specification: Behavioural modelling and simulation.		
Module 2	**Tool for logic Implementation**	12 hours
Hardware description languages, combinational and sequential design, state machine design, synthesis issues, test benches. Overview of FPGA architectures and technologies: FPGA Architectural options, granularity of function and wiring resources, coarse vs fine grained, vendor specific issues (emphasis on Xilinx / Altera).		
Module 3	**Implementation on FPGA**	12 hours
Logic block architecture: FPGA logic cells, timing models, power dissipation I/O block architecture: Input and Output cell characteristics, clock input, Timing, Power dissipation, Programmable interconnect - Partitioning and Placement, Routing resources, delays.		
Module 4	**Applications**	10 hours
Applications - Embedded system design using FPGAs, DSP using FPGAs, Dynamic architecture using FPGAs, reconfigurable systems, application case studies. Simulation / implementation exercises of combinational, sequential and DSP kernels on Xilinx / Altera boards.		

Reference Books

1. M. J. S. Smith, *Application Specific Integrated Circuits*, Pearson, 2000.
2. Peter Ashenden, *Digital Design using Verilog*, Elsevier, 2007.
3. W. Wolf, *FPGA based system design*, Pearson, 2004.
4. Clive Maxfield, *The Design Warriors's Guide to FPGAs*, Elsevier, 2004.

<table>
<tr><td>Subject Code

EC803</td><td colspan="2">System on Chip Design</td><td>Credits: 3(3-0-0)

Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="3">This course covers SoC design and modeling techniques with emphasis on architectural exploration, assertion-driven design and the concurrent development of hardware and embedded software.</td></tr>
<tr><td>Module 1</td><td colspan="2">Low-level modeling and design refactoring</td><td>12 hours</td></tr>
<tr><td colspan="4">Verilog RTL Design with examples. Simulation styles (fluid flow versus eventing). Basic RTL to gates synthesis algorithm. Using signals, variables and transactions for component inter-communication. SystemC overview. Structural hazards, retiming, refactoring.</td></tr>
<tr><td>Module 2</td><td colspan="2">Design partition, high-level and hybrid modeling</td><td>12 hours</td></tr>
<tr><td colspan="4">Bus and cache structures, DRAM interface. SoC parts. Design exploration. Hardware/software interfaces and co-design. Memory maps. Programmer's model. Firmware development. Transactional modeling. Electronic systems level (ESL). IP-XACT. Instruction set simulators, cache modeling and hybrid models.</td></tr>
<tr><td>Module 3</td><td colspan="2">Assertions for design, testing and synthesis</td><td>10 hours</td></tr>
<tr><td colspan="4">Assertion based design: testing and synthesis. PSL/SVA assertions. Temporal logic compilation to FSM. Glue logic synthesis. Combinational and sequential equivalence. High- level Synthesis and Automated Assembly.</td></tr>
<tr><td>Module 4</td><td colspan="2">Power control and power modeling</td><td>8 hours</td></tr>
<tr><td colspan="4">Power consumption formulae. Pre-layout wiring estimates. Clock gating. Frequency and voltage dynamic scaling.</td></tr>
<tr><td colspan="4">Reference Books

1. Lin, Y-L.S. Essential issues in SOC design: designing complex systems-on-chip, Springer, 2006.
2. Grotker, T., Liao, S., Martin, G. & Swan, S. System design with SystemC, Springer, 2002.
3. Ghenassia, F. Transaction-level modeling with SystemC: TLM concepts and applications for embedded systems, Springer, 2010.
4. D. Gajski, S. Abdi, A. Gerstlauer, G. Schirner, Embedded System Design: Modeling, Synthesis, Verification, Springer, 2009.
5. G. De Micheli, Synthesis and Optimization of Digital Circuits, McGraw-Hill, 1994.</td></tr>
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<table>
<tr><td>Subject Code

EC804</td><td colspan="2">Mixed Signal Design</td><td>Credits: 3(3-0-0)

Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="3">This course covers theory and concepts to Integrate both Analog and Digital subsystems on a single monolithic chip to create an electronic system. The syllabus includes primitive cells, biasing and references, op-amp designs, switched capacitor A/D and D/A converters, and clock generation systems for digital and mixed signal.</td></tr>
<tr><td>Module 1</td><td colspan="2">Filter basics</td><td>10 hours</td></tr>
<tr><td colspan="4">Analog continuous-time filters: passive and active filters, Basics of analog discrete-time filters and Z-transform, Sample and Hold Circuits, Switched-capacitor filter architectures.</td></tr>
<tr><td>Module 2</td><td colspan="2">ADC and DAC</td><td>12 hours</td></tr>
<tr><td colspan="4">Basics ADC, Successive approximation ADCs, Flash ADC, folding-and-interpolation ADC, Pipeline ADC, Introduction/Characterization of DACs, various architectures of high speed DAC</td></tr>
<tr><td>Module 3</td><td colspan="2">Over sampled ADC</td><td>10 hours</td></tr>
<tr><td colspan="4">Over sampled ADC: Working principle and architecture of a Sigma-delta ADC, multistage sigma-delta converters, Design of decimation filter.</td></tr>
<tr><td>Module 4</td><td colspan="2">Advanced Topics</td><td>10 hours</td></tr>
<tr><td colspan="4">VCO, Loop Filter, Charge pump, Precautionary measures for integrating analog and digital modules within an IC, floor planning and physical design of mixed signal IC design.</td></tr>
<tr><td colspan="4">Reference Books

1. B. Razavi, Design of Analog CMOS Integrated Circuits, McGraw-Hill Education, 2002.
2. David Johns & Ken Martin, Analog Integrated Circuit Design, Wiley-India, 2008.
3. P. Allen & D. R. Holberg, CMOS Analog Circuit Design, Oxford Press, 2011.
4. B. Razavi, Principles of Data Conversion System Design, IEEE Press, 1995.
5. Schreier & Temes, Understanding Delta-Sigma Data Converters, Wiley-IEEE Press, 2004.
6. Franco Maloberti, Data Converters, Springer-2007.
7. Jacob Baker, CMOS Mixed Signal Circuit Design, Wiley-IEEE Press, Second Edition, 2009.</td></tr>
</table>

Subject Code **EC805**	**VLSI & Embedded systems**	Credits: 3(3-0-0) Total hours: 42
Course Objectives	The course covers prototype development of embedded VLSI system. The course focuses on software application by mapping of functions onto hardware components. In addition to the conceptual foundations, this course also covers various design methodologies and platforms based on ARM and FPGA.	
Module 1	**Embedded System on chip platforms**	5 hours
Introduction to embedded system and design methodology for ARM and FPGA devices, Prototype development of embedded application advantages, design challenges, Differences between General Purpose Processor, Digital signal Processor, ASIC and FPGA based System On Chip.		
Module 2	**MPSoC platform for FPGAs and ARM**	25 hours
Embedded Computer Organization, emphasis on different embedded processors and multiprocessor and architectures. Application profiling, Hardware-software co-design, Simple & Autonomous I/O Controllers, Custom IP (Intellectual-Property) hardware design for System-On-a-Chip; Design of Master and Slave Bus protocols based IPs, Bus protocols (AXI, PLB, FSL, NPI etc.). Concepts & types of Memory and interfacing, Cache Memory, Cache mapping techniques and impact on system performance, Design Metrics, General purpose peripherals (interrupt, timer, clock, DMA etc.) and special purpose peripherals Serial Transmission techniques & Standards, Wireless protocols, and advanced high speed buses.		
Module 3	**Analysis and case-studies**	12 hours
Architecture exploration of IP, System Level Design Trade-offs, Power, Energy, Performance and Area. Frequency, memory and power, Productivity, Reusability, Clocking and Synchronisation issues, Co-simulation using different simulators, system level optimization, Design for Test, Advanced design Methodologies using HLS for an application like JPEG 2000, MJPEG, H.264, Embedded operating systems for SoC platforms.		

Reference Books

1. Ron Sass and Andrew G. Schmidt, *Embedded Systems Design with Platform FPGAs Principles and Practices*, Elsevier Inc, 2010.
2. Doug Amos, Austin Lesea and Rene Richter, *FPGA-Based Prototyping Methodology Manual Best Practices in Design-for-Prototyping*, Synopsys, Inc, Mountain View, 2010.
3. *Embedded System Design: A unified Hardware/Software Introduction*, Frank Vahid, and Tony Givargis.
4. Lin, Y.L.S., *Essential issues in SOC design: designing complex systems-on-chip*, Springer, 2006.
5. Sloss, Andrew, Dominic Symes, and Chris Wright, *ARM system developer's guide: designing and optimizing system software*. Morgan Kaufmann, 2004.
6. G. DeMicheli, R. Ernst, and W. Wolf, *Readings in Hardware/Software Co-Design*, Academic Press, 2002.
7. Peter J. Ashenden, *Digital Design: An Embedded Systems Approach Using Verilog*, Morgan Kaufmann Publication, 2008.

Subject Code **EC806**	**VLSI Design Automation**	Credits: 3 (3-0-0) Total hours: 42
Course Objectives	The objective of physical design automation is to carry out mapping of the given structural representation into layout representation optimally using computers so that the resulting layout satisfies topological, geometric, timing and power-consumption constraints of the design.	
Module 1	**VLSI CAD basics**	12 hours
VLSI CAD Flow, Chip Layout styles, High-level synthesis, Algorithm Design Approaches for VLSI CAD, models for physical design, Graph theory fundamentals.		
Module 2	**Partitioning and Routing**	12 hours
Partitioning, Floorplanning-tutte's approach, Graph-theoretic models of floorplans, Placement-general problem, quality metrics, Gordian, Design Rule Check, Compaction, Clock and Power Routing–Global routing, Channel routing.		
Module 3	**Optimization and Synthesis**	10 hours
Optimization techniques, Logic synthesis and Technology Mapping-Dynamic Programming, Dagon, VLSI and Circuit Design Issues including power and delay analysis.		
Module 4	**New topics in VLSI CAD**	8 hours
Design consideration for Analog and Mixed Signal Design. Emerging topics in the VLSI CAD.		

Reference Books

1. S. M. Sait, and H. Youssef, *VLSI Physical Design Automation: Theory and Practice*, World Scientific, 1999.
2. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, *Introduction to Algorithms*, MIT Press, Third Edition, 2009.
3. C. J. Alpert, D. P. Mehta, S. S. Sapatnekar, *Handbook of Algorithms for Physical Design Automation*, Auerbach Publications, 2008.
4. Sung Kyu Lim, *Practical Problems in VLSI Physical Design Automation*, Springer, 2008.
5. Naveed A Sherwani, *Algorithms for VLSI Physical Design Automation, Third Edition*, 1998.

