Academic Requirements for the M Tech (ICT) Program

(Effective from 2019-20 batch)

Master of Technology (Information and Communication Technology): M Tech (ICT) duration- 2 years (Four semesters) full-time postgraduate program of DA-IICT will be governed by these rules, subject to amendments, from time to time, as per the needs and requirements. These rules deal only with the post-admission academic activities of this program. Eligibility for admission, admission procedures etc. for this program are outside the purview of this document.

The Dean (Academic Programs)/Registrar may, from time to time, issue such instructions or directions as may be necessary to give effect to and carry out the provisions of these rules. Director, as chairman of the Academic Council, may relax/exempt some provision(s) of the rules in exceptional situations and all such cases shall be reported to the Academic Council in the immediate next meeting.

Important terms/expressions used in the document have been defined in the GLOSSARY at the end of this document.

1. REGISTRATION

1.1 Categories of Registration:

a) A student may register in a given semester in two possible categories: resident registration and external registration. Only resident registration will count towards the residence requirement for a degree. A foreign student on student visa will not be allowed to register as an external student.

b) To qualify for resident registration, the student must register for a duly approved course programme and pay the prescribed tuition and other fees, including any outstanding dues.

c) To qualify for external registration, a student must register for a duly approved research programme, and pay the prescribed registration fees, with the provision that the Dean (Academic Programs) in consultation with Postgraduate Committee (PGC) may permit/require registration for coursework also. However, this qualification is subject to the proviso that a regular M Tech student may not avail of external registration for the purpose of obtaining an 'S' grade for thesis work, as detailed in Section 2.3 (e).

1.2 New entrants to the postgraduate programs, who are awaiting the results of the qualifying examination may be allowed "provisional" registration. Latest by the date given in the academic calendar (usually about 8 weeks from the date of registration) such candidates will be required to submit, for verification, the certificates of having passed the qualifying examination. Original certificates will be returned to the students and a copy will be kept for records.

1.3 Late Registration:

a) If for any compelling reason like illness, a student is unable to register on the day of registration, he/she will be allowed to register during the late registration period as specified in the academic calendar (which is about one week from the date of registration). Any student registering late will be required to pay the specified late registration fee.

b) In exceptional cases, the Dean (Academic Programs) on the recommendation of the ~~Postgraduate Committee~~ PGC may consider registration beyond the date of late registration. In such a case, the student will be allowed to register for thesis credits only.

1.4 Academic Advising:

a) A student will be advised in the selection of courses by the faculty adviser appointed by Dean (Academic Programs) in consultation with the PGC. For M Tech students, thesis supervisors will be assigned based on mutual consent of student and faculty supervisor after one semester of course work.

b) A student may be permitted to repeat or substitute courses in which he/she has obtained DD, DE or F grades. Permission to repeat/substitute a course will be governed by the guidelines laid down in section 2.3.

1.5 Semester Load Requirements:

The load of a student is 14/15 credits per semester in the first year and second year. The total credits requirement for the degree is 55 credits out which 36 credits are earned through coursework and 19 credits through research credits. Out of the 36 required coursework credits, 8 credits are allocated to compulsory courses (Program core), 25 credits are allocated to Specialization core courses, 3 credits are allocated to an elective. Depending on the merits of the case, the PGC may permit a student to register for a maximum of 18 credits or a minimum of 12 credits in a regular semester.

1.6 Adding/Dropping of Courses and Withdrawal from a Semester

a) Adding and dropping of courses is permitted, during the Add/Drop period, only if the student's request is endorsed by the instructor of the course and the Convener PGC. The last dates of applying for adding and dropping of courses are specified in the academic calendar.

b) A student who wishes to withdraw prior to registration for a semester must obtain a formal approval from the Dean (Academic Programs) before the prescribed last date for late registration for the concerned semester. Withdrawal after registration for a semester is permitted only on medical grounds or for other exceptional reasons and formal approval for such withdrawal must be obtained from the Dean (Academic Programs) before the date of commencement of the end-semester examination for the concerned semester. Withdrawal from a semester, either prior to registration or after registration, is permitted for only one semester at a time. If a student does not register for a regular semester or does not withdraw with permission from the Dean (Academic Programs) as indicated above, his/her name is liable to be struck off from the rolls of the Institute.

c) A student who registers for a semester after having withdrawn in previous semester(s) can register for the available courses as prescribed in the curriculum for that particular semester subject to pre-requisites, if any.

d) The transcript of a student who has "withdrawn" status would show the appropriate status for the concerned semester(s). The transcript of a student who is suspended for an academic or disciplinary reason would also show "withdrawn" status.

e) The maximum period for completion of M Tech (ICT) program is given in the appropriate subsection of Section 2 includes any semester in which the student has "withdrawn" status.

2. ACADEMIC REQUIREMENTS

2.1 M Tech (ICT) Program:

The total credits required in the M Tech (ICT) program will be at least 55. The actual credits will be as specified in the approved curriculum applicable to the concerned batch. The maximum permissible duration for the completion of the programs will be 3 years (six semesters), except that the maximum permissible duration for the M Tech program (sponsored category) will be 4 years (eight semesters).

2.2 Audit Courses:

The students are permitted to audit courses. They will be given a "P" grade, which will be entered in their grade card if they satisfy the requirements placed by the course instructor. If they do not meet the requirements, then they will not get any grade and no entry will be made in the grade-card/transcript for that course.

2.3 Grades, Semester and Cumulative Performance Index:

A student is awarded a letter grade in each course he/she is registered for, indicating his/her overall performance in that course. These letter grades are assigned points on a 10-point scale as described in the table below:

Letter Grade	Grade Points	Explanation
AA	10	
AB	9	
BB	8	
BC	7	
CC	6	
CD	5	
DD	4	
DE	3	
F	0	Fail
I	-	Incomplete
P*	-	Pass

*For Pass/Fail and Audit Courses only.

a) If a student does not complete all the requirements for a course for a genuine reason, the instructor may award grade I (Incomplete). An I grade must be converted by the instructor to a regular letter grade by the last date for such conversion specified in the Academic Calendar, failing which it is automatically converted to an F grade.

b) A student getting an F grade in a core course must repeat it. An elective course must be either repeated or substituted as suggested by PGC.

c) A student getting a DD or DE grade in a course may substitute it by another course, provided his/her CPI is less than the prescribed minimum for getting the degree for which he/she is registered and the student is allowed to continue in the program.

d) In case a course is repeated or substituted, the old grade will also appear on the transcript although it will not be taken into account while computing the CPI.

e) The grade S or X will be awarded for research credits as follows:

At the end of the semester, the thesis supervisor(s) will assess the student's progress towards the research work during the semester and will award the grade S for each set of 3 credits if the work is satisfactory and X for every unsatisfactory set of 3 credits.

f) If a student is on leave for a part of the semester or submits his/her thesis in the middle of a semester, the PGC may reduce his/her research credits appropriately.

