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ENGINEERS WITH
SOCIAL RESPONSIBILITY

NAAC Accredited
Recipient of Centre of Excellence Award by the Government of Gujarat
Recipient of '5 Star' in GSIRF Ranking by Government of Gujarat

Syllabus of courses offered in the Undergraduate and Postgraduate Programmes

Undergraduate Programmes

EL111 Basic Electronic Circuits (3-0-2-4)

Course objective: Basics of electrical and electronic circuits and applications in the areas of sensors, signal processing, communications, controls.

Review of basic circuit laws: KCL, KVL, Thevenin and Norton's theorems, Superposition theorem. Ohm's law and physics of R, L, C, independent and dependent current and voltage sources. Elements of linear and time-invariant systems, piecewise continuous and sinusoidal signals. Basics of semiconductors, semiconductor diodes and their applications, MOSFETs – basics, biasing, amplifiers, inverters. Op Amps, idea of feedback, circuits with ideal op amps, amplifiers, filters. Complex arithmetic and ideas on sinusoidal steady-state response, phasors, impedances, transformers. Time and frequency response of first-order RC and RL circuits, filters, solution of initial-value problems. Use of SPICE circuit simulator and hardware based laboratory.

Reference book:

Introduction to Electric Circuits - R C. Dorf and J A Svoboda [John Wiley, 2000].

Focus Area	Yes/No	Details

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Focus on Employability	Yes	The students taking the Basic Electronics course can be employed in industries focusing on chip manufacturing, hardware.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in basic electronics that become prerequisite for other subsequent courses..
Focus on entrepreneurship	No	-

IT112 Introduction to Programming (3-0-0-3)

Course objective: This course aims to introduce problem solving techniques using C programming to help the students to develop analytical and logical skills. The course starts with basic concepts of computer programming and follows in building up knowledge in program development, deployment and testing to solve computational problems. The course also provides visualization of memory and time requirements for solving problems using C programming language. The coverage of this course includes problem solving techniques, flow charts, algorithms development, pseudo codes, and implementation of algorithms using C programming.

Topics: Primitive data types, control structures, structured programming, arrays, strings, functions, and pointers including memory allocation and deallocation efficiently. Problem solving approaches such as recursive, iterative, inductive, top-down, bottom-up and backtracking should give adequate emphasis for building up logical and analytical skills while solving real-life problems using the mentioned broad concepts. At the end of the course, students will be able to develop logical and analytical ability to perceive and solve computational problems; to write and test computer programs developed with C programming language; and to work effectively with various computer software tools like editors, compilers, office automation, imaging, etc., debugging, structures, unions, file handling.

Textbook:

- C How to Program - Deitel & Deitel [PHI, 2010].
- C Programming Language – Kernighan & Ritchie [PHI, 1998].
- Let Us C – Y. Kanetkar [BPB, 2013].
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Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the Programming course can be employed in industries focusing on coding, web development.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in basic programming skills that become prerequisite for other subsequent courses..
Focus on entrepreneurship	Yes	The students apply their coding skills in entrepreneurship, start-up.

IT113 Introduction to Programming LAB (0-0-4-2):

Course objective: This course aims to provide hands-on practical knowledge on C programming on topics, exercises and use cases discussed in the course, Introduction to Programming.

Focus Area	Yes/No	Details

Focus on Employability	Yes	The students taking the Programming course can be employed in industries focusing on coding, web development.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in basic programming skills that become prerequisite for other subsequent courses..
Focus on entrepreneurship	Yes	The students apply their coding skills in entrepreneurship, start-up.

SC107 Calculus (3-1-0-4)

Course objective: The students after completing the course will get a basic overview of Calculus and its applications. They will get an insight how it is used in various applications (both old and new). Through this course students can develop the ability to apply the knowledge of mathematics, science, engineering fundamentals, and engg. specialization to the solution of complex engineering problems, understand and create mathematical arguments for solving problems, understand mathematical structures such as functions, variables, integrations and learn their uses, develop skills towards mathematical modelling and analysis of engineering problems.

Topics: This course aims at building an advanced understanding of calculus in single, multivariate and complex variables. The course includes:

Calculus of One Variable: Limits and continuity, discontinuity, Differentiation, Applications of Derivatives: mean value theorems, extreme values of a function, Taylor's series and Taylor's theorem; Integration – definite integrals, Riemann sums, The fundamental theorem of calculus, combining the fundamental theorem and the mean value theorem, The second fundamental theorem of calculus; Applications of definite integrals.

Calculus of Two or More Variables: Functions of two variables – graphs, level curves and contour plots; Differentiation – partial derivatives, total differentials and the chain rule, gradient, directional derivatives, constrained differentials, Taylor's theorem; Integration – double integral in the plane, exchanging the order of integration, double integrals in polar coordinates, change of variables, Leibniz's theorem for differentiation of integrals, triple integrals in rectangular, cylindrical and spherical coordinates. Introductory Vector Calculus: Vector fields and line integrals, Fundamental theorem of line integrals, Green's theorem; Surface integrals, Divergence theorem, line integrals in space, curl in 3D, Stoke's theorem.

Differential Equations: ODE of first order, linear ODE of second and higher order with constant and non-constant coefficients, non-homogeneous equations

Calculus of Complex Variables: Complex functions, Limit, continuity, differentiation, analytic functions, Cauchy-Riemann conditions, harmonic functions, contour integral; Exploring the infinite – infinite sequences and series, power series, Laurent Series, Singularities and Residues.

Textbook:

- Calculus and Analytical Geometry - Thomas and Finney [Addison-Wesley].
- Advanced Engineering Mathematics, Jain, RK and SRK Iyengar, Narosa,
-

Focus Area	Yes/No	Details
Focus on Employability	No	-
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in calculus that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

IC101 Introduction to ICT (1-0-2-2)

Course Objective: This course is designed to provide students a contextual understanding of different facets of ICT along with the practical exposure to basic engineering tools. Lectures will include expositions and discussions by a panel of ICT experts from academia and industry. Lab work involves visualization of spaces and objects using engineering drawing – 2D, 3D visualization, animation, projections, isometric views of lines, embedding of solids; work with lathes and CNC (Computer Numerical Control) machines for realizing complex machined parts; and working with circuit boards and chips – soldering, PCB design, multi-layer service-on-chip. The laboratory sessions for the first module includes AutoCAD/3D printer, the second module includes lathes with CNC, and the third module is on PCB design accessories.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on service on chip, prototype design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in ICT that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

PC110 Language and Literature (3-0-0-3)

Course Objective: This course is designed to introduce students to the study of the English language and literature at the undergraduate level. It follows a two-pronged approach, first, teaching the English language through literature; secondly, introducing

the students to the world of literature and teaching them strategies of reading and comprehending.

Literature is known to widen readers' perspective by sharpening critical thinking and enhancing emotional response simultaneously. This course harnesses literature to sensitize the students on the debates of culture, gender, race and class. The students are exposed to a wide variety of texts and are asked to engage with them in multiple ways through class discussions, written analysis, presentations etc. Reading diverse texts familiarizes students with the features and structures of the written language. In addition to the essential linguistic competencies, the students will acquire the sensibility to appreciate nuances of the language. The activities are centred around reading, speaking, critical thinking and writing.

Readings: The texts for the classes are selected by the Instructor from a wide range of short stories, poetry, essays, folktales, artworks, TED talks, videos, films, etc. The selected literary readings are approachable as well as complex enough to challenge the students. Some of these readings are chosen to further discussions on the intersections of class, gender, race and other issues that are crucial to the understanding of the lived human experiences.

Focus Area	Yes/No	Details
Focus on Employability	Yes	Communication skills and language proficiency helps students in employment.
Focus on Skill development	Yes	The students develop necessary skills for communicative english, writing and presentation skills
Focus on entrepreneurship	No	-

CO111 Co-Curricular Activities 1-4 (0-0-2-1)

Course Objective: This is an attempt to bring co-curricular activities within the ambit of the ICT curriculum. It is envisaged that through these courses, students will be able to internalize the ICT context in an informal setting and make the campus more vibrant. These courses run over first four semesters and are graded Pass/Fail.

Alternate between sports in odd semester and club activity participation in even semesters. Students can choose to participate in any of the large number of clubs e.g. Electronic hobby club, programming club, press club, Theatre club etc. Evaluation based on participation threshold (min activity hours). Remedial Programming and Remedial English Communication to be part of 2nd semester CoCurr-2 course. To be facilitated through Programming Club and English Literature Club and their respective faculty mentors.

Focus Area	Yes/No	Details
Focus on Employability	No	-
Focus on Skill development	Yes	This course allows students to upskill their knowledge in co-curricular activities that makes mind relaxed, looking at others and to become a responsible citizen
Focus on entrepreneurship	No	-

IC121 Digital Logic and Computer Organization (3-0-2-4)

Course objective: This course provides an introduction to the design and implementation of digital circuits and microprocessors. Topics include transistor network design, Boolean algebra, combinational circuits, sequential circuits, finite state machine design, processor pipelines, and memory hierarchy. Design methodology using both discrete components and hardware description languages is covered in the course.

Topics: Combinational Circuits: Small and large Designs, Logic Expressions, Sum of Product Expression & Product of Sum Expression, Canonical Expression, Min-Terms, Max-Terms, Logic Minimization, Karnaugh Map, K-Map Minimization, Logic Minimization Algorithm, Minimization Software

Other Gates, Buffer, Tri-State Buffer, Full Adder, Multiplexer, Decoder, Encoder, Circuit Timing Diagram, Signal Propagation Delay, Fan-In and Fan-Out, Programmable Logic Devices, Design Flow, Hardware Description Languages, Floating point standard

Sequential Circuits: Core Modules, Small and large Designs. Latches, flipflops, Registers, HDL models, FSM, Single cycle, multi cycle, pipelining, Multipliers

Memory. Multiplayers of memory, Memory types, Design Example: Multiprocessor Memory Architecture, HDL Models.

Instruction Set Architecture. Types of Instruction Set Architecture, Design Example, Advanced Processor Architectures

Computer Architecture: Interconnection, Memory Controller, I/O Peripheral Devices, Controlling and Interfacing I/O Devices, Data Transfer Mechanisms, Interrupts, Design Example: Interrupt Handling CPU. Computer Architecture: Security

Textbook:

Digital Design - M Mano and M Ciletti [Pearson]

Digital Design and Computer Architecture, Harris, Harris, 2nd Edition, Morgan Kaufmann.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on systems design and VLSI.

Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in computer organization that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

IT205 Data Structures (3-0-0-3)

Course objective: The course aims to introduce the concept of data structures, and their indispensability in implementing algorithms and also how they aid in improving performance. An extensive coverage of the well-known and important data structures and routines/algorithms associated with them will be covered. Basic algorithms as well as some more advanced ones demonstrating the use of data structures are covered. The course will also cover the analysis of the performance of data structures and algorithms, in terms of the time and space resources they consume.

Topics: Representation of data on a computer, data types & array and linked list representations, ways of representing programs and associated data on computers. Notion of the running time of an algorithm, Recurrences, Parameters of performance. Dictionary operations: Find, Max, Min, Successor, Predecessor (query operations); Insert, Delete (modify operations). List data: Stacks, queues, variants implementation using arrays and linked lists, hashing

Comparison based sorting algorithms, other sorting algorithms, lower bounds for comparison- based sorting algorithms, Best-case, worst-case and average-case running times. Quicksort, Heap Sort, insertion sort, bubble sort etc.

Maximum and minimum elements of a set, finding median, searching for an element of a given rank, finding the rank of a given element, ranks of a subset of elements, maintaining rank information for a dynamic set

Trees: Heaps, Binary search trees (BST), height of BST, Tries, Balanced BSTs, Red Black trees, AVL Trees, 2,3,4-trees, B Trees.

Graphs: Representation using adjacency matrices and adjacency lists, Graph searching algorithms BFS and DFS

Textbook:

Data Structures and Algorithms - Aho, Hopcroft and Ullman [Addison-Wesley]

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software development, coding and computing.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in data structures that become prerequisite for other subsequent courses.
Focus on entrepreneurship	Yes	Data structure is a foundational course that helps in exploring startups, entrepreneurship.

IT206 Data Structures Lab using OOP (1-0-2-2)

Course objective: Aim of this course is to provide practical exposure to different data structures and algorithms concepts that are taught in the course "IT205: DataStructures". Preferred programming language is C++.

Topics: Object Oriented Programming concepts to be taught in the lectures. OOP based implementation strategies for the data structures taught in the *Data Structures* theory course will also be discussed here.

Textbook/References:

- Data Structures and Algorithms in C++', by Goodrich, Tamassia, and Goldberg,Wiley 2011
- Other materials or references provided in due course of the LAB
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Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software development, coding and computing.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in data structures that become prerequisite for other subsequent courses.
Focus on entrepreneurship	Yes	Data structure is a foundational course that helps in exploring startups, entrepreneurship.

SC205 Discrete Mathematics (3-1-0-4)

Course objective: Students are expected to learn logical reasoning to solve variety of problems to learn different proof methods, algorithms to solve problems, and to learn discrete probability and number theory to solve problems.

Topics: Mathematical Logic and Proof Techniques: Propositional logic, Predicates and quantifiers, Rules of inference, Basic proof techniques.

Basic Discrete Structures: Sets, Functions, Sequences and summations, Matrices

Fundamentals of Algorithms and Number Theory. Growth of functions, Complexity of algorithms, Modular arithmetic, primes and representation of integers

Relations: Relations and their properties, Representation of binary relations; Equivalence relations; Closure of relations, and Partial orderings;

Induction and Recursion: Induction, strong induction, well-ordered property, recursion, structural induction, and generalized induction; Combinatorial Principles and Techniques, Counting, pigeonhole principle, permutations and combinations, binomial coefficients and identities, principle of inclusion-exclusion.

Graphs: Basic graph terminology, Operations on graphs, subgraphs, representation of graphs, Isomorphism of graphs

Textbook:

- Discrete Mathematics and its Application - K. Rosen [Tata McGraw Hill, 2011].
- Discrete Mathematical Structure - B. Kolman, R.C. Busby and S. C. Ross [PHI, 2000].
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Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software development.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in discrete mathematics that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

HM106 Approaches to Indian Society (3-0-0-3):

Course Objective: This course aims to construct a comparative framework for the understanding of different cultures with particular reference to social organization, politics, religion and symbolism illustrated with various ethnographic examples. The

course is designed to provide with the means to apply basic anthropological understandings of society and culture in the analysis of meanings, actions and explanations that is the basis for communication in the society. Student will be expected to reflect upon the Indian society utilizing the readings and lectures.

Readings: The reading materials for this course will be selected by the instructor from the wide range of texts available in the resource centre. The pointers for reading will be provided to students by the course instructor.

Focus Area	Yes/No	Details
Focus on Employability	No	-
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in culture, society and identity.
Focus on entrepreneurship	No	-

SC217 Electromagnetic Theory (3-1-0-4)

Course objective: The course is targeted at students of engineering who want to understand medium and its response to a signal. Electromagnetic wave is the simplest signal, its propagation, energy associated with such wave and the techniques to understand its behavior in different media, are what under the scope of this course.

Topics: It starts with vector algebra, basic operations of del operator in different coordinate systems, connection between inverse square law and Gauss's law, Stoke's theorem. It introduces the electric charge and electric current as sources of the vector fields E and B, Ampere's law as an integral statement of Biot-Savart law and thus covers concept of field energy. It discusses Faraday's law as connecting link between E and B

fields leading to Maxwell's equations. Wave equation, Poynting vector and Poynting Theorem, plane electromagnetic waves in vacuum and in other media, polarization, reflection and refraction at interfaces will be covered in this course. Concept of waveguides and radiation from different antenna systems will also be introduced. In this way the course will prepare students to take up advanced ideas in radio frequency engineering or communications. This will also let the students get a first glimpse of kind of ideas involved in several branches of Physics.

Textbook

Introduction to Electrodynamics - David. J. Griffiths [Pearson, 2012].

Focus Area	Yes/No	Details
Focus on Employability	No	-
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in the course that becomes a prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

PC125 Exploratory Project 1 (0-1-0-1) and PC222 Exploratory Project 2 (0-0-2-1)

Objective: This course allows students to explore their surroundings to identify interesting problems that admit a hardware based solution and design and make such a product by leveraging the engineering workshop skills learnt in the first semester. Students are expected to work in groups of 8 to 10 under a faculty mentor and conceive and implement a project over two semesters. The course will conclude with a class demonstration and exhibition. This course will be graded on Pass/Fail basis.

Focus Area	Yes/No	Details
Focus on Employability	No	-
Focus on Skill development	Yes	The students develop necessary skills to develop hands-on knowledge in the course that becomes a prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

CT203 Signals and Systems (3-1-0-4)

Course Objective: This course concentrates on classification and description of signals and systems. The emphasis is primarily on linear time invariant systems using both the time domain and frequency domain representations.

Topics: Introduction: Signal, System and their coupling, Practical applications: Speech, audio, music, image, video, etc. Standard Problems in Signals and Systems: Analysis of Systems via impulse-like excitation, step, or sinusoidal excitation, Design of Systems (filtering), Design of Signals (modulation), Information Extraction and Pattern Recognition, Instrumentation and Process Control, Inverse Problems (super-resolution, measurement noise).

Basic mathematical background: Signal modelling via Vectors, Complex Number, Cartesian vs. Polar Representation, Argand's diagram, geometrical interpretation of j=sqrt(-1), Euler's formula, Linear combination. Signals and Systems as study of linear combinations.

Energy and Power signals, Periodicity, Complex exponential, impulse, step signals. System properties: linearity, time-invariant, causality.

Fourier analysis and LTI systems: Analysis of Periodic Signals: Fourier series (CTFS vs. DTFS), Properties. Dirichlet Conditions, Michelson's effect or Gibbs Phenomenon, Analysis of Aperiodic signal: Fourier transform, CTFT, DTFT, Properties, Hilbert transform, Energy Spectral Density (ESD) and Power Spectral Density (PSD), Time and frequency-domain representation: Significance of Fourier transform Phase (Image Processing, Speech and Audio, Ocean Acoustics, etc.)

Sampling and Reconstruction, Shannon's sampling theorem, Shannon's Standard three-step Setup , Limitation of Shannon's Sampling Paradigm:

Laplace transform, ROC, Poles and zeroes, System Function in s-domain, Electrical circuit analysis, Solution of differential equation,Z-transform, ROC, Poles and zeroes, Properties,

Textbook:

Signals and Systems - A. V. Oppenheim, A. S. Wilsky and S. H. Nawab [PHI, 1999].

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication engineering.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in signals and systems that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

IT216 Design and Analysis of Algorithms (3-1-0-4)

Course Objective: This course intends to provide a rigorous introduction to fundamental techniques in the design and analysis of algorithms.

Topics: The course aims to cover the asymptotic notation, divide and conquer techniques, recurrences, sorting and searching algorithms, depth first search, breadth-first search, topological sort, minimum spanning trees, greedy algorithms, dynamic programming, pattern matching, NP-completeness and approximation algorithms.

Textbook:

- Introduction to Algorithms - Cormen, Leiserson, Rivest and Stein [PHI, 2010].
- Algorithm Design - Kleinberg and Tardos [Addison-Wesley, 2005.].
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Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software development, coding and computing.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in Algorithms that become prerequisite for other subsequent courses.
Focus on entrepreneurship	Yes	Algorithms is a foundational course that helps in exploring startups, entrepreneurship.

SC223 Linear Algebra (3-1-0-4)

Course Objective: Vectors is an essential idea to understand numerous natural phenomenon. Its applications starts right from mechanics and electrostatics and magnetostatics. These applications use equations involving vectors. Such ideas are abstracted to study solutions of a system of linear equations in several variables. A general framework abstracting general properties of vectors is called the vector space. Once abstracted these ideas unify several areas of physics, engineering and mathematics. This is essentially due to linear response approximation in most applications. Vector spaces helps in understanding ideas in coding theory and cryptography for ICT students.

Topics: Linear Equations: System of Linear Equations, Elementary Row Operations, RREF, Invertible Matrices.