Subject Code EC807	**Compound Semiconductor Devices**	Credits: 3 (3-0-0) Total hours: 42
Course Objectives	The goal of this course is to impart the elements of III-V compound semiconductor materials and their related electronic and photonic devices.	
Module 1	**Introduction to compound semiconductor**	12 hours
Compound semiconductor crystals, structural, optical properties and electrical properties, free carrier concentration and Fermi-Dirac integral, III-V alloys, Fermi level pinning, theories of barrier formation and of current flow, diffusive vs. ballistic flow; contrasts with p-n diodes.		
Module 2	**Heterostructures**	12 hours
E-x Profiles, modulation doping. Conduction parallel to heterojunction; mobility in semiconductors and carrier scattering mechanisms, Conduction normal to junction: I-V models and characteristics.		
Module 3	**MESFETs**	10 hours
Basic concept, models for terminal characteristics; accounting for velocity saturation. Dynamic models: large signal switching transients; small signal, high f models. Fabrication sequences; application-specific designs, examples of fabrication sequences.		
Module 4	**HFETs & HBTs**	8 hours
Basic device, theory, Deep level problem, non-ideal behaviour, pseudomorphic solution, RF characteristics,.		
Reference Books 1. M. S. Shur, M. S, *Physics of Semiconductor Devices*, Prentice-Hall, 1990. 2. Adachi, Sadao, *Physical Properties of III-V Semiconductor Compounds: InP, InAs, GaAs, GaP, InGaAs, and InGaAsP*, John Wiley & Sons, 1992. 3. S. M. Sze, High *Speed Semiconductor Devices,* Wiley, 1990. 4. S. M. Sze, *Physics of Semiconductor Devices,* Wiley, Second Edition, 1981.		

<table>
<tr><td>Subject Code

EC808</td><td colspan="2">Nano-Electronic Device Engineering</td><td>Credits: 3(3-0-0)

Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="3">This course will introduce the rapidly developing field of nano-engineering materials and various device structures with special focus on their electronic properties.</td></tr>
<tr><td>Module 1</td><td colspan="2">Device Physics and Introduction to scaling issues</td><td>12 hours</td></tr>
<tr><td colspan="4">Challenges going to sub-100 nm MOSFETs – fundamental limits for MOS operation, SCEs and DIBL effects, sub-threshold current, velocity saturation, Oxide layer thickness, tunneling, High-K gate dielectrics, effects of high-K gate dielectrics on MOSFET performance, power density, non-uniform dopant concentration,. interconnect and lithography issues.</td></tr>
<tr><td>Module 2</td><td colspan="2">Novel Device Structures</td><td>12 hours</td></tr>
<tr><td colspan="4">Novel MOS-based devices – Multiple gate MOSFETs, Silicon-on-nothing, Silicon-on-insulator devices, FD SOI, PD SOI, FinFETs, vertical MOSFETs, strained Si devices. SiGe HBTs.</td></tr>
<tr><td>Module 3</td><td colspan="2">Hetero structure based devices</td><td>10 hours</td></tr>
<tr><td colspan="4">Hetero structure based devices – Type I, II and III Heterojunction, Si-Ge heterostructure, hetero structures of III-V and II-VI compounds - resonant tunneling devices, MODFET/HEMT, Carbon nanotubes based devices – CNFET, characteristics, Spin-based devices – spinFET, characteristics.</td></tr>
<tr><td>Module 4</td><td colspan="2">Quantum Effects</td><td>8 hours</td></tr>
<tr><td colspan="4">Quantum structures – quantum wells, quantum wires and quantum dots, Single electron devices – charge quantization, energy quantization, Coulomb blockade, Coulomb staircase, Bloch oscillations</td></tr>
<tr><td colspan="4">Reference Books

1. Mircea Dragoman and Daniela Dragoman, Nanoelectronics – Principles & devices, Artech House Publishers, 2005.
2. Karl Goser, Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum Devices, Springer 2005.
3. Mark Lundstrom and Jing Guo, Nanoscale Transistors: Device Physics, Modeling and Simulation, Springer, 2005.
4. Vladimir V Mitin, Viatcheslav A Kochelap and Michael A Stroscio, Quantum heterostructures, Cambridge University Press, 1999.
5. S. M. Sze (Ed), High speed semiconductor devices, Wiley, 1990.
6. H.R. Huff and D.C. Gilmer, High Dielectric Constant Materials for VLSI MOSFET Applications, Springer 2005.
7. B. R. Nag, Physics of Quantum Well Devices, Springer 2002.
8. E. Kasper, D. J. Paul, Silicon Quantum Integrated Circuits Silicon-Germanium Heterostructures Devices: Basics and Realisations, Springer, 2005.</td></tr>
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Subject Code **EC809**	**Active Filter Design**	Credits: 3(3-0-0) Total hours: 42
Course Objectives	To understand the fundamental concepts involved in the design of Continuous-time filters. To develop the skills required to design and verify the various filter circuits using op-amps and OTA's.	
Module 1	**Filter Fundamentals**	10 hours
Filter Characterization, Continuous-Time Filter Functions, Steps in Filter design, Butterworth, Chebyshev & Inverse-Chebyshev filter response and pole locations. The Approximation Problem.		
Module 2	**Ladder filter structures**	10 hours
LC ladder filter - prototype & synthesis; Frequency transformation of low-pass filter. Active elements , Impedance converters, Characteristics of IC op-amps , The Ideal Operational Transconductance Amplifier (OTA).		
Module 3	**Realizations of active filters**	12 hours
Active-RC filters, Gm-C filters- Elementary Transconductance Building blocks, off-set problems, Limitations of opamp based filters. Characterization of on-chip integrated continuous time filters.		
Module 4	**Switched capacitor circuits**	10 hours
Switched capacitor filters- First-order building blocks- Second order sections.		

Reference Books

1. R. Schaumann and M.E. Van Valkenburg, *Design of Analog Filters*, Oxford University Press, 2003.
2. P. V. Ananda Mohan, *Current-Mode VLSI Analog Filters - Design and Applications*, Birkhauser, 2003.
3. Gobind Daryanani, *Properties of Active networks synthesis and Design*, Wiley, First Edition, 1976.
4. M.E. Van Valkenburg, *Analog Filter Design*, Oxford University Press, 1995.
5. T. Deliyannis, Y. Sun and J. K. Fidler, *Continuous-Time Active Filter Design*, CRC Press, 1998.
6. Material from the Journal of Solid-state Circuits and the International Solid-state Circuits Conference proceedings.

Subject Code **EC810**	# Low-Power VLSI Design	Credits: 3 (3-0-0) Total hours: 42
Course Objectives	To understand the critical requirements and implementation of Low-power VLSI circuits. The course also covers critical issue related to continued scaling of microelectronic circuits.	
Module 1	**Introduction**	08 hours
Introduction: Need for low power VLSI chips, Sources of power dissipation on Digital Integrated circuits, Emerging Low power approaches. Device & Technology Impact on Low Power: short circuit and leakage in CMOS, Dynamic dissipation in CMOS.		
Module 2	**Low-Voltage CMOS Circuits**	10 hours
Introduction, Design style, Leakage current in Deep sub-micron transistors, device design issues, minimizing short channel effect, Low voltage design techniques using reverse Vgs, steep sub threshold swing and multiple threshold voltages, Testing with elevated intrinsic leakage, multiple supply voltages.		
Module 3	**Circuit and logics**	12 hours
Low Power Circuits: Transistor and gate sizing, network restructuring and Reorganization, Special Flip Flops & Latches design, Low power digital cells library. Logic level- Gate reorganization, signal gating, logic encoding, state machine encoding, pre-computation logic.		
Module 4	**Architecture and system**	12 hours
Low power Architecture & Systems: Power & performance management, switching activity reduction, parallel architecture with voltage reduction, flow graph transformation, low power arithmetic components. Adiabatic Computation, Pass Transistor Logic Synthesis.		
Reference Books		

1. Gary K. Yeap, *Practical Low Power Digital VLSI Design*, KAP, 2002
2. Kaushik Roy, and Sharat Prasad, *Low-Power CMOS VLSI Circuit Design*, Wiley, 2000.
3. Anantha P. Chandrakasan, and Robert W. Brodersen, *Low Power Digital CMOS Design*, Kluwer Academic Publications, 1995.
4. Rabaey, and Pedram, *Low Power Design Methodologies*, Kluwer Academic,1997
5. Philip Allen, and Douglas Holberg, *CMOS Analog Circuit Design*, Oxford University Press, 2002.

Subject Code **EC811**	**Power Management ICs**	Credits: 3(3-0-0) Total hours: 42
Course Objectives	This course covers operation principles of different dc-dc converters: switched-mode power converters, switched-capacitor power converters and linear regulators. Design and analysis of voltage references are also covered.	
Module 1		12 hours
Introduction to DC to DC converter, Mechanisms of switching loss, Switching in Inductor, Buck converter, Synchronous Buck converter, Boost converter, Cuk Converter, dc-ac inverters, Small-signal ac modeling, and analysis of various DC to DC converters.		
Module 2		12 hours
Single ended primary inductance converter, interleaved converters, PWM building blocks, Various control techniques, PWM control of DC-DC converter, Stabilization.		
Module 3		8 hours
Zero current switching DC-DC converters, Zero Voltage switching DC-DC converter, ZVS converter, flyback converter, resonant converters, PWM for Class D audio amplifier.		
Module 4		10 hours
Voltage references, Temperature and power supply sensitivity, Analysis of negative feedback circuits, voltage regulators. Applications emphasized include dc-dc converters for computer power and portable applications, dc-ac inverters for gas discharge lighting ballasts and wireless power transfer, LED drivers and solar micro-inverters.		
Reference Books 1. Gabriel Rincon-Mora, *Analog IC Design with Low Dropout Regulators*, McGraw-Hill, 2009. 2. Marian K. Kazimierczuk, *Pulse-Width Modulated DC-DC Power Converters*, Wiley, 2008. 3. R. W. Erickson and D. Maksimovic, *Fundamentals of Power Electronics*, Kluwer, Second Edition, 2001.		