2.4 Sponsored Category (M Tech):

A student may be admitted as a sponsored student to the M Tech program provided DA-IICT signs an agreement with the sponsoring agency for the same. The Table below indicates the aspects of the student's degree program which would be specified by the agreement. All other requirements would be as indicated in the Academic Requirements for M Tech (ICT) Program.

Requirement	**Sponsored M Tech**
Course Work	36 credits min. at DA- IICT.
Research	19 credits min. Part or all the research may be carried out at the sponsoring agency as indicated in the agreement.
Guidance	Guide from DA-IICT (mandatory), Co-Guide from sponsoring agency (optional).
Infrastructure (Research & Course)	DA-IICT and sponsoring agency respectively for the part in which student stays at DA- IICT and at the sponsoring agency.
Financial Support (TA/RA)	Not Applicable unless indicated in the agreement
Intellectual Property Rights	DA-IICT jointly with sponsoring agency as specified in the agreement.

3. ACADEMIC PERFORMANCE REQUIREMENT

3.1 Semester Performance Index (SPI) and Cumulative Performance Index (CPI):

The SPI is an indicator of the academic performance of a student in all the courses he/she has registered during a given semester. It is computed by taking the weighted average of the grades obtained in that semester. The CPI indicates the cumulative academic performance in all the courses taken including those taken in the current semester. CPI is computed by taking the cumulative weighted average of the grades earned till that semester. The SPI and CPI is calculated up to two decimal places. Courses with S and X will not be taken into account in the above computations.

3.2 Minimum CPI requirements for graduation in the program:

Program	CPI for Graduation
M Tech (ICT)	6.0

3.3 Academic Probation and Dismissal:

A student whose CPI falls below the minimum required for graduation at the end of any semester will be placed on Academic Probation for the next semester with written intimation. A student will also be placed on Academic Probation if he/she obtains an X in a research course. For every student placed on Academic Probation for a semester, the PGC will prescribe a specified course load in the concerned semester and may also prescribe a minimum SPI the student must attain in the semester. The PGC will keep a watch on the progress of every student placed on probation and if the performance of a student is poor so that he/she is not likely to benefit from continuing in the program any further, will recommend to the Director that he/she should leave the Institute. If a student's continuation in the program is terminated, the appropriate authority will issue the letter of termination.

4. <u>Teaching Assistantships:</u>

A student may expect financial support by stipend at par with GATE scholarship in the form of Teaching Assistantship based on need and merits. Weightage should be given to the performance of student in his/her TAship while deciding for the continuation of the TAship or amount of the stipend. The eligibility criteria and amount of stipend will be decided by academic administration of the Institute.

5. <u>MIGRATION RULES</u>

5.1 Eligibility: Students in the M Tech program are eligible to migrate to the Ph D program provided they fulfil the following criteria:

- Student should have entered the program with a B Tech/BE degree or equivalent
- Student should have completed a minimum of two semesters of the M Tech program with at least 18 credits
- Student should have a minimum CPI of 7.0/10.

5.2 Admission Process: A student who wishes to migrate must submit an application to the Dean (Academic Programs) according to the format specified for admission to the Ph D program in the concerned academic year. This must include a research statement. In addition, the student must submit letters of recommendation from three faculty members who were the instructors in courses taken by the student. The application would be considered as per the procedure laid down for Ph D admissions. However, no application fee or admission fee would be applicable.

5.3 Ph D Requirements: The migrated student would be subject to all the requirements as specified for Ph D students with a B Tech/BE degree or equivalent. However, semesters registered (with resident/external registration) and credits earned as an M Tech student would be carried over to the Ph D program. The prescribed duration for completion of the degree and for passing the comprehensive examination would be regarded as commencing from the time of admission to M Tech program.

5.4 Eligibility for M Tech Degree: A Ph D student who fails to pass the Ph D comprehensive examination within the specified duration, whether admitted directly or via internal migration, is eligible to receive the M Tech degree under the following conditions:

- The student fulfils the eligibility criteria for M Tech program
- The student fulfils the criteria for continuation in the M Tech program
- The student submits an M Tech thesis which fulfils the requirements for such within a maximum of two semesters. This duration would commence from the semester immediately following the semester in which the Ph D comprehensive examination has been failed. Furthermore, the student would not be eligible for financial support during this period.

5.5 Completion of Requirements for M Tech Program: A student who migrates to the M Tech (ICT) program from the Ph D program must complete all requirements for the M Tech (ICT) degree within two years (four semesters) from the time of migration. However, credits earned as a Ph D student would be carried over to the M Tech (ICT) program.

6. GLOSSARY

Academic Probation: Academic Probation indicates that a student's academic performance is not up to the expected level. Over and above the academic consequences described in section 3.3, a student who has been placed on probation at any time may be subjected to other restrictions related to financial support, award of medals and prizes, etc.

Cumulative Performance Index (CPI): CPI indicates the cumulative academic performance in all the courses taken including those taken in the current semester. CPI is computed by taking the cumulative weighted average of the grades earned till that semester.

Grade Points: Product of the credits and points of a letter grade awarded to the course.

Postgraduate Committee (PGC): Committee of the Institute responsible for Policy Guidelines and Implementation Strategies covering the Postgraduate Programs.

Semester: Approximately 16 weeks duration each, the first one (Autumn Semester) extending from July to November and the second (Winter Semester) from December/ January to April.

Semester Credits: The sum of credits of courses registered by the student in a semester.

Semester Grade Points: The sum of the products of credits and points for each course registered by a student in a semester.

Semester Performance Index (SPI): SPI is an indicator of the academic performance of a student in all the courses he/she has registered during a given semester. It is computed by taking the weighted average of the grades obtained in that semester.

DA-IICT, Gandhinagar
23 October 2019.