Vector Spaces: Basic definitions and properties, Subspace, Linear Independence, Bases and Dimension , Co-ordinates, Direct sum of subspaces

Linear Transformations: Definition , Matrix representation of linear transformations, Invertible transformations, Change of Basis, Fundamental Subspaces, Definition of Rank and Nullity and the Rank-Nullity theorem, Dual spaces. Inner product spaces. Orthogonality, Gram –Schmidt orthogonalization, Orthogonal (Fourier) expansions, Orthogonal Projections, Rotations and reflections in real vector spaces

Eigenvalues and Eigenvectors: Definition of Eigen values and Eigen vectors, The Characteristic Polynomial, Diagonalization and conditions , algebraic and geometric multiplicities, Diagonalization of real symmetric matrices, Solving differential equations by diagonalization, Exponential of a matrix

Complex vector spaces: The complex inner product, definition of Adjoint Hermitian and Unitary matrices, Normal matrices, Spectral theorem and Singular value decomposition

Textbooks:

- Linear Algebra, Kenneth Hoffman, Ray Kunze
- Linear Algebra and its application David C. Lay

- Linear Algebra, Jin Ho Kwak, Sungpyo Hong
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Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on Machine Learning, Data Science.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in Linear Algebra that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

HM216 Science, Technology, Society (3-0-0-3)

Course objective: This course is designed to encourage students to understand, explore and critically analyze ways in which science and technology work in diverse social contexts. It draws its basic approaches from Science and Technology studies (STS) which is a growing field of interdisciplinary studies that seeks to understand how science and technology shape human lives and livelihoods and how society and culture, in turn, shape the development of science and technology. By focusing attention on science and technology as disciplinary practices situated in wider historical, social, and political contexts, the course offers insights into the deep relationship between science and technology and such basic categories of social thought as race, caste, class, gender, colonialism, nationalism, democracy and development and social justice among others.

Selected Readings:

- Sergio Sismondo, 2009, An Introduction to Science and Technology Studies, 2nd Edition
- October, Wiley-Blackwell
- Kuhn TS (1962) The Structure of Scientific Revolutions. Chicago: University of Chicago Press.
- Bijker, Wiebe E., Hughes, Thomas Parke., Pinch, T. J. 2012, The Social Construction of Technological Systems : New Directions in the Sociology and History of Technology, Cambridge, Mass. MIT
- Jasanoff S (ed.) (2004) States of Knowledge: The Co-Production of Science and Social Order. London: Routledge.
- Arnold, D. (2000). Science, Technology and Medicine in Colonial India (The New Cambridge History of India). Cambridge: Cambridge University Press.
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Focus Area	Yes/No	Details
Focus on Employability	No	-
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in science, technology and society.
Focus on entrepreneurship	No	-

IT227 Computer Systems Programming (3-0-2-4)

Course objective: The course takes an introductory look at the core abstractions in operating systems: processes, virtual memory and files. It takes an in-depth look at the OS services provided by system calls, how system calls work, and how they can be used. Students will become familiar with writing application programs using system calls.

Topics: Key OS abstractions: processes, virtual memory and files, virtual address space, system calls, interrupts, user and kernel mode, process state transition, context switching, saving and restoring context

Process creation, process termination, reaping child processes, putting processes to sleep, loading and running programs, Unix shell

Signal terminology, sending signals, receiving signals, normal and abnormal termination, signal blocking, job control using signals

Address translation, segmentation, page tables, TLB, page fault control flow, page replacement policies, Belady's anomaly, thrashing, case study: Linux VM system

Opening and closing files, Unbuffered I/O vs buffered I/O, directories, file metadata, file sharing, symbolic link, I/O redirection

Thread creation, thread termination, reaping terminated threads, thread memory model, shared variables, race conditions

Mutual exclusion problem, solutions to mutual exclusion problem using locks/semaphores, deadlocks, necessary conditions for deadlock, dining-philosophers problem, producer-consumer problem, readers-writers problem

Textbooks:

- Bryant and O'Hallaron, Computer Systems: A Programr's Perspective, 3rd edition, Pearson India, 2016.
- *Operating Systems: Three Easy Pieces*, Remzi H. Arpaci-Dusseau and Andrea C. Arpaci-Dusseau, 2018, Version 1.00. (Freely available online.)
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Focus Area	Yes/No	Details

Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software engineering, developer.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in systems software that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

SC224 Probability and Statistics (3-0-1-4)

Course objective: The course introduces students to the basics of probability and statistics. Probability theory has got wide scale applications in mathematics, engineering and finance. The student is introduced to the axiomatic way at looking at probability invented by Kolmogorov. The different types of random variables (both discrete and continuous) are introduced with context and examples. The student learns the limit theorems such as the central limit theorem with their applications. The course ends with some introductory statistics in the form of estimation and regression. The course has mathematical rigor but at the same time practical examples as well as an experimental approach where the students can simulate probabilistic situations on a computer is encouraged.

Topics: Introduction to probability: Axiomatic probability: Sample space, sigma algebra of event space, Probability measure. Conditional probability, Reduced sample space, Law of total probability and Bayes theorem, Independence

Random variables: Probability mass functions of discrete r.v.'s, Distribuiton functions, Discrete r.vs Binomial, Poisson, Geometric Continuous r.v.'s : Uniform, Exponential, Gaussian, Expectations and Variance and their properties, Linearity of expectations and applications

Joint distributions: Conditional distributions, Marginal distributions, Covariance Transformations of r.v.'s

Limit theorems and applications, Law of large numbers, Central Limit theorem

Inequalities: Markov, Chebychev inequality and Chernoff bounds.

Introduction to Statistics, Point and interval estimation, Maximum likelihood estimation, Introduction to linear regression

Textbooks:

- A first course in probability, Sheldon Ross
- Probability and Statistics for Engineers, Sheldon Ross
- Introduction to Probability Grinsead and Snell
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Focus Area	Yes/No	Details
Focus on Employability	No	-
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in probability and statistics that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	

HM116 Principles of Economics (3-0-0-3)

Course Objective: This course provides students an understanding of what is Economics, the problems of Economic Organization, what, how and for whom to produce.

Topics: Demand and Supply, elasticity of demand and supply, consumer behavior and demand, theory of production, analysis of cost, overview of the market structure and various types of markets, perfectly competitive market, monopoly, oligopoly and

monopolistic markets. It also emphasizes on aggregate demand and aggregate supply, determination of national income, consumption, saving and investment, business cycle and aggregate demand, balance of international payment, International Monetary Systems, International Institutions, problems of Indian Economy, Mixed Economy and Welfare State, Planning, Liberalization, India as a Knowledge-Based Economy.

Readings:

- Economics - Samuelson and Nordhaus [Tata-McGraw Hill, 2006].
- Indian Economy - Datt & Sundharam [S. Chand & Co., 2004].
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Focus Area	Yes/No	Details
Focus on Employability	No	-
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in economics that helps students taking related elective courses.
Focus on entrepreneurship	No	-

CT216 Introduction to Communication Systems (3-0-2-4)

Course objective: This is a foundation course for analog and digital communication and other advanced communication courses. The objective of this course is to make the students appreciate what a telecommunication system is, why it is required and its fundamental concepts.

Topics: The course will include the topics of Analog Communication (Review of Fourier Transform and Its Properties, Amplitude Modulation (DSB, DSB-SC, SSB, Hilbert Transform), Frequency Modulation, demodulation techniques, Performance analysis of the AM and the FM transceivers in the presence of noise), Digital Communication (Shannon Theory of Information, energy and spectral efficiencies, the Entropy concept, sampling theorem, ideal and practical sampling, scalar quantization, PCM, adaptive delta modulation, speech coding, digital modulation techniques, etc.) and Applications (wireless communication systems (wireless channel models, TDMA, FDMA, CDMA), SATCOM, fiber optic systems, microwave transmission engineering, transmission line concepts).

Textbook:

- Introduction to Communication Systems – Upmanyu Madhow
- Digital and Analog Communication Systems – L. W. Couch

Focus Area	Yes/No	Details
Focus on Employability	No	-
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in communication systems that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

IT214 Database Management Systems (3-0-3-4.5)

Course objective: In DBMS, students will learn Relational databases in detail.

Topics: The course contains database architecture, E-R data model, Relational data model. Relational Query languages: Relational algebra and SQL, Database design: E-R model, Functional dependency and normalization, Physical design: Data storage and indexing, Query Processing and Optimization, Materialized Views. Transaction management: concurrency control protocols: lock-based, time stamp based, validation based protocols. Crash recovery: Buffer management, ARIES algorithm. Distributed Databases: data storage, query processing and optimization, transaction processing, cloud databases. Data Warehousing and Mining: Basic concepts, decision support systems, decision tree, association rules, clustering algorithms. Research issues in modern databases

In the labs, the students will learn to design, implement and query a database using a DBMS tool like postgres or Oracle. They will also learn to connect application with a database.

Textbook

Silberschatz, Korth & Sudarshan, Database System Concepts, Seventh Edition, 2019, McGraw –Hill

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking DBMS course can be employed to industries focusing on database and software development.
Focus on Skill development	Yes	The students develop necessary skills to work with real use cases using databases.
Focus on entrepreneurship	Yes	The students can work on real time projects

		focusing on development of small, medium and large enterprises through entrepreneurship/self-employability and start-ups.

EL203 Embedded Hardware Design (3-0-2-4)

Course Objective: This course aims to cover computing devices, associated peripherals and networks along with high level software(C) and hardware language (Verilog HDL) which are used in the design of a modern day embedded system.

Topics: Since peripherals and networks are independent of the computing device used, the course would first only consider the Microcontroller as a computing device and build up the concept of peripherals and networks around it. Standard peripherals like Analog to Digital and Digital to Analog Converters, Universal Asynchronous Receiver Transmitter, Interrupt Controller, Programmable Peripheral Interface, Real Time Clock will be covered. Different communication standards and protocols such as RS 232, RS 485, I2C, Controller Area Network, Input output devices like keyboard, keypad and LCD would be discussed. Multitudes of computing devices that are used in an embedded system such as General Purpose Processors, Micro controllers, Digital Signal Processors, Programmable Logic Devices, custom designed Application Specific chips will be introduced. The course will focus on the architecture and C programming using the AVR microcontroller followed by digital circuit design using Hardware Description Language (Verilog) using Field Programmable Gate Array (FPGA) for prototyping.

Textbook:

- Designing Embedded Hardware - John Catsoulis [O'Reilly].
- Embedded C programming and the Atmel AVR - Barnett, O'Cull, Cox [Cengage Learning].

Focus Area	Yes/No	Details

Focus on Employability	Yes	The students taking the course can be employed in industries focusing on chip manufacturing, hardware.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in embedded systems.
Focus on entrepreneurship	Yes	Embedded Hardware Design offers a lot of opportunities for start-ups, entrepreneurship.

CT303 Digital Communications (3-0-2-4)

Course objective: The course aims to cover introduction to digital communication systems and digitization of analog signals-analog versus digital communications

Topics: Overview of digital communication based system, review of sampling theorem, ideal and practical sampling, aliasing, analog signal reconstruction from discrete-time samples, pulse code modulation (PCM): uniform and non-uniform quantization and companding, and Differential PCM; Digital modulation - signal space concepts: representation of signals as vectors and Gram-Schmidt orthonormalization. Signal representation and constellations: amplitude shift keying (ASK), phase shift keying (PSK), rectangular and non-rectangular quadrature amplitude modulation (QAM) and frequency shift keying (FSK). Design for bandlimited channels: power-bandwidth tradeoff and Nyquist criterion for ISI avoidance; Digital demodulation and detection - optimal demodulation in additive white Gaussian noise (AWGN): maximum-likelihood (ML) decision rule and minimum probability error (MEP) decision rule. Realization of optimal receiver using matched filters. Performance analysis of ML reception and link-budget analysis; and Elements of Information theory-notion of channel capacity, capacity of discrete-time AWGN channel: sphere packing interpretation,

capacity of band-limited AWGN channel, power- bandwidth tradeoff in bandlimited AWGN channel, and design implications of Shannon limits.

Textbook:

- Introduction to Communication Systems - U. Madhow [Cambridge University Press].
- Digital Communications - J G Proakis and M A Salehi [McGraw Hill].

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication engineering.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in digital communication..
Focus on entrepreneurship	No	-

CT304 Computer Networks (3-0-2-4)

Course objective: The course explains the evolution of computer and communication networks and the design principles of modern network architectures. Primary focus is on system level concepts and engineering design and implementation issues. Some of the recent advancements including multimedia networking, and Software Defined Networking (SDN) will also be studied. In addition, we will study the design and implementation of modern network applications using sockets library. The associated laboratory component is designed to expose students to the network simulation tools for the analysis of traffic and network protocols.

Topics: Overview: Internet-Birds' Eye View, History, Internet-Layered Architecture, Packet Switching, Best Effort Services

Network Applications: Client-Server Applications, Chat Application Design, Socket Programming, SFTP File Transfer Protocol, Domain Name Service, Mail, SMTP, Peer to Peer Search, Distributed Hash, Video Streaming, DASH, Content delivery Networks.

End to End Issues, Transport Layer Basics, Reliability, Connectionless and Connection Oriented Transport, TCP and UDP protocols, Congestion Management, TCP Performance Measure

Routing and Congestion: Scheduling, Best Effort Service, Scheduling for Guaranteed Service, Switching. Packet Switching, Batcher Banyan Switch, Routing - Introduction, Multicast, Broadcast, Addressing, CIDR, IP Protocol IPv4, IPv6. Hierarchical Routing, BGP, Mobile Routing, Control and Data Path, Open Flow, Software Defined Networking

Link Layer Technologies: Media Access Protocols, ALOHA, IEEE 802.3 Ethernet Protocol, MACA, Switched LAN, Virtual LANs

Wireless Networks: IEEE 802.11 MAC protocol, Cellular architecture and Mobility management. Introduction to Network security.

Textbook:

- Computer Networking: A Top-Down Approach - Kurose and Ross [Pearson, 2012].
- Computer Networks: A Systems Approach - L. L. Peterson and B. S. Davie [Morgan Kaufmann, 2011].

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on Software Engineering, Network Administrator.

Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in computer networks.
Focus on entrepreneurship	No	-

IT314 Software Engineering (3-0-2-4)

Course objective: The Software Engineering course introduces the basic principles, practices, tools and techniques required to engineer large complex software systems. The course is project intensive, where students learn by example and practice. The main objective is to understand and learn how complexity and change are engineered during large software development. Here, we would focus on the methodologies (processes), techniques (methods), and tools that can be used to successfully design and validate large software. Wherever relevant, we will make use of various technologies (e.g., DevOps, CASE) to represent various aspects of software development.

Topics: The contents 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) Computer Aided Software Engineering and Tool Support (DevOps, Automation), (5) Software Quality Standards and Quality Assurance, (6) Applications of ML and AI in analyzing software products.

Course Project Outline: Specific to the software process model chosen for development of the course project. For example, for Agile Process Model (SCRUM) 1. Requirements in the form of user story (both functional and non-functional), 2. Acceptance Criteria, 3. Burn-down chart, 4. Daily SCRUM planning and development of sprints

Textbooks:

- Shari Lawrence Pfleeger, and Joanne M. Atlee, Software Engineering: Theory and Practice, 4th Edition, 2006, Pearson.
- Pressman, Roger S. Software engineering: a practitioner's approach. Palgrave Macmillan, 2015.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on Software Engineering.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in software engineering.
Focus on entrepreneurship	Yes	Software Engineering is an essential course for start-ups and entrepreneurship.

SC209 / MC226 Environmental Science (3-0-0-3)

Course objective: Sensitize students on various issues and problems of environment affecting our society. Allow students to do hands on exercise on few specific problems related to environment. Enable the student to conceive ICT based solution of the environmental problems. With the broad understanding of the environment and underlying principles, the students should be able to relate the changes and challenges of environment related issues.

Topics: Introduction to environmental science as a multidisciplinary subject - Definition, scope and importance. Biogeochemical cycle - Hydrologic, carbon, nitrogen, phosphorus and sulphur cycles

Ecosystems e.g. forest, agriculture, desert and aquatic (both inland and marine) ecosystems Natural Resources - energy, land, water and air resources - conservation, development

Biodiversity and its conservation – Biodiversity at global, National and local levels, Threats and Conservation of biodiversity

Environmental Pollution - Air pollution, Water pollution, Marine pollution. Climate change, global warming, climate feedback loops, climate change and the oceans, responding to climate change. Environment laws and statutes. Anthropological and economic perspective of environment

Thermodynamic principles applied to environment. Modeling and simulation applied to environmental processes.

Textbook:

Environmental Studies for Undergraduate Courses – E Bharucha [UGC Publications]

Focus Area	Yes/No	Details
Focus on Employability	No	-
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in environmental science.
Focus on entrepreneurship	No	-

MC111 Mathematical, Algorithmic, and Computational Thinking (3-1-0-4)

This course aims to motivate students with mathematical, analytical, logical thinking with emphasis on algorithmic and computational thinking.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on computing.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in mathematical and algorithmic thinking.
Focus on entrepreneurship	No	-

MC112 Computer Organization and Programming (3-0-0-3) /

MC113 Computer Organization and Programming Lab (0-0-4-2)

Model of computer and working principle, digital logic building blocks, information representation and number systems, basic elements of a processor, storage and I/O interface, assembly-level programming, execution of program and programming languages, pipelining, components of CPU and external interface, main memory, instruction execution, instruction format, instruction set, addressing modes, flags and conditional instructions, procedure call and return, instruction cycle and micro-operations, handling different addressing modes, handling control transfer instructions, basics of memory and cache, direct-mapped caches – misses, writes and performance, associative and multi-level caches, virtual memory and address translation, paging and segmentation, page replacement algorithms, page frame allocation and thrashing

Idea of algorithms, flowchart, pseudocode, introduction to programming language concepts, variables and memory, types of software and compilers, introduction to C programming language, variables and variable types in C, functions, address and content of variables and types, assignment statement and operators in C, arithmetic and relational expressions, logical operators and change in control flow, use of logical operators in branching, if…else statement, switch statement, implementing repetitions (loops), loops through for statement, programming using arrays, linear search, character array and strings, string operations, 2D array operation, scanf and printf functions, function prototype, parameter passing in function, substitution of # include and macro, use of pointers in function, data representation, recursion, structure, structure with typedef, pointer in structures, dynamic allocation and file

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on systems design and VLSI.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in computer organization that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

MC116 Digital Logic Design (1-0-2-2)

This course provides an introduction to digital logic design and its applications.

Focus Area	Yes/No	Details

Focus on Employability	Yes	The students taking the course can be employed in industries focusing on systems design and VLSI.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in computer organization that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

MC125 Functions of Single Variable and ODEs (3-1-0-4)

Real numbers, functions, sequence, limits and continuity, properties of continuous function, uniform continuity, derivative, maxima and minima, Rolle's theorem, mean value theorem, indeterminate forms, Taylor's polynomial and Taylor's series, curve sketching, infinite series, tests of convergence, power series, Riemann integral, Riemann integrable function, applications of Riemann integration,

Introduction to ordinary differential equations, existence and uniqueness of solutions of differential equations, first order differential equations, exact differential equations, first order linear differential equations, higher order linear differential equations, solution of higher order homogeneous linear equations, solutions of higher order non-homogeneous linear equations, Cauchy-Euler equations, power series solution of second order homogeneous equations, BVPs for second order differential equations,

Transform Calculus – Introduction to integral transforms and Laplace transformation, existence of Laplace transformation, Shifting properties of Laplace transformation, Laplace transformation of derivatives and integrals of a function, Laplace transform of periodic functions, Laplace transform of some special functions like error function, Dirac delta function, Bessel function, inverse Laplace transform, convolution and its application, evaluation of integrals using Laplace transform, Solution of ODEs with constant

coefficients using Laplace transform, solution of ODEs with variable coefficients using Laplace transform, introduction to integral equation and its solution process, Fourier series, Fourier series of even and odd functions, Fourier series of functions with arbitrary period, Half-range Fourier series, introduction to Fourier transform

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking this course can be employed to industries focusing on Maths and Computing.
Focus on Skill development	Yes	The students develop necessary foundational skills in functions of single variable and ODEs.
Focus on entrepreneurship	No	-

MC216 Probability and Random Processes (3-1-0-4)

Random experiment, sample space, axioms of probability, probability space, conditional probability, independence of events, multiplication rule, total probability rule, Bayes' theorem, random variable, cumulative distribution function, types of random variables, probability mass function, probability density function, distribution of function of random variables, mean and variance, higher order moments and inequalities, generating functions, common discrete distributions, applications of random variables, random vector and joint distribution, joint probability mass function, joint probability density function, independent random variables, functions of several random variables, order statistics, conditional distributions, random sum, moments and covariance, variance-covariance matrix, multivariate normal distribution, probability generating function and moment generating function, correlation coefficient, conditional expectation, modes of convergence, law of large numbers, central limit theorem, stochastic processes,

classification of stochastic processes, Bernouli process, Poisson process, simple random walk, time series, strict sense stationary process, wide sense stationary process, discrete time Markov chain,

Chapman-Kolmogrov equations and N-step transition matrix, classification of states, limiting and stationary distributions, continuous time Markov chain, state transition diagram and Chapman-Kolmogrov equation, infinitesimal generator and Kolmogrov differential equations, limiting and stationary distributions, birth-death process, Poisson process, non-homogeneous and compound Poisson process, introduction to queueing models and Kendall notation, M/M/1 queueing model, M/M/c queueing model, M/M/1/N model, other Markovian queueing models, transient solution of finite capacity Markovian queues.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on machine learning, data science.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in linear algebra and random processes.
Focus on entrepreneurship	No	-

MC122 Object Oriented Programming (2-0-2-3)

Recap of structured programming - programs with I/O and loops, arrays and strings, sorting and searching, constants and inline functions, reference and pointers, default parameters and function overloading, operator overloading, dynamic memory management.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the Programming course can be employed in industries focusing on coding, web development.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in OOPs and OODs.
Focus on entrepreneurship	Yes	The students apply their coding skills in entrepreneurship, start-up.