Subject Code **EC812**	**Advanced Topics in VLSI**	Credits: 3(3-0-0) Total hours: 42
Course Objectives	This course covers the advanced topics in the VLSI Design and emphasis will be given to one specific domain of integrated circuit design. Most often, this will address an application space that has become particularly relevant in recent times. Examples are serial links, ultra-low-power design, wireless transceiver design.	
Module 1		21 hours
Topics on Wireless transceiver design, Sensor design, Wireless body area networks, RF ID		
Module 2		21 hours
Topics on Ultra low power design, Serial links etc.		

References

1. Journal of Solid-State Circuits (JSSC)
2. Transactions of Circuits and Systems I (TCAS-I)
3. Transactions of Circuits and Systems II (TCAS-II)
4. Transactions on Very Large Scale Integration Systems (TVLSI)
5. IEEE Journal on Emerging and Selected Topics in Circuits and Systems
6. Other relevant Journal and conference papers

Subject Code **EC813**	**Memory Design & Testing**	Credits: 3(3-0-0) Total hours: 42
Course Objectives	This course covers the analysis, design and testing of Memory Circuits starting from basic building blocks. Memory technologies like DRAM, SRAM, FLASH and interfacing circuits are covered.	
Module 1		12 hours
Review of CMOS circuit design, architectures, Open and folded arrays, sensing basics, refresh, kickback, SRAM (Read and Write operation, 6T, 8T cell implementation etc.), floating-gate architectures, sense amplifiers, Sensing using Sigma-Delta Modulation.		
Module 2		12 hours
Introduction to DRAM, High speed DRAM architectures, bandwidth, latency, and cycle time, Power, Timing circuits, Control logic, FLASH (FLASH array sensing and programming), Charge Pump, PROM, EPROM		
Module 3		10 hours
RAM Fault Modeling, RAM Electrical Testing, RAM Pseudorandom Testing, Megabit DRAM Testing, IDDQ Fault Modeling and Testing, Application Specific Memory Testing. General Design for Testability Techniques, RAM Built-in Self-Test (BIST), Embedded Memory DFT and BIST Techniques, Advanced BIST and Built-in Self-Repair Architectures. DFT and BIST for ROMs, Memory Error-Detection and Correction Techniques, Memory Fault-Tolerance Designs.		
Module 4		8 hours
Reliabilities issues, Topics in Advanced Memory Technology, Application Specific Memories and Architectures, High Density memory package Technologies.		

Reference Books

1. Betty Prince, *Semiconductor Memories: A Handbook of Design, Manufacture and Application*, Wiley, Second Edition, 1996.
2. Keeth, Baker, Johnson, and Lin, *DRAM Circuit Design: Fundamental and High-Speed Topics*, Wiley-IEEE, 2007.
3. Jacob Baker, *CMOS Circuit Design, Layout, and Simulation*, Wiley-IEEE, Third Edition, 2010.
4. Ashok K. Sharma, *Semiconductor Memories: Technology, Testing, and Reliability*, Wiley-IEEE, 2013.

Subject Code **EC814**	**IC for Broadband communication**	Credits: 3(3-0-0) Total hours: 42
Course Objectives	The objective of this course is to study digital signal transmission over lossy and dispersive channels, equalization, IC broadband amplifiers, feed-forward and decision feedback equalization, clock and data recovery circuits. It provides an understanding of signal degradation, techniques to combat them, and integrated circuit implementation of these techniques.	
Module 1	**Digital signal transmission**	12 hours
Digital signal transmission over lossy and dispersive channels: Eye diagrams; Eye closure; crosstalk, and jitter; Synchronization: clock and data recovery circuits using phase locked loops and delay locked loops,		
Module 2	**Equalization**	12 hours
Equalization: Transmit pre-emphasis, Receive feed-forward equalization, and decision feedback equalization.		
Module 3	**IC broadband amplifiers for transmitter and receiver**	10 hours
Integrated circuit implementation of broadband amplifiers for transmission and reception, feed-forward and decision feedback equalization.		
Module 4	**Clock and data recovery circuits**	8 hours
Clock and data recovery circuits, multiplexers, and demultiplexers.		

Reference Books

1. David Johns and Ken Martin, *Analog Integrated Circuit Design*, John Wiley & Sons, 1997.
2. Y. Tsividis, *Mixed Analog Digital VLSI Devices and Technology (An introduction)*, World Scientific, 2002.
3. Gray, Hurst, Lewis, and Meyer, *Analysis and design of Analog Integrated Circuits*, John Wiley and Sons, Fifth Edition, 2009.
4. K. R. Laker and W.M.C. Sansen, *Design of Analog Integrated Circuits and Systems*, McGraw-Hill, 1994.
5. Behzad Razavi, *Design of Analog CMOS Integrated Circuits*, McGraw-Hill, 2000.

Subject Code EC815	**CMOS RF IC Design**	Credits: 3 (3-0-0) Total hours: 42
Course Objectives	The objective of this course is to cover the circuit design theory and their implementation techniques at RF frequencies specific to CMOS technologies.	
Module 1	**Historical Aspects**	8 hours
Historical Aspects — From Maxwell to current wireless standards, The bridge between communication system designer and RF IC designer, common system characterization, RF system characterization.		
Module 2	**Transceiver Architectures**	8 hours
Transceiver Architectures — motivation for the individual blocks, lumped, passive RLC, RF properties of MOS, Tuned amplifiers.		
Module 3	**Low Noise Amplifier and mixer**	14 hours
Noise sources, cascades, Low Noise Amplifier — design examples, Mixers — Introduction, active and passive.		
Module 4	**Oscillators & synthesizers**	12 hours
Analysis fundamentals and inductors, LC oscillators and VCOs, Frequency Synthesizers: Principles, design, Integer N vs. Fractional PLL.		

Reference Books:

1. T. H. Lee, *The Design of Radio-Frequency Integrated Circuits,* Cambridge University Press, 2004.
2. B. Leunge, *VLSI for Wireless Communication, Personal Education Electronics and VLSI series,* Pearson Education, 2002.
3. B. Razavi, *RF Microelectronics,* Prentice Hall, 1998.

Subject Code EC816	**Advanced Antenna Theory**	Credits: 3(3-0-0) Total hours: 42
Course Objectives	The main objective is to study modern antenna concepts for various applications. The course will explain basic antenna parameters, different types of antenna and array configurations. The concepts can further be extended in the VLSI domain for RF IC design.	
Module 1	**Fundamental Concepts**	10 hours
Physical concept of radiation, Radiation pattern, near-and far-field regions, reciprocity, directivity and gain, effective aperture, polarization, input impedance, efficiency.		
Module 2	**Radiation from Wires and Loops.**	10 hours
Infinitesimal dipole, finite-length dipole, linear elements near conductors, dipoles for mobile communication, small circular loop.		
Module 3	**Aperture, Reflector and Broadband Antennas.**	12 hours
Huygens' principle, radiation from rectangular and circular apertures, radiation from sectoral and pyramidal horns, prime-focus parabolic reflector antennas, Log-periodic and Yagi antennas, frequency independent antennas, broadcast antennas.		
Module 4	**Microstrip Antennas and Antenna Arrays**	10 hours
Basic characteristics of microstrip antennas, feeding methods, methods of analysis, design of rectangular and circular patch antennas, Analysis of uniformly spaced arrays with uniform and non-uniform excitation amplitudes.		
Reference Books 1. C. A. Balanis, *Antenna Theory and Design*, John Wiley & Sons, Third Edition, 2005. 2. W. L. Stutzman, and G. A. Thiele, *Antenna Theory and Design*, John Wiley & Sons, Second Edition, 1998. 3. R. S. Elliot, *Antenna Theory and Design*, Wiley-IEEE Press, Revised Edition, 2003.		

<table>
<tr><td>Subject Code

EC817</td><td>VLSI Signal Processing</td><td>Credits: 3(3-0-0)

Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="2">This course covers the various VLSI architectures and algorithms for digital signal processing. This course describes the basic ideas about digital signal processing. This course also describes the techniques of critical path and algorithmic strength reduction in the filter structures.</td></tr>
<tr><td>Module 1</td><td>DSP Concepts</td><td>12 hours</td></tr>
<tr><td colspan="3">Linear system theory, DFT, FFT, realization of digital filters. Typical DSP algorithms, DSP applications. Data flow graph representation of DSP algorithm.</td></tr>
<tr><td>Module 2</td><td>Architectural Issues</td><td>10 hours</td></tr>
<tr><td colspan="3">Binary Adders, Binary multipliers, Multiply Accumulator (MAC) and Sum of Product (SOP). Pipelining and Parallel Processing, Retiming, Unfolding, Folding and Systolic architecture design.</td></tr>
<tr><td>Module 3</td><td>Fast Convolution</td><td>10 hours</td></tr>
<tr><td colspan="3">Cook-Toom algorithm, modified Cook-Toom algorithm, Winograd algorithm, modified Winograd algorithm, Algorithmic strength reduction in filters and transforms, DCT and inverse DCT, parallel FIR filters.</td></tr>
<tr><td>Module 4</td><td>Power Analysis in DSP systems</td><td>10 hours</td></tr>
<tr><td colspan="3">Scaling versus power consumption, power analysis, power reduction techniques, power estimation techniques, low power IIR filter design, Low power CMOS lattice IIR filter.</td></tr>
<tr><td colspan="3">Reference Books

1. Keshap K. Parhi, VLSI Digital Signal Processing Systems, Design and Implementation, John Wiley, 2007.
2. U. Meyer-Baese, Digital Signal processing with Field Programmable Arrays, Springer, 2007.
3. V. K. Madisetti, VLSI Digital Signal Processors: An Introduction to Rapid Prototyping and Design Synthesis, IEEE Press, New York, 1995.
4. S. Y. Kung, H. J. Whitehouse, VLSI and Modern Signal Processing, Prentice Hall, 1985.</td></tr>
</table>

<table>
<tr><td>Subject Code

EC818</td><td colspan="2">Multi-rate Signal Processing</td><td>Credits: 3(3-0-0)