M Tech (ICT) Program

COURSE STRUCTURE 2019 onwards

M Tech (ICT) is a full-time two-year (four semesters) program. The program has been specially designed to meet the increasing needs of professionals who would be able to respond to the convergence between computers and communication systems. The program aims to provide exposure to students who wish to build a professional career in ICT, working at the intersection of technology, research, and development in the areas of Machine Intelligence; Data Analytics; Intelligent Systems; Cyber Security; Distributed Computing; Software Engineering; Image Processing; Computer Vision; Speech Communication; RF and Antenna Theory; Signal Processing; Wireless Systems; Next Generation communication technology and MIMO channel; Embedded Systems; VLSI Subsystem Design; FPGA, and Nano electronics.

The Program curriculum includes four specializations tracks that provide a strong foundation and advanced courses in each track. The Program tries to leverage the strength and diversity of our faculty and currently offers the following specialization tracks:

- Communication and Signal Processing
- Machine Learning
- Software Systems
- VLSI and Embedded Systems

The specializations offered by this Program are different in a qualitative way from the specializations offered in other institutions. Apart from courses, students are required to pursue one full year (two semesters) of research under the guidance of a faculty advisor and submit a master’s thesis in order to obtain the degree of M Tech (ICT) specializing in the respective track. On successful completion of the program, the students will be able to acquire essential technical and practical knowledge for solving real-world problems in the ICT domain using modern technologies and tools, and will have the ability to demonstrate excellent analytical and logical problem-solving skills which may bridge the digital divide between urban and rural worlds. Apart from receiving rigorous exposure to various areas of scholastic study and research, students will be groomed to cultivate sound professional ethics.

Semester-wise course sequence
(L-lecture, T-tutorial, P-practical, C-credit)

Semester	Courses	Credit Structure (L-T-P-C)
Semester 1	Program Core 1	3-0-0-3
	Program Core 2	1-0-4-3
	Program Core 3	1-0-0-1
	Specialization Core 1	3-0-0-3
	Specialization Core 2	3-0-2-4

Semester	Courses	Credit Structure (L-T-P-C)
Semester 2	Specialization Core 3	3-0-0-3
	Specialization Core 4	3-0-2-4
	Specialization Core 5	3-0-2-4
	Elective	3-0-0/2-3/4
Semester 3	Program Core 4	1-0-0-1
	Specialization Core 6	3-0-0-3
	Specialization Core 7	3-0-2-4
	Thesis	0-0-12-6
Semester 4	Thesis (continuation)	0-0-26-13
Total Credits		30-0-50/52-**55/56**

1 lecture hour contributes 1 credit; 1 tutorial hour contributes 1 credit; 2 laboratory hours contribute 1 credit

The curriculum mandates a minimum of 55 credits, 36 earned through coursework and 19 through research credits. Out of the 36 required coursework credits, 8 credits are allocated to compulsory courses (Program core), 25 credits are allocated to Specialization core courses, 3 credits are allocated to an elective.

The distribution of courses for M Tech (ICT) degree is as under:

Subject area	No. of credits
Program Core courses	8
Specialization Core courses	25
Elective courses	3
Thesis work	19
Total credits	**55**

Detailed Curriculum

The Program Core courses are targeted to strengthen mathematical foundations required in all specializations, along with imparting proper technical communication and writing skills. The Specialization Core courses impart foundational knowledge specific to each specialization to begin with, followed by advanced courses in the respective specialization. Some specializations may offer a choice for specialization core courses, especially in Semester 2 and 3. Topics covered in such advanced courses typically will introduce students to possible areas of research in the respective specialization. The Research Thesis gives a firsthand experience of contributing knowledge to the existing body of knowledge in each specialization, under the supervision of a faculty member at DA-IICT.

The Program Core and Specialization Core courses are mentioned below:

Program Core Courses

Probability and Random Variables

The objective of this course is to study the concepts of probability, random variables, and their applications in information and communication technology. Topics include: review of probability theory, Definitions, Set theory, Axioms of probability, Conditional probability, Bayes' theorem, Total probability, Concept of Random variable, Discrete and Continuous random variables, Commutative Distribution Function and its properties, Probability density function and its properties, Function of a random variable, Mean, variance and moments of a random variable, Characteristic functions, Bernoulli trials, Binomial distribution, Poisson distribution, Geometric distribution, Uniform distribution, Exponential distribution, Gaussian distribution, Rayleigh distribution, Joint random variables and their characterization and their application to real world problem solving, Convergence concepts, Law of large numbers, Central limit theorem, concept of mean square estimation.

Programming Lab

This course aims to provide hands-on practice in software tools and technologies used in ICT. The broad coverage of this course is as follows:

Module 1: Familiarity in Linux; Shell Programming; Perl (basic and process control); Programming tools (Makefiles, version control, debugger, profiler).

Module 2: Problem solving and programming using Python.

Module 3: Introduction to circuit modelling and analysis through LTSPICE; System design using FPGA.

Module 4: Understanding MATLAB; Lab on Sampling, Quantization and PCM; Bit error rate based performance analysis of PSK and QAM.

Communication Skills

This course is especially designed for the post graduate students of engineering to train them in communicating effectively. Not only will the students develop skills required for everyday writing, but they will also be able to present their ideas in the professional scenario. Most of the classes will employ task based activities aimed at providing the students with the basic competencies in language viz., reading, writing, listening, speaking and thinking. Modules in this course include:
Comprehension; Everyday communication; Descriptive Writing; Writing Paragraphs; Group Discussions; and Presentation Skills

Technical Writing

Fluent communication and technical writing are functional skills central to science and engineering research. This course will provide the learners with a practical framework and structural orientation toward language used in technical documents. The course will teach and train students to read, decipher and comprehend complex ideas which are indispensable to technical discourse. Besides preparing the students to construct documents (such as abstracts, research papers, proposals, memorandums and notes) the course will enable them to edit and proof read their own constructions. The communication aspect of the course will cater to honing the skills of speaking, expressing and adequately conveying one's ideas across. This will include teaching the students to successfully carry out powerpoint presentations, interviews, impromptu speeches and discussions/deliberations. The writing aspect will focus on document construction and information processing.

Specialization Core Courses

Software Systems

Advanced Algorithms

This course aims to cover the fundamentals of algorithm design and to enhance the problem-solving skills necessary for developing efficient software systems in various applications. The coverage of the course starts with the algorithm design technique including divide-and-conquer, greedy approaches, dynamic programming, heuristic algorithms, and approximation algorithms. Substantial emphasis will be given for discussion on relevant data structures while discussing these topics and the complexity analysis of algorithm design.