MC124 Data Structures and Algorithms (3-0-2-4)

Abstract data types – data + methods, list data type, access and update methods, doubly linked list data type, arrays, ADT stacks, applications of stacks for checking balanced parenthesis, infix and postfix expression evaluation, ADT queues, merging using queue ADT and queue types, non-linear data structures – Tree ADT and its traversals, Binary Tree ADT and its traversals, applications of Tree ADTs in Huffman coding, Dictionary - BSTs, balanced BSTs, ADT priority queues and heaps, Graph ADT, transitive closure, Floyd Warshall algorithm, connectedness, spanning trees, BFS, DFS.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software development, coding and computing.

Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in discrete mathematics that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

MC221 Mathematical Statistics (3-1-0-4)

Introduction to descriptive statistics and frequency distributions – types of data, categorical data, describing categorical data, describing numerical data, association between categorical variables, association between numerical variables, , graphics and plots, central tendency of data – arithmetic mean, median, quantiles, mode, geometric and harmonic mean, range, interquartile range, quartile deviation, absolute deviation and absolute mean deviation, mean least squared error, variance and standard deviation, coefficient of variation, raw and central moments, skewness and Kurtosis, correlation coefficient, rank correlation coefficient, method of least squares, correlation and regression, normal distribution, bivariate normal distribution, distribution of order statistics, Chi-square distribution, t-distribution, F-distribution, unbiased and consistent estimators, LSE, MME, MLE, MSE, UMVUE, sufficiency, completeness, Rao-Blackwell theorem and its applications, confidence intervals, types of errors, Neyman-Pearson fundamental lemma and its applications, testing of hypothesis – testing of normal mean, testing of normal variance, large sample test for variance, paired t-test, testing equality of proportions, Chi-square test for goodness fit, testing for independency in rxc contingency.

Focus Area	Yes/No	Details

Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in data structures that become prerequisite for other subsequent courses.
Focus on entrepreneurship	Yes	Data structure is a foundational course that helps in exploring startups, entrepreneurship.

MC123 Discrete Mathematics (3-1-0-4)

Sets, set operations and laws of set operations, the principle of inclusion-exclusion and its applications, fundamentals of logic, logical inference, methods of proof of an implication, first order logic, rules of inference for quantified propositions, mathematical induction, graphs, isomorphism and subgraphs, walks, paths and cycles in graphs, bipartite graph, Euler graphs, Hamilton graphs, shortest path problem, planar graphs, relations, properties of relations, graph of a relation, matrix of a relation, closure of relation, Warshall's algorithm, partially ordered relation, posets, lattices, Boolean algebra, Boolean function, discrete numeric function, generating function, recurrence relations and its applications, permutations, combinations and the binomial theorem, congruences and modular arithmetic, the Chinese remainder theorem, the Euclidean algorithm.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software development.

Focus on Employability	Yes	The students taking the course can be employed in industries focusing on data science.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in statistical methods.
Focus on entrepreneurship	No	-

MC214 Operating Systems (3-0-2-4)

Introduction to OS, PC hardware, from programs to processes, sharing the CPU, virtual memory, MMU mapping, segmentation, memory management in xv6, PC booting, create, execute and exit from processes, system calls for process management, interrupts, interrupt handling, software interrupts and system calls, CPU context switching, CPU scheduling, priority based scheduling algorithm, multi-processor scheduling, scheduling in Linux, completely fair scheduling, inter process communication, synchronization, software solutions for critical sections, Bakery algorithm, hardware locks, mutexes, semaphores, dining philosophers problem, deadlocks, dealing with deadlock, threads, OS security, information flow policies, buffer overflows, preventing buffer overflow attack.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software engineering, developer.

Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in operating systems.
Focus on entrepreneurship	No	-

MC213 Design and Analysis of Algorithms (3-1-0-4)

Input size, worst case, average case, quantifying efficiency – O( ), Omega(), Theta( ), analysis of iterative and recursive algorithms, substitution method, The master method, divide-and-conquer, Straseen's algorithm, arrays and lists, searching in an array, selection sort, insertion sort, merge sort and its analysis, quick sort and its analysis, randomized quicksort, heap, heapsort, decision tree, linear time sorting, radix sort and bubble sort, order statistics, randomized order statistics, worst case linear time order statistics, hash function, open addressing, universal hashing, perfect hashing, BST sort, randomly build BST, Red Black tree, augmentation of data structure, interval trees, fixed universe successor, Van Emde Boas data structure, amortized analysis, representing graphs, DFS and BFS with applications, topological sort on DAGs, longest paths on DAGs, single source shortest paths – Dijkstra's algorithm and its analysis, negative edge weights – Bellman Ford algorithm, all pair shortest paths, minimum cost spanning tree – Prim's and Kruskal's algorithm, union-find using arrays, union-find using pointers, priority queues, heaps – updating values and sorting, counting inversions, closest pair of points, BSTs – interval scheduling, scheduling with deadlines, Huffman codes, dynamic programming – memorization, grid paths, common subwords and subsequences, edit distance, matrix multiplication, matrix inversion and decomposition, Knuth-Morris-Pratt algorithm, Rabin-Karp algorithm, integer polynomial operations, Chinese remainder, DFT, LP modelling – production planning and bandwidth allocation, network flows – Edmond's matching algorithm, Ford-Fulkerson method, Edmond-Karp algorithm, reductions, checking algorithms, P and NP, approximation algorithms

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software development, coding and computing.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in Algorithms that become prerequisite for other subsequent courses.
Focus on entrepreneurship	Yes	Algorithms is a foundational course that helps in exploring startups, entrepreneurship.

MC313 Algebraic Structures (3-1-0-4)

Set theory, binary relation, equivalence relation, mapping, permutation, binary composition, groupoid, group, basic properties of groups and group tables, order of an element, subgroup, types of groups, cyclic group, subgroup operations, group homomorphisms, group isomorphisms, normal subgroups, equivalence relations, cosets and Lagrange's theorem, quotient groups, first, second and their isomorphism theorems, Cauchy's theorem, symmetric groups, odd and even permutations, alternating groups, group actions, orbits and stabilizers, counting formula, Cayley's theorem, class equation, group action on subsets, rings, polynomial rings, homomorphisms, kernels, ideals, quotient rings, first isomorphism and correspondence theorems, prime ideals, maximal ideals, integral domains, existence of maximal ideals, field of fractions, Noetherian rings, Hilbert basis theorem, irreducible and prime elements, GCD, principal ideal domains, unique factorization domains, Gauss lemma, Eisenstein criterion, field extensions, degree of a field extension, algebraic elements of a field, field homomorphisms, splitting fields, finite fields.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on Machine Learning, Data Science.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in Algebraic structures.
Focus on entrepreneurship	No	-

MC223 Theory of Computation (3-1-0-4)

Alphabets, strings, languages, finite representation, CFG, derivation trees, regular grammars, finite automata, nondeterministic finite automata, equivalence of NFA and DFA, language of DFA, Myhill-Nerode theorem, building DFA, minimization of finite automata, subset construction, RE, FA, RG and their equivalences, variants of finite automata, properties of regular languages, homomorphism, substitution, pumping lemma, Ardena's theorem, two way FA, finite automata with output, equivalence of Moore and Mealy machines, simplification of CFG, normal forms of CFG, properties of CFLs, derivation/parse tree, left and rightmost derivations, ambiguity of CFG, simplification of CFG, algorithms to construct reduced grammar, elimination of null and unit productions, Chomsky normal form, Greibach normal form, pushdown automata, equivalence of PDA and CFG, Turing machines, Turing compatible functions, combining Turing machines, multi-input, Turing decidable language, variants of Turing machines, structured grammars, decidability and undecidability, time bounded Turing machines, P and NP, NP-Completeness, NP-Complete problems, Rice's theorem, Chomsky hierarchy, new paradigms for computing – DNA computing, membrane computing, quantum computing.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on theory of computation.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in models of computation.
Focus on entrepreneurship	No	-

MC215 Linear Algebra (3-1-0-4)

Course Objective: Vectors are an essential idea to understand numerous natural phenomena. Its applications start right from mechanics and electrostatics and magnetostatics. These applications use equations involving vectors. Such ideas are abstracted to study solutions of a system of linear equations in several variables.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on Machine Learning, Data Science.
Focus on Skill development	Yes	The students develop necessary skills to

		develop foundational knowledge in Linear Algebra that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

MC211 Functions of Several Variables and PDEs (3-1-0-4)

Limit of functions of two variables, evaluation of limit of functions of two variables, continuity of functions of two variables, partial derivatives of functions of two variables, partial derivatives of higher order, derivative and differentiability, differentiability of functions of two variables, composite and homogeneous functions, chain rule, Euler's theorem for homogeneous functions, Taylor's theorem for functions of two variables, extrema of functions of two variables, constrained extrema-Lagrange multipliers, improper integrals, Beta & Gamma function, differentiation under integral sign, double integrals, double integral over a region, double integrals in polar form, change of order of integration, change of variables in a double integral, surface area through double integrals, triple integrals, area of a plane region, surface integral, volume integral, Gauss divergence theorem

Vector calculus – vector differentiation, successive differentiation, integration of vector function, gradient of a function, divergence and curl, directional derivatives, level surfaces, line integral, surface integral, Green's theorem, volume integral, Gauss theorem, Gauss divergence theorem, Stoke's theorem Origins and classification of first order PDE, principle of linear superposition, standard Eigenvalue problem and special ODEs, adjoint operator, generalized Sturm-Louiville problem, properties of adjoint operator, separation of variables – rectangular coordinate system, solution of elliptical PDE, solution of hyperbolic PDE, existence and uniqueness of solutions, Cauchy method of characteristics, Charpit's method, second order PDE with variable coefficients, classification and canonical form of second order PDE, Laplace equation, Laplace and

Poisson equation, one-dimensional wave equation and its solution, two dimensional wave equation and its solution.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking this course can be employed to industries focusing on Maths and Computing.
Focus on Skill development	Yes	The students develop necessary foundational skills in functions of several variables.
Focus on entrepreneurship	No	-

MC212 Database Management Systems (3-0-2-4)

ER model, relational model, relational algebra –basic operators, composition of operators, additional operators, extended relational operators, database modifications, TRC, SQL – basic and advanced queries, updates, joins, views and triggers, normalization theory, - 1NF, 2NF, 3NF, BCNF, MVD, physical design, indexes – hashing, tree-based indexing, query processing – nested loop joins and merge join, hash join and other operations, query optimization – equivalent expressions and simple equivalence rules, complex equivalence rules, join order, heuristics and sizes, transaction processing – properties and failures, states and systems, recovery systems – deferred database modification, immediate database modification, checkpointing and shadow paging, schedules – conflict serializability, view serializability, result equivalence and testing for serializability, recoverability, concurrency control – locks, two-phase locking protocol, timestamp ordering protocol, validation-based protocol, multiple granularity for locks, deadlock prevention and deadlock detection, deadlock recovery and update operations, NoSQL – columnar families, different NoSQL systems, Big data.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking DBMS course can be employed to industries focusing on database and software development.
Focus on Skill development	Yes	The students develop necessary skills to work with real use cases using databases.
Focus on entrepreneurship	Yes	The students can work on real time projects focusing on development of small, medium and large enterprises through entrepreneurship/self-employability and start-ups.

MC224 Parallel and Distributed Algorithms (3-1-0-4)

Parallel algorithm models - Shared memory models and interconnection networks, performance of parallel algorithms, cost and optimality, dense algorithms – matrix multiplication, matrix multiplication using mesh networks and hypercube networks, block matrix multiplication, decomposition and mapping techniques – parallel query processing, dense LU factorization, comparator networks and sorting – OEMS, BSMS, analysis and applications of parallel algorithmic techniques, optimal list colouring, optimal list ranking, expression tree evaluation, merging, Cole's merge sort, sorting lower bound, parallel searching and selection, components of a graph, components on CREW model, vertex colouring, sorting on 2D, 3D meshes, offline routing on a 2D mesh, algorithm on interconnection networks – mesh of trees, hypercube, CCC, butterfly network, Benes network, shuffle-exchange network, deBruijn network, parallel complexity theory – P-complete and NC reductions

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on distributed systems.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in parallel and distributed algorithms.
Focus on entrepreneurship	No	-

MC311Mathematical Optimization (3-1-0-4)

Assumptions and mathematical modelling of LPP, geometry of LPP, graphical solution of LPP, Simplex method, Big-M method, two phase method, special cases of LPP, degeneracy of LPP, sensitivity analysis, duality theory, dual simplex method, post optimality analysis, ILP, branch and bound method, transportation problem and its solutions, assignment problems, project management, critical path analysis, PERT, shortest path algorithm, travelling salesman problem, mixed integer programming problem, single variable optimization, NLP, graphical solution of NLP, types of NLP, one dimensional constrained optimization, unconstrained optimization, region elimination technique, multivariate unconstrained optimization, NLP with equality constrained, constrained NLP, constrained optimization, KKT, feasible direction, penalty and barrier method, convex sets and functions, properties of convex functions, convex programming problems, KKT optimality conditions, quadratic programming problems, separable programming, geometric programming, dynamic programming, search techniques, multi-objective decision making, multi-attribute decision making.

Focus Area	Yes/No	Details

Focus on Employability	Yes	The students taking the course can be employed in industries focusing on data science.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in optimization.
Focus on entrepreneurship	No	-

MC312/CS302 Modelling and Simulation (3-0-2-4)

Introduction to modeling process, Modeling Concepts, Model Classifications, System Dynamics Models, Compartment model, Discrete and Continuous time deterministic models, logistic equation, models of opinion and epidemic spread, competition models. Stochastic Models, Discrete and Continuous distributions, Markov Chains, Limit theorem for Markov Chains in discrete and continuous time, Poisson processes, Brownian Motion, Random Walk, Queueing Systems, Monte Carlo Simulations. Birth death processes, stochastic opinion and epidemic spread models. Introduction to Cellular Automata Simulations, Binary and probabilistic cellular automata, Ising spin system and applications.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on machine learning.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in machine learning.

Focus on entrepreneurship	Yes	Machine Learning offers enormous scope for entrepreneurship.

MC321/IE406/IT608 Machine Learning (3-0-2-4)

The learning paradigm, foundation of AI and ML, intelligent autonomous systems and AI, applications of ML, characterization of learning problems, hypothesis space and inductive bias, evaluation and cross-validation, objects, categories and features, feature related issues, scenarios for concept learning, forms of representation, decision trees, Bayesian belief networks, ANNs, genetic algorithm, logic programming, inductive learning based on symbolic representations and weak theories, generalization as search, decision tree learning algorithms, instance based learning, cluster analysis, ML enabled by prior theories, explanation based learning, inductive logic programming, reinforcement learning, linear regression, least squares, gradient descent, generalized function for linear regression, goodness of fit, bias-variance trade off, gradient descent algorithms, Deep learning – logistic regression, binary entropy cost function, OR gate via classification, NOR, AND, NAND, XOR gates, differentiating the sigmoid, gradient of logistic regression, multinomial classification, multinomial logistic regression, biological neuron, structure of an artificial neuron, feedforward neural network, back propagation, CNN, types of convolution, CNN architecture, train network for image classification, semantic segmentation, hyperparameter optimization, transfer learning, activation functions, learning rate decay, weight initialization, data normalization, batch norm, RNNs, Hebbian learning and associative memory, Hopfield networks and Boltzman machines, sequence classification, training RNNs – loss and BPTT, vanishing gradients and TBPTT, RNN architectures, LSTM, Deep RNNs and Bi-RNNs, Knn, feature selection, feature extraction, collaborative filtering, binary decision trees, binary regression trees, bagging, random forest, boosting, gradient boosting, unsupervised learning and Kmeans, agglomerative clustering, Naïve Bayes, MLE, PCA, SVM, MLE, MAP, Bayesian regression, generative model, GAN, VAE, applications, ML visualization.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on machine learning.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in machine learning.
Focus on entrepreneurship	Yes	Machine Learning offers enormous scope for entrepreneurship.

MC222 Real and Complex Analysis (3-1-0-4)

Countable and uncountable sets, concepts of metric space, open ball, closed ball, limit point of a set, ordered set, lub, glb, compact set, Heine Borel theorem, Weierstrass theorem, Cantor set and its properties, derived set and dense set, limit of a sequence and monotone sequence, properties of limit of sequences, ratio test, Cauchy's theorems on limits of sequences of real numbers, fundamental theorem of limits, Bolzano-Weierstrass theorem, criteria for convergent sequence, criteria for divergent sequence, Cauchy sequence, Cauchy convergence criteria for sequences, infinite series of real numbers, convergence criteria for series of positive real numbers, comparison test of series, absolutely and conditionally convergent series, rearrangement theorem and test for convergence of series, ratio and integral test for convergence of series, Raabe's test for convergence of series, limit of functions and cluster point, divergence criteria for limit, left and right hand limits for functions, limit of functions at infinity, continuous functions (Cauchy's definition), continuous functions (Heine's definition), properties of continuous functions, boundedness theorem and min-max theorem, location of root and Bolzano's theorem, uniform continuity and related theorems, absolute continuity and related theorems, types of discontinuities, relation between continuity and compact sets,

differentiability of real valued functions, local min-max Cauchy's and Lagrange's mean value theorem, Rolle's mean value theorem and its applications. Analytic function, Cauchy-Riemann equations, harmonic function, harmonic conjugate and Milne's method, complex integration, Cauchy's theorem, Cauchy's integral formula for the derivatives of analytic function, Morera's theorem, Liouville's theorem, Fundamental theorem of Algebra, Winding number and maximum modulus principle, sequences and series, uniform convergence of series, power series, Taylor's series, Laurent series, zeros and singularities of analytic function, residue of a singularity, residue theorem, meromorphic functions, evaluation of real integrals using residues, bilinear transformations, conformal mapping.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking this course can be employed to industries focusing on Maths and Computing.
Focus on Skill development	Yes	The students develop necessary foundational skills in real and complex analysis.
Focus on entrepreneurship	No	-

IE407 Internet of Things (3-0-2-4)

Internet of Things (IoT) is the study of embedded smart devices in the Internet based interconnection network. Going beyond the Internet applications, it looks at agent based distributed computation compliant to standard protocol suite. The course begins by covering a broad range of introductory topics such as wireless communication basics,

wireless MAC layer protocols, before moving on to the problems arising out of applications designed for the sensor networks. These include localization, coverage, data aggregation, topology control, mobility, and application design. Next we look at the building blocks of IoT and their characteristics. A number of domain specific IoT applications and their architecture in vehicular, social, and sensor networks are discussed. Data analysis tools and machine learning techniques are introduced to process large datasets produced by IoT applications. In the lab, we introduce the programming aspects of IoT applications using Cloud-based platforms. All students are expected to complete a course projects that involves designing and building a complete IoT application. A combination of reference books and a set of research papers will be used to cover the fundamentals, seminal findings and new directions in IoT research.

Suggested Text book(s)

1. Murthy, Manoj, "Ad Hoc Wireless Networks," Pearson Education.

2. Waltenegus Dargie,Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice"

3. Vijay Madisetti, Arshdeep Bahga, "Internet of Things: A Hands- On Approach"

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on machine learning.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in IoT.
Focus on entrepreneurship	Yes	IoT offers enormous scope for entrepreneurship.