Total hours: 42</td></tr>
<tr><td>Course Objectives</td><td colspan="3">This course covers the basic ideas about decimator, interpolator, multi-rate filter design and DFT filter banks. This course also describes the design of filter bank and efficient implementation of the filter banks.</td></tr>
<tr><td>Module 1</td><td colspan="2">Introduction</td><td>10 hours</td></tr>
<tr><td colspan="4">Introduction, Sampling and Signal Reconstruction, Sampling rate conversion, Decimation by an integer factor, Interpolation by an integer factor, Sampling rate conversion by a rational factor, Sampling rate converter as a time variant system, Practical structures for decimators and interpolators.</td></tr>
<tr><td>Module 2</td><td colspan="2">Multi-rate filter design</td><td>10 hours</td></tr>
<tr><td colspan="4">Direct form and Polyphase FIR structures, FIR structures with time varying Coefficients, Design of FIR filters for sampling rate conversion, Multistage design of decimator and interpolator, Applications of Interpolation and decimation in signal processing.</td></tr>
<tr><td>Module 3</td><td colspan="2">Maximally Decimated Filter Banks</td><td>10 hours</td></tr>
<tr><td colspan="4">Introduction, errors created in QMF bank, alias free QMF system, power symmetric QMF banks, M-channel filter banks, polyphase representation, perfect reconstruction systems; Paraunitary Perfect Reconstruction (PR) Filter Banks, lossless transfer matrices, filter bank properties induced by paraunitariness, two channel FIR paraunitary QMF banks, two channel paraunitary QMF lattice, M-channel FIR paraunitary filter banks;</td></tr>
<tr><td>Module 4</td><td colspan="2">Linear Phase Perfect Reconstruction QMF Banks</td><td>12 hours</td></tr>
<tr><td colspan="4">Introduction, lattice structures for linear phase FIR PR QMF banks, formal synthesis of linear phase FIR PR QMF lattice; Cosine modulated Filter Banks, efficient polyphase structures, cosine modulated perfect reconstruction systems. Applications of Multirate Signal Processing: Analysis of audio, speech, image and video signals.</td></tr>
<tr><td colspan="4">Reference Books

1. P. P. Vaidyanathan, Multirate Systems and Filter Banks, Pearson-Education, 2004.
2. N. J. Fliege N J, Multirate Digital Signal Processing, John Wiley and sons, 1994.
3. J. G. Proakis, & D. G. Manolakis, Digital Signal Processing Principles, Algorithms and Applications, Prentice Hall of India, 2002.
4. S. K. Mitra, Digital Signal Processing-A Computer Based Approach, Tata McGraw Hill, 2003.</td></tr>
</table>

Subject Code **EC819**	**Multimedia-Systems**	Credits: 3(3-0-0) Total hours: 42
Course Objectives	The objective of the course is to learn hardware accelerators for various modules in embedded systems. The course covers basics of embedded multimedia, image processing systems and various algorithms for multimedia and image processing.	
Module 1	**Multimedia Application**	5 hours
An extensive overview of state-of-the-art techniques, traditional development flows and algorithms on multimedia, image and multimedia processing, audio processing and highlight their limitations in the light of performance, power, and memory requirements. Programmable and custom architectures and algorithms, advanced video memories hierarchies and specialized (multi-/many-core) hardware processor architectures and design methods (e.g., Pipelined MPSoCs, Stream Processors, and Stochastic Processors).		
Module 2	**Algorithms and Embedded systems**	17 hours
Review of various architecture types, design consideration, memory reuse mechanisms, sub-task scheduling, architecture evaluation, resource sharing; High performance architectures, wavelet VLSI architectures; DCT architectures; lossless coders, Advanced arithmetic architectures and design methodologies: division and square root; finite field arithmetic; cordic algorithms and architectures for fast and efficient vector-rotation implementation; advanced systolic design; low power design; power estimation approaches; system exploration for custom low power data storage and transfer; hardware description and synthesis of DSP systems.		
Module 3	**Architectures for multimedia CODEC module**	20 hours
Design and analysis of several light-weight multimedia and image processing algorithms and computation management techniques. Study of various architectures for motion estimation, Intra prediction, Integer discrete cosine transform, motion compensation , deblocking filter, entropy coder, system integration and Future generation hardware codecs.		

Reference Books

1. Richardson, Iain E, *The H.264 advanced video compression standard*, John Wiley & Sons, 2011.
2. Articles on IEEE Transactions on Circuits and Systems for Video Technology, Multimedia, VLSI Systems, consumer electronics etc.,.
3. Lee, Jae-Beom, and Hari Kalva. *The VC-1 and H. 264 video compression standards for broadband video services*. Vol. 32, Springer, 2008
4. Parhi, Keshab K., and Takao Nishitami, *Digital signal processing for multimedia systems*, CRC Press, 1999.
5. Parhi, Keshab K, *VLSI digital signal processing systems: design and implementation*, John Wiley & Sons, 2007.
6. Tian, Xiaohua, M. Le Thinh, and Yong Lian, *Entropy Coders of the H. 264/AVC Standard*, Springer, 2011.
7. Lin, Youn-Long Steve, et al. *VLSI Design for Video Coding*, Springer, 2010.
8. Ramachandran, and Seetharaman, *Digital VLSI systems design*, springer, 2007.

Subject Code **EC820**	**Selected Topics in ECE-I**	Credits: 1 Total hours: 14
Course Objectives	This course covers the current topics in the ECE and emphasis will be given to application space that has become particularly relevant in recent times.	
Syllabus can be framed according to the need.		

Subject Code **EC821**	**Selected Topics in ECE-II**	Credits: 2 Total hours: 28
Course Objectives	This course covers the current topics in the ECE and emphasis will be given to application space that has become particularly relevant in recent times.	
Syllabus can be framed according to the need.		

Subject Code **EC822**	**Selected Topics in ECE-III**	Credits: 3 (3-0-0) Total hours: 42
Course Objectives	This course covers the current topics in the ECE and emphasis will be given to application space that has become particularly relevant in recent times.	
Syllabus can be framed according to the need.		

Program Electives

Subject Code **EC850**	**Data Structures & Algorithms**	Credits: 3 (3-0-0) Total hours: 42
Course Objectives	Following this course, students will be able to: 1) Solve problems using data structures such as linear lists, stacks, queues, hash tables, binary trees, heaps, tournament trees, binary search trees, and graphs and writing programs for these solutions. 2) Solve problems using algorithm design methods such as the greedy method, divide and conquer, dynamic programming, backtracking, branch and bound and writing programs for these solutions.	
Module 1		4 hours
Introduction to data structures and objectives, basic concepts Arrays: one dimensional, multi-dimensional, Elementary Operations.		
Module 2		6 hours
Stacks: Representation, elementary operations and applications such as infix to postfix, postfix evaluation, parenthesis matching, Queues: Simple queue, circular queue, dequeue, elementary operations and applications.		
Module 3		8 hours
Linked lists: Linear, circular and doubly linked lists, elementary operations and applications such as polynomial manipulation.		
Module 4		8 hours
Trees: Binary tree representation, tree traversal, complete binary tree, heap, binary search tree, height balanced trees like AVL tree and 2-3 tree and other operations and applications of trees.		
Module 5		8 hours
Graphs: Representation, adjacency list, graph traversal, path matrix, spanning tree; introduction to algorithm analysis and design techniques, algorithms on sorting: selection sort, bubble sort, quick sort, merge sort, heap sort, searching, linear and binary search.		
Module 6	**(Miscellaneous Topics)**	10 hours
Hash tables, direct address tables, hash tables, hash functions, open addressing, search trees , binary search trees, red-black Trees, splay trees. B – Trees, binomial heaps, fibonacci heaps, data structures for disjoint sets. Suffix Trees-Tries-Text compression, text similarity testing-range trees, priority search trees, quad trees and k-d trees.		

Reference books

1. Alfred V Aho, John E Hopcroft, Jeffrey D. Ullman, *Data structures & algorithms*, Addison Wesley, 2003.
2. Ellis Horowitz, Sartaj Sahni and Dinesh Mehta, *Fundamentals of data structures and algorithms using C++*, Galgotia Publications, Second Edition, 2006.
3. Michael T. Goodrich, Roberto Tamassia, *Data Structures and algorithms in Java*, John Wiley & Sons, Inc., Fourth Edition, 2010.
4. Thomas H. Cormen, Charles E. Leiserson, Ronald L.Rivest, Clifford Stein, *Introduction to algorithms*, MIT Press, Second Edition, 2003.

Subject Code EC851	Advanced Computer Architecture	Credits: 3(3-0-0) Total hours: 42
Course Objectives	The objective of the course is to cover concepts related to parallel computer models, advanced processors, pipelining, multiprocessors, and memory hierarchy design for optimal performance of the system.	
Module 1	**Parallel Computer Models**	10 hours
Classification of parallel computers, multiprocessors and multicomputer, conditions of parallelism, data and resource dependencies, grain size and latency, grain packing and scheduling, program flow mechanisms, system interconnect architectures.		
Module 2	**Advanced Processors**	12 hours
Principles of scalable performance, performance metrics and measures, superscaler and vector processors, advanced processor technology, CISC scalar processors, RISC scalar processors, superscalar processors, VLIW architectures, vector and symbolic processors.		
Module 3	**Pipelining and Multiprocessors**	12 hours
Linear pipeline processor, nonlinear pipeline processor, instruction pipeline design, mechanisms for instruction pipelining, dynamic instruction scheduling, branch handling techniques, branch prediction, arithmetic pipeline design, multifunctional arithmetic pipelines, Multiprocessors and multi computers, multiprocessor system interconnects, cache coherence and synchronization mechanisms, message passing schemes.		
Module 4	**Memory Hierarchy Design**	8 hours
Cache basics & cache performance, reducing miss rate and miss penalty, multilevel cache hierarchies, main memory organizations, design of memory hierarchies.		

Reference Books:

1. K. Hwang, *Advanced Computer Architecture*, TMH, 2001.
2. W. Stallings, *Computer Organization and Architecture*, McMillan, 1990.
3. M. J. Quinn, *Designing Efficient Algorithms for Parallel Computer*, McGraw Hill, 1994.

Subject Code **EC852**	**Optimization Techniques**	Credits: 3 (3-0-0) Total hours: 42
Course Objectives	The objective of this course is to study convex optimization techniques, non-linear programming with unconstrained and constrained optimization problems, reliability theory and dynamic programming.	
Module 1	**Convex optimization techniques**	12 hours
Convex sets and functions, constrained optimization methods: Introduction, Kuhn-Tucker conditions, convex optimization, Lagrange multipliers.		
Module 2	**Non-linear programming**	8 hours
One-dimensional minimization method, search method, unconstrained and constrained optimization theory and practices.		
Module 3	**Reliability**	10 hours
Basic concepts, conditional failure rate function, Failure time distributions, Certain life models, Reliability of a system in terms of the reliability of its components, series system, and Parallel system.		
Module 4	**Dynamic Programming**	12hours
Multistage decision problems, computation procedure and case studies. Fundamentals of queuing system, Poisson process, the birth and death process, special queuing methods.		