Software Engineering

The main objective of this course is to understand and learn how complexity and change are engineered during large software development. The course will focus on the methodologies (processes), techniques (methods), and tools that can be used to successfully design and validate large software systems. The course will focus on the state-of-the-art in applying quantitative assessment methods in Software Engineering and other related fields. The contents of this course to be covered are: (1) Software Requirements Modeling and Specifications, (2) Software Architecture and Design Patterns, Software Development Methodologies, (3) Software Measurement and Metrics, (4) Empirical Software Engineering, (5) Computer Aided Software Engineering and Tool Support (DevOps, Automation), (6) Applications of ML and AI in analyzing software products, and (7) Assessment and Evaluation in Software Engineering.

Network Security

In this course the student is exposed to different attacks and threats in computer networks including network mapping, port scanning, sniffing, DDoS, reflection attacks, attacks on DNS and leveraging P2P deployments for attacks. The course will also review some cryptographic primitives, such as the concepts of block ciphers, stream ciphers, pseudo-random functions, public key cryptography, digital signatures and key distribution, relevant to secure networking protocols. The course will discuss several secure networking protocols, including PGP, SSL, IPsec and wireless security protocols. The course is expected to examine operational security, including firewalls and intrusion-detection systems. Students would be expected to read recent research papers on network security and participate in an important lab component that includes packet sniffing, network mapping, firewalls, SSL and IPsec.

Computing and Complexity

The objective of the course is twofold. The first objective is to introduce the students with the exact notion of algorithms in terms of time and storage capacity. For this, different mathematical machine models are defined. The second objective of this course is to teach students how to divide problems in to various complexity classes based on the resources required to solve them. Topics include Formal definition of Turing machine, variants of Turing machine, decidable languages, semi decidable languages, Universal Turing machine, undecidable languages, Cantor's diagonalization, Halting problem, Post correspondence problem, Turing computable function, Rice's theorem, decidable logical theory, undecidable logical theory, Godel's incompleteness theorem, the class P, the class NP, NP-completeness, polynomial reducibility, Cook-Levin theorem, Savitch's theorem, the class PSPACE, PSPACE-completeness, the class L and NL, EXPSPACE, EXPSPACE completeness, Hierarchy theorem, relativization, introduction to circuit complexity, and introduction to communication complexity.

Distributed Databases

Collection of correlated databases distributed over a cluster of servers can facilitate scalable query processing. This course includes foundational work, recent developments and trends in scalable database management systems. Modern Data Storage and Query processing for Parallel and distributed databases will be discussed. Students will be working on projects in the domain of modern distributed data storage and query processing during labs. Students will be using various SQL and NoSQL database management tools for implementing their projects. Topics include: Distributed architecture, distributed database design considerations and strategies, fragmentation and allocation, distribution and replication models, scalable query processing and optimization, query cost estimation, distributed transaction management, concurrency control, database interoperability, various data models, SQL and NoSQL databases, RDF and graph databases, static and streaming data, research issues in modern distributed database management.

Advanced Computer Networks
This course aims to provide an exposure to basic knowledge of networking concepts and background, such as basics of Internet protocols, link layer and framing concepts etc. However, an in-depth review of undergraduate level networks material will be done in this course. This course will emphasize the concepts and issues underlying the design and implementation of the Internet. We will also spend time learning to quantitatively analyze the performance of network protocols. Topics include: Datagram, circuit, and connection-oriented networks; Multiple access: contention and ordered techniques; TCP/IP group of protocols: routing and end-to-end reliability; Open and Closed loop flow control; CSMA/CD protocol analysis - efficiency, latency; Point-to-point routing: OSPF, BGP, convergence, Performance Analysis; Multicast protocols and Anycast protocols; Reliability Issues in Broadcast and Multicast; Performance Issues in TCP: Modeling and Analysis; Active Queue Management in TCP Networks; QoS definition, Mapping models; Label Switching, MPLS; Mobility support in Internet; Networking virtualization.

Distributed Systems
Distributed systems are systems comprising of computing elements that are spread across geographical locations. Examples include Internet, Google file systems etc. Contents of the course include (a) architectures of various distributed systems, (b) refresher on processes, clients and servers, (c) fundamentals of network communication, remote procedure calls, message oriented versus stream oriented communication, multicast communication, (d) domain name service and its architecture, (e) synchronization using Lamport logical clocks, mutual exclusion algorithms, (f) replication and consistency models, and (g) fault tolerance.

Blockchain and Crypto-Currency
This course explores the fundamentals of blockchains and cryptocurrencies. Topics covered include basic cryptographic tools, early digital cash, Bitcoin blockchain, Script language, Bitcoin wallets, applications of Bitcoin scripts, distributed consensus algorithms, proof of work, mining pools, mining attacks, altcoins, virtual mining, cross-chain transactions, Bitcoin exchanges, anonymity and privacy techniques, scaling blockchains, smart contracts, decentralized applications, and Ethereum blockchain.

Software Testing and Verification
Testing and verification of the software systems is not a ―silver bullet‖ that can guarantee the production of high quality applications. While a ―correct‖ correctness proof demonstrates that a software system (which exactly meets its specification) will always operate in a given manner, software testing that is not fully exhaustive can only suggest the presence of flaws and cannot prove their absence. Software systems are therefore always checked for correctness before they are deployed. Verification and testing are two predominant ways for checking the correctness of software systems. This course is aimed at learning various techniques of testing and verification. The coverage of this course includes the following modules:
Module 1: Software Testing: Basic concepts and preliminaries
Module 2: Model-based Testing
Module 3: Design and Code Inspections to Reduce Errors in Program Development
Module 4: Applications of AI in Software Quality Assurance
Module 5: Verification of Software Systems
Module 6: Testing of Web GUI and Mobile Apps
Module 7: AI and ML for Security Testing

Machine Learning

Linear Algebra and Optimization

This course aims to strengthen the mathematical foundations in the areas of Linear Algebra and Optimization, necessary to understand and analyze problems and algorithms in Machine Learning. Machine Learning deals with modeling, analysis and processing of large amounts of data. A popular way of modeling data is using vector spaces, which are (pre-)processed using tools from Linear algebra and Optimization. The contents of the course are: (a) Linear Algebra - Importance of Vector spaces, Basis, Linear transformations, Matrices, Matrix Rank, Similarity transformations, Matrix Diagonalization, Eigenvectors & Eigenvalues, SVD, Norms, Inner products, Least squares, Projection and (b) Optimization-Unconstrained Optimization (First & Second Order Conditions, Gradient Descent and its variants), Constrained Optimization (KKT Conditions), Convex sets and functions.