CS401 Computational Finance (3-0-2-4)

A derivative is a financial instrument that derives its price from an underlying asset like a stock. An example is a forward contract where two parties agree to buy/sell an asset at a fixed price at some future date. Another example is that of a call option where one party (option buyer) agrees to buy an asset from another party (option seller) at a future date. But in this case the contract is asymmetric, that is, the option buyer has the right but no obligation to exercise the option whereas the option seller is obligated to exercise the option at end date. How do you value such a financial contract? The value of the option is the option price of the call option. There is a nice mathematical theory of option pricing which is based on principles of efficient markets and mathematical theory of probability. The Black-Scholes-Merton model of pricing a European call option is a landmark work in financial and economic theory which received the Nobel price for economics in 1997. Current financial markets are replete with complicated financial instruments; exotic options and option exchanges are common place. Everyday billions of dollars of options are traded on various exchanges of the world. Options are traded everyday on various underlying assets like stock, currency or commodities. This course introduces the student to the theory of option pricing and financial derivatives.

Suggested Text/s:

Options, Futures and Other Derivtives J.C. Hull and S. Basu

Stochastic calculus for finance I and II Shreve

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking this course can be employed to industries focusing on Computing and Finance.

Focus on Skill development	Yes	The students develop necessary foundational skills in computing and finance.
Focus on entrepreneurship	No	-

CS301 High Performance Computing (3-0-3-4.5)

Overview of latest parallel machines and architecture. Introduction to high performance computing. Parallel Programming concepts. Need for Parallel Computing. Limitations. Parallel

programming languages. Parallel libraries. Amdahl's law, speedup. Basics of parallelization.

Improving performance on a single processor: basic optimization techniques for serial code.

Measuring performance, parallel-serial problem breakdown, bandwidth measures, thread vs

process, thread synchronization, Memory structures and bandwidth optimization, performance

improvements. Optimization, performance analyzer tools, debugging. Amdahl's law, Gustafson's Law, Karp–Flatt metric, isoefficiency metric.

Multi-threading model using OpenMP. OpenMP: parallel do, private variables, nested loops,

reductions, loop dependencies, thread-safe functions, parallel sections, and barriers.

Message Passing Programming, its implementation and important details, MPI send and receive, MPI communicators, broadcast, reduce.

Parallel complexity analysis, speedup, efficiency, cost, task and data dependency graphs.

Several Important Parallel Algorithms and implementation strategies from different class of

problems such as Integration using trapezoidal rule. Vector addition, Calculation of PI using

monte carlo method. Matrix operations. Reduction, Inclusive and exclusive scan. Image processing. Sorting algorithms. Solution of Differential Eqns using Finite Difference etc. Hybrid
parallelization with MPI and OpenMP.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking this course can be employed to industries focusing on HPC.
Focus on Skill development	Yes	The students develop necessary foundational skills in HPC.
Focus on entrepreneurship	No	-

Suggested textbook/references:

1. An Introduction to Parallel Programming; Elsevier; by Peter S. Pacheco.
2. Scientific Parallel Computing; Princeton University Press; by Babak Bagheri Terry Clark L
Ridgway Scott Bagheri Clark Scott
3. Introduction to High Performance Computing for Scientists and Engineers; G. Hager & G. Wellein. CRC Press.

CT474 Satellite Communications (3-0-0-3)

A brief history of satellite communications. Description of satellite communications system: uplink, downlink, transponder and receiving earth stations. Satellite frequency bands

Launching of objects into space, basic orbital mechanics, Kepler's three basic laws, locating the satellite in orbit, locating the satellite with respect to earth, look angle determinations and geostationary satellites. The mechanics of launching a synchronous satellite, U. S. expendable launch vehicles and launch vehicles: Ariane and space Shuttle. Basic transmission theory. System noise temperature and G/T ration. Design of uplink and downlink. Design of satellite links for specified carrier-to-noise ratio.

Analog telephone transmission. Digital modulation and demodulation. Bit and symbol error rates, binary phase shift keying and quadrature phase shift keying. Digital transmission of voice and digital TV.

Frequency division multiple access (FDMA). Calculation of carrier-to-noise ratio, Effect of intermodulation noise and practical limitations of FDMA. Time division multiple access (TDMA). TDMA frame structure and design. TDMA synchronization and timing. Code division multiple access (CDMA). Spread spectrum transmission and reception.

Earth station design: for low system noise temperature and large earth station antenna. Design of large antennas. Optimizing the gain of large antennas. Antenna noise temperature. Feed system for large antennas. Tracking feeds. Tracking of geostationary antennas. Small earth station antennas. Equipment for earth station. Low-noise amplifiers.

Textbooks:

1. Dennis Roddy, *Satellite Communications*, McGraw-Hill, Fourth Edition, 2006.

2. Timothi Pratt, Charles W. Bostian & Jeremy Allnutt, *Satellite Communications*, John Wiley & Sons, Second Edition, 2003.

3. Tri T. Ha, *Digital Satellite Communication*, McGraw-Hill, Second Edition, 1990

4. Electronic Communications, *Dennis Roddy & John Coolen*, Prentice Hall India, ISBN: 81-203-0984-7, Fourth Edition, 2006.

Focus Area	Yes/No	Details

Focus on Employability	Yes	The students taking this course can be employed to industries focusing on satellite communication.
Focus on Skill development	Yes	The students develop necessary foundational skills in satellite communication.
Focus on entrepreneurship	No	-

CT321 Digital Signal Processing (3-0-2-4)

Discrete time signals, discrete time systems, Concept of frequency domain representation in discrete time signals and discrete time systems, Z transform, Analysis of discrete time systems in Z domain. Frequency domain characterization of LTI systems, Discrete time Fourier transform, Discrete Fourier transform, Fast Fourier transform, circular convolution, Design of infinite and Finite impulse response filters.

Recommended books:

1. Digital Signal Processing, Principles, Algorithms, and Applications by Proakis and Manolakis, Prentice Hall of India.
2. Digital Signal Processing, A computer based approach by Sanjit K. Mitra, MGH

Focus Area	Yes/No	Details

Focus on Employability	Yes	The students taking this course can be employed to industries .
Focus on Skill development	Yes	The students develop necessary foundational skills in DSP and its applications.
Focus on entrepreneurship	No	-

CT351 Radio Frequency Engineering (3-0-0-3)

Introduction: RF Spectrum, High frequency (Radio Frequency and Microwaves) in Perspective and Applications, RF versus DC or Low AC signals, High Frequency Behaviour of Passive Components, Noise Figure, Equivalent Noise Temperature, Harmonic and Inter-modulation Distortion, Gains/Losses, Signal to Noise Ratio, Tracking noise and signal level through a complete system.

Transmission Lines: Concept of Distributed Elements, Transmission Line Equations, Phase and

Attenuation Constants, Propagation Constant and Characteristic Impedance, Lossless, Low-Loss and Distortion-less Lines, Travelling and Standing Waves, Reflection Coefficient and Standing Wave Ratio (SWR), Input Impedance, Impedance and Admittance Transformations, Impedance Matching – Quarter and Half-Wave Lines, Equivalent Reactive Elements, Load Impedance Measurement, Analysis of Opencircuited and Short-circuited Lines, Stub Matching, Power Flow in a Transmission Line, Maximum Power Transfer Condition, Graphical Representation of a Transmission Line, Smith Chart, Transmission Line Calculations using the Smith Chart, Design of Matching Networks and Stub Matching, Various Types of Transmission Lines.

RF Networks: Applications of Smith Chart, Maximum Power Transfer Condition, Design of Matching

Networks and Stub Matching. Single and Multi-port Networks, Symmetric and Reciprocal Networks,

Scattering Parameters and Scattering Matrix.

Antennas and Propagation: Antenna System Parameters, Friis Equation, Antenna Noise Temperature, Practical Antennas and Antenna Arrays, Propagation, Scattering Loss, Multipath, Fading Models.

References:

1. R. Ludwig and Pavel Bretchke, "RF Circuit Design: Theory and Applications", Pearson Education Asia Publishers, ISBN-81-7808-333-7, 2001.

2. Christopher Bowick, "RF Circuit Design", Publisher: Science & Technology Books, December 1998, ISBN: 0750699469.

3. Peter Vimuller, "RF Design Guide: Systems, Circuits, and Equations", Artech House, January 2003, ISBN: 0890067546.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking this course can be employed to industries.
Focus on Skill development	Yes	The students develop necessary foundational skills in RF, Wave propagation.
Focus on entrepreneurship	No	-

CT477 Adaptive Signal Processing (3-0-0-3)

Introduction to Adaptive Filters, Stochastic Processes, Wiener Filters, Steepest Descent Technique, Least-Mean-Square Adaptive Filters, Other LMS-Based Adaptive Filters,

Sparse Adaptive Filters, Recursive Least Square Adaptive Filters, Kalman Filters and Blind Decovolution.

Suggested Texts:

1. Behrouz Farhang-Boroujeny, "Adaptive Filters: Theory and Applications", John Wiley & Sons, Ltd., 2013.
2. F. Gustafsson,"Adaptive Filtering and Change Detection", John Wiley & Sons, Ltd., 2000.
3. P. S. R. Diniz, "Adaptive Filtering: Algorithms and Practical Implementation", Springer, 2008.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking this course can be employed to industries.
Focus on Skill development	Yes	The students develop necessary foundational skills in Adaptive DSP and its applications.
Focus on entrepreneurship	No	-

CT503 Wireless Communication (3-0-2-4)

Basics of Information Theory; Wireless Channel Models; Diversity Concepts; Capacity Evaluation; OFDM Systems; MIMO Systems.

Suggested Texts:

1. Fundamentals of Wireless Communication, David Tse & Pramod Vishwanath, Cambridge

University Press.

2. Wireless Communications, Andrea Goldsmith, Cambridge University Press.

3. MIMO Wireless Coommunications, Ezio Biglieri et. al., Cambridge University Press.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking this course can be employed to industries.
Focus on Skill development	Yes	The students develop necessary foundational skills in Wireless Communication.
Focus on entrepreneurship	No	-

CT505 Detection and Estimation Theory (3-0-0-3)

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.

References: 1. Steven M. Kay - Fundamentals of Statistical Signal Processing, Volume II_ Detection Theory-Prentice Hall (1998)

2. Steven M. Kay - Fundamentals of Statistical Signal Processing, Volume I_ Estimation Theory-Prentice Hall (1993)

3. H. Vincent Poor - An introduction to signal detection and estimation Springer-Verlag (1988)

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking this course can be employed to industries.
Focus on Skill development	Yes	The students develop necessary foundational skills in DET.
Focus on entrepreneurship	No	-

CT507 Cyber-Physical Systems (3-0-2-4)

Basic Automata Theory; Synchronous Models; Safety Requirements; Liveness Requirements; Dynamical Systems; Timed Models.

References:

1. Principles of Cyber-Physical Systems, Rajiv Alur, The MIT Press.

2. Introduction to Embedded Systems - A Cyber-Physical Systems Approach, E. A. Lee & S.

A. Seshia, 2nd edition, The MIT Press.

3. Logical Foundations of Cyber-Physical Systems, Andr_e Platzer, Springer.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on machine learning.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in IoT.

Focus on Employability	No	-
Focus on Skill development	Yes	This course allows students to upskill their knowledge in humanities and social sciences which train them how to think, looking at others and to become a responsible citizen.
Focus on entrepreneurship	No	-

EL422 CMOS Analog IC Design (3-0-0-3)

Basic MOS Devices; Single Stage Amplifiers; Differential Amplifiers; Current Mirrors; Frequency Response of Amplifiers; Noise Analysis of Amplifiers; Operational Amplifiers and Common Mode Feedback Circuits; Band Gap References.

References:

Gray, Hurst, Lewis, Meyer, Analysis and Design of Analog Integrated Circuits, 2009.

Allen, Phillip E., and Douglas R. Holberg, CMOS Analog Circuit Design, 2011.

Willy M.C Sansen, Analog Design Essentials, Springer, 2007.

Johns, David A., and Ken Martin, Analog integrated circuit design, John Wiley Sons, 2008.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in VLSI, which help them in visualizing concepts and contexts in industrial applications.

Focus on entrepreneurship	Yes	IoT offers enormous scope for entrepreneurship.

HM 327 Culture. Politics, Identity (3-0-0-3)

Starting from an understanding of the meaning of culture, this course intends to introduce students to some of the major debates on the subject of "identity politics." From basic concepts and definitions, students will be introduced to contemporary debates on the problem of identity particularly those emerging from post-modernist positions. Are individual and collective identities primordial or are they historically constituted? Are identities fixed or mutable? How do individuals define themselves and their identities through active negotiations with political structures and cultural codes? This preliminary discussion will be followed by more specific case studies that would try to show how our individual and collective identities are born out of collective struggles for power among social groups who seek to impose and define identities of class, gender, caste, nation, religion through varied practices of domination over others.

Reading Materials:

Benedict Anderson- Imagined Communities; Reflections on the Origins and Spread of Nationalism, London, Verso, 1983

Partha Chatterjee- Nationalist Thought and the Colonial World- A Derivative Discourse? (Zed Books, 1986)

Christopher Jaffrelot (ed) Hindu Nationalism: A Reader, Princeton University Press,2007

Christopher Jaffrelot – India's Silent Revolution: The Rise of Lower Castes In Northern India, Columbia University Press, 2003

Focus Area	Yes/No	Details

Focus on Skill development	Yes	This course allows students to upskill their knowledge in VLSI.
Focus on entrepreneurship	No	-

HM 432 Organisation Behaviour (3-0-0-3)

Introduction to organizational behavior

Manegement communication.

Individual behaviour (perception, motivation and learning)

Group and team

Performance appraisal

Conflicts and negotiation

Organisation structure and culture

Decision making

Organisational change and resistance to change.

Stress management and coping skills.

Focus Area	Yes/No	Details
Focus on Employability	No	-
Focus on Skill development	Yes	This course allows students to upskill their knowledge in humanities and social sciences which train them how to think, looking at others and to become a responsible citizen.

Focus on entrepreneurship	No	-

HM402. Publics in South Asia: Contemporary Perspectives (3-0-0-3)

The course will begin by discussing the concept of 'public' distinguished from the 'private', and how to think with a category like 'South Asia.' Subsequent topics include studies of urban spaces; practices of reading, circulation of gossip and censorship; and visual publics created and sustained by cinema, movie posters, truck art and monuments. The course is divided into broadly four sections, consisting of the readings given below:

I. Framing Questions: Concepts

II. Spaces: Urban spaces and belonging, mobility

III. Words in the World: Circulation and media, prohibitions

IV. Arts of the Public: Cinema and other visual publics

Books (Extracts):

Calhoun, Craig. 1992. Habermas and the Public Sphere. MIT Press.

Hutt, Michael and Pratyush Onta eds. 2016. Political Change and Public Culture in Post-1990 Nepal. Cambridge UP.

Kaviraj, Sudipta. 2011. The Enchantment of Democracy and India: Politics and Ideas. Ranikhet: Permanent Black.

Nair, Janaki. 2005. The Promise of the Metropolis: Bangalore's Twentieth Century. New Delhi: Oxford UP.

Focus Area	Yes/No	Details
Focus on Employability	No	-

Focus on Skill development	Yes	This course allows students to upskill their knowledge in humanities and social sciences which train them how to think, looking at others and to become a responsible citizen.
Focus on entrepreneurship	No	-

IE410 Introduction to Robotics (3-0-2-4)

Course Overview, History of Robotics, Robot Arm, Kinematic Structure of Human Arm and Humanoid Robot. Coordinate Frames, Rotation Matrix, Translations, Euler Angles, Quaternion

Homogeneous Transform, Compound Transformations, Jacobians, Denavit-Hartenberg (D-H) Parameters Inverse Kinematics for Position/Orientation/Velocities, Redundancy, Singularities

Equation of Motion, Euler-Lagrange Formulation, Newton-Euler Formulation Sensors, Actuators, Control Overview, Joint Space Control, PD Control, PID Control, Trajectory Generation, Cartesian Planning, Visual Servoing, Vision-based Robot Control Zero-Moment Point (ZMP), Center of Mass (CoM), Humanoid Robot Stabilization, Kalman Filter, Preview Control PoseNet, Localization, Filters, Search, SLAM (Simultaneous Localization And Mapping), AI/ML-based Control Architecture, Reinforcement Learning High-Performance Robotics Computing, Robotics IoT, Robotics Cloud, Robotics Grid Computing, Robotics Apps, etc.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in robotics,

		which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in robotics.
Focus on entrepreneurship	No	-

Suggested Textbook

[1] Peter Corke, Robotics, Vision and Control, Fundamental Algorithms, 2nd ed., Springer, 2017.

[2] B. Siciliano, L. Sciavicco, L. Villani, and G. Oriolo, Robotics - Modelling, Planning and Control, Springer, 2009.

[3] S. Kajita, H. Hirukawa, K. Harada, and K. Yokoi, Introduction to Humanoid Robotics, Springer, 2014.

[4] John J. Craig, Introduction to Robotics: Mechanics and Control, Addison-Wesley Publishing Company, 3rd Edition, 2003.

IT509 Computational Numerical Methods (3-0-0-3)

LU Decomposition, Eigenvalues and eigenvectors, Singular value decomposition, QR factorization, least square approximations, Low rank matrix approximations Approximation of optimal points: Gradient descent, Steepest descent, Newton's method, Conjugate direction method. Interpolation and function approximation: Lagrange interpolation, Newton's interpolations, Difference operators, Spline interpolation: linear, quadratic and cubic splines, applications of natural splines.

Numerical methods for graph data: Adjacency, Graph Laplacian and other graph matrices, Function interpolation on graphs, Spectral clustering, Graph partitioning.

Reference Books:

1. Fundamental Numerical Methods and Data Analysis by George W. Collins, II
2. Exploring Numerical Methods: An Introduction to Scientific Computing Using MATLAB by Peter Linz and Richard L. C. Wang (Jones and Barlett Publishers)
3. A Tutorial on Spectral Clustering, Technical Report by Ulrike Von Luxburg

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in numerical methods, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in numerical methods.
Focus on entrepreneurship	No	-

IT413 No SQL Databases (3-0-2-4)

The course teaches data models such as key-value, columnar, and graph databases, that have become important in the era of big data. This course discusses Models, Programming Abstractions, and insight into selected techniques for implementing such data models. Selected implementations are also discussed.

Texts:

1. Sadalage, Pramod J., and Martin Fowler. *NoSQL distilled: a brief guide to the emerging world of polyglot persistence*. Pearson Education, 2013.
2. Sullivan, Dan. *NoSQL for mere mortals*. Addison-Wesley Professional, 2015.
3. Perkins, Luc, Eric Redmond, and Jim Wilson. *Seven databases in seven weeks: a guide to modern databases and the NoSQL movement*. Pragmatic Bookshelf, 2018.
4. Harrison, Guy. *Next Generation Databases: NoSQLand Big Data*. Apress, 2015.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in databases, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in databases.
Focus on entrepreneurship	No	-

IT424 Logic for Computer Science (3-0-0-3)

Propositional Logic

Syntax, Semantics, Normal Forms, Natural Deduction, Resolution procedure

First Order Logic

Syntax, Semantics, Natural Deduction, Herbrand Theory, Resolution Procedure

Further First Order Features

Craig's Interpolation Theorems, Beth's Definability Theorems,

Introduction to a Theorem Prover Tool

Suggested textbook/references:

1. Mathematical Logic for Computer Science, M. Ben-Ari, Springer, 2003

2. Logic in Computer Science: Modelling and reasoning about systems, M. Huth, M. Ryan, Cambridge University Press, 2004

3. First Order Logic and Automated Theorem Proving, Melvin Fitting, Springer, 1996

Focus Area	Yes/No	Details

Focus on Employability	Yes	This is an elective course that excites students develop knowledge in automata theory, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in automata theory.
Focus on entrepreneurship	No	-

IT441 Computer Graphics (3-0-2-4)

1. Introduction: Definition; applications; overview of computer system and display sub-system; role of GPUs; problem definition; mathematical preliminaries; layers of graphics software; concept and realization of rendering pipeline.

2. Graphics primitives: Points; lines; circles and ellipses; scan conversion algorithms for primitives; fill area primitives; scan-line polygon filling; inside-outside test; boundary and flood-fill; character generation; line attributes; area-fill attributes; character attributes.

3. 2D transformations and viewing: Translation, rotation, scaling; matrix representation; homogeneous coordinates; composite transformations; reflection and shearing; affine transformations; viewing pipeline and coordinate system; window-to-viewport transformation; clipping; basic line clipping algorithms.