Reference Books:

1. S. S. Rao, *Optimization: Theory and Practices,* New Age Int. (P) Ltd. Publishers, 2009.
2. E. K. P. Chong, and S. H. Zak, *An Introduction to Optimization*, John Wiley & Sons, 2013.
3. A. L. Peressimi, F. E. Sullivan, J. J. Uhl, *Mathematics of Non-linear Programming,* Springer Verlag, 1993.

Subject Code **EC853**	# Linear Algebra	Credits: 3 (3-0-0) Total hours: 42
Course Objectives	This course covers the fundamentals of linear algebra and matrices theory. It is intended as a broad course from engineering perspective. The first part covers the vector space, transformations and matrices theory and also provides the geometrical setting. The second part is intended to solve practical problems and provide algorithmic solutions.	
Module 1	**Vector Space**	5 hours
Vector Spaces, vector algebra, subspaces, basis vectors, Linear Transformations and Matrices, matrix rank, matrix norms, determinant, inverse, condition number;		
Module 2	**Characteristic Equation**	5 hours
Eigen values and vectors of matrices and eigenvalue decomposition; Hermitian and symmetric matrices, positive definite matrices, unitary matrices, projection matrices and other special matrices;		
Module 3	**Inner Product Space**	5 hours
Inner product spaces and vector norms, Gramm-Schmidt orthonormalization; bilinear forms;		
Module 4	**Solution of Equations**	5 hours
Solution of equations: Gaussian Elimination, pivoting, LU and Cholesky factorizations;		
Module 5	**Orthogonolization**	7 hours
Orthogonalization and Least Squares: Householder and Givens Matrices, QR factorizations, Full Rank Least Squares(LS) Problem, Rank Deficient LS Problem;		
Module 6	**Eigen Value Problem**	8 hours
Symmetric Eigenvalue Problem: power iterations, symmetric QR algorithm, Jacobi methods, tridiagonal methods, SVD, Lanczos and Arnoldi methods;		
Module 7	**Iterative Methods**	7 hours
Iterative Methods for Linear Systems: Jacobi and Gauss-Seidel iterations, SOR methods;		

Reference Books

1. Golub and Van Loan, *Matrix Computations*, Johns Hopkins University Press, Thrid Edition, 1996.
2. Strang, *Linear Algebra and its Application*, Cengage Learning, Fourth edition, 2005.
3. Horn and Johnson, *Matrix Analysis*, Cambridge University Press, 1990.
4. Hoffman and Kunze, *Linear Algebra*, Prentice Hall, Second Edition, 2009.

Subject Code **EC854**	**Random Processes**	Credits: 3(3-0-0) Total hours: 42
Course Objectives	This course covers the foundations and major concepts in random processes which are required for communications and signal processing concepts.	
Module 1	**Preliminaries**	8 hours
Axioms of Probability, Independence and Conditional Probability, Random Variables and their Distribution, Functions of Random Variables, Expectation, Frequently used Distributions, Jointly Distributed Random Variables, Cross Moments, Conditional Densities,		
Module 2	**Convergence of Sequence of Random Variables**	10 hours
Various types of Convergence, Cauchy Criteria for Convergence, Limit Theorems, Convex Functions and Jensen's Inequality, Chernoff Bound and Large Deviation Theory.		
Module 3	**Random Vectors and MMSE Estimation**	10 hours
Basic Definitions, The Orthogonality Principle of MMSE Estimation, Gaussian Random Vectors, Linear Innovations Sequences, Discrete Time Kalman Filtering		
Module 4	**Random Processes**	14 hours
Random Processes, Stationarity, Counting Processes and Poisson Process, Markov Process, Discrete Time Markov Chain, Continuous Time Markov Chain, Renewal Theory, Introduction to Martingales.		
Reference Books 1. Bruce Hajek, *An Exploration of Random Processes for Engineers*, Class Notes, 2014. 2. Sheldon Ross, *Stochastic Processes*, John Wiley and Sons, 1996. 3. Dimitri Bertsekas, John Tsitsiklis, *Introduction to Probability*, Athena Scientific, First Edition, 2002. 4. A Papoulis, S. U. Pillai, *Probability*, *Random Variables and Stochastic Processes*, Tata McGraw-Hill, Fourth Edition, 2002.		

Course Curriculum

for

Master of Technology Programme

in

Power Electronics and Power Systems

Department of Electrical and Electronics Engineering

National Institute of Technology Goa

Farmagudi, Ponda, Goa - 403 401

Semester-wise Credits Distribution

Semester	Total Credits
I	12+4+2=18 (4-Programme Core + 2-Labs+1-Seminar)
II	9+3+4+2=18 (3-Programme Core +1-Elective+ 2-Labs+1- Viva)
III	06+08 =14 (2-Electives + Major Project -I)
IV	14 (Major Project Work-II)
Total Credits	**64**

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	EE600	Power Electronic Converters & Drives	3-0-0	3
2	EE601	Machine Modeling & Analysis	3-0-0	3
3	EE602	Advanced Power system Analysis	3-0-0	3
4	EE603	Renewable Energy Systems	3-0-0	3
5	EE604	Power Electronics Laboratory	0-0-3	2
6	EE605	Simulation Laboratory	0-0-3	2
7	EE606	Seminar	0-0-3	2
		Total Credits		18

M.Tech II – Semester				
Sl. No	**Sub. Code**	**Subjects**	**L-T- P**	**Credits**
1	EE650	Advanced Electric Drives	3-0-0	3
2	EE651	HVDC & FACTS	3-0-0	3
5	EE652	Systems & Control Theory	3-0-0	3
3	EE8xx	Elective-I	3-0-0	3
4	EE653	DSP & FPGA Laboratory	0-0-3	2
5	EE654	Electric Drives Laboratory	0-0-3	2
6	EE655	Viva		2
7	HU650	Communication Skills and Technical Writing	1-0-2	0
		Total Credits		18

M.Tech III - Semester				
Sl. No	**Sub. Code**	**Subjects**	**L-T- P**	**Credits**
1	EE8xx	Elective – II	3-0-0	3
2	EE8xx	Elective – III	3-0-0	3
3	EE700	Major Project-I	0-0-12	08
		Total Credits		14

M.Tech IV- Semester				
Sl. No	**Sub. Code**	**Subjects**	**L-T- P**	**Credits**
1	EE750	Major Project-II	0-0-21	14
		Total Credits		14

List of Electives

Program Electives				
SI. No.	**Course Code**	**Course Name**	**Total Credit (L-T-P)**	**Credits**
		Elective-I		
1	EE 801	Modelling and Simulation of Power Electronic Systems	3(3-0-0)	3
2	EE 802	Advanced Power Electronics	3(3-0-0)	3
3	EE 803	Photovoltaic and its Applications	3(3-0-0)	3
		Elective-II		
1	EE 804	Power System Dynamics & Control	3(3-0-0)	3
2	EE805	Smart Electric Grid	3(3-0-0)	3
3	EE 806	Power Quality	3(3-0-0)	3
		Elective-III		
1	EE807	Soft Computing	3(3-0-0)	3
2	EE 808	DSP Controlled Drives	3(3-0-0)	3
3	EE 809	Digital Control Theory	3(3-0-0)	3
4	EE810	Optimal Control	3(3-0-0)	3

Course Contents

Subject Code EE600	Power Electronic Converters & Drives	Credits: 3 (3-0-0) Total hours: 45
Module 1		
Phase controlled converters: Single phase Half controlled and fully controlled converters, input power factor and harmonic factor, single phase dual converters, power factor Improvements. Three phase half controlled and fully controlled converters, evaluation of input power factor and harmonic factor and effect of input line inductance, power factor improvement, 12 pulse/18 pulse converter, dual converters, front end converter or synchronous link converters. Basic power electronic drive system and components, Different types of loads, shaft-load coupling systems. Stability of power electronic drive. Torque-speed characteristics of converter controlled separately excited dc motor in continuous and discontinuous mode of conduction.		
Module 2		
DC-DC converters: Study of Class - A, B, C, and D choppers, non-isolated and isolated DC-DC converters. Separately excited DC motor drive using DC-DC converters, four quadrant operation, dynamic and regenerative braking.		
Module 3		
Inverters: single phase inverters, three phase inverters, pulse width modulation techniques, multi-level inverters.		
Module 4		
Induction to motor drives: Equivalent circuit, speed control, slip power recovery schemes. Synchronous motor drives: Operation with fixed frequency and variable frequency source. Closed-loop control of drives: D.C drives, A.C. Drives.		
Reference books	1. M.H. Rashid: Power Electronics-circuits, Devices and Applications, 3rd Edition, PHI, 2005. 2. Ned Mohan, T.M. Undeland and William P. Robbins: Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009 3. S.B. Dewan, Gordon R. Slemon and A. Straughen: Power Semiconductor Drives, John Wiley Pub.,1996. 4. B.K. Bose: Modern Power Electronics and AC Drives, 1st Edition, Pearson, 2002. 5. Philip T. Krein: Elements of Power Electronics, Oxford University Press. 6. John G. Kassakian, Martin F. Schlect, Geroge C. Verghese: Principles of Power Electronics , Pearson Education. 7. R. Krishnan: Electronic motor drives modeling Analysis and control I Edition Prentice Hall India.	

Subject Code EE601	Machine Modelling & Analysis	Credits: 3 (3-0-0) Total hours: 45

Module 1

Basic principles of electric machine analysis: Magnetically coupled circuits, Electro-magnetic (EM) energy conversion,Single and double excited systems. Machine windings and air-gap MMF, Winding inductances and voltage equations, Production of electromagnetic torque.

Module 2

Reference frame theory: Equations of transformation, transformation between reference frames, variables observed from various frames. Theory of symmetrical induction machines: Voltage and torque expression, state-space model of Induction motor in'd-q-0' variables. Computer simulation of arbitrary reference frame.

Module 3

Theory of synchronous machines: Voltage and torque equations, equations in arbitrary reference frame.Concept of sub-transients, transient armature inductances and field time constant, Operation of synchronous machine under asynchronous running, Hunting and small oscillations, Synchronizing and damping torques, equal area criteria, computer simulation.

Module 4

Field aspects of electrical machines: Vector potential, Classical two-dimensional analysis of air gap field. Field analysis and performance calculation in linear Induction motor and linear synchronous motor. Finite element method of calculation, vector potentials in machines and actual boundaries, magnetic saturation.