Accelerated Computing

This course aims to cover the important topics of GPU programming such as design of parallel algorithms, GPU and CPU architecture, data parallelism, CUDA programming model, GPU memory model, memory performance and optimization, parallel complexity analysis, performance modeling, and case studies focused on important parallel patterns supported by lab assignments.

Pattern Recognition and Machine Learning

Machine learning concerns with designing and developing of algorithms that allow machines, essentially computers, to evolve realistic or human like behavior based on the empirical data available. This course aims to discuss the building blocks of pattern recognition problem and provide an overview of the machine learning and advanced topics. The focus would be to discuss various algorithms for pattern recognition and discuss the tools for pattern recognition.

Brain Cognitive Science

The objective of this course is to familiarize the student about brain science and cognition, and its entanglement with artificial intelligence and computer sciences. This course will introduce you about how various mental processes (information processing) like sensation, perception, attention, memory, learning, action and decision making etc. that are accomplished by the brain. In the later part of this course, we will study the various topics and techniques in the area of artificial intelligences that are partly or fully inspired from the principles of information processing in the brain. This course will also introduce you about brain-computer interaction (BCI) and neuromorphic computing.

Advanced Image Processing

The objective of this course is to introduce some basic to advanced levels of techniques for processing image. The techniques include various spatial domain, transformed domain techniques to enhance, to restore, and to segment image for higher level processing. This also includes 3D vision related perspective, and also discusses different metrics to measure the quality of image. The course will emphasize mathematical model of degradation, Noise models, Restoration in presence of noise, Periodic noise reduction, Linear position-invariant degradation, Estimating the degradation function, Inverse filtering, Wiener filtering, Constraint least square filtering. Image quality assessment metrics with Reference based metrics: MSE, PSNR, ISNR, SSIM, FSIM. No-Reference based metrics: FADE, UIQM, UCIQE will also be discussed in this course.

Information Retrieval

Unstructured information accounts for more than 70–80% of all data in organizations and is expected to grow even more in days ahead. The lion share of this is typically text. Apart from navigating the web (e.g. Google, Bing) a search engine is also useful for several other tasks like searching within intranet of an organization, looking for information in a database of documents that might not always be in public domain (e.g. enterprise search). The objective of this course is to study different components of an information retrieval system to access information from unstructured and semi-structured text. The three major components of this course are: Indexing, Retrieval and Evaluation. Indexing (Representation) includes vector space and embedded space representation. Implementation of Vector-Space Model, tokenizing, stop-word removal, and stemming. Retrieval models include vector space model, language model, probabilistic model, boolean model and a fair understanding of query processing. Query operations like Query expansion (Relevance feedback) in both supervised and unsupervised framework will be discussed. Evaluation will cover performance metrics: recall, precision, and F-measure; Evaluations on benchmark text collections. Given the above foundation this course will explore several domain Specific IR problems, like, IR form Legal, Medical, Financial and Social Domain.

Computer Vision

Past several decades researchers have endeavored hard to develop computers with the capacity to ―seeǁ and comprehend the world around them, as humans would do. This course aims to convey the nature of some of the fundamental problems in computer/machine/robot vision, and to explain a variety of techniques used to overcome them. Vision is a rapidly evolving area and new and emerging approaches to vision problems. We will cover some of them along with some classical techniques. Various vision problems are considered, including: feature detection in images, edge detection, and the accumulation of edge data to form lines; recovery of 3D shape from images, the use of a stereo image pair to derive 3D information; forming image mosaics; video surveillance techniques. Tracking objects in video; motion detection in video images; recognizing and classifying objects in images.

Deep Learning

Deep learning is a new area of Machine Learning research and a growing field in the area of pattern recognition, natural language processing, speech processing, image processing and vision. This course provides a broad introduction to deep learning architectures. The objectives include: (1) Formulate machine learning problems related to different applications and solve using deep learning approaches; and (2) Read current research papers and understand the issues in current research. The coverage of this course includes the following modules:

Module 1 – Machine learning (ML): Types of learning - Supervised, unsupervised, reinforcement. Linear Regression, Logistic Regression, Algorithms in ML–k-means, SVM, PCA. Concept of Over-fitting, Regularization.

Module 2 – Introduction to Neural Networks: Motivation, Simple Neural Network (shallow) and its learning (Intuition), Back propagation, Convergence Issues.

Module 3 – Deep learning Architectures: Deep Neural Network, Auto-encoder and Deep Auto-encoders, Sparse, De-noising, Convolutional Neural Networks (CNN) and Deep CNN. Recurrent Neural network, Generative Adversarial Networks (GANs), mode collapse, Variational Encoder Enhancement GAN (VEEGAN), Variational Autoencoder (VAE), and applications.

Natural Language Processing

This course presents an introduction to the computational modelling of natural language. Topics covered include: computational morphology, language modelling, syntactic parsing, lexical and compositional semantics, and discourse analysis. We will consider selected applications such as automatic summarization, machine translation, and speech processing. We will also study machine learning algorithms that are used in natural language processing.

Communication and Signal Processing

Advanced Digital Signal Processing

This course aims to discuss few advanced topics from digital signal processing, and also to explore current research areas like compressive sensing and graph signal processing. This course would be useful for some specialized courses like speech signal processing, image processing and adaptive signal processing. The coverage of this course includes the following modules:

Module 1: Discrete-time Filters: DTFT, DFT, Design of FIR and IIR Filters.

Module 2: Multirate Signal Processing: Sampling Rate Change Operations: Upsampling and Downsampling; Fractional Sampling; Interpolation.

Module 3: Compressive Sensing: Sub-Nyquist Sampling, Reconstruction of sparse signals- Orthogonal Matching Pursuit, Orthogonal Least Square, Subspace Pursuit, Basis Pursuit, Generalized Orthogonal Matching Pursuit.

Module 4: Wavelet Transform and Filter Banks: Haar Wavelets, Daubechies Wavelets, Orthogonal and Biorthogonal Wavelets, Gabor Transform.

Module 5: Graph Signal Processing: Representation of Signals over Graphs, Graph Fourier Transform, Graph Filters.

Advanced Digital Communication

A digital communication system converts the information to be transmitted into a stream of bits, and then into symbols that can be transmitted over wireline or wireless channels. This concept applies regardless of the type of information generating source (audio, video, image, etc.) and the type of information conveying medium or channel (cable, satellites, microwave and terrestrial links, etc.). This course will combine mathematical principles and their practical engineering applications to build the student's skills in designing and analyzing the digital method of communications.