4. 3D transformations and viewing: 3D scaling, rotation and translation; composite transformation; viewing pipeline and coordinates; parallel and perspective projection.

5. 3D object representation: Surface modelling; polygon mesh representation; curves and surfaces; quadric surfaces; spline representation; cubic spline; interpolation methods; Bezier curves and surfaces; B-spline curves and surfaces.

6. Further topics (TBD based on time available): Visible surface detection concepts; back-face detection; depth buffer method; Illumination and shading; multi-core graphics processors.

References:

1. Hearn and Baker, "Computer Graphics", Pearson Education [*main reference*]
2. Foley and van Dam, "Computer Graphics", Person Education
3. Rogers, "Mathematical Elements for Computer Graphics", Mc-Graw Hill

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in computer graphics, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in computer graphics.
Focus on entrepreneurship	No	-

IT505 Brain and Cognitive Science (3-0-0-3)

Human brain physiology and anatomy, sensory-motor function, attention, memory, learning, higher cognitive functions, neuroimaging techniques, analysis and interpretation of recorded brain activity. Neural network, artificial intelligence and other cognitive architecture inspired from brain functioning, computational neuroscience, brain-computer interaction and neuromorphic computing.

References:

1. Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, Steven A. Siegelbaum, A. J. Hudspeth, *Principles of Neural Science*, 5th Ed.

2. Michael S. Gazzaniga, *The Cognitive. Neurosciences,* 4th Ed.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in cognitive science, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in cognitive science.
Focus on entrepreneurship	No	-

IT507 Advanced Image Processing (3-0-0-3)

Introduction to digital image and its processing

Intensity transformation

Filtering in Spatial Domain

Filtering in Frequency Domain

Image restoration and reconstruction

Mathematical morphology

Image Segmentation

Representation and Description

Color Image Processing

Image quality assessment metrics

References:

1. R. C. Gonzalez, R. E. Woods, "Digital Image Processing", 3rd Edition, Pearson Prentice Hall, 2008.
2. M. Sonka, V. Hlavac, R. Boyel, "Image Processing Analysis, and Machine Vision", 2nd Edition, PWS Publishing, 1999.
3. S. E. Umbaugh, "Digital Image Processing and Analysis", 2nd Edition, CRC Press, 2010.
4. A. L. Bovik, "The Essential Guide to Image Processing", Academic Press, 2009.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in image processing, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in image processing.
Focus on entrepreneurship	No	-

IT531 Advanced Computer Networks (3-0-0-3)

Major topics include: Internet protocols for congestion control, approaches to achieve reliability,

scalability. Network measurement, p2p networks, Wireless networks, and content delivery networks. Software Defined Networking (SDN) artictecture, Network Functions Virtualization (NFV).

Texts

1. Kurose, James and Ross, Keith, "Computer Networking - A Top Down Approach," Pearson Ed.

2. Hassan, Mahboob and Jain, Raj, "High Performance TCP/IP Networking," Prentice Hall India

3. Murthy, Manoj, “Ad Hoc Wireless Networks,” Pearson Education.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in networks, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in networks.
Focus on entrepreneurship	No	-

IT542 Pattern Recognition and Machine Learning (3-0-2-4)

Vector valued Random variable (Multivariate Gaussian)

Supervised and unsupervised learning # Lec. 22

(i) BDR

(ii) KNN

(iii) K-Means

(iv) Fuzzy K-Means

(v) Hierarchical Clustering

(vi) Feature Selection

(vii)Dimensionality Reduction - PCA, LDA, LPP

Correlation, Regression, multivariate regression, Logistic regression for pattern recognition

Gaussian Mixture Model, Regression to Neural Networks

References:

1. Pattern Recognition: Concepts, Methods and Applications, J. P. Marques d sa, Springer, 2001.

2. Pattern Classification, R. O. Duda, P. E. Hart and D. G. Stork, John Wiley, New York, 2001.

3. Probabilistic Graphical Models, Daphne Koller and Nir Friedman, MIT Press, 2009.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in machine learning, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in machine learning.
Focus on entrepreneurship	No	-

IT545 Computational Number Theory (3-0-0-3)

Historical Introduction and Motivation of Computational number theory, Basic review of elementary number theory and algebra, introduction to algebraic coding theory, Computational Complexity, Elementary operations: the complexity of basic operations like additions, multiplications for integers and polynomials. Polynomials: The complexity of factorization, irreducibility testing, ideal membership etc. for polynomials over finite fields. Motivating example: Reed-Soloman codes. Integer Lattices: the complexity of finding a short vector in an integer lattice. Motivating example: polynomial factorization. Integers: The complexity of factorization, primality testing, discrete log computation etc. for integers. Motivating examples: RSA and El Gamal cryptosystems. Elliptic curves: the

Texts:

Photo Forensics by Hany Farid, MIT Press.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in multimedia security, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in multimedia security.
Focus on entrepreneurship	No	-

IT322/IT547 Security Protocols (3-0-0-3)

Security properties – authentication, privacy, integrity, non-repudiation, anonymity

Cryptographic primitives – modes of operations, hash functions, public key cryptography

Threats, Attacks, and Defenses – replay, man-in-the-middle, session freshness, forward secrecy, denial-of-service

Key agreement – secret key based, public key based

Fundamental Security Protocols – Needham-Schroeder, Diffie-Hellman, Kerberos, SSL/TLS, IPSec.

Payment protocols – Electronic-cash, micro-payment, e-commerce protocols

Wireless security protocols – WEP, WPA, WPA2

Multiparty computation – Oblivious transfer, bit commitment, coin flipping

Texts:

Network Security -- Kaufman, Perlman, Speciner, [Prentice Hall], 2002.

complexity of addition, point counting etc. for elliptic curves. Motivating examples: Elliptic curve cryptosystems and integer factoring.

Texts:

Victor Shoup (2012). A Computational Introduction to Number Theory and Algebra. Cambridge University Press

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in number theory, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in number theory.
Focus on entrepreneurship	No	-

IT546 Multimedia Security & Forensics (3-0-0-3)

The course aims to introduce an overview of the major problems and recent developments in the field of multimedia security & forensics. Manipulation of digital assets is possible in ways that were unimaginable ten years ago. Tampered digital media can have great financial, legal, political and social impact. Effective forensic tools to authenticate digital media and detect tampering operations. It is a fascinating field with rapid developments. In this course, we will cover the two most important areas i.e., multimedia security and forensics. We will discuss relevant aspects: multimedia data authentication, digital image forensics, anti-forensics, video surveillance techniques as well as a myriad of interesting research topics.

Cryptography and Network Security: Principles and Practice -- William Stallings, [Prentice Hall], 2003.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in security, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in security.
Focus on entrepreneurship	No	-

IT559 Distributed Systems (3-0-2-4)

Introduction: Goals of distributed systems, common types of distributed systems

Architectures: Architectural styles, system architectures, self-management

Processes: Threads, virtualization, clients & servers, server clusters, code migration

Communication: Fundamentals, remote procedure call, message-oriented communication, stream-oriented communication, multicast communication"

Naming: Flat naming, structured naming, attribute-based naming

Synchronization: Clock synchronization, logical clocks, totally-ordered multicast, causally-ordered multicast mutual exclusion, global positioning of nodes, leader election"

Replication and Consistency: Replica management, continuous consistency, data-centric consistency models, consistency protocols

Fault Tolerance: Failure models, failure masking, failure detection, reliable client-server communication, atomic multicast, two-phase commit, three-phase commit, checkpointing, logging, recovery, agreement in faulty systems.

Texts:

Tanenbaum and M. Steen, Distributed systems: Principles and Paradigms, Prentice Hall, Second Edition

Coulouris, G., Dollimore, J., Kindberg, T., and Blair G., Distributed Systems: Concepts and Design, Addison-Wesley, Fifth Edition.

M.L. Liu, Distributed Computing, Principles and Applications, First/Second edition

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in distributed systems, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in distributed systems.
Focus on entrepreneurship	No	-

IT422 Models of Computation (3-0-0-3)

Mathematical notations, different types of proofs, regular languages, DFA, NFA, regular expressions, context-free grammar, pushdown automaton, Turing machines and un-decidability.

Texts:

Introduction to Theory of Computation, 2nd Ed, Michael Sipser, Wadsworth Publishing Co Inc, 2012.

Languages and Machines, 3rd Ed, Thomas A. Sudkamap, Addison Wesley, 2006.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in computation, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in computational models.
Focus on entrepreneurship	No	-

SC402 Introduction to Cryptography (3-0-0-3)

Week1: Classical cryptography: Caesar cipher, substitution, transposition, cryptanalysis of the substitution cipher

Week 2: Classical cryptography: Vignere cipher, homophonic substitution cipher, cryptanalysis of the Vignere cipher, ADFGVX cipher, Enigma and its cryptanalysis

Week 3: Shannon's definition of perfect secrecy, one-time pad, key distribution problem, Diffie-Hellman's solution, introduction to public-key cryptography

Week 4: Mathematical foundations: divisibility, division algorithm

Euclidean GCD algorithm and its run-time analysis, fundamental theorem of arithmetic

Week 5: Mathematical foundations: Euclid's theorem and its proof, sieve of Eratosthenes, congruence, complete residue system, Euler's totient function, Chinese Remainder Theorem

Week 6: Mathematical foundations: Euler's theorem and its proof, Fermat's theorem and its proof, fast exponentiation, Carmichael numbers, discrete log, SQRT problem

Week 7: PKC: Diffie-Hellman key exchange, RSA public key cryptosystem, Digital signatures

Week 8: PKC: Rabin public key cryptosystem, Diffie-Hellman problem, Generalized Diffie-Hellman problem, ElGamal public key cryptosystem and signature scheme

Week 9: SKC: block ciphers, stream ciphers, pseudorandom bit generators, testing for pseudorandomness, designing a cryptographically secure pseudorandom bit generator, Blum-Blum-Shub generator

Week 10: SKC: m-sequence, linear feedback shift registers, designing m-sequences, primitive polynomials, finite fields

Week 11: Integer factorization algorithms

Week 12: Primality testing algorithms

Week 13: Discrete log algorithms

Textbooks

1. Topics in Algebra by I. N. Herstein, Second Edition, Wiley India

2. Introduction to Cryptography with Coding Theory, Trappe, Washington, Pearson Education, 2007

3. Cryptography with Network Security: Principles and Practice, William Stallings, Pearson Education, 2006

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in cryptography, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in cryptography.
Focus on entrepreneurship	No	-

SC403 Einstein's Physics (3-0-0-3)

The twentieth century was in certain ways the darkest in all of human history. Yet this century shall stand redeemed in the eyes of future humanity due to one figure - Albert Einstein. In this course we study Einstein's physics and its paradigm-shifting impact, that, going beyond Newton and Maxwell, radically revised conventional notions of space, time, mass and energy. The course shall initially revolve around the discoveries published by Einstein in his 1905 "Annus Mirabilis" papers – the special theory of relativity, mass-energy equivalence, the photoelectric effect (Einstein's Nobel Prize winning discovery) and Brownian motion. Beyond these seminal discoveries, we take up radiation through phenomena like Bose-Einstein statistics and lasers. We also look into Bose- Einstein condensates. And finally, we qualitatively consider Einstein's most
startling contribution to human knowledge – the general theory of relativity – a theory that lends a physical character to the geometrical properties of space-time, and is now the foundation of modern cosmology, as well as mysterious astrophysical phenomena like black holes and gravitational waves.

Texts:

Modern Physics – Beiser; Relativity – Resnick; Berkeley Course in Physics;
General Properties of Matter – Newman & Searle; Gravity – Hartle.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in advanced physics, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in advanced physics.

Focus on entrepreneurship	No	-

SC332 Introduction to Quantum Mechanics (3-0-0-3)

Motivation for quantum mechanics

. Black body radiation

. Photoelectric Effect

. Wave-particle duality

. Particle properties of waves

. Wave properties of particles

. De-Broigle wavelength

. The uncertainty principle

Quantum Theory

. Bohr model of the atom

. Probability waves

. Wave functions

. Schrodinger's equation

. Operators, Eigenvalues and Expectationvalues

Applications

. Particle in a box

. Harmonic Oscillator

. Hydrogen Atom

Angular Momentum

. L and Lz Quantization

. Spin, Stern Gerlach Experiment

. Spin Quantization (S and Sz)

Approximate Methods

. Perturbation Theory

Time evolution of spin in magnetic field

. Addition of Spin Angular momentum

. Symmetric and antisymmetric states.

. Density Operators and Ensembles.

Bohm Aharanov Effect

. Quantum Cryptography

. Quantum Computers.

Texts:

1. Perspectives of Modern Physics- Arthur Beiser
2. Quantum mechanics- L.I. Schiff

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in quantum mechanics, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in quantum mechanics.
Focus on entrepreneurship	No	-

CT478 Speech Technology (3-0-0-3)

Speech technology plays a key role in design of conversational interfaces which is announced as one of the 10 breakthrough in MIT's Technology Review 2016. Innovation in voice-based technologies has been derived by surge in use of smart phones across the world. In addition, it can be time consuming and in fact, frustrating to interact with computers using keyboard whereas speech is so natural to produce and it carries multiple levels of information, such as, linguistic message, speaker's identity, health condition,

acoustic environment in which it is recorded, emotion, cognition, attitude, gender, language, etc.

Texts:

Thomas F. Quatieri, Discrete-Time Speech Signal Processing

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in speech technology, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in speech technology.
Focus on entrepreneurship	No	-

CT405 Quantum Computation (3-0-0-3)

The course introduces the student to quantum computation and information theory. Quantum computation is a new paradigm for computing based on the principles of quantum mechanics. The student can readily find connections with SC220 (Groups and Linear Algebra) and SC432 (Quantum mechanics). In 1994 Peter Shor demonstrated a quantum algorithm for factoring that is asymptotically faster than any known classical algorithm. This result gave a major boost to the field of quantum computation which is now an active area of research. The course will do some review of Linear Algebra and then give a basic introduction to the axioms of quantum mechanics. Students will then learn basics of building blocks of the circuit model of quantum computation called quantum gate along with and some basic quantum circuits and algorithms. We then study main quantum algorithms like Shor's algorithm, Grover's search, amplitude estimation

and amplification. Later part of the course will have elements of quantum error correction and quantum cryptography. If time permits we will also study some quantum machine learning algorithms.

Suggested Text/s:

Quantum computation and information, Nielsen and Chuang, Cambridge University Press

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in quantum computation, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in quantum computation.
Focus on entrepreneurship	No	-

CS406 Algorithmic Graph Theory (3-0-0-3)

Handshaking lemmas, Havel-Hakimi theorem, Erdos and Gallai theorem, The matrix-tree theorem, Cayley-Kirchoff theorem, Menger's theorem(s), Characterization of Eulerian graphs, Dirac's theorem, Ore's theorem, Chvatal's theorem, Hall's matching condition, Konig-Egervary theorem, Tutte's theorem, Brook's theorem, Vizing's theorem, Shannon's theorem, Robertson-Seymour theorem, Kuratowski's theorem, Five colour theorem, Max-flow min-cut theorem.

Graph traversal algorithm(s), Shortest path algorithm(s), Warshall's algorithm, Prufer sequence and labeled tree construction, Minimum spanning tree algorithm(s), Fleury's algorithm, Colouring algorithm(s), Planarity testing algorithm(s), Finding strong components, Ranking in tournaments.

Texts:

A. Gibbons, Algorithmic Graph Theory, Cambridge University Press.

S. Even, Graph Algorithms, Computer Science Press.

D.B. West, Introduction to Graph Theory (2nd edition), Prentice Hall of India.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in graph theory, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in graph theory.
Focus on entrepreneurship	No	-

CT476 Microwave Engineering (3-0-0-3)

1. Design and analysis of TEM mode transmission lines such as open two-wire lines, coaxial line, stripline and microstripline.

2. Types of antennas, fundamental Parameters of antennas and wire antennas (short dipole and half-wavelength antenna). Measurement methods for gain and radiation pattern of antennas.

3. Theory, design and analysis of rectangular and circular waveguides.

4. Rectangular and circular waveguide components such as couplers, waveguide couplings, waveguide junctions, impedance matching using irises, attenuators, resonators and phse shifters.

5. Operation and applications of microwave vacuum tube devices such as klystron, magnetron and traveling-wave tube (TWT) amplifiers.

6. Operation and applications microwave solid state devices such as Gunn diode oscillator, IMPATT diode amplifiers, bipolar transistors and MOSFET.
7. Introduction to MMIC (Monolithic Microwave Integrated Circuits) and MIC technologies.
8. Microwave Measurements with slotted lines, network analyzers, spectrum analyzers.
9. Microwave Radiation Hazards. IEEE standards, concept of SAR and biological effects of microwaves.
10. Applications of Microwaves such as radar, microwave oven, RF-ID

Texts:

1. G. S. Raghuvanshi, Microwave Engineering, Cengage Learning, 2012.
2. Peter A. Rizzi, Microwave Engineering: Passive Circuits, Prentice Hall, 1998.
3. Robert E. Collin, Foundation for Microwave Engineering, McGraw-Hill, Second Edition, 1992.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in communication engg., which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in microwave.
Focus on entrepreneurship	No	-

CT509 Next Generation Wireless Communication Systems (3-0-2-4)

- A unified signal model for the next generation wireless systems. While the techniques such as CDMA, NOMA, MIMO (diversity as well as spatial multiplexing configurations), frequency-selective wireless/wireline channel, and

Spatial Source Separation by antenna array beamforming have many characteristics that are unique to each system, there is an underlying similarity
with which they all can be conceptualized. This will be the focus at the start
of the course.

. Linear front-end receiver for the unified signal model. Use of LS and MMSE techniques for optimal linear reception of the transmitted signal.

. Nonlinear second-stage algorithms. Iterative message passing, SIC and PIC, EM, blind detection and estimation algorithms, neural network based learning.

Compressive Sensing. CS concept, the Restricted Isometric Property (RIP) and Mutual Coherence, Matching/Basis Pursuit and their variants, Sub Nyquist rate architectures for compressive wideband spectrum sensing for
Cognitive Radios (CRs)

. MIMO. Beamforming by antenna array, Direction of Arrival (DoA) estimation algorithms, promise of MIMO spatial multiplexer, diversity advantages of MIMO, Alamouti transmit diversity scheme, Space-Time Codes, Index Modulation

. Network Coding and Physical Layer Security. will be included if time permits

References:

1. Tse, David, and Pramod Viswanath. Fundamentals of wireless communication. Cambridge university press, 2005.

2. Goldsmith, Andrea. Wireless communications. Cambridge university press, 2005.

3. John G. Proakis and Masoud Salehi, Digital Communications, Fifth Edition, McGraw-Hill, 2014.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in communication engg., which help them in

		visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in wireless communication.
Focus on entrepreneurship	No	-

CT516 Advanced Digital Communication (3-0-0-3)

Signal Theory for Communication

Digital Modulation Schemes

Receivers for AWGN Channels

Digital Communication Over Band-Limited Channels

Basics of Information Theory

Linear Block Codes

Texts:

1. Digital Communication, John G. Proakis & Masoud Salehi, McGraw-Hill, 5th Edition.
2. Digital Communication: Fundamentals & Application, Bernard Sklar, Prentice Hall.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in communication engg., which help them in visualizing concepts and contexts in industrial applications.