Reference books

1. P. C. Krause, O. Wasynczuk and S.D. Sudhoff: Analysis of Electric Machinery and Drive Systems, 2nd Edition, IEEE Press, 2002.
2. J. Meisel: Principles of Electromechanical Energy Conversion, R.E. Krieger, 1984.
3. N. Bianchi: Electrical Machine Analysis using Finite Elements, CRC Press, 2005
4. P.S. Bhimbra: Generalized Theory of Electrical Machines, Khanna Publishers, 2006.

Subject Code EE602	**Advanced Power System Analysis**	Credits: 3 (3-0-0) Total hours: 45

Module 1

Network Modelling: Formation of network matrices, Singular and non-singular Transformation. Algorithms for formation of bus admittance and bus impedance matrices with mutually coupled branches, Sparsity Technique and optimal ordering.

Module 2

Load flow: Load flow-Newton Raphson method, Decoupled ,Fast decoupled Load flow, Sensitivity factors,Multi area power flow analysis, ATC assessment, DC power flow model.

Module 3

Fault and Contigency Analysis: Balanced and unbalanced faults, Digital simulation techniques in fault analysis,Z Bus method in contingency analysis, Contingency Analysis of DC Model, System Reduction for Contingency and Fault Studies.

Module 4

Security and State Estimation:Security assessment, State Estimation in Power Systems, Maximum Likelihood Weighted Least-Squares Estimation, State Estimation of an AC Network, Detection and Identification of Bad measurements, Network Observability and Pseudo-measurements.

Reference books

1. Stagg.G.W , El. Abiad.A.H: Computer Methods in Power System Analysis, McGra w Hill.
2. Kundur.P: Power System Stability and Control, McGraw Hill
3. Wood.A.J and Wollenberg.B.F: Power Generation Operation and Control, John Wiley and sons, New York.
4. D. P. Kothari and I. J. Nagrath: Modern Power System Analysis, Tata McGraw Hill Publishing Co. Ltd.
5. J. Arrilaga, C. P. Arnold, B. J. Harker: Computer Modelling of Electric Power System, John Wiley & Sons.
6. K.Mahailnaos, D. P. Kothari, S. I. Ahson: Computer Aided Power System Analysis & Control, Tata McGraw Hill Publishing Co. Ltd.
7. G. T. Heydt: Computer Analysis Methods for Power Systems, Macmillan Publishing Company, NewYork.
8. L. P. Singh: Advanced Power System Analysis and Dynamics, New Age International Publishers, New Delhi.

Subject Code EE 603	**Renewable Energy Systems**	Credits: 3 (3-0-0) Total hours: 45
Module 1		
Non-renewable reserves and resources; renewable resources, Transformation of Energy. Distributed Generation, renewable energy economics. Solar Power: Solar processes and spectral composition of solar radiation; Radiation flux at the Earth's surface. Solar collectors. Types and performance characteristics. Photo-Voltaic power plants: Solar energy, generation of electricity PV cell characteristic, Stand alone system with DC and AC loads with and without battery storage, Grid connected PV systems, Maximum Power Point Tracking Fuel cells: Fuel cells, commercial and manufacturing issues, equivalent circuit, Applications.		
Module 2		
Wind Energy: Wind energy conversion, efficiency limit for wind energy conversion, types of converters, aerodynamics of wind rotors, power- speed and torque - speed characteristics of wind turbines, wind turbine control systems. conversion to electrical power: induction and synchronous generators, grid connected and self-excited induction generator operation, constant voltage and constant frequency generation with power electronic control, single and double output systems, reactive power compensation, characteristics of wind power plant, applications.		
Module 3		
Tidal Energy: Wave characteristics. Conversion systems and their performance features. Application. Geothermal energy: Biological conversion of Energy.		
Module 4		
Induction generators: operating principle, self-excited induction generator, speed and voltage control, performance analysis, semi variable speed induction generator, variable speed induction generators with full and partial rated power converter topologies, isolated systems, self excited induction generator		
Module 5		
Energy Storage systems: Parameters, lead-acid batteries, ultra-capacitors, flywheels, superconducting magnetic storage system, pumped hydroelectric energy storage, compressed air energy storage.		
Reference books	1. S. N. Bhadra, D. Kastha, S. Banerjee: Wind Electrical Systems, Oxford Univ. Press, 2005. 2. S.A. Abbasi, N. Abbasi: Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India,2004. 3. Felix A. Farret and M. Godoy Simões: Integration of Alternative Sources of Energy, John Wiley & Sons,2006. 4. R. Teodorescu, M. Liserre and Pedro Rodríguez: Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons, 2011.	

<table>
<tr><td>Subject Code
EE604</td><td>Power Electronics Laboratory</td><td>Credits: 2 (0-0-3)
Total hours: 45</td></tr>
<tr><td colspan="3">1) Single phase Half and Full controlled Converter with R-L and R-L-E loads.
2) Three-phase Half and Full controlled Converter with R-L and R-L-E loads.
3) Single phase AC voltage controller feeding R and R-L loads.
4) Characteristics of Power Semiconductor devices (SCR, Triac etc.).
5) DC-to-DC Switched Mode Converters.
6) 1- Φ & 3- Φ Inverter with square wave, quasi-square wave and SPWM Control</td></tr>
<tr><td>Reference books</td><td colspan="2">1. M.H. Rashid: Power Electronics-circuits, Devices and Applications, 3rd Edition, PHI, 2005.
2. Ned Mohan, T.M. Undeland and William P. Robbins: Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009.</td></tr>
</table>

<table>
<tr><td>Subject Code
EE605</td><td>Power Electronics Simulation Laboratory</td><td>Credits: 2 (0-0-3)
Total hours: 45</td></tr>
<tr><td colspan="3">Modelling of DC-DC converters
Study of different PWM techniques
Study on the 'dq0' transformation in various frames of reference
Modelling of DC motor, Induction motor and synchronous motor drives</td></tr>
<tr><td>Reference books</td><td colspan="2">1. M.H. Rashid : Power Electronics-circuits, Devices and Applications, 3rd Edition, PHI, 2005.
2. Ned Mohan, T.M. Undeland and William P.Robbins: Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009.</td></tr>
</table>

Subject Code EE650	**Advanced Electric Drives**	Credits: 3 (3-0-0) Total hours: 45
Module 1		
Basic power electronic drive system and components, Different types of loads, shaft-load coupling systems. Stability of power electronic drive. Scalar and Vector control of Induction motor, Direct torque and flux control of Induction motor.		
Module 2		
Self-controlled synchronous motor drive, Vector control of synchronous motor drive.		
Module 3		
Switched reluctance motor drive, Brushless DC motor drive, Permanent magnet drives and Industrial drives.		
Reference books	1. B.K. Bose: Modern Power Electronics and AC Drives, 1st Edition, Pearson, 2002. 2. Bin-Wu: High-power Converters and AC Drives, IEEE Press, John Wiley & Sons, 2006 3. R. Krishnan: Electric Motor drives - Modelling, Analysis and Control, PHI India Ltd., 2002.	

Subject Code EE 651	HVDC and FACTS	Credits:3 (3-0-0) Total hours: 45
Module 1		
Historical development of HVAC and HVDC links, comparison, economics of power transmission, technical performance, reliability, limitations, application of dc transmission, description of DC Transmission System, types of DC links and converter station, planning for HVDC transmission. Modern trends in DC transmission.		
Module 2		
HVDC transmission analysis of HVDC converters, pulse number, analysis with and without overlap, converter bridge characteristics, converter and HVDC system control, principles of dc link control- starting and stopping of dc link, power control . Introduction to harmonics & filters, generation of harmonics, types of ac filters.		
Module 3		
Power flow in AC Systems. Definition of FACTS, power flow control, constraints of maximum transmission line loading. Benefits of FACTS transmission line compensation: uncompensated line, shunt compensation. Series compensation, phase angle control.		
Module 4		
Static shunt compensators: SVC and STATCOM. Operation and control of TSC, TSR, TCR and STATCOM, compensator control, comparisons between SVC and STATCOM. Static series compensation: TSSC, SSSC, TCBR, TCPAR. Operation and control applications		
Module 5		
Unified Power Flow Controller: circuit arrangement, operation and control of UPFC, basic principle of P and Q control, independent real and reactive power flow control, applications, introduction to interline power flow controller.		
Reference books	1. K. R. Padiyar: HVDC Power transmission System, New age International, 1996. 2. N.G Hingorani, L. Gyugyi: Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001. 3. J. Arrillaga: HVDC transmission, IET, 1998. 4. E.X. Kimbark: Direct Current Transmission, Vol. I, Wiley Interscience, Newyork, 1971. 5. K. R. Padiyar: Power System Dynamics, Stability and Control, 2nd Edition, B.S. Publishers. 1994. 6. X.P. Zang, C. Rehtanz and B. Pal: Flexible AC Transmission Systems: Modeling and Control, Birkhauser,2006. 7. Y. H. Song and A. T. Johns: Flexible AC Transmission Systems, IET, 1999.	

Subject Code EE652	**Systems and Control Theory**	Credits: 3 (3-0-0) Total hours: 45
Module 1		
Review of matrices, vector space, group, rings, and fields.		
Module 2		
State Space Description: State space representations of systems, state variable modelling of dynamical systems, transfer functions, solution of state equation, transient response, stability of linear systems, Lyapunov methods.		
Module 3		
System Analysis: controllability, observability, duality, equivalent systems, system decomposition, diagonal form, controllable and observable canonical forms, state space realizations and minimal realizations.		
Module 4		
State Feedback Design: Linear State variable feedback, pole placement for single and multivariable systems, optimal control concept, solution of linear quadratic regulator problem, system decoupling, direct transfer function design procedures.		
Module 5		
State Estimation and Servo Control: State observer, reduced order observers, combined observer-controller system, integral control, asymptotic tracking and regulation, robust servo control design.		
Module 6		
Nonlinear system Dynamics & Control: Analysis of Modelling equations: state-plane Analysis, Principles of linearization, Describing function methods, Introduction to Nonlinear Control Techniques: Sliding mode control, feedback linearization methods.		
Reference books	1.S.H. Zak: Systems and Control, Oxford Univ. Press, 2003. 2. H.K. Khalil: Nonlinear Systems, Prentice Hall, N.J., 2002. 3. R. C. Dorf and R. H. Bishop: Modern Control Systems, Prentice Hall, 2001. 4. K. Ogata: Modern Control Engineering, Pearson, 2006.	