(a) Information Theoretic Limits and Power versus Bandwidth Tradeoff (Entropy and Mutual Information, Channel Capacity, power and bandwidth efficiencies, and trade-off between them);

(b) Digital Modulation Schemes (Base band and bandpass communication, vector space representation of signals, linear and nonlinear modulation techniques, M-ary modulation techniques (PSK, QAM), orthogonal modulation techniques, spectral characteristics of digital modulation);

(c) Design of Receivers and Demodulators (Maximum A Posteriori Decision Theory, Optimum Receivers, Probability of Error Analysis, Correlation demodulator, matched filter, maximum likelihood sequence detector, differential and noncoherent detectors; characterization of fading multipath channels, RAKE demodulator, multiuser detection techniques);

(d) Digital Communication Transceiver Signal Processing (transmitter side signal processing (pulse shaping and zero ISI Nyquist criteria, Direct Digital Synthesis), signal processing at the receiver (symbol timing, carrier frequency and phase offset estimation), interference mitigation techniques (Intersymbol Interference and Channel Equalization));

(e) Wireless Communication Channels and Advanced Architectures (flat and frequency selective channel fading, SIMO and MISO diversity for fade mitigation, MIMO architectures, OFDM and SC-FDMA, spread-spectrum techniques and Non-Orthogonal Multiple Access (NOMA)); Channel Coding Schemes (linear block codes, convolution codes, trellis-coded modulation, Turbo coding, Soft-Output Viterbi Algorithm (SOVA), LDPC Codes, Message Passing Algorithms).

Adaptive Signal Processing

This course aims to discuss algorithms to process the signals in an adaptive manner where it is assumed that the underline system/channel may vary over time. Its application areas include sonar, radar, biomedical and communication signal processing. This course will discuss all the classical adaptive algorithms like LMS, NLMS, RLS etc. The emphasis is on finding theoretical analyses of the adaptive algorithms and also on the recently proposed algorithms.

Wireless System Design

Wireless System Design is one of the most exciting fields in Communication Engineering today. This course combines theory with real-life examples to provide students wireless communication system concepts and to help them close the gap between traditional RF engineering design and the needs of modern communication systems. A key premise of this course is that a coherence understanding of wireless system performance and design can only be obtained by treating the relevant technical topics in an integrated manner. Topics include:

Introduction to Wireless Systems: Classification of Wireless Systems, Design and Performance Issues, Introduction to Wireless System Components, Cellular telephone Systems and Standards.

Noise and Distortion in Systems: Noise in Linear Systems, Noise Temperature, Noise Figure and Inter-modulation Distortion.

System Design Fundamentals: Radio Receiver Architectures, Wireless Communication Requirements: Methodologies, Eb/No vs SNR, BER vs Noise, Bandwidth Limitation.

RF System Design Considerations: Receiver Sensitivity, Spurious-free and Blocking (Linear) Dynamic ranges, Power Output and Spectral Efficiency, System Limitations.

Mixers: Properties and Characteristics: Conversion Loss/Gain, Noise Figure, RF/IF Isolation, LO/IF Isolation, Distortion, Power Consumption, Mixer Types (Single-ended, Balanced, Double-Balanced, Image Rejection).

Amplifiers & Oscillators: Large Signal: Power Output vs Efficiency, Gain and Phase Requirements, Non-linearity issues Inter-modulation Distortion (IMD) in Amplifiers, VCOs & Frequency Synthesisers.

Support Circuit Design: Frequency Multipliers, RF Switches, Attenuators, AGCs, Baluns, Splitters/Combiners, Directional Couplers, Phase Shifters.

Systematic Analysis of Transceiver Design: Specifications, Block diagrams, Small Signal Analysis, dB Power, Link Budgets, System Design Trade-offs, Gains/Losses, Signal-to-Noise, Probability of Error, Bit Error Rate, Eb/No, Link Margin, Tracking Noise and Signal level through a complete system, Effects and Advantages of using Spread Spectrum techniques.

Transmitter Design: Various types and system designs of transmitters, local oscillator, upconverters, sideband elimination, power amplifiers, standing wave ratios.

Receiver Design: Dynamic Range, Image Rejection, Limiters, Minimum Discernable Signal (MDS), Tangential Signal Sensitivity (TSS), Super-heterodyne Receivers, Importance of Low Noise Amplifiers, Phase Noise.

Measurement Tools and Instruments: Spectrum Analyzer, Scalar and Vector Network Analyzer, Time Domain Reflectometer (TDR), Power Meter and Sensors, Software Tools like Agilent Technologies' ADS.

EMI & EMC Issues: Electromagnetic Interference and Electromagnetic Compatibility in Wireless Devices.

Recent Trends & Technologies: Practical aspects of designing with RFICs and MMICs, MEMS, MIMO, Smart Antennas.

Detection and Estimation Theory

Different problems in signal processing and communication involve detection and processing of the signals to make inference. In practical scenario, the signals could be noisy. The objective of this course is to provide fundamental and theoretical concepts to develop frameworks such that the inference problem can be addressed in those areas.

(a) Foundations: Probability- conditional probability, PDFs, Continuous random variable, Functions of random variables, Characteristic Functions, Expectation and Moments, Central Limit Theorem. Random processes - Ensemble Correlation Functions, Time averages, Power Spectral Density, Gaussian Process, Sampling and Random Sequences, Poisson Process. Linear Vector Spaces, Hilbert Spaces.Constrained and unconstrained optimization.

(b) Detection theory: Hypothesis testing - The Neyman-Pearson Criterion, Bayes Criterion, Minimum Error Probability Criterion, Minimax Criterion, Sequential Hypothesis Testing. Detection in the Presence of Unknowns: Random Parameters, Non-random parameters. Detection of

Signals in Gaussian Noise: White Gaussian, Colored Gaussian, Spectral detection. Detection in the Presence of Uncertainties: Unknown signal and Noise parameters. Non-Gaussian Detection Theory: Robust Hypothesis Testing, Non-Parametric Model Evaluation, Partially Known Signals and Noise, Partially Known Signal Waveform, Partially Known Noise Amplitude Distribution, Non-Gaussian Observations.
(c) Estimation theory: Terminology in Estimation Theory. Minimum variance unbiased estimation: Unbiased estimators, Minimum variance criterion, Existence and search of the minimum variance unbiased estimator, Extension to a vector parameter. Cramer-Rao Lower Bound - Signals in white Gaussian noise, parameter transformation, vector parameter, general Gaussian case, and WSS Gaussian random process. Practical Estimation of Signal Parameter: Best Linear Unbiased Estimators, Maximum Likelihood Estimators, Least Squares estimation. Parameter Estimation via Bayesian: Bayesian linear model, nuisance parameter, Bayesian Estimation for Deterministic Parameters, Risk Functions, MMSE and MAP Estimator, Sequential Linear MMSE estimators, Wiener Filtering, Kalman Filtering.