Focus on Skill development	Yes	This course allows students to upskill their knowledge in digital communication.
Focus on entrepreneurship	No	-

EL421 Introduction to VLSI Circuits (3-0-2-4)

1. Introduction to VLSI

▪ VLSI Market and Trends ▪ Modern Processors ▪ VLSI Design Methodologies

2. Basic of MOS Transistors

▪ Semiconductor Device Physics ▪ CMOS Transistor

3. Logic Design with CMOS Transistor

▪ Static and Dynamic CMOS Logic ▪ Combinational and Sequential Logic Circuits

4. Memory Elements and Arrays

▪ Latches ▪ Registers ▪ Random-Access Memory (RAM) ▪ SRAM ▪ DRAM

5. Arithmetic Circuits in VLSI

▪ Full-Adder ▪ Half-Adder ▪ Adder Circuits ▪ Subtractor Logic Circuits ▪ Multiplication Circuits

6. Basic of AI/ML Architecture

▪ Nearest Neighbors Search ▪ SVM Classification ▪ Neural Network Architecture

7. Processor Design

▪ Introduction to TinyCPU ▪ VLSI Aspects of Computer Architecture ▪ Concept of Parallel Computing

▪ VLSI Sub-blocks of GPU

Suggested Textbook:

1. Introduction to VLSI Circuits and Systems by John P. Uyemura, Wiley, 2006.

2. Strain-Engineered MOSFETs by C.K. Maiti and T.K. Maiti, CRC Press, 2018.

3. Principles of CMOS VLSI Design: A Systems Perspective with Verilog/VHDL Manual by Neil H. E. Weste, K. Eshraghian, and M. J. S. Smith, Addison Wesley; 2 Edition, 2000.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in VLSI, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in VLSI.
Focus on entrepreneurship	No	-

EL453 Nanoelectronics (3-0-0-3)

The first part of the course covers ITRS predictions about emerging research devices, the limitations of nano CMOS and various options to MOSFET optimization. The next part covers the definition of the term nanoelectronics and its relationship to the broader topic of nanotechnology. Following this, the topic begins with an introduction to the principles of quantum mechanics, the wave particle duality, wavefunctions and Schrödinger's equation, energy bands, electrical conduction and low-dimensional structures. Then, the course discusses on the emerging research devices for nanocircuits, their long-range potential, technological maturity and challenges. The objective is to pursue long term alternative solutions to technologies addressed in More-than-Moore ITRS entries.

Texts:

1. Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, edited by Rainer Waser Publisher John Wiley & Sons, 2012

2. Semiconductor Physics And Devices: Basic Principles Hardcover by Donald A. Neamen (Author), Publisher: McGraw-Hill

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in nanoelectronics, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in nanoelectronics.
Focus on entrepreneurship	No	-

EL504 Selected Topics in VLSI (3-0-2-4)

Physical Design and Verification

1. Introduction to PD flow, Floor plan, Power plan
2. Placement, Types of Placement, Congestion
3. Clock tree synthesis, Clock skew, Clock tree optimization
4. Routing, Types of routing, Crosstalk
5. Physical Verification, Timing fixes

System Verilog Based Verification

1. Verilog for design and Verification refresh, Introduction to HVLs, Why System Verilog?
2. System Verilog Data types
3. Arrays, Queues, OOPs concepts, Classes
4. Randomization, Constraints, Mailboxes, Semaphores, Interfaces, mod port, clocking block
5. BFM development, Code Coverage and functional coverage, Introduction to SV assertions, Demonstration of Memory Test bench using System Verilog

Focus Area	Yes/No	Details

Focus on Employability	Yes	This is an elective course that excites students develop knowledge in VLSI, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in VLSI.
Focus on entrepreneurship	No	-

EL525 - Digital Design using HDL and FPGA (3-0-2-4)

1. Introduction to Digital Design, Concept of Hierarchical and Structured Design

Digital meaning and essence, Basics of digital VLSI design, role of CAD tools in VLSI design process, Hierarchical and design methodologies in VLSI systems, CAD algorithms for device, circuit, gate and system levels of abstraction, Physical design process in VLSI design, Testing.

2. Introduction to HDL, Synthesis and FPGA

Introduction to hardware description language, Basic language elements of Verilog, Behavioral modeling, Data flow modeling, Structural modeling, Switch level modeling, Constructs and conventions in Verilog, Data types, Number system, Operators.

Modeling and synthesis issues in Verilog, Familiarization with analog and mixed signal designing in Verilog.

Concept of CPLD, FPGA, Familiarization with Xilinx Spartan-3E FPGA development board, design constraints using FPGA, implementing designs using FPGA.

3. Combinational Systems Realization Using HDL and FPGA

Verilog description of gates, User-defined primitives, Instantiation, Design of arithmetic functions-adder, subtractor, multiplier, divider, Implementation of multiplexer, demultiplexer, encoder and decoder, code converters, Design of complex systems, Parameterized module, Realization of test benches, Timing and delay models.

4. Description and Design of Sequential Circuits

Defining procedural blocks, Procedural flow control, Blocking and non-blocking assignments,

Realization of latches, flip-flops, register, counter, Implementation of synchronous and asynchronous designs.

5. Data Subsystems

Storage modules, Memory, Stack, Queue, Functional modules, Data paths, Control subsystems.

6. FSM and I/O Subsystem

Finite state machine, 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, Design of practical systems.

Reference Books:

1. Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Prentice Hall.

2. Stephen Brown and Zvonko Vrsaniec, Fundamentals of Digital Logic with Verilog Design, McGraw Hill.

3. Zainalabedin Navabi, Verilog Digital System Design, McGraw Hill.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in HDL, FPGA, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in HDL, FPGA.

Focus on entrepreneurship	No	-

HM 484: Modern European Philosophy (3-0-0-3)

Building on the Cartesian foundations, Immanuel Kant had initiated a complete revolution in modern philosophy, "Copernican revolution" in his own terms, which spawned a period of intensely productive period called Post-Kantian philosophy. While Kant was a major champion of the Enlightenment, a great enthusiast of Isaac Newton's physics, and created a rich architectural account of human reason in his *Critique of Pure Reason*, the Post-Kantians like Fichte, Schelling, and Hegel absorbed the powerful currents of the German Romanticism and vehemently reacted against the influence of Kant in ways that the latter did not anticipate. Later on Schopenhauer and Nietzsche introduced important variant readings of Kant's ideas and in due course offered their own metaphysics. Each one of the Post-Kantians, except for Nietzsche, developed systematic metaphysics taking off from the Kantian breakthrough. And Nietzsche iconoclastically overturned all attempts to offer a systematic philosophy.

Texts:

Emmanuel, Steven M. (ed). *Modern Philosophy from Descartes to Nietzsche.* Oxford: Blackwell, 2002.

Gaarder, Jostein. *Sophie's World.* London: Penguin Putnam Inc, 2007.

Scruton, Roger. *A Short History of Modern Philosophy: From Descartes to Wittgenstein.*

Pinkard, Terry. *German Philosophy, 1760-1860: The Legacy of Idealism*

Focus Area	Yes/No	Details

Focus on Employability	No	-
Focus on Skill development	Yes	This course allows students to upskill their knowledge in humanities and social sciences which train them how to think, looking at others and to become a responsible citizen.
Focus on entrepreneurship	No	-

HM333 Human Behaviour Management (3-0-0-3)

1. Introduction to human behaviour: Importance and core issues in human relationship Management. Self-awareness, SWOT analysis, Role of values and beliefs in influencing Human behaviour.

2. Behavioural aspects in human relations: Individual attitudes and their effects, Attitude behaviour relationship, Transactional analysis of human behaviour.

3. Business Communication: Communication in personal and professional life, communication skills.

4. Performance management and appraisal: Rewards and punishment and its role in influencing human behaviour. Fairness and transparency in appraisal processes, Grievance redressal mechanisms.

5. Diversity at work place and Decision making: Understanding people from different cultures and backgrounds, Multi-cultural group dynamics.

6. Behavioural issue management: Crowding, Aggression, Anger Management, Need for healthy work-life balance.

Focus Area	Yes/No	Details
Focus on Employability	No	-
Focus on Skill development	Yes	This course allows students to upskill their knowledge in humanities and social sciences which train them how to think, looking at others and to become a responsible citizen.
Focus on entrepreneurship	No	-

HM334 Art : Ideas & Perspectives

Beginning from the origins of art to the European Renaissance, surveying the art movements from the 17th to 19th the century, the course shall focus on the complexities of 20th century Modern art in the West and then in India – this course shall familiarize students with the most iconic artworks of all times. Along with the major artists of the art movements, the aesthetic principles shaping these movements will also be discussed.

Texts:

Ways of Seeing – John Berger

- Sections from *The Story of Art* – E. H Gombrich
- Sections from *Aesthetics from Classical Greece to Present : A Short History* – Monroe C. Beardsley

Focus Area	Yes/No	Details

Focus on Employability	No	-
Focus on Skill development	Yes	This course allows students to upskill their knowledge in humanities and social sciences which train them how to think, looking at others and to become a responsible citizen.
Focus on entrepreneurship	No	-

HM487 Technology & Economy

Economy: Implicit assumptions behind conventional Economics; difference between microeconomics and macroeconomics. Is it right to view and treat a human being as a 'consumer'? If the marketplace determines the *price*, what decides the *value* of anything in a person's life? When is an economy 'better'? What is the underlying premise?

Money: What is 'money'? Who creates 'money'? Role of 'money' as (i) store of value, and (ii) medium of exchange; importance of liquidity and velocity.

Capital: Original meaning; savings. Role of banks, capital markets, stock exchange, debt and leverage; effects of 'financialization' on the real economy.

Technology: Origin of the word; historical developments. Does technology automatically lead to 'a better economy'? Should it? Case studies of some recent and new technologies. Disruption *versus* continuity; the concept of 'unlocking hidden value'.

Globalization: Interplay of energy, technology, communication, economies of scale.

State of the global economy: Can the highly developed economies develop further? Recent developments in India and elsewhere. True meaning and implications of 'free markets' and 'capitalism'; global population trends.

Focus Area	Yes/No	Details
Focus on Employability	No	-
Focus on Skill development	Yes	This course allows students to upskill their knowledge in humanities and social sciences which train them how to think, looking at others and to become a responsible citizen.
Focus on entrepreneurship	No	-

IE402 Optimization (3-0-2-4)

1. Introduction to optimization methods
    - Introduction
    - Formulation of an LPP
    - Graphical Method to solve an LPP
    - Nature of a solution
2. Linear programming problem
    - Algebraic method
    - Simplex method
    - Revised simplex method
    - Duality
    - Dual simplex method
    - Sensitivity analysis
3. Transportation problem

- North-west corner Rule
- Row-minimum method
- Vogels Approximation
- u-v method

4. Introduction to Game Theory (Decision making under competition)
   - Game with pure strategies
   - Game with mixed strategies
   - Dominance property
   - Graphical method for 2 _ n (or m _ 2) Games
5. Introduction to Queuing Model (6 hr.s)
   - Characteristics involved in queuing models
   - Markovian models (variations of MjMj1 and MjMjc models)

Texts:

1. An introduction to optimization by E. K. P. Chong and S. H. Zak (Wiley)
2. Engineering optimization Theory and practice by S. S. Rao (New Age international Pvt. Ltd.)

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in optimization, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in optimization.
Focus on entrepreneurship	No	-

IE403 Human Computer Interaction (3-0-2-4)

Introduction to HCI: basic terminology, history
Interactive System design: concepts of usability engineering, Graphical user interface design and aesthetics,
Model based design: Keystroke model, GOMS, human factors models
Task Modeling and Analysis
Prototyping: Low and high fidelity prototyping techniques
Evaluating prototypes: Principles and guidelines
Cognitive Architecture: Human processor model, experimental cognitive psychology

Texts:

Interaction Design - Beyond Human-Computer Interaction 3e, Yvonne Rogers, Helen Sharp and Jenny Preece, Human Computer Interaction, A. Dix, J. Finlay, G. D. Abowd, R. Beale, Pearson Education, 2005.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in HCI, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in HCI.
Focus on entrepreneurship	No	-

IE404 Digital Image Processing (3-0-3-4)

Introduction and Digital Image Fundamentals
Digital Image Fundamentals, Human visual system, Image as a 2D data, Image

representation - Gray scale and Color images, image sampling and quantization
Image enhancement in Spatial domain:
Basic gray level Transformations, Histogram Processing Techniques, Spatial Filtering, Low pass filtering, High pass filtering
Filtering in the Frequency Domain: Preliminary Concepts, Extension to functions of two variables, Image Smoothing, Image Sharpening, Homomorphic filtering
Image Restoration and Reconstruction: Noise Models, Noise Reduction, Inverse Filtering, MMSE (Wiener) Filtering
Color Image Processing: Color Fundamentals, Color Models, Pseudo color image processing
Image Compression: Fundamentals of redundancies, Basic Compression Methods: Huffman coding, Arithmetic coding, LZW coding, JPEG Compression standard
Morphological Image Processing: Erosion, dilation, opening, closing, Basic Morphological Algorithms: hole filling, connected components, thinning, skeletons
Image Segmentation: point, line and edge detection, Thresholding, Regions Based segmentation, Edge linking and boundary detection, Hough transform
Object Recognition and Case studies
Object Recognition- patterns and pattern classes, recognition based on decision – theoretic methods, structural methods, case studies – image analysis.

Texts:

Gonzalez Rafael C and Woods Richard E, Digital Image Processing, 3rd Edition, Prentice Hall, 2008

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in DIP, which help them in visualizing concepts and contexts in industrial applications.

Focus on Skill development	Yes	This course allows students to upskill their knowledge in DIP.
Focus on entrepreneurship	No	-

IT410 Web Data Management (3-0-0-3)

Introduction: Data on the Web Traditional Web Search and Search Engines Basics of Distributed Database and searching Web Data Models: XML, RDF, OWL Ontologies and Ontology Tools Intelligent Web Search Querying Web Data Distributed Databases, Storage, Query Processing Web Databases: Semantic Data, Social Data, Sensor Data, Cloud Data, main memory databases Research Topics in Large Scale Data Management

Texts:

Serge Abiteboul, Ioana Manolescu, Philippe Rigaux, Marie-Christine Rousset, Pierre Senellart , Web Data Management, Cambridge University Press, 2011

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in web data management, which help them in

		visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in web applications.
Focus on entrepreneurship	No	-

IT468 Natural Computing (3-0-0-3)

The course provides basic overview of natural ICT and it covers basic notation of biochemistry and molecular biology that are needed to learn about DNA computing. Basic models of computing such as finite automata (FA), push-down automata (PDA), linear bounded automata (LBA) and Turing machine (TM) with corresponding languages and their relationships, Quantum Turing machine (QTM) and quantum languages, computation by circuits, thermodynamics of computation, post systems, rewriting systems, L-systems, algorithmic botany, cellular automata, block cellular automata, Adleman experiment with DNA computer, different models of DNA computation (Lipton model, Sticker model, DNA splicing model, DNA self-assembly, hair pin model) and complexity problems such as integer factorization, basic arithmetic etc. Overview of algorithmic self-assembly (ASA), algorithms for natural security and cryptography, Experiments in self-assembly, DNA origami (2D and 3D), Error-correction in self-assembly, Applications, Bacterial computers and data storage, Peptide computing, Membrane computing, Chemical computing, Strand Displacement Systems. Some Open Problems, Popular Software Tools: Xgrow, XTile, CadNano, Sarse, Tiamat, programming language for designing and simulating DNA circuits, playing games with DNA computers (MAYA-I & II), Synthetic biology, Morphological (Liquid) Computing.

Texts:

1. Martyn Amos, Theoretical and Experimental DNA Computation, 2005, Springer.
2. Gheorge Paun, Grzegorz Rozenberg and Arto Salomaa, DNA Computing-New Computing Paradigms, 1998, Springer.
3. Sudheer Sahu and John H. Reif, DNA based self-assembly and Nan robotics, 2008.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in natural computing, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in natural computing.
Focus on entrepreneurship	No	-

IT486 Blockchains and Cryptocurrencies (3-0-0-3)

Topics covered include basic cryptographic tools, early digital cash (Chaum et al), 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

References

• Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction, Narayanan,

et. al. Princeton, 2016. ISBN: 978-0691171692.

• Programming Bitcoin, Jimmy Song, O'Reilly, 2019. ISBN: 978-93-5213-808-1

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in blockchain technology, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in blockchain technology.
Focus on entrepreneurship	Yes	Blockchain technology offers enormous scope for entrepreneurship.

IT506 Accelerated Computing (3-0-2-4)

Know-how of principles of parallel algorithm design and ability to program on heterogeneous computing systems using CUDA C.
Ability to express data and instruction level parallelism in applications using CUDA.
Understanding of important parallel patterns.
Hands-on experience with the fundamental tools and techniques for accelerating/ optimizing applications (C language) on GPUs with CUDA (taking into account processor architecture features)

References:

1. Programming Massively Parallel Processors: A Hands-on Approach 3rd Edition by David B. Kirk, Wen-mei W. Hwu.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in HPC, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in HPC.
Focus on entrepreneurship	No	-

IT524 Computer Vision (3-0-0-3)

Topics covered are basis knowledge of image processing, image formation, cameras, and camera geometry. Projective geometry, feature extraction, feature formation, feature matching. Single view geometry and multiple view geometry. Camera calibration both single camera and stereo cameras. Extracting real world information from images, automated alignment of images takes with restricted camera motion (e.g. panoramas), and tracking. Face detection, object detection, video processing and tracking. Clustering, classification, segmentation, different approaches to image and video segmentation. Time permitting we will also cover some basics of convolution neural networks (CNNs) and its applications in computer vision.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in computer vision, which help them in visualizing

		concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in computer vision.
Focus on entrepreneurship	No	-

IT548 Software Testing and Verification (3-0-2-4)

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

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in software engineering, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in software engineering.

Focus on entrepreneurship	No	-

IT549 Deep Learning (3-0-2-4)

Artificial Neural Network (ANN)

Architecture tuning

Data pre-processing

Selected Topics or/and Hybrid architectures

Reinforcement Learning

References:

Ian Goodfellow, Yoshua Bengio, and Aaron Courville. 2016. Deep Learning. The MIT Press.

Satish Kumar. 2004. Neural Networks: A Classroom Approach. Tata McGraw-Hill Education.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in deep learning, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in deep learning.
Focus on entrepreneurship	No	-

IT561 Advanced Software Engineering (3-0-2-4)

The contents 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 (7) Assessment and Evaluation in Software Engineering

References:

Shari Lawrence Pfleeger, and Joanne M. Atlee, Software Engineering: Theory and Practice, 3rd Edition, 2006, Pearson.

Martin, Robert C. Agile software development: principles, patterns, and practices. Prentice Hall, 2002.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in software engineering, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in software engineering.
Focus on entrepreneurship	No	-

IT627 Cloud Computing (3-0-2-4)

1. Introduction to Cloud Computing
2. Fundamental Concepts
3. Ensuring High Availability & Disaster Recovery
4. SQL and No SQL Databases
5. Identity and Security in Cloud
6. Containers
7. Serverless Applications
8. Cloud and IoT
9. Microservice based architectures

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in cloud computing, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in cloud computing.
Focus on entrepreneurship	No	-

SC322 Introduction to Graph Theory (3-0-0-3)

Definitions of graphs, representations, models and applications, Standard terminology and parameters of graphs (degree, girth, connectedness, connectivity, circumference, diameter, radius, eccentricity, chromatic number independence number etc.), Classes of graphs: Bipartite graphs, petersen graph, regular graphs, complete graphs, complete multipartite graphs, intersection graphs, harary graphs etc., Isomorphism, Counting of graphs, labelled and unlabelled graphs, graph properties

related to the presence or absence of subgraphs, Paths, cycles and related graph theoretic concepts, Eulerian trails, Eulerian cycles, chinese postman tour etc., Vertex degrees and basic properties, Havel-Hakimi Theorem, Analogous concepts for directed graphs, problems specific to directed graphs, oriented graphs, Trees, properties, spanning trees of graphs, and distances, Matchings, covers correlation to vertex covers, and other related concepts. Augmenting Paths theorem, Hall's Theorem, Tutte's Theorem for matchings in general graphs, Cuts and connectivity, vertex and edge connectivity, the relation between them, k connected graphs, Menger's Theorem and the relation between connectivity and alternative paths, Flows in networks, correlation with connectivity, Vertex colouring, basic properties of chromatic numbers, upper and lower bounds and corresponding algorithms. Relation to Independent Sets, Cliques, Edge colouring and vizing's theorem, Planar graphs, planarity, Kuratowski's Theorem, Cycles, girth and circumference, Hamiltonian cycle problem, Algorithmic aspects of all the above, wherever applicable.

Texts:

Introduction to Graph Theory by Douglas B. West

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in graph theory, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in graph theory.
Focus on entrepreneurship	No	-

Convolutional Codes, Turbo Codes and Low density parity check (LDPC) codes, Algebraic

Geometry codes - Goppa codes, Applications of Coding Theory to Networks (Cloud Computing: Cloud Data Storage and Cloud Security), Cryptography, Wireless Communications, Quantum Computing, and DNA computing.

Texts:

1. Raymond Hill, A first course in coding theory, Oxford University Press, 1990 (Elementary Text Book for Coding Theory)
2. Norman Abramson, Information theory and Coding, McGraw-Hill, 1993 (Classic Book)

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in coding theory, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in coding theory.
Focus on entrepreneurship	No	-

SC435 Introduction to Complex Networks (3-0-0-3)

This course aims to introduce students to many of these concepts in detail from the point of view of analytical and algorithmic and computational methods. A variety of examples from physical systems to social and biological systems would be discussed. The course will cover three main topics of networks science: (i) network structure and metrics (ii) network models (iii) dynamical processes on networks.