Subject Code EE653	DSP & FPGA Laboratory	Credits: 2 (0-0-3) Total hours: 45

CCS introduction, aliasing, quantization

Saw tooth wave generation

Single pulse , multiple pulse, sin-triangle and space vector modulation PWM generation

Digital filter design

FPGA based motor control applications

Reference books	1. Hamid A. Toliyat: DSP Based Electromechanical Motion Control, 1st Edition, CRC Press, 2004. 2. Bin-Wu: High-power Converters and AC Drives, IEEE Press, John Wiley & Sons, 2006 3. Wolf: FPGA based system design, Dorling kindersley, 2004.

Subject Code EE654	Electric Drives Laboratory	Credits: 2 (0-0-3) Total hours: 45

Thyristorised drive for 1hp DC motor with closed loop control

Single phase & three phase half control and fully controlled bridge rectifier fed separately excited DC motor drive

Four quadrant chopper drive for separately excited DC motor drive

Speed control of 3 phase wound rotor Induction motor

Implementation of single pulse, multiple pulse, sine-triangle and space vector modulation PWM schemes with DSP controller.

Reference books	1. M.H. Rashid : Power Electronics-circuits, Devices and Applications, 3rd Edition, PHI, 2005. 2. Ned Mohan, T.M. Undeland and William P.Robbins: Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009.

Subject Code HU650*(Audit Course)	**Communication Skills and Technical Writing**	Credits: 0 (1-0-2) Total hours: 15 Hrs
Module 1		12 hours
Communication-Definition-Types-Classifications, Presentation Skills-Do's and Don'ts, Reports-Types-Format-Ethics to be followed.		
Module 2		12 hours
Writing Skills: Technical Document-Reports-Instruction Manuals-Project Proposal		
Module 3		10 hours
Writing Exercises: Precis-Summary/Executive Summary/Abstract		
Module 4		8 hours
Preparation of Report- Prefatory Part- Main Part- Terminal Section		

Reference Books:

5. Raman & Sharma, *Communication Skills*, New Delhi: OUP, 2011.
6. Mandel, Steve, *Technical Presentation Skills: A Practical Guide for Better Speaking* (Revised Edition), Crisp Learning, 2000.
7. Wood, Millett, *The Art of Speaking*, New York: Drake Publishers, 1971.
8. Lencioni, Patrick, *The Five Dysfunctions of a Team*: NJ, John Wiley and Sons, 2006.

Electives

Subject Code EE801	Modeling and Simulation of Power Electronic Systems	Credits: 3 (3-0-0) Total hours: 45
Module 1		
Introduction to ODE solvers, steps of using ODE solvers, Types of mathematical models, Developing a model, Mathematical modeling of simple electrical, Mechanical and electro mechanical systems.		
Module 2		
Simulation of power electronic converters: State-space representation, Trapezoidal integration, M and N method.		
Module 3		
Modeling: steady state analysis of converters, dynamic analysis of converters, state space average modeling, PWM modeling ,modeling of converters operating in continuous and discontinuous conduction mode, converter transfer functions. Simulation of electric drives: Modeling of different PWM Techniques, Modeling and simulation of Induction motor, V/f Control of Induction motor and Vector controlled 3-Ph Induction motor.		
Module 4		
Control Techniques in Power Electronics: State space modelling and simulation of linear systems, conventional controllers using small signal models, Fuzzy control, Hysteresis controllers, Output and state feedback switching controllers. Modeling, simulation of switching converters with state space averaging, State Space Averaging Technique and its application in simulation and design of power converters.		
Reference books	1. M. B. Patil, V. Ramnarayanan and V. T. Ranganathan: Simulation of Power Electronic Converters, 1st Edition, Narosa Publishers, 2010. 2. Ned Mohan, T.M. Undeland and William P.Robbins: Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009. 3. Chee-Mun Ong: Dynamic Simulation of Electric Machinery: Using Matlab/Simulink	

Subject Code EE802	Advanced Power Electronics	Credits: 3 (3-0-0) Total hours: 45

Module 1

Non-isolated dc-dc converters: Buck, boost, buck-boost, Cuk, SEPIC, Zeta in DCM and CCM, solated dc-dc converters: Flyback, forward, Cuk, half bridge, push-pull and bridge in DCM and CCM. Single-phase, single-stage converters (SSSSC), power factor correction. Their application in SMPS, UPS, welding and lighting systems.

Module 2

Single-phase improved power quality ac-dc converters: Buck, boost, buck-boost, PWM VSC (Voltage source converters), multilevel VSCs, PWM CSC (Current voltage source converters).

Module 3

Three-phase improved power quality ac-dc converters: VSC , multilevel VSCs, multipulse VSCs, PWM CSC (Current voltage source converters). Multipulse ac-dc converters: Diode and thyristor based converters, power factor correction.

Module 4

Solid state controllers for motor drives: Vector control and direct torque control of induction, synchronous, permanent magnet sine fed, synchronous reluctance motors, Permanent magnet brushless dc (PMLDC) and switched reluctance motors, LCI (load commutated inverter) fed large rating synchronous motor drives, Energy conservation and power quality improvements in these drives.

Reference books

1. M.H. Rashid : Power Electronics-circuits, Devices and Applications, 3rd Edition, PHI, 2005.
2. Ned Mohan, T.M. Undeland and William P. Robbins: Power Electronics Converters, Applications, 3rd Edition, John Wiley & Sons, 2009.
3. Marian K. Kazimierczuk: Pulse-width Modulated DC-DC Power Converters, John Wiley & Sons Ltd., 1st Edition, 2008.
4. Robert W. Erickson and DraganMaksimovic: Fundamentals of Power Electronics, Springer, 2nd Edition,2001

Subject Code EE 803	Photovoltaic and its applications	Credits: 3 (3-0-0) Total hours: 45

Module 1	
Solar energy: solar insolation vs world energy demand, current energy consumption from different sources, environmental and health effects.Sustainable Energy: production and storage, resources and utilization.	
Module 2	
Photovoltaic (PV): Fundamentals of solar cells, types of solar cells, semiconducting materials, band gap theory, absorption of photons, excitation and photoemission of electrons, band engineering, Solar cell properties and design, p-n junction photodiodes, depletion region, electrostatic field across the depletion layer, electron and holes transports, device physics, charge carrier generation, recombination and other losses, I-V characteristics, output power, single junction and triple-junction solar panels, metal-semiconductor hetero junctions and semiconducting materials for solar cells. solar cell applications: pv cell interconnection, module structure and module fabrication, equivalent circuits, load matching, efficiency, fill factor and optimization for maximum power; design of stand-alone PV systems, system sizing, device structures, device construction, installation, measurements, DC to AC conversion, inverters, on-site storage and grid connections.	
Module 3	
Optical engineering: Optical design, anti-reflection coatings, beam splitters, surface structures for maximum light absorption, operating temperature Vs. conversion efficiency, types of solar energy concentrators, fresnel lenses and fresnel reflectors, operating solar cells at high incident energy for maximum power output. Cost analysis and environmental issues: Cost analysis and pay back calculations for different types of solar panels and collectors, installation and operating costs; environmental and safety issues, protection systems, performance monitoring.	
Module 4	
Thin film solar cells: Single crystal, polycrystalline and amorphous silicon solar cells, cadmium telluride thin-film solar cells, conversion efficiency; current trends in photovoltaic research and applications, nanotechnology applications, quantum dots, solution based processes solar cell production. Photo electrochemical cells for hydrogen production: photo electrochemical electrolysis, photoelectron chemical cells for hydrogen production, solar hydrogen efficiency, hydrogen storage, hydrogen economy.	

Reference books	1. Jenny Nelson: The Physics of Solar Cells, Imperial College Press, 2003 2. Stephen J. Fonash: Solar Cell Device Physics, 2nd edition ,Academic Press 3. Soteris A. Kalogirou**:** Solar Energy Engineering: Processes and Systems, Academic Press, 2009 4. F Lasnier: Photovoltaic Engineering Handbook CRC Press

Subject Code EE804	# Power System Dynamics and Control	**Credits: 3 (3-0-0)** **Total hours: 45**

Module 1

Modelling: Synchronous machine theory and modelling:- armature and field structure, Parks transformation, machine with multiple pole pairs-mathematical description, d-q transformation, per unit representation, equivalent circuit for d-q axes, steady state analysis- voltage-current and flux linkage, phasor representation, rotor angle – steady state equivalent circuit, Excitation system modelling-excitation systems block diagram - system representation by state equations- State space representation concept, Eigen properties of the state vectors.

Module 2

Stability Analysis: Small signal stability analysis -small signal stability of a single machine connected to infinite bus system, classical representation of generator, small signal stability of a multi machine connected to infinite bus system. Characteristics of small - signal stability problems.

Transient stability- Concept of transient stability, response to a step change in mechanical power input, Swing equation, multi-machine analysis, factors influencing transient stability, numerical integration method , Euler method, R-K method (4rth order), critical clearing time and angle,methods for improving transient stability.

Voltage stability:- Basic concept, transmission system characteristics, generator characteristics, load characteristics, PV curve, QV curve and PQ curve, characteristics of reactive power compensating devices. Voltage collapse and prevention of voltage collapse.

Module 3

Power System Stabilizer: Block diagram of PSS, system state matrix including PSS, analysis of stability, small-signal stability improvement methods: delta-omega and delta P-omega stabilizers. Frequency-based stabilizers, Digital Stabilizer, Excitation control design Exciter gain, Phase lead compensation, Stabilizing signal washout stabilizer gain, Stabilizer limits

Reference books

1. Kundur: Power System Stability and Control, McGraw-Hill
2. Anderson.P.M and Fouad: Power System Control and Stability", IEEE Press Power Engineering Series
3. K R Padiyar: Power system Dynamics Stability and Control, B S Publication.
4. Peter W. Sauer and M APai: Power system Dynamics Stability, Pearson Education Asia.
5. Nasser Tleies: Power Systems Modelling and Fault Analysis, Elsevier, 2008.