Speech Technology
The objective of this course is to understand the potential of various speech technologies, such as, speech, speaker and language recognition, voice conversion, text-to-speech (TTS) synthesis, audio search, query-by-humming (QBH). Finally, course also discusses applications of speech technology in medical-domain, such as, infant cry classification, autism spectrum disorder (ASD), cleft speech, vocal fold pathology, hearing aids, voice cloning or voice banking, etc. Topics include: Overview of Speech Technology, Speech Production, Speech Analysis, Speaker and Language Identification, Voice Conversion, Automatic Speech Recognition, Audio Search, Query-by-Humming, Text to Speech Synthesis.

Wireless Communication
The course aims to expose the students to understand mobile radio communication principles and to study the recent trends adopted in cellular systems and wireless standards. The coverage of this course includes the following modules:
Module 1: Cellular Concepts – System Design Fundamentals: Cellular concept-channel reuse-handoff strategies-dynamic resource allocation-interference and system capacity-improving capacity and coverage of cellular systems. Second and third generation network standards: GSM standardization-architecture and function partitioning-GSM radio aspects-security aspects-protocol model-call flow sequences-evolution to 2.5G mobile radio networks. IS-95 service and radio aspects, key features of IS-95 CDMA systems ECWDMA-UMTS physical layer-UMTS network architecture-CDMA 2000 physical layer.
Module 2: Radio Wave Propagation: Free space propagation model- basic propagation mechanisms –reflection- ground reflection model diffraction-scattering-practical link budget design-outdoor and indoor propagation models. Small scale fading and multipath: Small scale multipath propagation-Impulse response model of multipath channel –small scale multipath measurements-parameters of mobile multipath channels –types of small-scale fading.
Module 3: Capacity of Wireless Channels: Capacity of Flat Fading Channel- Channel Distribution Information known – Channel Side Information at Receiver – Channel Side Information at Transmitter and Receiver – Capacity with Receiver diversity – Capacity comparisons – Capacity of Frequency Selective Fading channels. Performance of digital modulation over wireless channels: Error probability of BPSK, FSK, MSK, GMSK, QPSK, M-ary PSK, M-ary QAM and M-ary FSK on AWGN channels- Fading– Outage Probability, Average Probability of Error, Combined Outage.
Module 4: Diversity: Realization of Independent Fading Paths – Receiver Diversity – Selection Combining – Threshold Combining – Maximal-Ratio Combining – Equal - Gain Combining – Transmitter Diversity – Channel known at Transmitter – Channel unknown at Transmitter – The Alamouti Scheme-basic concepts of RAKE receivers.
Module 5: Multiple Access Techniques: Frequency division multiple access-time division multiple access-spread spectrum multiple access space division multiple access- packet radio. MIMO and

multicarrier modulation: Narrowband MIMO model-parallel decomposition of MIMO channel-MIMO channel capacity-MIMO diversity gain –data transmission using multiple carrier multicarrier modulation with overlapping sub channels-mitigation of subcarrier fading-basic concepts of OFDM.

Optical Communication

Fiber optic and optical wireless communication systems are the backbones which support the Internet and Telephone/ Cellular phone/ E-Commerce/Entertainment industries in the world. In 5G communication networks we use millimetre-wave technology now. In the near future 6G and 7G will rest heavily on optical frequencies in the range of 1014-1015 Hz. Optical interconnects are revolutionising computer industry hardware. Optical surgery and optical medical instruments have made medical diagnosis and treatments more effective and painless. Aircrafts, rockets and satellites are becoming —fly-by-light‖. Optical communication principles behind all these advancements in the information technology is discussed in this course.
Maxwell’s equations, Propagation of Light, Gaussian beam and diffraction, propagation of light in planar dielectric waveguides, optical fibers, propagation of light in fiber waveguides, modes, single and multimode fibers, attenuation and dispersion in optical fibers, nonlinearities in optical fiber, optical resonators, laser principles, diode lasers, coupling of laser and optical fibers, photodiodes, optical receivers, bit-error-rate in IM-DD optical communication, EDFA amplifiers, dispersion compensators, IMDD optical fiber communication link design, optical LANs, time-division-multiplexing in optical communication, wavelength-division-multiplexing and demultiplexing, optical MZ interferometers, electrooptic modulation, optical switches, optical wireless design in free space, atmospheric effects, optical wireless communication systems for LAN and FTTH.

Information Theory and Coding

Information Theory and Coding are the primary building blocks of any digital communication system. This course introduces the principles and applications of information theory. The course aims to the following modules:
Module 1: Basics of Information Theory: Introduction to Information theory - Information –- Measure of Information – Average information content (Entropy) of symbols in long independent sequences - Average information content (Entropy) of symbols in long dependent sequences – Joint and conditional entropies – Mutual information - Markov statistical model for information sources – Entropy and information rate of Markov sources – Information measure for continuous random variables.
Module 2: Source Encoding: Shannon’s first fundamental theorem – Noiseless coding – Source with finite memory – Shannon’s second fundamental theorem on coding for memory less noisy channels – Channel capacity theorem - Shannon’s Encoding algorithm – Huffman Coding Algorithm.
Module 3: Channels and Channel Capacity: Communication channels, discrete communication channel - Rate of information transmission over a discrete channel - capacity of a discrete memory less channel – Shannon – Hartley theorem and its implications. Types of channels and their capacities – Binary channel - BSC, BEC - cascaded channels-symmetric channel – asymmetric channel - channel capacity for MIMO system.
Module 4: Error Correcting Codes: Types of errors – Linear block codes – Error detection and error correction – Single error correcting Hamming codes – Binary cyclic codes – Encoder, Syndrome calculation, error detection and correction - BCH Codes – Burst Error Correcting codes – Burst and random error correcting codes - Galois fields, vector spaces and matrices – Convolution codes and Trellis codes – Viterbi decoding of convolutional codes – Turbo codes – Encoding and Decoding- Trellis coded modulation – Majority logic decoding –Two dimensional codes – ARQ.