Texts:

M. E. J.Newman, Networks – An introduction. Oxford Univ. Press, 2010.
A. L. Barabasi, Network Science, Cambridge, 2015.

Focus Area	Yes/No	Details
Focus on Employability	Yes	This is an elective course that excites students develop knowledge in complex networks, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in complex networks.
Focus on entrepreneurship	No	-

SC461 Coding Theory and Applications (3-0-0-3)

Historical Introduction and Motivation of Coding and Information Theory, Basic Review of Finite Fields and Finite Rings, Introduction to Algebraic Coding Theory, Codes over finite fields and finite rings, Linear and Non-linear Codes, Hamming Codes, Golay Codes, Cyclic, Quasi-cyclic and Quasi Twisted Codes, Quadratic Residue Codes, Reed Muller, Reed Solomon Codes and BCH Codes, Quadratic Residue Codes, Art of Decoding,

PC503 Programming Lab (1-0-4-3)

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.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on coding and web development.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in programming.
Focus on entrepreneurship	No	-

PC512 Communication Skills and Technical Writing (2-0-0-2)

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. 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 presentations, interviews, impromptu speeches and discussions/deliberations. The writing aspect will focus on document construction and information processing.

Focus Area	Yes/No	Details
Focus on Employability	Yes	Communication skills and language proficiency helps students in employment.
Focus on Skill development	Yes	The students develop necessary skills for communicative english, writing and presentation skills
Focus on entrepreneurship	No	-

SC531 Probability and Random Variables (3-0-0-3)

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.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The course allows students to develop knowledge in probability theory, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in probability theory.
Focus on entrepreneurship	No	-

SC421 Linear Algebra and Optimization (3-0-0-3)

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.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The course allows students to develop knowledge in linear algebra, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in linear algebra.
Focus on entrepreneurship	No	-

IT551 Information Retrieval (3-0-2-4)

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.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The course allows students to develop knowledge in IR, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in IR.
Focus on entrepreneurship	No	-

IT412 Natural Language Processing (3-0-2-4)

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. The course will also study machine learning algorithms that are used in natural language processing.

Focus Area	Yes/No	Details

Focus on Employability	Yes	The course allows students to develop knowledge in NLP, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in NLP.
Focus on entrepreneurship	No	-

CT421 Advanced Digital Signal Processing (3-0-2-4)

This course aims to cover a few familiar topics to EC students in a mathematically rigorous manner, and introduced a few advanced topics as well.

Module 1: Basic Functional Analysis: Metric Space, Normed Spaces, Inner Product Space, Convergence of Sequences, Completeness, Banach and Hilbert Space. L_2 norm, inner product, $L_2(R)$.

Module 2: Fourier Analysis: LTI Operator (System) and Impulse Response, Fourier transform in L1(R) and its properties, Defining Fourier Transform in L2(R), via Density Extension, Global regularity of signal and spectrum decay, Gibbs Oscillations. Module 3: Sampling and Reconstruction, Shannon's three-step sampling paradigms and its limitations, Removal of Aliasing, Generalized Sampling Theorem in Hilbert Space Framework, Compressive sensing, Concept of frames (linearly dependent vectors).

Module 4: Time-Frequency analysis and wavelet: Spectrogram vs. Scalograms, Wavelets: CWT, Admissibility condition, real vs. analytic wavelets. Module 5: Multirate DSP: Upsampling, Downsampling, Quadrature Mirror Filterbank (QMF), Paraunitary Filterbanks, Wavelets and Filterbanks. Module 6: Inverse Problems, Homomorphic deconvolution, Blind deconvolution, Singular Value Decomposition (SVD), Weiner filter, All-pole models for inverse filtering. Module 7: Feature Engineering (Dimensionality Reduction):- Binning, Log-transform, Principal Components Analysis (PCA), Discrete Cosine Transform (DCT).

Focus Area	Yes/No	Details
Focus on Employability	Yes	The course allows students to develop knowledge in DIP, which help them in visualizing concepts and contexts in industrial applications.
Focus on Skill development	Yes	This course allows students to upskill their knowledge in DIP.
Focus on entrepreneurship	No	-

IT580 Advanced Algorithms (3-0-2-4)

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.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software development, coding and computing.

Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in Algorithms that become prerequisite for other subsequent courses.
Focus on entrepreneurship	Yes	Algorithms is a foundational course that helps in exploring startups, entrepreneurship.

IT561 Advanced Software Engineering (3-0-2-4)

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.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on Software Engineering.

Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in software engineering.
Focus on entrepreneurship	Yes	Software Engineering is an essential course for start-ups and entrepreneurship.

SC612 Discrete Mathematics (3-1-0-4)

The objective of the course to build mathematical background needed for better understanding of computing techniques studied in various courses of the program. This course begins with quick revision of Logic, Sets, Relations and Functions, and provides a detailed discussion of Basics of counting (Permutations, Combinations, Recurrence relations, Solving Linear recurrence relations), Discrete Probability (Basic probability theory, Bayes theorem, expected value and variance), and Graph theory (Graph and graph models, graph representations, basic graph problems like traversals, shortest path and Euler paths)

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software development.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in discrete mathematics that become prerequisite for other subsequent courses.
Focus on entrepreneurship	No	-

IT603 C Programming (3-0-2-4)

This course introduces basic concepts of computer programming and phases of program development, deployment and testing to solve computational problems. Topics include: problem solving techniques, flow charts, decision tables and C programming. At the end of the course, student will be able to develop logical analytical ability to perceive and solve computational problems; to write and test computer programs developed with C programming language; and to work effectively with various computer software tools like editors, compilers, office automation, imaging, etc.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the Programming course can be employed in industries focusing on coding, web development.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in basic programming skills that become prerequisite for other subsequent courses..
Focus on entrepreneurship	Yes	The students apply their coding skills in entrepreneurship, start-up.

IT616 Algorithms and Data Structure (3-0-2-4)

Asymptotic analysis: Big O, little o, omega, and theta notation, worst case and average case analysis, and solving recurrences. Algorithm Design Techniques: Brute-force algorithms, Divide-and-conquer, Dynamic programming, Greedy algorithms, Backtracking and Heuristics. ADTs that covered are Lists, Stacks, Queues, Trees, and Graphs. Sorting and Searching, Binary search trees, Hashing, Graph representations, Graph Algorithms

(DFS, BFS, Shortest- path (Dijkstra's and Floyd's algorithms), Minimum spanning tree (Prim's and Kruskal's algorithms) and Topological sort.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software development, coding and computing.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in data structures that become prerequisite for other subsequent courses.
Focus on entrepreneurship	Yes	Data structure is a foundational course that helps in exploring startups, entrepreneurship.

IT615 Database Management Systems (3-0-2-4)

This course is intended to give a solid background in database design and implementation with the focus on relational model. The course covers data modeling, theory of relational model, Functional Dependencies, and Normalization, Querying relational databases using Relational Algebra and SQL. Students also learn and practice creating stored procedures, accessing databases in host programming languages. The course also introduces Storage and Indexing structures, Query Execution and Transaction Processing concept. During Lab hours, students should practice concepts learned in theory and would be asked to design and implement a database system for a mid-size real life scenario.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking DBMS course can be employed to industries focusing on database and software development.
Focus on Skill development	Yes	The students develop necessary skills to work with real use cases using databases.
Focus on entrepreneurship	Yes	The students can work on real time projects focusing on development of small, medium and large enterprises through entrepreneurship/self-employability and start-ups.

PC613 Communication Skills (3-0-2-4)

This course is designed to provide students with (a) the skills to enhance communication – both verbal and written, as well as presentations skills, (b) skills for job interviews (c) self- motivation and measurable goal setting, (d) professional behavior, and (e) principles of consultation as an appropriate tool for relating to others.

Focus Area	Yes/No	Details
Focus on Employability	Yes	Communication skills and language proficiency helps students in employment.

Focus on Skill development	Yes	The students develop necessary skills for communicative english, writing and presentation skills
Focus on entrepreneurship	No	-

IT602 Object Oriented Programming (3-0-2-4)

The objective of this course is to discuss object oriented programming paradigms and implementation of common data structures using OOP language like C++ or Java. Topics include: Objects and Classes, Attributes, Methods, Visibility; Class Relationships, Association, Aggregation, Composition; OOP principles (Abstraction, Information Hiding, Encapsulation, Inheritance, Polymorphism). This course is about programming in Java. Java is the most widely used language for developing open source software systems. With Java, there comes huge library support which reduces the development time and enhances software reuse for faster development.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the Programming course can be employed in industries focusing on coding, web development.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in OOPs and OODs.
Focus on entrepreneurship	Yes	The students apply their coding skills in entrepreneurship, start-up.

IT632 Software Engineering (3-0-2-4)

The course intends to teach complete life cycle of software develop. The course covers Software Processes and SDLCs; Requirements Engineering; Software Testing, Verification and Validation; Software Evolution; CASE Tools; Introduction to Software Project Management, Appreciate Software Reliability and Risk Assessment; Software Quality Standards and Quality Assurance.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on Software Engineering.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in software engineering.
Focus on entrepreneurship	Yes	Software Engineering is an essential course for start-ups and entrepreneurship.

IT628 Systems Programming (3-0-2-4)

The purpose of this course is to provide the students with an introduction to system-level programming in a UNIX environment. Students will be introduced with the standard Linux commands, memory management, interacting with the operating system by making system calls for file management, file execution, process control, and interprocess communication, shell scripting, Sockets and using TCP/IP, Shell principles, exec family of functions, naming conventions, and so on. A primary goal of the course then is to train the students in a systems programming context to develop code that is robust.

Focus Area	Yes/No	Details

Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software engineering, developer.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in systems programming.
Focus on entrepreneurship	No	-

IT694 Computer Networks (3-0-2-4)

The course explains the evolution of computer and communication networks and the design principles of modern network architectures. Focus is on application layer protocol design and implementation along with system level concepts and engineering design and implementation issues. A top down approach is used to familiarize students with network application design and progressively define the underlying support needed to build such application. A thorough treatment of TCP/IP set of protocols is done. At the end of the course, a student should be able to design and develop a wide variety of network applications. Students will also be able to analyze and compare network technologies and use the appropriate tools to design network systems. The associated laboratory component is designed to expose students to basic networking hardware and software along with configuration and operation of standard network protocols. They will also design and develop network applications and test network performance.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on Software Engineering, Network Administrator.

Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in computer networks
Focus on entrepreneurship	No	-

IT629 Web Programming (3-0-2-4)

The objective of this course is to discuss the structured approaches to identify the needs, interests, and functionality of a webpage using various technologies such as JavaScript, CSS and HTML. This course covers the most current tools available for developing HTML documents and posting pages on the World Wide Web in order to improve the users experience in different perspectives; use of JavaScript libraries (e.g. JQuery) to create dynamic pages; use JavaScript to access and use web services for dynamic content (AJAX, JSON, etc.).

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software developer, web developer.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in web development
Focus on entrepreneurship	Yes	The students taking this course will be equipped with the required exposure for initiating start-ups, entrepreneurship.

IT619 Design of Software Systems (3-0-2-4)

The objective of the course is to teach good software design practices at architectural

level as well as component level. Prime focus is on designing software systems using object oriented principals. The scope of course begins with given software requirements and ends with producing a detailed design in software development life cycle. Emphasis is on learning Unified Modeling Language from the ground; students should be able draw UML diagrams using very basic tools like Dia. Students are encouraged to take a mid-size software design projects, submit detailed design and take up to the implementation. Students also learn and attempt to apply common design patterns.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software developer, web developer.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in web development
Focus on entrepreneurship	No	-

IT618 Enterprise Computing (3-0-4-5)

Objective of the course is to learn whole array of java technologies for building enterprise applications. The course intends to provide lots of hands, and students are engaged in developing mid-size projects drawn from real world, using J2EE technologies. Technologies that are to be included are Core Java with Collections, Swing, and JDBC API; HTML, XML, JSP/Servlet. Use of MVC frameworks like Apache Struts for building java based web applications. Students are also exposed to various J2EE patterns.

Focus Area	Yes/No	Details

Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software developer, web developer.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in enterprise applications.
Focus on entrepreneurship	Yes	The students taking this course will be equipped with the required exposure for initiating start-ups, entrepreneurship.

SC613 Mathematical Foundation for Data Science (3-1-0-4)

Linear Algebra, Probability and Random Variables; Vector spaces, subspaces, Sum & direct sum of subspaces, Linear Dependence, Span, Basis, Dimension; Definitions of Norms, Inner Products and metrics. Orthogonality; Representation of linear transformations as a matrix, Similarity transformation, Four fundamental subspaces associated with a matrix, Rank-Nullity theorem, Fundamental Theorem of Linear Algebra, Orthogonal Projections; Matrix Diagonalization: Eigenvectors and Eigenvalues, Spectral Theorem for Hermitian matrices, SVD, Least squares using Normal equations and SVD; Basic of Probability: Axioms of Probability, Independence, Conditional Probability, Bayes theorem; Random Variables: Random Variables, Discrete and Continuous Random Variables, Functions of One Random Variable, Expectation, Mean, Variance and Moments, Characteristic Function; Univariate Discrete and Continuous Probability Distribution; Binomial, Poisson, Geometric, Uniform, Exponential, Gamma, Gaussian

References:

1. Sheldon Axler, Linear Algebra done right, 3rd ed., Springer, 2005.

2. David C. Lay, Steven R. Lay and Judi McDonald, Linear Algebra and its applications, Pearson,

5th ed., 2015.

3. Gilbert Strang, Linear Algebra and its applications, 4th ed., Cengage Learning, 2005.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on data science, machine learning.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in data science and linear algebra.
Focus on entrepreneurship	No	-

IT605 Data Structures and Algorithms (3-0-2-4)

Abstract Data Types: Abstraction, ADT, Bags, Iterators, Application

Arrays: Array Structure, The Python list, 2D arrays, Matrix abstract data types, Application

Sets and Maps: Sets, Maps, Multi-dimensional arrays, Application

Algorithm analysis: Complexity analysis, Python list evaluation, Amortized cost, Set ADT evaluation, Application

Searching and sorting: Linear search, binary search, Bubble sort, Selection sort, Insertion sort,

Working with sorted list.

Linked Structures: Singly linked list, Ways to build linked list, The bag ADT, Sparse matrix, Polynomials, Doubly linked list, circular linked list, multi linked list, Complex iterators.

Stacks: The stack ADT, Implementing stack, Applications.

Queues: The queue ADT, Implementing queue, Priority queues, Applications.

Recursion: Recursive functions, Properties of recursion, How recursion works, Recursive applications.

Hash Tables: Hashing, Separate chaining, Hash functions, The Hash-map abstract data type,

Application

Tries: Standard (handling keys, searching, Deletion), Compressed, Suffix.

Advanced sorting: Merge sort, Quick sort, Radix sort, Sorting linked list.

Binary trees: The tree structure, The binary tree, Expression trees, Heaps, Heapsort, Applications

Search trees: The binary search tree, Search tree iterators, AVL trees, B-Trees, 2-3-4 Trees

References:

1. Data Structures and Algorithms - Aho, Hopcroft and Ullman [Addison-Wesley, 1999]

2. Data Structures and Algorithms Using Python - Rance D. Necaise [Wiley, 2011]

3. Introduction to Algorithms - Cormen, Leiserson, Rivest and Stein [PHI, 2010].

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on software development, coding and computing.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in data structures that become prerequisite for other subsequent courses.
Focus on entrepreneurship	Yes	Data structure is a foundational course that helps in exploring startups, entrepreneurship.

SC614 Statistical Methods (3-0-2-4)

Frequency distribution, measure of central tendency, dispersion and moments. Joint Distribution Discrete and Continuous, Conditional Distributions, Covariance and

Correlation Coefficient, Regression, Least square. Multivariate Distribution: Multinomial, Multivariate Gaussian and its properties, Wishart distribution, Generalized Linear Regression Limit laws: Chebyshev's inequality, W.L.L.N., S.L.L.N. and their applications, De-Moivre Laplace theorem, Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T. Methods of estimation, Method of Moments, Maximum Likelihood (MLE), Expectation Maximization (EM). Nonparametric Tests: Introduction and Concept, Test for randomness based on total number of runs, Kolmogrov Smirnov test for one sample, Sign tests- one sample and two samples, Wilcoxon signed rank test- one sample and two samples, Mann-Whitney U test.

References:

1. An Introduction to Multivariate Statistical Analysis by T. W. Anderson
2. Linear Statistical Inference by C. R. Rao
3. Fundamentals of Statistics by A.M. Goon, M.K. Gupta and B. Dasgupta
4. Fundamentals of Mathematical Statistics by S.C. Gupta and V.K. Kapoor

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on data science.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in statistical methods.
Focus on entrepreneurship	No	-

IT606 Programming Lab (0-0-4-2)

Basics of Python Programming; Loops and Conditional Statements Arrays; Strings and Lists; Tuples; Functions; Dictionaries; User-defined Modules; Exception Handling; File Handling

Class and Object.

References:

1) Al Sweigart, Automate the Boring Stuff with Python: Practical Programming for Total Beginners, 2015.

2) Zed A. Shaw, Learn Python 3 the Hard Way, 2017.

3) Paul Barry, Head First Python: A Brain-Friendly Guide, O'Reilly, 2017.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on coding, software development.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in Python programming.
Focus on entrepreneurship	No	-

IT607 Introduction to Database Management (3-0-2-4)

Basic definitions, data storage, queries, transaction management, administration; Requirements collection and analysis; Structuring Data– Data Models, E-R Model, Conceptual Design using E-R Model; integrity constraints, Database Design; Relational Algebra, SQL; Query Processing; Conceptual Database Design & Tuning– Stored data in terms of relational data model; Normal Forms, Decomposition, Normalization, Schema Refinement; Physical Database Design– Storage/organization of data on disks, tapes; Transaction Management – Concurrency Control, Crash Recovery; Distributed & Parallel

Databases– Fragmentation & Distribution Schemes; Database Administration and DBM Tools Oracle, postgresql/ postgres

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking DBMS course can be employed to industries focusing on database and software development.
Focus on Skill development	Yes	The students develop necessary skills to work with real use cases using databases.
Focus on entrepreneurship	Yes	The students can work on real time projects focusing on development of small, medium and large enterprises through entrepreneurship/self-employability and start-ups.

SC602 Numerical Methods for Data Science (3-0-2-4)

Polynomial functions – linear, quadratic, cubic, quartic and n-order polynomials set as a summation series. Transcendental functions.

Quadrants, fixed points, turning points and asymptotic properties of functions. Plotting of the

Gaussian function and the Lorentz function as a first-order approximation of the Gaussian function.

Monomials – with positive exponents greater than unity and less. Plotting functions with odd and

even exponents greater than unity. Fractional exponents – odd and even roots. Inflection points,

coinciding roots and turning points. Monomials with negative exponents.

Series expansion, Taylor series and Taylor polynomials. The theory of polynomials.

The basic principle and the application of the bisection method. The algorithm of bisection. The basic principle of the Newton-Raphson method with examples. The basic principle of the secant method with examples. Two methods of the initial guess values of the roots of the secant method.

Curve fitting and Interpolation: Basic definitions, the Weirstrass approximation theorem and the

Lagrange polynomial. Linear Lagrange interpolation of two points with examples. Quadratic

polynomials to interpolate three points.

Divided differences, definition, the first-order divided difference, the mean-value theorem. Approximating a divided difference to the derivative of a function about the average position between points. Second, third and higher-order divided differences. Properties of divided differences.

Newton's divided-difference interpolation of linear, quadratic and cubic orders with examples.

Forward difference. Forward difference form of the interpolation polynomial. Backward difference and Newton's backward difference interpolation. Piecewise linear interpolation and spline interpolation. The natural cubic spline. Matching of derivatives and obtaining the cubic spline function. Constructing a cubic spline with four points.

Numerical integration: – the trapezoidal rule. The trapezoidal formula for n sub-intervals. Simpson's rule and its derivation. Simpson's rule for n sub-intervals. Monte Carlo Integration Schemes.

Numerical differentiation, the forward difference and the backward difference formulae. Error

estimation. Differentiation using interpolation and the central difference formula. Gaussian

quadrature with one and two nodes.

Fourier and Laplace Transforms, Discrete Fourier Transform, z transform, Fast Fourier Transform

Numerical solution of systems of algebraic equations: Systems of linear equations, matrix arithmetic.