<table>
<tr><td>Subject Code
EE805</td><td colspan="2">Smart Electric Grid</td><td>Credits: 3 (3-0-0)
Total hours: 45</td></tr>
<tr><td colspan="4">Module 1</td></tr>
<tr><td colspan="4">Introduction to Smart Grid-Smart Grid Functions - Advantages - Indian Smart Grid - Key Challenges for Smart Grid</td></tr>
<tr><td colspan="4">Module 2</td></tr>
<tr><td colspan="4">Smart Grid Architecture -Components and Architecture of Smart Grid Design - Transmission and Distribution Automation - Computational Intelligence Techniques - Distribution Generation Technologies.</td></tr>
<tr><td colspan="4">Module 3</td></tr>
<tr><td colspan="4">Introduction to Renewable Energy Technologies - Micro grids - Storage Technologies - Electric Vehicles andplug - in hybrids - Environmental - Synchro Phasor Measurement Units (PMUs) - Wide Area MeasurementSystems (WAMS) - Control of Smart Power Grid System</td></tr>
<tr><td colspan="4">Module 4</td></tr>
<tr><td colspan="4">Introduction to Factory & Process Automation, PLC, Networking standards. Vertical Integration of Industrial Automation, field bus and Ethernet.Supervisory Control and Data Acquisition (SCADA), introduction to SCADA: grid operation and Control.Distributed Control Systems (DCS), difference between SCADA system and DCS, architecture, local control unit, Programming language, communication facilities, operator interface, engineering interfaces.</td></tr>
<tr><td>Reference books</td><td colspan="3">1. Stuart Borlase: Smart Grids: Infrastructure, Technology, and Solutions, Series: Electric Power and Energy Engineering Published: October 24, 2012 by CRC Press
2. Gil Masters: Renewable and Efficient Electric Power System , Wiley-IEEE Press, 2004.
3. A.G. Phadke and J.S. Thorp: Synchronized Phasor Measurements and their Applications, Springer, 2008.
4. T. Ackermann: Wind Power in Power Systems, 2nd Edition, John Wiley & Sons, 2012
5. Michael P. Lukas: Distributed Control Systems, Van NostrandReinfold Company, 1995.</td></tr>
</table>

Subject Code EE806	Power Quality	Credits: 3 (3-0-0) Total hours: 45
Module 1		
Introduction to power quality: terms and definitions: overloading, under voltage, over voltage. Concepts of transients: short duration variations such as interruption, long duration variation such as sustained interruption. Voltage sag, voltage swell, voltage imbalance, voltage fluctuation, over voltages, under voltages, power frequency variations. Harmonics: harmonic sources from commercial and industrial loads, locating harmonic sources. Power system response characteristics: harmonics Vs transients. Effect of harmonics, harmonic distortion, voltage and current distortion, harmonic indices, inter harmonics, resonance. Harmonic distortion evaluation, devices for controlling harmonic distortion, passive and active filters. IEEE and IEC standards of power quality.		
Module 2		
Introduction to APF technology, solutions for mitigation of harmonics, classification of power filters- passive filters, active filters, hybrid filters; active filters applications depending on power quality issues; selection of power filters; categorization of active power filter: converter based categorization, topology based categorization, supply system based categorization, selection considerations of APFS; technical and economic considerations.		
Module 3		
Introduction to active power filter control strategies: shunt active filter basic compensation principle, Clark's transformations, parks transformations, active power filter control strategies, signal conditioning, current control techniques for derivation of gating signals, generation of gating signals to the devices of the APF, hysteresis current control scheme and adaptive hysteresis current control scheme, derivation of compensating signals, compensation in frequency domain, compensation in time domain.		
Module 4		
Control strategies: Instantaneous active and reactive power (p-q) control strategy, Instantaneous active and reactive current (I_d-I_q) control strategy and perfect harmonic cancellator. Introduction to Dc link voltage regulation: DC link voltage regulation with PI Controller, Type-1 fuzzy logic controller, Type-2 fuzzy logic controller, and neural networks.		
Reference books	1) H. Akagi: Instantaneous Power Theory and Applications to Power Conditioning, IEEE Press, 2007. 2) G.T. Heydt: Electric Power Quality, 2nd Edition, West Lafayette, IN, Stars in a Circle Publications, 1994. 3) M.H.J Bollen: Understanding Power Quality Problems: Voltage Sags and Interruptions, NewYork, IEEE Press, 1999.	

Subject Code EE 807	**Soft Computing**	Credits: 3 (3-0-0) Total hours: 45

Module 1

Introduction to biological and artificial neuron models, operations of artificial neuron, types of neuron activation function, history of artificial neural systems development, Mc-culloch-Pitts neuron model, ANN architectures, neural dynamics (activation and synaptic), neural processing, learning strategies, learning rules.

Module 2

Classification model, features, and decision regions, discriminant functions, models of Artificial Neural Networks: feed forward network, feedback network, single and multilayer feed forward neural networks- introduction, perceptron models: discrete, continuous and multi-category, training algorithms: discrete and continuous perceptron networks, perceptron convergence theorem, limitations of the single layer perceptron model (XOR Problem), Applications; credit assignment problem, generalized delta rule, Back Propagation Algorithm (BPA), learning difficulties and improvements.

Module 3

Associative memories: Hebbian learning, general concepts of associative memory (associative matrix, association rules, hamming distance, Bidirectional Associative Memory (BAM) architecture, architecture of Hopfield network: discrete and continuous versions, storage and recall algorithm. Neural network applications: process identification, control, fault diagnosis and load forecasting.

Module 4

Introduction to classical sets - properties, operations and relations; fuzzy sets, membership, uncertainty, operations, properties, fuzzy relations, cardinalities, membership functions. Fuzzification, membership value assignment, development of rule base and decision making system, fuzzy inference systems: Mamdani max-min and max-product composition scheme, defuzzification to crisp sets, defuzzification methods: COA, BOA, MOM, SOM, and LOM. Design of control rules: trapezoidal MF, triangular MF and Gaussian MF. Rule base fuzzy logic applications: fuzzy logic control and fuzzy classification. Applications of fuzzy systems.

Module 5

Evolutionary Computation: Different variants, Genetic Algorithm. ; Hybrid Systems: ANFIS, Fuzzy Filtered NN & Neural Fuzzy Systems, GA tuned Fuzzy System. Introduction to Type-2 FLC: The structure of Type-2 FLC, Type-2 fuzzy inference system with different fuzzy MFs (Trapezoidal membership function, Triangular membership function and Gaussian MF).

1. J. M. Zurada: Introduction to artificial neural networks, Jaico publishers, 1997.
2. Simon Haykin: Neural Networks A Comprehensive Foundation, Prentice Hall

Reference books	3. J. S. R. Jang, C. T. Sun , E. Mizutani: Neuro-Fuzzy and Soft Computing A Computational Approach to Learning and Machine Intelligence, PHI, 2002. 4. Timothy J Ross: Fuzzy Logic with Engineering Applications, TMH, 2007. 5. B.Kosko: Fuzzy Engineering, Prentice Hall, 1997

Subject Code EE808	**DSP Controlled Drives**	**Credits: 3 (3-0-0) Total hours: 45**
Module 1		
Overview of TMSLF2407 or Advanced DSP controllers: Instruction Set, Interrupts,ADC, Event managers.		
Module 2		
Implementation of PWM schemes: Single pulse , Multiple pulse , Sine triangle PWM, Space vector PWM.		
Module 3		
Clarke's and park's transformations: Implementation of Clarke's and Park's transformation,		
Module 4		
DSP-Based Control of Stepper Motors, BLDC Motors, synchronous motors, Induction Motor		
Reference books	1. Hamid A. Toliyat: DSP Based Electromechanical Motion Control, 1st Edition, CRC Press, 2004. 2. Bin-Wu: High-power Converters and AC Drives, IEEE Press, John Wiley & Sons, 2006 3. R. Krishnan: Electric Motor drives - Modelling, Analysis and Control, PHI India	

<table>
<tr><td>Subject Code
EE809</td><td>Digital Control Theory</td><td>Credits: 3 (3-0-0)
Total hours: 45</td></tr>
<tr><td colspan="3">Module 1</td></tr>
<tr><td colspan="3">Introduction to Digital Control Systems: Continuous-time Vs Discrete-time Systems, Digital Control Vs Digital Signal Processing (DSP),Signal Discretization, Continuous-time System Analysis, Discrete-time System Analysis, Continuous-time Controller Design, Controller Design for Discrete-time Systems, Controller Implementation.</td></tr>
<tr><td colspan="3">Module 2</td></tr>
<tr><td colspan="3">State Variables Approach to Discrete time Systems: Definition of the State Vector, The MIMO Transfer Function Matrix G(z), State Transformations, Observability and Controllability, Solution of State Equations.</td></tr>
<tr><td colspan="3">Module 3</td></tr>
<tr><td colspan="3">Direct Design of Digital Control Systems Using Transform Techniques: Z-plane Specification of Control System, Design by Discrete Equivalent, Root Locus Design in the z-plane.</td></tr>
<tr><td colspan="3">Module 4</td></tr>
<tr><td colspan="3">Design of Digital Control Systems: A State Space Approach, Control Law Design, State Feedback, Estimator Design, Regulator Design.</td></tr>
<tr><td colspan="3">Module 5</td></tr>
<tr><td colspan="3">The Effect of Quantization, Analysis of Finite Precision Errors, Limit Cycles, Optimal control, Parameter estimation, Adaptive control.</td></tr>
<tr><td>Reference books</td><td colspan="2">1. K. Zhou, J. Doyle, and K. Glover: Robust and Optimal Control, Prentice-Hall, 1996.
2. K. Zhou andJ. C. Doyle: Essentials of Robust Control, Prentice Hall, 1996</td></tr>
</table>

Subject Code EE810	**Optimal Control**	**Credits: 3 (3-0-0) Total hours: 45**
Module 1		
Calculus of Variations: problems of Lagrange, Mayer and Bolza, Euler-Language equation and transversality conditions, Lagrange multiplier technique		
Module 2		
Dynamic programming, Numerical solution techniques, Static and dynamic optimization, Parameter optimization		
Module 3		
Pontryagin's principle: theory, application to minimum time, control problems, and terminal control problem		
Module 4		
Dynamic programming: Belaman's principle of optimality, multistage decision processes		
Module 5		
Linear regulator problem: matrix Riccati equation and its solution, Tracking problem, Computational methods in optimal control, Application of mathematical programming, singular perturbations		
Reference books	1. M. Athans and P.L. Falb: Optimal Control, McGraw Hill, 2007 2. S.P. Sethi and G.L. Thompson: Optimal Control Theory, 2nd edition, Kluwer Academic Publishers, 2000 3. D.P. Bertsekas: Dynamic Programming and Optimal Control, Volume I, 3rd edition, Athena Scientific, 2005 4. M. Green, D.E. Johnson and D.J. N. Limebeer: Linear Robust Control, Prentice Hall, Digitized Dec 2007	

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