VLSI and Embedded Systems

Basics of VLSI

This course is an overview to modern CMOS VLSI Design, mostly digital logic. It will start with a basic introduction of MOS transistors as switches and CMOS inverter characteristics. Following topics will be covered in this course: Introduction to VLSI Design; MOSFET Transistor Theory and characteristics; Scaling; CMOS Process Technology and Design Rules; Physical Layout of CMOS ICs, Stick Diagram; CMOS inverter characteristics, Power Dissipation; Pass Transistor Logic; Static Logic Gates; Logical effort and delay estimation of logic gates; Delay estimation in long wire: buffer insertion; Driving large capacitive load, delay minimization in an inverter cascade; Ratioed logic: Resistive load inverter, Pseudo-nMOS logic, inverter and other logic gates using Pseudo-nMOS; Transmission gate circuits; Dynamic logic circuits, Domino logic; Clocking strategies: one phase and two phase clocking. Clock Distribution; Physical Design Automation: Partitioning, Floor planning, Placement and Routing; VLSI testing.

Digital Design using HDL and FPGA

The course aims to impart digital logic concept realization using hardware description language (HDL) and its practical implementation on FPGA based hardware kits. The HDL will be discussed in detail with all its abstraction levels and modeling schemes. The focus of the course will be to develop practical realizable projects using HDL and FPGA. Topics include:
Introduction to digital design, concept of hierarchical and structured design, role of CAD tools in VLSI design process. Introduction to HDL, basics of Verilog language, synthesis, FPGA, familiarization with Xilinx Spartan-3E FPGA development board. Combinational systems realization using HDL and FPGA—arithmetic functions, multiplexer, demultiplexer, encoder and decoder, code converters. User-defined primitives, instantiation, parameterized module, realization of test benches, timing and delay models. Description and design of sequential circuits—latches, flip-flops, register, counter. Defining procedural blocks, procedural flow control, blocking and non-blocking assignments, implementation of synchronous and asynchronous designs. Data subsystems, storage modules, memory, stack, queue, functional modules, data paths, control subsystems, FSM and I/O subsystem, Mealy and Moore designs. System task and functions, operations related to I/O subsystems, compiler directives. VeSPA (Very Small Processor Architecture) processor - developing behavioral and structural modeling using HDL and FPGA. Designing of practical systems.

Digital System Architecture

This course covers the basics of uniprocessor, Multicore architecture and programming; Fundamentals of Computer Design; ARM architecture; Instruction Level Parallelism and its Dynamic Exploitation; Memory Hierarchy Design; Multiprocessors and TLP; Parallel Programs (Lab); CiLK (Lab); Programming for performance; Workload Driven Evaluation; Shared memory multiprocessor.

VLSI Subsystem Design

The objective of this course is to provide students with a sound knowledge of VLSI subsystem design. The modules of this course include:
Wires and Interconnect: Resistance, Capacitance, RC delay analysis, Cross-talk delay and noise effects, Repeaters, Logical Effort, Crosstalk control, etc.
Dynamic Logic, Domino logic, Keepers, etc.
Sequential Circuits: Latches, Flip-flops, RC delay analysis, Sequencing Methods: FF based, 2-phase Latch based, and Pulsed latch based. Timing analysis: Set-up time (Max-delay) constraint, Hold time (Min-delay) constraint, Clock-skew budgeting, Time borrowing, simple synchronizer, FSM, introduction to pipelined system/ALU, etc.
Datapath Subsystems:

- Adders: Full Adder using a variety of Logics styles, bit-serial Adder, Ripple Carry Adder, Carry-skip Adder, Carry Look-ahead Adder, Brent-Kung Adder, Kogge-Stone Adder, Carry-Save Adder (multi -operand addition), etc.

- Multipliers: Unsigned Array Multiplier, Booth Encoded Multiplier, Baugh-Wooley Multiplier, Wallace tree multiplier, etc.
- Division: Non-restoring method, and restoring method, etc.
- Standard Math function implementation: Cordic Algorithm, Newton-raphson mehod, etc.
- Comparators, shifter-registers, random number generator based on Linear Feedback Shift-Registers (LFSR), etc.
- Error Correcting Codes: LFSR based CRC, and Hamming7-4 codes.

Memory Array Subsystems: Register-file; Content-addressable memory; LIFO and FIFO; SRAM: decoders, column MUX, RC Analysis, etc.

Embedded System Design

This course aims to provide the students an in-depth understanding of fundamental concepts on embedded systems. The course focuses on embedded system overview, design challenge: Optimizing design metrics, Processor Technology, General purpose Processors, Single purpose Processors, and Application Specific Processors, IC Technology: Full custom/ VLSI, Semicustom ASIC, PLD, Trends, Design Technology; Processor Design: Custom Single purpose Processor: RTL combinational components, RTL sequential components, Custom Single purpose Processor Design, Optimizing Custom Single purpose Processors, Optimizing the FSMD, Optimizing the datapath, optimizing the FSM. General purpose Processors: Basic architecture, Datapath, Control unit, Memory, Pipelining. The course will emphasize on portable embedded devices design and implementation features with some use cases.

Analog CMOS IC Design

This course will introduce advanced concepts in analog circuit design specifically relevant to CMOS IC design. The course will cover circuit noise and mismatch, their analysis, and their impact on CMOS and design. Topics include: Revision of Circuit Theory, Poles and Zeros, Dominant pole concept and stability; Passive elements in CMOS technology; MOSFET model, small signal parameter of the MOSFET; Current Sources and Current Mirrors; Single ended single stage amps -CS,CD,CG; Differential Amps; Cascade and Cascode Amplifiers; Effect of feedback in amplifiers; Layout of CMOS analog circuits; Noise in CMOS analog circuits

Low Power VLSI Design

The aim of this course is to give a broad grounding in the principles and practice of Electronic Design Automation techniques for System on Chip Design. The course covers topics in Ultra Low Power VLSI digital circuits (Digital IC design, layout, simulation, synthesis, VLSI design techniques and system architecture; CAD tools and techniques, Low Power, ultra-low power circuit techniques and energy harvesting electronics). This course is a design intensive course that will cover moderate to advanced use of the following tools and languages:

- Magic or Cadence icfb, h/p/lt Spice
- VHDL simulator, synthesis tool
- (Circuits) MOS gate characteristics
- (HDL)VHDL or Verilog
- CMOS technology (0.18µ CMOS).

Selected topics in VLSI

The content of this course will be made available to students before the start of semester III of respective batch.

Representative list of Electives (typically the list gets updated in every academic session)