The matrix inverse, orthonormality, cofactor and transpose. The rules of matrix algebra. Solvability of linear systems. Gaussian elimination, the augmented matrix.

Texts:

1. Elementary Numerical Analysis, K. Atkinson & W. Han, Wiley-India, New Delhi

2. Numerical Methods for Engineers and Scientists, J. D. Hoffman, Marcel Dekker Inc., New York

3. Borse, G.J., Numerical Methods with MATLAB: A Resource for Scientists and Engineers, PWS Publishing Co., Boston, 1997.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on data science.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in Numerical methods for data science.
Focus on entrepreneurship	No	-

IT609 Big Data Processing (3-0-2-4)

Introduction to Map Reduce Programming Model.

Overview of Hadoop Ecosystem - HDFS, Yarn.

Appreciate commonly used tools like Sqoop, Pig, Hive, HBase.

Apache Spark Framework, Resilient Distributed Datasets (RDDs).

Programming Spark for analytical tasks.

Spark SQL.

References:

1. White, Tom. Hadoop: The definitive guide. " O'Reilly Media, Inc.", 2012.

2. Karau, Holden, et al. Learning spark: lightning-fast big data analysis. " O'Reilly Media, Inc.", 2015.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on Big-Data, Analytics.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in big-data processing.
Focus on entrepreneurship	Yes	Big-Data, Data Analytics provide enough opportunities for entrepreneurship.

SC601 Optimization (2-0-2-3)

Calculus of functions of several variables: Limit, Continuity, Differentiability, Gradient, Directional derivative, Hessian, Local minimum and local maximum, Saddle points, Necessary and sufficient conditions for local extreme points.

Unconstraint nonlinear optimization: Gradient methods, Newton's method, Conjugate direction methods.

Linear and nonlinear regression, Logistic regression, stochastic gradient descent

Numerical solution of linear systems: Least square analysis, Recursive least squares algorithms, Solution to a linear equation with minimum norm.

Constraint nonlinear optimization: Lagrange multiplier method, KKT conditions

Linear programming problems, Quadratic programming: Wolf's method and Beale's method.

References:

1. An Introduction to Optimization (4th Edition) by E. K. P. Chong and S. H. Zak (Wiley)
2. Optimization in Operations Research (2nd Edition) by R. L. Rardin (Pearson)
3. An Introduction to Statistical Learning with Applications in R by G. James, D. Witten, T. Hastie and R. Tibshirani (Springer)

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on data science.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in optimization.
Focus on entrepreneurship	No	-

IT642 Interactive Data Visualization (3-0-2-4)

Overview of Visualization, 2-D Graphics, SVG-examples, 2-D Drawing, 3-D Graphics, Photorealism, Non-Photorealism, the Human memory, Reasoning, The Human Retina, Perceiving Two Dimensions, Perceiving Perspective.

Visualization of numerical data: Data, Mappings, Charts, Glyphs, Parallel Coordinates, Stacked Graphs, Tufte's Design Rules, Using Color.

Visualization of non-numerical data: Graphs and Networks, Embedding Planar Graphs, Graph

Visualization, Tree Maps, Principal Component Analysis, Multidimensional Scaling, Packing.

Introduction to Vega-Lite, Data Types, Graphical Marks, and Visual Encoding Channels, Data

Transformation, Scales, Axes, and Legends, Multi-View Composition, Interaction.

Examples of good visualizations, Matrix visualizations, Interactive data visualizations.

References:

1. Hand book of Data Visualizations by C. H. Chen, W. Hardle, A. Unwin (Springer)
2. Fundamentals of Data Visualization: A Primer on Making Informative and Compelling Figures by Claus O. Wilke (O' Reilly)
3. Data Visualization – A Practical Introduction by Kieran Healy (Princeton University Press)

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on computer vision, data analytics.
Focus on Skill development	Yes	The students develop necessary skills to develop knowledge in data visualization.
Focus on entrepreneurship	No	-

PC721 Approaches to Culture and Communication (3-0-3-4)

This course will introduce students to a series of lectures and discussions on the role of technology and culture in communication. It aims to explore the ways in technology mediates and transforms cultural meanings in practices of social communication. The primary focus of this course would be on identifying specific fields of social communication, and understanding the kinds of design problems and solutions these can generate. It will introduce students to a range of analytical frameworks derived from studies of both aesthetics and semiotics. These frameworks would apply to understanding communication practices in Indian as well as in cross-cultural contexts. Students will be encouraged to understand that an appreciation of the intent of communication is a significant factor in the process of effective communication design and that it is important to develop the ability to decode 'point of view' and 'perspective' in relation to meanings. The course which will be organized through readings, lectures, and seminar presentations

aims to help students to intellectually integrate the domains of design and technology with society and culture. It will provide the essential foundations for them to undertake their individual projects in the second year when they would be oriented to develop a more in-depth understanding of the principles of communication through either Visual Design or Interaction Design.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in culture and communication.
Focus on entrepreneurship	No	-

PC722 Fundamentals of Design I (3-0-4-5)

Design is an interdisciplinary activity - characterized by the constant preoccupation of co-relating disciplines, dealing with and trying to understand the complex and interesting worlds of the physical, biological, imaginary, and human all of which are multivariate in character. The Fundamentals of Design course is an attempt to sensitize students to this complex, dynamic and multidimensional scenario. The main objective of this course is to acquaint students of Communication Design to the means and methods of approaching, investigating and solving problems creatively by providing them with appropriate design and conceptual skill sets. The course would emphasize the latitude and value of individual thinking and the students' ability to observe and see which would enable them to apply themselves creatively in solving problems. The areas that would be covered would be drawing - a process of observation, recording and representation which would include various kinds of representation for 2D. Objective of this course is in providing the student

with a foundation in the grammar for design for communication based on ideas and concepts like color, composition, typography and layouts/space, illustration for specific needs. The course would culminate in a project that student would integrate skills and aptitude acquired in the course.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on visual communication.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in design principles.
Focus on entrepreneurship	No	-

PC746 Information Design (3-0-4-5)

Information design covers the promoting and enhancing of making the complex simple. It facilitates and transforms complex, unorganized, or unstructured data into useful, usable information both with efficiency and effectiveness. The attempt would be to discover and articulate the meaning in data, and create the map that allows others to use the information easily, through meaningful reductions and interpretations of complex data by using writing and analytical skills to transform unstructured ideas into concrete, meaningful information.

The course would cover the defining, planning, and shaping of the contents of a message: it is designing understanding for a particular environment it is presented in with the intention of achieving specific objectives with reference to the needs of users and creating navigation and hierarchy that makes information intuitively and easily accessible.

The course would also cover the essential aspects of Information Systems and Architecture to establish and understand types of information systems and the role of

such systems and their technological foundations. The key components of Information Systems and key issues in implementation, explaining how design problems are conceived, researched, analyzed and resolved in different contexts would be discussed. The methods and frameworks used in conceptualizing, designing and implementing information systems, through Information Architecture would also be considered.

The course encourages exploring how information can be structured and visualized to create effective communications and to stimulate viewer attention and engagement through design. Building sensitivity, via case studies, Information Collection, Conceptual Data Analysis, Information Mapping and Visualization along with User Studies are introduced as means towards developing concise, clear and visually sophisticated communication material. The course provides students with an introduction to structuring and presenting information with an emphasis on meaning, clear communication and visual aesthetics that in turn enhance how people read, understand and use information.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on information design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in information design.
Focus on entrepreneurship	No	-

PC749 Image-Text-Sound (3-0-4-5)

Introduction to elements of composition: This course aims at exploring how words, images and sounds are put together for a range of communication events and forms. Students would be expected to research, document and compose presentations deploying multi-media. They will be encouraged to read and explore ideas from design aesthetics and

semiotics to understand compositional styles and aesthetic choices in traditional as well as contemporary forms of communication media in which visual, verbal and aural elements are combined to make effective communication events. Students would be able to appreciate diverse technologies of communication in rural or urban, India or in local or global media platforms and explore how image, text and sounds are combined to generate a context specific meanings in specific contexts.

This could be exemplified in case of advertisements, mounting of event such as theatrical, exhibition, and installation or ritual performances. By the end of the semester students are expected to acquire the skills and the theoretical insights that are needed to understand the relationships between composition and context in multimedia formats.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in visual communication.
Focus on entrepreneurship	No	-

PC748 Design History (1-0-2-2)

This module will introduce students to a brief history of Design practice and pedagogy as it evolved in the context of the Industrial Revolution and the onset of the age of mass production in the late 19th and early 20th century. The objective of this course is to enrich students' understanding of Design not merely as practice but as a vast intellectual field spanning several disciplines. Students will be introduced to the economic, political, cultural and technological contexts within which Design Schools, Design movements and Design Styles took shape in Europe, the United States and later India. The objective is to help students understand how

Design practice and pedagogy was closely linked to modern consumerism and nationalism on the one hand and on social, political, and environmental movements on the other. The course will focus on specific movements as the Art and Crafts Movement of the late 19th century, Art Noveau, Bauhaus and the Modernist Era, along with Alternative Design movements, such as appropriate design, universal design, and socially responsible design etc. By the end of the module students expected to be able to make connections between what they learn in class and the larger economic, social and cultural context in which they would work.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in design history.
Focus on entrepreneurship	No	-

PC732 Fundamentals of Design - II (3-0-4-5)

This course deals with the advanced aspects of color, composition, virtual 3D spaces, Typography as image, Illustration for information design, and Digital Photography as means of explore, visualize and communicate complex ideas with high levels of data density. This course would present an entry point to moving image and sound analysis, structure, methodology, concepts and experimentation for communicating specific ideas as well as to explore the possibilities/potential of each medium. Consideration of 'mediums' would focus on moving image scenarios that would include cinema, animation, multimedia and Sound Design and for 2D and virtual 3D environments. Students should acquire from the field of 'Design History' the understanding of visual language that is applied for range of visualization essential for practice of sketching, photography, film and animation.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on visual communication.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in design principles.
Focus on entrepreneurship	Yes	The students will find opportunities for start-ups, entrepreneurship.

PC731 Research Methodologies - Ethnography and its Applications (3-0-0-3)

Contemporary information technologies are often said to be immersive, creating distinctive and highly detailed virtual experiences. Thus the discipline of ethnography, which teaches researchers to understand social activity through immersive exposure, seems particularly appropriate to study of communication design Ethnographic analysis provides powerful tools to understand how communication systems deeply affect individuals and societies. The course introduces the foundations and basic methods of ethnography derived from the fields of visual anthropology and cognitive anthropology. It will look at several applications of these disciplines to current communication practices. Students would be expected to undertake fieldwork assignments and related applied activities such as collection of empirical data, qualitative data, contextual inquiry and usability testing that provides the foundations for user-centered interaction and visual design. The objective of the course is to provide the student the intellectual tools to develop research capacity for the final design projects they would have to undertake.

Focus Area	Yes/No	Details

Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in ethics, research methodology.
Focus on entrepreneurship	No	-

PC725 Introduction to Narratology (3-0-2-4)

This course will introduce students to the critical place of narratives in communication practices. The theoretical starting point of this course will be an understanding that narratives are found and communicated through a range of media such as verbal and written language, gestures, music, visual art and film. Narratives have also acquired in new and complex forms in computing environments and digital networks. Beginning from a range of questions related to simple forms of story –telling, students in this course will be acquainted with the more sophisticated insights of practitioners of what is known as "narratology". Starting from the theoretical propositions of Vladimir Propp (Morphology of the Folktale 1928) the course will survey the writings of Claude Levi Strauss, Gerard Genette, Roland Barthes, and Mieke Baal among others. By the end of the course students will be expected to develop a deep understanding of both the thematic and modal aspects of story –telling. In other words, they will be engaging with both the structure of the narrative and the manner of its telling. This course is intended to prepare them for a subsequent course on the construction and translation of narratives in different media.

Focus Area	Yes/No	Details

Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in narratology.
Focus on entrepreneurship	No	-

PC750 Photography (1.5-0-2-2.5)

The course will commence with the History of Photography with an overview of the technical and creative development of photography through time and will introduce students to the science of Photography with and overview of the chemistry and physics in the subject. The course will emphasize on the critical analysis of the works of masters, around a broad range of photographic images from a variety of genres and institutions including: advertising, print and digital news media, social-networking sites and art. In doing so, they are expected to build sensitivity to the reading of Photographic imagery. They will be encouraged to engage in a critical evaluation of the relationship between the textual specificity of the photograph and the contexts of its production, distribution and reception. This would be an opportunity for the students to engage and reflect on photographic images.

This module on Photography will build on previously learnt skill sets of the students to learn how to frame an image using the camera - through observation, content, context, composition, colour, and light primarily to understand and build an aesthetic sensibility. The students will learn to train the eye train to develop perfect compositions through the viewfinder and learn to effectively capture expressive moments with accuracy and aesthetics to develop a keen sense of storytelling through still images

Focus Area	Yes/No	Details

Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in photography.
Focus on entrepreneurship	No	-

PC751 Video (1.5-0-2-2.5)

The aim of the course is to establish an understanding in students about the elements of documentary filmmaking through a practical approach; to establish an understanding of the complexities of this medium through critical analysis and study of acclaimed documentaries and documentary filmmakers.

The courses would introduce students to a brief history of documentary filmmaking to examine the narratives of historically important films and filmmakers and how they have affected society - biopics, video essays, craft documentaries etc. and compare it to current trends in documentary filmmaking. With this as a base the basic narrative tools/devices used to tell a story - interviews, montages, inserts, intercuts, color family, mood boards, voice over would be discussed, to examine how each tool and device makes an impact on the overall narrative. How narrative structures differ and are constructed based upon what is to be communicated. Understanding audiences - shaping films according to the audience - how geography, history, culture, language and understanding affect a film.

The course would also examine the relationship between the subject and a filmmaker; engaging with the subject, understanding the aspects of communication, establishing perspectives, ethics and integrity.

The course would cover the technical aspects of moving image and sound - treatment for a documentary - elements of composition – the camera as a narrative tool – the Art of framing, camera movements, angles, lensing, compositions, video gear, and elements of

cinematography to help tell a story. Sound as a narrative tool - sound recording, voice over, music to support a story.

The students will be introduced to the complexities of shooting in the field – focusing on narrative/direction – establishing a balance between style and content, the technical and aesthetic aspects.

Editing for moving image - The concepts that govern editing as a process in which a documentary film takes its form, accommodating and integrating different basic editing techniques to support narratives – relevance and importance of devices like voice over, montage, overlay edit, silence. The course would also cover Sound in details as an integral part of film making – both the aesthetic and practical aspects of sound leveling, mixing, foley recording, voice over, music would be covered in theory and practice, and finally subtitling, graphics, motion graphics, end and opening credits, title of the film, data intermediate etc. to conclude the process.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in Video.
Focus on entrepreneurship	No	-

PC752 Interaction Design (1-0-4-3)

Interaction Design involves designing for meaningful interactions between humans and their artifacts and this idea is easily extended to include interactions between humans with the help of their artifacts. Designing for interaction requires understanding human engagement and communication with technology and to use that knowledge to design artifacts within specified contexts and constraints that create more useful and satisfying

experience for the users. With the explosive growth of digital technology, interaction design is now being applied largely to interactions with digital artifacts. Interaction design includes elements from the fields of human factors; human computer interaction, collaborative work and learning, digital design, cognitive ergonomics, informatics, information systems, and interface design. This course will cover the underlying principles of a wide range of issues, and includes empirical studies with design implications and extensive work on lab and field based exercises. This course is designed to cover the breadth of the field and to enable the students to be adept and competent in grasping and dealing effectively with design issues involving interaction with a range of devices, services and users. This course requires the students to investigate a specific area or a context in depth and develop understandings and design implications in order to deliver an innovative proposal and prototype.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in interaction design.
Focus on entrepreneurship	Yes	Interaction design opens up business opportunities and entrepreneurship.

PC741 Animation (3-0-2-4)

The aim is to sensitize students to the structure, nature, systems, and communication potential of the medium of animation. This course would be an introduction to the

fundamentals (principles and dynamics) of motion and movement in animation – both theory and practice. The course would equip students with the basic concepts, methods/means and language to conceptualize and visualize simple ideas through animated sequences/films. Storytelling, Storyboarding, Animatics, Setting a stage, and kinetics would be the main areas to explore the limits of the medium. The course is set to exploring ways to communicate complex ideas and hidden worlds effectively using the language of animation, from entertainment -films and gaming to Instructional material. The course would also introduce students to the art of developing and visualizing characters for animated films. Exploration and experimentation with lip synchronization, aesthetics of sound, track lying, and creating animated sequences with/to sound.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in animation.
Focus on entrepreneurship	Yes	Animation offers scopes for start-ups, entrepreneurship.

PC733 Web Design: Applications, Inter-connectibility (3-0-2-4)

Through discussing various examples students would be introduced to Web Concepts and Design. What are the basic technical requirements and production processes needed for a basic web site development and construction. Topics include site design, image processing, visual web editors, html and layout, interface design and basic behaviors. Along with this aspects of connecting to a network would be provided as hands on

experience. As a class project, students would start setting up a site that would become a context to apply things they learn and present the work for others. Through this process the student will learn to combine various software that are available and that must be utilized to create a multimedia content. As each multimedia approach requires a different combination of software the students need to understand the potential advantage and disadvantages of specific software, their compatibility amongst each other, cross-platform applications and the optimum manner in which they can be used with minimum generation-loss of end product. The rationale behind this course is that hardware-software compatibility for the optimum communication is essential and it is best understood by a hands-on, lab-based exploration of multimedia fundamentals. Emphasis will on end product design, concept development and collaborative techniques as used in professional multimedia prototyping. Additionally, students will learn about a variety of hardware and software options including, but not limited to, image editing, digital video and input/output concerns. This course will consider the concepts, technical requirements and production processes needed for web site development and construction. Topics covered will include interface design, web animation and interactivity, video and audio for the web and interactive end products. Primary objective is to present and explore concepts and tools for interactivity in multimedia.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in multimedia.
Focus on entrepreneurship	No	-

PC742 Thematic Seminar/Workshop or a RR Course (3-0-0-3)

Faculty involved with the M.Des. program and or visiting faculty would conduct a seminar or a workshop for the students to either learn or explore some new areas of multimedia techniques and applications. If and when required an open elective offered in the Institute may be considered as a substitute for the seminar course. In case a seminar or workshop is not offered the student could take up a reading and research (RR) course with any faculty member after providing the formal plan of arrangement between the student and the faculty concerned to the M.Des. committee. Please note that the focus of this course has been not fixed in order to take advantage of students' changing interests, faculty's own research interest and the particular area of expertise that a visiting faculty brings from outside including the design industry.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in technical writing, presentation and communication.
Focus on entrepreneurship	No	-

PC745 Research Application: Constructing Narratives (3-0-2-4)

This course is meant to encourage students to apply the theoretical insights drawn from the earlier course on narratives and develop their own narrative form around a particular idea or message they wish to communicate. They will encourage translating narratives from one medium to another and analyzing the differing demands of each. This course will involve a group project wherein students will be tested on their capacities to work together and develop a product that reflects coordinated team work. For example, they

can work together to develop a public interest message through paper, voice and screen and develop a keen sense of the narrative as it takes shape through each medium.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in narratology.
Focus on entrepreneurship	No	-

PC740 Research Proposal Seminar: Rationale, Process, Outcome (1-0-4-3)

This seminar's main focus will be help students to formulate their final project proposals. Students will be expected to engage in informed discussions about their design problems with the faculty. They will be required to provide a clear rationale for the selection of a project and explain how they intend to implement the skills and aptitudes gained from the courses offered in the program. It is essential that students in this seminar are intellectually capable of integrating the technical component of their design project with questions derived from their understanding of the social and cultural contexts of communication. They are expected apply the research methodologies learnt in the previous course and write up a concrete proposal in accordance with a set of given guidelines. The primary objective of this seminar is to enable students to make informed decisions about the nature of the project they wish to undertake and the range of intellectual skills they need to work on it. Once they have decided on a proposal, they will in the next and final semester work in consultation with an assigned team of faculty. This course will equip student with the necessary tools to determine appropriate methodology for specific design research needs and teach them how to find supporting resources, and the ability to critically evaluate existing research.

Focus Area	Yes/No	Details
Focus on Employability	Yes	The students taking the course can be employed in industries focusing on communication design.
Focus on Skill development	Yes	The students develop necessary skills to develop foundational knowledge in technical writing, presentation and communication.
Focus on entrepreneurship	No	-

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